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Open-File Report 57-UR

INVESTIGATION OF THE GROUND-WATER QUALITY
NEAR AURORA, SOUTH DAKOTA

by

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INTRODUCTION

The investigation was conducted by the South Dakota Geological Survey (SDGS), at the request of the city of Aurora, South Dakota, to assist the city in locating a future drinking water supply. The purpose of the study was to determine if water of acceptable quantity and quality containing less than 10 milligrams per liter (mg/L) nitrate could be located near the city for municipal use. The investigation was financed by the city of Aurora, the East Dakota Water Development District, and the state of South Dakota. This report contains the results of the investigation, which was conducted in the Aurora area (fig. 1).

Land Use and the Aurora Water Supply

The city of Aurora (population 507) is located 3 miles east of Brookings, South Dakota, in Brookings County. Land in the vicinity of Aurora is used for agriculture and nearly all is irrigated. Irrigation is heavily concentrated in a 2-mile radius around the city and is less concentrated farther to the east, west, and south. All irrigation wells in the study area are completed in the Big Sioux aquifer. The application of nitrogen-based fertilizers in this area is a common farming practice.

Until 1984, a feedlot containing approximately 150 head of cattle was located adjacent to the northwest side of Aurora (fig. 2) and may have contributed nitrate to the ground water. This feedlot was in operation for about 30 years. Actual contribution of nitrate from this source, either in the past or the present, is undocumented.

The Aurora sewage lagoon is located southwest of Aurora (fig. 2) and downgradient from the present municipal well. An earlier report (South Dakota Department of Water and Natural Resources, undated, appendix A, Aurora Sewage Lagoon section) presented data which show that the sewage lagoon leaks and has contaminated ground water with nitrate. The sewage lagoon was not included in the current investigation, however, it is a documented point-source for nitrate contamination.

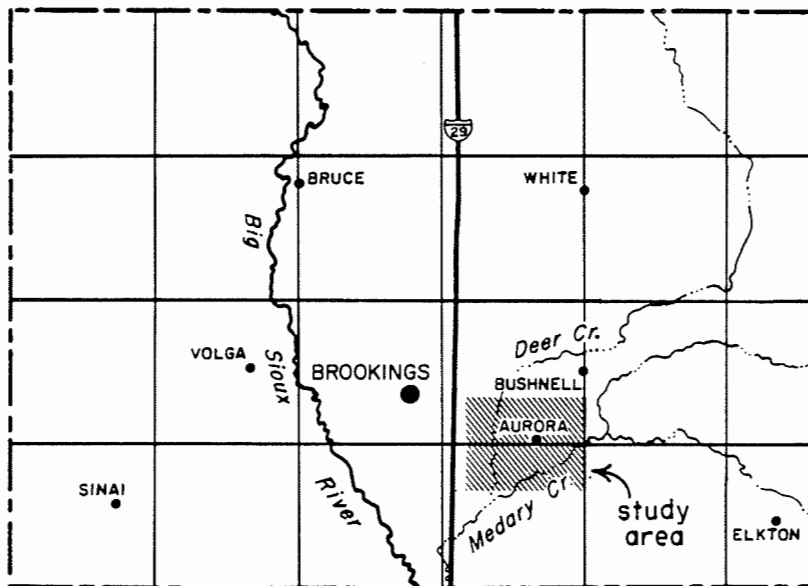
Elevated nitrate concentrations were known to exist in the ground water on the northwest side of Aurora as early as 1971 (water-quality analyses were performed by South Dakota State University Water Analysis Testing Laboratory and the State Testing Laboratory and are on file at the South Dakota Department of Health, and the SDGS). At that time, individual homes and businesses in Aurora were served by private wells. However, because nitrate-nitrogen concentrations in private wells within the city limits were above the South Dakota drinking water standard of 10 mg/L, a municipal well was drilled.

This municipal well, drilled in 1972, is located on the west side of town, and is completed in the Big Sioux aquifer. The depth of the well is 66 feet and, at this site, the top and bottom of the outwash are 2 and 64 feet, respectively, below land surface. The well is downgradient from the location of the discontinued feedlot and from irrigated agricultural land, and upgradient from the sewage lagoon (fig. 2).

The nitrate-nitrogen concentration in water collected from the municipal well on September 13, 1988, was 10.6 mg/L. This is in excess of the South Dakota drinking water standard of 10 mg/L. With one exception, a water sample collected on April 23, 1984, water-quality analyses have shown nitrate-nitrogen concentrations of 6.5 mg/L or higher since 1974 (table 1 and fig. 3). Figure 3 shows that while nitrate



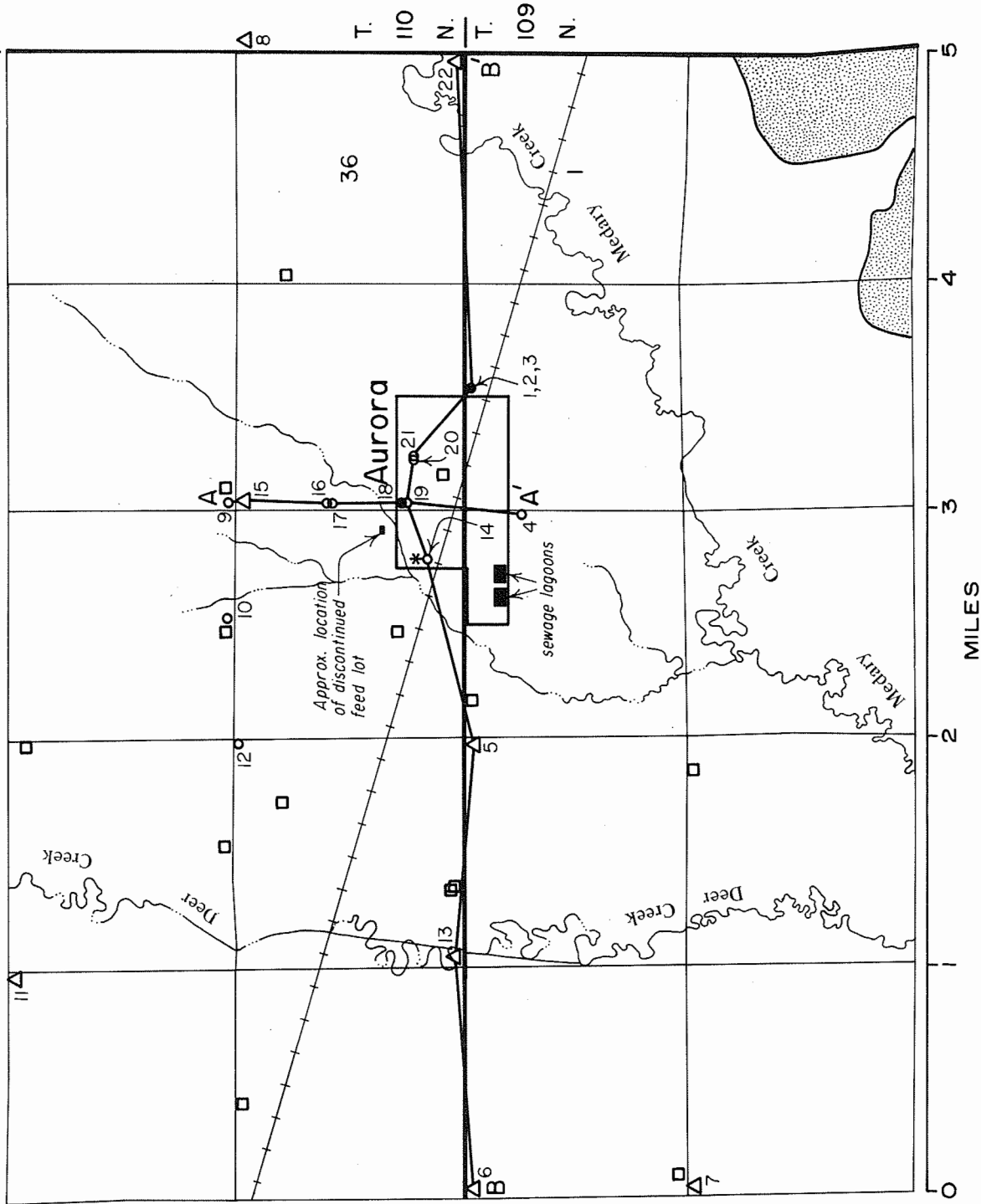
Index map of South Dakota showing location of Brookings County.



Map of Brookings County showing study area location.

Figure 1. Location of the study area.

R. 49 W. R. 48 W.



Data from this study

- 16 Observation well
- 18 Test hole

Other data

- △ 6 Observation well
- Private well
- * Municipal well

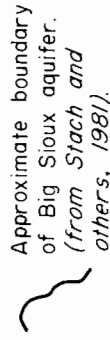
Numbers are Map Location (ML) numbers. See Appendix A for explanation.



Area where Big Sioux aquifer is absent.



Line of cross section. See figures 4 and 5.



Approximate boundary of Big Sioux aquifer. (from Stach and others, 1981).

Figure 2. Locations of test holes, municipal, private and observation wells; extent of the Big Sioux aquifer; and locations of geologic cross sections.

Table 1. Nitrate-nitrogen data for the Aurora municipal well

Date collected	Nitrate-nitrogen concentrations (milligrams per liter)
11-27-73	0
10-17-74	7.4
10-28-75	8.73
07-21-76	10.6
08-23-76	10.8
02-13-78	7.3
01-16-80	6.5
04-07-81	7.5
01-27-82	7.7
09-13-83	6.7
04-23-84	4.7
10-02-85	8
03-30-87	9.3
05-05-87	9
07-07-87	8.9
08-10-87	8.4
09-08-87	8.7
10-19-87	9
11-09-87	9.3
12-08-87	9
01-19-88	9.6
02-08-88	10.4
03-07-88	9.7
04-04-88	9.6
05-09-88	9.8
06-06-88	10.2
07-18-88	10.9
08-08-88	11.5
09-13-88	10.6

Analyses performed by the South Dakota Department of Health, Pierre, South Dakota.

