TEXAS WATER COMMISSION

Joe D. Carter, Chairman
O. F. Dent, Commissioner
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MEMORANDUM REPORT NO. 63-02

RECONNAISSANCE OF SOIL DAMAGE

AND GROUND-WATER QUALITY

FISHER COUNTY, TEXAS

By

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FOREWORD

Significantly large areas of cultivated land in Fisher County are currently being seriously affected by soil salinization. The chemical quality of the base flow of intermittant surface streams in some areas of the county has reached high levels of concentrations of total dissolved mineral solids. The results of this brief field reconnaissance indicate that these problems are related to elevated ground-water tables and in some places perhaps "perched" soil-water zones which have resulted in surface seepage of ground water where geologic and topographic conditions are favorable.

The results of this reconnaissance were orally presented by the author and Mr. Jerry T. Thornhill, Head, Waste Disposal Section, to a public meeting held at Roby on April 2, 1963. Present at this meeting were Fisher County authorities and approximately 130 landowners and other interested persons. Also present were Mr. Fred Osborne and Mr. Ed Parker, District Supervisor and District Engineer respectively of the District 7B Railroad Commission office, and several representatives of the Soil Conservation Service, United States Department of Agriculture.

During this presentation, it was emphasized that the investigation was of a very limited nature for the purpose of first determining the magnitude and seriousness of this problem. The general geology of Fisher County and the occurrence and historical chemical quality of natural ground water in the county were briefly summarized. Statistical data concerning historical rainfall records and reported volumes and methods of disposal of brine produced with oil and gas in Fisher County were also presented. Several preliminary conclusions as to probable causes of high water tables and deterioration of water quality were discussed: these included (1) changes in land management practices (land clearing, terracing, and contour plowing), which have reduced surface runoff, coupled with continuous high rainfall rates during the period 1957-62; (2) disposal of produced oil-field brine into unlined surface pits; and (3) surface and shallow subsurface leakage of brine from deep artesian aquifers, primarily the Coleman Junction Limestone. It was emphasized that the problem as a whole was possibly the effect of a combination of causes, although in several areas of the county data strongly indicated brine contamination of native ground water.

A series of recommendations for further action which is considered necessary to accurately predict causes and further effects of the present problem were then offered. These included the urgency of group organization into a committee or association which could more effectively secure help and plan remedial action. It was further recommended that a much more comprehensive study of the occurrence and quality of both ground and surface water in the county would be necessary in conjunction with a possible test-drilling program around selected oil wells or abandoned holes suspected to be leaking brine.

The results of this reconnaissance are presented in this report as it is believed that similar problems exist in many other counties of this region. The recommendations contained in the report for necessary studies and information to identify each problem and provide appropriate solutions will be helpful to individuals and groups desiring to take action in similar situations.

TEXAS WATER COMMISSION

John J. Vandertulip

John J. Vandertulip
Chief Engineer

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RECONNAISSANCE OF SOIL DAMAGE AND GROUND-WATER QUALITY FISHER COUNTY, TEXAS

INTRODUCTION

On July 5, 1962, the Texas Water Commission received a letter from Mr. H. F. Grindstaff, then County Attorney of Fisher County, requesting assistance in determining the source of alleged salt-water contamination of ground water in several areas of Fisher County. Mr. Donald C. Draper and Mr. Jerry T. Thornhill of the Ground Water Division met with Mr. Grindstaff and Mr. James Norman, County Agent, in Roby to discuss this problem. As a result of this meeting and a brief field inspection of several affected areas, it was ascertained that a potentially serious problem of soil damage and general deterioration of ground-water quality was present throughout the county. It was therefore suggested to Mr. Norman that he obtain a list of landowners in the county who were confronted with this problem and to notify the Water Commission when this information was available.

Purpose and Scope

The purpose of this reconnaissance, which was conducted by the writer and Mr. L. E. Walker, Geologist, Ground Water Division, on September 10, 12, 13, and 14, 1962, was to determine the magnitude of the problem and to reach some preliminary conclusions as to causes, so that the Commission might advise county authorities of possible courses of action. The study included: (1) a meeting with County Agent James Norman on September 10, at which time the names of all landowners that had made formal complaints were obtained; (2) location, on county ownership map, of all property allegedly affected and a discussion with each landowner, where possible; (3) the location of water wells on each of the farms visited; collection of water samples, completion data, and water-level determinations for each well, where possible; and (4) the location of areas of oil production or drilling, and brine-disposal facilities near each site visited.

Included in this report is a geologic map of Fisher County which also shows the areas of current oil and gas production, all water wells for which pertinent current data are available, and areas investigated during the current study; a geologic cross section; tables of chemical analyses of water samples; a table of reported brine production and methods of brine disposal in Fisher County for the year 1961; and a pattern diagram illustrating chemical quality of ground and surface water.

Location, Climate, and Economy

Fisher County is in west-central Texas (Figure 1) and covers approximately 906 square miles. The population in 1960 was 7,865, of which 5,073 was rural.

The county had an average annual rainfall of 20.86 inches for the period 1931-61 (Rotan Station). Annual rainfall for this period is shown in Figure 2. The mean annual temperature is 63°F with an average January temperature of 44°F and an average July temperature of 82°F. The net annual fresh water evaporation rate from a free water surface in this area for the period 1940-57 was approximately 61 inches per year.

The economy of Fisher County is based primarily upon agriculture and oil and gas production. Other industries include a large gypsum products plant and a cottonseed oil mill. Cotton is the primary agricultural product, followed by wheat, grain sorghums, oats, and corn. Several large beef cattle ranches are also located within the county. Comparatively few farms in the county practice irrigation.

Roby, the county seat with a population of about 900, is a commercial center for farming and the headquarters of a 9-county electric cooperative. Rotan, with a population of 2,788, is a farm and ranch market and shipping point.

Topography and Drainage

Topography of the region ranges from relatively level to gently rolling with altitudes ranging from approximately 1,600 to about 2,300 feet above sea level. The eastern part of the county is generally more level than the western half.

Principal surface streams in the county include the Double Mountain Fork and the Clear Fork of the Brazos River, both of which flow southeast through the county. These perennial streams are fed primarily by several intermittant streams, the largest of which are Rough Creek, Buffalo Draw, Alkali Creek, and Plum Creek.

GENERAL GEOLOGY

Rocks of sedimentary origin which range in age from Cambrian to Recent overlie the Precambrian igneous and metamorphic rocks in Fisher County. At the surface, rocks of Permian, Triassic, Tertiary, Quaternary, and Recent ages are exposed. The depositional histories of the Permian and Triassic rocks are related to a structural feature commonly known as the Permian or "West Texas" basin. These rocks were deposited in a province known as the Eastern Shelf area of the Permian basin, and they dip toward the west into the Midland basin, a subordinate feature of the great West Texas geosyncline.

