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CONTAMINATION OF SURFACE AND GROUND WATER IN SOUTHEAST YOUNG COUNTY, TEXAS

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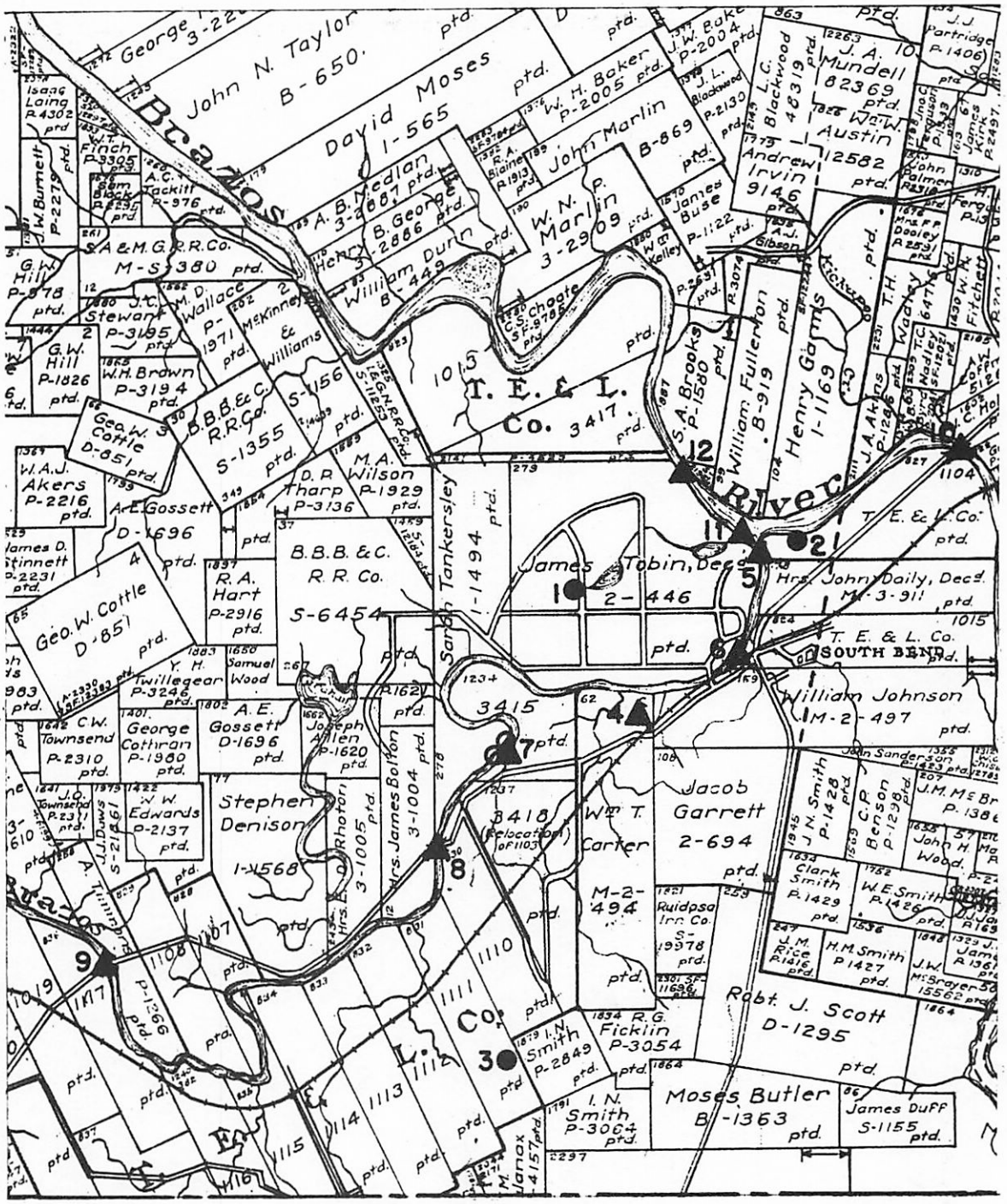
Introduction

