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OPEN-FILE REPORT 79-UR

HYDROGEOLOGIC INVESTIGATION OF THE OGALLALA AQUIFER NEAR BONESTEEL, SOUTH DAKOTA

by

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CONTENTS

FIGURES

Page

TABLES

INTRODUCTION

The investigation was conducted in May 1982, May 1983, and June 1984, by the South Dakota Geological Survey, a program within the Department of Environment and Natural Resources, at the request of the East Gregory Rural Water District. The purpose of the investigation was to assist the water district in locating a new ground water supply. This report contains the results of the investigation that was conducted in the area of Bonesteel, South Dakota (fig. 1).

A previous investigation was conducted by the South Dakota Geological Survey in 1975 for the purpose of locating a water source for the East Gregory Rural Water District. During that investigation, test holes were drilled in an area west of the city of Bonesteel. An aquifer test was conducted and the results indicated that the aquifer in the area could yield the amount of water required by the East Gregory Rural Water District. However, water samples collected during the aquifer test had nitrate concentrations above the 10 milligrams per liter (mg/L) drinking water standard for public water systems (U.S. Environmental Protection Agency, 1994).

LOCATION OF STUDY AREA

The study area is located in sec. 12, T. 95 N., R. 69 W (figs. 1 and 2). This report contains the results of a two-phase ground water investigation conducted at that location. In early 1982, the East Gregory Rural Water District obtained permission to conduct further drilling on a parcel of land south of the city of Bonesteel near a test hole recommended in the 1975 investigation conducted by the South Dakota Geological Survey (Barari and Beissel, 1976). The parcel of land was 200 feet wide by approximately 1,500 feet long and was the area of investigation for the first phase of this study. The first phase of the study was conducted from May 11 through May 19, 1982, in this parcel of land half a mile south of Bonesteel (fig. 1). The second phase of the study covered a larger area approximately half to 1 mile south of the city of Bonesteel. The second phase was conducted from May 9 through May 11, 1983.

METHODS AND PROCEDURES

Drilling and Well Installation

During the first phase of drilling (May 1982), 11 test holes were drilled, 5 of which were cased with 2-inch diameter polyvinyl chloride (PVC) casing and screen for use as monitoring wells. Well CO-82-29 was installed as a monitoring well but failed to develop; the casing was cut off below the ground surface, the well was properly abandoned, and well CO-82-35 was drilled to replace CO-82-29.

After an agreement was obtained from the land owner, the South Dakota Geological Survey began the second phase of drilling. During the second phase of drilling (May 1983), 12 test holes were drilled, 8 of which were cased with 2-inch diameter PVC casing and screen for use as monitoring wells. In addition to the South Dakota Geological Survey monitoring wells, a 6-inch diameter production well was drilled by Sioux Well Drilling for the East Gregory Rural Water District. Figure 2 shows the locations of all test holes, monitoring wells, and the East Gregory Rural Water District production well. Lithologic logs for test holes, monitoring wells, and the production well are on file at the South Dakota Geological Survey.

Water Level Measurements

The depths to water in the monitoring wells were measured on several occasions (table 1) to the nearest 0.01 foot. Measurements were made using a fiber glass tape measure with a concave shaped device on the end that makes an audible sound upon impact with the water.

Water Sampling and Analysis

After the first phase of drilling, in 1982, water samples were collected from four South Dakota Geological Survey monitoring wells (CO-82-27, CO-82-30, CO-82-32, and CO-82-35; fig. 2). After the second phase of drilling, in 1983, water samples were collected from five other South Dakota Geological Survey monitoring wells (CO-83-07, CO-83-06, CO-83-10, CO-83-11, and CO-83-09; fig. 2) and the East Gregory Rural Water District Water District production well. Water quality analyses were performed by the South Dakota Geological Survey Basic and Analytical Studies Laboratory.

HYDROGEOLOGIC SETTING

Surficial deposits in the study area consist of the Tertiary age Ogallala Group. These sediments are thought to have been deposited by fluvial processes. Directly underlying the Ogallala Group is the Pierre Shale of Cretaceous age. Only the Ogallala Group and Pierre Shale units were drilled into during this investigation, therefore only those units will be discussed.

RESULTS OF INVESTIGATION

Three cross sections, whose locations are shown on figure 3, illustrate the spatial distribution of sediments in the study area. In the study area, the Ogallala Group consists of a complex mixture of interbedded sand, silt, and clay (figs. 4, 5, and 6). The Pierre Shale directly underlies the Ogallala Group.

The Ogallala Group was found to be a semi-confined aquifer composed of very fine to coarse sand with interbedded silt and clay layers. The Ogallala Group underlies the entire study area and ranges in thickness from 51 feet (CO-83-12) to 77 feet (CO-83-11). Saturated thickness of the Ogallala Group on June 5, 1984, varied from 44 feet (CO-83-01) to 66 feet (CO-83-11). Depth to water was measured on several occasions (table 1) and based on this information, the water elevations generally were found to decrease in a northeasterly direction (fig. 7).

A concern at the outset of this project was a sewage lagoon located in the northwest corner of section 7, east and northeast of the study area. The question was raised as to whether or not contamination from the sewage lagoon would have an impact on ground water in the study area. Figure 7 illustrates that ground water flow appears to be in a northeasterly direction. Ground water will, therefore, flow from the study area toward the lagoon.