It must be noted that numerous conflicts exist in stratigraphic nomenclature applied to the Permian rocks in this area. Published rock- and time-stratigraphic terms originally applied to the Permian rocks in Fisher County have been revised as a result of more recent field studies in adjacent areas where the same sequence of rocks is exposed. Furthermore, no current, accurate

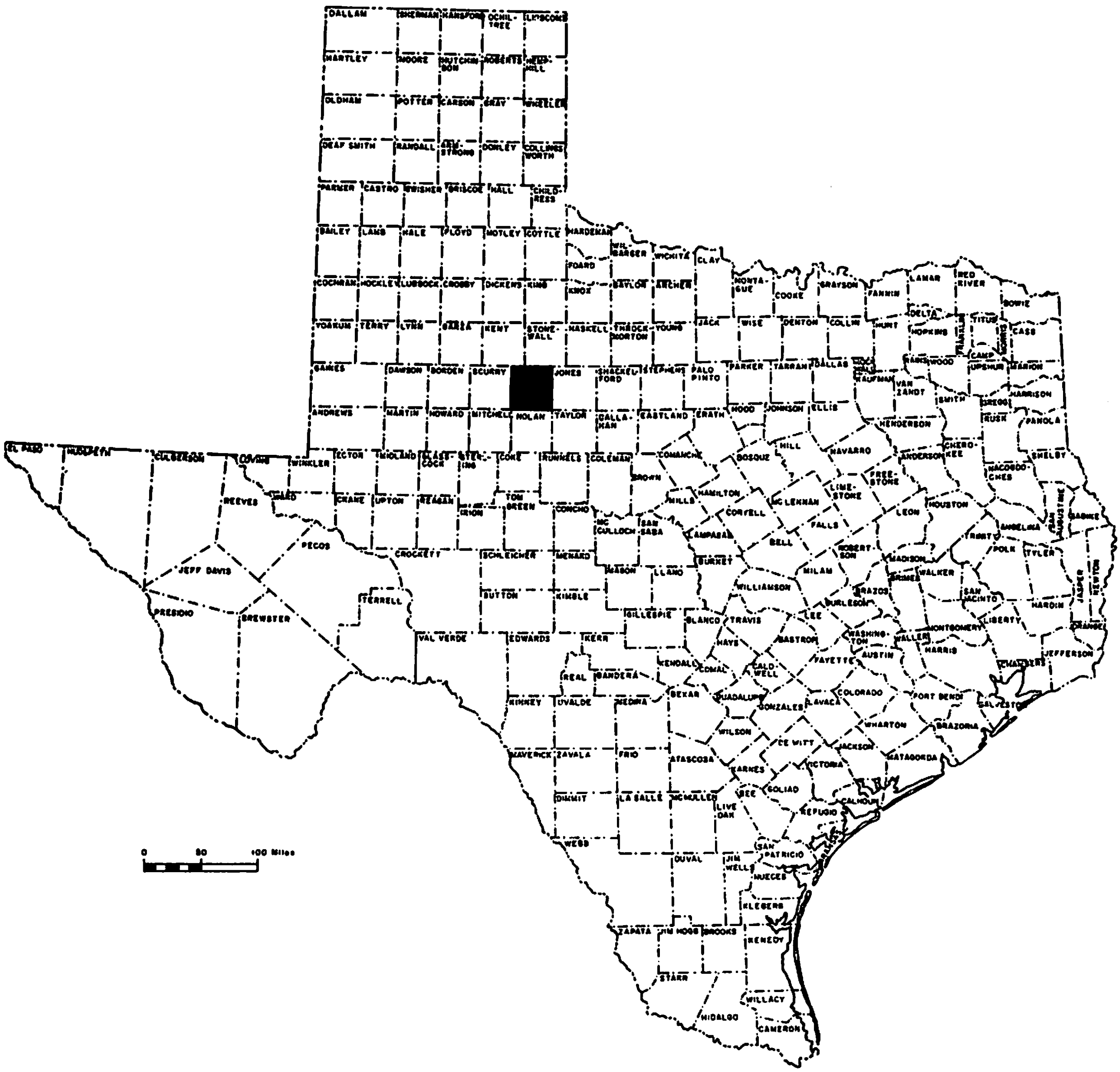

Figure 1

Index Map Showing Location of Fisher County

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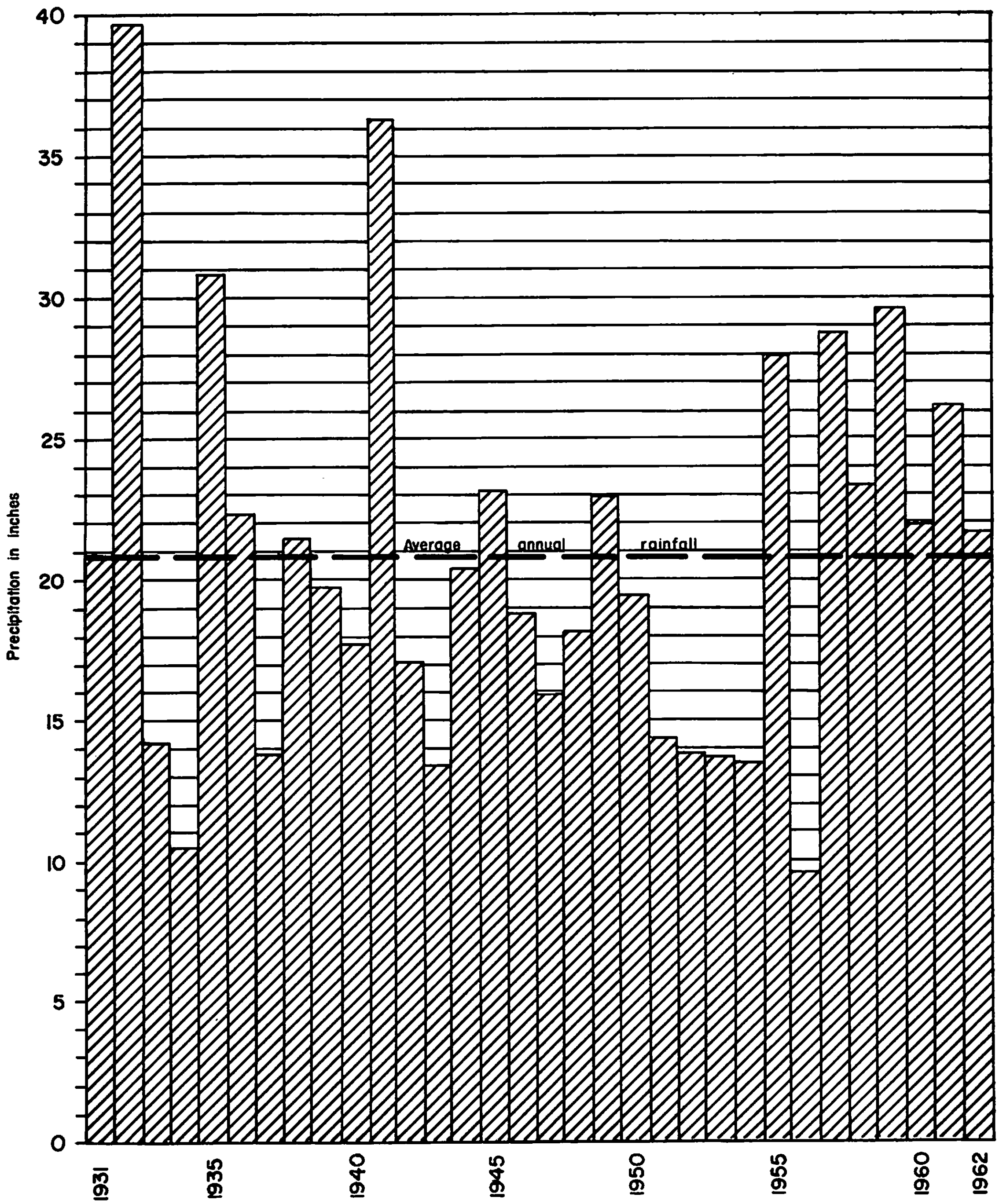

Figure 2

Average Annual Precipitation at Rotan, Fisher County, 1931-62

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geologic map has been published for Fisher County. The terminology followed in this report is believed to generally correspond to currently-used geologic nomenclature.

A composite electric log and columnar section of subsurface formations in the county is shown in Figure 3, and a somewhat generalized geologic section through Fisher County showing a part of the entire sequence of rocks present is shown in Plate 2. This section was prepared primarily to indicate stratigraphic relationships and relative depths of some of the deeper artesian brine aquifers of Permian age which are believed to be pertinent to the problems with which this report deals. Detailed stratigraphy of the shallow subsurface section is omitted, primarily because of lack of sample data and problems of correlation. The revised geologic map (Plate 1) is also somewhat generalized and delineates only the major groups or formations and several important members. Because of apparent errors in existing geologic maps of this area, further subdivision of the rocks is not indicated.