In southeast Young County, oil field brines are produced from stratified marine rocks of Pennsylvanian and Mississippian ages. Brine is pumped or flows to the surface with oil production from many wells that tap "pay" horizons which range in depth from 1,900 to 4,500 feet. The brine is of little economic value being used locally only for bathing purposes. Hence, it is disposed largely as waste and is thus a liquid contaminant. Because of inadequate disposal methods the brine, has mingled with surface and ground waters and impaired their quality locally beyond beneficial use.

This investigation is concerned specifically with contamination of shallow ground water in the alluvium of Clear Fork near its confluence with the Brazos River (figure 1). In addition, however, sources of brine and disposal methods were investigated briefly in the Salt Creek watershed north of Graham, Texas. City officials of Graham are concerned about present methods of disposal on this watershed and the possible contamination of proposed surface storage.

Ground-water conditions with reference to percolation of brine in the shallow subsurface were investigated April 12 to 14, 1956. Disposal pits, wells that flow "salt" water, and domestic water wells that have become too salty for use were inspected and water samples obtained. Samples of stream flow of Clear



O
Abandoned oil wells

SAMPLING POINTS

▲
Stream flow

●
Wells

FIGURE 1 — MAP OF SOUTH BEND AREA
SHOWING THE LOCATION OF SAMPLING POINTS

Fork and the Brazos River were obtained at sites above and below their confluence.

Resume of Oil Development

Reportedly, oil production began near South Bend in about 1918 with the completion of a well known as the "Lindy Lou" by the North American Oil Company in about the J. G. Garrett Survey, Abstract 108. An oil boom ensued, reaching peak drilling activity in 1922 and subsiding in 1929. During this period, oil was produced without regard to well spacing or flow regulations. Field and pool gas pressures were largely dissipated and many individual wells, capable of several thousand barrels initial daily production, began to flow "salt" water shortly after completion.

The number of wells drilled during this period was not precisely determined but estimates by informed residents of the area run as high as 200. As the wells began to produce brine many were plugged with drilling mud or merely filled with rock and dirt. These methods were inadequate and did not eliminate leakage upward between water-bearing formations of different hydrostatic head. Two old oil wells were visited which are on the left bank of Clear Fork in the SW part of the S. Tankersly Survey, A-278. These wells were never plugged and long-time residents report that they discharged "salt" water for many years. The wells are caved and covered by silt and clay. There is no direct "salt" water discharge but leakage through alluvial deposits is evident by brine precipitates.

There was little drilling activity in the 1930's due to adverse economic conditions. Oil leases were allowed to lapse and revert to original land owners. With the approach of World War II, leases were renewed and new "pay" zones were

explored with modern drilling methods. Oil is now produced under conservation laws of Texas enforced by the Railroad Commission. Considerable brine is produced with the oil but is not disposed under any regulation and locally discharges directly into surface drainage ways.

Geologic Setting

Stratified rocks that form the surface are a succession of sandstone, shale and limestone belonging to the Cisco group of Pennsylvanian age. These strata dip northwestward an average of 40 feet to the mile with local flattening or dip reversal. Members of the Graham and Thrifty formations crop out in the vicinity of South Bend near the confluence of Clear Fork and the Brazos River. Members of the Harpersville and Pueblo formations crop out in the Salt Creek watershed.

The stratigraphic section from a depth of about 1,900 feet to the Chappel limestone at an average depth of 4,500 feet produces oil and salt water from structural and stratigraphic traps. This section, together with formations of the Cisco group appear in Table 1 which was compiled from all available sources, but principally Bulletin 3232 of the Bureau of Economic Geology of the University of Texas.

