TEXAS BOARD OF WATER ENGINEERS

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Contamination Report No. 10

INVESTIGATION OF SALT WATER CONTAMINATION IN A WOODBINE WELL NEAR SHERMAN, GRAYSON COUNTY, TEXAS

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INTRODUCTION

The city of Sherman on January 11, 1961 forwarded to the Texas Board of Water Engineers a chemical analysis indicating a chloride content of 3,700 parts per million in water from a Woodbine well owned by Major R. C. Good and located about three and one-half miles east of Sherman in northern Grayson County, requesting the advice and assistance of the Board in determining the source of contamination indicated in this well. Earlier records of wells contained in the Board of Water Engineers Bulletin 6013, "Geology and Ground-Water Resources of Grayson County, Texas," show a regional pattern of generally excellent quality water in the Woodbine formation with less than 50 parts per million chloride. Water from the Woodbine is used by the city of Sherman for its municipal water supply and is used for domestic purposes in surrounding areas. Any widespread contamination to this formation would thus be of concern to a large number of people.

In response to the inquiry by the city of Sherman, a field investigation of the cause and extent of contamination encountered in the well of Major R. C. Good was made by the Board of Water Engineers March 1 through March 3, 1961. In the course of this brief investigation, water samples for chemical analysis were collected from Major Good's well; from ten nearby wells that draw water from the Woodbine formation; from three wells that draw water from the Eagle Ford shale; and from one salt water injection well. Shallow wells that produce water from the Austin chalk were not reported to produce salt water and were not sampled. Information pertaining to the wells was obtained through interviews with landowners, tenants, and well drillers. Chemical analyses were made by the Texas State Department of Health. Well data and results of the analyses are given at the end of this report. A generalized geologic section and a well location map also are included at the end of the report.

Appreciation is expressed to Mr. John Middleton of the Texas Railroad Commission District office in Wichita Falls for contributing information obtained in his earlier studies of this contamination problem. This included locations of many water wells, chloride content of water samples, and data on oil-field brine disposal methods in nearby areas. Mr. Middleton also worked with the writer in collecting water samples for more complete chemical analysis.

GENERAL GEOLOGY

Stratigraphic relationships of rock units mentioned in this report, the Woodbine formation and other Upper Cretaceous units above the Woodbine, are shown on Figure 2. More detailed information on geology of this area is given in Board of Water Engineers Bulletin 6013.

The Austin chalk underlies the ground surface in most of this area. A few very shallow wells obtain small amounts of fresh water from open joints and fractures in this chalky limestone. Eagle Ford shale underlies the Austin chalk, and thin layers of sand within this predominantly shaly unit also furnish small amounts of water to a few wells in this area, though of marginal to very poor quality. The Woodbine formation, which underlies the Eagle Ford shale, is a major fresh water aquifer that consists mainly of sands interlayered with thinner beds of shale.

QUALITY OF WATER IN THE WOODBINE FORMATION

Water in the Woodbine formation of this area generally is suitable for domestic, municipal, and industrial uses. Quality of water obtained from a number of the Woodbine wells in this area is shown by the chemical analyses in Table 1. Locations of these wells are shown on Figure 1. Wells 13 and 14 produce water with higher content of dissolved solids than other Woodbine wells in the area. However, analyses available for Well 13 show there was no significant increase in the salinity of water from this well between 1958 and 1961. Analyses available for Woodbine Wells 8 and 11 also show there has been no significant change in the quality of Woodbine water from these two wells during the same period.

QUALITY OF WATER IN THE EAGLE FORD SHALE

Thin layers of sand in the Eagle Ford shale, which overlies the Woodbine formation, yield small quantities of saline water in much of the area of this investigation. Wells 2, 3, and 4, locations of which are shown on Figure 1, produce water from the Eagle Ford with a natural gas odor, soda taste, and relatively high content of sodium, bicarbonate, and chloride. Salt water is reported to have been produced from Wells 2 and 3 from the time they were completed. The gas produced with the water from Well 2 is reported by the well owner to be explosive.

