Report LD-0664

INVESTIGATION OF ALLEGED GROUND-WATER CONTAMINATION NEAR KILGORE GREGG COUNTY, TEXAS

By

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April 1964

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INVESTIGATION OF ALLEGED GROUND-WATER CONTAMINATION NEAR KILGORE GREGG COUNTY, TEXAS

INTRODUCTION

Purpose

The Texas Water Commission received a copy of a letter dated January 27, 1964, addressed to the Texas Railroad Commission, from Mrs. B. L. Ruffner of the Tex Water Corporation requesting assistance in determining the cause of reported "salt" taste in drinking water supplied by the Corporation's water wells west of Kilgore, Gregg County, Texas.

The letter further stated that the problem was perhaps due to improperly plugged oil tests on the Muckelroy lease, J. S. Caruthers Survey, East Texas Oil Field. It also stated that the Tex Water Corporation supplies water to approximately 2,000 people, including a large school.

A field investigation of the complaint was conducted during the period February 17 to February 20, 1964 by the writer and Mr. Bruce Fink, Geologist, Ground Water Division.

Location and Extent

The area covered by this investigation extends north and south of state highway 31 and west for approximately 2 miles from state highway 135 at the west city limits of Kilgore, Gregg County (see Figure 1 and Plate 1).

Previous Investigations

An investigation of the complaint by the Tex Water Corporation was made by Mr. R. L. Johnson of the District 6 Railroad Commission office in Kilgore. During this investigation, two water samples were collected for field chloride tests. The results of the tests made by Mr. Johnson are discussed in this report.

Three investigations of ground-water resources of Gregg County, which include the area of investigation, have been made previously. A list of the reports of these investigations is included in the Selected References of this report.

Acknowledgements

Appreciation is expressed to the East Texas Salt Water Disposal Company for the use of their field map covering the area of investigation and to Mr. Leo K. Walker, General Superintendent in charge of operation for the company,

