STATE OF SOUTH DAKOTA
Archie Gubbrud, Governor

STATE GEOLOGICAL SURVEY
Allen F. Agnew, State Geologist

SPECIAL REPORT 17

SHALLOW WATER SUPPLY FOR THE CITY OF BURKE

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[redacted]
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CONTENTS

ILLUSTRATIONS

INTRODUCTION

Present Investigation

This report contains the results of a special investigation by the South Dakota State Geological Survey during the summer of 1961 in and around the city of Burke, Gregory County, South Dakota (fig. 1), for the purpose of assisting the city in locating future water supplies. Burke now receives its water from two wells which in recent years have not produced the quantity of water needed by the city. The two wells obtain water from the Valentine Formation at a depth of about 120 feet, and are located within the city limits (fig. 2).

A survey of the ground water possibilities was made of a 12 square mile area around the city, and consisted of a review of the geology as mapped by the State Geological Survey (Stevenson, 1958), a well inventory, the drilling of five rotary test holes, and the taking of four water samples for analysis.

The field work and preparation of this report were performed under the supervision of Merlin J. Tipton, geologist in charge of ground water studies for the State Geological Survey. The aid of Robert Schoon, geologist-driller, and James McMeen who drilled test holes with the Survey's Bucyrus-Erie 10-R rotary rig, is gratefully acknowledged.

The cooperation of the residents of Burke, especially Mayor Arthur Lewis, City Manager Clair Turgeon, Water Commissioner Roy Gartner, and City Auditor Harold Gunvordahl, is greatly appreciated. Special thanks are due to Wilbur Oliver and Sheriff Lyle Oliver for making their well records available.

Location and Extent of Area

The city of Burke is located in Gregory County in south-central South Dakota, and has a population of 811 (1960 census). The area is in the Great Plains physiographic province (fig. 1).

Climate

The climate is semiarid with large daily fluctuations in temperature. The average daily temperature is 48.9°F., and the average annual precipitation is 21.00 inches, at the U. S. Weather Bureau Station in Gregory, 10 miles to the northwest.

Topography and Drainage

The topography of the Burke area is characterized by gently rolling hills and mature valleys. The city of Burke is located on a divide; thus, the area to the north of Burke drains into the Missouri River and the area to the south drains into Ponca Creek (fig. 1).

Fig I. Major Physiographic Divisions of Central South Dakota.

