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Open-File Report 45-UR

**GROUND-WATER STUDY FOR THE CITY OF
KEYSTONE, SOUTH DAKOTA**

by

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1996

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INTRODUCTION

This report contains the results of a ground water investigation conducted by the South Dakota Geological Survey for the city of Keystone, Pennington County, South Dakota. Field work was conducted intermittently from late August 1983 to late September 1984. The investigation included the analysis of existing water quality data and well logs, collection and analysis of 42 water samples, drilling a test well for monitoring and aquifer test (pump test) use, and conducting three aquifer tests.

The investigation was financed by the South Dakota Geological Survey, the Black Hills Conservancy Sub-District, and the city of Keystone.

Prior to the investigation, the city of Keystone did not have a central water supply system. Water was obtained from a number of private and a few city wells for domestic, lawn watering, and fire protection. These wells varied greatly in depth, water production, water quality, and construction. Water quality problems and a lack of adequate fire protection capabilities prompted the decision to seek an adequate central supply source.

The assistance of the city officials, especially Mayor Siemonsma, the volunteer fire department, Alexander Drilling Company, and the residents of Keystone in conducting this study were greatly appreciated.

GENERAL TOPOGRAPHIC AND GEOLOGIC SETTING

Keystone is located along the valleys of Battle Creek and Grizzly Bear Creek in the rugged Precambrian core of the Black Hills. There are two major aquifers in the area. One of the aquifers is the Quaternary alluvium that occurs in the valleys of Battle Creek and Grizzly Bear Creek. The alluvium consists of material derived from the surrounding Precambrian rocks and is usually a mixture of sand, gravel, boulders, and some clay. It ranges from zero to 45 feet in thickness and averages 30 feet (Johnson, 1975). The other aquifer is the fractured Precambrian metamorphic and igneous rocks, exposed on the uplands and valley walls and buried beneath the valley alluvium.

The Precambrian rocks in the area are often highly mineralized and have given the area a long and colorful mining history. Numerous studies of these mineralized rocks and mines have been conducted, too numerous to mention here. The reader is referred to Norton (1957, 1976), Powell and others (1973), and Raymond (1981) for further information on the general geology of the area.

PREVIOUS WATER RESOURCES STUDIES

Previous water resources investigations conducted in the immediate vicinity of the city of Keystone are limited to Gries (1960), Johnson (1975), Powell and others (1973), and Rahn (1983). Published data on surface and/or ground water quality in the area can be found in publications including: Black Hills Conservancy Sub-District (1973), South Dakota Department of Environmental Protection (1976 and 1979), South Dakota Department of Water and Natural Resources (1983), and Stewart and Thilenius (1964). There are also some unpublished data on surface and/or ground water quality data on file at the Department of Environment and Natural Resources and Black Hills Council of Local

Governments and numerous unpublished well logs on file at the Water Rights Program, Department of Environment and Natural Resources. A report by the United States Geological Survey (1962-1983) contains streamflow data for Battle Creek, Grizzly Creek, and their tributaries in the Keystone vicinity.

Reports by Gries (1960) and Powell and others (1973) deal with a water supply for Mount Rushmore National Memorial. These studies indicate that adequate water supplies might be difficult to obtain on the Precambrian uplands of the area.

Surface and ground water conditions in the immediate Keystone area are addressed in Johnson (1975) and Rahn (1983). Johnson (1975) studied the surface and ground water quality along Battle Creek and Grizzly Bear Creek through the city of Keystone. His study showed that nitrate concentrations often exceeded the required EPA limit and that iron and manganese values were often higher than the recommended EPA limits. Fecal coliform bacterial contamination was noticed in some of the private wells. His field work was, however, conducted before the city of Keystone had constructed a sanitary sewer system. Rahn (1983) recommended that a central supply system for Keystone consisting of infiltration galleries or shallow large diameter gravel-packed wells.

A review of the previous studies and the available data indicates that the quality and quantity of surface water (streams) in the area are quite variable. The present study was therefore designed to examine water quality and quantity in deeper wells that penetrate the alluvium and/or fractured Precambrian rocks beneath the alluvium, rather than examining the feasibility of infiltration galleries or shallow large diameter alluvial wells. Generally, the cost of constructing infiltration galleries or shallow large diameter wells is greater than that of constructing deeper, small diameter wells.

PRESENT STUDY

Forty-two water samples were collected from wells along and adjacent to the valleys of Battle Creek and Grizzly Bear Creek were collected and analyzed during this study. Sampling localities are shown in figure 1, results of analyses are shown in table 1, and well information and locations are presented in appendix A. Examination of these analyses revealed that nitrate concentrations were lower than those found by Johnson (1975) and all were below the required EPA limit. These lower values could be attributed to the construction of the sanitary sewer system. However, like many of Johnson's samples, many of the samples collected for this investigation contain iron and manganese concentrations that exceed the recommended EPA limits. Most of the other water quality parameters analyzed are within the EPA required or recommended limits.

In conjunction with water quality analyses, production data from wells and well logs were also examined. Well logs are presented in appendix B and locations are shown in figure 2.

Based on the available data, two areas were selected for further testing. One area was located in the city park and the other located across the street from the City Hall. In the city park area, at the recommendation of the Geological Survey, a 125-foot well was constructed by Alexander Drilling Company. This new well was located 392 feet from the city park well. This new well and an unused private well, located 341 feet from the city park well, were used as observation wells during an aquifer test conducted on the city park well.

On June 7, 1984, the 60-foot deep city park well was pumped for 22 hours at a rate of 73 gallons per minute. Total drawdown was 21.28 feet in the city park well, 0.27 feet in the new well, and 0.97 in the unused private well. Recovery after shutoff in the pumped well was 18.67 feet in 1 minute and 20.92 feet in 10 hours and 5 minutes. Water samples were collected and analyzed and the results are shown in table 1.

A second aquifer test was conducted using the 125-foot deep new well as the production well. The city park well, at a distance of 392 feet and the unused private well at a distance of 156 feet, were used as observation wells. Beginning at 12:00 noon on September 17, 1984, the production well was pumped for 24 hours at a rate of approximately 92 gallons per minute. Total drawdown was 25.18 feet in the new well, 0.49 feet in the city park well, and 1.53 feet in the and unused private well. Recovery after shutoff in the new well was 10.8 feet in 1 minute and 24.83 feet, in 27 hours. Water samples were collected and analyzed and the results are shown in table 1.

A third aquifer test was conducted using the 83-foot deep unused city well located across the street from the City Hall. Beginning at 2:30 p.m., on September 18, 1984, the city well was pumped for 19 hours at a rate of approximately 90 gallons per minute. Leakage from the alluvium into the well bore gave somewhat unreliable water level readings. Total drawdown was estimated to be 28 feet in the city well and 1.17 feet in a fire sump located 15.92 feet from the pumped well. Recovery after shutoff in the pumped well was estimated as 21 feet in 1 minute and 28 feet in 5 hours 35 minutes. Water samples were collected and analyzed and the results are shown in table 1.

CONCLUSIONS AND RECOMMENDATIONS

The results of this investigation show that the two areas selected for detailed analysis, the city park area and the City Hall area, would produce water of satisfactory quality (comparable to samples 8, 32, 34-38, 836648, 842720, 844534, and 844535) and quantity (75 to 100 gallons per minute) for municipal use.

Each of the two wells in the city park or any similar wells in the same area could be pumped at a rate of 75 to 100 gallons per minute during average precipitation years. The well in front of the City Hall or any similar well in this location could also pump 75 to 100 gallons per minute during average precipitation years. It should be noted, however, that closely spaced wells could reduce yield. Deepening the 60-foot city park well will allow for the greater drawdown that will occur during prolonged drought conditions.

Water quality from the wells in these two areas should be comparable to the previous water quality results presented in table 1. During dry years a decrease in the pumping capacity and a variation in water quality could be expected. It should also be noted that iron bacteria were detected in the city park well. To minimize this problem, the city should periodically treat this well and other wells, using the guidelines of the letter included in appendix C.

