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Joe Foss, Governor

STATE GEOLOGICAL SURVEY
E. P. Rothrock, State Geologist

REPORT OF INVESTIGATIONS

NO. 77

ARTESIAN CONDITIONS IN NORTHEASTERN SOUTH DAKOTA

by

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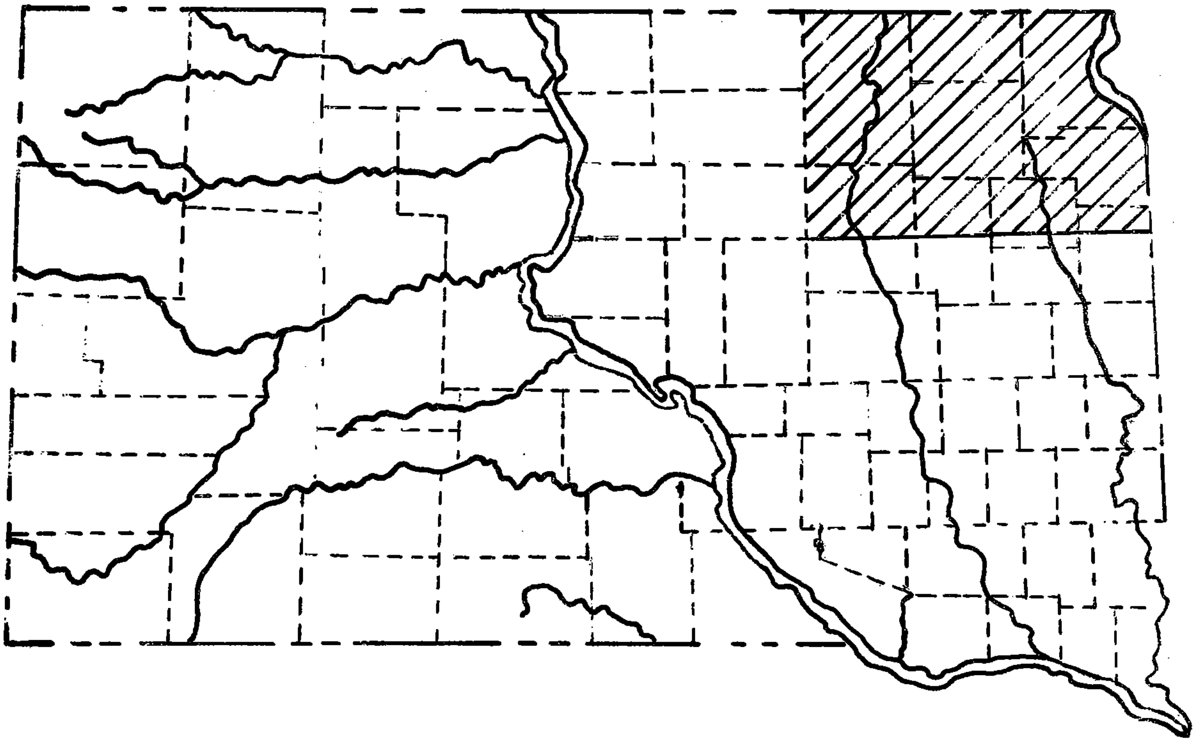
ARTESIAN CONDITIONS

IN

NORTHEASTERN SOUTH DAKOTA

Index Map of Area



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INTRODUCTION

Location and Area

The area concerned in this report includes five counties; Brown, Day, Marshall, Roberts, and Grant, as well as the northern portion of four other counties; Spink, Clark, Codington, and Deuel which lie north of the line running between Townships 116 and 117 North. The north boundary is formed by the North Dakota-South Dakota state line, while the eastern boundary is the Minnesota-South Dakota state line. The western boundary is formed by the west county lines of Brown and Spink counties, while the southern boundary is formed by the line running between T. 116 N. and T. 117 N.

The area covers approximately 6,200 square miles or nearly 4,000,000 acres. The area is well supplied with transportation facilities, both arterial highways and secondary highways as well as railroad and airline services. In the past few years some of the county roads have been hard surfaced to further improve the transportation facilities. There are numerous large cities and towns in the area, some of which are: Aberdeen, Watertown, Redfield, Sisseton, Webster, Milbank and Britton.

Purpose and Method of Investigations

The primary purpose of this investigation was to determine the piezometric head or static level to which the water from the underlying artesian aquifers would rise. Also the rate and amount of decline of the piezometric head for the past 45 years was determined.

The second purpose of this survey was to study the surface and subsurface stratigraphy as well as the structure of this area.

The investigation was made by a two man party consisting of William J. Matousek as field assistant and the author as geologist.

To obtain the information desired on the piezometric head the investigation was carried out as follows: A brief history of the well as obtained including depth, date drilled, driller, and so forth. The well itself was then measured for pressure, rate of discharge, temperature, and sea level altitude. The pressure was measured with a standard pressure gauge on wells in good condition, otherwise an approximation of the pressure was made. The rate of discharge was determined by use of a gallon measure and stop watch. The temperature of the water was taken with a standard Taylor thermometer, and the altitude of the well was determined with topographic maps and by altimeter where topographic maps were not available.

Since this survey was conducted only for a period of two months,it was impossible to check every well in the area. Therefore, a well was measured every three to six miles to determine the piezometric gradient of the water level. Where pumped wells were encountered the accuracy of the piezometric head was extremely variable, for an accurate reading could be made only by lowering a line down into the well. This was usually not feasible as the entire pumping system had to be removed to take the reading. As a result, the information had to be obtained from the well owner. This was occasionally misleading, for many times the pump rods had not been pulled for two or three years, which made the reading of the piezometric head higher than it actually is now.

Another factor which affected the accuracy in reading the piezometric head on pumped wells was the amount of drawdown the well had. If the drawdown was great, one could not get an indication as to how high the water rose in the well by the number of feet of pump rods in the well, but if the drawdown was small the footage of pump rods would give an approximate indication as to the height of the piezometric head. Still another factor that prevented accurate readings of the static water level was that some wells are extracting water from two or more artesian horizons (Dakota, Lakota, and Sundance)and are, therefore, giving a reading which is a combined result of the pressures in two or more artesian sands.

Information on the subsurface formations of this area was procured largely through the use of sample logs and electric logs. A number of newly drilled wells were logged this past summer along with the work on artesian conditions. They were logged with a Widco 2000 foot, electric logger owned by the State Geological Survey.

Previous Investigations

Little investigation of the artesian water conditions has been carried on in South Dakota during the past 40 years. The first investigation of artesian water in the region affected by this report was made by Nettleton (1892), who made a general investigation to determine depths, pressures, and flows of wells in North Dakota and South Dakota. Darton (1896) made a more detailed study of the South Dakota artesian basin for the United States Geological Survey. His preliminary report investigated the location of water bearing beds and the limits of the territory in which artesian flows were expected in South Dakota and adjoining states. Todd (1898) made some investigations of the geology and underground waters of South Dakota. Darton (1909) wrote a second report on the geologic conditions that had a bearing on the occurrence of artesian water in South Dakota. Todd (1909), also, wrote a report for the United States Geological Survey concerning the geology and artesian conditions in the Aberdeen-Redfield area.

The State Planning Board (1937) of South Dakota prepared a report concerning the existing conditions of artesian flow which was used as a basis for the sound planning and conservation of the natural resources of South Dakota. A series of reports covering individual counties in the state was prepared by the Works Progress Administration (1940) under the direction of the Extension Service at South Dakota State College. The reports were prepared to present recent data on the types and the sources of underground water in the different counties.

By comparing these past investigations with the present, it is possible to determine, approximately, the average rate and total decline in the piezometric head or static level of the water that has occurred in this area in the past sixty years.