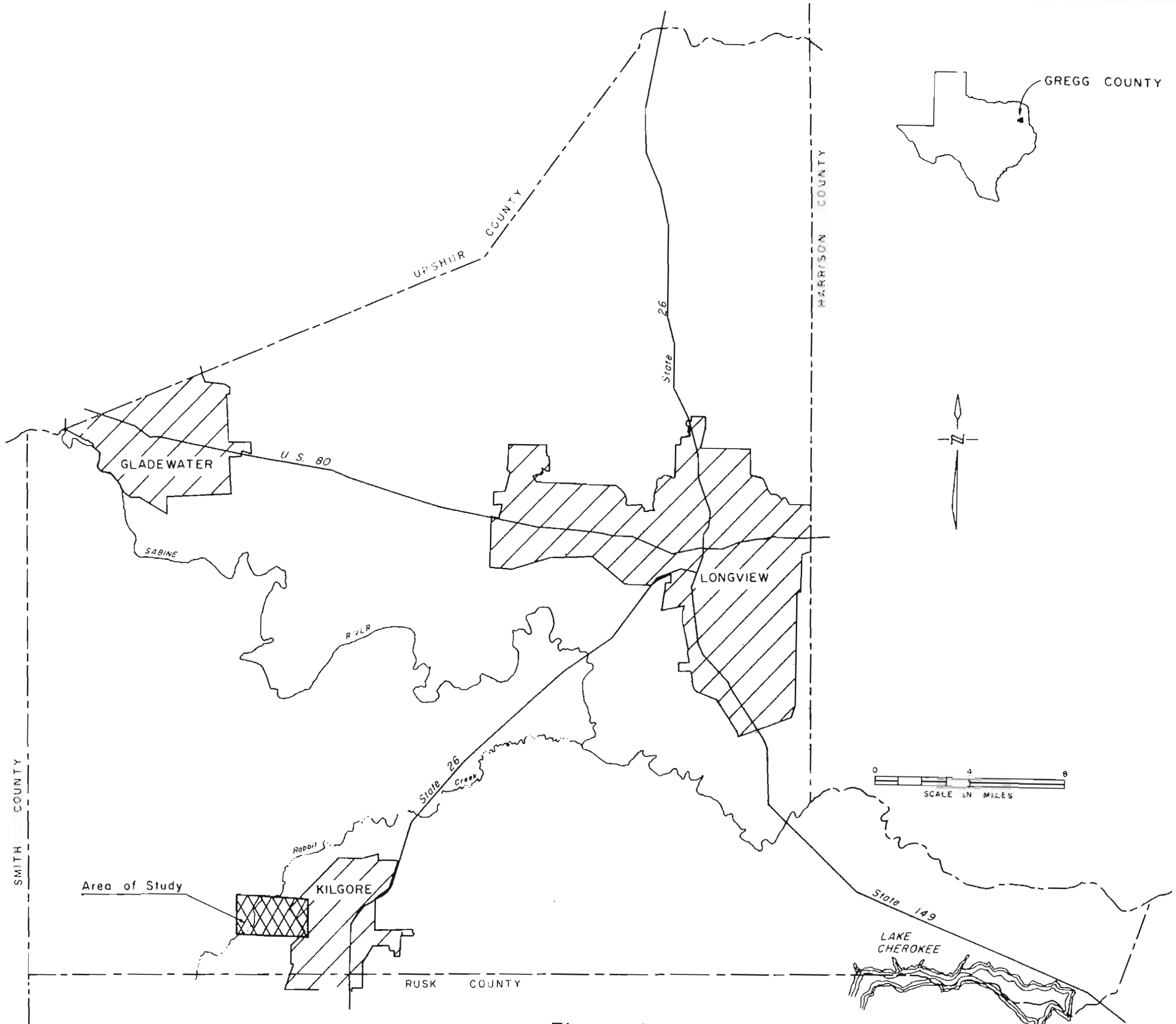

Figure 1

Index Map Showing Location of Area of Investigation

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for explaining the collection and disposal systems the company has in operation in this area of the East Texas Field.

Mr. P. J. Lehnhard, Field Chairman of The East Texas Engineering Association, provided useful information concerning the Association's operations in the East Texas Field. Special thanks are also extended Mr. R. L. Johnson, Engineer of the District 6 office, Texas Railroad Commission, for discussing the results of his investigation of the alleged contamination problem.

Appreciation is also expressed to Mr. Bruce Fink, associate, for his assistance in the field work.

Method of Investigation

During the course of this investigation special emphasis was placed on the following items:

1. Inventory of large public supply wells.

2. Compilation of existing chemical analyses and sampling of water from six water wells for additional analyses. Collection of water samples for bacteriological analysis and for analysis for algae and other organisms.

3. Collection and interpretation of readily available subsurface geologic and hydrologic data.

4. Correlation and analysis of all data to determine the nature of the alleged contamination problem.

The basic data used in the preparation of this report are given in Tables 1 and 2.

Well-Numbering System

In order to facilitate the location of wells and to avoid duplication of well numbers in present and future studies, the Texas Water Commission has adopted a statewide well-numbering system. This system is based on division of the State into quadrangles formed by degrees of latitude and longitude and the repeated division of these quadrangles into smaller ones.

The area of this investigation is in the 1-degree quadrangle number 35 and the 7-1/2 minute quadrangle number 33. All of the water wells located during the present investigation, as well as those that have previously been assigned statewide well numbers, are in the 2-1/2 minute quadrangle number 9. These wells are identified on Plate 1 by using the 9 plus the well number--that is,904. (The complete number for this well would be 35-33-904).

GEOGRAPHY

The topography of the area of investigation is hilly. Surface elevations in the area range from about 300 feet above sea level in Rabbit Creek to about 381 feet at well 909. Drainage is to the northeast along Caney and Rabbit Creeks which empty into the Sabine River northeast of Kilgore.

The natural vegetation is typical East Texas piney woods and the soils are sandy and sandy clay. Oil production and related services represent the principal economy.

GENERAL GEOLOGY AND OCCURRENCE OF GROUND WATER

Gregg County lies in the Gulf Coastal Plain of northeastern Texas. It is on the west flank of the Sabine uplift and the geologic formations dip westward into the East Texas basin. The Recklaw Formation crops out at the surface in the area of investigation. It generally consists of shale with thin layers of sand and shaley sand. The Recklaw is underlain, in descending stratigraphic order, by the Carrizo Formation and undifferentiated beds of the Wilcox Group.