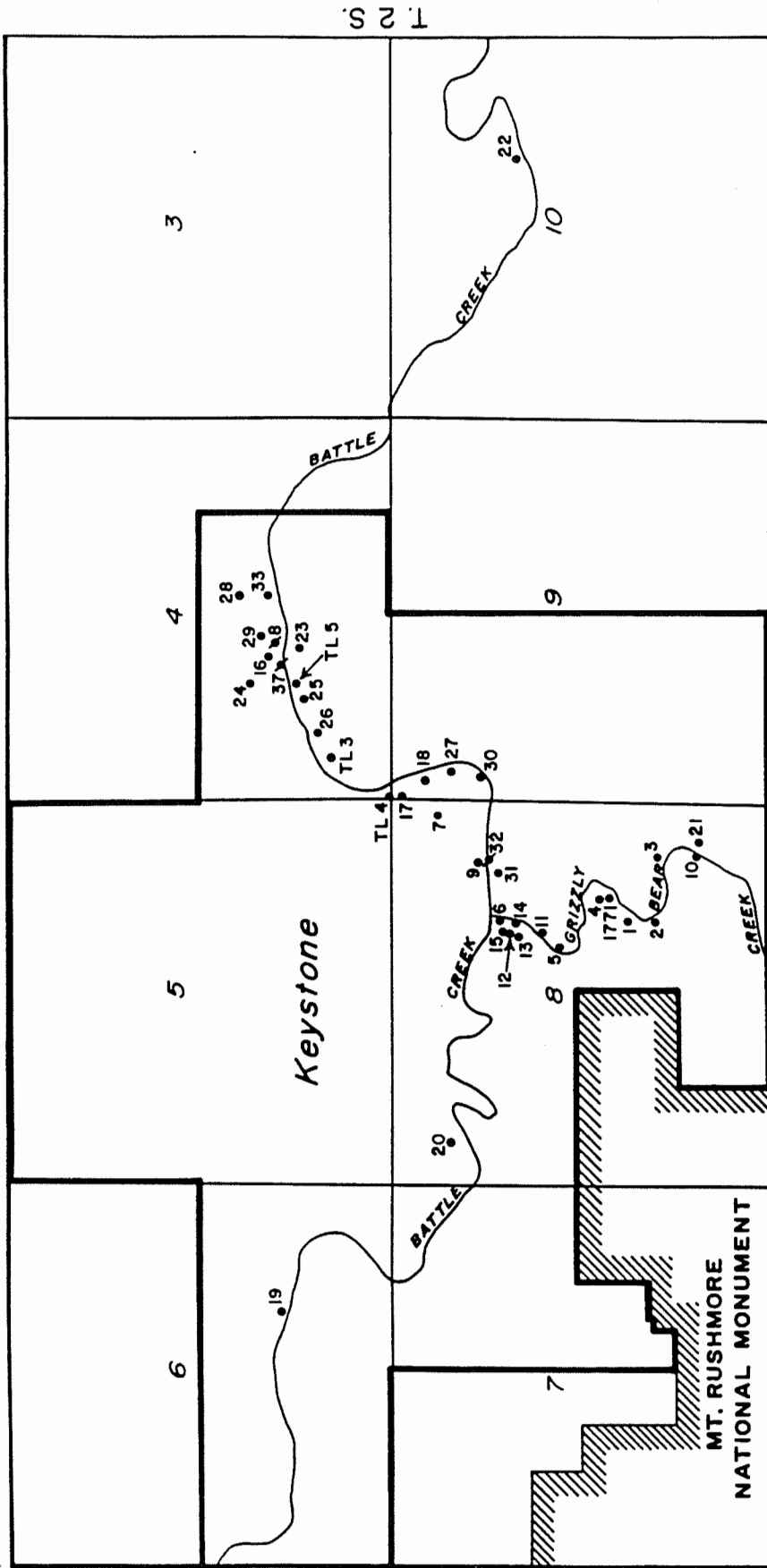
After the analysis of data, the Geological Survey presented the results and recommendations to the city of Keystone (app. D). Considering these recommendations, the city utilized the new well and the city park well in the park area and the unused well in the City Hall area for their municipal water

supply. Use of these three wells for the city's municipal supply system has continued through the date of finalizing this report.

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T. 2 S.

Figure 1. Locations of water samples and pump tests. Refer to table 1 and appendix A for data on each location.

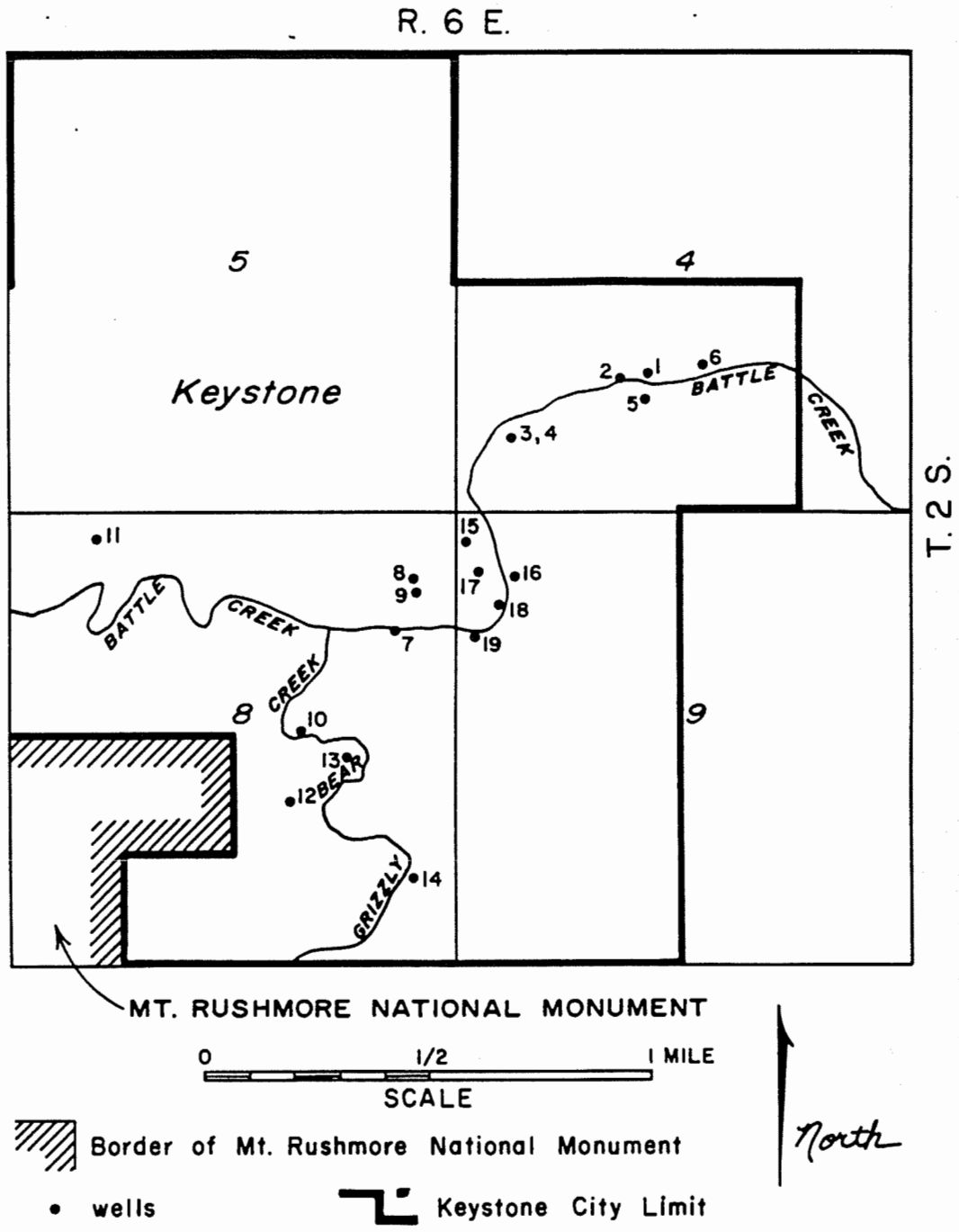


Figure 2. Locations of well logs. Refer to appendix B for data on each map location.

TABLE 1. Chemical analyses of water samples from the Keystone area
(for location, refer to fig. 1 and app. A)

Sample	Sampling Procedure	Parts per million											Hardness as CaCO ₃	Conductivity (micro-mhos)	pH	
		Ca	Na	Mg	HCO ₃	Cl	SO ₄	K	Mn	Fe	F	N				
A	---	---	---	---	---	250 ¹	250 ¹	250 ¹	---	0.05 ¹	0.30 ¹	4.0 ²	10.0 ²	---	---	6.5 8.5 ¹
1	NS	57.0	12.0	21.0	---	20.0	22.0	---	---	0.08	0.44	---	0.36	228.81 (13.38)	---	---
2	NS	30.0	13.0	15.0	---	2.0	21.0	---	---	0.06	0.54	---	<0.04	136.68 (7.99)	---	---
3	NSU	31.0	11.0	13.0	150.0	6.0	17.0	3.0	0.06	5.02	0.23	0.23	0.62	130.94 (7.66)	288	6.70
4	NSU	60.0	17.0	19.0	216.0	3.0	10.5	4.8	<0.05	2.38	0.19	0.56	0.56	228.06 (13.34)	500	6.80
5	NSU	35.0	12.0	16.0	179.0	7.0	19.0	3.2	0.06	<0.05	0.29	0.64	0.64	153.28 (8.96)	330	6.50
6 ⁴	NSU	2.0	100.0	1.0	226.0	20.0	8.0	0.6	0.08	0.37	0.30	<0.05	<0.05	9.11 (0.53)	417	6.70
7	NSU	66.0	12.0	39.0	335.0	10.0	42.0	4.9	<0.05	<0.05	0.48	1.1	1.1	325.4 (19.03)	617	7.7
8	NSU	58.0	27.0	21.0	193.0	10.0	109.0	4.0	<0.05	0.23	0.58	0.95	0.95	231.31 (13.53)	536	6.90
34	NS	---	---	---	---	---	---	---	<0.05	0.08	---	---	---	---	---	---
836648	SA	61.7	14.1	19.4	181.0	15.6	99.0	4.8	<0.02	0.30	0.30	2.8	2.8	234 (13.7)	---	7.02
35	NSU	67.0	16.0	16.0	---	19.0	124.0	4.7	<0.05	0.13	0.76	0.6	0.6	233.19 (13.64)	590	---
36	NSU	80.0	16.0	19.0	---	22.0	124.0	4.8	<0.05	<0.05	0.58	0.5	0.5	278.0 (16.26)	623	---
842720	SA	68.8	14.2	24.0	193	26.7	103.0	4.7	<0.02	<0.02	0.37	0.5	0.5	270 (15.18)	552	7.14
9	NSU	68.0	16.0	28.0	232	40.0	60.0	10.9	<0.05	0.62	0.30	0.28	0.28	285.1 (16.67)	600	7.10
10	NSU	18.0	8.0	8.0	107.0	<2.0	11.0	2.1	1.52	0.92	0.28	<0.05	<0.05	77.89 (4.55)	182	7.10
11	NSU	36.0	14.0	16.0	197.0	10.0	18.0	3.4	0.65	<0.05	0.26	1.2	1.2	155.78 (9.11)	354	7.00
12	NSU	64.0	41.0	24.0	244.0	42.0	93.0	5.8	1.06	1.22	.50	<0.05	<0.05	258.64 (15.12)	613	6.70

Table 1 -- continued.