Water Quality

The results of chemical analyses of water samples collected from the study area are reported in table 2. Water samples were obtained from nine monitoring wells and the East Gregory Rural Water District production well. As indicated in table 2, water collected from the monitoring wells is of good quality. In water collected from the monitoring wells, total dissolved solids ranged in concentration from 282 to 464 mg/L and hardness ranged in concentration from 197 to 265 mg/L. In all the monitoring wells, iron and manganese concentrations were below the recommended drinking water standards for public water systems of 0.3 and 0.05 mg/L, respectively (U.S. Environmental Protection Agency, 1994). The nitrate-nitrogen plus nitrite-nitrogen concentrations are below the drinking water standard of 10 mg/L for public water systems (U.S. Environmental Protection Agency, 1994) and ranged from 1.00 to 4.80 mg/L.

Selenium is another ground water constituent that was evaluated. When this project was conducted, during 1982 and 1983, the drinking water standard for selenium was 10 micrograms per liter (µg/L). At that time, only one water sample (collected from monitoring well CO-83-06) had a concentration (11.00 µg/L) which was above the drinking water standard of 10 µg/L. However, since the 1982-1983 investigation, the U.S. Environmental Protection Agency has changed the drinking water standard for selenium from 10 µg/L to 50 µg/L. With this new standard, water collected from all monitoring wells had selenium concentrations below the drinking water standard of 50 µg/L. Water collected from the East Gregory Rural Water District production well had a selenium concentration of 4.90 µg/L.

Aquifer Test Description and Results

An aquifer test was conducted from June 5 through June 7, 1984, using the East Gregory Rural Water District production well (fig. 2) as the test well. The production well is 80 feet deep and 6 inches in diameter with a PVC screen between 53 and 70 feet. The screened interval is described on the lithologic log as a fine to coarse sand with a small clay layer between 63 and 66 feet. The well was pumped at an average rate of 107 gallons per minute for 47.5 hours. The saturated thickness of the aquifer at the production well was 61 feet on June 5, 1984. Nine monitoring wells were monitored for the aquifer test. The monitoring wells form a monitoring network surrounding the production well. The monitoring wells were screened in the same aquifer as the production well. Water levels were monitored throughout the test using a "plopper" device at the monitoring wells, and an electric probe and measuring tape combination at the production well.

A complete analysis of the aquifer test data and results are on file at the South Dakota Geological Survey. During the aquifer test, monitoring wells CO-83-06, CO-83-07, CO-83-10, CO-83-11, and CO-83-09 showed a decline in water level (drawdown) ranging from 0.74 to 3.39 feet. These five monitoring wells are within 478 feet of the production well, and CO-83-11 is only 93 feet from the production well. Farther out from the production well, monitoring wells CO-83-01, CO-82-30, and CO-83-12 showed very small drawdowns, with a maximum of only 0.15 feet. These three monitoring wells are located 2,500 feet, 2,000 feet, and 700 feet, respectively, from the production well. Because of the small amount of drawdown associated with these three monitoring wells, they were not considered when calculating transmissivity and storativity.

The drawdown data from the aquifer test were analyzed using the Theis nonequilibrium equations. The Jacob time-drawdown method was also used for drawdown measured during the latter part of the test. Analyses showed the transmissivity of the aquifer to be approximately 37,601 gallons per day per foot and

the storage coefficient to be 0.00045. The low storage coefficient is indicative of an aquifer under semi-confined conditions. This also suggests that the silt and clay layers in the aquifer (figs. 4, 5, and 6) are acting as confining or semi-confining layers. With an average saturated thickness of 58 feet, the permeability was found to be 747 gallons per day per square foot. The specific capacity of the test well was 5.3 gallons per minute per foot.

SUMMARY AND RECOMMENDATIONS

Considering the aquifer characteristics and the distribution of drawdowns during the aquifer test, it was estimated that during years with normal precipitation the aquifer can yield adequate amounts of water to meet the needs of the East Gregory Rural Water District. Recommendations were made assuming the average saturated thickness of the aquifer to be 58 feet and that the specific capacity of the well will be maximized by proper well construction. It was also recommended that some monitoring wells be maintained for future monitoring of water levels and water chemistry.

During periods of below normal precipitation and prolonged drought, production from wells will probably decrease due to the limited thickness and variable lithology of the Ogallala aquifer in the study area. For this reason and for planning future expansion of the East Gregory Rural Water District, it would be prudent to look for an additional source of water outside of the present wellfield area.

Currently (November 1996), the East Gregory Rural Water District is utilizing water produced from three wells located in the northeast quarter of section 12, T. 95 N., R. 69 W. One well was drilled in 1982 to a depth of 68 feet and the other two wells were drilled in 1984, both to a depth of 72 feet. All wells are completed in the Ogallala aquifer.

REFERENCES

Barari, A. and Beissel, D., 1976, *Ground-water study for the city of Bonesteel and East Gregory Rural Water District*: South Dakota Geological Survey Open-File Report 3-UR.

U.S. Environmental Protection Agency, 1994, *Drinking water regulations and health advisories:* November 1994.