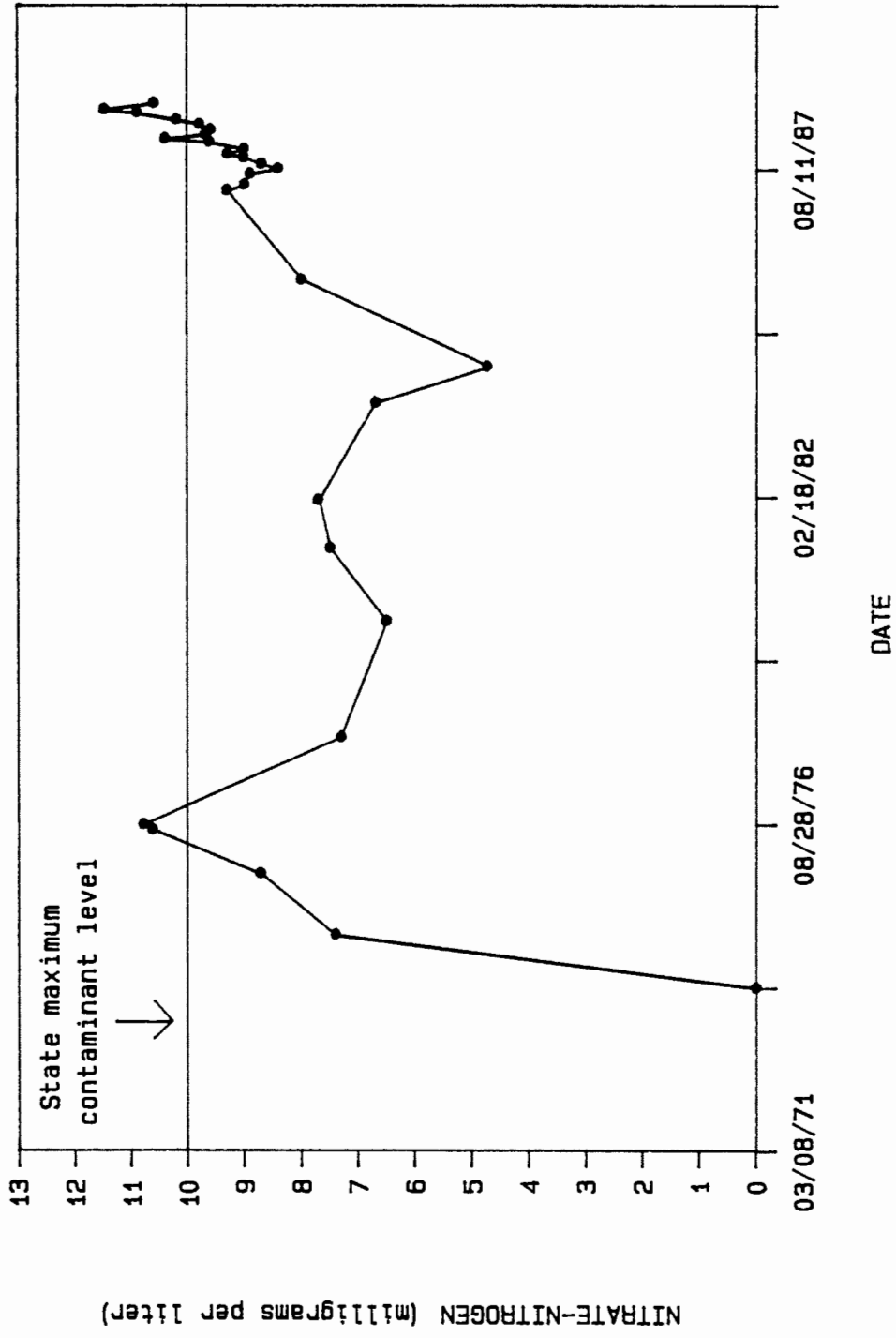


Figure 3. Nitrate-nitrogen concentrations in the Aurora municipal well.

concentrations in the municipal water supply fluctuate, they have generally increased from 1984 to the present. The city of Aurora continues to use water from this municipal well.

METHODS AND PROCEDURES

Drilling and Well Installation

Drilling occurred during two periods: from June 6, 1988, through June 21, 1988, and from November 21, 1988, through November 22, 1988. Drilling was performed using the mud rotary and hollow stem auger drilling methods. The drill bit diameter was 4 3/4 inches on the mud rotary drilling rig and 13 1/2 inches on the hollow stem auger rig. Fourteen test holes were drilled for this investigation; map locations (ML) 1, 2, 3, 4, 9, 10, 12, 14, 16, 17, 18, 19, 20, and 21, fig. 2, app. A). Ten of these holes were completed as observation wells (ML 4, 9, 10, 12, 14, 16, 17, 19, 20, and 21). Six wells were completed in the surficial Big Sioux aquifer (ML 9, 10, 12, 16, 19, and 21) and four were completed in an unnamed (Pleistocene Series) buried outwash (ML 4, 14, 17, and 20). Geophysical logs are available, at the SDGS, for three test holes drilled into the buried outwash (ML 3, 18, and 20) and include the parameters single-point resistivity and natural gamma (app. A).

Observation wells were constructed using 2-inch diameter, schedule 80, threaded, polyvinyl chloride (PVC) casing and screen. Data on screen length and well depth are presented in appendix A. Filter pack, (Grand Island sand, a well sorted, coarse sand), was placed around the outside of the screen up to at least 2 feet above the top of the screen. Bentonite grout was then pumped into the remaining annular space (from the bottom up to land surface) around the outside of the casing. At a later date, an upper portion of the annular space was filled with cement grout and finally topped with soil. These data are on file at the SDGS.

Of the six observation wells installed for this investigation in the Big Sioux aquifer, three wells (ML 16, 19, and 21) were screened within 5 feet of the bottom of the aquifer and had screen tops positioned greater than 11 feet below the water table, and three wells (ML 9, 10, and 12) had screens which intersected the water table. The importance of the positioning of the screens will be discussed later.

Surveying

Casing-top elevations of seven observation wells, and land-surface next to these wells, were surveyed to the nearest 0.01 foot. The bench mark used as a datum was a U.S. Coast and Geodetic Survey bench mark located in NE 1/4 NE 1/4 SE 1/4 SE 1/4 section 34, T. 110 N., R. 49 W. The bench mark is stamped "UU 95 1934" and has an elevation of 1,624.485 feet above mean sea level.

Water-Level Measurements

The depth to water in the observation wells was measured on three occasions (table 2) to the nearest 0.01 foot. Measurements were made using a fiber glass tape measure with a concave-shaped device on the end which makes an audible sound upon impact with the water.

Table 2. Water levels in observation wells

Map Loca- tion No. ¹	Location ²	Well ID Number	Aquifer ³	Casing Top Elevation ⁴	Depth to water and date of measurements ⁵		
					06-22-88	09-21-88	11-22-88
4	109N-49W-03ADAA	CO-88-15	Buried	1621.73 I	9.18	10.30	----
5	109N-49W-04AAAA	BK-7-79	Big Sioux	1616.60 T	----	8.52	----
6	109N-49W-05BBBB	BK-6-79	Big Sioux	1610.40 T	----	10.10	----
7	109N-49W-08BBBB	R1-87-69	Big Sioux	1603.00 T	----	8.24	----
8	110N-48W-31BBBB	BG-77I	Big Sioux	1654.10 T	----	25.96	----
9	110N-49W-26CCCC1	R20-88-65	Big Sioux	1635.50 T	----	----	13.63
10	110N-49W-27DCCC	R20-88-64	Big Sioux	1634.50 T	----	----	15.34
11	110N-49W-29AAAA	BG-79D	Big Sioux	1626.20 T	----	9.83	----
12	110N-49W-33AAAA1	R20-88-66	Big Sioux	1634.50 T	----	----	20.96
13	110N-49W-33CCCC	BG-77R	Big Sioux	1611.40 T	----	8.25	----
14	110N-49W-34DDBC	CO-88-09	Buried	1624.22 I	10.84	11.46	----
15	110N-49W-35BBBB	R2-85-61	Buried	1637.00 T	----	16.89	----
16	110N-49W-35BCCB	CO-88-18	Big Sioux	1631.62 I	11.93	13.64	----
17	110N-49W-35BCCB1	CO-88-19	Buried	1631.62 I	12.01	14.82	----
19	110N-49W-35CBCC1	CO-88-17	Big Sioux	1621.56 I	5.82	6.03	----
20	110N-49W-35CCAA	CO-88-13	Buried	1630.32 I	14.08	10.93	----
21	110N-49W-35CCAA1	CO-88-14	Big Sioux	1630.22 I	11.46	12.84	----
22	110N-49W-36DDDD	BG-77J	Big Sioux	1629.90 T	----	8.27	----

¹ Map-Location Number - corresponds to number on figure 2 and in appendix A.

² See appendix A for explanation of location format.

³ Big Sioux = Big Sioux aquifer; buried = an unnamed buried outwash in the study area.

⁴ Presented in feet above mean sea level; T = the estimated ground-surface elevation from a topographic map plus the length of casing extending above ground surface; I = elevation surveyed with instrument. (See logs in appendix A.)

⁵ All water levels are presented in feet below top of casing.

Well Development and Water Sampling

All observation wells were developed by pumping with compressed air. A minimum of 70 well volumes of water was removed from each well during this process.

All water samples from observation wells were collected with a bladder pump or, when that was not possible, with a bailer. A minimum of three well volumes of water were evacuated before a sample was collected. Water samples were collected from the 10 observation wells installed for this investigation, four observation wells controlled by the Division of Water Rights, four observation wells drilled previously by the SDGS for other studies, and 14 private wells. Water-quality analyses (table 3) were performed by the South Dakota Geological Survey.

HYDROGEOLOGIC SETTING

General Geology

The study area is underlain by Pleistocene drift (Barari, 1968; Tomhave, 1988). The drift is composed of till and outwash, both of which are present in the study area. Till consists of a heterogeneous mixture of boulders, gravel, sand, clay, and silt. The till matrix is composed predominantly of clay and silt. Outwash consists primarily of sand and gravel that has been washed, sorted, and deposited by flowing meltwater. Varying amounts of less permeable materials, silt and clay, may be dispersed throughout the outwash matrix. One particular outwash, named the Big Sioux aquifer, is the source of water for the city of Aurora. The top of the deeper, buried outwash is found approximately 20 to 92 feet below the bottom of the Big Sioux aquifer. Separating the outwash units is a clayey till unit which is weathered in some locations and unweathered in others (see app. A for site specific lithologic descriptions).

Big Sioux Aquifer

The Big Sioux aquifer (fig. 2) is an unconfined, surficial aquifer composed of sand and gravel (outwash). The predominant grain size of the aquifer material ranges from very coarse sand to very coarse gravel. Ground-water recharge in the Aurora area is thought to be from (1) downward percolation of water from precipitation and excess irrigation, and (2) lateral inflow of water in transient storage (Barari, 1968). Surface water may also infiltrate into the aquifer when surface-water elevations are higher than adjacent ground water elevations. Average depth to water is approximately 12 feet below the ground surface, and ground water flow direction in the study area is generally to the southwest.

RESULTS OF INVESTIGATION

Buried Outwash

Two cross sections, whose locations are shown in figure 2, illustrate the spatial distribution of outwash units in the study area (figs. 4 and 5). Of the 10 observation wells installed for this investigation, four were