Sample	Sampling Procedure	Parts per million											Conductivity (micro-mhos)	pH	
		Ca	Na	Mg	HCO ₃	Cl	SO ₄	K	Mn	Fe	F	N			Hardness as CaCO ₃
13	NSU	49.0	34.0	23.0	251.0	31.0	50.0	6.2	0.52	0.26	0.37	0.24	217.06 (12.69)	582	6.70
14	NSU	40.0	24.0	21.0	265.0	18.0	19.0	3.3	0.36	1.20	0.46	<0.05	186.36 (10.9)	440	7.00
15	NSU	58.0	7.0	23.0	233.0	6.0	70.0	2.2	<0.05	0.08	1.35	0.45	239.54 (14.01)	472	7.80
16	NSU	55.0	14.0	20.0	180.0	7.0	96.0	3.8	<0.05	<0.05	0.80	1.1	219.69 (12.85)	438	7.10
TL1	UN	----	----	----	----	29.0	----	<0.03	0.20	----	----	----	----	----	6.73
17	NSU	41.0	14.0	18.0	----	18.0	29.0	3.4	<0.05	0.61	0.23	2.0	176.5 (10.32)	402	6.60
18	NSU	33.0	12.0	16.0	179.0	13.0	30.0	4.0	0.07	0.52	0.19	0.92	148.29 (8.67)	344	6.50
19	NSU	56.0	18.0	15.0	228.0	20.0	35.0	4.5	<0.05	<0.05	0.20	4.3	201.6 (11.79)	463	6.70
20	NSU	53.0	17.0	21.0	250.0	20.0	28.0	3.4	0.13	<0.05	1.24	5.7	218.82 (12.8)	494	6.50
21	NSU	39.0	11.0	15.0	236.0	5.0	26.0	3.1	0.25	1.40	0.34	1.0	159.15 (9.31)	348	6.50
22	NSU	45.0	19.0	17.0	192.0	17.0	52.0	4.6	<0.05	<0.05	0.90	2.5	182.37 (10.66)	399	6.90
23	NSU	92.0	16.0	33.0	271.0	28.0	198.0	4.9	<0.05	0.77	0.23	0.6	365.61 (21.38)	714	6.90
24	NSU	54.0	21.0	31.0	349.0	11.0	44.0	2.7	0.14	0.17	0.67	<0.2	262.5 (15.35)	539	7.20
25	NSU	88.0	18.0	35.0	262.0	36.0	137.0	4.8	<0.05	1.84	0.54	0.6	363.87 (21.28)	728	6.60
26	NSU	74.0	11.0	32.0	215.0	14.0	153.0	3.9	<0.05	0.08	0.35	3.9	316.56 (18.51)	636	6.90
RB1	U	36.0	8.25	12.0	134.0	6.0	23.0	8.7	0.18	0.05	0.28	<0.10	139.31 (8.15)	350	7.69
27	NSU	35.0	11.0	11.0	196.0	12.0	23.0	7.2	0.16	0.69	0.19	0.2	132.69 (7.76)	328	6.60
28	NSU	35.0	41.0	18.0	221.0	2.0	39.0	3.2	<0.05	0.17	1.02	<0.2	161.51 (9.44)	464	7.40
29	NSU	56.0	24.0	21.0	178.0	11.0	20.0	3.9	<0.05	<0.05	0.48	1.5	226.31 (13.23)	546	6.90
30	NSU	36.0	11.0	11.0	128.0	14.0	28.0	3.4	<0.05	<0.05	0.24	0.3	135.19 (7.91)	336	7.00
TL2	UN	----	----	----	----	----	11.0	----	2.0	0.70	----	----	----	----	6.73
31	NSU	38.0	11.0	10.0	152.0	11.0	15.0	3.7	1.56	0.64	0.17	<0.2	136.07 (7.95)	332	6.80

Table 1 -- continued.

Sample	Sampling Procedure	Parts per million													Hardness as CaCO ₃	Conductivity (micro-mhos)	pH
		Ca	Na	Mg	HCO ₃	Cl	SO ₄	K	Mn	Fe	F	N					
32	NSU	47.0	11.0	14.0	159.0	22.0	44.0	6.0	<0.05	1.14	0.26	0.18	175.01 (10.23)	410	----		
38	NSU	40.0	12.0	14.0	-----	15.0	52.0	4.2	<0.05	0.70	0.22	<0.2	157.53 (9.21)	373	7.30		
844535	SA	41.3	12.6	14.8	160.0	23.2	28.0	4.0	0.04	0.04	0.25	<0.1	164 (9.6)	378	7.15		
33	NSU	67.0	18.0	22.0	204.0	20.0	90.0	6.8	<0.05	0.24	0.41	0.88	257.90 (15.08)	510	---		
844534	SA	69.6	13.8	25.9	195.0	24.2	110.0	4.5	0.04	0.11	0.36	0.3	280 (16.4)	594	7.28		
37	NSU	70.0	15.0	25.0	-----	18.0	138.0	4.6	<0.05	0.14	0.36	<0.2	277.74 (16.24)	583	7.70		
39	U	66.0	31.0	28.0	215.0	21.0	128.0	4.8	ND	ND	0.05	3.30	280 (16.37)	---	7.00		
40	U	60.0	31.0	27.0	207.0	18.0	114.0	5.0	<0.02	<0.10	0.40	3.20	258 (15.09)	---	7.20		
41	SA	55.0	25.0	24.0	224.0	11.0	104.0	6.0	<0.05	<0.05	0.54	1.20	248 (14.50)	560	7.11		
1771	U	35.0	9.5	12.0	136.0	6.0	14.0	3.45	0.03	0.05	0.29	<0.10	138 (18.00)	310	7.96		
TL3	UN	-----	-----	-----	-----	-----	95	-----	0.03	0.40	-----	-----	-----	---	6.94		
TL4	UN	-----	-----	-----	-----	-----	19	-----	0.03	0.13	-----	-----	-----	---	6.67		
TL5	UN	-----	-----	-----	-----	-----	173	-----	<0.03	0.06	-----	-----	-----	---	6.89		

Ca - calcium; Na - sodium; Mg - magnesium; HCO₃ - bicarbonate; Cl - chloride; SO₄ - sulfate; K - potassium; Mn - manganese; Fe - iron; F - fluoride; N - nitrate + nitrite (both as N); CaCO₃ - calcium carbonate

ND - not detected

Sample A

¹ U.S. Environmental Protection Agency "Drinking Water Regulations and Health Advisories": November 1994 (Secondary maximum contaminant levels. Recommended limits.)

² U.S. Environmental Protection Agency "Drinking Water Regulations and Health Advisories": November 1994 (Maximum contaminant level. Enforceable limits.)

³ Under Hardness as CaCO₃ the number above the parentheses is in parts per million and the number in parentheses is in grains per gallon.

⁴ Water sample 6 had been through a water softener.

< Means less than the value shown.

≤ Means less than or equal to the value shown.

Sample 39: South Dakota Public Water Supply Chemical Data 1976, South Dakota Department of Environmental Protection.

Sample 40: South Dakota Public Water Supply data 1979, South Dakota Department of Environmental Protection.

Sample 41: South Dakota Public Water Supply Data 1983, Office of Drinking Water, Department of Water and Natural Resources.

Water Source: All ground-water samples are from alluvium and/or fractured Precambrian rocks along or adjacent to the valleys of Battle and Grizzly Bear Creeks.

Sampling Procedure

NS The water sample was collected in two bottles; one bottom was preserved with nitric acid; the other with sulfuric acid. The sample was not filtered at the time of collection or analysis.

NSU The water was collected in four bottles; one preserved with nitric acid, one with sulfuric acid, the other two untreated. The sample was not filtered at the time of collection or analysis.

SA The water sample was collected in three bottles; two of the three bottles were treated with chemical preservatives. The sample was not filtered at the time of collection, but was filtered at the time of analysis.

UN Sampling and treatment procedures unknown.

APPENDIX A

Well information and locations of the water samples

Well logs with the same location as a water sample are in appendix A.

Sample Identification

- * For water analyses, see table 1.
- * For map location, see figure 1.

Location

All descriptions for the location within a section (i.e., NE NW SW SE) refer to quarter sections unless otherwise noted.

Aquifer

All ground-water samples are from alluvium and/or fractured Precambrian rocks along or adjacent to the valleys of Battle and Grizzly Bear Creeks.

Well Depth

The depths to water for wells and depth of the wells were obtained from the driller and/or well owner.

Usage

- D – Domestic
- M – Municipal
- OB – Observation
- U – Unused
- S – Stock

Notes

Samples 8, 34, 836648, 35, 36, and 842720 are from the same well. Only the number 8 is shown on figure 1.

Samples TL1 and 17 are from the same well. Only the number 17 is shown on figure 1.

Samples RB1 and 27 are from the same well. Only the number 27 is shown on figure 1.

Samples TL2 and 31 are from the same well. Only the number 31 is shown on figure 1.

Samples 32, 38, and 844535 are from the same well. Only the number 32 is shown on figure 1.

Samples 844534 and 37 are from the same well. Only the number 37 is shown on figure 1.

Samples 29, 39, 40, and 41 are from the same well. Only the number 29 is shown on figure 1.