Permian System

Rocks of Permian age crop out over a large part of Fisher County. These rocks, which comprise a stratified sequence about 4,000 feet thick, are primarily chemical precipitates (limestone, dolomite, anhydrite, and gypsum) of marine origin. Rocks of Wichita and Clearfork Groups, primarily limestone and dolomite, make up the lowermost 2,500 to 2,800 feet, whereas overlying rocks of the El Reno Group (interchangeable with Pease River Group) and the Whitehorse Group are predominantly interlayered sandstone and evaporite deposits with thin intercalated shale beds. Permian rocks present at the surface in Fisher County belong to the El Reno and overlying Whitehorse Groups. They strike generally north-northeast and dip toward the west.

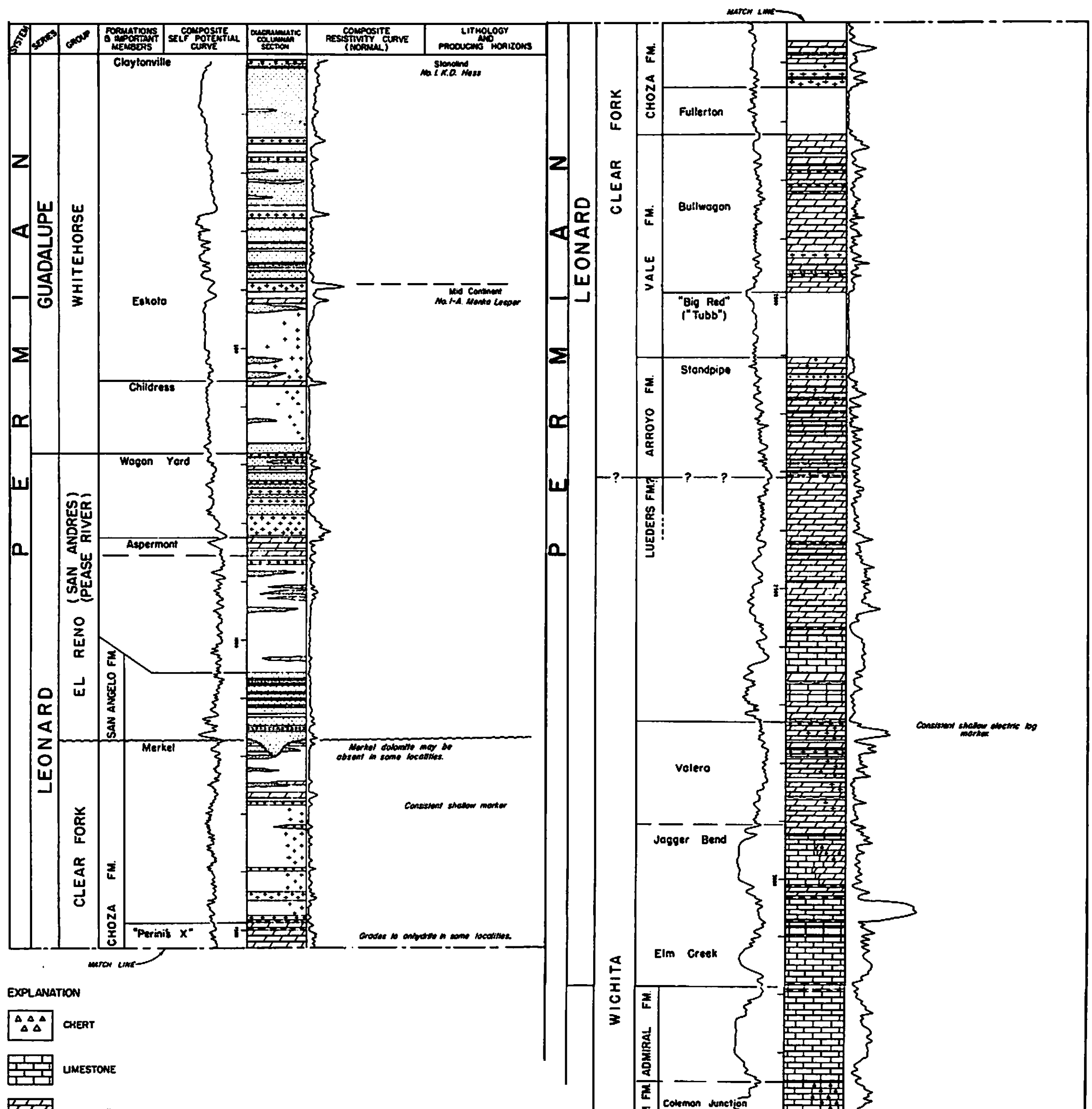
Leonard Series

El Reno Group

The El Reno Group in Fisher County includes all of the rocks between the base of the San Angelo Formation (also termed San Angelo Sandstone) and the base of the Grayburg Formation (or its equivalent) of the Whitehorse Group. It comprises a sequence of rocks approximately 500 feet thick.

The San Angelo Formation crops out along the eastern edge of Fisher County. It unconformably overlies the Choza Formation of the Clear Fork Group. The San Angelo can be recognized rather easily on electric logs in most areas by its stratigraphic position above the persistent Merkel Dolomite Member of the Choza Formation. The San Angelo Formation is made up mainly of cross-bedded, chert-bearing, conglomeratic, medium-grained sandstone with intercalated shale, clay, and conglomerate beds locally. It reaches a maximum thickness of about 150 feet in the county.

Overlying the San Angelo Formation in ascending order stratigraphically are the Flower Pot, Blaine, and Dog Creek Formations. The term Blaine is commonly used to include all these formations above the San Angelo, and for purposes of



EXPLANATION

- CHERT
- LIMESTONE
- DOLOMITE
- ANHYDRITE
- GRAY SHALE
- SANDSTONE
- RED SHALE
- LINES OF UNCONFORMITY

Figure 3

Composite Electric Log and Columnar Section (diagrammatic) of Subsurface Formations in Southwestern Fisher County

Compiled by the Stratigraphic Committee of the Abilene Geological Society

Horizontal Scale ~ Diagrammatic

0 100 200 300 Feet

Vertical Scale

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this report they are not differentiated in the geologic section. In general, the sequence consists predominantly of red shale in the lower part, massive anhydrite and dolomite beds in the middle part, and alternating fine-grained sandstone, anhydrite, and dolomite near the top. Many of the anhydrite, dolomite, and sandstone beds are lenticular and therefore difficult to map and correlate from surface to subsurface. However, several persistent members which serve as marker horizons in subsurface correlation include the Aspermont Dolomite Member of the Blaine Formation, a massively-bedded dolomite about 30 feet thick, and the Wagon Yard Gypsum, a thin gypsum bed which is defined as the uppermost bed within the El Reno Group.

Guadalupe Series

Whitehorse Group

Rocks of the Whitehorse Group conformably overlie those of the El Reno Group in Fisher County and by definition include all beds from the top of the Wagon Yard Gypsum to the top of the Claytonville Dolomite. The sequence of rocks placed within this group in Fisher County are correlative with the Grayburg, Queen, Seven Rivers, Yates, and Tansill Formations which are identifiable in areas to the west of the county. In general, the Whitehorse Group in Fisher County consists of about 700 feet of rocks which are made up of gypsiferous red shale in the lower part grading upward through alternating fine- to medium-grained sandstone, shale, and anhydrite to predominantly sandstone in the upper part. The Childress Dolomite Member in the lower part of the group reportedly correlates with the basal part of the Grayburg Formation to the west, whereas the Eskota Gypsum correlates with the upper part of the Grayburg. The Claytonville Dolomite (and anhydrite) constitutes a thin marker horizon at the top of the Whitehorse Group, and it reportedly correlates with the upper part of the Tansill Formation.