Table 3. Chemical analyses of water samples

Concentration in milligrams per liter ¹

ML No. ²	Location ²	Well ID No.	Aquifer ³	Date Sampled	Well Depth (ft) ⁴	Conduc-tivity (mmhos) ⁵	Concentration in milligrams per liter ¹													Field pH		
							TDS	Hard-ness as CaCO ₃	Fe	Mn	SO ₄	NO ₃ -N	Na	Ca	Mg	K	Cl	F	Alk T		HCO ₃	
---	---	---	---	---	---	---	500 ⁶	---	0.3 ⁶	0.05 ⁶	250 ⁶	10	---	---	---	---	250 ⁶	2.4 ⁷	---	---	---	
4	109N-49W-03ADAA	CO-88-15	Buried	06-16-88	114.7	1022	668	473	0.05	1.26	230	<0.04	50	122	41	3.1	1	0.47	351	428	7.52	
5	109N-49W-04AAAA	BK-7-79	Big Sioux	09-20-88	26.2	---	---	---	---	---	---	8.42	---	---	---	---	---	---	---	---	---	---
6	109N-49W-05BBBB	BK-6-79	Big Sioux	09-20-88	18.6	---	---	---	---	---	---	<0.04	---	---	---	---	---	---	---	---	---	---
7	109N-49W-08BBBB	R1-87-69	Big Sioux	09-20-88	70.0	---	---	---	---	---	---	<0.04	---	---	---	---	---	---	---	---	---	---
8	110N-48W-31BBBB	BG-77I	Big Sioux	09-20-88	34.3	---	---	---	---	---	---	16.9	---	---	---	---	---	---	---	---	---	---
9	110N-49W-26CCCC1	R20-88-65	Big Sioux	11-22-88	26.7	851	562	417	<0.05	<0.05	97	27.2	21	101	40	7.5	10	0.34	260	317	7.52	
10	110N-49W-27DCCC	R20-88-64	Big Sioux	11-22-88	28.4	658	426	342	<0.05	<0.05	64	14.9	8	81	34	1.9	6	0.26	238	290	7.70	
11	110N-49W-29AAAA	BG-79D	Big Sioux	09-21-88	36.7	---	---	---	---	---	---	<0.04	---	---	---	---	---	---	---	---	---	---
12	110N-49W-33AAAA1	R20-88-66	Big Sioux	11-22-88	30.0	722	466	365	<0.05	<0.05	43	25.5	9.2	85	37	2.5	8	0.24	242	295	7.64	
13	110N-49W-33CCCC	BG-77R	Big Sioux	09-20-88	18.5	---	---	---	---	---	---	<0.04	---	---	---	---	---	---	---	---	---	---
14	110N-49W-34DDBC	CO-88-09	Buried	06-14-88	115.9	2285	1765	1130	4.46	0.94	918	0.04	119	296	95	7.5	4	0.30	496	605	7.42	
15	110N-49W-35BBBB	R2-85-61	Buried	06-14-88	118.0	961	588	454	1.13	0.69	179	<0.04	47	116	40	3.3	2	0.32	381	464	7.59	
16	110N-49W-35BCCB	CO-88-18	Big Sioux	06-22-88	53.4	780	482	365	<0.05	<0.05	67	15.2	23	85	37	2.2	10	0.31	285	347	7.61	
16	110N-49W-35BCCB	CO-88-18	Big Sioux	09-21-88	53.4	---	---	---	---	---	---	15.1	---	---	---	---	---	---	---	---	---	---
17	110N-49W-35BCCB1	CO-88-19	Buried	06-22-88	112.5	970	604	431	0.28	0.72	172	0.17	48	110	38	3.6	2	0.23	374	456	7.68	
19	110N-49W-35CBCC1	CO-88-17	Big Sioux	06-21-88	38.6	790	496	346	<0.05	<0.05	141	7.76	38	81	35	2.5	4	0.33	268	327	7.39	
20	110N-49W-35CCAA	CO-88-13	Buried	06-15-88	109.7	2523	2090	1276	1.06	1.63	1210	0.06	154	333	108	9.4	4	0.42	390	475	7.35	
21	110N-49W-35CCAA1	CO-88-14	Big Sioux	06-15-88	34.6	703	454	337	<0.05	<0.05	76	12.5	18	84	31	1.5	2	0.26	249	304	7.60	
22	110N-49W-36DDDD	BG-77J	Big Sioux	09-20-88	45.4	---	---	---	---	---	---	<0.04	---	---	---	---	---	---	---	---	---	---
	109N-49W-03BBAB	Private	Big Sioux	06-21-88	22.2	696	397	358	<0.05	<0.05	62	10.9	13	84	36	1.6	5	0.27	273	333	7.71	
	109N-49W-05CCCD	Private	Big Sioux	09-13-88	14.0	---	---	---	---	---	---	<0.04	---	---	---	---	---	---	---	---	---	---
	109N-49W-09AABA	Private	Big Sioux	09-13-88	32.0	---	---	---	---	---	---	19.8	---	---	---	---	---	---	---	---	---	---
	110N-49W-26CCCD	Private	Big Sioux	09-13-88	20.0	---	---	---	---	---	---	30.1	---	---	---	---	---	---	---	---	---	---
	110N-49W-27CDDD	Private	Big Sioux	06-22-88	31.6	682	429	342	<0.05	<0.05	54	16.3	6.6	86	31	1.3	8	0.22	244	297	7.74	
	110N-49W-28AAAD	Private	Big Sioux	09-13-88	30.0	---	---	---	---	---	---	19.5	---	---	---	---	---	---	---	---	---	---
	110N-49W-28DCCC	Private	Big Sioux	09-13-88	30.0	---	---	---	---	---	---	16.4	---	---	---	---	---	---	---	---	---	---
	110N-49W-32BAAB	Private	Big Sioux	09-20-88	15.0	---	---	---	---	---	---	<0.04	---	---	---	---	---	---	---	---	---	---
	110N-49W-33ABDD	Private	Big Sioux	06-20-88	50.0	683	421	352	<0.05	<0.05	53	14.3	7.4	90	31	1.4	6	0.26	260	317	7.79	
	110N-49W-33CDCCD	Private	Big Sioux	09-13-88	20.0	---	---	---	---	---	---	15.7	---	---	---	---	---	---	---	---	---	---
	110N-49W-33CDCCD1	Private	Big Sioux	09-13-88	20.0	---	---	---	---	---	---	11.9	---	---	---	---	---	---	---	---	---	---
	110N-49W-34CADD	Private	Big Sioux	06-21-88	58.0	723	442	370	<0.05	<0.05	129	6.49	18	87	37	1.7	5	0.23	249	304	7.60	
	110N-49W-35CCDB	Private	Big Sioux	06-15-88	10.2	648	396	323	<0.05	<0.05	44	9.87	8.9	83	28	3.5	5	0.30	268	327	7.45	
	110N-49W-36BBCC	Private	Big Sioux	06-22-88	34.2	638	383	306	<0.05	<0.05	26	16.8	9.2	78	27	2.8	5	0.22	246	300	7.77	

¹ TDS - total-dissolved solids; FE - iron; MN - manganese; SO₄ - sulfate; NO₃-N - nitrate-nitrogen; NA - sodium; CA - calcium; MG - magnesium; K - potassium; Cl - chloride; F - Fluoride; Alk T - total alkalinity; HCO₃ - bicarbonate.

² See appendix A for explanation of location format and map-location (ML) number.

³ Big Sioux = Big Sioux aquifer; buried = an unnamed buried outwash in the study area.

⁴ Well depth is presented in feet below top of casing and excludes any blank casing below the screen.

⁵ mmhos - microhos.

⁶ U.S. Environmental Protection Agency recommended maximum limit (U.S. Environmental Protection Agency, 1985b).

⁷ U.S. Environmental Protection Agency enforceable maximum limit (U.S. Environmental Protection Agency, 1985a).