Salt water-bearing strata also have been encountered in the Eagle Ford in the course of drilling Woodbine wells. The generalized geologic section shown on Figure 2 illustrates the horizons at which a few wells in this area are completed. Well 8, completed in the Eagle Ford in 1939 at approximately the same depth as Well 2, produced saline water. Later, it was drilled to the present depth of 700 feet and the well now produces excellent water from the Woodbine. Salt water also was reportedly encountered at a depth of approximately 250 feet in the course of drilling Well 9 to its completed depth of 911 feet. Mr. M. L. Burk reports that about 40 years ago, a well was completed in the Eagle Ford about 100 feet west of Well 15. This well, completed at a depth of about 400 feet, produced salt water. The well was deepened in 1953 and completed in the Woodbine at a depth of about 1,000 feet. Salt water was produced at this increased depth and the well was abandoned. Because the casing was ruptured during installation, water from Eagle Ford strata may have been entering the well. Well 15, drilled for Mr. Burk in 1954, draws water from the Woodbine between depths of 944 feet and 973 feet. Water from this well, which has the annular space outside the casing above the zone of perforation filled with cement, is of excellent quality.

QUALITY OF OIL-FIELD BRINE PRODUCED IN THE AREA

Brine is produced with oil in the East Sherman Oil Field, and salt water from several leases is injected into a disposal well (Well 16 on Figure 1) as part of a pilot water-flood program. Other salt water disposal wells are present northwest of Sherman, considerably further away from the water wells of Major R. C. Good. Surface pits are not used for disposal of salt water in the area covered by this investigation.

Completion information for Well 16 is given in Table 2. A spinner survey conducted by the operator in September 1958, indicated that 100 percent of the salt water injected at that time was leaving the well between depths of 3,704 and 3,726 feet. The present injection rate is reported to be 250 barrels per day with an injection pressure of 1,100 psi (pounds per square inch).

The analysis given in Table 1 shows that the injected brine has a high ratio of calcium and magnesium to sodium, and a very low content of bicarbonate, relative to that of water from Eagle Ford and Woodbine water wells east of Sherman.

CONDITIONS ENCOUNTERED AT THE WATER WELL BELONGING TO MAJOR R. C. GOOD

Information supplied by the city of Sherman and Mr. O. W. Witherspoon, the driller, indicates the water well of Major R. C. Good (Well 1 of this report) was drilled initially to a depth of approximately 557 feet and completed two feet into a section of water sand encountered at that level. The driller installed 5½-inch blank casing to this depth and filled the top 50 feet of the annular space outside the casing with cement. Water of poor quality was encountered and, after standing overnight, the water level in the well was at a depth of about 100 feet below ground level. The well subsequently was deepened to 669 feet, and 4½-inch casing, perforated near the bottom, was inserted in the well between depths of 554 and 669 feet. No seal was placed in the annulus formed by the lap between the 5½-inch casing and the 4½-inch casing. After final well completion, the water level in the well was at a depth of about 180 feet below ground level.

The tenant, Captain Millisor, reports that the taste of water from the well changes from time to time, and that sometimes the water is cloudy while at other times it is clear. Soda, salt, and metallic tastes are reported. Natural gas is reported to have emanated from the water, at times in sufficient quantities to flare when ignited at the faucet.

To determine whether these reported variations in water quality are related to the quantity of water withdrawn, the well was pumped continuously for four hours at approximately 10 gallons per minute and water samples were collected for chemical analysis three minutes after pumping started and at one-hour intervals thereafter. The analyses given in Table 3 show that the salinity of water at the tap decreased during the first two hours of pumping and then became relatively stable. The sample obtained three minutes after pumping began showed lower salinity than an analysis obtained by the city of Sherman in December, 1960. The well was used for household purposes shortly before pumping for sample collection, and it is likely that the prior pumping accounts for the lower maximum salinity determined for the water during the current investigation. Had the small portion of the upper Woodbine screened by the well been contaminated areally, no significant decrease in salinity would have been expected during the relatively short period of pumping. Therefore, the change in salinity indicates that contamination occurs locally.

The changing salinity shown by the analyses indicates a mixing of water from two or more sources in the well, and the last three samples probably contained a higher proportion of water from the source with greatest permeability. The type of construction used at this well could allow mingling of water from several horizons, because only the upper 50 feet of annulus between the hole and the casing is filled with cement, and there is no seal between the two segments of casing in the well. Water levels are reported by the driller to have been higher when the well was drilled to a depth of 557 feet than after the well was deepened to 669 feet. Because of this difference in hydrostatic head, water could flow from upper water-bearing zones into lower water-bearing zones through the annulus between the casing and the hole or through the lap of the two casings. Poorer quality water that might collect in the well or in the formation adjacent to the screened portion of the well would have to be withdrawn before the naturally fresher Woodbine formation water could be obtained. Intermittent pumping would tend to distribute varying concentrations of poorer quality water throughout the well. This would account for the changing quality of water reported by the tenant as well as the decreasing salinity that occurs with continuous pumping.