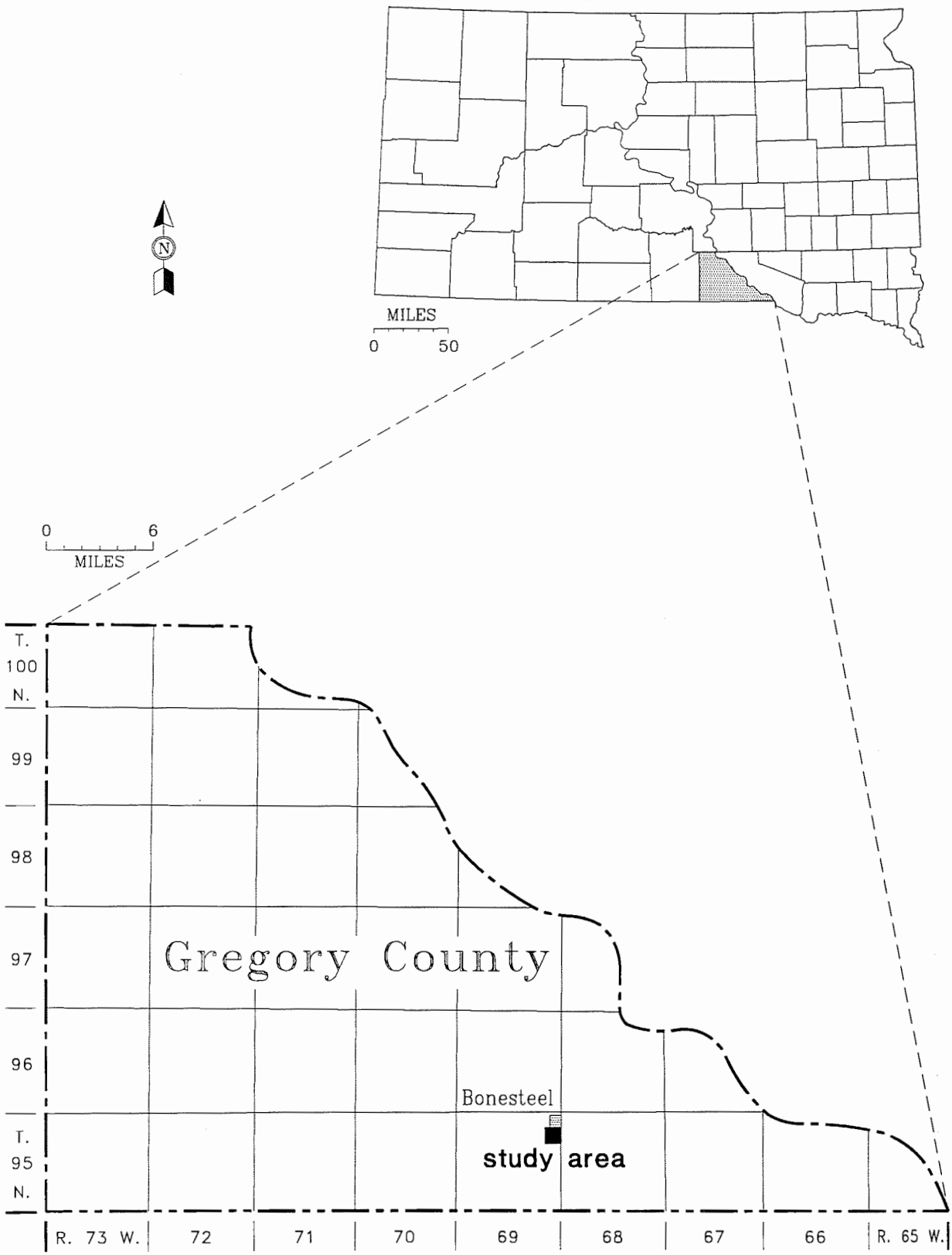
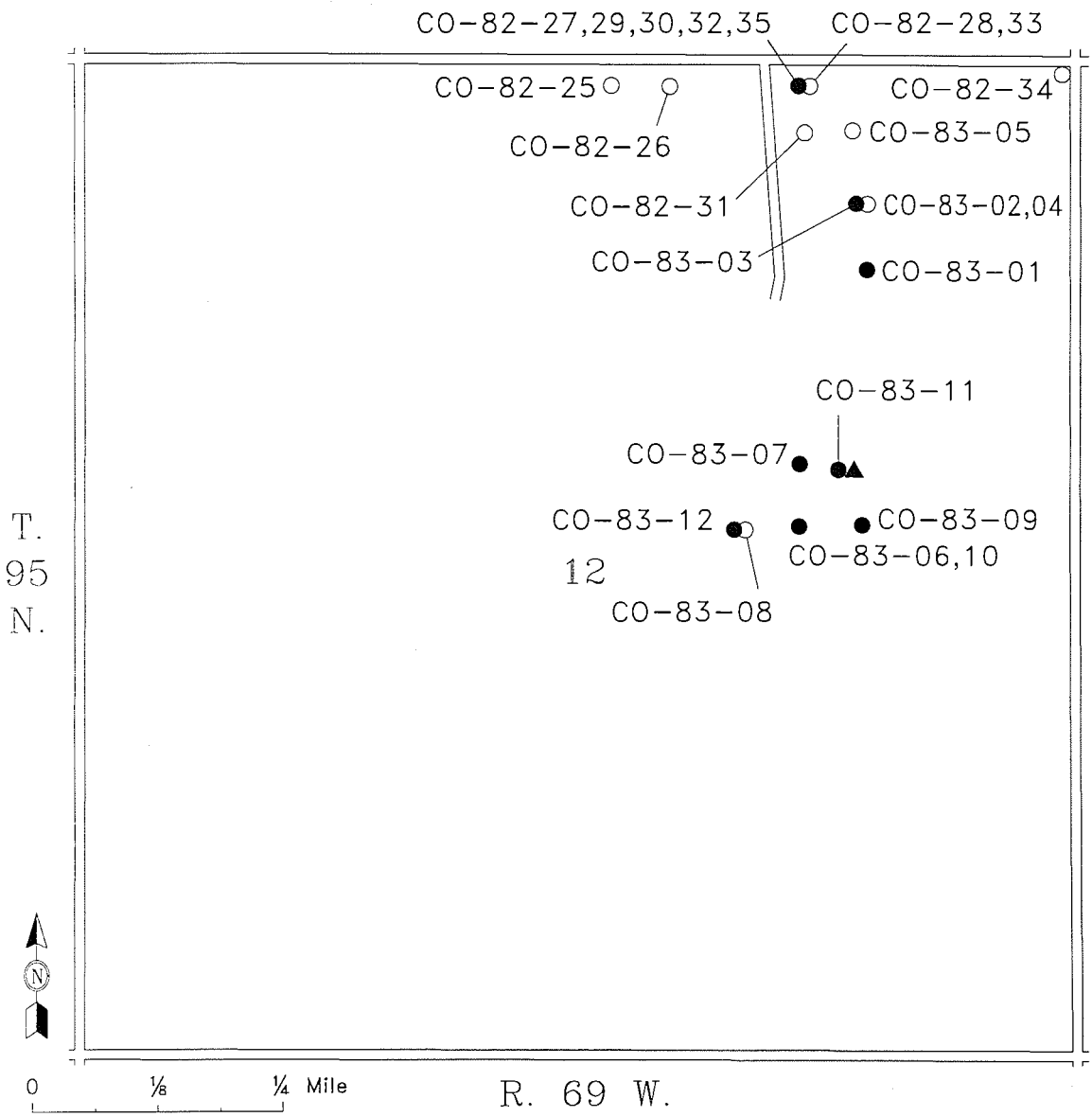