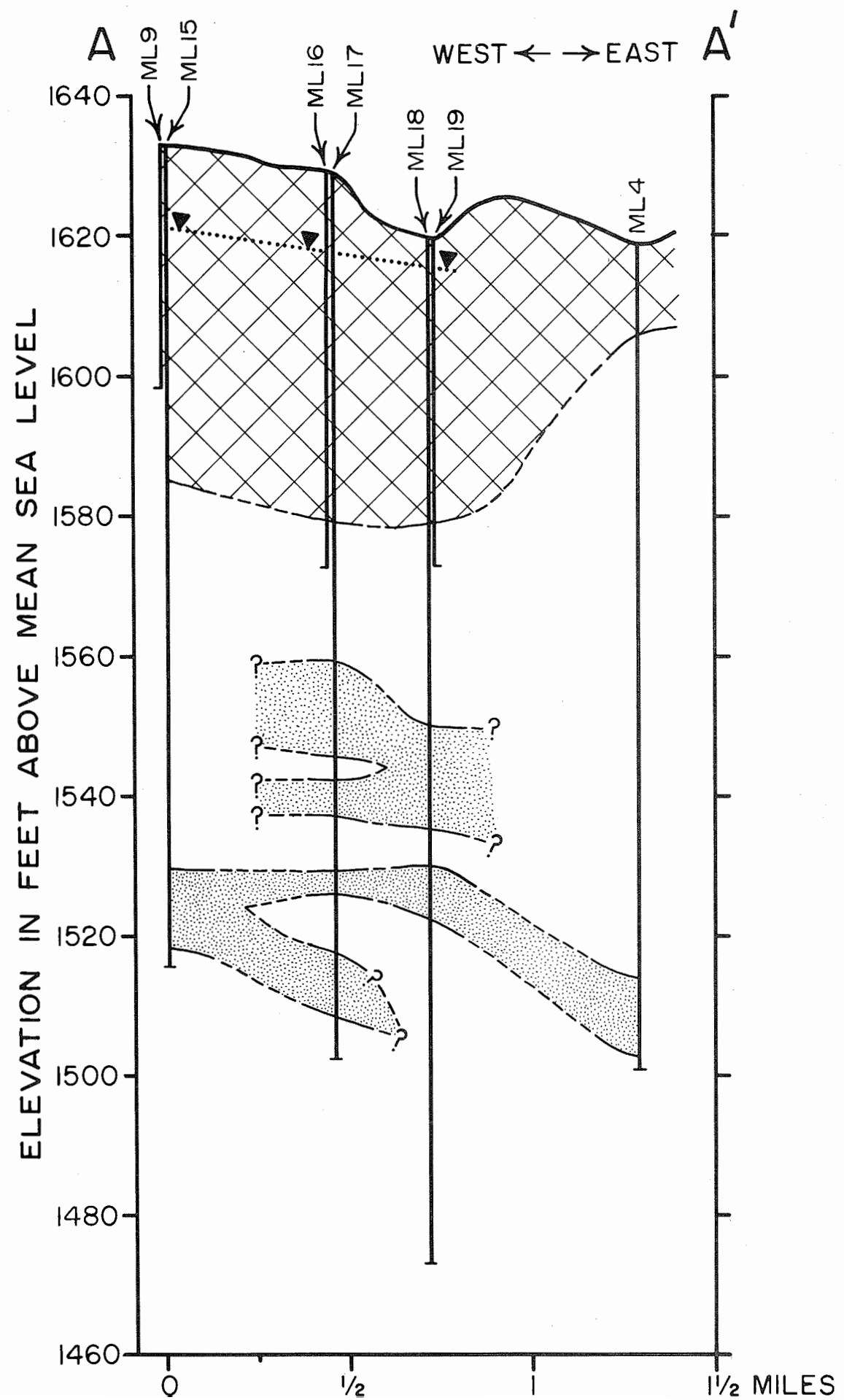






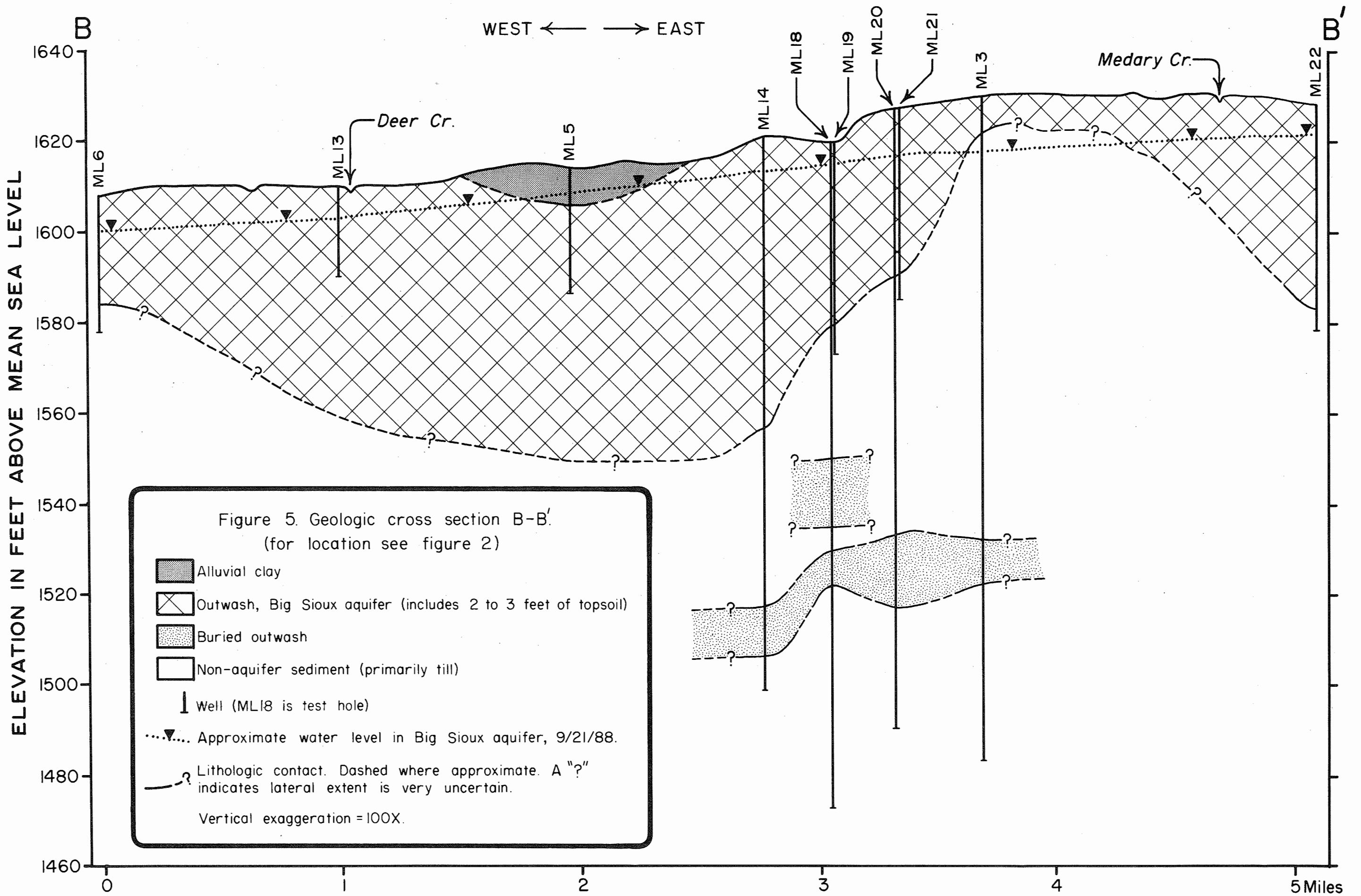


Figure 4. Geologic cross section A-A'
(for location see figure 2)

-  Outwash, Big Sioux aquifer (includes 2 to 3 feet of topsoil)
 -  Buried outwash
 -  Non-aquifer sediment (primarily till)
 -  Well (ML18 is test hole)
 -  Approximate water level in Big Sioux aquifer, 9/21/88, 11/22/88 for ML9.
 -  Lithologic contact. Dashed where approximate. A "?" indicates lateral extent is very uncertain.
- Vertical exaggeration = 100X.



drilled into a buried, confined outwash unit (ML 4, 14, 17, and 20). Data were also gathered from one observation well previously installed in buried outwash (ML 15).

The top of the buried outwash ranges approximately from 70 to 105 feet below the ground surface and 20 to 90 feet below the bottom of the Big Sioux aquifer, and consists predominantly of medium size gravel. The average static water level, in the observation wells installed in the buried outwash, is approximately 12 feet below land surface and the direction of ground-water flow is generally to the southwest. All five observation wells installed in the buried outwash are completed in the same outwash unit. Figures 4 and 5 illustrate that buried outwash occurs throughout the study area, however, additional drilling is necessary to determine the areal extent of this outwash.

Water produced from the wells mentioned above is generally of varying quality (table 3, figs. 6 and 7). Figure 6 illustrates that the total dissolved solids content varies from 588 mg/L (ML 15) to 2,090 mg/L (ML 20) and the hardness concentration varies from 431 mg/L (ML 17) to 1,276 mg/L (ML 20). Iron and manganese concentrations also vary throughout the outwash. Figure 7, illustrates that iron concentrations vary from 0.05 mg/L (ML 4) to 4.46 mg/L (ML 14) and manganese concentrations vary from 0.69 mg/L (ML 15) to 1.63 mg/L (ML 20). Sulfate concentrations are also variable (table 3) and range from 172 mg/L (ML 17) to 1,210 mg/L (ML 20). Because of the variable water quality in this outwash and the unknown areal extent, the buried outwash was not considered as a potential source of municipal water for the city of Aurora.

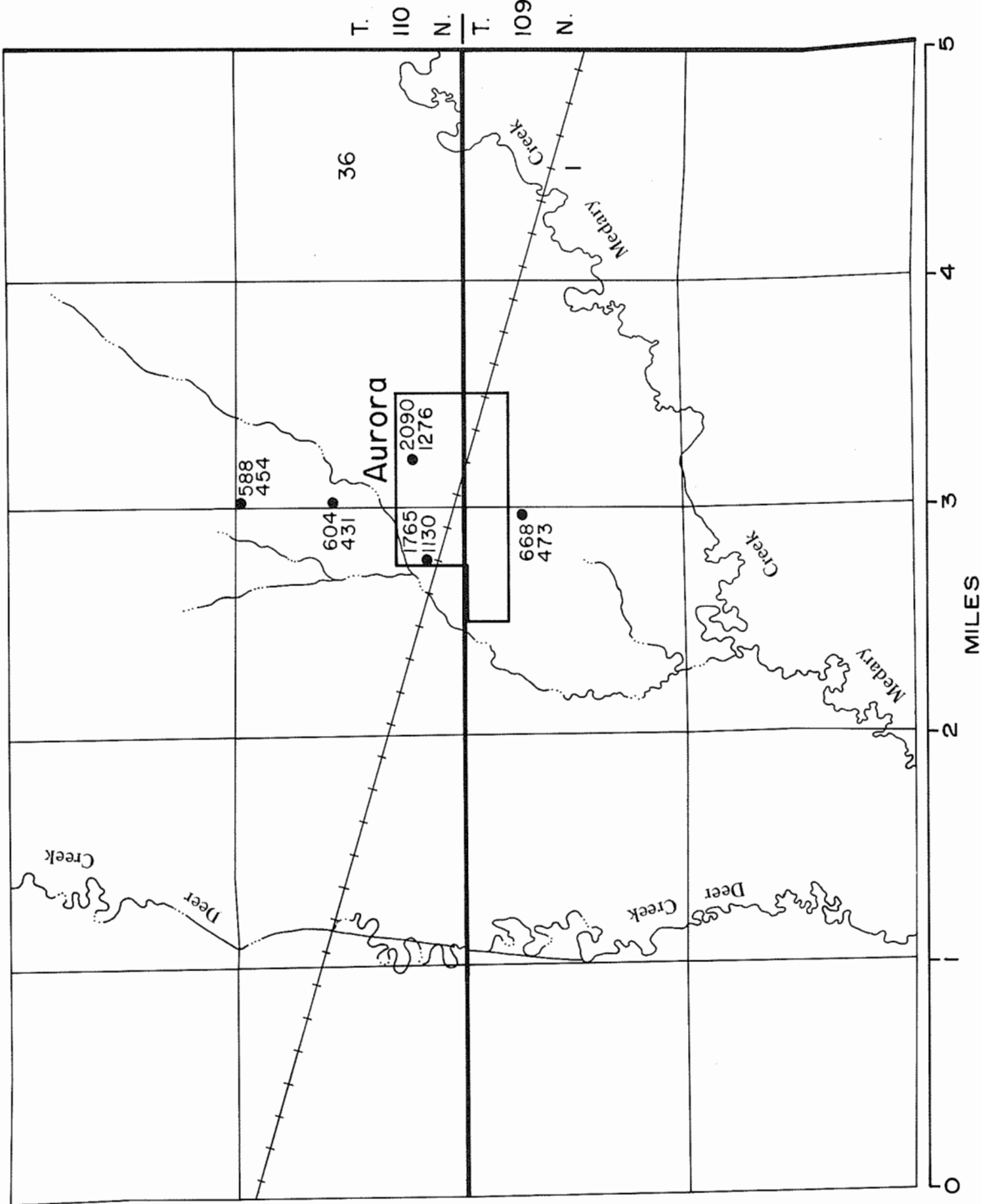
Big Sioux Aquifer

The Big Sioux aquifer underlies the entire area around Aurora except in the southeast corner of the study area where the aquifer is absent (fig. 2). In the Aurora area, the top of the Big Sioux aquifer is generally within 3 feet of the land surface and lies directly below the soil profile. The saturated thickness of the Big Sioux aquifer in the Aurora area varies from approximately 16 feet (ML 6) to 70 feet (ML 7).

Holm and others (1986) found that nitrate concentrations will tend to decrease with depth. This means that observed nitrate concentrations may be higher in wells which were screened at the water table. Of the six observation wells installed in the Big Sioux aquifer for this investigation, three wells (ML 16, 19, and 21) were screened within 5 feet of the bottom of the aquifer and had screen tops positioned greater than 11 feet below the water table, and three wells (ML 9, 10, and 12) had screens which intersected the water table. Table 3 shows elevated nitrate concentrations in all six of the wells, with the highest concentrations generally found in those wells having screens which intersect the water table. However, the fact that nitrate concentrations are found to be high at the water table and below the water table near the bottom of the aquifer suggests that nitrate contamination is not limited solely to the upper portion of the aquifer.

This investigation found high nitrate concentrations in the Big Sioux aquifer in the vicinity of Aurora (fig. 8 and table 4). As shown in figure 8, 13 wells are observation wells, 14 are private wells, and one is the Aurora municipal well. Six of the 13 observation wells (46 percent) exceed the drinking water standard of 10 mg/L for nitrate-nitrogen, and eight of the 13 observation wells sampled (62 percent) have nitrate-nitrogen concentrations greater than 5 mg/L. Of the 14 private wells sampled, 10 (71 percent) exceed the drinking water standard of 10 mg/L, and 12 (86 percent) have nitrate-nitrogen concentrations greater than

R. 49 W. R. 48 W.



● 2090
● 1276

Observation well. Upper number is concentration of total-dissolved solids and lower number is hardness, in milligrams per liter.

Figure 6. Distribution of total-dissolved solids and hardness in the buried outwash.