Ground Water Hydrology

The occurrence of both brine and ground water was investigated, therefore, a distinction is made. The brine is believed to be largely connate water entrapped in the interstices of the sedimentary rocks at the time of deposition. The science of ground-water hydrology deals primarily with that part of the hydrologic cycle beginning with infiltration of precipitation and runoff into rocks of the earth's

Table 1. Rocks in Southeast Young County, Texas
(Compiled from all available sources)

System	Epoch or Series	Formation and Member	Thickness	Physical Characteristics	Hydraulic Characteristics
Quaternary	Recent	Alluvium	0-50(?)	Lenticular sand and gravel covered and admixed with clay and silt derived from rocks of the Cisco group.	Contains unconfined ground water. Water quality has deteriorated owing to pollution of major stream by "salt" water.
Pennsylvanian	Cisco group	Pueblo fm Camp Colorado ls Stockwether ls	168-207	Chiefly shale, sandy shale and sandstone with numerous thin beds of limestone, many of which are discontinuous. Formation contains a great many unconformities which are particularly conspicuous in the lower formation. Throughout the Cisco section are channel deposits of sand, sandstone and some conglomerate.	Sandy members contain usable ground water locally for a short distance down dip from the outcrop. The formations largely contain "salt" water which in geologic time has migrated from lower horizons under hydrostatic head to near-surface horizons.
		Harpersville fm Saddle Creek ls Upper Waldrip ls Middle Waldrip ls Lower Waldrip ls	180-233		
		Thrifty fm Breckenridge ls Black Ranch ls Ivan ls Avis ss	117-215		
		Graham fm Gunsight ls Bunger ls Gonzales ls	510-590		

Table 1. Rocks in Southeast Young County--Continued

System	Epoch or Series	Formation and Member	Thickness	Physical Characteristics	Hydraulic Characteristics
Pennsylvanian		Caddo Creek fm Home Creek ls Colony Creek shale	350	Shale, sandy shale, sandstone and limestone	Contains little or no ground water in this area. Permeable zones contain oil or "salt" water.
	Canyon group	Brad fm Ranger ls Placid shale Winchell ls	125-200 --		
		Graford fm Wolf Mt. shale Willis ls Posidium shale Palo Pinto ls	550 50-100		
		Mineral Wells fm	750-800		Permeable zones contain usable water in and immediately down dip from outcrop areas.
	Strawn group	Garner fm Brazos R. cg Thurber coal	400-500	Shale, sandstone and conglomerate with thin seam of coal at the base.	
		Milsap Lake fm	1,600-3,000	Largely shale with thin beds of sandstone and some conglomerate.	

Table 1. Rocks in Southeast Young County--Continued

System	Epoch or Series	Formation and Member	Thickness	Physical Characteristics	Hydraulic Characteristics
Pennsylvanian	Bend group	Smithwick shale	300-600	Shale and interbedded limestone	Permeable zones probably contain "salt" water.
		Marble Falls ls	350-600	Limestone with thin strata of shale.	
Mississippian		Bennett shale	100-200	Largely shale with a few feet of limestone at the top. Shale is very bituminous, it is dark with usually a brown tinge.	
		Chappel ls	150±	Hard, medium dark limestone, with abundant crinoid fragments	Highly mineralized "salt" water occurs in limestone. (See analysis of Stovall Hot Well)

crust and movement therein until discharged naturally by springs or artifically by wells. Ground water in Young County thus occurs in coarse-grained channel deposits of the Cisco group and in stream alluvium of Recent geologic age. Ground water enters sandstone beds of the Cisco group at their outcrops and percolates down dip and forms an interface or mingles with brine. The depth of ground-water occurrence is controlled by stratigraphic and hydrostatic conditions and, in southeast Young County, is not known to exceed a 100 feet. Excessive oil development and inadequate plugging methods have permitted interformational leakage. Brines from deeper strata have invaded near-surface strata and mingled with confined ground-water storage where there is sufficient difference in hydrostatic head in old, improperly plugged wells.