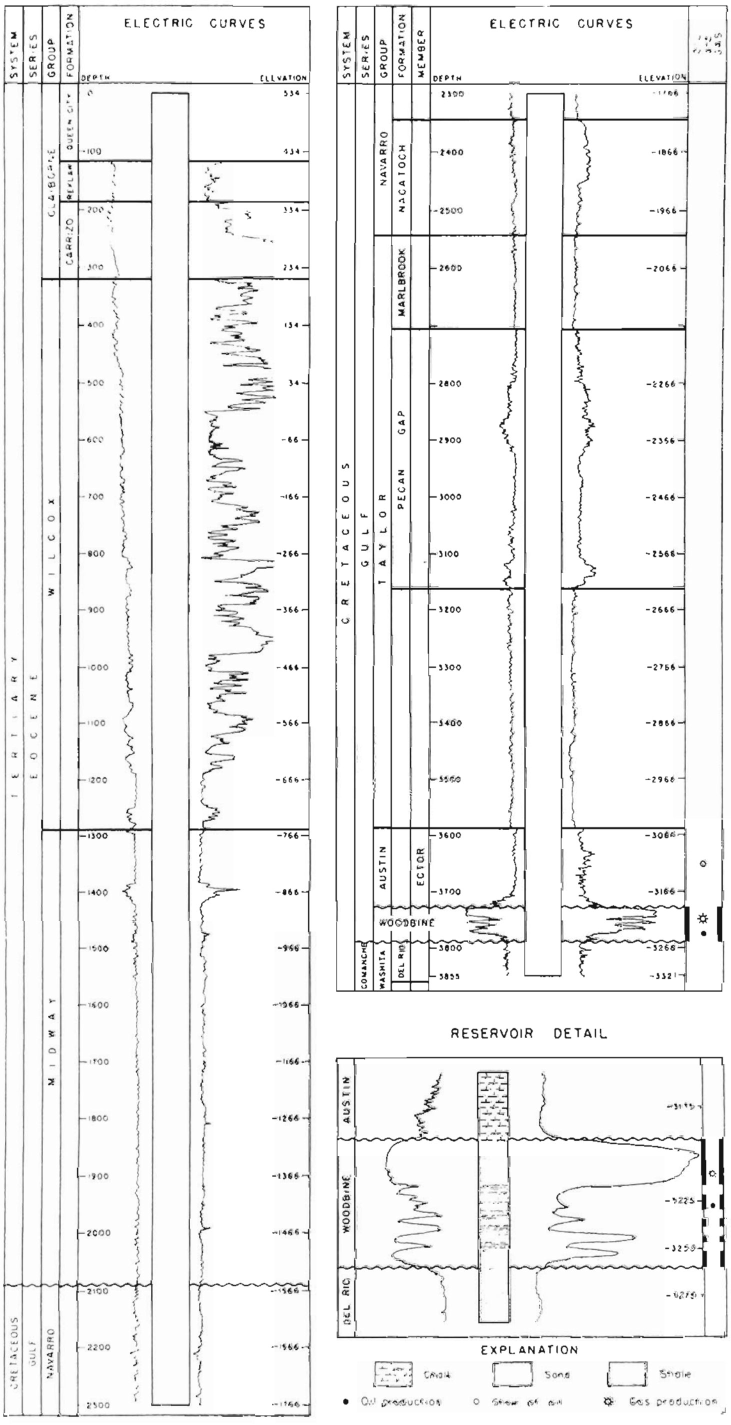
The Carrizo Formation and the Wilcox Group are the principal ground-water reservoirs in the area and the base of the Wilcox Group generally conforms with the base of usable-quality ground water or water that contains less than 3,000 ppm (parts per million) dissolved solids. Other stratigraphic units occurring below the Wilcox belong to the Midway Group of Eocene age, and the Navarro, Taylor, Austin,and Woodbine Groups of Cretaceous age.

The Carrizo Formation and Wilcox Group are two separate geologic units, having their own distinct geologic and hydrologic characteristics. The sand of the Carrizo Formation overlies sand and shale of the Wilcox Group. In places, shale beds separate the two units, and in other places the shale is missing,and sand of the Carrizo is in direct contact with upper sand beds of the Wilcox Group. Because the shale is absent in many places,the two units are hydraulically connected; therefore they are usually considered as one aquifer (Baker, 1963).