Acknowledgements

The author wishes to express his thanks to Dr. E. P. Rothrock under whose supervision this report was written, and to Bruno Petsch who contributed some of the data on electric logs in the area.

Special thanks is given to William J. Matousek who served as field assistant.

Thanks is also given for the cooperation received from the well owners and well drillers of this area.

GEOLOGY OF THE AREA

Procedures For Obtaining Stratigraphic Information

The information used for logs of subsurface formations of this area was interpreted from samples and electric logs.

From samples that were studied with the aid of the microscope, it was possible to determine the lithologic character and the tops of the different formations.

With the use of the electric logger it was possible to obtain added information, particularly on the tops of the different formations. The general lithologic character as well as the permeability of the rock could also be determined. The procedure used when running an electric log on a well and the physics behind it was explained to some extent in the previous report (Erickson, 1954) and will not be repeated in this report. Suffice to say that an electric log is composed of two curves plotted against depth on graph paper. One, the resistance curve, is a measure of the resistance of a formation to the passage of an artificial electric current. The other, the potential curve, is a measurement of natural earth currents produced by the electro-chemical reaction taking place between the different types of rock strata.

STRATIGRAPHY

The stratigraphy of this area is represented by the four geologic groups, namely the Cenozoic, Mesozoic, Paleozoic, and the Pre-Cambrian. Not all the formations of these groups, however, lie conformably upon one another. As seen from the Time Rock Chart (page 5), there are five major unconformities in this area, major signifying that parts and even whole systems are missing from the stratigraphic column. These unconformities which are actually disconformities are located between the Pleistocene and Cretaceous, Cretaceous and Jurassic, Jurassic and Detrital zone (Permo-Triassic, see footnote on page 8), Detrital zone and Pennsylvanian, and the Pennsylvanian and Ordovician systems.

As well as major unconformities, we find minor unconformities occurring nearly all the way through the geologic column as the different formations of the different systems pinch out unconformably on the Pre-Cambrian granite and other crystalline rocks of the area.

The minor unconformities represent successive advances in the seas, while the major unconformities represent both large scale advance as well as retreat of the seas during Paleozoic and early Mesozoic time. The unconformity that occurs between the Pleistocene and Cretaceous systems, however, does not represent a change in sea level, but is an erosional unconformity due to continental glaciation.

Below is given a Time Rock Chart with Lithologic Descriptions of all surface and subsurface formations found in this area.

TIME ROCK CHART WITH LITHOLOGIC DESCRIPTIONS

GROUP	SYSTEM	Lithologic Descriptions	POSITION
CENOZOIC	QUATERNARY	Stream Deposits Alluvial deposits of silt, clay, sand, and gravel make up the floodplains of the Big Sioux and James rivers as well as the floodplains of some of the larger creeks. Glacial Lake Deposits Parts of two glacial lakes are present in the area, Lake Dakota which borders the James river on both sides and Lake Agassiz which extends just into the very northeastern corner of Roberts county. These deposits are characterized by sand, silt, and clay with occasional beds of coarser sand and gravel. Glacial Deposits These deposits are characterized by moderately high morainic ridges with lower ground moraine and outwash slopes and plains in between. The dominant moraines in the area are the Bemis, Altamont, Gary, Antelope, and Gary-Altamont. The glacial till is composed of clay with scattered boulders and occasional pockets of poorly sorted gravel as found in kames and eskers, while the outwash slopes and plains usually yield good sands and gravels.	SURFACE

		Wind Deposits The only wind deposits located in this area are a few loessial deposits and some dune sand located on the flat surface of glacial Lake Dakota.	SURFACE
MESOZOIC	CRETACEOUS	Pierre Formation, Undifferentiated (Meek & Hayden, 1861) Light to dark gray, clayey, bentonitic shales and sandy shales, ironstone and lime concretions occasional pure bentonite beds as well as some chalky shales. Undifferentiated signifies only that the outcrops of Pierre in this region have not as yet been correlated with the recognized members of the Pierre formation. Thickness ranges from 0-270 feet through the area.	
		Niobrara Formation, (Meek and Hayden, 1861) Predominantly a light gray chalk to a chalky marl weathering buff to cream. Composed largely of foraminifera and other microfossil shells as well as calcite. Its thickness varies from 0-160 feet in the area.	SUBSURFACE
		Carlile Formation, (Gilbert, 1896) Consists of gray to dark gray, fissile, bentonitic shale with ironstone and lime concretions, thin sandstone layers and impure limestone layers. The thickness varies from 0-230 feet throughout the area.	
		Greenhorn Formation, (Gilbert, 1896) Light gray to gray fragmental to dense limestone, composed largely of broken and worn shell fragments, *Inoceramus* prisms, and foraminifera, with beds of darker gray calcareous shale and occasional thin beds of bentonite. The upper and lower portions are usually more argillaceous. Its thickness varies from 0-60 feet in this region.	
		Graneros Formation, (Gilbert, 1896) Gray to dark gray clayey shale, bentonitic, with some lime and thin sandstone beds and ironstone concretions two to six inches in diameter. Its thickness ranges from 0-270 feet.	
		Dakota Formation, (Meek and Hayden, 1861) Yellowish to grayish white, waterbearing, sandstone with alternations of gray to dark gray shales and siltstone. Lignite beds are occasionally found.	

MESOZOIC	CRETACEOUS	Carbonaceous material is usually found scattered throughout as well as numerous ironstone and pyritic concretions. It varies in thickness from 0-170 feet in the area. Fuson Formation, (Darton, 1800) Composed chiefly of fine grained sandstone and siltstones with much massive varicolored, highly bentonitic shale. Manganese pellets are abundant. Its thickness ranges from 0-30 feet. Lakota Formation, (Darton, 1899) Massive, buff to reddish, medium grained, crossbedded, waterbearing sandstone, with partings of shale and local carbonaceous and lignitic horizons. Its thickness varies considerably as it pinches out against the basement rocks of the area before it reaches the area around Milbank. It ranges from 0-150 feet.	SUBSURFACE
	JURASSIC	Sundance Formation, (Darton 1899) Composed of gray to green marine shales, bentonitic clays, and waterbearing, glauconitic sandstone usually a grayish to greenish white, with some gray to cream colored limestone. Its thickness varies from o-130 feet.	
? ?		Detrital Zone[1] Predominantly a grit to coarse grained waterbearing sandstone, composed largely of white angular quartz grains with small amounts of granitic material. Its thickness ranges from 0-50 feet in this area.	
PALEOZOIC	PENN.	Minnelusa Formation, Winchell (Ludlow, 1875) Varicolored bentonitic clays and shale with some gray to brownish gray argillaceous (silty) as well as crystalline limestone. Some white to reddish sandstone. Its thickness ranges from 0-100 feet in the western part of the area.	
	ORD.	Winnipeg Formation, (Dowling, 1896) Only the upper portion of the Winnipeg formation has been drilled in this area. It is a light grayish green to gray, mottled, bentonitic shale and siltstone with a few sandy horizons. The greatest thickness penetrated in this area is 26 feet in the Oil Hunters-Raetzman #1 well in Brown county.	

