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OPEN-FILE REPORT 82-UR

GROUND WATER INVESTIGATION AT THE BIG STONE CITY WASTE WATER TREATMENT FACILITY

by

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INTRODUCTION

At the request of Big Stone City, South Dakota, and the East Dakota Water Development District, the South Dakota Geological Survey conducted a hydrogeologic investigation in the area near Big Stone City's waste water treatment facility. Test hole drilling for this study began in September of 1992. The purpose of this study was to install a system of monitoring wells around the city's three waste water stabilization ponds. These monitoring wells would allow determination of any impact on ground water quality due to seepage from the stabilization ponds

METHODS AND PROCEDURES

Test Hole Drilling

A total of 12 test holes were drilled between September 9, 1992, and September 15, 1992. Drilling was performed with a hollowstem auger rig. The outer diameter of the auger was 10 inches. Prior to drilling any test holes, the auger rig and the auger flights were cleaned with high pressure hot water. This procedure was used to minimize the possibility of introducing contamination into a test hole. Samples were collected from the drill cuttings at 5-foot intervals and a lithologic log was written by the project manager. Copies of the lithologic logs may be obtained from the South Dakota Geological Survey.

Monitoring Well Installation

All well construction materials were cleaned with high pressure hot water and then wrapped in plastic by the manufacturer prior to transport to the site. Monitoring wells were constructed using 2-inch diameter, schedule 40, flush-threaded, polyvinyl chloride (PVC) casing and screen. Filter pack, a washed coarse sand, was placed around the outside of the screen to a depth of no less than 3 feet above the top of the screen. A minimum of 2 to 3 feet of bentonite grout seal was placed on top of the filter pack. A cement grout was then placed from the top of the bentonite grout to ground level. At this point, a locking steel well protector was installed. All 12 test holes drilled for this study had monitoring wells completed in them (figs. 1 and 2).

Monitoring Well Development

All monitoring wells installed for this study were developed by removing water with a dedicated PVC bailer. Wells were bailed until temperature and conductivity had stabilized and the well water was clear. In all cases, a minimum of 3 well volumes were evacuated.

Surveying of Monitoring Wells

Casing top elevations of monitoring wells were surveyed to the nearest 0.01 foot above mean sea level using an automatic level and stadia rod. Monitoring wells were surveyed in relative to monitoring well R20-92-39, which had an assumed casing top elevation of 1,100.00 feet above mean sea level.

Water Level Measurements

The depths to water in the monitoring wells were measured to the nearest 0.01 foot using electronic water level tapes. The depth to water from casing top was read directly from the tape that was marked in 0.01-foot intervals.

Hydraulic Conductivity Testing

Slug tests were performed on three of the monitoring wells by bailing all of the water that could be removed from the wells and then measuring water levels as they recovered. Hydraulic conductivity, which is a measure of the capacity of a porous medium to transmit water, was then calculated from the slug test data based on the method outlined by Hvorslev (1951).

Water Sampling

A minimum of 3 well volumes of water were evacuated from the well before a sample was collected. Water samples from monitoring wells were collected from the screened interval of the well using a dedicated PVC bailer.

All of the water samples collected were analyzed for major inorganic ions by the South Dakota Geological Survey Basic and Analytical Laboratory. Additional samples collected for fecal coliform and trace metals analyses have been analyzed by the State Health Laboratory in Pierre.

RESULTS OF INVESTIGATION

Geologic Setting

The geologic material encountered in the study area is glacial till. Till is an unsorted mixture of silt, sand, and gravel in a clay matrix. Till is deposited directly from glacial ice, with little or no reworking by water. The till found in the study area is very silty and is slightly sandy. The upper portion of this till, at least the upper 40 feet, is also weathered and fractured.

Ground Water Levels and Flow Directions

Table 1 lists the water table elevations in the monitoring wells and stabilization ponds on September 30, 1992, and figure 3 shows the configuration of the water table near the stabilization ponds on this date. The configuration of the water table indicates an outward, radial flow pattern of ground water. This means that the ground water in the area is flowing outward and away from the stabilization ponds in all directions. This flow pattern is created by the inflow of waste water into the ponds which elevates the water table. Water which does not evaporate from the surface of the ponds then infiltrates downward and outward, recharging the ground water system.