The Carrizo Formation is approximately 40 feet thick in the area. The formation consists of well-sorted, fine-to medium-grained, loosely cemented sand. Thin shale beds may occur locally in the formation, but generally they are of limited areal extent.

The Wilcox Group consists of interbedded, lenticular sand, sandy shale, shale, clay, and minor amounts of lignite. In the area, the Wilcox Group is about 850 feet thick. In the Gulf Oil Corporation No. 13 Ben Watson, the base of the Wilcox Group occurs at a depth of approximately 980 feet below ground surface. A composite electrical log showing the typical geologic section penetrated by oil tests in the East Texas field is shown in Figure 2.

TYPE SECTION OF ROCKS PENETRATED



(Adopted from Hudnall, 1950)

Figure 2

Composite Electrical Log Showing Type Section of Rocks Penetrated in the East Texas Oil Field, Gregg, Rusk, Upshur, Smith, and Cherokee Counties, Texas

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Ground water in the Carrizo-Wilcox aquifer is under artesian conditions except in the outcrop area where water table conditions normally exist. The natural hydraulic gradient is in the direction of the dip of the beds, that is, from structural highs toward structural lows. Data developed during the statewide ground-water reconnaissance investigations indicate that the hydraulic gradient in this area ranges from about 5 to 8 feet per mile toward the west. However, changes in the natural gradient may be expected to exist in the vicinity of well fields where large volumes of ground water are pumped to supply municipalities and industries. Cones of depression in the piezometric surface develop in the vicinity of the well fields, causing water to move toward these points of discharge.

The chemical quality of water in the Carrizo-Wilcox aquifer varies from place to place and with depth. In the area of study, the water is a sodium bicarbonate water and locally has objectionable amounts of iron. In general, ground water in the lower part of the Wilcox is somewhat more highly mineralized than water in the upper sand beds.

Data on water wells located in this investigation indicate that the wells are completed in upper sand beds of the Wilcox part of the aquifer. Chemical analyses of water taken from these wells are given in Table 2. These analyses indicate that the quality of water is presently within the limits set by the U. S. Public Health Service for drinking water used on interstate carriers.

OIL DEVELOPMENT

Oil was discovered in the East Texas field in 1931. Production is from the Woodbine Group at a depth of about 3,550 feet below ground surface in the area of investigation. The extent of oil development in the area of current investigation is indicated on Plate 1. Many of the wells shown in the map area (Plate 1) have been plugged and abandoned because of water encroachment.

Oil producing sands of the Woodbine Group are water-drive reservoirs. Available data indicate three factors are responsible for the encroachment of water in the field---these being (1) compaction of the Woodbine throughout the oil field and extending into the East Texas Basin, (2) expansion of the water within the reservoir throughout the basin due to release of pressure, and (3) expansion of gas, both gas in solution in the water and as free gas trapped in sand lenses (Hudnall, 1950).

Available bottom hole pressure data on the Woodbine reservoir in the area of investigation indicate a decrease in pressure from about 1,175 psi (pounds per square inch) on the west to about 1,050 psi on the east, which is a differential of about 125 psi. This pressure differential can probably be attributed to low formation permeability so that equalization of pressure does not readily occur. The apparent pressure differential indicates a pressure build-up of about 60 pounds in the past 15 years which might be related to increased salt water injection operations on the west side of the field.

Methods of Well Completion and Abandonment

Records of the Texas Railroad Commission indicate that in many of the older oil tests in the area surface casing was not set at a sufficient depth to protect ground water of usable quality. The production casing was commonly set on top of the producing formation and cemented back up the hole to varying depths. Data are not readily available as to the amount of cement used in setting casing in these wells.

According to Mr. Johnson, Railroad Commission plugging reports indicate that in plugging an oil test in this area, the production casing is commonly pulled, a cement plug is placed at the top of the Woodbine Group, and the hole is filled with 10-pound mud.