Triassic System

Dockum Group

Rocks of Late Triassic age are represented in Fisher County by the Dockum Group. The Dockum beds overlie the uneven Permian erosional surface in the southwestern part of the county, and they consist of sandy clay, medium- to coarse-grained, cross-bedded sandstone, and a basal conglomerate which has been defined as the Camp Springs Conglomerate after the community of Camp Springs in northeastern Scurry County. Locally, the Triassic beds form a prominent escarpment in some areas west of Claytonville, and they are believed to reach a maximum thickness of about 170 feet in Fisher County. The Dockum beds are of continental origin, probably representing stream alluviation and flood-plain deposition.

Quaternary System

Alluvial deposits consisting of unconsolidated sand, silt, and clay of Quaternary age overlie comparatively large areas of the Permian and Triassic rocks in Fisher County. The general extent of these surface deposits is indicated on the geologic map (Plate 1), although alluvial sediments bordering many of the streams in the area have not been mapped in detail.

A great part of these sediments are the result of stream deposition, although some are of eolian origin. Some were derived from rocks of Triassic or Cretaceous age which lie to the west; however, much of the material was apparently derived from Permain rocks which crop out in the area. Probably most of the alluvial deposits which lie north and east of the Clear Fork of the Brazos River, commonly referred to as the "shinnery sand" belt, were derived from the local Permian rocks. As a consequence, this material commonly contains a high percentage of gypsum and/or anhydrite.

The alluvium in Fisher County is relatively thin in most places, generally not exceeding about 35 feet in thickness. The maximum thickness of alluvium reported occurs east of Rotan, where approximately 80 feet of this material has been penetrated by water wells.

GROUND WATER

Occurrence

The source of ground water in Fisher County is precipitation which falls upon the land surface. The volume and quality of shallow ground water in the county is directly related to the type of rocks in which it occurs. Three principal aquifers are present; these are (1) Permian rocks, (2) Triassic rocks, and (3) Quaternary alluvium.

Permian Rocks

The Permian rocks yield very small quantities of water to wells in the county, and in most places the quality of the water is such that it is suitable only for livestock-watering purposes. The wells producing from the Permian rocks range in depth to about 200 feet, and many are converted seismic test holes. The location of wells completed in the Permian rocks indicates that most are producing from sandstone beds belonging to the Whitehorse Group. A few wells in extreme northeastern Fisher County produce from rocks of the El Reno Group, possibly from shallow sandstone of the San Angelo Formation. Several wells in the Rotan area reportedly produce water at rates up to about 50 gallons per minute from a sandstone bed, about 25 feet thick, belonging to the Whitehorse Group. For example, well no. 32 (Table 3) penetrated 3 feet of red clay and 20 feet of red sandstone below the overlying alluvial sand and gravel. These sandstone beds are probably receiving recharge from overlying thin alluvial sediments which serve as catchment areas.

Ground water in very shallow Permian siltstone and sandstone in some areas is apparently under water-table conditions. Locally, however, water in the near-surface Permian rocks is under moderate artesian pressure. Saline water in some of the deeper permeable strata of the El Reno Group is reportedly under sufficient artesian head to flow at the surface in areas of eastern Fisher County.

Comprehensive investigations of the surface and shallow subsurface geology of Fisher County are needed to more accurately determine the exact stratigraphic position of local, permeable, water-bearing beds of Permian age and the position of the interface between moderately saline water and underlying highly mineralized water.

Triassic Rocks

Sandstone and conglomerate of the Dockum Group yield moderate volumes of water to wells in southwestern Fisher County. These wells reportedly range in depth to about 175 feet, and water is produced primarily from conglomerate and conglomeratic sandstone which predominates near the base of this sequence. Near the eastern edge of the Triassic escarpment, well yields are generally low, primarily because effluent ground-water flow into stream valleys which dissect the escarpment has partly dewatered the aquifer. Toward the west, however, the saturated thickness of the Triassic rocks increases and locally more than one water-bearing sandstone is present.

The city of Rotan has maintained a well field in the Triassic rocks near Camp Springs in eastern Scurry County for more than 25 years. Currently, about 250 acre-feet of ground water is reportedly pumped annually from three wells in this field to supply the city.

Quaternary Alluvium

Unconsolidated alluvial sediments furnish water to most of the rural domestic wells in the county and furnish almost all of the water used for irrigation. Irrigation has developed in the county principally during the period 1955-59, and currently about 80 wells pump an estimated 1,600 acre-feet of ground water annually for irrigation. Most of the irrigation development is in an area which trends southeastward across the county on the north side of the Clear Fork of the Brazos River. Ground water in this area is produced primarily from terrace-channel sediments which were apparently deposited as the result of a general southward migration of the river channel. Approximately 85 acre-feet of ground water from alluvium is pumped annually for industrial supply by the National Gypsum Company located at Rotan.

Wells which produce from alluvium in Fisher County range in depth to about 80 feet, although most irrigation wells producing from channel deposits along the north side of the Clear Fork are between 30 and 50 feet deep. Current measured yields of some of these wells range from about 50 gpm (gallons per minute) to as much as 700 gpm with average yields of 400 gpm not uncommon in the area southeast of Rotan.

Movement

Ground water under water-table conditions moves in the direction of the hydraulic gradient from areas of recharge to points of natural or artificial discharge. Ground water which occurs under confined or artesian conditions moves in the direction of the regional dip of the beds and is discharged at the surface by wells or by springs which result from vertical fractures through the confining beds. In Fisher County, the configuration of the water table and hence the direction of ground-water flow is controlled principally by the surface drainage pattern. Ground water under water-table conditions in the alluvium and shallow Permian rocks moves toward surface drainageways, and is either discharged as seeps or springs or more commonly moves as underflow in alluvium in the direction of the drainage system. Hence, much of the ground-water flow from large areas of the county ultimately becomes the base flow of the major streams or saturates the alluvial deposits along these streams. Therefore, the general direction of ground-water flow in any area of Fisher County can be estimated by inspecting the drainage pattern and the configuration of the surface topography in the area.

Water Levels

No continuous water-level measurement program has been conducted in Fisher County. The only data available are from a few scattered wells measured by J. W. Lang in his 1943 study of ground-water conditions in the Roby-Camp Springs area. These measurements (Table 2, wells 51 through 103) indicated that water levels ranged from 20 to 71 feet below land surface in 8 water wells of various depths in the Permian rocks. However, brine from some of the shallow Permian sandstone beds was reportedly under sufficient hydrostatic head to flow at the surface in some areas of northeastern Fisher County.

The 1943 measurements also showed water levels varying from 5.5 to 56.5 feet below land surface in 17 water wells producing from alluvium. The highest water levels were encountered in wells located in topographic depressions near the edge of alluvium outcrops where the deposits are relatively thin. Water levels in most wells penetrating thicker parts of the alluvium generally exceeded depths of 20 feet below land surface.

During the 1959-60 reconnaissance investigation of ground water in the Brazos River Basin (Cronin and others, 1962), water levels were measured in a number of irrigation wells in Fisher County, most along the north side of the Clear Fork of the Brazos River. Water levels in these wells ranged from 10 to 34 feet below land surface, with water levels in most wells ranging from 16 to 25 feet.

During the current investigation, water levels were measured in eight wells and two flooded concrete storm cellars, all of which are in areas of ground-water seepage and soil damage. Relatively recent measured water levels in three additional wells were also reported by landowners. Water levels measured or reported during the current study ranged from about 3 feet to a maximum of 100 feet below land surface. Most water levels, and all those in shallow wells producing from alluvium, ranged from 3 to 16 feet below land surface. It must be noted, however, that less than a week prior to the current measurements the area had received heavy rains totaling about 7 inches.

Although there are no past records of water levels in wells in these areas of soil damage and ground-water seepage with which to compare current data, discussions with landowners indicated that water levels in most of these areas have risen more or less continually since the late 1930's and have risen substantially in the past few years. The invasion of storm cellars and underground cisterns noted during the current study supports these reports. Water levels in alluvial deposits near surface streams reportedly have shown the largest rises. For example, water levels in wells on one farm have reportedly risen more than 10 feet in the past decade and 4 feet since about 1957. Accurate detailed topographic maps are needed in order to map the altitude of the water table in these areas.