Hydraulic Conductivity Testing

Slug tests were performed in order to estimate the hydraulic conductivity of the till in the area of the stabilization ponds. Slug tests were performed in three of the wells constructed for this study, R20-92-40, R20-92-43, and R20-92-48. The estimated values of hydraulic conductivity were 1.3 x 10E-5 cm/sec, 1.2 x 10E-4 cm/sec, and 1.3 x 10E-4 cm/sec, respectively. These values of hydraulic conductivity are slightly higher than observed values for weathered glacial tills in most other areas of the state. This is likely due to the very silty nature of the tills in this area. These hydraulic conductivity values indicate that the tills in this area have a moderately low permeability, but are still capable of transmitting quantities of water.

Water Quality

Results of the chemical analyses performed by the South Dakota Geological Survey Basic and Analytical Laboratory are shown in table 2. The ground water in the study area is characterized by total dissolved solids concentrations that range from 947 to 2,210 parts per million in the area immediately adjacent to the stabilization ponds (with one exception, R20-92-41, which has a value of 5,280 part per million). At greater distances from the stabilization ponds (approximately 400 to 500 feet), total dissolved solids concentrations increase to 2,750 to 3,670 parts per million.

Chemical analyses data indicate that only iron, manganese, and ammonia as nitrogen concentrations are elevated near the ponds. All other measured inorganic parameters mimic total dissolved solids concentrations as they also increase with increasing distance from the ponds. The only exception is water found within monitoring well R20-92-41.

Because the concentrations of most inorganic constituents increase with increasing distance from the ponds, and ground water flow directions are radially outward from the ponds, the water infiltrating from the ponds contains less dissolved constituents than do the "background" waters farther from the ponds. Therefore, water infiltrating into the ground from the ponds is actually of a better "overall" quality than the "background" ground water in the study area. The only exceptions are iron, manganese, and ammonia as nitrogen, which have elevated concentrations near the ponds.

Results of the fecal coliform and trace metal analyses were not available at the time of writing, but may obtained from the State Health Laboratory in Pierre, South Dakota.

DISCUSSION AND CONCLUSIONS

A hydrogeologic investigation was conducted near Big Stone City's three waste water stabilization ponds. Test hole drilling indicated that the geologic material in the vicinity of these ponds is a very silty glacial till.

Twelve monitoring wells were installed in these test holes in order to conduct hydraulic conductivity tests, to measure water levels, and to collect water samples.

Results of hydraulic conductivity tests indicate that the very silty till in this area has a moderately low permeability, but is permeable enough so that quantities of ground water can move through it. Ground water flow directions are radially outward from the ponds in all directions. This is the result of inflow of waste water into the ponds which elevates the water table near the ponds.

Chemical analyses of water samples indicate ground water near the ponds has lower concentrations of dissolved inorganic constituents than ground water farther from the ponds, with the exception of iron, manganese, and ammonia as nitrogen. Present data indicate that the ponds have not had a negative impact on the inorganic water quality in the area.