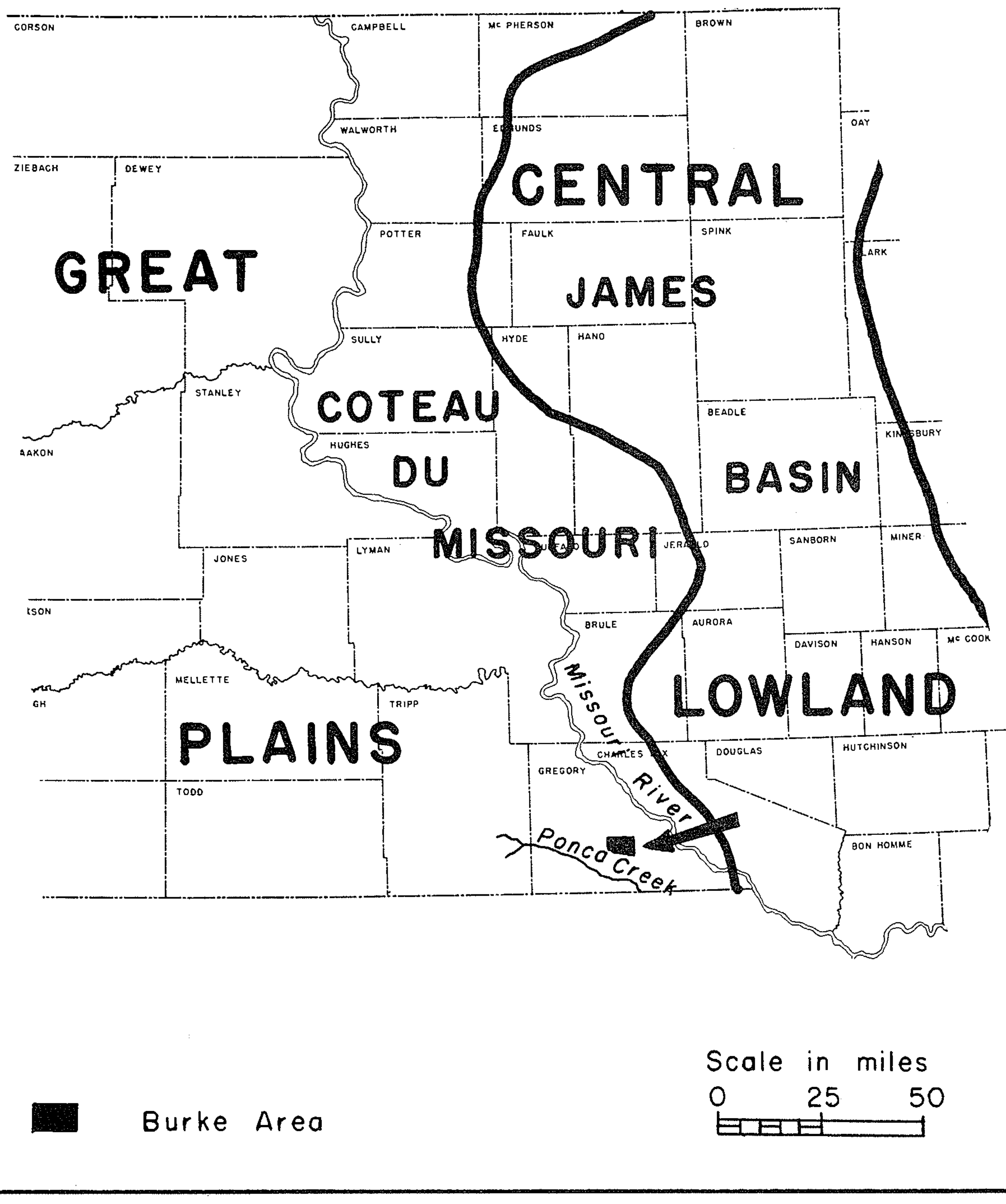
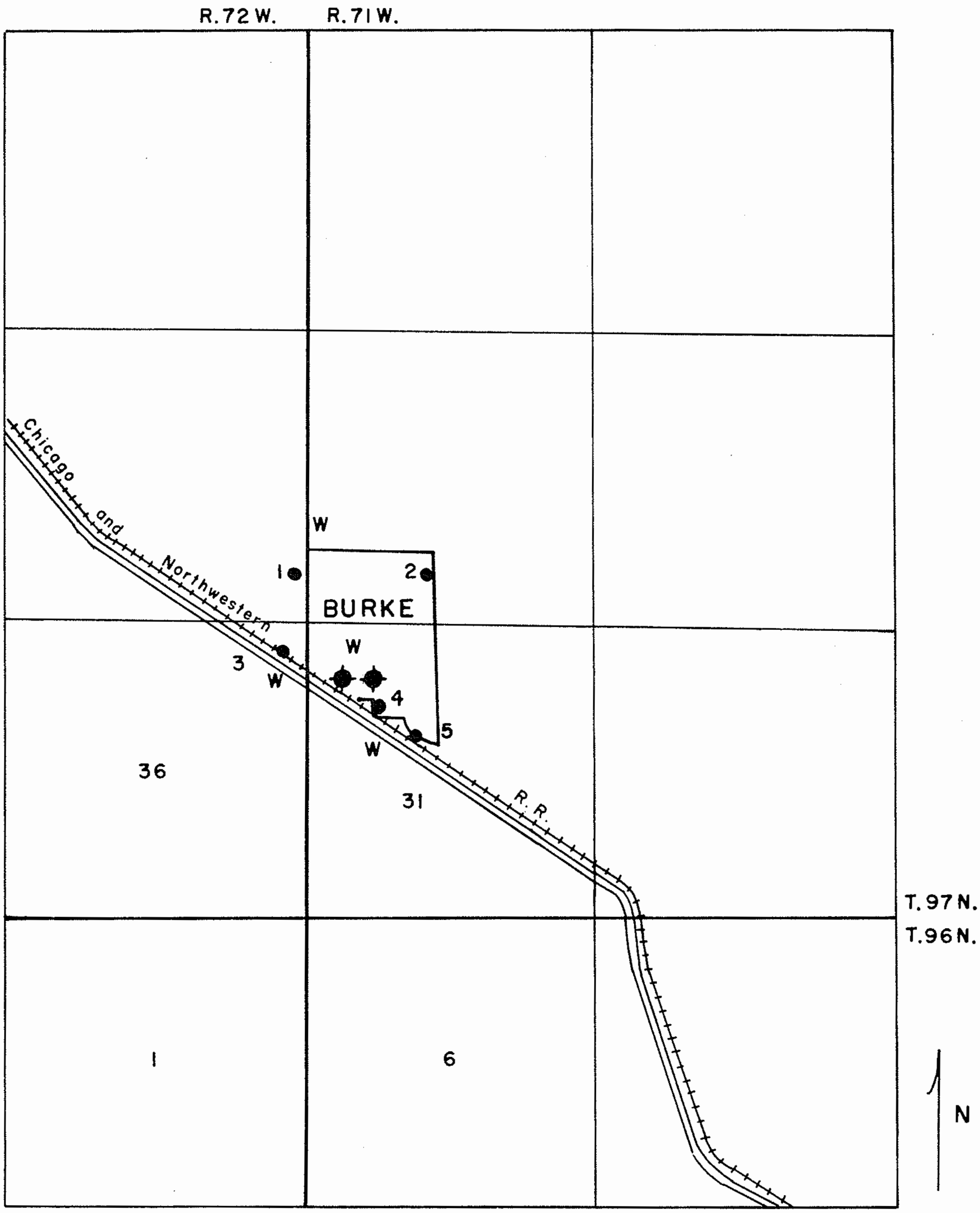