Sample identification: 1

Location: SW NE NW SE sec. 8, T. 2 S., R. 6 E.
Date sampled: 08-31-1983
Aquifer: See notes
Well depth (ft): ----
Depth to water from casing top (ft): ----
Well owner: Wax Museum
Usage: D

Sample identification: 2

Location: NW SE NW SE sec. 8, T. 2 S., R. 6 E.
Date sampled: 08-31-1983
Aquifer: See notes
Well depth (ft): ----
Depth to water from casing top (ft): ----
Well owner: Keystone Heliport
Usage: D

Sample identification: 3

Location: SE SW NE SE sec. 8, T. 2 S., R 6 E.
Date sampled: 09-07-1983
Aquifer: See notes
Well depth (ft): 30
Depth to water from casing top (ft): ----
Well owner: Roggenthen/Leonard
Usage: D

Sample identification: 4

Location: NE NE NW SE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-07-1983
Aquifer: See notes
Well depth (ft): ----
Depth to water from casing top (ft): ----
Well owner: Miners Motel
Usage: D

Sample identification: 5

Location: NW SE SW NE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-07-1983
Aquifer: See notes
Well depth (ft): ----
Depth to water from casing top (ft): ----
Well owner: Rushmore Borglum
Usage: D

Sample identification: 6

Location: NE NE SW NE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-07-1983
Aquifer: See notes
Well depth (ft): 45
Depth to water from casing top (ft): 15
Well owner: L. Toskin/Ruby House
Usage: D

Sample identification: 7

Location: SE NE NE NE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-07-1983
Aquifer: See notes
Well depth (ft): 95
Depth to water from casing top (ft): ----
Well owner: Keystone Public School
Usage: D

Sample identification: 8

Location: SW SE NE SW sec. 4, T. 2 S., R. 6 E.
Date sampled: 09-07-1983
Aquifer: See notes
Well depth (ft): 60
Depth to water from casing top (ft): 11
Well owner: Keystone City
Usage: M

Sample identification: 34

Location: SW SE NE SW sec. 4, T. 2 S., R. 6 E.
Date sampled: 11-21-1983
Aquifer: See notes
Well depth (ft): 60
Depth to water from casing top (ft): 11
Well owner: Keystone City
Usage: M

Sample identification: 836648

Location: SW SE NE SW sec. 4, T. 2 S., R. 6 E.
Date sampled: 11-21-1983
Aquifer: See notes
Well depth (ft): 60
Depth to water from casing top (ft): 11
Well owner: Keystone City
Usage: M

Sample identification: 35

Location: SW SE NE SW sec. 4, T. 2 S., R. 6 E.
Date sampled: 06-07-1984
Aquifer: See notes
Well depth (ft): 60
Depth to water from casing top (ft): 11
Well owner: Keystone City
Usage: M

Sample identification: 36

Location: SW SE NE SW sec. 4, T. 2 S., R. 6 E.
Date sampled: 06-08-1984
Aquifer: See notes
Well depth (ft): 60
Depth to water from casing top (ft): 11
Well owner: Keystone City
Usage: M

Sample identification: 842720

Location: SW SE NE SW sec. 4, T. 2 S., R. 6 E.
Date sampled: 06-08-1984
Aquifer: See notes
Well depth (ft): 60
Depth to water from casing top (ft): 11
Well owner: Keystone City
Usage: M

Sample identification: 9

Location: SE SW NE NE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-08-1983
Aquifer: See notes
Well depth (ft): 100
Depth to water from casing top (ft): ----
Well owner: Keystone City
Usage: D

Sample identification: 10

Location: NE NW SE SE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-08-1983
Aquifer: See notes
Well depth (ft): ----
Depth to water from casing top (ft): ----
Well owner: L. Thomas
Usage: D

Sample identification: 11

Location: NW SE SW NE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-08-1983
Aquifer: See notes
Well depth (ft): ----
Depth to water from casing top (ft): ----
Well owner: Four Presidents Motel
Usage: D

Sample identification: 12

Location: NW NE SW NE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-08-1983
Aquifer: See notes
Well depth (ft): ----
Depth to water from casing top (ft): ----
Well owner: G. Stiverak/Taffy Shop
Usage: D

Sample identification: 13

Location: SW NE SW NE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-08-1983
Aquifer: See notes
Well depth (ft): ----
Depth to water from casing top (ft): ----
Well owner: D. Demmers/Sandwich Shop
Usage: D

Sample identification: 14

Location: SE NE SW NE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-08-1983
Aquifer: See notes
Well depth (ft): ----
Depth to water from casing top (ft): ----
Well owner: D. Demmers/Dip-A-Lot
Usage: D

Sample identification: 15

Location: NW NE SW NE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-08-1983
Aquifer: See notes
Well depth (ft): 39
Depth to water from casing top (ft): 15
Well owner: E. Jelliffe/The Indians
Usage: D

Sample identification: 16

Location: NW SE NE SW sec. 4, T. 2 S., R. 6 E.
Date sampled: 09-08-1983
Aquifer: See notes
Well depth (ft): ----
Depth to water from casing top (ft): ----
Well owner: B. Rensch/Key Hostel
Usage: D

Sample identification: TL1

Location: NW NW NW NW sec. 9, T. 2 S., R. 6 E.
Date sampled: 10-00-1982
Aquifer: See notes
Well depth (ft): 60
Depth to water from casing top (ft): ----
Well owner: G. Kuhnel
Usage: D

Sample identification: 17

Location: NW NW NW NW sec. 9, T. 2 S., R. 6 E.
Date sampled: 09-08-1983
Aquifer: See notes
Well depth (ft): 60
Depth to water from casing top (ft): ----
Well owner: G. Kuhnel
Usage: D

Sample identification: 18

Location: SW NW NW NW sec. 9, T. 2 S., R. 6 E.
Date sampled: 09-08-1983
Aquifer: See notes
Well depth (ft): ----
Depth to water from casing top (ft): ----
Well owner: J. McNeary/Keystone Country Store
Usage: D

Sample identification: 19

Location: SW SE NW SE sec. 6, T. 2 S., R. 6 E.
Date sampled: 09-09-1983
Aquifer: See notes
Well depth (ft): ----
Depth to water from casing top (ft): ----
Well owner: G. Woldt/Kemps Kamp
Usage: D

Sample identification: 20

Location: NE SW NW NW sec. 8, T. 2 S., R. 6 E.

Date sampled: 09-09-1983

Aquifer: See notes

Well depth (ft): ----

Depth to water from casing top (ft): ----

Well owner: Battle Creek Campground

Usage: D

Sample identification: 21

Location: SW NE SE SE sec. 8, T. 2 S., R. 6 E.

Date sampled: 09-12-1983

Aquifer: See notes

Well depth (ft): 40

Depth to water from casing top (ft): 107

Well owner: Litzenberg

Usage: D

Sample identification: 22

Location: SW NE SW NE sec. 10, T. 2 S., R. 6 E.

Date sampled: 09-12-1983

Aquifer: See notes

Well depth (ft): 18

Depth to water from casing top (ft): ----

Well owner: E. Metz

Usage: D, S

Sample identification: 23

Location: NW NE SE SW sec. 4, T. 2 S., R. 6 E.

Date sampled: 09-12-1983

Aquifer: See notes

Well depth (ft): 50

Depth to water from casing top (ft): 15

Well owner: G. Grover

Usage: D

Sample identification: 24

Location: NW SW NE SW sec. 4, T. 2 S., R. 6 E.

Date sampled: 09-12-1983

Aquifer: See notes

Well depth (ft): 80

Depth to water from casing top (ft): ----

Well owner: V. Chase

Usage: D

Sample identification: 25

Location: NW NW SE SW sec. 4, T. 2 S., R. 6 E.

Date sampled: 09-12-1983

Aquifer: See notes

Well depth (ft): ----

Depth to water from casing top (ft): ----

Well owner: K. Meinecke

Usage: D

Sample identification: 26

Location: NW NE SW SW sec. 4, T. 2 S., R. 6 E.

Date sampled: 09-12-1983

Aquifer: See notes

Well depth (ft): 42

Depth to water from casing top (ft): ----

Well owner: J. Halley

Usage: D

Sample identification: RB1

Location: NE SW NW NW sec. 9, T. 2 S., R. 6 E.

Date sampled: 09-16-1980

Aquifer: See notes

Well depth (ft): 40

Depth to water from casing top (ft): ----

Well owner: Rushmore Bar

Usage: D

Sample identification: 27

Location: NE SW NW NW sec. 9, T. 2 S., R. 6 E.

Date sampled: 09-12-1983

Aquifer: See notes

Well depth (ft): 40

Depth to water from casing top (ft): 10

Well owner: B. French/Rushmore Bar

Usage: D

Sample identification: 28

Location: SW NW NW SE sec. 4, T. 2 S., R. 6 E.

Date sampled: 09-14-1983

Aquifer: See notes

Well depth (ft): ----

Depth to water from casing top (ft): ----

Well owner: B. Siemonsma

Usage: D

Sample identification: 29

Location: NW SE NE SW sec. 4, T. 2 S., R. 6 E.
Date sampled: 09-14-1983
Aquifer: See notes
Well depth (ft): ----
Depth to water from casing top (ft): ----
Well owner: B. Siemonsma/Parkview (B and B Trailer Court?)
Usage: D

Sample identification: 30

Location: SE SW NW NW sec. 9, T. 2 S., R. 6 E.
Date sampled: 09-14-1983
Aquifer: See notes
Well depth (ft): 45.92
Depth to water from casing top (ft): 11.62
Well owner: Rohde/Brookside Motel
Usage: D

Sample identification: TL2

Location: NE NW SE NE sec. 8, T. 2 S., R. 6 E.
Date sampled: 10-00-1982
Aquifer: See notes
Well depth (ft): 45
Depth to water from casing top (ft): 9
Well owner: Hagen
Usage: D

Sample identification: 31

Location: NE NW SE NE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-14-1983
Aquifer: See notes
Well depth (ft): 45
Depth to water from casing top (ft): 16
Well owner: Hagen
Usage: D

Sample identification: 32

Location: NE NW SE NE sec. 8, T. 2 S., R. 6 E.
Date sampled: 11-18-1983
Aquifer: See notes
Well depth (ft): 83
Depth to water from casing top (ft): 6.47
Well owner: Keystone City
Usage: U

Sample identification: 38

Location: NE NW SE NE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-18-1983
Aquifer: See notes
Well depth (ft): 83
Depth to water from casing top (ft): ----
Well owner: Keystone City
Usage: U

Sample identification: 844535

Location: NE NW SE NE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-19-1984
Aquifer: See notes
Well depth (ft): 83
Depth to water from casing top (ft): ----
Well owner: Keystone City
Usage: U