R. 49 W. | R. 48 W.

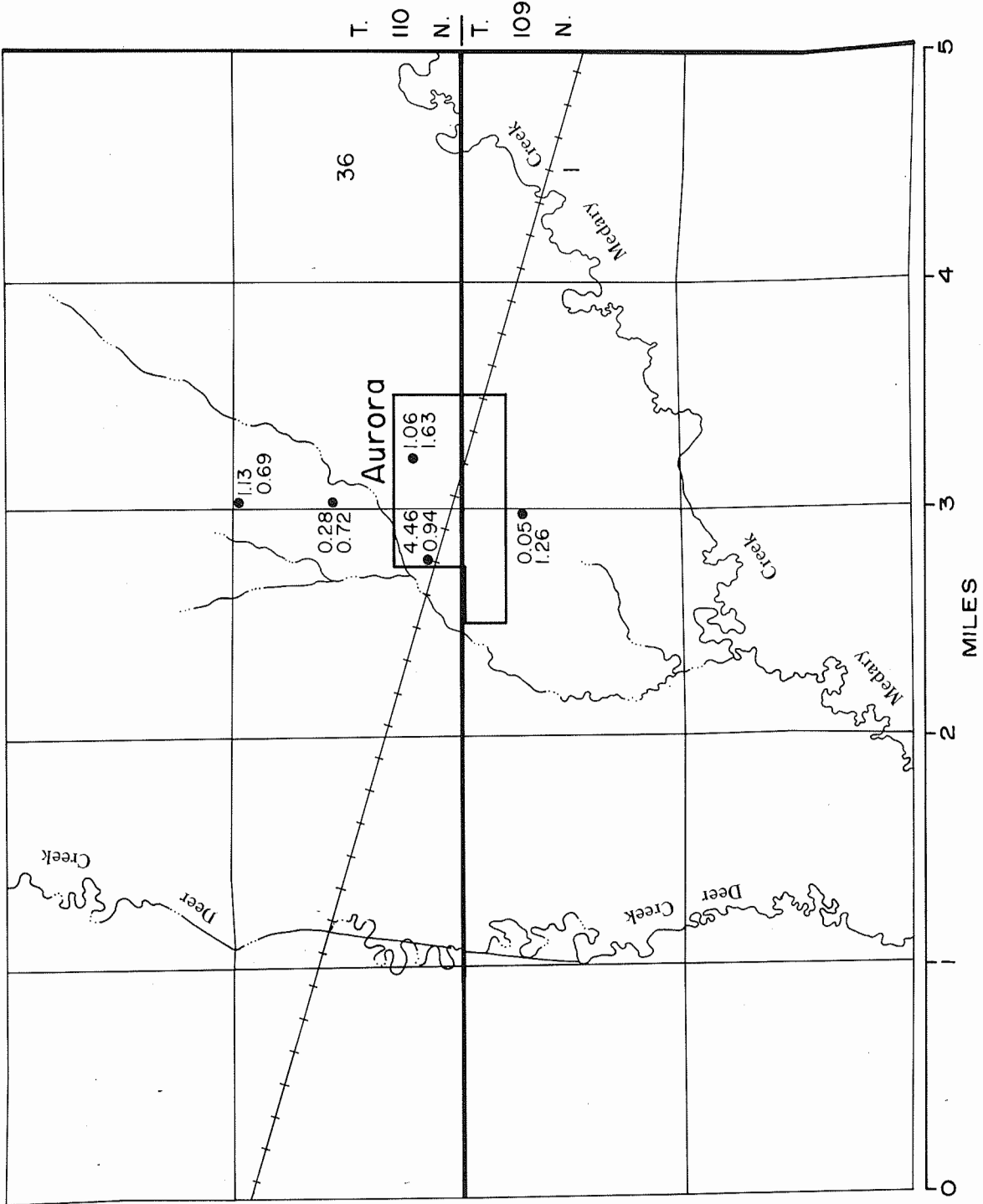
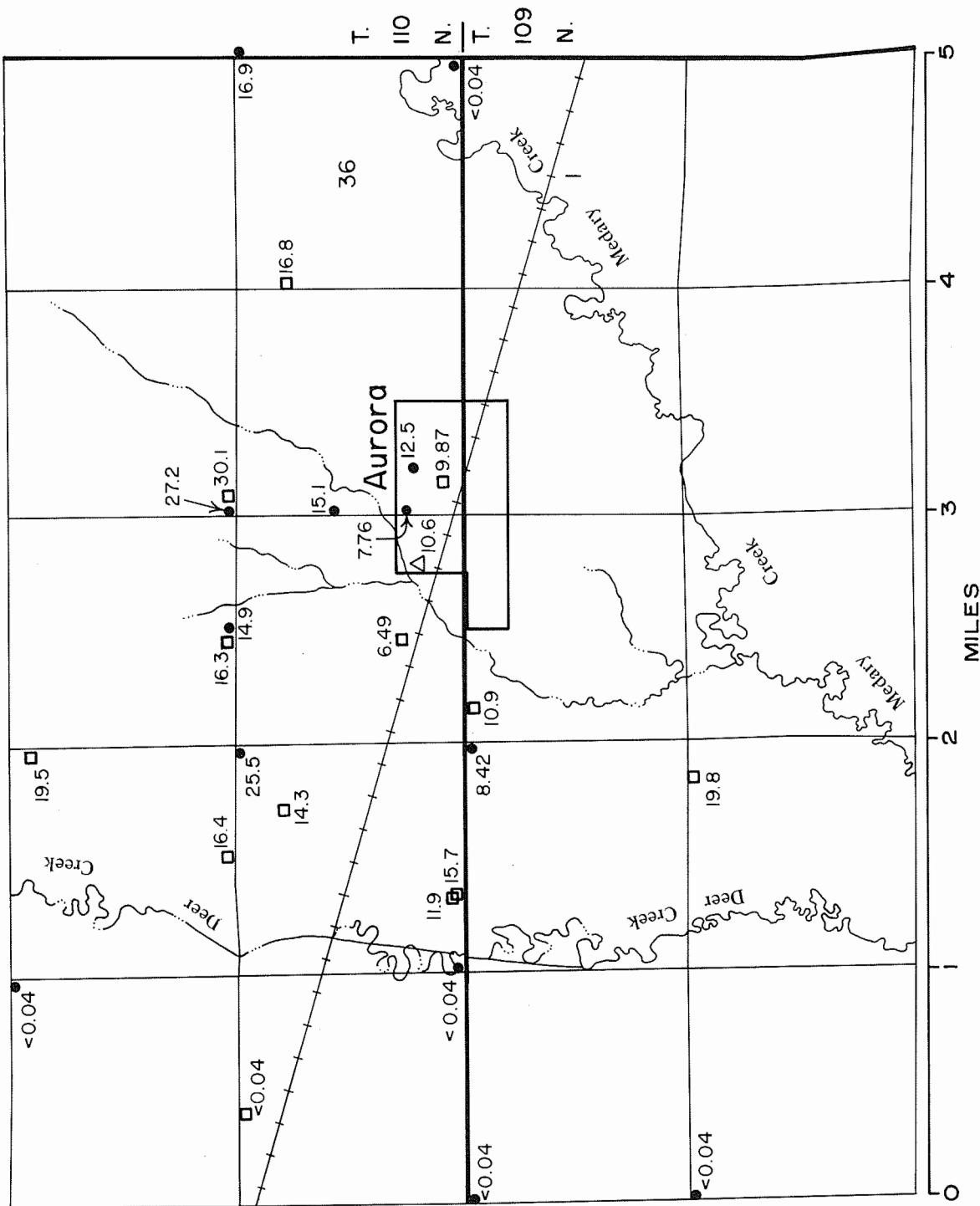


Figure 7. Distribution of iron and manganese concentrations in the buried outwash.

R. 49 W. R. 48 W.



● 12.5
Observation well

□ 16.8
Private well

△ 10.6
Municipal well

Numbers are concentrations
of nitrate-nitrogen, in
milligrams per liter.

Figure 8. Nitrate-nitrogen concentrations in the Big Sioux aquifer.

Table 4. Nitrate-nitrogen concentrations in the Big Sioux aquifer, Aurora area

ML Number ¹	Location ¹	Well Depth (feet) ²	Nitrate-Nitrogen (mg/L) ³
Private	109N-49W-03BBAB	22.2	10.9
5	109N-49W-04AAAA	26.2	8.42
6	109N-49W-05BBBB	18.6	<0.04
Private	109N-49W-05CCCD	14.0	<0.04
7	109N-49W-08BBBB	70.0	<0.04
Private	109N-49W-09AABA	32.0	19.8
8	110N-48W-31BBBB	34.3	16.9
9	110N-49W-26CCCC1	26.7	27.2
Private	110N-49W-26CCCD	20.0	30.1
Private	110N-49W-27CDDD	31.6	16.3
10	110N-49W-27DCCC	28.4	14.9
Private	110N-49W-28AAAD	30.0	19.5
Private	110N-49W-28DCCC	30.0	16.4
11	110N-49W-29AAAA	36.7	<0.04
Private	110N-49W-32BAAB	15.0	<0.04
12	110N-49W-33AAAA1	30.0	25.5
Private	110N-49W-33ABDD	50.0	14.3
13	110N-49W-33CCCC	18.5	<0.04
Private	110N-49W-33CDCD	20.0	15.7
Private	110N-49W-33CDCD	20.0	11.9
Private	110N-49W-34CADD	58.0	6.49
City	110N-49W-34DDBB	66.0	10.6
16	110N-49W-35BCCB	53.4	15.1
19	110N-49W-35CBCC1	38.6	7.76
21	110N-49W-35CCAA1	34.6	12.5
Private	110N-49W-35CCDB	10.2	9.87
Private	110N-49W-36BBCC	34.2	16.8
22	110N-49W-36DDDD	45.4	<0.04

¹ See appendix A for explanation of location format and map-location (ML) number. Private = sample collected from private well; City = sample from Aurora municipal well.

² Well depth is presented in feet below top of casing and excludes any blank casing below the screen.

³ mg/L - milligrams per liter.

5 mg/L. The Aurora municipal well has had nitrate-nitrogen concentrations above 10 mg/L since June, 1988, and with one exception, consistently above 5 mg/L since 1974.

Figure 8 shows high nitrate concentrations in the Big Sioux aquifer near the city of Aurora. It is likely that point-source pollution, such as the previously mentioned Aurora sewage lagoon, is a factor in some wells in the Aurora area but due to the large areal extent of nitrate contamination (fig. 8), non-point-source pollution must also be considered and examined.

CONCLUSIONS AND RECOMMENDATIONS

Much of the Big Sioux aquifer near the city of Aurora contains nitrate in excess of drinking water standards. Currently, it is not possible to recommend a location for a municipal well in the Big Sioux aquifer, near the city, with the assurance that it will produce water with an acceptable nitrate concentration after prolonged pumping. Before a well site near the city can be recommended it will be necessary to have a better understanding of (1) the extent and severity of the contamination, and (2) the mechanisms of the contaminant transport. Because high nitrate concentrations were found to be extensive in the Big Sioux aquifer in the Aurora area, a more detailed study is needed in order to address the above-mentioned points.

As a result of the high nitrate concentrations found in the Big Sioux aquifer near Aurora, it is recommended that the city use water produced from an area, or aquifer, where nitrate contamination is not a problem. Possible options to improve water quality are to obtain water from (1) the rural-water system nearest the city, or (2) the city of Brookings, and (3) to drill a well at some location where nitrate is not a problem. Before the last option is implemented, additional testing is required.

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- 1985b, *National secondary drinking water regulations - secondary maximum contaminant levels*: Code of Federal Regulations, Title 40, Part 143, Section 143.3, p. 584.

APPENDIX A

Logs of test holes and observation 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 listed on figure 2.

LEGAL LOCATION and LOCATION

The logs are listed by smallest township number, then the smallest range number, the smallest section number, and then by quarter section: NE = A; NW = B; SW = C; SE = D. A comparison of **Legal Location and Location** is as follows. A **Legal Location** of SW 1/4 NW 1/4 SE 1/4 SE 1/4 sec. 34, T. 110 N., R. 49 W., is the same as a **Location** of 110N-49W-34DDBC. In several **Locations**, the smallest quarter section is followed by the number 1 or 2 which indicates that more than one log may exist for that particular location.

LATITUDE and LONGITUDE

The format is DD.MMSS where D is degrees, M is minutes, and S is seconds.

DRILLING COMPANY

SDGS is an abbreviation for South Dakota Geological Survey.

TOTAL DRILL HOLE DEPTH, SCREEN LENGTH, TOTAL CASING AND SCREEN, and CASING STICK-UP

The numbers are presented in feet.

SCREEN TYPE and CASING TYPE

PVC is an abbreviation for polyvinyl chloride. MFG. is an abbreviation for manufactured and indicates a product that is commercially available. HM. is an abbreviation for homemade and indicates a hacksaw-slotted casing.

CASING DIAMETER

The numbers are presented in inches.

CASING TOP ELEVATION and GROUND SURFACE ELEVATION

The numbers are presented in feet above mean sea level. I - the elevation was determined using a surveying instrument. T - the elevation was estimated from 7½ minute series topographic map.