Figure 2. Data Map of the Burke Area.
by
C.M. Christensen, 1961



Drafted by Kay Baker

EXPLANATION

● Test hole
City well
W Water sample

Scale
0 1/2 1
Miles

GENERAL GEOLOGY

Surficial Deposits

The surficial deposits of the Burke area include the Pleistocene Herrick Formation, whose sands cover the uplands and small Pleistocene terrace deposits along present drainages (fig. 3).

Exposed Sedimentary Rocks

The exposed sedimentary rocks in this area belong to the Tertiary system (fig. 3). The Pliocene Ash Hollow Formation underlies the Herrick Formation and crops out elsewhere in the area, except where it has been removed by erosion. The Ash Hollow is composed of interbedded greenish-tan fine-grained arkosic sand, and ledge-forming fine-grained arkosic sandstone.

Underlying the Ash Hollow Formation is the Valentine Formation which is also of Pliocene age. The Valentine is a greenish-tan to tan, clayey, fine- to very fine-grained arkosic sand and sandstone.

Beneath the Valentine Formation is the Brule Formation which is Oligocene in age. This formation is a pinkish-tan silty clay which has a waxy appearance.

Subsurface Bedrock

Stratified sedimentary rocks of Mesozoic, Paleozoic and Precambrian age underlie the exposed sedimentary rocks in the Burke area. The Pierre Shale lies beneath the Brule Formation and is underlain in descending order by the Niobrara, Carlile, Greenhorn, and Graneros Formations and the Dakota Group, all of Cretaceous age. These are underlain by older (Paleozoic ?) clastic rocks and limestones, which rest on Precambrian basement rocks.

The Pierre Formation consists of a gray to black shale and siltstone with local limonitic and calcareous concretions.

The Niobrara Formation is light to medium blue-gray marl containing numerous white calcareous specks.