Sample identification: 33

Location: NW SW NW SE sec. 4, T. 2 S., R. 6 E.
Date sampled: 11-21-1983
Aquifer: See notes
Well depth (ft): 52
Depth to water from casing top (ft): 12
Well owner: K. Gardner
Usage: D

Sample identification: 844534

Location: SE SW NE SW sec. 4, T. 2 S., R. 6 E.
Date sampled: 09-18-1984
Aquifer: See notes
Well depth (ft): 125
Depth to water from casing top (ft): ----
Well owner: Keystone City
Usage: OB (now M)

Sample identification: 37

Location: SE SW NE SW sec. 4, T. 2 S., R. 6 E.
Date sampled: 09-18-1984
Aquifer: See notes
Well depth (ft): 125
Depth to water from casing top (ft): ----
Well owner: Keystone City
Usage: OB (now M)

Sample identification: 39

Location: NW SE NE SW sec. 4, T. 2 S., R. 6 E.
Date sampled: 07-00-1975
Aquifer: See notes
Well depth (ft): 100(?)
Depth to water from casing top (ft): ----
Well owner: B and B Trailer Court
Usage: D

Sample identification: 40

Location: NW SE NE SW sec. 4, T. 2 S., R. 6 E.
Date sampled: 09-00-1976
Aquifer: See notes
Well depth (ft): 42(?)
Depth to water from casing top (ft): ----
Well owner: B and B Trailer Court
Usage: D

Sample identification: 41

Location: NW SE NE SW sec. 4, T. 2 S., R. 6 E.
Date sampled: 08-25-1983 for standard analysis
Aquifer: See notes
Well depth (ft): 60(?)
Depth to water from casing top (ft): ----
Well owner: B and B Trailer Court
Usage: D

Sample identification: 1771

Location: SW NW NE SE sec. 8, T. 2 S., R. 6 E.
Date sampled: 09-16-1980
Aquifer: See notes
Well depth (ft): 65
Depth to water from casing top (ft): ----
Well owner: Miners Motel
Usage: D

Sample identification: TL3

Location: SE NW SW SW sec. 4, T. 2 S., R. 6 E.
Date sampled: 10-00-1982
Aquifer: See notes
Well depth (ft): ----
Depth to water from casing top (ft): ----
Well owner: K. Hunsaker
Usage: D

Sample identification: TL4

Location: SW SW SW SW sec. 4, T. 2 S., R. 6 E.

Date sampled: 10-00-1982

Aquifer: See notes

Well depth (ft): ----

Depth to water from casing top (ft): ----

Well owner: Cullem

Usage: ----

Sample identification: TL5

Location: SW SW NE SW sec. 4, T. 2 S., R. 6 E.

Date sampled: 10-00-1982

Aquifer: See notes

Well depth (ft): ----

Depth to water from casing top (ft): ----

Well owner: Grover

Usage: D

APPENDIX B

Logs of Wells

MAP LOCATION (ML): A number arbitrarily assigned to the log according to the order in which it is listed (see **LEGAL LOCATION AND LOCATION**). This number corresponds to the numbers shown on figure 1.

LEGAL LOCATION AND LOCATION: The logs are listed by the smallest section number and then by quarter section NE (A), NW (B), SW (C), SE (D). All logs are from Township 2 South, Range 6 East. In a few locations, the smallest quarter section is followed by the number 1 or 2, which designates the first or second well drilled at that particular location.

LATITUDE AND LONGITUDE: The format is **DDD.MMSS** where **D** is degrees, **M** is minutes, and **S** is seconds.

DRILLING COMPANY: All the wells were drilled by private drilling companies. The company is indicated where known.

TOTAL DRILL HOLE DEPTH, SCREEN LENGTH, CASING STICK-UP, AND TOTAL CASING AND SCREEN: The numbers are presented in feet.

SCREEN TYPE AND CASING TYPE: Steel or PVC (polyvinyl chloride).

CASING DIAMETER: The numbers are presented in inches.

CASING TOP ELEVATION AND GROUND SURFACE ELEVATION: The numbers are presented in feet above the National Geodetic Vertical Datum of 1929 (NGVD). This was formerly called mean sea level. **T** - the elevation was estimated from 7½ minute series topographic map. **I** - the elevation was determined by surveying instrument.

NOTES: Water levels are given in feet below ground surface; production data are given in gallons per minute (gpm) at depths (in feet) below ground surface.

County: PENNINGTON
 Map Location: 1
 Legal Location: NW SW SE NE sec. 4, T. 2 S., R. 6 E.
 Latitude: 43.5406
 Land Owner: KEYSTONE CITY
 Project:
 Drilling Company: ALEXANDER DRILLING
 Driller:
 Geologist:
 Date Drilled: 07-28-1981
 Ground Surface Elevation: 4306 T
 Total Drill Hole Depth: 60
 Water Rights Well:
 Other Well Name: MUNICIPAL
 Basin: BATTLE CREEK
 Management Unit:
 Screen Type: NONE
 Casing Type: STEEL
 Casing Top Elevation:
 Casing Stick-up:
 Well Maintenance Date:
 USGS Hydrological Unit Code: 10120109
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma:
 Samples:

Location: 002S-06E-04ADCB

Longitude: 103.2438

Driller's Log: X
 Geologist's Log:
 Drilling Method: AIR HAMMER

Test Hole Number:
 SDGS Well Name:

Aquifer:

Screen Length:
 Casing Diameter:

Total Casing and Screen: 38.0

Single Point Resistivity:
 Extra:

NOTES: Water level: 11.0 feet; water from fractures; 20 gallons per minute (GPM) from 39 to 40 feet; 50 GPM from 52 to 53 feet, 50 GPM from completed well.

0	-	30	Drift (alluvium)
30	-	39	Schist, gray; hard
39	-	40	Schist; fractured
40	-	52	Schist, gray; hard
52	-	53	Quartz; fractured
53	-	60	Schist, gray; hard

County: PENNINGTON
 Map Location: 2
 Legal Location: SE SW NE SW sec. 4, T. 2 S., R. 6 E.
 Latitude: 43.5405
 Land Owner: KEYSTONE CITY
 Project: KEYSTONE CITY STUDY
 Drilling Company: ALEXANDER DRILLING
 Driller:
 Geologist:
 Date Drilled: 05-00-1984
 Ground Surface Elevation: 4308 I
 Total Drill Hole Depth: 125
 Water Rights Well:
 Other Well Name: MUNICIPAL
 Basin: BATTLE CREEK

Location: 002S-06E-04CADC

Longitude: 103.2450

Driller's Log: X
 Geologist's Log:
 Drilling Method: AIR HAMMER

Test Hole Number:
 SDGS Well Name:

Aquifer:

Management Unit:
Screen Type: NONE
Casing Type: STEEL
Casing Top Elevation:
Casing Stick-up: 0.75
Well Maintenance Date:
USGS Hydrological Unit Code: 10120109
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Screen Length:
Casing Diameter: 6.0
Total Casing and Screen: 125.0

Single Point Resistivity:
Extra:

NOTES: Water level: 11.17 feet on 05-24-1984; fractures at 46, 83, and 105 feet.

0 - 35 Alluvium
35 - 125 Pegmatite

County: PENNINGTON
Map Location: 3
Legal Location: SE NW SW SW sec. 4, T. 2 S., R. 6 E.
Latitude: 43.5357
Land Owner: K. HUNSAKER
Project:
Drilling Company: ALEXANDER DRILLING
Driller:
Geologist:
Date Drilled: 10-19-1977
Ground Surface Elevation: 4350 T
Total Drill Hole Depth: 170
Water Rights Well:
Other Well Name: PRIVATE
Basin: BATTLE CREEK
Management Unit:
Screen Type: NONE
Casing Type: PVC
Casing Top Elevation:
Casing Stick-up:
Well Maintenance Date:
USGS Hydrological Unit Code: 10120109
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Location: 002S-06E-04CCBD 1

Longitude: 103.2500

Driller's Log: X
Geologist's Log:
Drilling Method: AIR HAMMER

Test Hole Number:
SDGS Well Name:

Aquifer:

Screen Length:
Casing Diameter: 6.0

Total Casing and Screen: 20.0

Single Point Resistivity:
Extra:

NOTES: Water from fractures; 1 GPM at 90 feet, 3 GPM on final test.

0 - 4 Topsoil; clay
4 - 18 Schist; soft, broken
18 - 35 Schist; medium hard
35 - 90 Schist, gray; hard
90 - 148 Schist; medium hard
148 - 160 Schist; with granite

160 - 170 Schist; medium hard, with granite

County: PENNINGTON

Map Location: 4

Legal Location: SE NW SW SW sec. 4, T. 2 S., R. 6 E.

Latitude: 43.5357

Land Owner: K. HUNSAKER

Project:

Drilling Company:

Driller:

Geologist:

Date Drilled: 09-10-1971

Ground Surface Elevation: 4350 T

Total Drill Hole Depth: 45

Water Rights Well:

Other Well Name: PRIVATE

Basin: BATTLE CREEK

Management Unit:

Screen Type: NONE

Casing Type: STEEL

Casing Top Elevation:

Casing Stick-up:

Well Maintenance Date:

USGS Hydrological Unit Code: 10120109

Electric Log Information:

Spontaneous Potential:

Natural Gamma:

Samples:

Location: 002S-06E-04CCBD 2

Longitude: 103.2500

Driller's Log: X

Geologist's Log:

Drilling Method:

Test Hole Number:

SDGS Well Name:

Aquifer:

Screen Length:

Casing Diameter: 6.0

Total Casing and Screen: 22.0

Single Point Resistivity:

Extra:

NOTES: Water level: 14 feet; 0.5 GPM at 15 feet; 10 GPM from 34 to 39 feet; 10 GPM from 43 to 45 feet.