Maximum salinity noted for water from this well is very similar to the salinity of water from Well 2, which is completed in the Eagle Ford. In other areas of Grayson County, natural gas and water with high bicarbonate content also have been reported in the thin uppermost sands of the Woodbine formation. Test drilling to obtain truly representative samples of water from each of the water-bearing zones for chemical analyses would be required to determine whether the Eagle Ford shale or a thin upper Woodbine sand is the contaminating source at the well of Major R. C. Good.

SUMMARY OF CONCLUSIONS

1. Available data indicate that major water-bearing sands of the Woodbine formation are not contaminated regionally in the area of study, one to six miles east of Sherman.

2. Water in the major sands of the Woodbine formation in this area generally has a low content of dissolved solids and is suitable for domestic, municipal, and industrial uses.

3. Small amounts of poor quality water containing natural gas and a high content of sodium, bicarbonate, and chloride are present in the Eagle Ford shale, which overlies the Woodbine formation. Poor quality water also may be present in the uppermost part of the Woodbine formation.

4. An improvement in water quality noted during continuous pumping of the well of Major R. C. Good indicates that contamination occurs at the well and that the rate and areal extent of contamination is small. This small amount of contamination probably will not noticeably impair the quality of water produced from other wells that screen the Woodbine formation in the general area.

Table 1.—Analyses of water from selected wells east of Sherman

(Analyses given are in parts per million, except specific conductance and pH)

Analyses by Texas State Department of Health except where noted.

Well	Owner	Depth (feet)	Water-bearing Unit	Date of Collection	Iron ~~(feet)~~ (fe)	Magnesium (Mg)	Calcium (Ca)	Sodium (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos/ Cm.)	pH
1	Major R. C. Good	669±	--	a/12-19-60	1.59	15	33	2,455	418	0	6	3,700	7,344	145	12,240	8.0
				b/3-2-61	0.78	8	14	1,242	566	0	30	1,710	4,110	70	6,850	8.3
				c/3-2-61	0.22	1	5	640	671	0	12	660	2,046	18	3,410	8.2
2	Alva Alexander	260±	Eagle Ford	3-3-61	1.8	14	27	2,000	427	0	176	2,900	6,756	128	11,260	7.8
3	L. T. Milligan	516	do	3-3-61	0.65	9.3	7	931	976	0	4	840	2,607	31	4,375	8.3
4	J. C. Bryant	360	do	3-4-61	0.89	2	5	606	974	49	84	280	1,701	23	2,835	9.1
5	O. L. Little	600±	Woodbine	3-3-61	0.06	1	3	323	432	24	10	210	864	10	1,440	8.9
6	E. M. Buzby	--	do	3-3-61	0.11	< 1	2	134	232	12	55	18	341	5	568	9.0
8	K. O. Merriman, Jr.	700	do	d/5-16-58	-	-	-	-	390	-	-	58	-	3	783	8.7
				3-3-61	0.13	< 1	2	180	310	60	17	48	465	5	775	9.5
9	O. E. Hughes	911	do	3-3-61	0.31	< 1	2	126	281	12	27	8	331	6	552	8.5
10	C. R. Grigg	610±	do	3-3-61	0.06	< 1	2	186	264	49	64	34	481	5	802	9.3
11	J. H. Washburn	745	do	d/5-16-58	-	-	-	-	330	-	-	7	-	4	555	8.5
				3-3-61	0.08	< 1	2	137	227	15	54	14	343	6	572	9.0
12	S. G. Kumler	737±	do	3-3-61	0.03	< 1	1	148	222	53	16	16	312	3	620	9.6
13	Jimmy Fant	497	do	d/5-4-58	-	-	-	-	742	-	-	750	-	19	3,310	8.3
				3-4-61	0.81	1	13	718	703	24	10	644	2,016	38	3,360	8.5
14	F. C. Wood	600±	do	3-3-61	0.52	1	3	512	610	36	26	400	1,500	13	2,500	8.8
15	M. L. Burk	973	do	3-3-61	0.06	< 1	2	225	376	48	18	37	523	7	872	9.3
16	Standard Oil Co. of Texas #8 L. W. Kimball	3,880	(Salt water produced with oil)	3-3-61	53	3,120	15,000	56,000	34	0	9	112,600	256,200	50,500	427,000	5.6

a/ Data furnished by City of Sherman.
b/ Water sample three minutes after pumping began.
c/ Water sample four hours after pumping began.
d/ Analyses from Board of Water Engineers Bulletin 6013.