The Carlile Formation is composed of medium- to dark-gray bentonitic shale with siderite concretions, and layers of fine brown siltstone. Medium-grained sandstone is present in the upper part of the formation.

The Greenhorn Formation consists of a light-gray limestone and calcareous sandstone containing abundant fossil fragments.

The Graneros Formation (Belle Fourche and Mowry of Stevenson, 1958) is a gray shale and siltstone with a few stringers of quartzose sandstone.

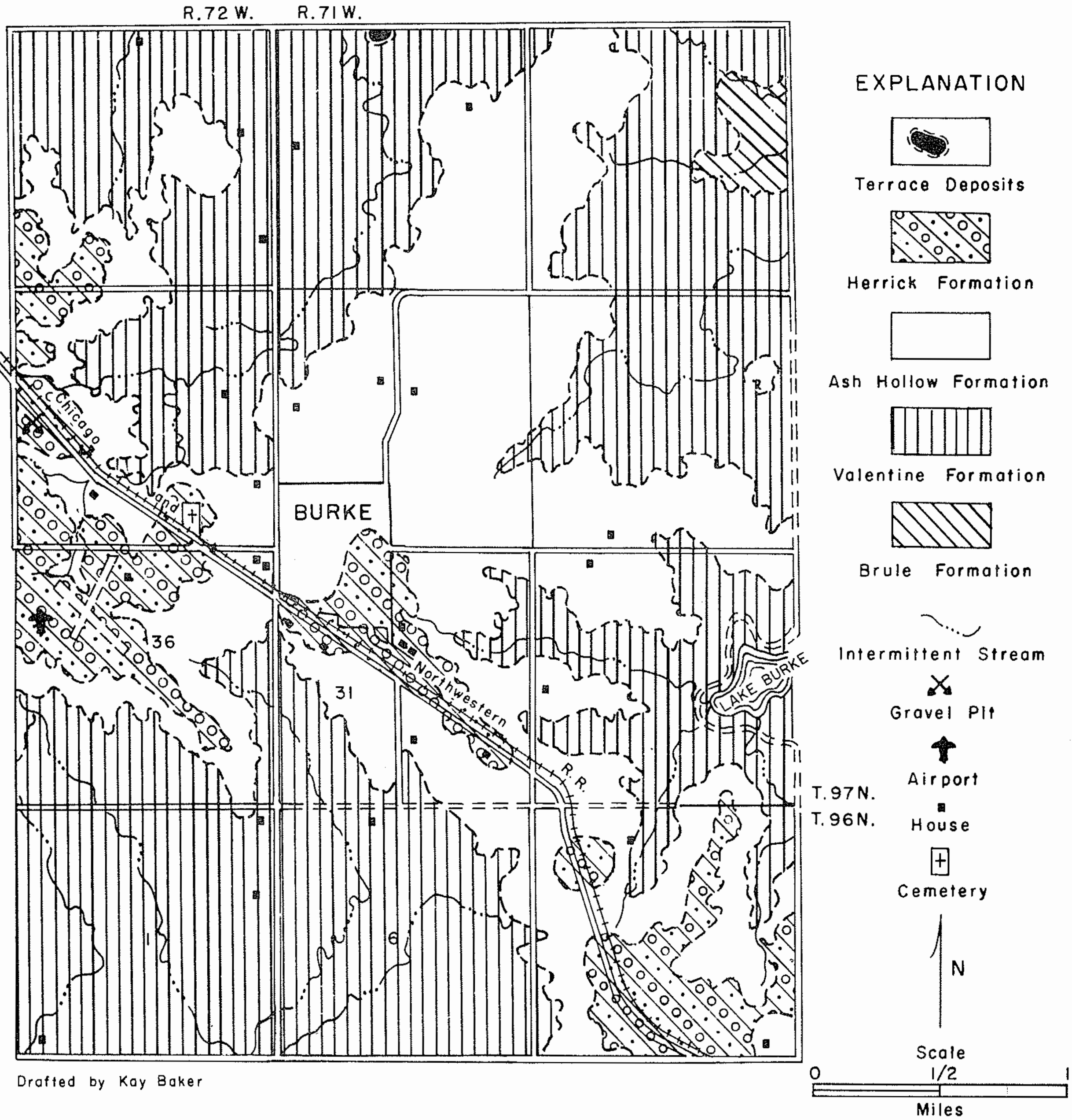
The Dakota Group (Newcastle, Skull Creek, and Inyan Kara of Stevenson, 1958) consists of medium- to coarse-grained, massive quartzose sandstones with shale interbeds.