0	-	15	Slate, gray; hard, crack at 15 feet (schist)
15	-	28	Slate, gray; hard (schist)
28	-	33	Slate, brown; hard (schist)
33	-	34	Slate, brown; cracks are medium hard (schist)
34	-	39	Slate, brown; with cracks (schist)
39	-	43	Slate, brown; medium hard (schist)
43	-	45	Slate, gray; hard (schist)

County: PENNINGTON

Map Location: 5

Legal Location: NW NE SE SW sec. 4, T. 2 S., R. 6 E.

Latitude: 43.5402

Land Owner: G. GROVER

Project:

Drilling Company: ALEXANDER DRILLING

Driller:

Geologist:

Date Drilled: 01-16-1973

Ground Surface Elevation: 4318 T

Total Drill Hole Depth: 52

Water Rights Well:

Location: 002S-06E-04CDAB

Longitude: 103.2440

Driller's Log: X

Geologist's Log:

Drilling Method: AIR HAMMER

Test Hole Number:

SDGS Well Name:

Other Well Name: PRIVATE
 Basin: BATTLE CREEK
 Management Unit:
 Screen Type: NONE
 Casing Type: STEEL
 Casing Top Elevation:
 Casing Stick-up:
 Well Maintenance Date:
 USGS Hydrological Unit Code: 10120109
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma:
 Samples:

Aquifer:
 Screen Length:
 Casing Diameter: 6.0
 Total Casing and Screen: 37.0
 Single Point Resistivity:
 Extra:

NOTES: Water level: 13 feet; cracks from 41 to 42 feet; 20+ GPM from completed well.

0	-	10	Clay; rock (alluvium)
10	-	23	Gravel (alluvium)
23	-	28	Sand (alluvium)
28	-	34	Schist; broken
34	-	52	Schist

County: PENNINGTON
 Map Location: 6
 Legal Location: NW SW NW SE sec. 4, T. 2 S., R. 6 E.
 Latitude: 43.5406
 Land Owner: K. GARDNER
 Project:
 Drilling Company: ALEXANDER DRILLING
 Driller:
 Geologist:
 Date Drilled: 01-25-1973
 Ground Surface Elevation: 4310 T
 Total Drill Hole Depth: 52
 Water Rights Well:
 Other Well Name: PRIVATE
 Basin: BATTLE CREEK
 Management Unit:
 Screen Type: NONE
 Casing Type: STEEL
 Casing Top Elevation:
 Casing Stick-up:
 Well Maintenance Date:
 USGS Hydrological Unit Code: 10120109
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma:
 Samples:

Location: 002S-06E-04DBCB
 Longitude: 103.2430
 Driller's Log: X
 Geologist's Log:
 Drilling Method: AIR HAMMER
 Test Hole Number:
 SDGS Well Name:
 Aquifer:
 Screen Length:
 Casing Diameter: 6.0
 Total Casing and Screen: 42.0
 Single Point Resistivity:
 Extra:

NOTES: Water level: 12 feet; water from fissures; cracks from 41 to 43.2 feet.

0	-	10	Clay (alluvium)
10	-	28	Gravel (alluvium)

28 - 36 Sand (alluvium)
36 - 52 Schist; broken

County: PENNINGTON
Map Location: 7
Legal Location: SE SW NE NE sec. 8, T. 2 S., R. 6 E.
Latitude: 43.5337
Land Owner: KEYSTONE CITY
Project:
Drilling Company: ALEXANDER DRILLING
Driller:
Geologist:
Date Drilled: 00-00-0000
Ground Surface Elevation: 4350 T
Total Drill Hole Depth: 84
Water Rights Well:
Other Well Name: MUNICIPAL
Basin: BATTLE CREEK
Management Unit:
Screen Type: NONE
Casing Type: STEEL
Casing Top Elevation:
Casing Stick-up:
Well Maintenance Date:
USGS Hydrological Unit Code: 10120109
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Location: 002S-06E-08AACD

Longitude: 103.2520

Driller's Log: X
Geologist's Log:
Drilling Method: AIR HAMMER

Test Hole Number:
SDGS Well Name:

Aquifer:

Screen Length:
Casing Diameter: 6.0

Total Casing and Screen: 35.0

Single Point Resistivity:
Extra:

NOTES: Water level: 8 feet; water from fractures; some water from 34 to 44 feet; 50+ GPM from completed well.

0 - 30 Topsoil; sand, gravel (alluvium)
30 - 34 Schist
34 - 44 Schist, gray; hard
44 - 64 Schist; with granite
64 - 83.5 Schist, gray; hard

County: PENNINGTON
Map Location: 8
Legal Location: NE SE NE NE sec. 8, T. 2 S., R. 6 E.
Latitude: 43.5342
Land Owner: J. HALLEY
Project:
Drilling Company:
Driller:
Geologist:
Date Drilled: 08-30-1971
Ground Surface Elevation: 4450 T
Total Drill Hole Depth: 91

Location: 002S-06E-08AADA

Longitude: 103.2509

Driller's Log: X
Geologist's Log:
Drilling Method: AIR HAMMER

Test Hole Number:

Water Rights Well:
Other Well Name: PRIVATE
Basin: BATTLE CREEK
Management Unit:
Screen Type: NONE
Casing Type: STEEL
Casing Top Elevation:
Casing Stick-up:
Well Maintenance Date:
USGS Hydrological Unit Code: 10120109
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

SDGS Well Name:
Aquifer:
Screen Length:
Casing Diameter: 6.0
Total Casing and Screen: 20.0

Single Point Resistivity:
Extra:

NOTES: Water level: 24 feet; 0.5 GPM at 45 feet, 2 GPM from 59 to 65 feet, 3 GPM from 65 to 75 feet; 2 GPM from 80 feet.

0	-	14	Slate, brown; medium hard (schist)
14	-	18	Slate, light-gray; hard (schist)
18	-	30	Slate, gray; hard (schist)
30	-	35	Slate, brown; hard (schist)
35	-	50	Slate, light-brown; soft, crack at 45 feet (schist)
50	-	59	Slate, gray; medium hard (schist)
59	-	65	Slate, brown; soft (schist)
65	-	75	Slate, brown; hard (schist)
75	-	90	Slate, brown (schist)
90	-	91	Slate, black; hard (schist)

County: PENNINGTON
Map Location: 9
Legal Location: NE SE NE NE sec. 8, T. 2 S., R. 6 E.
Latitude: 43.5340
Land Owner: RENSCH/BRIDGE
Project:
Drilling Company: ALEXANDER DRILLING
Driller:
Geologist:
Date Drilled: 03-24-1977
Ground Surface Elevation: 4430 T
Total Drill Hole Depth: 44
Water Rights Well:
Other Well Name: PRIVATE
Basin: BATTLE CREEK
Management Unit:
Screen Type: NONE
Casing Type: STEEL
Casing Top Elevation:
Casing Stick-up:
Well Maintenance Date:
USGS Hydrological Unit Code: 10120109
Electric Log Information:

Location: 002S-06E-08AADA 1

Longitude: 103.2515

Driller's Log: X
Geologist's Log:
Drilling Method: AIR HAMMER

Test Hole Number:
SDGS Well Name:

Aquifer:

Screen Length:
Casing Diameter: 6.0

Total Casing and Screen: 21.0

Spontaneous Potential:
Natural Gamma:
Samples:

Single Point Resistivity:
Extra:

NOTES: Water level: 19 feet; water from fractures; 20± GPM from completed well.

0	-	7	Clay; schist, loose (colluvium)
7	-	15	Schist
15	-	19	Schist, gray; medium hard
19	-	28	Schist, gray; hard, with fractures
28	-	44	Schist, gray; hard, with quartz veins

County: PENNINGTON
Map Location: 10
Legal Location: SW SE SW NE sec. 8, T. 2 S., R. 6 E.
Latitude: 43.5325
Land Owner: VILLAGE LAUNDROMAT
Project:
Drilling Company: ALEXANDER
Driller:
Geologist:
Date Drilled: 00-00-0000
Ground Surface Elevation: 4390 T
Total Drill Hole Depth: 126
Water Rights Well:
Other Well Name: PRIVATE
Basin: BATTLE CREEK
Management Unit:
Screen Type:
Casing Type:
Casing Top Elevation:
Casing Stick-up:
Well Maintenance Date:
USGS Hydrological Unit Code: 10120109
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Location: 002S-06E-08ACDC

Longitude: 103.2534

Driller's Log: X
Geologist's Log:
Drilling Method: AIR HAMMER

Test Hole Number:
SDGS Well Name:

Aquifer:

Screen Length:
Casing Diameter:

Total Casing and Screen:

Single Point Resistivity:
Extra:

NOTES: Water level: 12 feet; 5 GPM pumping rate.

0	-	3	Topsoil
3	-	32	Sand and gravel (alluvium)
32	-	126	Schist

County: PENNINGTON
Map Location: 11
Legal Location: NE NW NW sec. 8, T. 2 S., R. 6 E.
Latitude: 43.5347
Land Owner: H. SHAFF
Project:

Location: 002S-06E-08BBA

Longitude: 103.2608

Drilling Company: ALEXANDER DRILLING

Driller:

Geologist:

Date Drilled: 10-13-1981

Ground Surface Elevation: 4490 T

Total Drill Hole Depth: 267

Water Rights Well:

Other Well Name: PRIVATE

Basin: BATTLE

Management Unit:

Screen Type: NONE

Casing Type: PVC

Casing Top Elevation:

Casing Stick-up:

Well Maintenance Date:

USGS Hydrological Unit Code: 10120109

Electric Log Information:

Spontaneous Potential:

Natural Gamma:

Samples:

Driller's Log: X

Geologist's Log:

Drilling Method: AIR HAMMER

Test Hole Number:

SDGS Well Name:

Aquifer:

Screen Length:

Casing Diameter: 6.0

Total Casing and Screen: 61.0

Single Point Resistivity:

Extra:

NOTES: Water level: 50 feet; trace water in fractured schist from 100 to 102 feet; 8 GPM from 246 to 249 feet.