Figure 1. Location of the study area.

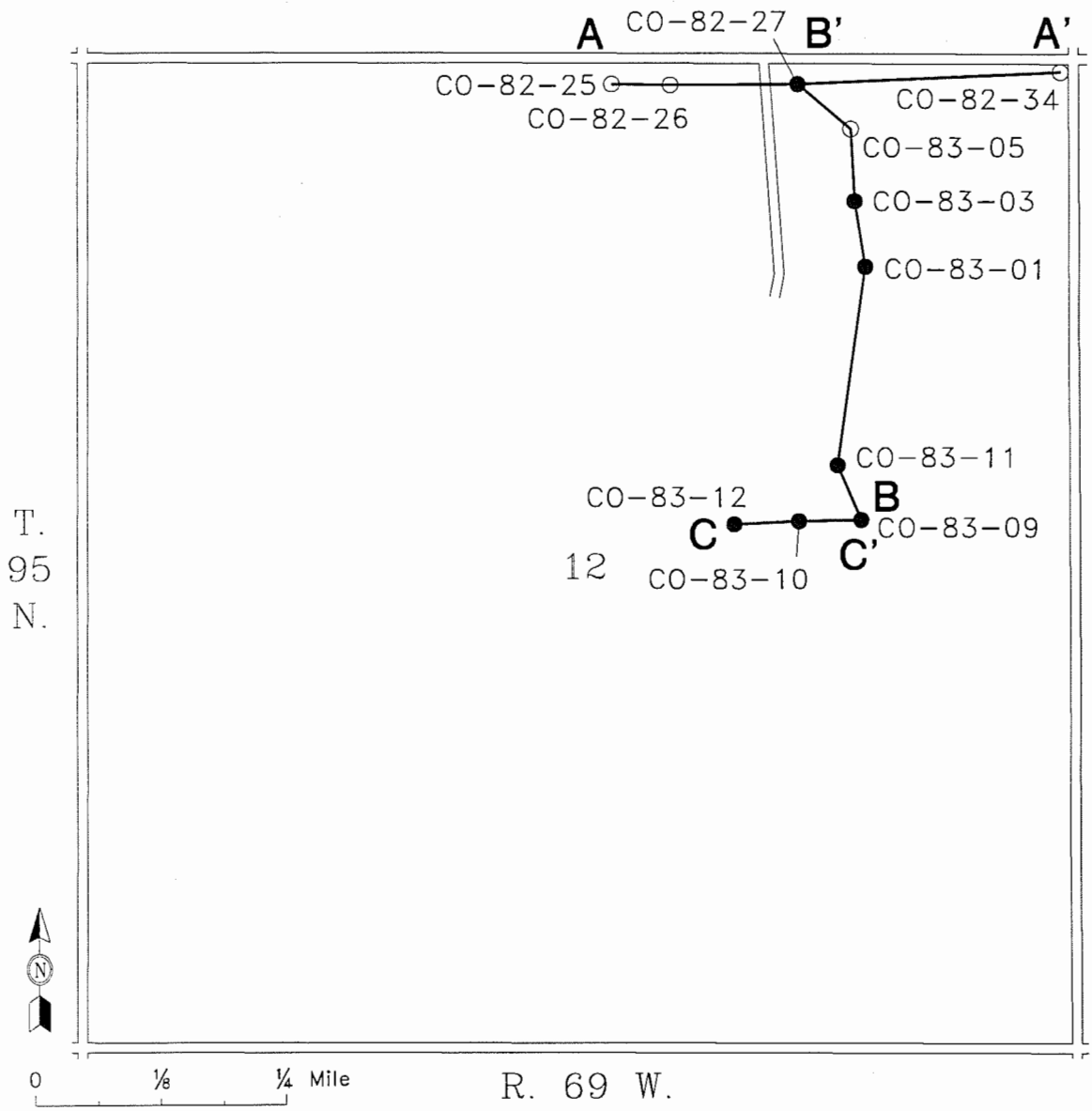


CO-83-01 ● Monitoring well
CO-83-05 ○ Test hole

Letters and numbers are the South Dakota Geological Survey test hole or well identifier.

▲ Production well

Figure 2. Locations of test holes, monitoring wells, and production well.



CO-83-01● Monitoring well