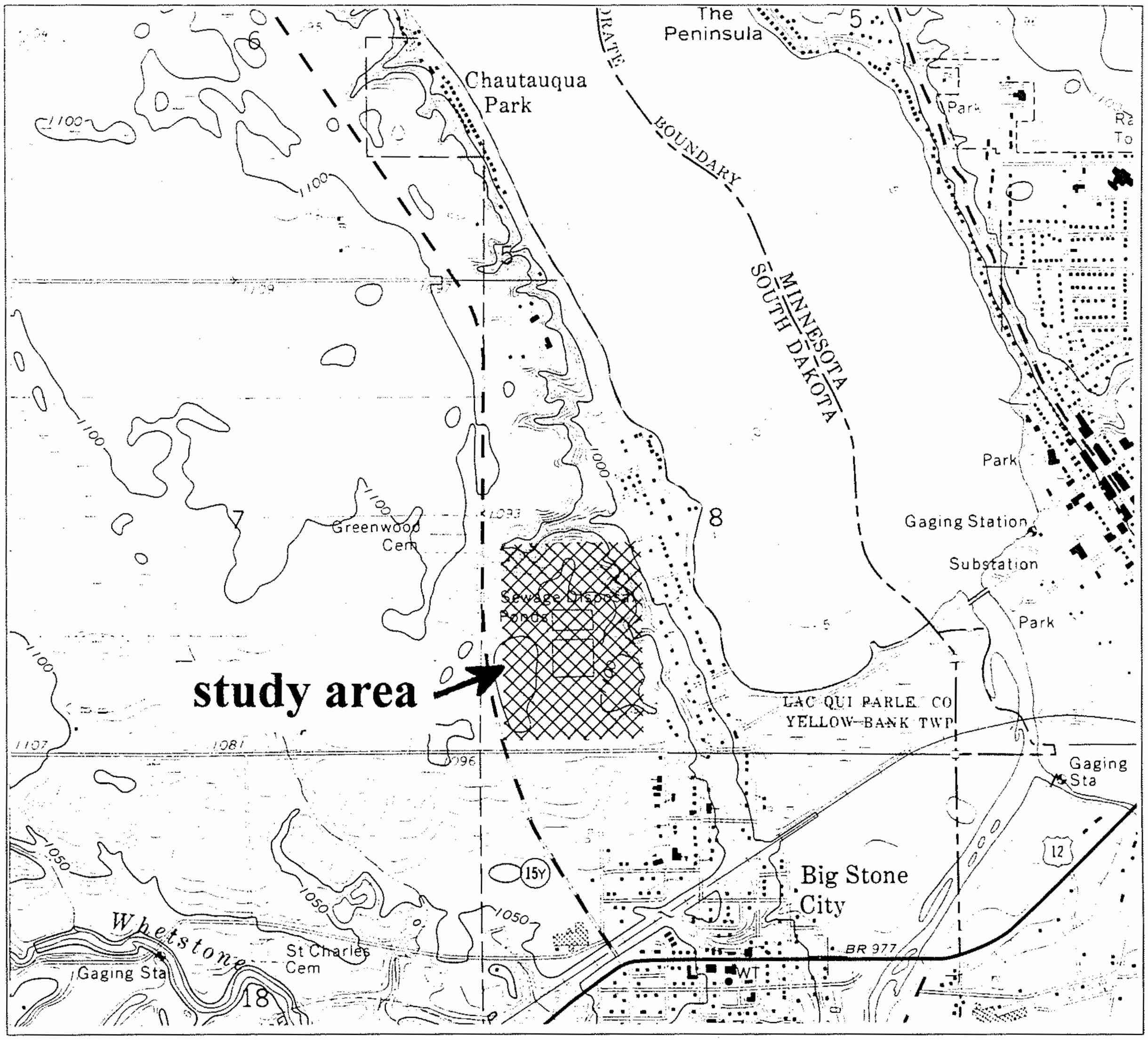
REFERENCES

Hvorslev, M.J., 1951, *Time lag and soil permeability in ground water observations:* U.S. Army Corps of Engineers Waterways Experimentation Station Bulletin 36, 50 pp.

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

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ORTONVILLE, MINN. - S. DAK. QUADRANGLE
MINNESOTA
7.5 MINUTE SERIES (TOPOGRAPHIC)



SCALE 1:24000

1 ½ 0 1 MILE

CONTOUR INTERVAL 10 FEET

QUADRANGLE LOCATION

Study area location: SE¼ sec. 8, T. 121 N., R. 46 W.
Grant County

Figure 1. Location of study area.