The alluvium of the Clear Fork and the Brazos River is recharged largely by flood runoff. Locally it is recharged by brine intrusion under conditions of interformational leakage as described above or by direct disposal of the brine on alluvial surfaces.

Meager data were obtained concerning the effects of percolation of the brine in alluvium near the confluence of Clear Fork and the Brazos River. Reportedly, a well dug in 1919, 103 feet deep, in the NW Cor. of T. Daily Survey, Abstract 78, obtained water too salty for use. A well dug in 1912, 65 feet deep, in T. E. & L. Co. Survey, Abstract 827, produced 2 to 5 gpm of highly mineralized, but usable, water until the Fall of 1955, at which time it became too salty for use.

"Salt" water seeps appear along the stream banks in this general area but they cannot be correlated with definite sources from the available data. Some were noted down gradient from the Stovall Hot Well which is about 3,500 feet south

and 3,200 feet east of the NW Cor. of the J. Tobin Survey, Abstract 279. Reportedly, the well was drilled 4,250 feet deep and bottomed in limestone in Mississippian age. The well flows an estimated 2,400 bbls. (70 gpm) of brine which is used for bathing and "healing" purposes. The water is disposed in a nearby pond and part of it percolates to the underlying alluvium. A drainage ditch leads from the lake to the Brazos River through which the lake overflows directly to the stream. This well apparently is a prime source of contamination to underlying alluvial deposits and ultimately to the stream flow of Clear Fork and the Brazos River.

Water Quality

The presence of excessive amounts of sodium and chloride in waters in this area was determined by partial chemical analyses (Table 2) which were made by the U. S. Geological Survey.

The most objectionable brine obtained was from Mississippian rocks in the Stovall Hot Well. The water obtained at the McClusky #2 well is partly from Mississippian rocks and partly from Pennsylvanian rocks. Water in Clear Fork ranged in chloride content from 10,200 to 1,060. The quality of the water improved upstream from the area of greatest oil development. The most highly mineralized surface water was found on the McClusky Place about 1-3/4 miles southwest of South Bend. This sample was obtained opposite two wells near the right bank of Clear Fork that reportedly had never been plugged. Within a radius of 1/2 mile from this sampling point incomplete records show that 121 oil wells were drilled. Most of them have been plugged and abandoned, but as previously stated, the methods by which they were plugged were inadequate.

Table 2.- Partial Chemical Analyses of Waters in Southeast Young County, Texas
(Constituents given in parts per million)

Sample No.	Location (approximate)	Sodium (Na)	Chloride (Cl)	Specific Conductance (Micromhos at 25°C)	Date collected
Stovall Hot Well (1)	3,500 ft. S, 3,200 ft. E, NW cor. J. Tobin Survey, A279	30,300	54,500	105,000	4-12-56
J.N. Boozer Well (2)	W part of T.E.& L. Co. Survey, A827	1,970	4,430	14,500	4-13-56
Discharge pipe at McClusky #2 Well (3)	SE-NE-S½, Sec.1111, T.E. & L. Co.Survey	29,100	50,500	100,000	4-12-56
"Salt" water seep (4)	150 ft. S, 300 ft W, NE Cor. Wm. T. Carter Survey,A62	10,600	32,500	68,300	4-12-56
Clear Fork, 100 ft. above confluence with Brazos (5)	W edge, T.E. & L. Co. Survey, A827	4,640	9,670	25,500	4-13-56
Clear Fork at South Bend (6)	W edge T.E. & L.Co. Survey, A-824	4,560	9,420	25,200	4-12-56
Clear Fork at McClusky Ranch (7)	640 ft. S, 560 ft. W of NE Cor. T.E. & L.Co. Survey, A1234	4,870	10,200	26,800	4-12-56
Clear Fork at bridge (8)	SW tip, Sarah Tankersley Survey, A278	2,810	6,130	17,400	4-12-56
Clear Fork at bridge (9)	Sw Cor., A. Timmons Survey, A258	420	1,060	3,710	4-12-56
Brazos R. at bridge (10)	SW edge, J. C. Holly Survey A1602	2,400	3,940	13,400	4-13-56
Brazos R. 100 ft. above confluence with Clear Fork (11)	E edge of J.Tobin Survey, A279	2,480	4,030		4-13-56
Brazos R. 3/4 mile above confluence with Clear Fork (12)	800 ft. SE of the NE Cor. of J. Tobin Survey, A279	2,380	3,880	13,400	4-13-56