Table 2.--Records of selected wells east of Sherman, Grayson County

All water wells are used for domestic purposes, although water from wells 1 and 2 is not used for human consumption.

Well	Owner	Driller	Date completed	Depth of well (ft.)	Water-bearing unit	Altitude of land surface (ft.) *	Remarks
1	Major R. C. Good	O. W. Witherspoon	1955	669±	--	650	Casing: $5\frac{1}{2}$ in. to 557 ft., $4\frac{1}{2}$ in. from 554 ft. to bottom; no seal between these two segments of casing. Perforated near total depth. Upper 50 ft. of annulus filled with cement.
2	Alva Alexander	do	1939	260±	Eagle Ford	695	Salt water sand reported encountered near total depth, just below an extremely hard, caprock, 6 to 8 in. thick.
a/ 3	L. T. Milligan	do	1949	516	do	760	Perforated 504 ft. to bottom.
4	J. C. Bryant	do	1946	360	do	760	
5	O. L. Little	--	--	600±	Woodbine	740	
6	E. M. Buzby	--	--	--	do	735	
a/ 7	City of Sherman	Layne-Texas Co., Ltd.	1958	2,380	Trinity	750	Portion of electric log shown in figure 2.
a/ 8	K. O. Merriman, Jr.	J. L. Myers Sons	1940	700	Woodbine	686	Perforated 680 ft. to bottom.
9	O. E. Hughes	do	1955	911	do	689	Casing: 6 in. to 20 ft., $4\frac{1}{2}$ in. from surface to 911 ft. Perforated 890 ft. to bottom.
10	C. R. Grigg	--	--	610±	do	650	Perforated near total depth.
a/11	J. H. Washburn	J. L. Myers Sons	1957	745	do	659	Casing: 6 in. to 10 ft., 4 in. from 10 to 745 ft. Perforated 700 ft. to bottom.
12	S. G. Kumler	--	--	737±	do	661	
a/13	Jimmy Fant	J. L. McClure	--	497	do	620	
14	F. C. Wood	O. W. Witherspoon	1960	600±	do	600	

See footnotes at end of table.

Table 2.--Records of selected wells east of Sherman, Grayson County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Water-bearing unit	Altitude of land surface (ft.) *	Remarks
15	M. L. Burk	J. L. Myers Sons	1954	973	Woodbine	750	Casing: 6 in. to 20 ft., 4½ in. from surface to 973 ft. Perforated 944 ft. to bottom.
16	L. W. Kimball #8	Standard Oil Co. of Texas	1952	3,880	--	740	Oil test used for brine disposal. b/
17	J. H. Washburn #1	Tennessee Gas Transmission Co.	1955	12,151	--	673	Abandoned oil test. Portion of electric log shown in figure 2.

* Altitude estimated from U. S. Geological Survey topographic maps. These maps have a contour interval of 10 feet except in the vicinity of wells 3, 4, 13, 14, and 15, where the contour interval is 20 feet.

a/Data from Board of Water Engineers Bulletin 6013.

b/Casing: 8 5/8 in. casing to 2,259 ft., cemented to surface with 500 sacks, tested with 1,000 psi for 30 min. without pressure loss. 5½ in. casing landed at 3,914 ft., cemented with 415 sacks, tested with 1,000 psi for 1 hr. without pressure loss. Plugged back to total depth of 3,880 ft., perforated in several intervals between 3,690 and 3,818 ft.