Quality

The chemical composition of ground water is a reflection of the relative concentrations of the ionic constituents. The most important ions present in ground water include the cations (positively charged ions) calcium, magnesium, sodium, and potassium, and the anions (negatively charged ions) sulfate, chloride, fluoride, nitrate, and those contributing to alkalinity which are commonly expressed in terms of an equivalent amount of carbonate and bicarbonate. Other substances commonly reported in analyses but generally present in comparatively low concentrations include boron, iron, manganese, and silica. More general chemical and physical properties of ground water include acidity, commonly expressed as hydrogen ion concentration (pH); hardness, usually expressed as calcium carbonate; total dissolved solids or salinity; and specific conductance, a measure of the electrical conductivity of the water which is, in effect, a measure of salinity.

The basic factors which affect the salinity of ground water include pH, rate of migration, base exchange, character of the aquifer material and reaction of certain ions in solution with aquifer material, and temperature of the water (generally a reflection of depth).

The chemical quality of natural ground water in Fisher County is directly related to the type of rocks in which it occurs. In general, water in the Permian rocks is highly mineralized, ground water in alluvium less so, and water contained in the Triassic rocks only slightly mineralized by comparison.

The earliest available chemical analyses of ground water in Fisher County are those obtained by J. W. Lang in 1943. Table 4 lists chemical analyses of 37 ground-water samples collected during that study. Location of the wells from which these samples were taken are shown on Plate 1. These analyses include 6 water samples from wells producing from Permian rocks and 20 samples of water from alluvial deposits.

No analyses of ground water in Fisher County are available for the period 1944-55. A number of samples have been analyzed by Texas A. & M. College and the U. S. Geological Survey during the period 1956-62, and analyses from these wells which could be located on the county ownership map and which are near areas of soil damage are also listed in Table 4.

Ground water in the Permian rocks in Fisher County is historically saline. Because of the depositional environment of these rocks, connate brine or the residual precipitates of this trapped water is present in the porous and permeable beds. Shallow ground water which is yielded to wells in the county represents precipitation which has accumulated in the uppermost permeable beds and has partly flushed out connate water or its precipitates which were originally present. This water is typically of the calcium sulfate variety commonly known as "gyp" water. In general, concentrations of calcium (plus magnesium) and sulfate ions are much higher than other constituents. Both calcium and sulfate are primarily the result of solution of gypsum and anhydrite beds, which are readily soluble in water without undergoing chemical decomposition. Permian sandstone also contains appreciable quantities of gypsum and anhydrite in the form of both clastic sand grains and interstitial silt and clay. Shallow Permian ground water also contains significant concentrations of sodium and chloride ions (generally as NaCl) which results from incomplete flushing of connate water, residual precipitates of connate water, and/or solution of interstitial clay minerals. Locally, sodium and chloride concentrations in Permian water approach calcium sulfate concentrations, although generally this is not the case.

Analyses of samples taken in 1943 from wells producing exclusively from Permian rocks (samples no. 54, 76, 77, and 85) showed chloride concentrations ranging from 160 to 1,220 ppm (parts per million), sulfate concentration from 1,770 to 2,310 ppm, and total dissolved solids from 3,100 to 4,520 ppm.

In general, ground water in the Triassic rocks is of good chemical quality, although near the eastern edge of the outcrop the water is more highly mineralized than in areas to the west. Wells which draw from the Triassic rocks and which were sampled in 1943 showed ranges in sulfate concentrations from 46 to

950 ppm, in chloride concentrations from 40 to 185 ppm, and in total dissolved solids from 434 to 1,760 ppm.

Ground water in the alluvium in Fisher County is variable in chemical quality from place to place. The best quality water seems to occur in the alluvial sand belt north of the Clear Fork east of Rotan. In general, water in the terrace deposits along and south of the Clear Fork and in extreme eastern Fisher County is more highly mineralized. Because much of the material comprising these alluvial sediments was derived from local, weathered Permian rocks, this water is also characteristically of the calcium sulfate type. Analyses of water samples taken in 1943 from alluvial deposits showed chloride concentrations ranging from 13 to 2,120 ppm, sulfate concentrations from 26 to 2,310 ppm and total dissolved solids from 370 to 6,380 ppm. However, only 1 sample (no. 92) exceeded 602 ppm chloride and 3,950 total dissolved solids. These extreme variations in quality probably reflect local differences in recharge-discharge relationships, variations in composition of the aquifer material, the position of the water table with respect to the land surface (evapotranspiration effect), and local contamination by gypsum in the underlying Permian rocks.

OIL AND GAS PRODUCTION

Exploration for oil and gas began during the late 1920's in Fisher County. The earliest reported commercial oil production was the Royston field discovery well, drilled in 1928. Most of the drilling activity in the county has occurred since 1950. At present there are 116 Railroad Commission designated oil fields in the county, 63 of which produced oil in 1961. Current drilling activity in the county is in the Rough Draw field in northwestern Fisher County and in the Rotan field just east of Rotan. About 5,000,000 barrels of oil are produced annually in Fisher County. Most of the oil is produced from sandstone of the Strawn and Canyon Groups of Pennsylvanian age and from dolomite and limestone of the Wichita Group of Permian age. The uppermost oil-productive zone currently producing in the county is the Camp Colorado "Noodle Creek" Limestone Member of the Pueblo Formation (See Plate 2).

Total cumulative oil production in the county as of January 1, 1962, was 75,585,195 barrels. Of this total, the Round Top, Royston, Rough Draw, Claytonville, Eskota, Sweetwater, Pardue, Ocho Juan, Weems, and Raven Creek oil fields have been the principal producers. The Round Top (Palo Pinto Reef) field has led all fields in cumulative oil production with 18,609,901 barrels produced.

Gas production in the county has been relatively small. The Norand, Jonisue Bowden, Round Top, and Tolar fields are the only reported commercial gas producing areas.

There is no readily available information regarding the total number of oil and gas tests which have been drilled within the county; however, it is estimated the number would probably exceed 1,200. In addition, an unknown number of seismic holes have been drilled throughout the county, reportedly to depths ranging from about 90 to slightly more than 200 feet. Stratigraphic tests were also reportedly drilled by several oil companies to depths ranging downward from 1,000 feet at intervals of 1 mile along traverses throughout the county.

BRINE PRODUCTION AND DISPOSAL

The 1961 inventory of salt-water production throughout the State, as reported by the oil companies and operators, shows that a total of 4,365,363 barrels of brine were produced in Fisher County in 1961. Of this total, 351,516 barrels were put into surface pits and 4,011,117 barrels went into injection wells. An additional 2,730 barrels of produced brine were disposed of by miscellaneous methods, such as hauling, spraying on roads and leases, etc.

Records of reported brine production and disposal in 1961 in Fisher County are tabulated, by field, in Table 6. The total volume of brine produced and the volume disposed of into surface pits in 1961 in each oil field is also indicated on Plate 1. These data obviously do not include information on brine production and disposal in fields which were abandoned prior to 1961, nor on new fields or recent development in existing fields. Furthermore, these figures should be considered as minimum, as field observations by Texas Water Commission personnel have shown that in many leases in the state, reported brine production was considerably under actual production.

The Royston field, in northeast Fisher County, leads all areas in surface-pit disposal with 122,052 barrels reported in 1961. Of the total brine volume put into surface pits, fields located in the eastern part of the county produced 243,313 barrels. The Claytonville, Claytonville, S. E., and Jonisue Bowden field complex, located in the area southwest of Roby, represent the next most significant area of surface-pit disposal with 47,730 barrels reported in 1961. The Rotan field, located several miles northeast of Rotan, represents another significant area of surface-pit disposal with 24,363 barrels reported in 1961.