The pre-Dakota Group clastic rocks (Sundance ? and older formations of Stevenson, 1958) consist of white, tan and pink fine- to coarse-grained quartzose sandstone, which is locally glauconitic and contains interbeds of red to red-brown shale.

The Paleozoic carbonate rocks (Minnelusa of Stevenson, 1958) consist of pale red to grayish-pink dolomite and sandy dolomite interbedded with white to pink limestones and thin sandstones.

The Precambrian Granite (Ortonville Granite of Stevenson, 1958) is a red medium- to coarse-grained granite.

Figure 3. Geologic Map of the Burke Area.
by
C.M. Christensen, 1961
(After R. E. Stevenson, 1958)



Drafted by Kay Baker

OCCURRENCE OF GROUND WATER

Principles of Occurrence

Contrary to popular belief, ground water does not occur in "veins" that criss-cross the land at random. Instead, it can be shown that water occurs nearly everywhere beneath the surface, but at varying depths. The top of this zone of saturation is known as the water table.

Nearly all ground water is derived from precipitation. Rain or melting snow either percolates downward to the water table and becomes ground water, or drains off as surface water. Surface water may percolate downward and become ground water, or it may evaporate or drain to the sea by means of streams. In general, ground water moves laterally down the hydraulic gradient, and is in transient storage.

Recharge is the addition of water to an aquifer (water-bearing material) and is accomplished in a number of ways: (1) by downward percolation of precipitation from the land surface, (2) by downward percolation from surface bodies of water such as lakes and streams, and (3) by lateral movement of water in transient storage.

Discharge of ground water from a water-bearing material 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, and (4) by pumping.

The amount of water which can be stored in a saturated material is equal to the amount of voids or pore spaces in that material. A measurement of the capability of a material to store water (or any other liquid) is called porosity. Porosity depends entirely on the shape and arrangement of the particles in a material, and is not affected by size. Sands and gravels usually have porosities of 20-40 percent, whereas sandstones normally have porosities of 15-25 percent; this lower porosity of sandstones is due to closer packing and the cementation of the particles.

Permeability is the rate at which a fluid will pass through a substance. If the pore spaces of a material are connected, the permeability of that material will be high. If the pore spaces are not connected, the permeability will be low. Thus, a material may have high porosity and still not yield water readily because of low permeability. Sands and gravels, however, tend to have both high porosity and high permeability. Thus the geologist is not concerned with finding a "vein" when looking for a good water supply, but because water occurs almost everywhere in the ground, he is searching instead for a sand or gravel deposit that lies beneath the water table.

Ground Water in Surficial Deposits

The Herrick Formation provides a good source of ground water where it is below the water table; however, in the mapped area (fig. 3) the Herrick Formation is present only on the uplands and must be disregarded as a source of ground water.

The terrace deposits likewise occur above the water table and are not important as a source of water in the mapped area.

Ground Water in Tertiary Sedimentary Rocks

The Valentine Formation is the only formation of Tertiary age which will yield water readily in the Burke area. The majority of wells in this area produce from the Valentine Formation, where sands have a fair degree of porosity and permeability.

Both the Ash Hollow and Brule Formations contain large amounts of water where they are below the water table but, because of the high silt and clay content, will not yield water readily.

Ground Water in Pre-Tertiary Subsurface Rocks

The sandstones of the Dakota Group are the only Cretaceous rocks in the Burke area known to yield water readily. These sandstones are at a depth of about 1400 feet and their waters are under artesian pressure. The recharge for these sandstones in South Dakota probably comes from the Black Hills or Rocky Mountains where the sandstones crop out at much higher elevations. The overlying Cretaceous shales provide the impervious material that confines the waters to the sandstones.