The Railroad Commission reports that a number of oil tests in this area were deviated from the vertical and these wells have been required to be plugged. In plugging a deviated test, where the production casing is to be left in the well, the Railroad Commission requires that the producing interval be squeezed-cemented, the casing filled with 10-pound mud up to 1,500 feet, and from 1,500 feet to the surface the casing must be filled with cement. If the production casing is to be pulled, the Railroad Commission requires (1) a cement plug be set at the top of the Woodbine, (2) a 200-foot cement plug set at the casing-cutoff point, 100 feet of cement in the top of the casing left in the hole and 100 feet of cement above the cutoff point, (3) the surface casing to be left in the well and a cement plug placed 50 feet above and 50 feet below the base of the surface casing, (4) a 50-foot cement plug in the top of the surface casing and (5) all intervals not cemented filled with 10-pound mud.

BRINE PRODUCTION AND DISPOSAL

The volume of brine produced with oil in the area of investigation was not determined. Most of the brine is apparently handled by the East Texas Salt Water Disposal Company. Several salt-water collection pits were noted in the area; however, the nearest injection well is located approximately one and one-half miles southwest of the area. Mr. Leo K. Walker of the Salt Water Disposal Company pointed out that his company disposed of approximately 397,000 barrels of salt water daily in the entire East Texas field during the month of January, 1964, with a maximum injection pressure of 400 psi; in some injection wells the water was taken by gravity.

Woodbine salt water produced in the East Texas Field ranges from about 27,000 ppm to 36,000 ppm chloride with an average of about 34,000 ppm. Total dissolved solids of the water are about 60,000 ppm. The estimated average specific gravity of the water is 1.045 at 60°F.

SUMMARY OF INVESTIGATION

The complaints received from customers of the Tex Water Corporation indicated that the water had a "salty" or mineral taste and that sometimes the water had a bad odor similar to rotten eggs or sewage. The owners of the Tex Water Corporation noted that salt water was seeping at the surface at the location of the Baton Swabbing Company No. 1-A Muckelroy abandoned oil test (see Plate 1). The owners stated that possibly the well was not properly plugged and that a nearby salt-water disposal well was increasing the pressure on the Woodbine reservoir causing salt water to come in contact with the fresh water aquifers and also causing salt-water seeps at the surface. It was pointed out that a salt-water collection pit was located on the Sklar Oil Company Muckelroy lease and that possibly a salt water disposal well was located at the pit. The Tex Water Corporation had previously filed a complaint with the Kilgore office of the Railroad Commission, and the complaint was subsequently investigated by Mr. R. L. Johnson of that office.

In discussions with Mr. Johnson, he stated that his investigation consisted of collecting water samples from wells 907 and 908 (Plate 1) for a field test for chloride. His test indicated that the water from wells 907 and 908 contained 18 ppm and 16 ppm chloride respectively. Also, Mr. Johnson, in the company of Mr. Dick Finney of Baton Swabbing Company, visited the location of the No. 1-A Muckelroy and noted that the salt water seeping at the surface was due to a corrosion leak in the bull plug in the old flow line. The flow line, which previously carried oil from the No. 1-A Muckelroy to the tank battery, was buried and pressure was still on the line. When this location was inspected during the present investigation, salt water was still leaking from the corroded bull plug.

Salt water collected in the pit located on the Sklar Oil Company Muckelroy lease is not disposed of at that location. The salt water is pumped from the collection pit through the East Texas Salt Water Disposal Company's distribution system to injection wells located west of the area of investigation.

In the area of water well 908, available data indicate the bottom hole pressure in the Woodbine ranges from approximately 1,100 psi to 1,150 psi. Assuming an average bottom hole pressure of 1,125 psi in the Woodbine in the vicinity of water well 908, this pressure would be sufficient to raise a column of water (water with a specific gravity of 1.045) in a well bore approximately 2,480 feet. The top of the Woodbine Group in the Gulf Oil Corporation No. 13 Ben Watson is at 3,574 feet below ground surface. If it is assumed that the static fluid level is 2,480 feet above the top of the Woodbine, this would indicate that the fluid level was about 1,094 feet below ground surface. The base of the Carrizo-Wilcox aquifer is at a depth of approximately 980 feet below the surface, indicating that the Woodbine fluid would not be in contact with the aquifer at the present time.