County: BROOKINGS
Map Location: 1
Legal Location: NW NW NW NE SEC. 02, T. 109 N., R. 49 W.
Latitude: 44.1656
Land Owner:
Project: AURORA CITY STUDY-1988
Drilling Company: SDGS
Driller: D. JACOBSON
Geologist: P. DAWSON
Date Drilled: 06-07-1988
Ground Surface Elevation: 1630.00 T
Total Drill Hole Depth: 67.0
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Location: 109N-49W-02ABBB
Longitude: 96.4037

Driller's Log:
Geologist's Log: X
Drilling Method: ROTARY
Test Hole Number: CO-88-10

Single Point Resistivity:
Extra:

ABANDONED HOLE DUE TO RIG BREAKDOWN, LOST 10 FEET
OF DRILL STEM IN HOLE (ONE DRILL STEM PLUS BIT).

0 - 2.0 TOPSOIL, BLACK
2.0 - 10.0 GRAVEL, MEDIUM TO VERY COARSE PEBBLE
GRAVEL; OXIDIZED
10.0 - 25.0 CLAY, LIGHT-BROWN, SANDY, PEBBLY (TILL)
25.0 - 47.0 CLAY, LIGHT-GRAY, VERY CLAYEY; STICKY
(TILL)
47.0 - 67.0 CLAY, LIGHT-BROWN, VERY CLAYEY, PEBBLY;
STICKY (TILL)

* * * * *

County: BROOKINGS
Map Location: 2
Legal Location: NW NW NW NE SEC. 02, T. 109 N., R. 49 W.
Latitude: 44.1656
Land Owner:
Project: AURORA CITY STUDY-1988
Drilling Company: SDGS
Driller: D. JACOBSON
Geologist: P. DAWSON
Date Drilled: 06-07-1988
Ground Surface Elevation: 1630.00 T
Total Drill Hole Depth: 117.0
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Location: 109N-49W-02ABBB 1
Longitude: 96.4037

Driller's Log:
Geologist's Log: X
Drilling Method: ROTARY
Test Hole Number: CO-88-11

Single Point Resistivity:
Extra:

ABANDONED HOLE - RIG BREAKDOWN.

0 - 2.0 TOPSOIL, BLACK
2.0 - 7.0 GRAVEL, MEDIUM TO VERY COARSE PEBBLE
GRAVEL; OXIDIZED

7.0 - 27.0 CLAY, LIGHT-BROWN, SANDY, PEBBLY; STICKY
(TILL)
27.0 - 53.0 CLAY, GRAY; VERY STICKY (TILL)
53.0 - 117.0 CLAY, LIGHT-BROWN, PEBBLY; STICKY (TILL)

* * * * *

County: BROOKINGS
Map Location: 3
Legal Location: NW NW NW NE SEC. 02, T. 109 N., R. 49 W.
Latitude: 44.1656
Land Owner:
Project: AURORA CITY STUDY-1988
Drilling Company: SDGS
Driller: D. JACOBSON
Geologist: P. DAWSON
Date Drilled: 06-13-1988
Ground Surface Elevation: 1630.00 T
Total Drill Hole Depth: 147.0
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma: X
Samples:

Location: 109N-49W-02ABBB 2
Longitude: 96.4037
Driller's Log:
Geologist's Log: X
Drilling Method: ROTARY
Test Hole Number: CO-88-12
Single Point Resistivity: X
Extra:

0 - 2.0 TOPSOIL, BLACK
2.0 - 8.0 GRAVEL, MEDIUM TO VERY COARSE PEBBLE
GRAVEL; OXIDIZED
8.0 - 26.0 CLAY, LIGHT-BROWN, PEBBLY; STICKY (TILL)
26.0 - 37.0 CLAY, GRAY; VERY STICKY (TILL)
37.0 - 47.0 CLAY, LIGHT-GRAY; VERY STICKY (TILL)
47.0 - 60.0 CLAY, LIGHT-BROWN; STICKY (TILL)
60.0 - 62.0 CLAY, BLACK; DRY
62.0 - 98.0 CLAY, LIGHT-BROWN; STICKY (TILL)
98.0 - 108.0 GRAVEL, MEDIUM TO COARSE PEBBLE GRAVEL
108.0 - 147.0 CLAY, TAN, SANDY (TILL)

LITHOLOGIC DESCRIPTION BASED ON ELECTRIC LOG
INTERPRETATION.

* * * * *

County: BROOKINGS
Map Location: 4
Legal Location: NE NE SE NE SEC. 03, T. 109 N., R. 49 W.
Latitude: 44.1643
Land Owner:
Project: AURORA CITY STUDY-1988
Drilling Company: SDGS
Driller: D. JACOBSON
Geologist: P. DAWSON
Date Drilled: 06-15-1988
Ground Surface Elevation: 1619.04 I
Total Drill Hole Depth: 117.0
Water Rights Well:

Location: 109N-49W-03ADAA
Longitude: 96.4116
Driller's Log:
Geologist's Log: X
Drilling Method: ROTARY
Test Hole Number: CO-88-15
SDGS Well Name: CO-88-15

Other Well Name:
Basin: BIG SIOUX
Management Unit:
Screen Type: PVC, MFG.
Casing Type: PVC
Casing Top Elevation: 1621.73 I
Casing Stick-up: 2.69
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma: Extra:
Samples:

Aquifer: PLEISTOCENE SERIES

Screen Length: 5.0
Casing Diameter: 2.0

Total Casing and Screen: 114.7

Single Point Resistivity:

SCREEN FROM 107 TO 112 FEET.

0 - 2.0 TOPSOIL, BLACK
2.0 - 13.0 GRAVEL, MEDIUM TO VERY COARSE PEBBLE
GRAVEL; OXIDIZED
13.0 - 20.0 CLAY, LIGHT-BROWN, PEBBLY; STICKY (TILL)
20.0 - 105.0 CLAY, LIGHT-GRAY; VERY STICKY (TILL)
105.0 - 116.0 GRAVEL, MEDIUM TO COARSE PEBBLE GRAVEL;
OXIDIZED
116.0 - 118.0 CLAY, GRAY, SANDY, PEBBLY (TILL)

* * * * *

County: BROOKINGS
Map Location: 5
Legal Location: NE NE NE NE SEC. 04, T. 109 N., R. 49 W.
Latitude: 44.1656
Land Owner:
Project: BROOKINGS OBS WELLS-1979
Drilling Company: SDGS
Driller:
Geologist: K. CARTER
Date Drilled: 06-13-1979
Ground Surface Elevation: 1614.00 T
Total Drill Hole Depth: 28.0
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit: AURORA
Screen Type: PVC, MFG. AND HM.
Casing Type: PVC
Casing Top Elevation:
Casing Stick-up:
Well Maintenance Date:
USGS Hydrological Unit Code: 10170202
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Location: 109N-49W-04AAAA

Longitude: 96.4229

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

Test Hole Number: BK-7-79
SDGS Well Name: BK-7-79

Aquifer: BIG SIOUX

Screen Length: 8.0
Casing Diameter: 2.0

Total Casing and Screen: 26.2

Single Point Resistivity:
Extra:

DEPTH TO WATER: 6 FEET. CASING SLOTTED 5 FEET

ABOVE A 3-FOOT SANDPOINT.

0 - 1.0 TOPSOIL, BLACK, CLAYEY
1.0 - 8.0 CLAY, BROWN TO GRAY, VERY SANDY
8.0 - 28.0 SAND, FINE, WELL-ROUNDED; TO GRAVEL

* * * *

County: BROOKINGS	Location: 109N-49W-05BBBB
Map Location: 6	
Legal Location: NW NW NW NW SEC. 05, T. 109 N., R. 49 W.	
Latitude: 44.1656	Longitude: 96.4450
Land Owner:	
Project: BROOKINGS OBS WELLS-1979	
Drilling Company: SDGS	
Driller:	Driller's Log:
Geologist: K. CARTER	Geologist's Log: X
Date Drilled: 06-13-1979	Drilling Method: ROTARY
Ground Surface Elevation: 1608.00 T	
Total Drill Hole Depth: 30.0	Test Hole Number: BK-6-79
Water Rights Well:	SDGS Well Name: BK-6-79
Other Well Name:	
Basin: BIG SIOUX	Aquifer: BIG SIOUX
Management Unit: AURORA	
Screen Type: PVC, MFG. AND HM.	Screen Length: 8.0
Casing Type: PVC	Casing Diameter: 2.0
Casing Top Elevation:	
Casing Stick-up:	Total Casing and Screen: 18.6
Well Maintenance Date:	
USGS Hydrological Unit Code: 10170202	
Electric Log Information:	
Spontaneous Potential:	Single Point Resistivity:
Natural Gamma:	Extra:
Samples:	

DEPTH TO WATER: 6.27 FEET. CASING SLOTTED 5 FEET
ABOVE A 3-FOOT SANDPOINT.

0 - 2.0 TOPSOIL, BLACK, VERY GRAVELLY
2.0 - 24.0 SAND, FINE, WELL-ROUNDED; TO MEDIUM
GRAVEL
24.0 - 30.0 CLAY, BROWN TO GRAY, SANDY, SILTY, PEBBLY
(TILL)

* * * *

County: BROOKINGS	Location: 109N-49W-08BBBB
Map Location: 7	
Legal Location: NW NW NW NW SEC. 08, T. 109 N., R. 49 W.	
Latitude: 44.1605	Longitude: 96.4344
Land Owner:	
Project: KINGSBURY-BROOKINGS STUDY	
Drilling Company: SDGS	
Driller: G. JENSEN/L. HELSETH	Driller's Log:
Geologist: L. HAMILTON	Geologist's Log: X

Date Drilled: 08-26-1987
Ground Surface Elevation: 1600.00 T
Total Drill Hole Depth: 95.0
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit: AURORA
Screen Type: PVC, MFG.
Casing Type: PVC
Casing Top Elevation: 1603.00 T
Casing Stick-up: 3.00
Well Maintenance Date:
USGS Hydrological Unit Code: 10170202
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Drilling Method: ROTARY
Test Hole Number: R1-87-69
SDGS Well Name: R1-87-69
Aquifer: BIG SIOUX
Screen Length: 5.0
Casing Diameter: 2.0
Total Casing and Screen: 70.0
Single Point Resistivity:
Extra:

LOG WRITTEN BY J.D. LEHR FROM DRILLER'S AND
HAMILTON'S LOGS.