The sandstones of the pre-Dakota Group clastic rocks generally yield water in South Dakota wherever they are present below the water table. These sandstones are not considered an important source of water in the Burke area because of their depth.

The Paleozoic carbonate rocks also yield water readily in South Dakota where they are present below the water table. These carbonates are also at great depths and thus are not considered an important source of ground water in the Burke area.

Quality of Ground Water

Precipitated water is nearly pure before it reaches the ground; however, all ground water contains minerals which are obtained: (1) from the atmosphere, (2) from soil and underlying deposits as the water percolates downward to the water table, and (3) from deposits beneath the water table in which the water is circulating. In general it can be said that the more minerals a water contains, the poorer its quality. Waters from the Dakota Sandstones, pre-Dakota Group clastic rocks, and Paleozoic carbonate rocks are of a much poorer quality than that from the Valentine Formation.

Table 1 is a comparison of the quality of water from several wells producing from the Valentine Formation in the Burke area, with one of the present city wells and with the Public Health Standards for drinking water. It can be seen from this table that, except for iron in Samples B and D, all analyses are well within the Public Health Standards. In general, the water analyzed is of excellent quality.

CONCLUSIONS AND RECOMMENDATIONS

It is recommended that the city of Burke test for future water supplies in the Valentine Formation. The thickest section of Valentine encountered in any of the Survey's test holes was 117 feet (Test Hole No. 4, Appendix A and fig. 2). However, all of the test holes show a good thickness of Valentine Sand (82 to 117 feet).

Table 1.--Chemical Analysis of Ground Water in the Burke Area

(for locations see fig. 2)

Sample	Parts Per Million											
	Calcium	Sodium	Magnesium	Chloride	Sulfate	Iron	Manganese	Nitrate	Fluoride	pH	Hardness $CaCO_3$	Total Solids
A	--	-	--	250	500*	0.3	0.05	10*	0.9-1.7**	--	--	1000 *
B	51	8	11	5	20	1.9	0	1	0.2	7.9	73	290
C	57	5	7	2	20	0.2	0	0.8	0.2	7.9	171	284
D	83	8	10	6	31	1.6	0	5.7	0.4	7.8	247	396
E	47	5	4	1	26	0.1	0	0.36	0.4	8.0	135	246

A. U. S. Public Health Drinking Water Standards (1961)
B. Burke City Well, NW¼NW¼ sec. 31, T. 97 N., R. 71 W.
C. Hillcrest Motel, NE¼NE¼ sec. 36, T. 97 N., R. 72 W.
D. T. Kemery, NW¼SW¼ sec. 30, T. 97 N., R. 71 W.
E. Hilltop Mobil Station, SW¼NW¼ sec. 31, T. 97 N., R. 71 W.

All samples were analyzed by the State Chemical Laboratory in Vermillion.

* Modified for South Dakota by the State Department of Health (written communication, February 5, 1962)

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The main ground water problem in the Burke area is the fine nature of the water-bearing material. For this reason, wells must be spaced far enough apart so that they will not interfere with each other. The only manner in which a safe distance between wells can be determined is by means of pump tests. These pump tests should be conducted by qualified engineers and run for a minimum of 72 hours.

The city should install a test well in the area where the Valentine Formation is thickest and run a pump test to determine yield, drawdown, and recovery. A proper well and water system can then be designed from data obtained in the pump tests.

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

REFERENCES CITED

Stevenson, R. E., 1958, Geology of the Gregory quadrangle: South Dakota Geol. Survey, geologic map and text.