Chemical analyses of water collected from wells during the current investigation do not indicate any significant alteration in the degree of mineralization or chemical character of the water in the upper part of the Carrizo-Wilcox aquifer as would be expected by introduction of sodium chloride brine produced from the Woodbine oil reservoir. Analyses given in Table 2 indicate minor variations in some of the mineral constituents over a period of time; however, these variations can probably be attributed at least partly to differences in laboratory procedures at the various laboratories where the samples were analyzed.

Water samples collected for bacteriological analyses from the Tex Water Corporation's wells 907, 908, and 909 did not indicate the presence of coliform organisms which might indicate bacteriological pollution of sewage origin. The water sample collected from well 904, located at the old Shell Oil Company camp, indicated the presence of coliform organisms with a confirmed test of 5; however, due to the size of the discharge pipe the sample was collected from, it is possible that the pipe was not adequately sterilized when the sample was collected. The chemical analysis of water from this well did not indicate abnormal nitrate content which would suggest organic pollution.

Four water samples were collected to determine if algae and other nuisance organisms were present in the ground water. Analyses of samples from wells 907 and 909 indicated no such organisms present. The analysis of water from well 904 indicated the presence of a very few filamentous "iron bacteria" and the analysis of water from well 908 indicated the presence of a number of filamentous "iron bacteria". No algae was reported in any of the samples collected.

The filamentous organisms associated with iron, and therefore termed "iron bacteria", are not true bacteria but represent a somewhat higher form of plant life. The most common of these organisms are Crenothrix, Leptothrix, and Gallionella.

A discussion of the nature and growth of these organisms taken from the American Water Works Association manual Water Quality and Treatment is given below.

> The fouling of water pipes carrying iron-and manganese-bearing water is now recognized as being the result of a complex series of biochemical reactions. ---Some of the factors which must be considered in attempting to explain the observed phenomena as they occur in water pipes can be summarized as follows: (a) Crenothrix and associated organisms thrive in water which bear traces of either iron or manganese salts or both. They develop in clumps or as slime attached to the wells of the pipe or other submerged surfaces. (b) The actively growing bacteria produce alkaline conditions which are favorable to the local or intercellular precipitation of the metal ions as insoluble hydrates.--- (d) During the process of organic decay, the chemical reactions are reversible and the local production of acid and lowered oxidation potential induces solution of the metal hydrates. The process of decay is accompanied by taste and odor production. (e) Local variation in pH and oxidation potential brought about by resistance to diffusion caused by cell walls and barriers are the cause of corrosion circuits, the by-products of which furnish additional nutrient material and increase the rate of deposition. (f) Precipitation of iron and manganese is catalyzed by existing deposits

of oxides of iron and manganese and depositions of this type grow by accretion.

The net result of these complex processes is that iron and manganese accumulate in distribution systems. The absence of oxygen, expecially in dead-end mains, will favor the reduction of sulfates to sulfides, which combine with iron and otherwise form odorous compounds. Organic matter in the nature of tannin will combinee with iron to form a black deposit, similar in appearance to ink. Thus, the problem is to remove iron and manganese from waters prior to their entrance into distribution systems, so as to deprive these organisms of necessary food, or to prevent their growth by the use of disinfectants.

Analysis for the Crenothrix and associated organisms do not always show the presence of the organisms. This is due to the manner in which the organisms grow and attach themselves to the pipes and casing walls in clumps or as slime. Initial surges of water through the pipe or casing have a tendency to temporarily remove the growths and clear the residual odors. One of the Water Corporation's customers reported that the water had a very bad odor early in the morning; however, later in the day the odor was not apparent. These organisms also cause plugging of the well screen, casing perforations, and may also plug the pore spaces of the water-bearing formation in the vicinity of the well bore, all of which may seriously decrease the well yield.

A number of treatment processes such as aeration, chlorination, sand filtration, and inhibited muriatic acid are commonly used for the attempted control of the growth of these organisms. In some instances, however, these methods have not proved completedly successful. LBA (Liquid Antibacterial Acid) is a new organic acid formulation which has reportedly been very successful in initial tests (Luthy, 1964).

CONCLUSIONS AND RECOMMENDATIONS

The chemical analyses of the water samples collected from water wells during this investigation show no indication of contamination from highly mineralized oil-field brines. Bottom hole pressure data on oil tests completed in the Woodbine indicate reservoir pressure at present is not sufficiently high to bring the Woodbine brine in contact with the upper Wilcox sands from which the water wells in this area produce. Brine injection operations apparently have not as yet created excessive pressure in the Woodbine reservoirs. The location of the leaking flow line and the volume of fluid lost do not appear to have any bearing on the present conditions of the water produced from the water wells.