Table 3.--Analyses of water from the well of Major R. C. Good showing variation in quality*

(Analyses given are in parts per million, except specific conductance and pH)

Analyses by Texas State Department of Health

Date of collection	Time after pumping began	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos/Cm.)	pH
a/12-19-60	--	1.59	33	15	2,455	418	6	3,700	1.0	7,344	145	12,240	8.0
3-2-61	3 minutes	0.78	14	8	1,242	566	30	1,710	2.3	4,110	70	6,850	8.3
	1 hour	0.17	6	2	685	666	22	690	2.4	2,112	23	3,520	8.3
	2 hours	0.29	6	1	655	671	20	666	2.7	2,040	20	3,400	8.3
	3 hours	0.20	6	1	677	671	15	620	3.0	2,052	20	3,420	8.2
	4 hours	0.22	5	1	640	671	12	660	2.4	2,046	18	3,410	8.2

* All analyses showed no carbonate and less than 0.05 manganese.
a/Data furnished by City of Sherman. Nitrate was less than 0.4.

Texas Board of Water Engineers

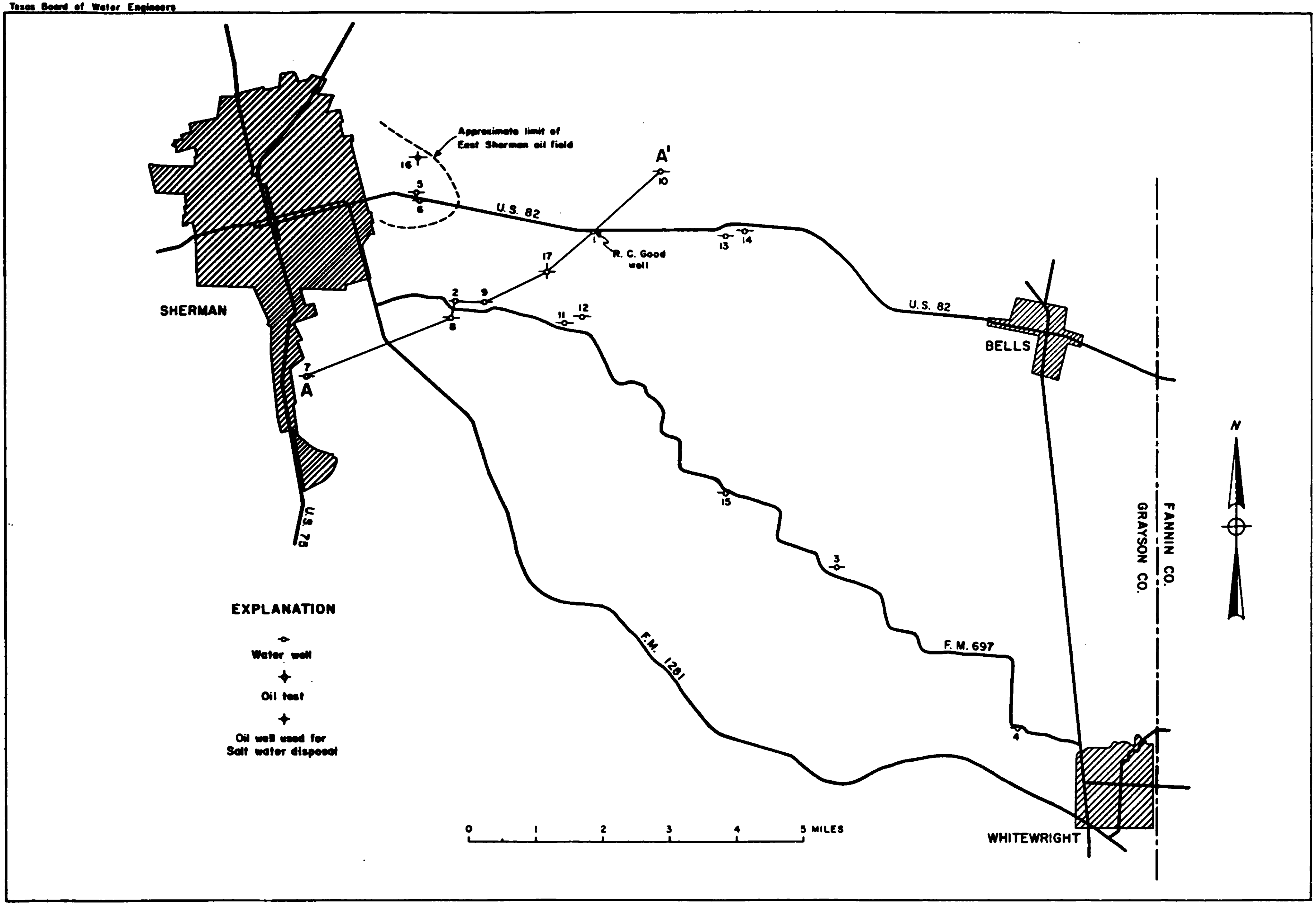

FIGURE I. - Map showing locations of selected wells east of Sherman, Grayson County