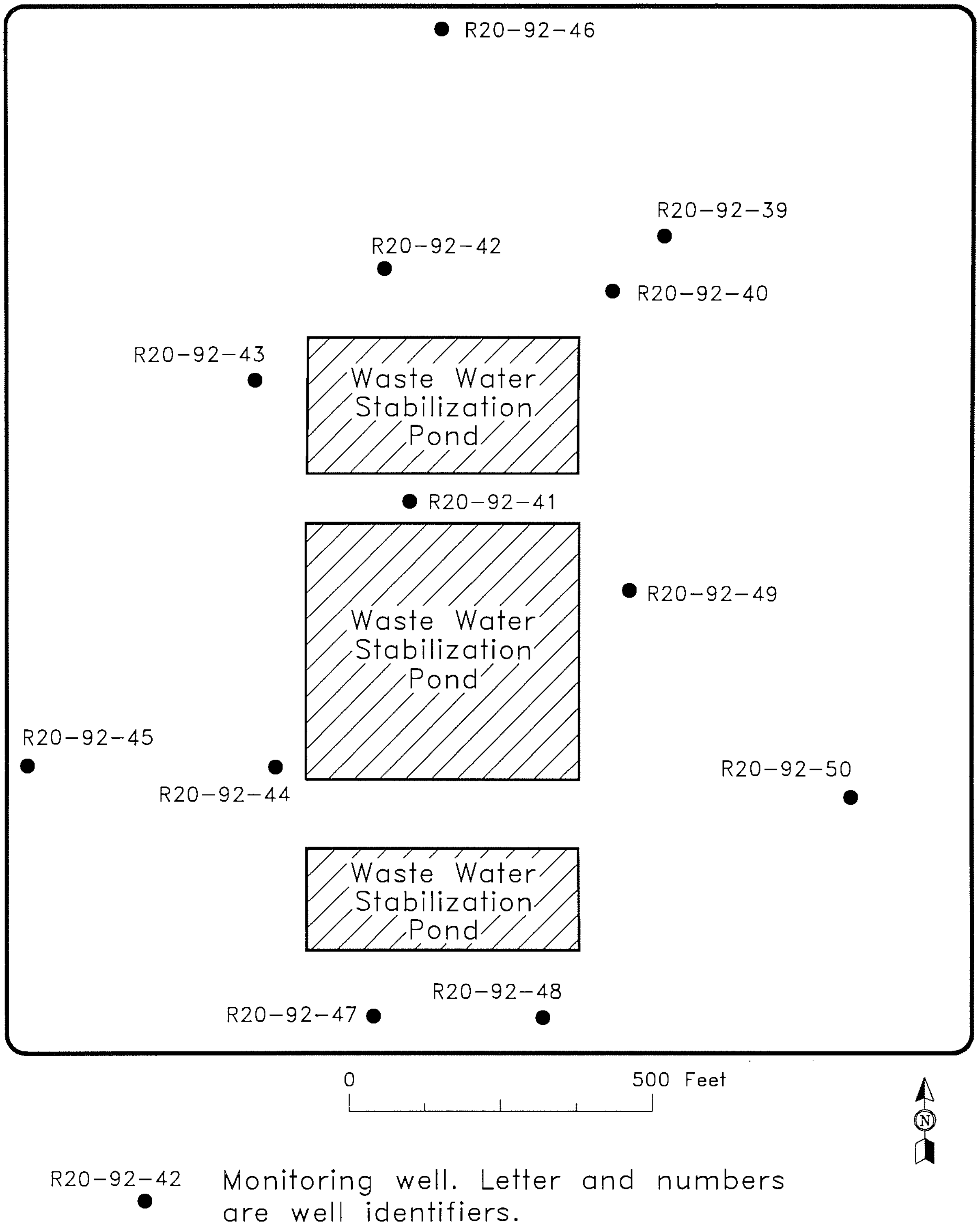
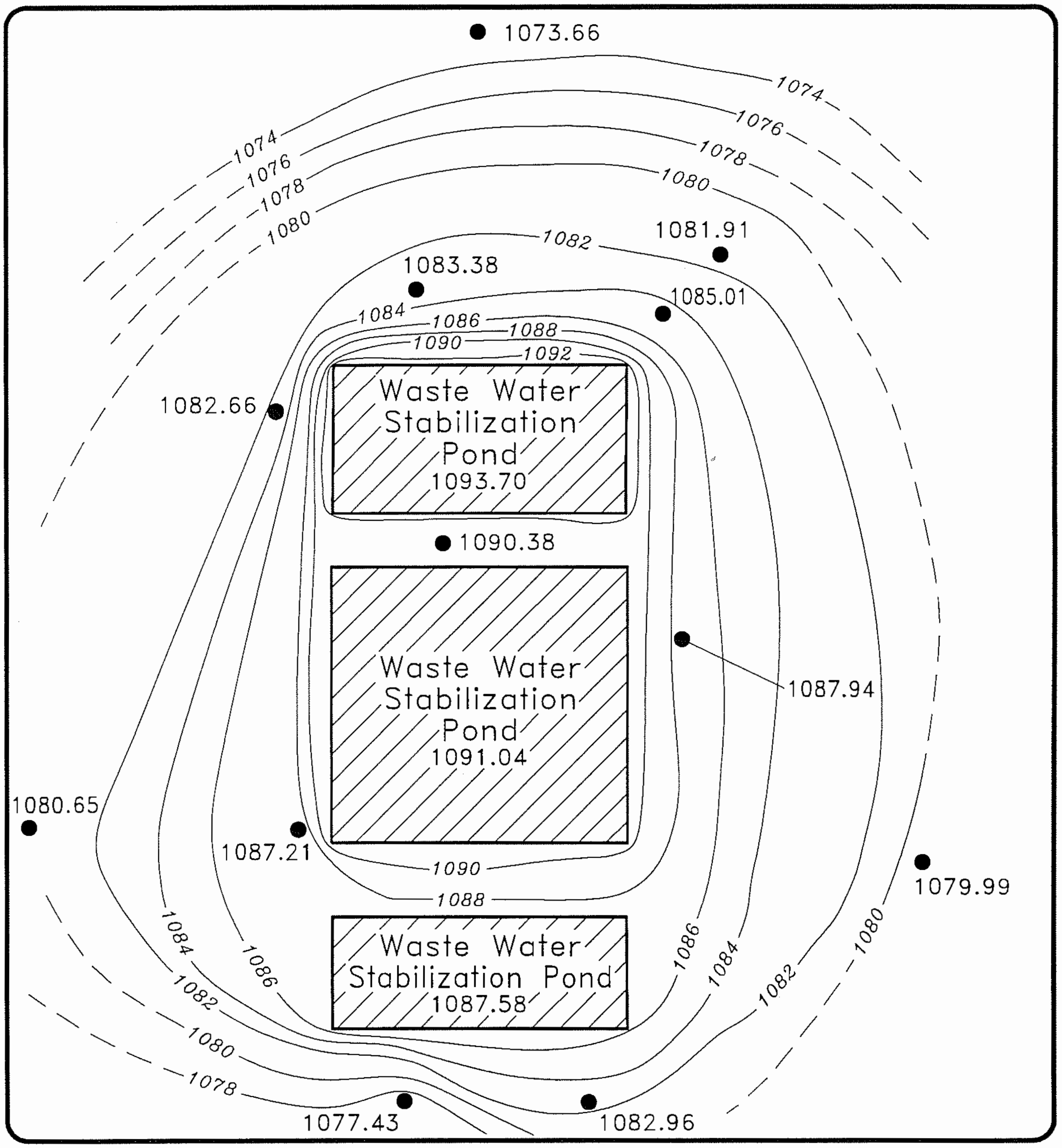