Much of the 4,011,117 barrels of brine injected into the subsurface represents waterflood operations in oil-producing horizons. Reported injection pressures are relatively low, ranging from gravity flow to a maximum of 600 psi (pounds per square inch). Shallow bradenhead injection of brine was reported in five fields, with a total of 183,792 barrels injected into casing set at depths from 66 to 607 feet below the surface. The largest volume reported was 45,441 barrels injected below 163 feet in the Pardue, W. field (northeast of Royston), followed by 39,220 barrels injected below 170 feet in the Tolar field, (northeast of Royston), 30,000 barrels injected below 66 feet in the Judy Gail field (extreme northeastern Fisher County), and 25,994 barrels injected below 667 feet in the Bernecker field (southwest corner of county). Areas where annulus injection or shallow injection of brine is practiced are shown on Plate 1.

Typical examples of the chemical quality of brine produced from various oil reservoirs in the county are tabulated in Table 5. These selected analyses indicate chloride concentrations ranging from 31,000 to 125,800 ppm, sodium concentrations ranging from 19,200 to 57,400 ppm, and sulfate concentrations ranging from 0 to 5,236 ppm. Typical brine quality is also graphically illustrated in Figure 7.

SUMMARY OF CURRENT INVESTIGATION

At the initiation of this reconnaissance, the County Agent supplied a list containing the names of 25 landowners who had made complaints. Nineteen of these farms were visited during the 4-day study. The remaining 6 landowners could not be located at the time; however, it was determined that problems in these areas were similar to those in areas that were investigated.

Magnitude of Soil Damage Problem

The most obvious problem affecting the agricultural economy in the area is soil damage. The current reconnaissance documented the existence of about 275 acres of cultivated land in Fisher County affected by soil damage. Many more such areas in the county probably exist. These areas, which are located on Plate 1, appear as irregular barren spots, devoid of vegetation except for extensive growth of salt cedar. They were first noticed in Fisher County in the late 1950's, but have increased in areal extent markedly in the past two years. Typically, the soils in these areas are characterized by white crusts on the surface and an apparent significant reduction of soil porosity. In some places, the spots remain muddy and "water logged" even during periods of sparse rainfall, and locally water continuously stands in the fields throughout the year. In most cases, the barren spots are confined to hill slopes, local topographic depressions, or areas bordering surface drainageways.

The areas currently affected formerly supported good dryland cotton crops. Characteristically, each of the spots produced bumper crops during the growing season immediately prior to the first evidence of water seepage and/or soil alteration. After the first "spot" appeared, the barren areas then became larger during each successive crop. A summary of the conditions noted at each farm visited is included in the Appendix.

The areas of soil damage are the result of the accumulation of mineral salts in the soil, a process commonly referred to as soil salinization. Analyses of soil samples which are available at the office of the County Agent indicate that the soils in several of the affected areas are of the saline-sodic type, in that high concentrations of both total mineral salts and adsorbed sodium are present. Typical examples of these areas in Fisher County are illustrated in Figures 4 and 5.

Causes of Soil Damage

Excessive accumulations of minerals in most areas are indicative of elevated saline ground-water tables and ground-water seepage. Dissolved minerals are precipitated as a result of evaporation of ground water where the water table is near or intercepts the ground surface. Most of the areas are located where thin soil covers have developed directly upon Permian rocks, or along the thin peripheries of outcrops of alluvium (see Plate 1).

In several places, measurements of static levels of ground water in the shallow Permian rocks suggest that the water table has not risen to a height sufficient to cause surface seepage. However, accurate topographic data are not currently available with which to relate these water-level measurements. This phenomenon would suggest that seepage in some areas may be the result of water-saturated soil and perched water zones. Upward movement and lateral migration of brine or highly saline water from deeper strata through unplugged seismic holes, core tests, or improperly plugged oil tests also represent another strong possibility.

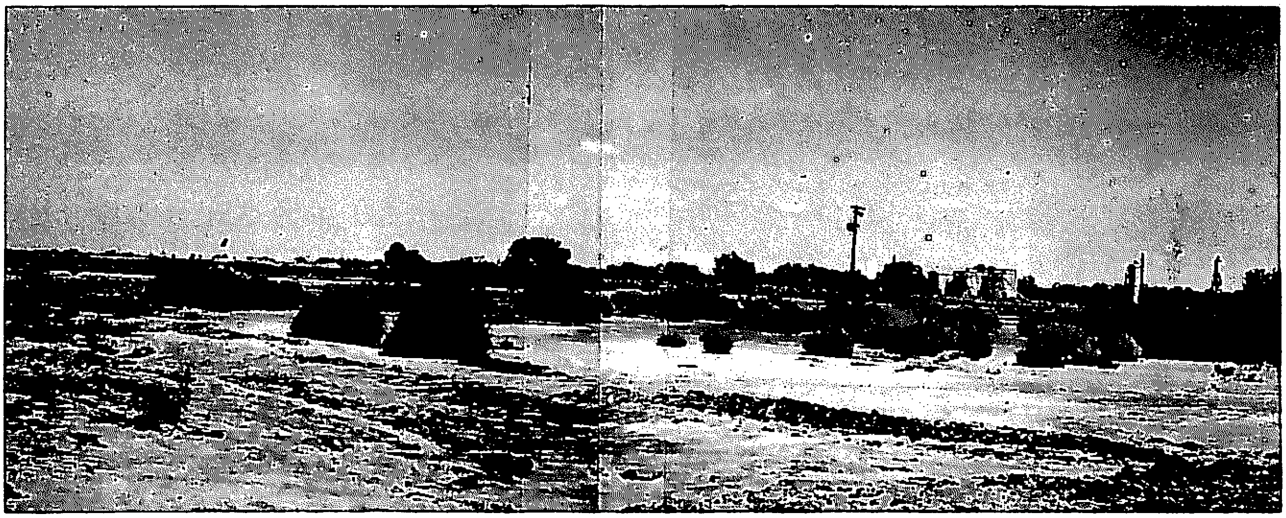

Figure 4

Salt Cedar Marsh on Reynolds Farm, located in Section 211, Block 1, BBB & C RR Co. Survey, about 9 miles northeast of Roby. Area supported cotton until 1960. View looking northwest.

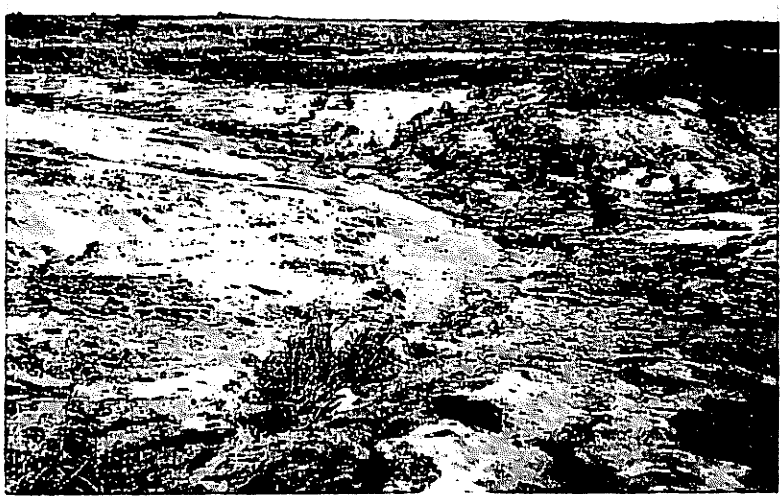

Figure 5

Saline Soil and "Water-Logged" Area in Cotton Field on Harvey Farm, located in Section 5, Block 2, T & P RR Co. Survey, about 10 miles southwest of Roby. Note saline water standing in field. View looking east.