PRE-CAMBRIAN	Pre-Cambrian Crystalline Rocks Granite underlies nearly all the area, but certain wells drilled to basement have yielded varying types of Pre-Cambrian rocks. A well just over the border in North Dakota in Sec. 11, T. 124 N., R. 63 W., was drilled into a basic igneous rock, (Strassberg 1954). This area probably extends over the state line into the north part of Brown county. The Veblen city well in Marshall county is reported to have reached a fine foliated hornblendic schist, cut by quartz veins, with surface slickensides. (Stevenson, 1954) The Bureau of Reclamation well at Watertown penetrated a dusky, yellow-green serpentine. These metamorphics probably extend in a narrow belt from a point north of Veblen through Watertown.	SUBSURFACE
	The Aberdeen city well hit pink granite, while the Oil Ventures-Naessig well in Day county and the Redfield city well penetrated a white granite. The granite found in the Aberdeen city well closely resembles that found in the outcrop area near Milbank but is somewhat lighter in color. The "Milbank" granite has more of a mahogany color to it.	SUBSURFACE and SURFACE

1. The Detrital zone is found only in the very western portion of this region, but extends west of the Missouri river. As of yet not enough evidence is found to accurately determine the age and origin of this sediment. There are, however, three possibilities which can be used to determine its age. Firstly, it could have resulted from an onlap of the Sundance sea. Secondly, it may have resulted from an offlap of the Minnelusa sea. Thirdly, it may correlate with the red beds to the west, for in some wells (Dakota-Texas-Williams-Thompson, Potter county and the Hunt School Land, Hyde county) a thin section of red silts are found below the basal Sundance and the top of the Detrital Zone. In the former well, thin red silts are found below the base of the Detrital Zone and the top of the Minnelusa.

The red beds of western South Dakota are believed to be Permo-Triassic, but are generally put in the Triassic system when described. When the sea retreated after the deposition of the Minnelusa formation it provided an excellent place for the red beds to develop. With the high land mass known as the Sioux Quartzite Ridge to the east, it is highly probable that the coarse detritus was derived from this area and was deposited at the same time as the red beds. Topographic contours drawn on the Pre-Cambrian surface would support this theory, for undoubtedly the high land mass of the Sioux was eroded further back to the east and south as Jurassic, Cretaceous, and Tertiary deposition took place in the Dakota trough. As the streams spread out on the relatively flat surface adjoining the ridge area and the likewise flat surface of the newly deposited Minnelusa formation farther to the west, the coarse detrital material was deposited unevenly in varying thicknesses and was interfingered with the red beds.

STRUCTURAL CONDITIONS

The structural features of this area consist wholly of very gentle warps and minor folds. As seen from the contours drawn on top of the Greenhorn limestone, shown on the geologic map (pocket in back), it is obvious that this region has little pronounced folding. The regional dip of the area varies locally, but is predominantly north and west into the Dakota basin. Throughout most of the area the dip is less than five feet per mile. In the western portion of Brown county, however, the dip on the Greenhorn increases to approximately ten feet per mile. The dip also increases in the east portion of the area around Milbank where the Pre-Cambrian rocks outcrop at the surface, but since few logs are available from this area, it is impossible to determine the dip accurately.

There is no evidence anywhere in this region to indicate tectonic movement after Pre-Cambrian time. The minor folds and flexures that occur are due entirely to the differential compaction of the sediments over the irregular topography on the Pre-Cambrian erosional surface. If more control was available the contour map on the Greenhorn would more than likely exhibit numerous high and low areas in this region rather than a uniform dip into the Dakota basin.

METHODS OF DETERMINING THE STATIC WATER LEVEL AND RATE OF FLOW IN OBSERVATION WELLS

The static water level was determined on both flowing and pumped wells. On flowing wells it was determined with the use of a pressure gauge and mathematical computation. For every pound per square inch of pressure measured on the well the water will rise 2.31 feet. Consequently, if a well had a pressure of 20 pounds per square inch, the water would rise 46.2 feet above the well disregarding frictional loses in the pipes.

On pumped wells the static level of the water is best measured by lowering a line into the well until the water level is reached. By subtracting the distance from the ground to the water level the static level is determined. Most of the pumped wells in this area, however, could not be gotten into without wasting precious time for all were equipped with a windmill or pumping equipment. As stated before, the information then had to be obtained from the farmer.

In both pumped and flowing wells the static water level is based on or referred to sea level. That is, the distance either above the ground or below is added or subtracted to the approximate sea level altitude of the well curb which was obtained largely through the use of topographic maps and aneroid barometer.

The rate of flow of the well was determined by using a gallon measure and stop watch. The flow of a well can also be found by use of mathematical formulas, but this was not employed this previous summer as most wells did not flow enough to warrant their use. A complete detailed description of how to determine the flow with formulas was discussed in the previous report, R. I. # 74, (Erickson 1954).

CONDITIONS AFFECTING THE PRODUCTION OF ARTESIAN WELLS

There are numerous factors that affect the production of artesian wells. The most important factor is the character of the aquifer itself, that is, whether it is a porous permeable sand or a tight impermeable sand. Drawdown, which is the distance the static water level drops when a well is pumped or is flowing also affects production. A well with a large amount of drawdown invariably produces less water.

There are other factors affecting production which are noticeable, but as a whole are minor. The changes in atmospheric pressure cause seasonal changes in production. Since the average atmospheric pressure is higher during the winter months, the production of the well is reduced slightly. During the summer, however, production increases as the average atmospheric pressure decreases. Sudden changes in atmospheric pressure as those occurring before a severe thunder storm often cause a roily effect in the well. Another factor which has no importance in this area, but definitely has an effect on production is gas lift. With a considerable amount of gas the water is more or less bouyed up. As a result many wells which contain gas flow which otherwise would have to be pumped if it were not present.

GENERAL GROUND WATER CONDITIONS

The availability of ground water in this area has been unquestioned to date, but unless something is done to conserve our rapidly diminishing supply, it no doubt, will become a problem in the future. The comparison between N. H. Darton's survey of 1909 and the present survey will show the approximate decrease in head in the Dakota formation.

The ground water conditions of this area may be divided into two distinct subdivisions; namely, the shallow subsurface ground water found in the unconsolidated, poorly stratified drift, and the deeper ground water found in the consolidated, stratified sedimentary formation.

The shallow subsurface ground water is found predominantly in the glacial deposits and in alluvial deposits of sand and gravel found along the existing streams. The majority of wells drilled into these deposits are pumped, but in an area trending northwesterly through the lower portion of Grant county on the eastern side of the Coteau, a large number of shallow flowing wells are found.

Many lenses and channels that occur in glacial deposits lie at an angle or are tilted. Thus, a hydrostatic pressure is built up at the lowest portion of this channel or lens. If the pressure is sufficient, a flowing well results. Wells of this type are characterized by small flows, low pressures, and relatively hard, very cold water. Unless the aquifer is large and carries a large amount of water, the wells are usually affected by extensive periods of drouth. This is the usual case in all of the shallow subsurface water supplies.

In the deeper subsurface formations there are five possible sands recognized as artesian aquifers. In order of their depth from the surface they are: the Dakota, Lakota, Sundance, Detrital zone, and the Minnelusa formations. The Dakota and Lakota sandstones underlie the entire area except for a small area around Milbank where they pinch out abruptly against the Pre-Cambrian rocks. The Sundance, Detrital zone, and Minnelusa formations are found only in the very western portion of Brown county and possibly the northwestern part of Spink county.

All of these formations or their equivalents are found outcropping in the Black Hills. As a result of rainfall, melting snow, etc., these outcrops serve as an intake for the water that enters the formations. Undoubtedly some of the water enters the formations on the east slope of the Rockies where they also outcrop at the surface. Since these formations have a steep outward dip from the Black Hills which carries them far beneath the adjoining plains in a relatively short distance where they are buried under a thick section of impermeable shales and clays, the water that enters the formations builds up a hydrostatic head or pressure which produces flowing wells in the eastern part of the state where the sea level altitude is lower than the area where the beds outcrop. The water does not come from the Black Hills as many people believe, but is composed largely of connate water. However, the pressure which enables the well to flow does originate in the Black Hills region and the Rocky Mountain region. It is impossible to determine whether any of the water entering the formations in the hills has percolated this far eastward.