Bacteriological analyses of the water do not indicate any contamination to the aquifer by coliform organisms. However, analyses for algae and other nuisance organisms indicate the presence of filamentous "iron bacteria" in wells 904 and 908.

It is recommended that the Railroad Commission require the operator to make the necessary corrections to stop the seepage from the abandoned flow line at the No. 1-A Muckelroy location.

It is further recommended that the Tex Water Corporation contact the Texas State Department of Health regarding methods of treating the water and well equipment to correct the odor and taste problem that is probably caused by the presence of "iron bacteria".

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U. S. Public Health Service, 1962, Drinking water standards: Federal Register, Mar. 6, pp. 2152-2155.

*Name of agency changed to Texas Water Commission January 30, 1962.

Table 1. --Records of water wells in the area of investigation, Gregg County, Texas

Method of lift and type of power: C, cylinder; T, turbine; E, electric; N, none.
Use of water : D, domestic; PS, public supply; N, none.

Well No.	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water Bearing unit	Water Level: Below land surface datum (ft.)	Water Level: Date of Measurement	Method of lift	Horsepower	Use of Water	Remarks
35-33-904	Shell Oil Co. (Shell Camp)	Layne-Texas	1931	528	10	450	Carrizo-Wilcox	165.6 154.8	5- 9-61 2-19-61	T,E	10	PS	Well No. 476 in Gregg Co. W.P.A. report, 1937.
35-33-906	Tex Water Corporation		1931	950	12	-	do	46.2	2-20-64	N		N	
35-33-907	do	Hawkeye Petr. Co.	1931	650	7	650	do	160	5-61	C,E	2	PS	Well not pumped in over 10 years. Water reported highly saline.
35-33-908	do	Cobb	1951	527	7	527	do	175	5-61	T,E	5	PS	Well No. 479 in Gregg Co. W.PA. report, 1937.
35-33-909	do		1956	501	7	501	do	160	5-61	T,E	5	PS	
35-33-912	Ben Watson	Max Herring		528			do			C,E		D	
35-33-913	Sklar Production Co.	Gulf Oil Co.	1946	400±			do			C,E		PS	

Table 2. -- Chemical analyses of samples of ground water in the Kilgore area, Gregg County

(Analyses given are in parts per million except Specific Conductance, pH, Percent Sodium, and SAR)

Well	Owner	Depth of Well (ft.)	Date of Collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Flouride (F)	Nitrate (NO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Percent Sodium	Specific Conductance (Micromhos at 25 C.)	pH
*35-33-904	Shell Oil Co.	528	4-13-36	-	-	-	4	184	457	21	14.0	-	-	448	16	-	-	-
+35-33-904	do	-	5- 9-61	13	0.1	.5	0	171	412	22	8.5	0.4	.00	418	1	100	682	8.2
‡35-33-904	do	-	2-19-64	13	-		1	188	428	24	8.0	0.5	0.4	462	4	-	776	8.8
*35-33-907	Tex Water Corp.	650	5-29-36	-	-	-	-	-	506	31	13.0	-	-	479	-	-	-	-
‡35-33-907	do	-	2-19-64	13	-		2	208	473	25	8.0	0.7	0.4	510	4	-	845	8.8
+35-33-908	Tex Water Corp.	527	5-26-61	13	0.02	.5	0	186	439	23	9.0	0.4	0.8	453	1	100	739	8.3
‡35-33-908	do	-	2-19-64	12	-		2	201	458	24	9.0	0.6	0.4	466	4	-	822	8.8
‡35-33-909	Tex Water Corp.	501	2-19-64	14	-		2	211	473	22	11.0	0.7	0.4	509	4	-	853	8.8
‡35-33-912	Tex Water Corp.	528	2-19-64	14	-		1	194	443	26	8.0	0.4	0.4	484	4	-	800	8.9
‡35-33-913	Tex Water Corp.	400±	2-19-64	13	-		1	170	387	18	9.0	0.5	0.4	413	3	-	696	8.6

* Analyses from Gregg County, Texas, Works Progress Administration Ground Water Survey, February 1937.
\+ Analyses by the U. S. Geological Survey.
‡ Analyses by the Texas State Department of Health.