Elevated Water Tables

The presence of high ground-water levels in the alluvium and shallow Permian rocks in Fisher County are probably due to a variety of causes. Since about 1940, the amount of land under cultivation in the county has rapidly increased, and each year more of the land is cleared of mesquite vegetation. The practice of land terracing and contour plowing, which is done specifically for the purpose of reducing surface runoff of rainfall, essentially reached its present magnitude of development in the early 1940's. Consequently, marked reduction in the volume of surface runoff coupled with the elimination of vegetation such as mesquite, which is known to transpire large quantities of ground water, has no doubt had a significant effect upon the volume of ground and soil water present in this area. This phenomenon at least partly accounts for the fact that water levels in wells in many areas of this region of Texas have been rising more or less continuously even during the drought years of the 1950's.

Also perhaps significant is the fact that annual rainfall in the area was consistently above average during the period 1957-62 (Figure 2), which generally corresponds with the development of the soil problems currently in evidence in the county.

Another probable cause of elevated water levels in this area is upward migration of brine and highly saline water through bore holes related to oil exploration and production. Because of high-pressure conditions present in some of the deeper Pennsylvanian and Permian strata which are characteristic to this area, this situation is considered to be a strong and extremely serious probability. In cases where deep brine-bearing zones are under very high hydrostatic head, the water level of this brine will stand in well bores at or near the ground surface and brine will flow at the surface in areas of low elevation. In many parts of west-central Texas, the Coleman Junction Limestone Member of the Admiral Formation is a high-pressure, low-volume aquifer which readily yields brine under these conditions. In Fisher County, this zone is encountered at depths generally ranging from about 2,100 feet in the eastern part of the county to approximately 3,800 feet in western Fisher County. (See Plate 2.) It is known that brine from this horizon stands at or near the surface in the Rough Draw field in northwestern Fisher County (Table 1) and in several other areas of the county (District 7B Railroad Commission office, oral communication). Interpretations of electric logs in the county also indicate that the entire Permian section ranging from the top of the Jagger Bend Limestone to the lower part of the Moran Formation contains numerous highly porous zones which are water-bearing and possibly hydraulically interconnected locally. In addition, the numerous bore holes in the county have allowed intercommunication of brine in these zones. It is therefore probable that high static water levels or artesian flow might be expected from other zones within this entire sequence as well as from the Coleman Junction Limestone.

All bore holes which penetrate these aquifers represent potential conduits for upward movement of brine. The methods by which most of the exploratory tests in Fisher County have been plugged and producing wells completed have resulted in these zones remaining exposed in most well bores. In dry tests or abandoned producing wells, it has not been the general practice of operators to set cement plugs above or through the Coleman Junction Limestone and related horizons. Furthermore, most of the very old abandoned bore holes in the county probably contain no surface casing, or very short surface casing, and contain no plugs

Table 1.--Pressure data on the Coleman Junction Limestone, Jones and Fisher Counties, Texas

(Source of data, Humble Oil and Refining Company)

County	Field	Depth of Coleman Junction [1] (feet)	Approximate surface elevation (feet)	Surface Pressure	Coleman Junction water chloride content (ppm)	Remarks
Coke	Bronte	2,010-2,325	1,800	None while flowing at rate of 1,440 barrels per day	47,700	O. L. Johnson #1 flowed at rate of 1,440 barrels per day in 1959 from open hole 2,010 to 2,325 feet.
Fisher	Rough Draw	3,422-3,428	2,009	Water will stand to the surface with slight pressure	--	Source: J. C. Stribling, Jr. #1 after perforating and acidizing string #3 for salt-water disposal at 3,422 to 3,428 feet.
Jones	Avoca	950-1,050	1,515	Water will stand to the surface with no pressure	38,000	Source: Experience on Hollums Lease.
Jones	Noodle	1,750-1,950	1,800	Shut-in 25 psi with water to surface	32,500	Source: Field Superintendent.
Jones	South Noodle	1,920-1,940	1,830	Slight flow with no pressure	--	Source: J. C. Sears #2; water to source well; perforated at 1,920 to 1,940 feet.

[1] Depth of Coleman Junction or interval open in Coleman Junction

other than mud which in many cases has probably undergone flocculation and decomposition and consequently has settled to the lower parts of the hole. In more recent abandoned holes, cement plugs were generally placed above the oil-producing reservoirs and in the bottom and/or top of the surface casing, which is commonly set at depths ranging from 60 to 400 feet below the surface. Therefore, these old bore holes, which number many hundreds, represent potential conduits for upward movement of brine to the surface or for lateral migration below surface casing depths or through corroded and deteriorated surface casing into shallow permeable rocks which have lower hydraulic pressures than that of these deeper brine-bearing horizons.

Completion practices on producing wells include the setting and cementing of surface casing at shallow depths (Railroad Commission field rules in the county specify depths ranging from 60 feet to 300 feet), and cementing the smaller-diameter production string of casing near the bottom of the hole. Railroad Commission rules pertaining to this cementing operation vary in each field; however, a review of these rules indicates that none specify that the top of the cement be above the Coleman Junction Limestone and associated brine aquifers. Therefore, most currently producing wells in Fisher County also offer access for upward movement of brine and recharge of shallow zones. In most fields in central and western Fisher County, relatively thick sections of sandstone of the Whitehorse Group are exposed in the well bores. In eastern Fisher County, shallow zones which might receive this brine recharge include the San Angelo Formation and uppermost sandstone beds of the El Reno Group.

Another source of ground water is brine produced with oil in the county which is disposed of into unlined surface pits. Although the 1961 salt-water inventory indicated that only about 8 percent of the brine produced in the county was put into pits, this percentage is known to have been very much higher prior to the initiation of waterflood programs and subsurface disposal in many fields in recent years.

Brine placed into unlined pits does not evaporate. Although a small part of the water content of brine may be evaporated (and this is generally negligable because of the very small surface areas of surface pits and because of evaporation retardants such as oil films on the brine surface), the dissolved minerals cannot be removed and are only concentrated in the solution. Therefore, all of the soluble salts and the greater part of the water content of brine is lost from surface pits by overflow or seepage into the subsurface. In areas where highly porous and permeable alluvium is present beneath the pits, this brine migrates rapidly downward to the water table. In other parts of the county where pits may be constructed in Permian or Triassic rocks, which are generally of lower permeability than alluvium, the rate of migration may be slower and the direction of movement of brine from a pit altered locally by lenticular shale, clay, or dolomite beds, so that this brine may migrate laterally for relatively long distances before entering ground water or surface drainageways.

A schematic diagram illustrating various methods by which brine from various sources discussed above may enter ground and surface water in Fisher County is shown in Figure 6. This diagram is of course highly generalized as geohydrologic conditions will vary in different areas of the county. It does serve to illustrate, however, the potentially serious problem which has apparently developed as a consequence of these cumulative circumstances.