The Piezometric map accompanying this report (pocket in back) shows the approximate hydrostatic head of the Dakota and Lakota sandstones. The head is shown by contours and represents the altitude above sea level that the water within these formations will rise. Since the piezometric head is lowering steadily, this map is valid only for a relatively short period of time. Estimations made from this map after a few years will have to be lowered slightly, before determining how much pressure the newly drilled well will have.

QUALITY, CHARACTER, AND PIEZOMETRIC HEAD OF THE ARTESIAN AQUIFERS

Dakota Formation

The pressure of the water in the Dakota formation is derived largely from the Black Hills region. A small amount may be derived from the Sioux Quartzite Ridge area to the south.

The quality of the water coming from the Dakota sandstone in this area is predominantly soft, but occasionally harder water is found. Throughout North Dakota, Minnesota, and South Dakota, it is a general rule that the upper waters of the Dakota sandstone are softer than the lower waters.

No well was checked in this area that contained any gas, but the majority of the water exhibits a slight to strong saline taste. All the Dakota water is potable and can be used for culinary purposes. Only one chemical constituent found in the water tends to make it undesirable for human consumption. This chemical is flourine. On the average, the Dakota waters contain too much flourine, which if found in excess is injurious and harmful to the enamel of the teeth. It has been established that water should contain between 1 and 1.5 parts per million of flourine, but much of the Dakota runs over 1.5 parts per million. In the area around Britton and Hecla, chemical analysis indicates it to contain as high as 9 parts per million. This high percentage quickly mottles the teeth and turns them brown.

It should also be stated here that the Dakota water is usually unfit for irrigation as it contains too much sodium as well as sulphates and chlorides. Small scale irrigation of garden plots can usually be done without serious injury to the crops, if the garden is watered only when natural rainfall does not occur.

The temperature of the Dakota waters usually runs between 57-60 degrees in this area. The higher temperatures occur in the western pottion of the region where the Dakota sandstone is covered by more sediments.

The location and number of all artesian wells checked in the area are found on the accompanying Piezometric map (pocket in back) and in Table No. IV.

As seen from the Piezometric map the general slope of the hydrostatic head is from west to east. As one approaches the James river valley, however, the slope is more gentle and reverses itself just east of the river. It continues to go up until the eastern portion of the area is reached, where it begins to dip sharply at about 10-15 feet per mile, from west to east.

The Table No. I (page 15) shows a comparison between Darton's survey and the present survey. When using the table however, it should be remembered that sea level altitude was not taken into consideration as Darton's survey did not give accurate elevations at the well site. The comparison serves to show, however, that the head has decreases in every area.

As seen from the table, there has been a considerable drop in head along the James river. This drop as well as the others in the area is due to many different factors. The factor which is most outstanding, however, is that too many wells have been drilled into the artesian basin in this area and allowed to flow unchecked. Since most of the wells have been flowing freely for a considerable number of years, it only stands to reason that more water has been taken out than can be replaced. Consequently the flow and pressure of the wells continue to decrease.

As seen from Table No. I., the greatest decline in pressure has occurred in T.121 N., R. 61 W., where it has gone down approximately 370 feet since 1909.

COMPARISON OF DARTON'S AND TODD'S SURVEY TO THE PRESENT SURVEY

TABLE NO. I

	DARTON'S AND TODD'S SURVEY		PRESENT SURVEY		
Location	Depth (ft.)	Head (ft.)	Depth (ft.)	Head (ft.)	Decline Since 1909
Brown County					
T121N-R61W	900-940	386	900	14	372
T123N-R60W	960	311	976	7	304
T126N-R61W	965	311	1010	1	310
T126N-R64W	1030	81	1050	4	77
T127N-R64W	1094-1200	151	1126	21	130
T123N-R62W	875	311	920	21	290
Spink County					
T120N-R61W	880	231	925	14	217
T119N-R62W	875	306	909	20	284
T117N-R63W	899	276	900	23	253
T119N-R63W	920	324	890	32	292
T120N-R64W	948	276	950	17	259

Lakota Formation

The water from the Lakota formation likewise has it's origin of pressure in the Black Hills region and regions farther west in the foot hills of the rockies.

The quality of this water is almost identical to that of the Dakota, but is slightly harder in most instances. The other qualities of the Lakota water also resemble the Dakota. It is too high in flourine content, but is usually considered slightly better for irrigating purposes. Its temperature averages around 60 degrees in this area, but decreases from west to east as the overlying sediments thin.

The piezometric head of the Lakota follows very nearly the general pattern of the Dakota, but in most instances is slightly higher. Usually a well drilled into the Lakota has a higher pressure at the surface than does a Dakota well, providing the ground altitude is the same.

The decline in head of the Lakota formation is difficult to determine, since no records were kept on these wells during the early nineteen hundreds. The main reason for this is of course the fact that hardly any of the early wells were drilled into this formation, as enough pressure and water could be obtained from the Dakota formation. Since this time, however, there have been numerous wells drilled into this aquifer and no doubt the piezometric head has dropped on an average about two hundred feet and even more in local areas. The greatest decline has undoubtedly ocurred in the James river basin area.

Sundance Formation

This water too has its origin of pressure in the Rockies and Black Hills. Actually no water analyses were taken on Sundance water, but field observation indicates it to be a hard to semi-hard, warm water. It is hard to determine in many cases if the well is extracting water from this formation only, for many times most of the Sundance is drilled through and the Detrital zone is perforated along with part of the Sundance.

Since these wells are quite recent there is no data on the decline of head. It is a well established fact, however, that the present wells are much stronger than either the Dakota or Lakota wells.

Detrital Zone

The origin of pressure of this water is also from the Black Hills and Rocky Mountain regions. Its qualities are not well known over an extensive area. Chemical analysis on the water, in the western part of this area, shows it to be a semi-hard, warm water. Its characteristics are much like that of the Sundance. It is much lower in flourine content and like the rest of the artesian water, is poor for irrigation. Its temperature averages about 65 degrees.

Minnelusa Formation

No wells are yielding Minnelusa water in this region. It is included under this discussion only because it is a potential source for water in the very western part of Brown County.

DEVELOPMENT OF WELLS

The process of how to develop a well so that the maximum amount of water may be withdrawn with the least amount of drawdown is a problem faced by many well drillers. The drillers in this area are indeed fortunate, for very little developing has to be done on wells drilled in the Dakota or Lakota formation. The majority of times no development is necessary other than perforating a few lengths of pipe. If the water sand is interbedded with soft shales and clays, however, it is wise to develop the well further by placing a screen in the well and packing gravel and coarse sand around it. This eliminates the possibility of particles of shale and clay coming up with the water, and lengthens the life of the well by preventing it from becoming clogged. It also lengthens the life of pumping equipment, plumbing utilities, and water mains.

Wells drilled into the Detrital zone should be developed much more than wells in the Dakota or Lakota. This formation carries water under a very high pressure and if wells are improperly developed they last only a few years. To properly develop this type of well the pipe should be cemented in, that is, a cement squeeze should be placed from the bottom of the hole to the top, and then the pipe should be perforated with a gun perforating tool. This method eliminates all chances of the water forcing its way up on the outside of the casing as has happened in a number of wells.

Electric logs should be run on all newly drilled wells. For if a log is run, one can determine exactly where and how much perforated pipe should be set to obtain the maximum amount of water.

CONSERVATION OF PRESENT WATER RESOURCES

Water, whether surface or subsurface has always been and always will be a dominant factor in establishing whether flora or fauna can exist in a certain region. Throughout the state of South Dakota, subsurface water has never been a problem, but in periods of drouth, surface water has. Even during these periods we have repeatedly fallen back on the enormous subsurface supply using it, for the most part, wastefully. And, the people of the state are still using it this way. Well owners throughout this entire region, and all of the area where artesian wells are found, have continued to draw water from the subsurface unrestricted and without cause for the past sixty years. Now it is possible to say that this subsurface supply is dwindling rapidly and will continue to do so unless some laws governing the right and use of water are enacted and enforced. It seems to be characteristic of human nature to use a natural resource until it is practically extinct and then try to bring it back to its original condition. It is so much easier to conserve it as it is being used.