0 - 4.0 CLAY, GRAY (TOPSOIL)
4.0 - 75.0 SAND AND GRAVEL, GRAYISH-BROWN, FINE TO
VERY COARSE SAND, VERY FINE TO MEDIUM
PEBBLE GRAVEL
75.0 - 95.0 CLAY, GRAY, SILTY, SANDY, PEBBLY (TILL)

* * * *

County: BROOKINGS
Map Location: 8
Legal Location: NW NW NW NW SEC. 31, T. 110 N., R. 48 W.
Latitude: 44.1746
Land Owner:
Project: USGS
Drilling Company: HURON DRILLING
Driller:
Geologist: J. GOODMAN
Date Drilled: 08-11-1977
Ground Surface Elevation: 1651.00 T
Total Drill Hole Depth: 50.0
Water Rights Well: BG-77I
Other Well Name:
Basin: BIG SIOUX
Management Unit: AURORA
Screen Type: PVC
Casing Type: PVC
Casing Top Elevation:
Casing Stick-up: 3.10
Well Maintenance Date: 06-23-1982
USGS Hydrological Unit Code: 10170202
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Location: 110N-48W-31BBBB
Longitude: 96.3846
Driller's Log:
Geologist's Log: X
Drilling Method: ROTARY
Test Hole Number:
SDGS Well Name:
Aquifer: BIG SIOUX
Screen Length: 5.0
Casing Diameter: 2.0
Total Casing and Screen: 34.3
Single Point Resistivity:
Extra:

0 - 1.0 TOPSOIL, BLACK
 1.0 - 9.0 SAND AND GRAVEL, BROWN, MEDIUM TO COARSE
 9.0 - 15.0 CLAY, YELLOW-BROWN, SILTY, PEBBLY (TILL)
 15.0 - 45.0 SAND AND GRAVEL, BROWN TO GRAY, MEDIUM
 TO COARSE
 45.0 - 50.0 CLAY, GRAY, SILTY, PEBBLY (TILL)

* * * * *

County: BROOKINGS
 Map Location: 9
 Legal Location: SW SW SW SW SEC. 26, T. 110 N., R. 49 W.
 Latitude: 44.1748
 Land Owner:
 Project: AURORA CITY STUDY-1988
 Drilling Company: SDGS
 Driller: D. IVERSON
 Geologist: K. WILKIE/P. DAWSON
 Date Drilled: 11-21-1988
 Ground Surface Elevation: 1633.00 T
 Total Drill Hole Depth: 35.0
 Water Rights Well
 Other Well Name:
 Basin: BIG SIOUX
 Management Unit: AURORA
 Screen Type: PVC, MFG.
 Casing Type: PVC
 Casing Top Elevation: 1635.50 T
 Casing Stick-up: 2.67
 Well Maintenance Date:
 USGS Hydrological Unit Code: 10170203
 Electric Log Information:
 Spontaneous Potential:
 Natural Gamma:
 Samples:

Location: 110N-49W-26CCCC 1
 Longitude: 96.4113
 Driller's Log:
 Geologist's Log: X
 Drilling Method: HOLLOWSTEM
 Test Hole Number: R20-88-65
 SDGS Well Name: R20-88-65
 Aquifer: BIG SIOUX
 Screen Length: 15.0
 Casing Diameter: 2.0
 Total Casing and Screen: 36.7
 Single Point Resistivity:
 Extra:

10 FEET OF BLANK CASING (OPEN TO SCREEN) FROM 34
 TO 24 FEET, SCREEN FROM 24 TO 9 FEET. WATER
 LEVEL IS 11 FEET BELOW GROUND SURFACE.

0 - 1.0 TOPSOIL, BLACK
 1.0 - 2.0 CLAY, YELLOW-BROWN
 2.0 - 4.0 SAND, FINE TO MEDIUM
 4.0 - 35.0 GRAVEL, MEDIUM TO VERY COARSE PEBBLE
 GRAVEL; SATURATED AT 14 FEET

* * * * *

County: BROOKINGS
 Map Location: 10
 Legal Location: SW SW SW SE SEC. 27, T. 110 N., R. 49 W.
 Latitude: 44.1747
 Land Owner:
 Project: AURORA CITY STUDY-1988

Location: 110N-49W-27DCCC
 Longitude: 96.4148

Drilling Company: SDGS
Driller: D. IVERSON
Geologist: K. WILKIE/P. DAWSON
Date Drilled: 11-21-1988
Ground Surface Elevation: 1632.00 T
Total Drill Hole Depth: 40.0
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit: AURORA
Screen Type: PVC, MFG.
Casing Type: PVC
Casing Top Elevation: 1634.50 T
Casing Stick-up: 2.40
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

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

Test Hole Number: R20-88-64
SDGS Well Name: R20-88-64

Aquifer: BIG SIOUX

Screen Length: 15.0
Casing Diameter: 2.0

Total Casing and Screen: 38.4

Single Point Resistivity:
Extra:

10 FEET OF BLANK CASING (OPEN TO SCREEN) FROM 36
TO 26 FEET, SCREEN FROM 26 TO 11 FEET. WATER
LEVEL IS 13 FEET BELOW GROUND SURFACE.

0 - 1.0 TOPSOIL, BLACK
1.0 - 2.0 CLAY, YELLOW-BROWN
2.0 - 40.0 GRAVEL, MEDIUM TO VERY COARSE PEBBLE
GRAVEL; SATURATED AT 15 FEET

* * * *

County: BROOKINGS
Map Location: 11
Legal Location: NE NE NE NE SEC. 29, T. 110 N., R. 49 W.
Latitude: 44.1840
Land Owner:
Project: BROOKINGS CITY STUDY-1979
Drilling Company: SDGS
Driller: T. KENYON
Geologist: K. CARTER
Date Drilled: 06-18-1979
Ground Surface Elevation: 1623.00 T
Total Drill Hole Depth: 50.0
Water Rights Well: BG-79D
Other Well Name:
Basin: BIG SIOUX
Management Unit: AURORA
Screen Type: PVC, MFG.
Casing Type: PVC
Casing Top Elevation:
Casing Stick-up: 3.20
Well Maintenance Date: 06-23-1982
USGS Hydrological Unit Code: 10170202
Electric Log Information:

Location: 110N-49W-29AAAA

Longitude: 96.4343

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

Test Hole Number: BK-11-79
SDGS Well Name:

Aquifer: BIG SIOUX

Screen Length: 8.0
Casing Diameter: 2.0

Total Casing and Screen: 36.7

Spontaneous Potential:
Natural Gamma:
Samples:

Single Point Resistivity:
Extra:

CASING SLOTTED 5 FEET ABOVE A 3-FOOT SANDPOINT.

0 - 1.0 TOPSOIL, BLACK, CLAYEY
1.0 - 18.0 SAND AND GRAVEL; OXIDIZED
18.0 - 28.0 SAND, FINE, SILTY
28.0 - 42.0 SAND AND GRAVEL; UNOXIDIZED
42.0 - 50.0 CLAY, BROWN TO GRAY, SANDY, SILTY, PEBBLY
(TILL)

* * * *

County: BROOKINGS
Map Location: 12
Legal Location: NE NE NE NE SEC. 33, T. 110 N., R. 49 W.
Latitude: 44.1748
Land Owner:
Project: AURORA CITY STUDY-1988
Drilling Company: SDGS
Driller: D. IVERSON
Geologist: K. WILKIE/P. DAWSON
Date Drilled: 11-21-1988
Ground Surface Elevation: 1632.00 T
Total Drill Hole Depth: 45.0
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit: AURORA
Screen Type: PVC, MFG.
Casing Type: PVC
Casing Top Elevation: 1634.50 T
Casing Stick-up: 2.50
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Location: 110N-49W-33AAAA 1

Longitude: 96.4227

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

Test Hole Number: R20-88-66
SDGS Well Name: R20-88-66

Aquifer: BIG SIOUX

Screen Length: 15.0
Casing Diameter: 2.0

Total Casing and Screen: 40.0

Single Point Resistivity:
Extra:

10 FEET OF BLANK CASING (OPEN TO SCREEN) FROM 37
TO 27.5 FEET, SCREEN FROM 27.5 TO 12.5 FEET.
WATER LEVEL IS 18.5 FEET BELOW GROUND SURFACE.

0 - 1.0 TOPSOIL, BLACK
1.0 - 13.0 SAND, MEDIUM
13.0 - 45.0 GRAVEL, MEDIUM TO COARSE PEBBLE GRAVEL;
SATURATED AT 21 FEET

* * * *

County: BROOKINGS
Map Location: 13

Location: 110N-49W-33CCCC

Legal Location: SW SW SW SW SEC. 33, T. 110 N., R. 49 W.
Latitude: 44.1655
Land Owner:
Project: USGS
Drilling Company: HURON DRILLING
Driller: E. LODMEL
Geologist: J. GOODMAN
Date Drilled: 08-11-1977
Ground Surface Elevation: 1610.00 T
Total Drill Hole Depth: 20.0
Water Rights Well: BG-77R
Other Well Name: BGGS-8
Basin: BIG SIOUX
Management Unit: AURORA
Screen Type:
Casing Type: PVC
Casing Top Elevation:
Casing Stick-up:
Well Maintenance Date: 06-23-1982
USGS Hydrological Unit Code: 10170202
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

0 - 1.0 TOPSOIL, BLACK
1.0 - 20.0 SAND AND GRAVEL, COARSE

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County: BROOKINGS
Map Location: 14
Legal Location: SW NW SE SE SEC. 34, T. 110 N., R. 49 W.
Latitude: 44.1704
Land Owner:
Project: AURORA CITY STUDY-1988
Drilling Company: SDGS
Driller: D. JACOBSON
Geologist: P. DAWSON
Date Drilled: 06-07-1988
Ground Surface Elevation: 1621.37 I
Total Drill Hole Depth: 122.0
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit:
Screen Type: PVC, MFG.
Casing Type: PVC
Casing Top Elevation: 1624.22 I
Casing Stick-up: 2.85
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:

Longitude: 96.4338

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

Test Hole Number:
SDGS Well Name:

Aquifer: BIG SIOUX

Screen Length:
Casing Diameter: 1.5

Total Casing and Screen: 18.5

Single Point Resistivity:
Extra:

Location: 110N-49W-34DDBC

Longitude: 96.4133

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

Test Hole Number: CO-88-09
SDGS Well Name: CO-88-09

Aquifer: PLEISTOCENE SERIES

Screen Length: 10.0
Casing Diameter: 2.0

Total Casing and Screen: 122.9

Single Point Resistivity:
Extra:

Samples:

7 FEET OF BLANK CASING (CLOSED TO SCREEN) FROM 120 TO 113 FEET, SCREEN FROM 113 TO 103 FEET.

0 - 2.0 TOPSOIL, BLACK
2.0 - 64.0 GRAVEL, COARSE TO VERY COARSE PEBBLE
GRAVEL; COARSE SAND LAYER FROM 40 TO
50 FEET; HIT ROCK AT 56 FEET; OXIDIZED
64.0 - 104.0 CLAY, GRAY, SANDY, PEBBLY (TILL)
104.0 - 115.0 GRAVEL, MEDIUM TO VERY COARSE PEBBLE
GRAVEL; OXIDIZED
115.0 - 122.0 CLAY, GRAY, SANDY, PEBBLY; CALCAREOUS
(TILL)

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PRELIMINARY LOG -- SUBJECT TO CHANGE

County: BROOKINGS

Location: 110N-49W-35BBBB

Map Location: 15

Legal Location: NW NW NW NW SEC. 35, T. 110 N., R. 49 W.

Latitude: 44.1743

Longitude: 96.4112

Land Owner:

Project: KINGSBURY-BROOKINGS STUDY

Drilling Company: SDGS

Driller: C. SCHMIG

Driller's Log:

Geologist: G. JOHNSON

Geologist's Log: X

Date Drilled: 07-04-1985

Drilling Method: ROTARY

Ground Surface Elevation: 1633.00 T

Total Drill Hole Depth: 118.0

Test Hole Number: R2-85-61

Water Rights Well:

SDGS Well Name: R2-85-61

Other Well Name:

Basin: BIG SIOUX

Aquifer:

Management Unit:

Screen Type: PVC, MFG.

Screen Length: 10.0

Casing Type: PVC

Casing Diameter: 2.0

Casing Top Elevation: 1637.00 T

Casing Stick-up: 4.00

Total Casing and Screen: 118.0

Well Maintenance Date:

USGS Hydrological Unit Code: 10170202

Electric Log Information:

Spontaneous Potential:

Single Point Resistivity:

Natural Gamma:

Extra: X

Samples:

NO E-LOG.

0 - 3.0 CLAY, LIGHT-BROWN, SILTY (TOPSOIL)
3.0 - 48.0 SAND AND GRAVEL, COARSE SAND TO VERY
COARSE PEBBLES
48.0 - 104.0 CLAY, LIGHT-GRAY, SILTY, SANDY, PEBBLY;
CALCAREOUS (TILL)
104.0 - 115.0 SAND AND GRAVEL; COARSEST FRACTION NEAR
BASE OF UNIT

115.0 - 118.0 CLAY, SAME AS INTERVAL FROM 48 TO 104
FEET

DESCRIPTION BASED ON LOGS FROM DRILLER AND FIELD
ASSISTANT (KATHY MARTIN); CUTTINGS EXAMINED
07-15-1985.