CO-83-05○ Test hole

} Letters and numbers are the South Dakota Geological Survey test hole or well identifier.

C ●—● C' Line of hydrogeologic cross section

Figure 3. Locations of hydrogeologic cross sections.

Figure 4. Hydrogeologic cross section A-A'.

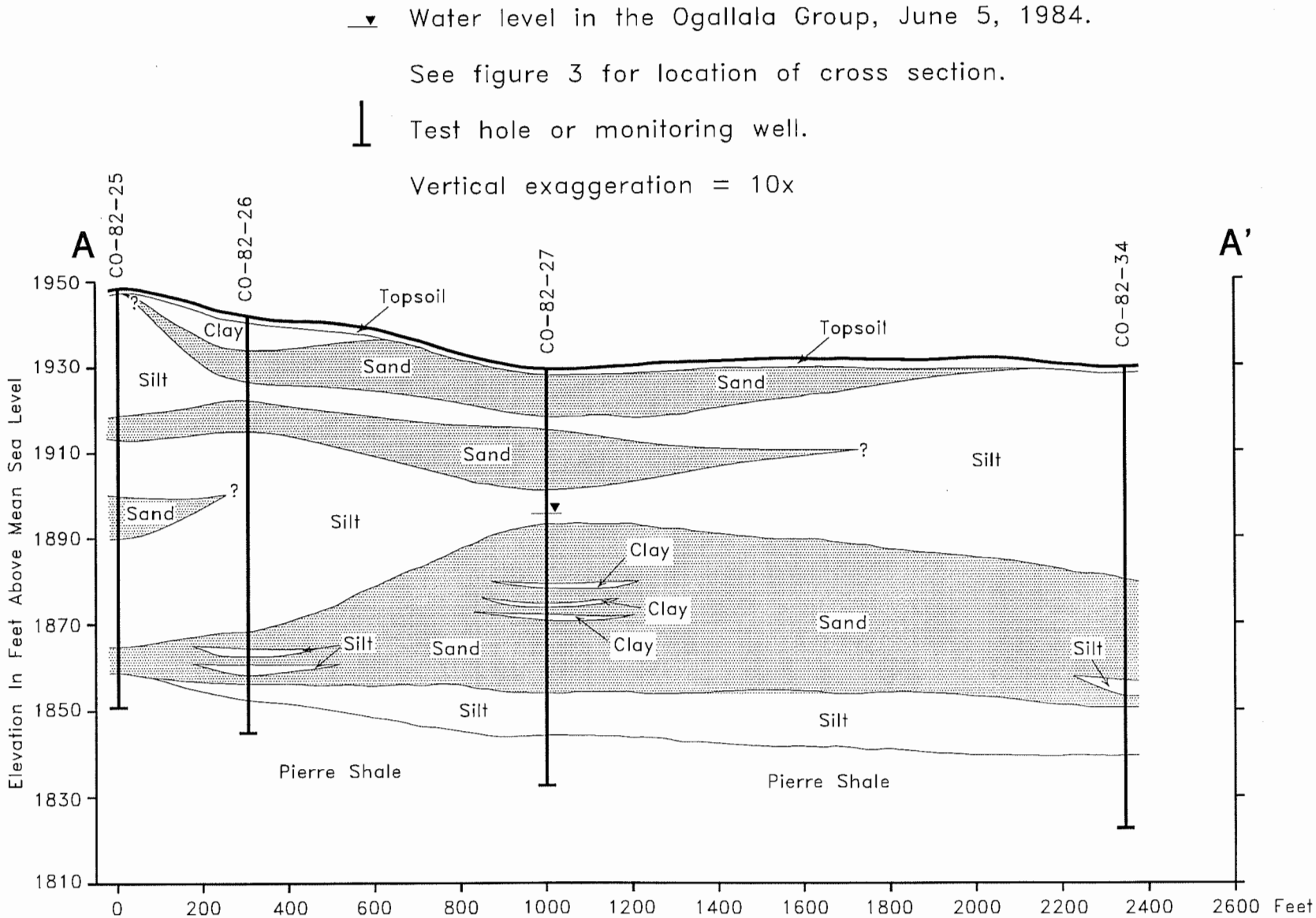


Figure 5. Hydrogeologic cross section B-B'.