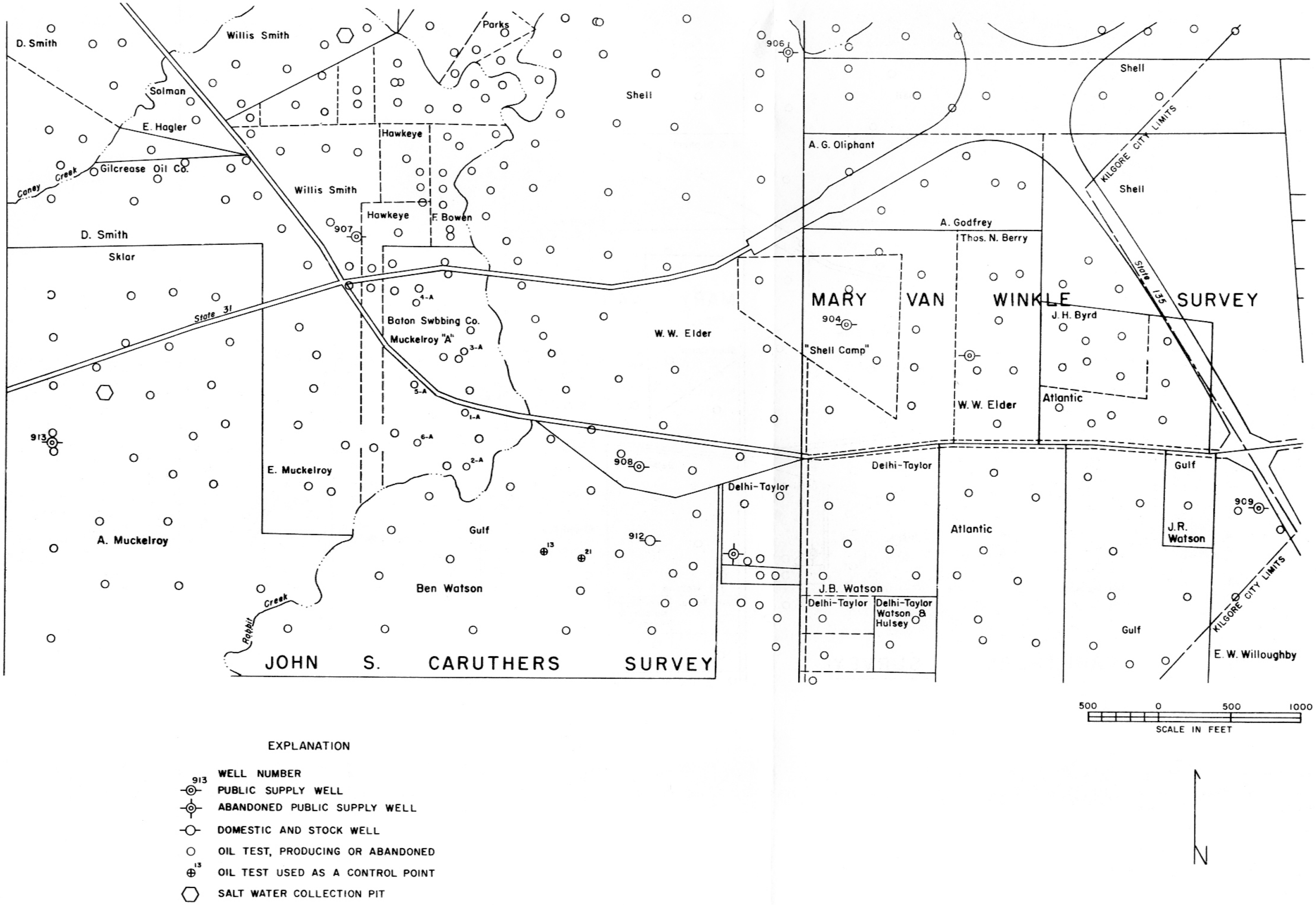

Plate I

Map Showing Location of Water Wells and Oil Tests in the Area of Investigation West of Kilgore, Gregg County, Texas

Texas Water Commission