Actually there is little that can be done to conserve our shallow subsurface supplies, which are derived largely from the glacial deposits. These supplies are directly dependent upon the amount of precipitation received throughout the year. Possibly the construction of small dams and contour farming will have a very great effect on the conservation of these surface and shallow subsurface supplies. The conservation of the deeper artesian supplies, however, can be saved to some degree if conservation measures are started now.

There are a number of factors that have contributed to the steady decline in head. Probably the most important factor in the reduction of the artesian head is that too many wells have been drilled into the artesian basin. The only method of prolonging the life of these wells already drilled and conserve the present supply of water, is to reduce the rate of flow to meet the farmers immediate demand. Actually there is no need for a well to flow more than 2-3 gallons a minute, for a well flowing this much still supplies all of a farmer's need for livestock and agriculture unless extensive irrigation is planned. Many of the wells in this area are flowing from 5-10 gallons, and others flowing from the deeper artesian sands flow better than 50 gallons a minute, which is pure waste. Other factors which have reduced the piezometric head in this area are poor well construction and casing corrosion. If a well is poorly constructed, as is the case where a small casing is put in a large hole, the artesian water will force its way up around the small pipe and escape into other permeable horizons. Casing corrosion is one of the main factors which cause underground leakage from one permeable horizon to the next. The only way this can be stopped is to plug all of the old unused wells so as to prevent underground leakage. This would be a tremendous job, but would definitely help to conserve the present supply.

If it is possible to make the well owners realize the need for conservation, then many of these preventive measures will be tried. As a result it will be found that the level of the piezometric head will lower much more slowly, and as years go by it may even slowly build itself up.

TABLE NO. II

ANALYSES OF WATER FROM WELLS IN NORTHEASTERN SOUTH DAKOTA

From State Geological Survey Files

County---------Brown
Location-------SE$\frac{1}{4}$, Sec. 25, T. 124 N., R. 65 W.
Owner----------Edwin Arlt
Depth----------1285 (Detrital Zone)
Date-----------12/27/54

	PPM[1]	GPG[2]
Total Solids	2136	125
Chlorides (Cl)	67	4
Sulfates (SO_4)	1236	72
Silica (SiO_2)	12	1
Calcium (Ca)	79	5
Magnesium (Mg)	23	1
Alkalinity		
Phenolphthalein	10	1
Methyl Orange	138	8
Total Hardness as $CaCO_3$	292	17
Fluoride (F)	2.8	--
Iron (Fe)	1.2	--
Manganese (Mn)	None	--
Sodium (Na)	594	35

County----------Clark
Location--------SE$\frac{1}{4}$, Sec. 9, T. 119 N., R. 59 W.
Owner-----------F. W. Dubs
Depth-----------1260 (Lakota)
Date------------12/27/54

	PPM	GPG
Total Solids	2320	135
Chlorides (Cl)	231	13
Sulfates (SO_4)	1012	59
Silica (SiO_2)	56	3
Calcium (Ca)	15	1
Magnesium (Mg)	4	--
Alkalinity		
Phenolphthalein	26	2
Methyl Orange	306	18
Total Hardness as $CaCO_3$	54	3
Fluoride (F)	4	--
Iron (Fe)	2.6	--

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1. PPM indicates parts per million
2. GPG indicates grains per gallon

Manganese (Mn)	None	--
Sodium (Na)	791	46

County-------Spink
Location-----NW¼, Sec. 11, T.119 N., R.63 W.
Owner--------Orvil Hammer
Depth--------968 (Lakota)
Date---------12/27/54

	PPM	GPG
Total Solids	2122	124
Chlorides (Cl)	315	18
Sulfates (SO_4)	824	48
Silica (SiO_2)	8	1
Calcium (Ca)	16	1
Magnesium (Mg)	9	1
Alkalinity		
Phenolphthalein	27	2
Methyl Orange	310	18
Total Hardness as $CaCO_3$	77	4
Fluoride (F)	3.5	---
Iron (Fe)	None	---
Manganese (Mn)	None	---
Sodium (Na)	722	42

County-------Roberts
Location-----NE¼, Sec. 10, T.127 N., R.51 W.
Owner--------Elmer Peterson
Depth--------660 (Dakota)
Date---------12/27/54

	PPM	GPG
Total Solids	7001	409
Chlorides (Cl)	1257	73
Sulfates (SO_4)	1033	60
Silica (SiO_2)	7	----
Calcium (Ca)	86	5
Magnesium (Mg)	52	3
Alkalinity		
Phenolphthalein	18	1
Methyl Orange	237	14
Total Hardness as $CaCO_3$	428	26
Fluoride (F)	1	---
Iron (Fe)	1.2	---
Manganese (Mn)	None	---
Sodium (Na)	2469	144

County--------Marshall
Location-----SE¼, Sec. 23, T.127 N., R.59 W.
Owner---------Richard Moeckly
Depth---------920 (Dakota)
Date----------12/27/54

	PPM	GPG
Total Solids	2629	154
Chlorides (Cl)	397	23
Sulfates (SO_4)	1093	64
Silica (SiO_2)	12	1
Calcium (Ca)	21	1
Magnesium (Mg)	1	---
Alkalinity		
Phenolphthalein	32	2
Methyl Orange	300	18
Total Hardness as $CaCO_3$	57	3
Fluoride (F)	9	.5
Iron (Fe)	.2	---
Manganese (Mn)	None	---
Sodium (Na)	902	53

County--------Marshall
Location-----SW¼, Sec. 3, T.125 N., R. 59 W.
Owner---------Ray Hartberg
Depth---------1000+ (Dakota)
Date----------12/27/54

	PPM	GPG
Total Solids	2683	157
Chlorides (Cl)	310	18
Sulfates (SO_4)	1329	78
Silica (SiO_2)	9	1
Calcium (Ca)	38	2
Magnesium (Mg)	10	1
Alkalinity		
Phenolphthalein	13	1
Methyl Orange	168	10
Total Hardness as $CaCO_3$	136	8
Fluoride (F)	5	---
Iron (Fe)	2.2	---
Manganese (Mn)	None	---
Sodium (Na)	2562	150

TABLE NO. III

LOGS OF WELLS IN NORTHEASTERN SOUTH DAKOTA

Brown County

NE$\frac{1}{4}$ Sec. 33, T.125 N., R.65 W.---Oil Hunters - Raetzman
Altitude --- 1425

Pierre-------------0
Niobrara------------260
Carlile-------------420
Greenhorn-----------660
Graneros------------700
Dakota--------------970
Fuson-------------1140
Lakota?-----------1160
Sundance?---------1230
Detrital zone-----1347
Minnelusa?--------1400
Winnipeg----------1496
Total Depth--1522

City of Aberdeen ------------------ Altitude ----- 1300

Glacial deposits--0
Pierre------------90
Niobrara----------185
Carlile-----------310
Greenhorn---------530
Graneros----------580
Dakota------------830
Fuson-------------940
Lakota------------995
Pre-Cambrian
(granite)-------1267
Total Depth--1300

SW$\frac{1}{4}$ Sec. 7, T.123 N., R.60 W. -------------- Neuman Farm
Altitude --- 1303

Glacial deposits--0
Pierre------------85
Niobrara----------152
Carlile-----------268
Greenhorn---------536
Graneros----------575
Dakota------------790
Total Depth---974