Brine Disposal in Relation to Runoff

In the vicinity of the confluence of Clear Fork and the Brazos River, brine is disposed in surface pits. These pits overflow or reportedly are blasted open open during heavy rains. The brine contained therein spills into natural drainage ways and ultimately is discharged into the Brazos River system. Evaporation of brines in natural drains precipitates minerals which seemingly are predominantly sodium chloride. During flood runoff the minerals are redissolved and contaminate surface and shallow ground waters throughout the drainage system.

The Salt Creek watershed of about 114,000 acres contains numerous disposal pits. Brine seeps down slope from the pits have killed considerable native vegetation and precipitated minerals from the brine. The number and extent of these mineralized areas are not precisely known but they are sources of contamination in the Salt Creek watershed and will seriously impair the quality of water impounded at the lower end of the watershed.

Suggestion for further studies

A detailed investigation of the ground and surface water hydrology of southeast Young County is suggested because of the information developed and reported herein and also because of public sentiment in the area regarding unplugged wells and brine disposal methods. The information obtained should be related to the problem of pollution by oil field brines to develop adequate recommendations for brine disposal. The investigation should include but not be limited to the following: (1) A detailed inventory of available ground-water supplies (2) Correlate and tabulate available subsurface data (3) Locate and determine extent and character of brine seepage into surface drainage ways (4) Obtain selective samples of brine, ground waters and

surface waters over a period of at least 6 months (5) obtain recorded information on all known oil wells both producing and non-producing and estimate the quantity of brine produced and (6) prepare a comprehensive report for publication as a bulletin of the Board of Water Engineers. It is estimated that the investigation and report will require about 2-man years and minimum cost of about $15,000.00.

The purpose and scope of the proposed investigation is primarily for hydrologic research and basic investigation. The subsurface pollution in this area from old, improperly plugged wells cannot be corrected but the proposed investigation will contribute to a better understanding of the problem of brine disposal and thus prevent pollution of surface and ground water in undeveloped areas of Texas having similar hydrologic and geologic characteristics.

Conclusions

The quality of ground water in alluvial deposits along Clear Fork and the Brazos River is unsuitable for any beneficial use.

There is evidence that poor but usable quality ground water was developed in alluvial deposits prior to the beginning of oil development in the early 1920's; that the ground-water quality has been impaired beyond any beneficial use by shallow subsurface leakage from abandoned oil wells that were improperly plugged.

Two adandoned and reportedly unplugged oil wells on the left bank of Clear Fork near the S. Tankersley Survey, Abstract 278 may be on state land. These wells should be positively identified and records concerning them obtained.

Thereafter it may be necessary to reopen them and determine the extent and character of their reported leakage and to make recommendations for adequate plugging if necessary.

The Stovall Hot Well produces an estimated 70 gpm of brine which contaminates both ground and surface water. This contaminant should be disposed by an injection well drilled to permeable horizons below the Gunsight limestone member of the Graham formation or below 250 feet whichever is greater.

Brine disposed in pits on the Salt Creek watershed above Graham, Texas and disposed in open pits is a source of pollution throughout the watershed.

Partial analyses of brines from stratified rocks showed an average of 69,165 ppm of sodium chloride and thus approach a supersaturated solution. Only small amounts of such brine are required to contaminate available supplies of ground and surface water.