U. S. Public Health Service, 1961, Drinking water standards: Am. Water Works Assoc. Jour., v. 53, no. 8, p. 935-945.

APPENDIX A

Logs of Test Holes in the Burke Area

(for locations see fig. 2)

Test Hole No. 1
Surface Elevation: 2170 feet

0- 3	topsoil
3- 48	sand, fine, buff to light green, argillaceous and calcareous cement, (Ash Hollow)
48-148	sand, fine, buff, argillaceous (Valentine)
148-163	clay, light pink, very silty (Brule)
163-190	clay, light green, light pink, waxy
190-200	shale (Pierre)

* * * * * *

Test Hole No. 2
Surface Elevation: 2164 feet

0- 10	sand, fine, buff, unconsolidated
10- 23	sand, fine, buff, calcium cemented (Ash Hollow)
23-127	sand, fine, buff, unconsolidated (Valentine)
127-177	silt, clayey, pinkish and yellowish (Brule)
177-200	shale (Pierre)

* * * * * *

Test Hole No. 3
Surface Elevation: 2213 feet

0- 15	sand, buff, fine-medium, clay unconsolidated
15- 78	sand, buff, fine-medium, clayey and calcareous cement
78-155	sand, buff, fine-medium grained unconsolidated to semi-consolidated with clayey cement
155-180	silt, buff to light pink, very clayey (Brule)

* * * * * *

Test Hole No. 4
Surface Elevation: 2214 feet

0- 4	gravels (Herrick)
4- 46	sand, buff, poor calcite cement (Ash Hollow)
46-157	sand, buff, fine argillaceous cement (Valentine)
157-178	silt, pink, clayey, dense (White River)
178-212	silt, pink and green, clayey
212-220	shale (Pierre)

* * * * * *

Test Hole No. 5
Surface Elevation: 2211 feet

0- 6	gravels, fine (Herrick)
6- 63	sandstone, (Ash Hollow), buff, fine to medium grained, calcareous cement
63-145	sandstone, buff, fine to medium, argillaceous cement (Valentine)
145-161	clay, light green, light pink, waxy,in part silty (Brule)
161-212	clay, light pink, waxy, sandy
212-220	clay, yellowish gray, plastic (Pierre)

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APPENDIX B

Table 2.--Records of Wells

Well Location: letters stand for quarter-quarter, first number for section, second for township north, and third for range west.
All Wells: bored
The geologic source of all wells is the Valentine Formation

Well Location	Owner or Tenant	Depth of Well (feet)	Depth to Water
NWSW30-97-71	Francine	110?	100±
SWNW25-97-72	Jones, R.	40?	
SESE24-97-72	Roades, J.	55±	
SWNW19-97-71	Kirch, T.	60±	
SENE24-97-72	Wiedeman, G.	70	46
SESW25-97-72	Hillcrest Motel	110	80
SWSW25-97-72	Dobbs, G.	70	45
SENE26-97-72	Cahill, B.	140	128
SWNW25-97-72	Cement Plant	90	70
NWNW26-97-72	Horne, E.	35±	15
SWSW23-97-72	Kallander	35?	15?
NENE 1-96-72	Lieble, P.	80±	60?
SENE 1-96-72	Drey, H.	40±	20±
SESE 1-96-72	Kline	20?	10
SWSE31-97-71	Hilltop Station	120	105
SWSE31-97-71	Deering, J.	80	60
NENW 6-96-71	Lewis, A.	30±	10?
NENW 5-96-71	Serny, W.	80	60±

Appendix B--Records of Wells--continued

Well Location	Owner or Tenant	Depth of Well (feet)	Depth to Water
NESE32-97-71	Lillibridge	90	70
NENE31-97-71	Wheeler	60±	40?
SWSE30-97-71	Osnes, A.	110±	90±
NWSE32-97-71	Umberger, C.	25?	10
NENE32-97-71	Hansen, H.	95	74
NWNW28-97-71	Stewart, M.	37	20?
NWNW21-97-71	Osnes, H.	?	
NWSE20-97-71	Osnes, J.	40	19±
SENE19-97-71	Lubbers, H.	70	55
SENW30-97-71	Glover, H.	80	65
SESE26-97-72	Bortz, W.	110	85±
NENE35-97-72	Gunvordahl, H.	125	110?
SWSW26-97-72	Hansen, A.	40?	20?