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County: BROOKINGS	Location: 110N-49W-35BCCB
Map Location: 16	
Legal Location: NW SW SW NW SEC. 35, T. 110 N., R. 49 W.	
Latitude: 44.1727	Longitude: 96.4113
Land Owner:	
Project: AURORA CITY STUDY-1988	
Drilling Company: SDGS	
Driller: D. JACOBSON	Driller's Log:
Geologist: P. DAWSON	Geologist's Log: X
Date Drilled: 06-21-1988	Drilling Method: ROTARY
Ground Surface Elevation: 1629.10 I	
Total Drill Hole Depth: 57.0	Test Hole Number: CO-88-18
Water Rights Well:	SDGS Well Name: CO-88-18
Other Well Name:	
Basin: BIG SIOUX	Aquifer: BIG SIOUX
Management Unit: AURORA	
Screen Type: PVC, MFG.	Screen Length: 10.0
Casing Type: PVC	Casing Diameter: 2.0
Casing Top Elevation: 1631.62 I	
Casing Stick-up: 2.39	Total Casing and Screen: 53.4
Well Maintenance Date:	
USGS Hydrological Unit Code: 10170203	
Electric Log Information:	
Spontaneous Potential:	Single Point Resistivity:
Natural Gamma:	Extra:
Samples:	

SCREEN FROM 41 TO 51 FEET.

0 - 2.0	TOPSOIL, BLACK
2.0 - 50.0	GRAVEL, MEDIUM PEBBLE GRAVEL FROM 2 TO 30 FEET, COARSE PEBBLE GRAVEL FROM 30 TO 50 FEET; OXIDIZED
50.0 - 57.0	CLAY, GRAY; STICKY (TILL)

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County: BROOKINGS	Location: 110N-49W-35BCCB 1
Map Location: 17	
Legal Location: NW SW SW NW SEC. 35, T. 110 N., R. 49 W.	
Latitude: 44.1727	Longitude: 96.4113
Land Owner:	
Project: AURORA CITY STUDY-1988	
Drilling Company: SDGS	
Driller: D. JACOBSON	Driller's Log:
Geologist: P. DAWSON	Geologist's Log: X

Date Drilled: 06-21-1988
Ground Surface Elevation: 1629.10 I
Total Drill Hole Depth: 127.0
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit:
Screen Type: PVC, MFG.
Casing Type: PVC
Casing Top Elevation: 1631.62 I
Casing Stick-up: 2.52
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Drilling Method: ROTARY
Test Hole Number: CO-88-19
SDGS Well Name: CO-88-19
Aquifer: PLEISTOCENE SERIES
Screen Length: 5.0
Casing Diameter: 2.0
Total Casing and Screen: 122.5
Single Point Resistivity:
Extra:

SCREEN FROM 115 TO 120 FEET.

0 - 2.0 TOPSOIL, BLACK
2.0 - 50.0 GRAVEL, MEDIUM TO VERY COARSE PEBBLE
GRAVEL; OXIDIZED
50.0 - 70.0 CLAY, GRAY; STICKY (TILL)
70.0 - 84.0 GRAVEL, FINE TO COARSE PEBBLE GRAVEL;
OXIDIZED
84.0 - 87.0 CLAY, GRAY; STICKY (TILL)
87.0 - 92.0 GRAVEL STRINGER, FINE TO COARSE PEBBLE
GRAVEL; OXIDIZED
92.0 - 100.0 CLAY, GRAY; STICKY (TILL)
100.0 - 103.0 GRAVEL STRINGER, FINE TO COARSE PEBBLE
GRAVEL; OXIDIZED
103.0 - 112.0 CLAY, GRAY; STICKY (TILL)
112.0 - 121.0 GRAVEL, MEDIUM TO COARSE PEBBLE GRAVEL;
OXIDIZED
121.0 - 127.0 CLAY, GRAY; STICKY (TILL)

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County: BROOKINGS
Map Location: 18
Legal Location: SW SW NW SW SEC. 35, T. 110 N., R. 49 W.
Latitude: 44.1712
Land Owner:
Project: AURORA CITY STUDY-1988
Drilling Company: SDGS
Driller: D. JACOBSON
Geologist: P. DAWSON
Date Drilled: 06-16-1988
Ground Surface Elevation: 1620.00 T
Total Drill Hole Depth: 147.0
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma: X

Location: 110N-49W-35CBCC
Longitude: 96.4113
Driller's Log:
Geologist's Log: X
Drilling Method: ROTARY
Test Hole Number: CO-88-16
Single Point Resistivity: X
Extra:

Samples:

0 - 2.0 TOPSOIL, BLACK
2.0 - 41.0 GRAVEL, MEDIUM TO VERY COARSE PEBBLE
GRAVEL; OXIDIZED
41.0 - 70.0 CLAY, LIGHT-GRAY; STICKY, ROCK AT 67 FEET
(TILL)
70.0 - 85.0 GRAVEL, FINE TO COARSE PEBBLE GRAVEL;
OXIDIZED
85.0 - 90.0 CLAY, LIGHT-GRAY; STICKY (TILL)
90.0 - 98.0 GRAVEL, FINE TO COARSE PEBBLE GRAVEL;
OXIDIZED
98.0 - 147.0 CLAY, LIGHT-GRAY; STICKY (TILL)

LITHOLOGIC DESCRIPTION BASED ON ELECTRIC LOG
INTERPRETATION.

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County: BROOKINGS	Location: 110N-49W-35CBCC 1
Map Location: 19	
Legal Location: SW SW NW SW SEC. 35, T. 110 N., R. 49 W.	
Latitude: 44.1712	Longitude: 96.4113
Land Owner:	
Project: AURORA CITY STUDY-1988	
Drilling Company: SDGS	
Driller: D. JACOBSON	Driller's Log:
Geologist: P. DAWSON	Geologist's Log: X
Date Drilled: 06-20-1988	Drilling Method: ROTARY
Ground Surface Elevation: 1619.93 I	
Total Drill Hole Depth: 47.0	Test Hole Number: CO-88-17
Water Rights Well:	SDGS Well Name: CO-88-17
Other Well Name:	
Basin: BIG SIOUX	Aquifer: BIG SIOUX
Management Unit: AURORA	
Screen Type: PVC, MFG.	Screen Length: 10.0
Casing Type: PVC	Casing Diameter: 2.0
Casing Top Elevation: 1621.56 I	
Casing Stick-up: 1.63	Total Casing and Screen: 38.6
Well Maintenance Date:	
USGS Hydrological Unit Code: 10170203	
Electric Log Information:	
Spontaneous Potential:	Single Point Resistivity:
Natural Gamma:	Extra:
Samples:	

SCREEN FROM 27 TO 37 FEET.

0 - 2.0 TOPSOIL, BLACK
2.0 - 41.0 GRAVEL, MEDIUM TO VERY COARSE PEBBLE
GRAVEL; OXIDIZED
41.0 - 47.0 CLAY, LIGHT-GRAY; STICKY (TILL)

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County: BROOKINGS
Map Location: 20
Legal Location: NE NE SW SW SEC. 35, T. 110 N., R. 49 W.
Latitude: 44.1708
Land Owner:
Project: AURORA CITY STUDY-1988
Drilling Company: SDGS
Driller: D. JACOBSON
Geologist: P. DAWSON
Date Drilled: 06-14-1988
Ground Surface Elevation: 1627.64 I
Total Drill Hole Depth: 137.0
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX
Management Unit:
Screen Type: PVC, MFG.
Casing Type: PVC
Casing Top Elevation: 1630.32
Casing Stick-up: 2.68
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma: X
Samples:

Location: 110N-49W-35CCAA

Longitude: 96.4057

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

Test Hole Number: CO-88-13
SDGS Well Name: CO-88-13

Aquifer: PLEISTOCENE SERIES

Screen Length: 10.0
Casing Diameter: 2.0

Total Casing and Screen: 138.7

Single Point Resistivity: X
Extra:

29 FEET OF BLANK CASING (CLOSED TO SCREEN) FROM
136 TO 107 FEET, SCREEN FROM 107 TO 97 FEET.

0 - 2.0 TOPSOIL, BLACK
2.0 - 37.0 GRAVEL, MEDIUM TO VERY COARSE PEBBLE
GRAVEL; OXIDIZED
37.0 - 94.0 CLAY, GRAY, SILTY, SANDY, PEBBLY (TILL)
94.0 - 110.0 GRAVEL, FINE TO COARSE PEBBLE GRAVEL;
OXIDIZED
110.0 - 137.0 CLAY, GRAY, SILTY, SANDY, PEBBLY (TILL)

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County: BROOKINGS
Map Location: 21
Legal Location: NE NE SW SW SEC. 35, T. 110 N., R. 49 W.
Latitude: 44.1708
Land Owner:
Project: AURORA CITY STUDY-1988
Drilling Company: SDGS
Driller: D. JACOBSON
Geologist: P. DAWSON
Date Drilled: 06-13-1988
Ground Surface Elevation: 1627.63 I
Total Drill Hole Depth: 42.0
Water Rights Well:
Other Well Name:
Basin: BIG SIOUX

Location: 110N-49W-35CCAA 1

Longitude: 96.4057

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

Test Hole Number: CO-88-14
SDGS Well Name: CO-88-14

Aquifer: BIG SIOUX

Management Unit: AURORA
Screen Type: PVC, MFG.
Casing Type: PVC
Casing Top Elevation: 1630.22 I
Casing Stick-up: 2.59
Well Maintenance Date:
USGS Hydrological Unit Code: 10170203
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Screen Length: 10.0
Casing Diameter: 2.0
Total Casing and Screen: 34.6

Single Point Resistivity:
Extra:

SCREEN FROM 22 TO 32 FEET.

0 - 2.0 TOPSOIL, BLACK
2.0 - 37.0 GRAVEL, MEDIUM TO VERY COARSE PEBBLE
GRAVEL; OXIDIZED
37.0 - 42.0 CLAY, GRAY, SILTY, PEBBLY; VERY STICKY
(TILL)

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County: BROOKINGS
Map Location: 22
Legal Location: SE SE SE SE SEC. 36, T. 110 N., R. 49 W.
Latitude: 44.1656
Land Owner:
Project: USGS
Drilling Company: HURON DRILLING
Driller:
Geologist: J. GOODMAN
Date Drilled: 08-11-1977
Ground Surface Elevation: 1628.00 T
Total Drill Hole Depth: 50.0
Water Rights Well: BG-77J
Other Well Name:
Basin: BIG SIOUX
Management Unit: AURORA
Screen Type: PVC
Casing Type: PVC
Casing Top Elevation:
Casing Stick-up: 1.90
Well Maintenance Date: 06-23-1982
USGS Hydrological Unit Code: 10170202
Electric Log Information:
Spontaneous Potential:
Natural Gamma:
Samples:

Location: 110N-49W-36DDDD

Longitude: 96.3851

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

Test Hole Number:
SDGS Well Name:

Aquifer: BIG SIOUX

Screen Length: 5.0
Casing Diameter: 2.0

Total Casing and Screen: 45.4

Single Point Resistivity:
Extra:

0 - 4.0 TOPSOIL, BLACK
4.0 - 45.0 SAND AND GRAVEL, BROWN, MEDIUM TO COARSE
45.0 - 50.0 CLAY, GRAY, SILTY, PEBBLY (TILL)

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