0	-	53	Drift, clay and schist, broken schist
53	-	100	Schist, black; hard
100	-	102	Schist, brown; hard, fractured
102	-	170	Schist, black; hard
170	-	220	Schist, gray; hard
220	-	225	Schist, gray; hard, fractured
225	-	246	Schist, gray; hard
246	-	249	Schist; broken, with quartz
249	-	267	Schist, gray; hard

County: PENNINGTON

Map Location: 12

Legal Location: NW SE sec. 8, T. 2 S., R. 6 E.

Latitude: 43.5318

Land Owner: H. HAUG

Project:

Drilling Company: ALEXANDER

Driller:

Geologist:

Date Drilled: 10-16-1980

Ground Surface Elevation: 4395 T

Total Drill Hole Depth: 84

Water Rights Well:

Other Well Name: PRIVATE

Basin: BATTLE CREEK

Management Unit:

Screen Type: NONE

Casing Type: STEEL

Location: 002S-06E-08DB

Longitude: 103.2536

Driller's Log: X

Geologist's Log:

Drilling Method: AIR HAMMER

Test Hole Number:

SDGS Well Name:

Aquifer:

Screen Length:

Casing Diameter:

Casing Top Elevation:
Casing Stick-up:
Well Maintenance Date:
USGS Hydrological Unit Code: 10120109
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Total Casing and Screen: 37.0

Single Point Resistivity:
Extra:

NOTES: Water level: 15 feet; 5 to 6 GPM from 63 to 65 feet.

0	-	30	Drift; gravel (alluvium)
30	-	63	Schist, gray; medium hard
63	-	65	Schist; with pegmatite
65	-	84	Schist, gray; hard

County: PENNINGTON
Map Location: 13
Legal Location: SE NE NW SE sec. 8, T. 2 S., R. 6 E.
Latitude: 43.5321
Land Owner: MINERS MOTEL
Project:
Drilling Company: ALEXANDER DRILLING
Driller:
Geologist:
Date Drilled: 00-00-0000
Ground Surface Elevation: 4390 T
Total Drill Hole Depth: 103
Water Rights Well:
Other Well Name: PRIVATE
Basin: BATTLE CREEK
Management Unit:
Screen Type: NONE
Casing Type: UNKNOWN
Casing Top Elevation:
Casing Stick-up:
Well Maintenance Date:
USGS Hydrological Unit Code: 10120109
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Location: 002S-06E-08DBAD

Longitude: 103.2527

Driller's Log: X
Geologist's Log:
Drilling Method: AIR HAMMER

Test Hole Number:
SDGS Well Name:

Aquifer:

Screen Length:
Casing Diameter:

Total Casing and Screen:

Single Point Resistivity:
Extra:

NOTES: Water level: 14 to 18 feet; 7 GPM pumping rate.

0	-	103	Schist
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County: PENNINGTON
Map Location: 14
Legal Location: SW NE SE SE sec. 8, T. 2 S., R. 6 E.
Latitude: 43.5307

Location: 002S-06E-08DDAC

Longitude: 103.2515

Land Owner: LITZENBERG
Project:
Drilling Company: HAMM DRILLING
Driller:
Geologist:
Date Drilled: 00-00-0000
Ground Surface Elevation: 4415 T
Total Drill Hole Depth: 32
Water Rights Well:
Other Well Name: PRIVATE
Basin: BATTLE CREEK
Management Unit:
Screen Type:
Casing Type:
Casing Top Elevation:
Casing Stick-up:
Well Maintenance Date:
USGS Hydrological Unit Code: 10120109
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

NOTES: Water level: 12 feet.

0 - 32 Schist, weathered

County: PENNINGTON
Map Location: 15
Legal Location: SW NW NW NW sec. 9, T. 2 S., R. 6 E.
Latitude: 43.5346
Land Owner: L. ROHDE
Project:
Drilling Company: ALEXANDER DRILLING
Driller:
Geologist:
Date Drilled: 03-26-1978
Ground Surface Elevation: 4350 T
Total Drill Hole Depth: 64
Water Rights Well:
Other Well Name: PRIVATE
Basin: BATTLE CREEK
Management Unit:
Screen Type: NONE
Casing Type: STEEL
Casing Top Elevation:
Casing Stick-up:
Well Maintenance Date:
USGS Hydrological Unit Code: 10120109
Electric Log Information:
Spontaneous Potential:
Natural Gamma:

Driller's Log: X
Geologist's Log:
Drilling Method:

Test Hole Number:
SDGS Well Name:

Aquifer:

Screen Length:
Casing Diameter:

Total Casing and Screen:

Single Point Resistivity:
Extra:

Location: 002S-06E-09BBBC

Longitude: 103.2507

Driller's Log:
Geologist's Log:
Drilling Method: AIR HAMMER

Test Hole Number:
SDGS Well Name:

Aquifer:

Screen Length:
Casing Diameter: 6.0

Total Casing and Screen: 42.5

Single Point Resistivity:
Extra:

Samples:

NOTES: Water level: 12± feet; water from fractures; 50 GPM from 44 to 46 feet, 50± GPM from completed well.

0	-	15	Topsoil; boulders (alluvium)
15	-	34	Gravel; boulders (alluvium)
34	-	44	Schist, gray; medium hard
44	-	46	Granite; quartz
46	-	64	Schist, gray; medium hard

County: PENNINGTON

Map Location: 16

Legal Location: NE SW NW NW sec. 9, T. 2 S., R. 6 E.

Latitude: 43.5343

Land Owner: T. HERSRUD

Project:

Drilling Company: ALEXANDER DRILLING

Driller:

Geologist:

Date Drilled: 08-25-1978

Ground Surface Elevation: 4360 T

Total Drill Hole Depth: 43

Water Rights Well:

Other Well Name: PRIVATE

Basin: BATTLE CREEK

Management Unit:

Screen Type: NONE

Casing Type: PVC

Casing Top Elevation:

Casing Stick-up:

Well Maintenance Date:

USGS Hydrological Unit Code: 10120109

Electric Log Information:

Spontaneous Potential:

Natural Gamma:

Samples:

Location: 002S-06E-09BBCA

Longitude: 103.2500

Driller's Log: X

Geologist's Log:

Drilling Method: AIR HAMMER

Test Hole Number:

SDGS Well Name:

Aquifer:

Screen Length:

Casing Diameter: 6.0

Total Casing and Screen:

Single Point Resistivity:

Extra:

NOTES: Water level: 16 feet; 30 GPM at 28 feet.

0	-	19	Drift (colluvium)
19	-	27	Schist, brown to gray; hard
27	-	43	Schist, gray; hard

County: PENNINGTON

Map Location: 17

Legal Location: NW SW NW NW sec. 9, T. 2 S., R. 6 E.

Latitude: 43.5343

Land Owner: H. MORRIS

Project:

Drilling Company: ALEXANDER DRILLING

Location: 002S-06E-09BBCB

Longitude: 103.2505

Driller:
Geologist:
Date Drilled: 11-03-1977
Ground Surface Elevation: 4340 T
Total Drill Hole Depth: 64
Water Rights Well:
Other Well Name: PRIVATE
Basin: BATTLE CREEK
Management Unit:
Screen Type: NONE
Casing Type: STEEL
Casing Top Elevation:
Casing Stick-up:
Well Maintenance Date:
USGS Hydrological Unit Code: 10120109
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Driller's Log: X
Geologist's Log:
Drilling Method: AIR HAMMER

Test Hole Number:
SDGS Well Name:

Aquifer:

Screen Length:
Casing Diameter:

Total Casing and Screen: 50.0

Single Point Resistivity:
Extra:

NOTES: Casing diameter 21 feet of 6-inch, 29 feet of 5-inch. Water level: 28 feet; water from fractures; 30+ GPM from completed well.

0	-	27	Drift; boulders (alluvium)
27	-	35	Schist; medium hard, broken
35	-	44	Schist; fractured, with quartz
44	-	64	Schist; medium hard, with quartz

County: PENNINGTON
Map Location: 18
Legal Location: SE SW NW NW sec. 9, T. 2 S., R. 6 E.
Latitude: 43.5338
Land Owner: L. ROHDE
Project:

Location: 002S-06E-09BBCD

Longitude: 103.2503

Drilling Company: ALEXANDER DRILLING

Driller:

Driller's Log: X

Geologist:

Geologist's Log:

Date Drilled: 03-28-1978

Drilling Method: AIR HAMMER

Ground Surface Elevation: 4350 T

Total Drill Hole Depth: 70

Water Rights Well:

Test Hole Number:

Other Well Name: PRIVATE

SDGS Well Name:

Basin: BATTLE CREEK

Aquifer:

Management Unit:

Screen Type: NONE

Screen Length:

Casing Type: STEEL

Casing Diameter: 6.0

Casing Top Elevation:

Casing Stick-up:

Total Casing and Screen: 36.0

Well Maintenance Date:

USGS Hydrological Unit Code: 10120109

Electric Log Information:

Spontaneous Potential:

Single Point Resistivity:

Natural Gamma:
Samples:

Extra:

NOTES: Water level: 10+ feet; water from fractures; 20 GPM from 42 to 44 feet; 20± GPM from completed well.

0	-	12	Topsoil; drift (alluvium)
12	-	32	Gravel; boulders (alluvium)
32	-	60	Schist, gray; medium hard
60	-	70	Schist, brown; medium hard

County: PENNINGTON

Location: 002S-06E-09BCBB

Map Location: 19

Legal Location: NW NW SW NW sec. 9, T. 2 S., R. 6 E.