Day County

SE¼ Sec. 15, T.124 N., R.59 W. -----------Torguson Farm
Altitude---1355 Approximately

Glacial deposits------0
Pierre----------------54
Niobrara--------------312
Carlile---------------348
Greenhorn-------------570
Graneros--------------590
Dakota----------------894
Total Depth----1174

NE¼ Sec. 32, T.121 N., R.55 W.-----Oil Ventures-Naessig
Altitude---1888

Glacial deposits-------0
Pierre-----------------510
Niobrara---------------804
Carlile----------------874
Greenhorn--------------1094
Graneros---------------1160
Dakota-----------------1354
Fuson------------------1400
Lakota-----------------1430
Pre-Cambrian
(granite)-----------1540
Total Depth--------1607

Spink County

NW¼ Sec. 13, T.117 N., R.61 W.---------Ottenbacher Farm
Altitude---1319

Glacial deposits------0
Pierre----------------15
Niobrara--------------223
Carlile---------------291
Greenhorn-------------526
Graneros--------------543
Dakota----------------867
Fuson-----------------881
Lakota----------------898
Total Depth------1061

Clark County

NE¼ Sec. 6, T.116 N., R.59 W.---------------Johnson Farm
Altitude----1441

Glacial Deposits--0
Pierre-------------207
Niobrara-----------321
Carlile------------403
Greenhorn----------630
Graneros-----------653
Total Depth---1059

Codington County

SE¼ Sec. 3, T.116N., R.52 W.------Bureau of Reclamation
Altitude----------1813

Surface pipe----0-518
Pierre------------ 518
Niobrara---------- 822
Carlile----------- 861
Greenhorn--------- 938
Graneros---------- 953
Dakota------------1064
Fuson-------------1090
Lakota------------1224
Pre-Cambrian
(serpentine)-----1274
Total Depth----1300

TABLE NO. IV

ARTESIAN WELLS CHECKED IN NORTHEASTERN SOUTH DAKOTA

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
			Brown County				
673	Henry Hazelhorse SE¼ S1-T121N-R65W	1924	1200	1345	11	1370	5.0
674	G. W. Bierman SE¼ S19-T121N-R65W	1910	1000	1350	Approx. 4	1358	.1
675	SE¼ S25-T121N-R65W			1298	Approx. 12	1325	1.5
676	Alfred Kuechle SE¼ S7-T122N-R65W	Nov. 1950	1377	1365	Over 100	Over 1585	15.0
677	E. C. Angerhofer NE¼ S13-T122N-R65W	1920	?? 1200	1335	2	1339	.6
678	Fred Brick SE¼ S31-T122N-R65W	1948	1134	1367	22	1418	8.0
679	Ray Wallberg SE¼ S21-T123N-R65W	About 1924	Over 1300	1380	Over 60	Over 1518	2.0
680	Andrew Schaeffer NE¼ S32-T124N-R65W	1951	1351	1452	Over 65	Over 1602	5.0
681	Edwin Arlt SE¼ S25-T124N-R65W	Nov. 1950	1286	1386	Over 100	Over 1616	30.0
682	Francis Schmidt NE¼ S8-T124N-R65W		900	1448	Poor Casing	1148	
683	Dale Broadbent SE¼ S13-T125N-R65W	1946	1155	1405	14	1437	4.0
684	Bartle Schile NE¼ S30-T125N-R65W	1947	1406	1440	25	1497	4.6
685	Wm. A. Raetzman NE¼ S33-T125N-R65W	Aug. 1952	1440	1425	70	1586	12.0

No.	Owner & Location	Date Drilled	Depth (ft.)	M.P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
686	Earl McCulloch NW¼ S34-T126N-R65W	1941	1456	1444	Approx. 60	App. 1582	App. 10.0
687	Pete Kranzler SW¼ S4-T126N-R65W	Old Well	??? 800	1464	7	1480	2.1
688	Marvin Graves NE¼ S36-T127N-R65W	New Well		1361	38	1448	3.3
689	Melvin Golnitz NW¼ S8-T127N-R65W			1463	7	1479	3.8
690	E.C. Rexinger SW¼ S1-T127N-R65W	Old Well	App. 1300	1440	6	1454	.7
691	John Storm SW¼ S14-T128N-R65W	1915	App. 1200	1458	4	1468	4.0
692	C. L. Seaman SE¼ S2-T121N-R64W	Old Well	App. 1000	1298	11	1324	4.3
693	Walt Rehfield SW¼ S25-T121N-R64W			1295	10	1318	2.1
694 SDU	Dale Eldredge NE¼ S23-T122N-R64W	March 1948	1120	1298	20	1344	10.0
695	Allen Crady NW¼ S20-T123N-R64W	Dec. 1948	1260	1310	Over 55	Over 1437	4.3
696	Leland Lindsey NE¼ S35-T123N-R64W	Old Well	App. 1100	1300	11	1325	.4
697	Raymond Hehn SE¼ S23-T124N-R64W	Old Well		1331	14	1363	2.4
698	NE¼ S7-T124N-R64W			1383	100	1613	
699	NW¼ S1-T124N-R64W			1355	7	1371	.5
700	James Miller NE¼ S14-T125N-R64W			1361	9	1380	.5

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
701	E. Pearl Rystrom NW¼ S25-T126N-R64W	1935	1080	1383	5	1395	2.4
702	W.D. Walworth NE¼ S30-T126N-R64W	1898	1050	1382	1.5	1386	.3
703	John Emery NE¼ S1-T126N-R64W	1903		1392		1392	
704	J.D. Gorder NE¼ S15-T127N-R64W	1945	1126	1392	App. 9	App. 1413	
705	Fred Rosebrock SW¼ S23-T128N-R64W	Old Well	App. 1000	1402	3	1409	1.1
706	Raymond Zinter SW¼ S5-T128N-R64W	Old Well		1457	10	1480	2.4
707	A.L. Dunker NE¼ S28-T121N-R63W	1934	1188	1308	10	1331	2.2
708	Ned Dixon NW¼ S15-T122N-R63W	Old Well		1300	App. 8	App. 1318	1.0
709	William Grohnke SW¼ S34-T122N-R63W	1935	1100	1303	9	1324	2.4
710	Carl A Wendt SE¼ S16-T123N-R63W	Old Well	1200	1300	6	1316	1.5
711	George H. Goodman SW¼ S4-T124N-R63W	New Well	1200	1303	13	1333	2.0
712	Richard Russel SE¼ S28-T124N-R63W	Old Well		1301	12	1329	1.3
713	Joe Huettle SW¼ S14-T125N-R63W	1941	1070	1319	9	1338	3.8
714	Art Schleder SE¼ S28-T126N-R63W	Old Well	App. 1100	1361		1347	1.0
715	Houser Mullner NW¼ S3-T126N-R63W	Old Well		1374		1374	.2

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
716	Orville Crawford NW¼ S15-T127N-R63W			1392	App. 60.	App. 1530	3.3
717	Herman Tiegs NW¼ S5-T128N-R63W	1916	1200	1363	21	1411	4.0
718	August Telin NE¼ S1-T128N-R63W	1910	1130	1395		1395	.4
719	J. A. Witala NW¼ S28-T128N-R63W	1939	App. 1300	1418	80	1602	10.0
720	Hans Hagen NE¼ S29-T121N-R62W	Sept. 1925	995	1300	11	1325	2.1
721	Ben Mathiew NE¼ S25-T121N-R62W	1946	1012	1300	7.5	1317	1.3
722	Herb Radke NE¼ S1-T121N-R62W	1943	1152	1295	28	1360	12.0
723	Henry Hoeft SE¼ S32-T122N-R62W	1910	950	1302	8.5	1322	1.3
724	Nelson Hundstad SE¼ S7-T122N-R62W	Old Well		1297	9	1318	.8
725	Harry Zoeller NE¼ S12-T122N-R62W	1939	1128	1302	20	1349	3.0
726	Zola Krahn NE¼ S19-T123N-R62W	Old Well		1302	5.5	1315	.7
727	Carrol Justesen SE¼ S13-T123N-R62W	Old Well	920	1295	9	1316	1.5
728	William Fetherhuff SE¼ S30-T124N-R62W	1942		1300	11	1325	1.0
729	Willis Weismantel NW¼ S4-T124N-R62W	1935	1090	1304	4	1313	.6
730	Elmer Roettele SE¼ S17-T125N-R62W	1946	???? 1265	1300	3	1307	1.0