Figure 2. Locations of monitoring wells.



1087.94 ● Monitoring well. Number is water table elevation in feet about mean sea level.

1078 — Line of equal water table elevation. Contour interval = 2 feet.

Figure 3. Water table elevations on September 30, 1992.

Table 1. Water levels in monitoring wells and stabilization ponds

Well or pond name	Date	Depth to water below casing top (feet)	Casing top elevation (feet above mean sea level)	Water elevation (feet above mean sea level)
R20-92-39	09/30/92	18.09	1100.00	1081.91
R20-92-40	09/30/92	15.02	1100.03	1085.01
R20-92-41	09/30/92	7.19	1097.57	1090.38
R20-92-42	09/30/92	12.74	1096.12	1083.38
R20-92-43	09/30/92	16.35	1099.01	1082.66
R20-92-44	09/30/92	8.36	1095.57	1087.21
R20-92-45	09/30/92	15.96	1096.61	1080.65
R20-92-46	09/30/92	14.20	1087.86	1073.66
R20-92-47	09/30/92	10.00	1087.43	1077.43
R20-92-48	09/30/92	6.71	1089.67	1082.96
R20-92-49	09/30/92	7.94	1095.88	1087.94
R20-92-50	09/30/92	18.64	1098.63	1079.99
North Pond	09/30/92	N/A	N/A	1093.70
Middle Pond	09/30/92	N/A	N/A	1091.04
South Pond	09/30/92	N/A	N/A	1079.99

N/A -- not applicable.