Latitude: 43.5335

Longitude: 103.2505

Land owner: C. STYGLES

Project:

Drilling Company: ALEXANDER DRILLING

Driller:

Driller's log: X

Geologist:

Geologist's Log:

Date Drilled: 05-17-1978

Drilling Method: AIR HAMMER

Ground Surface Elevation: 4355 T

Total Drill Hole Depth: 84

Water Rights Well:

Test Hole Number:

Other Well Name: PRIVATE

SDGS Well Name:

Basin: BATTLE CREEK

Aquifer:

Management Unit:

Screen Type: NONE

Screen Length:

Casing Type: STEEL

Casing Diameter: 6.0

Casing Top Elevation:

Casing Stick-up:

Total Casing and Screen: 43.0

Well Maintenance Date:

USGS Hydrological Unit Code: 10120109

Electric Log Information:

Spontaneous Potential:

Single Point Resistivity:

Natural Gamma:

Extra:

Samples:

NOTES: Water level: 15± feet; water from fractures; 10 GPM from 56 to 57 feet.

0	-	36	Drift (alluvium)
36	-	43	Schist, gray; medium hard
43	-	56	Schist, gray; hard
56	-	57	Schist; fractured
57	-	84	Schist, gray; hard

APPENDIX C

Letter on iron bacteria contamination and treatment techniques

DEPARTMENT OF WATER AND NATURAL RESOURCES
SOUTH DAKOTA GEOLOGICAL SURVEY
Science Center, USD
Vermillion, SD 57069
(605) 677-5227

March 1, 1984

Town of Keystone
Box 689
Keystone, SD 57751

To the City Council:

Following is the information on the iron bacteria problem in the city park well and information on treatment chemicals and techniques.

As I reported at the February 15, 1984 city council meeting, we found iron bacteria contaminating the city park well. In order to extend the useful life of this well, particularly if it is used as one of the central city water supply wells, it will be necessary to periodically treat this well for iron bacteria control.

The iron bacteria, when they contaminate a well, can lead to such problems as yellow or red colored water, odor problems (bad egg smell), clogging of casing, pipes, and pump impeller intakes, and may lead to corrosion of iron and steel components. These can lead to the water becoming unsuitable for domestic use and significantly decrease well yields, and even lead to well abandonment. Fortunately, they can be controlled to avoid these problems, but can seldom, if ever, be completely eliminated from the well system. Therefore, periodic retreatment is necessary.

General treatment guidelines: Regardless of the type of chemical treatment used, the following general guidelines apply.

It is really not necessary to know which type or types of iron bacteria (or other bacteria) are present. The idea is to kill as many of them as possible. The pump and pipe should be pulled from the city park well to visually inspect for the degree of contamination. The amount of visible contamination will determine the type and/or strength of the chemical to be used and give some idea how often retreatment will be necessary.

Before treatment begins, the pump and pipe should be placed back in the well so that the bacteria on these items can be treated. The chemical used can be poured into the well or it can be pumped into the well. Pumping the treatment chemical into the well will give better treatment, as it is necessary to get the chemical into all parts of the well bore and even into the water formation. After the chemical is pumped into the well and formation, it is advantageous to periodically agitate the water to break up the slimy bacteria deposits. The treatment compound should remain in the well for 24 to 48 hours depending on the degree of contamination.

At the end of the treatment period, the treatment material can be pumped to waste, with regard given to proper disposal of the waste material. The waste material should be pumped out slowly at first and the well should be pumped and surged alternately to break up the slimy coatings of bacteria. It is important to remove all of the waste material, so the well should be pumped for some time after the well has cleared up.

Chemical concentration used will depend on chemical type and should be given on label directions. No matter which chemical is used, a specified amount per gallon of water in the well will be needed. This can be determined with the following formula: $V = \pi r^2 h$, where $\pi = 3.14$, r^2 is the radius of the well bore squared (0.0625 square feet in this case--radius of well is 0.25 feet so $r^2 = 0.25 \times 0.25 = 0.0625$ square feet) h is the height of the water column in the well (49 feet in this case--60 feet deep well minus 11 feet water level=49 feet) $= 9.61625$ cubic feet. One gallon of water=0.1337 cubic feet so 9.61625 cubic feet=72 gallons of water in the city park well. Since this is the amount of water in the well bore only, the chemical should be mixed a bit stronger so that it can be surged into the water in the rock formation.

Nearly all the types of chemicals that can be used are hazardous to some degree, so a qualified well contractor or well driller should be hired to do the work.

Chemical types that can be used: various chemicals are available for the treatment process. Some of these have proven field experience while others have only been lab tested or only suggested as being effective. They include chlorine, inhibited muriatic (hydrochloric) acid, sulphamic acid, acetic acid, LBA (Liquid Antibacterial Acid), sodium hypochlorite (laundry bleach, Javex, Chlorox), calcium hypochlorite (HTH), quaternary ammonium compounds (quats, QACs, e.g., Benzethonium CL, Bardac-22, Barquat), Johnson Nuwell acidizing compound, iodine, copper sulfate, potassium permanganate, and polyphosphates.

All of these have their (1) advantages and (2) disadvantages, as follows:

Chlorine: (1) widely available; relatively inexpensive, (2) extremely corrosive; can cause staining problems; if incrustations involved, does not dissolve them.

Muriatic acid: (1) widely available, inexpensive; requires no special equipment or skills; disperses mineral incrustation, (2) highly corrosive; does a poor job of dissolving organic deposits of iron bacteria.

Sulphamic acid: (1) and (2) as above.

Acetic acid: (1) widely available; disperses mineral incrustation (2) costs more; may change chemically in well and become a nutrient for the bacteria.

LBA: (1) easy to use; non-volatile; has no toxic fumes; formulated especially for iron bacteria control; disperses iron and manganese deposits and bacteria (2) expensive (\$43.70/5 gallon pail \$362/55 gallon barrel in 1981); hydrogen ion concentration (pH) must be maintained at 3.5 to 5.0 throughout treatment period to be effective, so pH must be continually monitored during treatment; water analysis prior to treatment recommended (which we have).

Sodium hypochlorite: (1) widely available; inexpensive; requires no special skills or equipment (2) will not penetrate slime; inhibited by high dissolved iron content and cold water.

Calcium hypochlorite: (1) and (2) as above.

Quaternary ammonium compounds: (2) good killing and slime dispersing action; better penetration into incrustation (2) inhibited at low water temperatures requiring long contact time to be effective; some compounds severely restricted by hardness; has not had field application in water well disinfection.

Johnson Nuwell acidizing compound: advantages and disadvantages unknown.

Iodine, copper sulfate, potassium permanganate, and polyphosphates: these all have more severe limitations than the compounds above.

The calcium and sodium hypochlorite treatments are shock treatments and are used in 1% or more strength. The hypochlorites and muriatic or sulfamic acid can be used together to be more effective with a 7.5 to 21% concentration.

Bardac-22 and Barquat are tradenames of Lonza, Inc., Fairlawn NJ 07410, telephone (201) 791-7500. I do not have any price information. These products have apparently not had water well application but are claimed to have hard water tolerance.

LBA is a trademark of Compaction Engineering Co., Water Well Chemical Division, One First St., Los Altos, CA 94022, telephone (415) 948-5900. It has had application as a bactericide in water wells since 1962, requires a 5% solution for initial treatment, has controlled iron bacteria for 4-6 months or longer after initial treatment, and the amount needed for subsequent treatments is reduced by 80%. However, as stated above, it is expensive.

The other treatment compounds listed above can probably be obtained from the contractor doing the work for you or from one of the local chemical companies.

If you need further information or the names, addresses, and telephone numbers of chemical companies, please contact me.

Sincerely,

Richard Bretz
Geologist

For the State Geologist

RB:mjr
cc: M.J. Tipton
Assad Barari
Doug Sperlich

APPENDIX D

SUMMARY OF FINDINGS AND CONCLUSIONS FOR KEYSTONE GROUND-WATER STUDY

by

Richard F. Bretz and Assad Barari
South Dakota Geological Survey

1984

The following is a summary of findings and conclusions for a ground-water study which was conducted at the request of the city of Keystone by the South Dakota Geological Survey during 1983-1984. A complete report, including figures and tables of water quality, will be furnished to the city after it is published.

A review of the previous studies and the available data indicated that the quality and the quantity of surface water (streams) in the area is quite variable. Also, previous ground-water data from the area showed nitrate concentrations in many wells were higher than the recommended limits established by the EPA.

Forty-two water samples were collected and analyzed during this investigation. These samples contained lower nitrate concentrations than previous studies indicated. These lower nitrate concentrations could be attributed to the construction of the sanitary sewer system in the city. However, many of the recent samples showed higher iron and manganese in the wells than recommended EPA limits.

Based on general water quality and available data on well productions, the city park area was selected for further testing. A 125-foot well was drilled by a private driller at a distance of 392 feet from the city park well. The new well was used as an observation well during a pumping test on the city park well. On June 7, 1984, a park well was pumped for 22 hours at a rate of 73 gallons per minute with a total drawdown of 21.28 feet. The recovery was 20.92 feet 10 hours and 5 minutes after shutoff. Water samples were collected and analyzed, and the results are enclosed.

A second test was conducted on the new well and the park well was used as an observation well. A 24-hour test was started at 12:00 noon on September 17, 1984. This well was pumped at a rate of approximately 92 gallons per minute. The total drawdown was approximately 25 feet. The results of the water sample collected during the test are also enclosed.

A third test was conducted on a city well located across the street from the Fire Hall. A 19-hour test was started at 2:30 p.m. on September 18, 1984. The pumping rate was approximately 90 gallons per minute. Results of water samples from this test are also enclosed.

CONCLUSIONS

This investigation shows that each of the two wells in the park or any similar wells in this location could be pumped at a rate of 75–100 gallons per minute during average precipitation years. The well in front of the Fire Hall or any similar well in this location could also pump 75–100 gallons per minute during average precipitation years. However, closely spaced wells could reduce yield.

Water quality from the wells in these two areas should be comparable to the enclosed results. During dry years a decrease in the pumping rate and a variation in the quality of the water could be expected. It should also be noted that iron bacteria were detected in the city park well. This well and the other wells used by the city should be treated periodically to minimize this problem. The available data show that the park area and the City Hall area could produce water of satisfactory quality and quantity for municipal use.