NO.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
731	Harvey Eichler NW¼ S28-T126N-R62W	1926	1050	1301	10	1324	3.0
732	A.W. Dennert NW¼ S4-T126N-R62W	1941	1182	1308	9	1329	1.0
733	Arne Cero NE¼ S17-T127N-R62W	1918	1070	1363		1363	.4
734	Peter Siefkes SE¼ S20-T128N-R62W	Old Well		1352	App. 5	App. 1364	.9
735	B.W. Nutten NE¼ S25-T128N-R62W	1932	960	1307	14	1339	2.0
736	NE¼ S1-T128N-R62W			1351	6	1365	.3
737	Paul Rossow NE¼ S3-T121N-R61W	1903	900	1300	6	1315	.5
738	Andrew Goodman SW¼ S26-T121N-R61W	Old Well	1000	1303	9.5	1325	3.0
739	Ed Oliver NW¼ S11-T122N-R61W	Old Well		1302	4	1311	1.8
740	Bill Koelher SE¼ S12-T123N-R61W	Old Well		1304	4	1313	2.4
741	Robert L. Jensen SE¼ S18-T124N-R61W	1908	1025	1290	13	1320	1.3
742	Connie Hanson SW¼ S20-T125N-R61W	1913	930	1304	8	1322	.8
743	SE¼ S24-T125N-R61W			1304	9	1335	1.0
744	Elmer J. Knecht SE¼ S29-T126N-R61W	About 1930	1010	1318		1318	1.0
745	SW¼ S22-T126N-R61W			1300	14	1332	6.0

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
746	Jess Gates SE¼ S8-T127N-R61W		App. 1050	1302	11	1327	1.8
747	SW¼ S34-T127N-R61W			1302	8	1320	2.2
748	H. W. Pearson SW¼ S23-T128N-R61W	1905	950	1306	5	1318	1.3
749	Earl Bagley NW¼ S2-T128N-R61W	1928	965	1303	4.5	1313	3.0
750	Myron Fisk NE¼ S34-T121N-R60W		App. 1000	1365		1355	
751	Herman Wahl SE¼ S34-T121N-R60W	1914	1072	1366		1354	
752	Fred Ehrenberg NW¼ S15-T122N-R60W	1908	Over 1000	1301	2	1306	1.3
753	Wayne Feller SE¼ S34-T122N-R60W	1913		1343		1333	
754	Wayne Sanderson NE¼ S2-T123N-R60W			1301	14	1333	.9
755	Authur Rix NE¼ S26-T123N-R60W	1939		1312	6	1326	.7
756	Marvin Gengerke SW¼ S18-T124N-R60W	1933	941	1305	App. 13	1335	3.0
757	A. D. Schlieve SW¼ S12-T124N-R60W	Old Well	Over 1000	1310	App. 5	1322	1.0
758	Joe Wigdahl NW¼ S25-T125N-R60W			1308	3.5	1316	1.0
759	Walt Buntrock SE¼ S23-T125N-R60W			1309	3	1316	.3
760	Nina C. Pulfrey SE¼ S3-T126N-R60W	1921	961	1303	3	1310	.9

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
761	SE¼ S27-T126N-R60W			1302	App. 2	1306	.3
762	Robert Miller SW¼ S29-T126N-R60W	Old Well	App. 900	1306	8.8	1326	1.0
763	C. G. Mentzer NW¼ S21-T127N-R60W	1911	App. 1050	1317	9	1338	3.0
764	C. Henderks NW¼ S31-T127N-R60W	Old Well		1316	5	1328	3.0
765	Stewart Ruenz NE¼ S28-T128N-R60W	Old Well		1308	11	1335	3.3
766	Theodore Pikerine SW¼ S5-T128N-T60W	Old Well		1306		1306	.3
SPINK COUNTY							
767	Mrs. Harold Boyd SE¼ S8-T117N-R65W			1334	App. 8	1352	3.0
768	J. Z. Woodward NE¼ S29-T118N-R65W			1322	15	1355	2.0
769	Glen Hoellein NE¼ S4-T118N-R65W			1316	5	1328	1.0
770	Elmer H. Kramer SE¼ S9-T119N-R65W	1910	960	1332	4	1341	1.7
771	Lyle Smith #1 SW¼ S15-T120N-R65W	Feb. 1954	1130	1318	14	1350	6.0
772	Lyle Smith #2 SW¼ S15-T120N-R65W	1904	???? 1300	1309	6	1323	1.1
773	Wiliam Gieseke NE¼ S34-T117N-R64W	1952	900	1295	3	1302	2.6
774 WW	NE¼ S18-T117N-R64W	Old Well		1294	13	1324	10.0

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
775	Harold Holtz SE¼ S20-T118N-R64W			1292	2	1297	2.1
776	Bill Akin NE¼ S25-T118N-R64W	Old Well	Over 800	1274	10	1299	1.0
777	George Manning NE¼ S5-T118N-R64W	1940	995	1292	19.5	1337	6.0
778	Archie Smith SE¼ S6-T119N-R64W	Old Well		1295	14	1327	7.5
779	C.E. Robertson SW¼ S2-T119N-R64W	1916	?? 1100	1300	10	1323	2.0
780	H.E. Darcy NW¼ S24-T120N-R64W		App. 950	1300	7.5	1317	5.0
781	Ed C. Heidenreich SE¼ S18-T120N-R64W	1912	960	1300	11	1325	3.0
782	Roman Esser SW¼ S23-T117N-R63W	1949	990	1303	13.5	1334	15.0
783	Emil Leesch NW¼ S18-T117N-R63W	1938	App. 900	1302	10	1325	2.0
784	Howard Aldredge NE¼ S2-T118N-R63W			1303	11.5	1330	2.1
785	Leland Strahl SW¼ S26-T118N-R63W	1951	1012	1302	14	1334	10.0
786	Earl Plauvelt SW¼ S31-T119N-R63W	1923	890	1301	14	1333	.5
787	Orvil Hammer NW¼ S11-T119N-R63W	1949	968	1300	11.3	1326	11.0
788	Steve West NE¼ S15-T119N-R63W	Old Well		1290	23	1343	1.5
789	Louie J. Abrahamson SW¼ S11-T120N-R63W	1920	1030	1290	14	1322	.7