▼ Water level in the Ogallala Group, June 5, 1984.

See figure 3 for location of cross section.

Test hole or monitoring well.

Vertical exaggeration = 10x

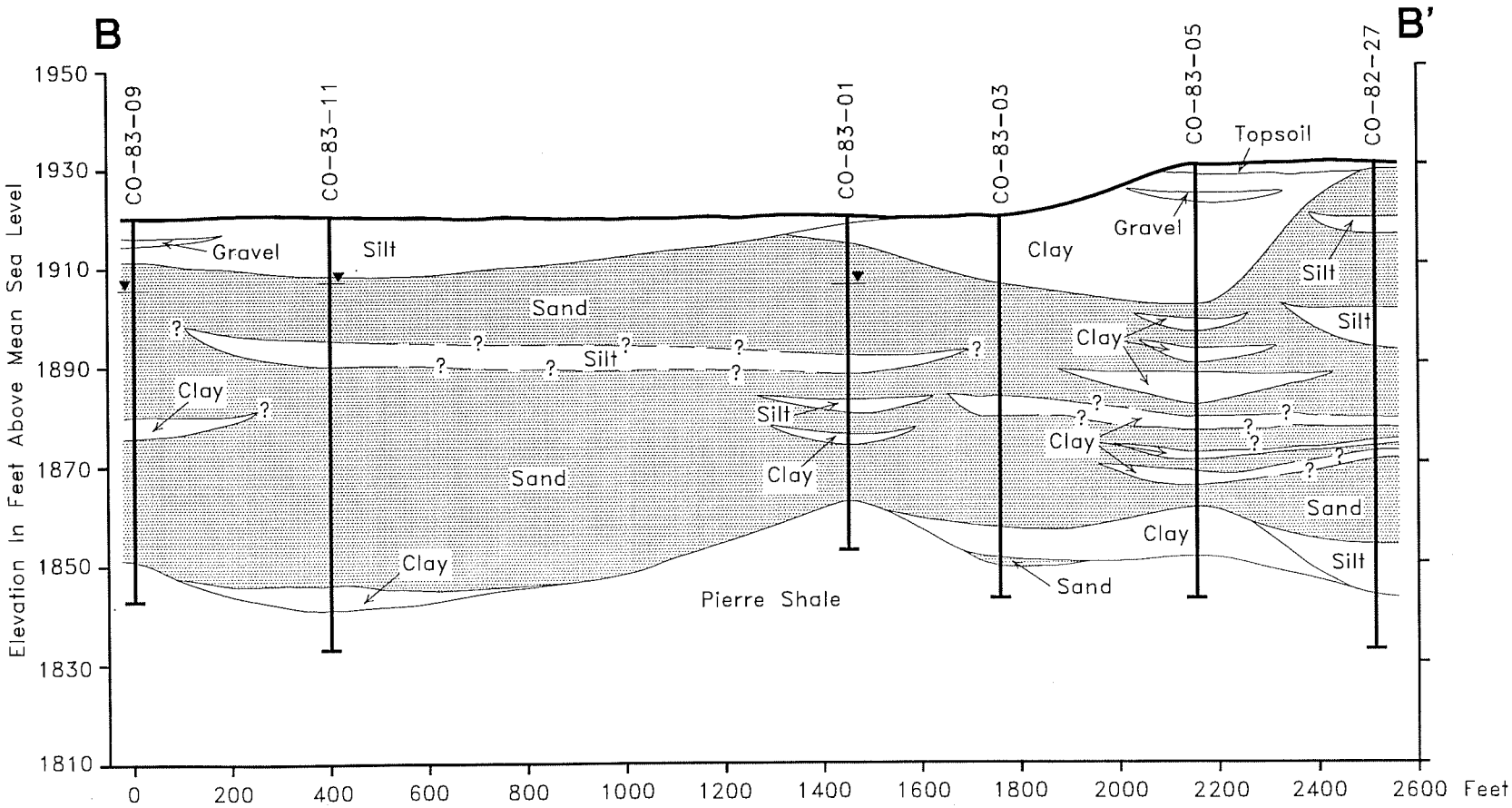