Table 2. Chemical analyses of water samples

Legal location	Well name	Date collected	Well depth[2]	Conductivity[3]	Parameters[1] and concentrations in milligrams per liter: Alk-T	HCO$_3$	Ca	Cl	F	Fe	K	Mg	Mn	Na	NH$_3$-N	NO$_3$-N + NO$_2$-N	SO$_4$	TDS	Hardness as CaCO$_3$
					--	--	--	250[4]	2.4[5]	0.3[4]	--	--	0.05[4]	--	--	10[5]	250[4]	500	--
SE SE NW SW sec. 8, T. 121 N., R. 46 W.	R20-92-40	04/26/93	27	3490	644	785	230	616	0.33	<0.05	16	105	0.72	394	4.87	0.04	365	2160	1007
NW NE SW SW sec. 8, T. 121 N., R. 46 W.	R20-92-41	04/26/93	13	8016	531	647	323	1870	0.27	0.25	4.0	493	5.72	755	0.15	<0.04	1300	5280	2840
NW SE NW SW sec. 8, T. 121 N., R. 46 W.	R20-92-42	04/26/93	28	2880	552	673	138	509	0.33	<0.05	15	111	0.97	325	3.45	0.06	268	1730	802
SW SE NW SW sec. 8, T. 121 N., R. 46 W.	R20-92-43	04/26/93	25	3185	613	747	159	626	0.39	4.31	2.6	152	2.43	313	1.16	<0.04	230	1870	1023
SW NE SW SW sec. 8, T. 121 N., R. 46 W.	R20-92-44	04/26/93	18	3658	488	595	192	730	0.38	14.4	2.2	105	14.9	432	8.88	<0.04	420	2210	912
SE NW SW SW sec. 8, T. 121 N., R. 46 W.	R20-92-45	04/26/93	28	3639	380	463	479	444	0.44	<0.05	10	259	<0.05	41	<0.05	0.61	1280	2820	2260
SE SE NW SW sec. 8, T. 121 N., R. 46 W.	R20-92-46	04/26/93	19	4336	362	441	289	570	0.25	<0.05	5.5	510	<0.05	28	<0.05	4.85	1580	3670	2820
NW SE SW SW sec. 8, T. 121 N., R. 46 W.	R20-92-47	04/26/93	9	1423	712	868	156	64	0.20	23.7	4.1	91	5.17	36	1.14	<0.04	95	947	760
NE SE SW SW sec. 8, T. 121 N., R. 46 W.	R20-92-48	04/26/93	10	3035	492	600	168	543	0.50	<0.05	1.0	119	<0.05	331	<0.05	1.96	370	1890	910
NW NW SE SW sec. 8, T. 121 N., R. 46 W.	R20-92-49	04/26/93	13	3549	497	606	142	692	0.30	2.26	16	101	2.78	461	10.4	<0.04	359	2050	770
SE NW SE SW sec. 8, T. 121 N., R. 46 W.	R20-92-50	04/26/93	24	3859	412	502	322	601	0.22	<0.05	14	196	<0.05	281	<0.05	1.20	943	2750	1611

[1] **Alk-T** - total alkalinity; **HCO$_3$** - bicarbonate; **Ca** - calcium; **Cl** - chloride; **F** - fluoride; **Fe** - iron; **K** - potassium; **Mg** - magnesium; **Mn** - manganese; **Na** - sodium; **NH$_3$-N** - ammonia as nitrogen; **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] U.S. Environmental Protection Agency "Drinking Water Regulations and Health Advisories": November 1994 (Secondary maximum contaminant levels. Recommended limits.)

[5] U.S. Environmental Protection Agency "Drinking Water Regulations and Health Advisories": November 1994 (Maximum contaminant levels. Enforceable limits).