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
790	Nels P. Johnson SW¼ S11-T117N-R62W	1947	935	1293	12	1321	3.3
791	Chris Holdorf NW¼ S21-T118N-R62W			1300	8.5	1318	1.2
792	NE¼ S33-T119N-R62W			1295	10	1318	1.4
793	L. R. Kettering NW¼ S9-T119N-R62W	1925	909	1301	8.5	1319	3.3
794	Glen Spear NW¼ S21-T120N-R62W	Old Well		1304	4	1313	1.3
795	Clarence Province NW¼ S17-T117N-R61W	1933	916	1313	8.5	1321	2.7
796	Ed Swenson NE¼ S20-T118N-R61W	Old Well		1302	10.0	1325	7.5
797	Ben Christensen SW¼ S29-T119N-R61W	1948	1070	1300	13.0	1330	1.0
798	Ben Cranfield NE¼ S7-T119N-R61W	Old Well		1302	13	1332	5.0
799	Mark VanHatten NE¼ S13-T-119N-R61W	Old Well		1308	9.5	1330	.5
800	B. C. Evans SE¼ S18-T120N-R61W	1907	925	1301	6	1314	1.6
801	Darryle Starr SW¼ S22-T117N-R60W	1950	922	1365		1361	
802	Hans Levsen NW¼ S19-T117N-R60W	1922	1040	1351	1	1353	
803	Elmer Erickson NE¼ S35-T118N-R60W	1904	1040	1382		1371	
804	Lester DeLauriers NE¼ S24-T118N-R60W	1904	1080	1390		1378	
805	Fred Rahm NW¼ S30-T118N-R60W	1951		1301	11	1326	7.0
806	Oscar Walner NW¼ S6-T118N-R60W			1318	10.5	1342	1.5

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head.**	Rate Discharge Gal/Min.
807	Ed Cunningham NW¼ S26-T119N-R60W	1914	1060	1366	3	1373	.2
808	August Schultz NW¼ S2-T119N-R60W	Old Well		1363		1363	
809	Taylor & Taylor NW¼ S14-T120N-R60W		1000	1380		1370	
810	Ray Masse SW¼ S19-T120N-R60W	Old Well		1300	12	1328	1.5

Clark County

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head.**	Rate Discharge Gal/Min.
811	Raymond City Well	Old Well	1100	1456		1422	70
812	Al Kneenabor NE¼ S26-T117N-R59W	1951	1190	1537		1513	
813	Pete Bymers SW¼ S5-T117N-R59W	1954	1060	1432		1394	
814	Everett Huber NW¼ S5-T118N-R59W	1916	1102	1459		1424	
815	F. W. Dubs SE¼ S9-T119N-R59W	1952	1260	1512		1422	

Day County

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head.**	Rate Discharge Gal/Min.
816	Steffes Farm NW¼ S28-T123N-R59W	Old Well		1414		1394	
817	Albert A. Schmidt SW¼ S8-T124N-R59W	1943	1022	1322	4	1331	.6
818	John Otto SE¼ S12-T124N-R59W	1952	1055	1382		1367	
819	George Wagner SE¼ S32-T124N-R59W	Old Well	App. 1050	1350	7	1365	2.7
820	Mrs. W. M. Whalen SE¼ S36-T124N-R59W	Oct. 1951	1082	1465		1395	
821	Carl Rye SW¼ S25-T124N-R58W	1931	1280	1598		1398	

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.

Marshall County

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
822	Ray Hartberg SW¼ S3-T125N-R59W			1312	8	1321	3.3
823	Dale Carson NW¼ S 34-T125N-R59W	Old Well		1319		1319	.3
824	W. I. Symens NE¼ S16-T126N-R59W	1943	?? 1200	1314	1.5	1318	2.4
825	SW¼ S20-T127N-R59W			1298	10	1321	1.9
826	Richard Moeckly SE¼ S23-T127N-R59W	Old Well	920	1312	12	1339	2.0
827	Alvin Carlson NW¼ S11-T128N-R59W	1909		1307	13	1324	5.1
828	John Fisher NE¼ S34-T128N-R59W	1952		1328	5	1339	3.0
829	Howard Carson SE¼ S20-T125N-R58W	Sept. 1952	1071	1358		1350	
830	Arden Vietmeier SW¼ S9-T126N-R58W	Old Well	App. 1000	1311	4	1321	.8
831	SE¼ S32-T126N-R58W			1325	7.5	1343	1.3
832	F. E. Sayer SW¼ S36-T126N-R58W	1907	1050	1390		1353	
833	Clifford Reyelts SW¼ S21-T127N-R58W	App. 1940	1050	1302	9	1323	3.0
834	Floyd Schussler SE¼ S12-T128N-R58W	Old Well	App. 900	1295	5.5	1308	2.0
835	Frank Mock NE¼ S17-T128N-R58W			1312	4	1321	.7
836	Harry Dyer SE¼ S32-T128N-R58W	1954	991	1325	6.5	1339	5.5

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
837	Arthur Jones SW¼ S17-T126N-R57W	Old Well	1060	1416		1348	
838	Robert Wanous NE¼ S6-T127N-R57W	Old Well		1312	4	1321	.7
839	Chan Benda SE¼ S22-T127N-R57W			1400		1400	.1
840	Arthur Elsner NW¼ S29-T127N-R57W	1954	1065	1338		1323	
841	Clarence Smith SW¼ S10-T128N-R57W	1912	860	1293	8.5	1311	1.7
842	Obert Lea SE¼ S34-T128N-R57W	1919	1100	1339	3.5	1347	.3
843	Clayton Osness SW¼ S32-T126N-R56W	Old Well		1316	½	1317	.3
844	F. S. Eisenhower SW¼ S5-T128N-R56W	Old Well	App. 1000	1340	1.5	1343	.6
845	Rueben Engnes NE¼ S3-T128N-R53W	1910		1254		1254	.5
846	George Hansen NE¼ S5-T128N-R53W		970	1261	½	1262	.3
847	Veblen Town Well NW¼ S22-T128N-R53W	Capped	860	1289	35	1370	.2
848	SE¼ S32-T129N-R53W			1256	4	1265	.5

ROBERTS COUNTY

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
849	Clifford Meland NW¼ S26-T127N-R52W	Old Well	App. 1000	1246		1246	.7
850	Harold Haaland SW¼ S32-T129N-R52W	Old Well		1211	19	1255	2.0

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
851	Allan Stapleton NE¼ S8-T126N-R51W			1242	½	1243	.2
852	Herman Heinecke NE¼ S14-T126N-R51W	Old Well		1176	26	1236	2.4
853	Ernest Nater NE¼ S32-T126N-R51W	Old Well		1280		1280	.2
854	Art Martinson SW¼ S35-T126N-R51W	1913		1219	15	1250	2.7
855	Fred Horneber SW¼ S25-T127N-R51W	Old Well	App. 750	1183	5	1195	2.2
856	Elmer Peterson NE¼ S10-T127N-R51W	1920	660	1205		1185	
857	John Fonder SW¼ S8-T125N-R50W		App. 700	1213		1203	
858	Albert Despiegler NE¼ S23-T125N-R50W	1951	500	1122		1122	
859	Vernon Johnson SE¼ S28-T125N-R50W	App. 1934	App. 650	1133	10	1156	8.0
860	SW¼ S9-T126N-R50W		600	1171	2	1176	.3
861	Clarence Anderson SE¼ S28-T126N-R50W	Old Well	700	1163		1163	.3
862	Lorin Riveland SW¼ S1-T127N-R50W	1920	600	1090	2	1095	
863	John Schade SE¼ S27-T127N-R50W	1920	585	1143	1.5	1147	.2
864	Russel Kallstrom SE¼ S5-T126N-R49W			1104	3.5	1112	2.4
865	SE¼ S6-T126N-R49W			1120	5	1132	1.5

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
866	Henry Pistorius SW¼ S21-T127N-R49W	1926	490	1085	8	1103	5.0

GRANT COUNTY

No.	Owner & Location	Date Drilled	Depth (ft.)	M. P. Alt.*	Pressure (lbs.)	Piez. Head**	Rate Discharge Gal/Min.
867	Stewart McFarland SE¼ S16-T120N-R49W	1952	334	1197		1197	.8
868	Gorden Bracht NW¼ S7-T120N-R49W	Old Well	427	1230	12	1258	2.3
869	Lester Schumacher NE¼ S2-T120N-R48W	1953	160	1076		1041	
870	Hubert Larson SW¼ S7-T120N-R48W	1952	295	1146		1101	

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