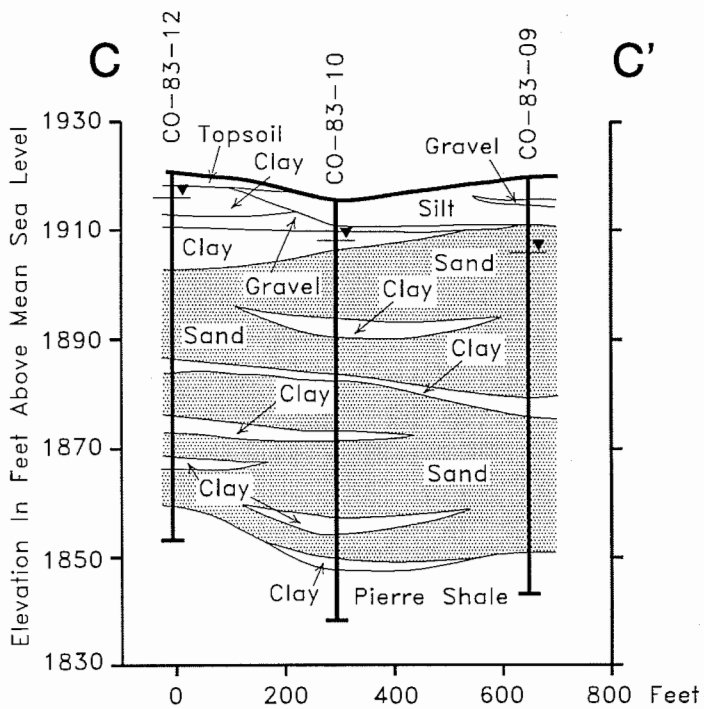
Figure 6. Hydrogeologic cross section C-C'.

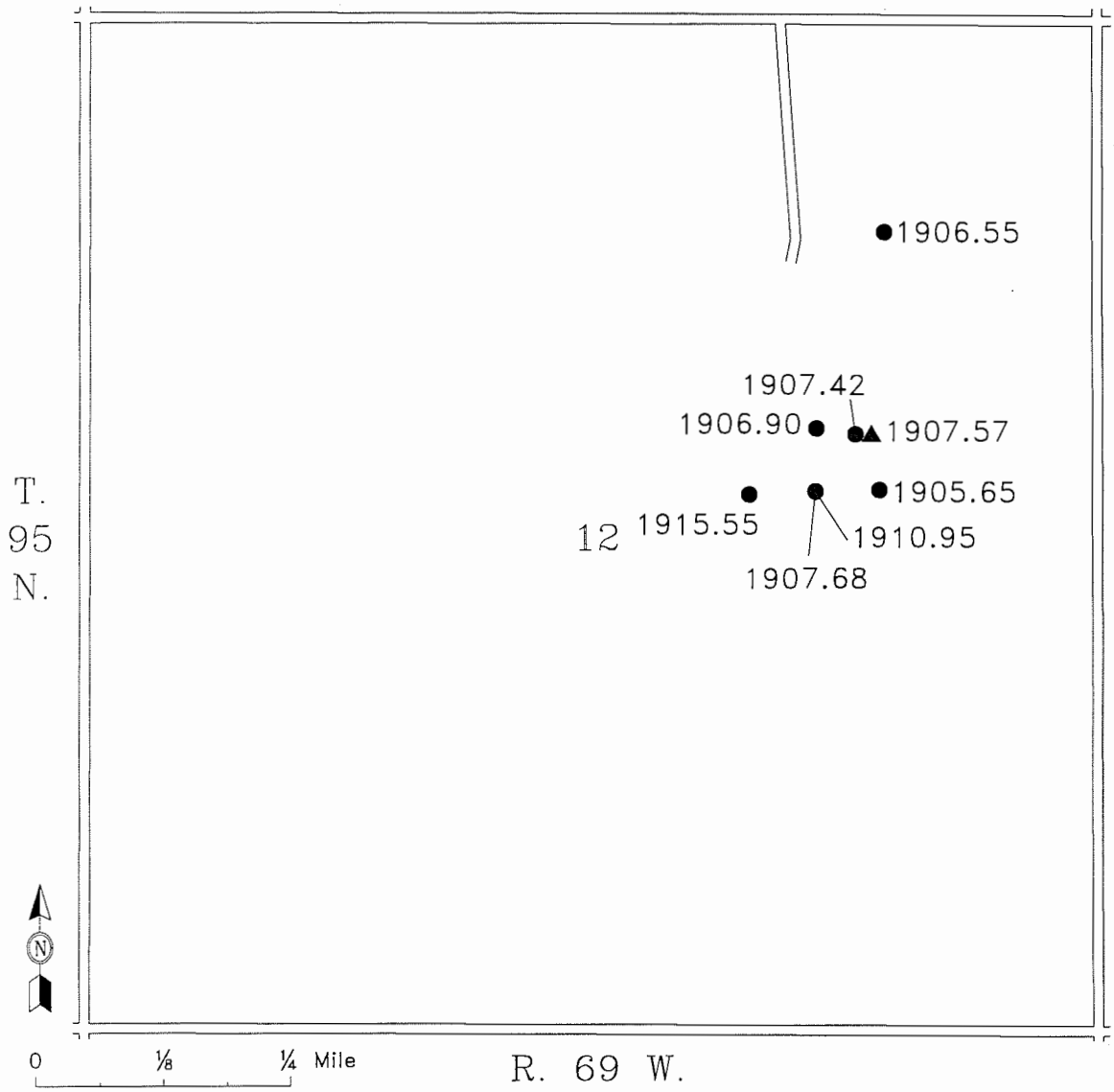
Water level in the Ogallala Group June 5, 1984.