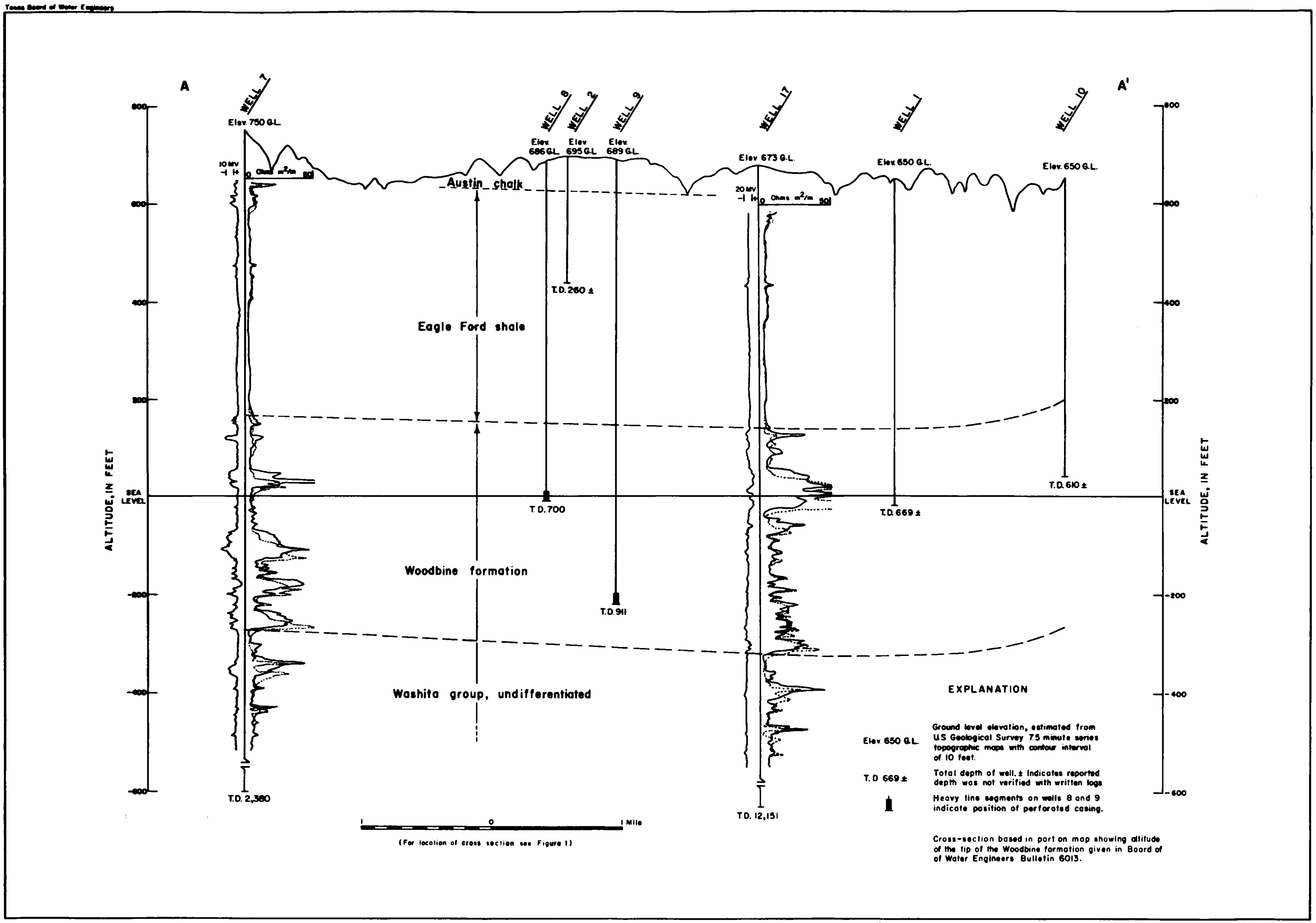

FIGURE 2.—Generalized geologic section A–A'