See figure 3 for location of cross section.

Test hole or monitoring well.

Vertical exaggeration = 10x





1915.55 ● Monitoring well
1907.57 ▲ Production well

Number is water level elevation, in feet above mean sea level.

Figure 7. Water level elevations in the Ogallala Group on June 5, 1984.

Table 1. Water levels in monitoring wells

Well name	Date	Depth to water below casing top (feet)	Casing top elevation above mean sea level (feet)	Water elevation above mean sea level (feet)
CO-83-03	05/10/83	21.90	1922.4	1900.50
CO-83-01	05/10/83	22.20	1921.4	1899.20
	06/05/84	14.85	1921.4	1906.55
CO-82-27	05/13/82	36.90	1931.9	1895.00
	06/10/82	36.90	1931.9	1895.00
CO-83-07	05/11/83	15.72	1917.3	1901.58
	06/05/84	10.40	1917.3	1906.90
CO-83-12	05/23/83	10.10	1920.8	1910.70
	06/05/84	5.25	1920.8	1915.55
CO-83-06	05/11/83	10.08	1916.8	1906.72
	06/05/84	5.85	1916.8	1910.95
CO-83-10	05/11/83	14.55	1917.3	1902.75
	06/05/84	9.62	1917.3	1907.68
CO-83-11	05/11/83	19.50	1921.7	1902.20
	06/05/84	14.28	1921.7	1907.42
Production well	06/05/84	11.23	1918.8	1907.57
CO-83-09	05/11/83	21.45	1922.1	1900.65
	06/05/84	16.45	1922.1	1905.65

Table 2. Chemical analyses of water samples

Legal location	Well name	Date collected	Well depth[2]	Conductivity[3]	Selenium[4]	Parameters[1] with concentrations in milligrams per liter									NO_3-N + NO_2-N	SO_4	TDS	Hardness as $CaCO_3$
						HCO_3	Ca	Cl	F	Fe	K	Mg	Mn	Na				
					50[5]	--	--	250[6]	2.4[5]	0.3[6]	--	--	0.05[6]	--	10[5]	250[6]	500[6]	--
NE NE NW NE sec. 12, T. 95 N., R. 69 W.	CO-82-27	05/13/82	76	509	<2.00	NA	61	6	0.33	0.20	NA	13	0.03	31	2.30	35	282	204
NE NE NW NE sec. 12, T. 95 N., R. 69 W.	CO-82-30	05/13/82	75	534	<2.00	NA	58	10	0.33	0.04	NA	13	0.01	32	3.80	49	360	197
NE NE NW NE sec. 12, T. 95 N., R. 69 W.	CO-82-32	05/13/82	79	506	<2.00	NA	64	6	0.31	0.01	NA	13	<0.01	29	2.10	49	406	212
NE NE NW NE sec. 12, T. 95 N., R. 69 W.	CO-82-35	05/13/82	74	606	<2.00	NA	78	10	0.34	0.01	NA	16	0.01	32	3.70	70	424	258
NE SE SW NE sec. 12, T. 95 N., R. 69 W.	CO-83-07	05/11/83	70	638	6.00	280	78	10	0.33	<0.05	8.0	14	<0.05	36	2.00	74	460	252
SE SE SW NE sec. 12, T. 95 N., R. 69 W.	CO-83-06	05/11/83	65	599	11.00	244	70	15	0.32	<0.05	6.8	13	<0.05	35	1.00	72	428	228
SE SE SW NE sec. 12, T. 95 N., R. 69 W.	CO-83-10	05/11/83	60	671	6.00	500	83	8	0.44	0.14	7.1	14	<0.05	36	4.80	80	450	265
NW SW SE NE sec. 12, T. 95 N., R. 69 W.	CO-83-11	05/11/83	65	597	6.00	500	70	8	0.37	0.08	7.4	12	<0.05	35	3.10	58	402	224
NW SW SW NE sec. 12, T. 95 N., R. 69 W.	production well	06/07/84	70	655	4.90	250	82	10	0.82	<0.05	7.1	6	<0.05	39	2.70	92	407	229
SW SW SE NE sec. 12, T. 95 N., R. 69 W.	CO-83-09	05/11/83	66.8	648	3.00	488	81	7	0.40	<0.05	6.1	14	<0.05	32	4.30	97	464	260

[1] **HCO_3** - bicarbonate; **Ca** - calcium; **Cl** - chloride; **F** - fluoride; **Fe** - iron; **K** - potassium; **Mg** - magnesium; **Mn** - manganese; **Na** - sodium; **NO_3-N + NO_2-N** - nitrate + nitrite as nitrogen; **SO_4** - sulfate; **TDS** - total dissolved solids; **Hardness as $CaCO_3$** - hardness as calcium carbonate.

[2] Well depth is presented in feet below top of casing.

[3] Numbers are presented in micromhos per centimeter.

[4] Numbers are presented in micrograms per liter.

[5] U.S. Environmental Protection Agency (1994).Maximum contaminant levels. Enforceable limits.

[6] U.S. Environmental Protection Agency (1994). Secondary maximum contaminant levels. Recommended limits.

NA - Parameter was not analyzed.