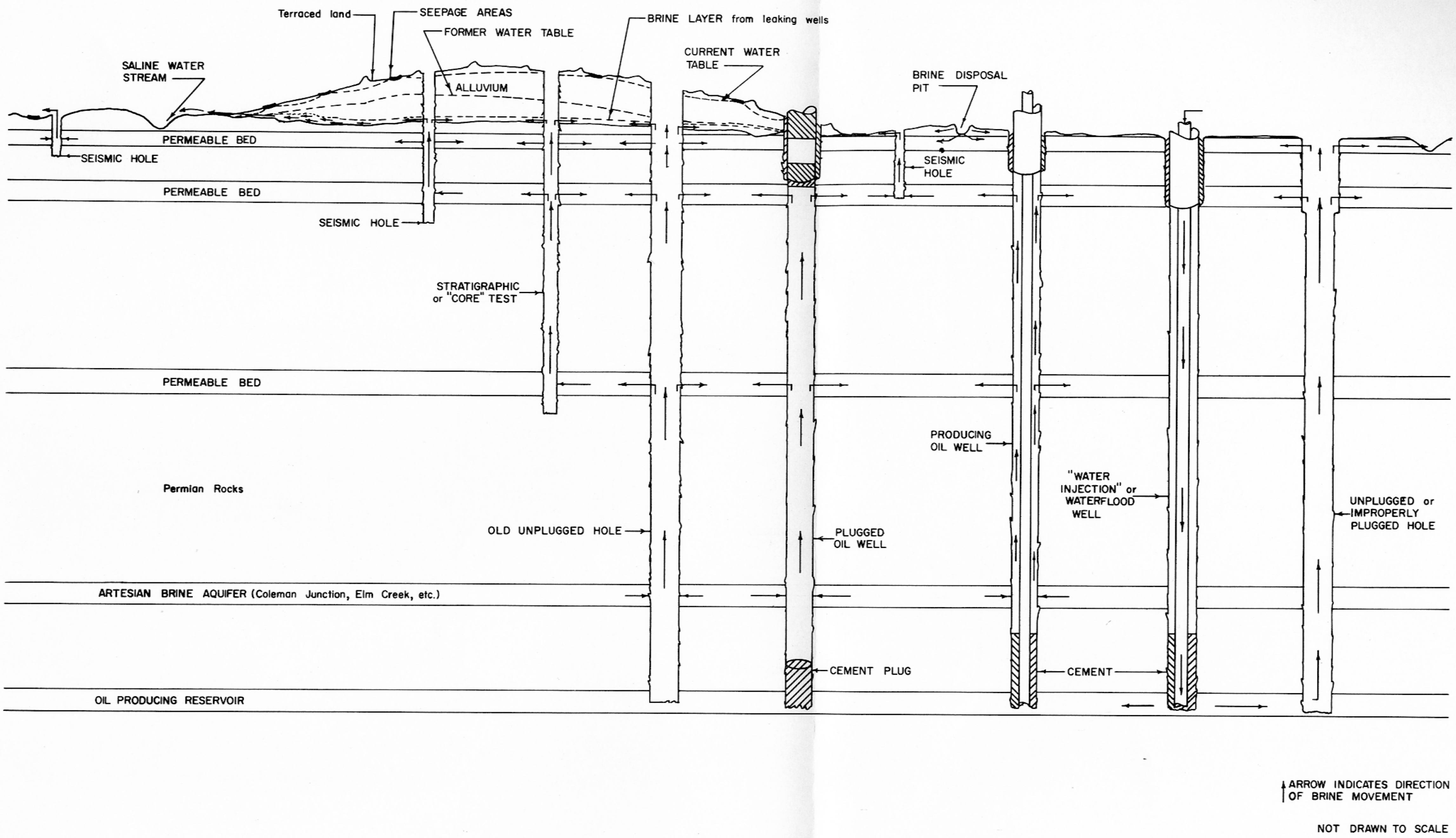

Figure 6

Schematic Diagram Illustrating Various Possible Causes of Elevated Water Tables and Deterioration of Ground and Surface Water Quality in Fisher County

Texas Water Commission

Saline Ground Water

The previous discussion pointed out the high variability in the quality of ground water throughout most of Fisher County and the complexities introduced into any analytical analysis of changes in ground-water quality accompanying elevation of water tables. It has been reasonably well established that the typical shallow ground water in most areas of the county is historically of the calcium sulfate variety, with sodium and chloride ions generally subordinate. A preliminary evaluation of the quality of water samples obtained during recent years, and including the nine water samples obtained during this investigation, indicates that the overall salinity of ground water in many areas has increased substantially over historical quality, and that in some places surface water and very shallow ground water is more saline than that in some of the deeper alluvial sand and gravel beds or Permian sandstone. In some areas, the typical "gypsiferous" water pattern is generally still present although total concentrations of solids have increased. In other places, however, and in particular those areas currently affected by surface seepage and soil salinization, increase in total salinity has been accompanied by significant increases in the relative proportions of sodium and chloride ions, so that a sodium chloride type of water has evolved or is in various stages of evolution; in particular, water samples from sites 1, 2, and 14 (Plate 1).

In evaluating various possible causes of this phenomenon, several factors must be examined. First of all, the effect of evaporation and soil solution upon water quality of a rising water table must be considered. The effect of evaporation is to increase the total concentration of dissolved salts and bring about precipitation of these minerals. As the saturation point is reached, the sequence of crystallization of sodium chloride (salt) relative to calcium-magnesium sulfate (gypsum) will have a significant effect upon the composition of the remaining liquid. In addition, as the water table rises through the soil profile, concentrations of minerals at various levels within the soil, which have resulted from leaching by rainfall, will be redissolved. Commonly, sodium from the water is exchanged for calcium and magnesium from the soils, although this reaction is reversible and may proceed in the opposite direction depending on the relative concentration of sodium in the ground water.

Second, the effect of the addition of sodium chloride brine upon the quality of the ground water must be considered. Typically, the principal constituents of most brine produced with oil in Fisher County, including brine from the Coleman Junction Limestone, are sodium and chloride ions, in some cases accompanied by significant concentrations of calcium. Because of the process of sulfate reduction in these deep horizons, the relative concentration of sulfate ions in these brines to these above constituents is commonly very low (see Table 5). Therefore, a theoretical simple mixture of ground water with highly mineralized brine would produce a water with very high proportions of sodium and chloride, in some cases accompanied by significant increases of calcium, but in no case would sulfate concentrations show significant increases. However, in many instances the quality of this theoretical mixture and the actual observed quality of brine-contaminated ground water bear little resemblance because of the effect of ion exchange between introduced brine and aquifer material. It is also known that the solubility of sulfate in an acidic high-chloride brine is much greater than for less mineralized waters, so that brine may contain considerably more sulfate in solution than in its original composition after only a short distance of travel through rocks high in gypsum and anhydrite. Only in the latter stages of contamination after equilibrium has been reestablished are the observed and theoretical mixtures more nearly the same. Thus, the fact that high sodium and chloride concentrations in some water samples from these areas of soil damage in Fisher County are accompanied by equally significant increases in sulfate ions does not preclude the possibility that there has been an addition of low sulfate, sodium chloride brine to these waters.

From available analyses, the relationship between the various types of waters present in Fisher County is illustrated graphically by means of patterns drawn on radial coordinates in Figure 7. The extension of the sodium and chloride areas in some samples indicates the development of a sodium chloride type of shallow ground water locally.

SUMMARY OF CONCLUSIONS

The problem of high water levels, saline ground and surface water, and soil damage in Fisher County as established by this reconnaissance is serious and will become increasingly so until the cause or causes are more definitely established so that remedial action can be initiated. Rising water levels in this area are believed to be at least in part due to vast land-clearing programs and prevalent land-management practices which have markedly reduced surface run-off. At the same time, the presence of a great number of bore holes resulting from seismic exploration and oil exploration and production and the condition of high pressure in deep artesian brine aquifers, notably the Coleman Junction Limestone, coupled with past practices of completion and plugging of wells and exploratory tests has led to a situation highly favorable for upward movement of brine in these bore holes and ultimate migration of large volumes of brine into shallow strata.

A general increase in water salinity is believed to be in part caused by evaporation and soil solution (base exchange) in areas where geologic and topographic conditions are favorable for the water table to be at or very near the land surface. In some areas, however, such as sites 1, 2, 14, and possibly 7 and 8, the development of a sodium chloride type of shallow ground water strongly indicates brine contamination. Present data is insufficient to determine the relative degree of increased salinity of water which can be attributed to either addition of brine from deep horizons or to evaporation and solution of soluble salts from soils and near-surface beds by the rising water tables.

RECOMMENDATIONS

1. A comprehensive, detailed water-sampling program throughout the county is necessary in order to evaluate current quality of both ground and surface water.

2. Current water levels and accurate topographic maps are needed to determine the altitude of the water tables in various aquifers in the county.

3. A study of soil composition throughout the county is needed to determine if areal variations in mineral composition of soils and alluvial deposits exist which might cause local variations in ground water quality.

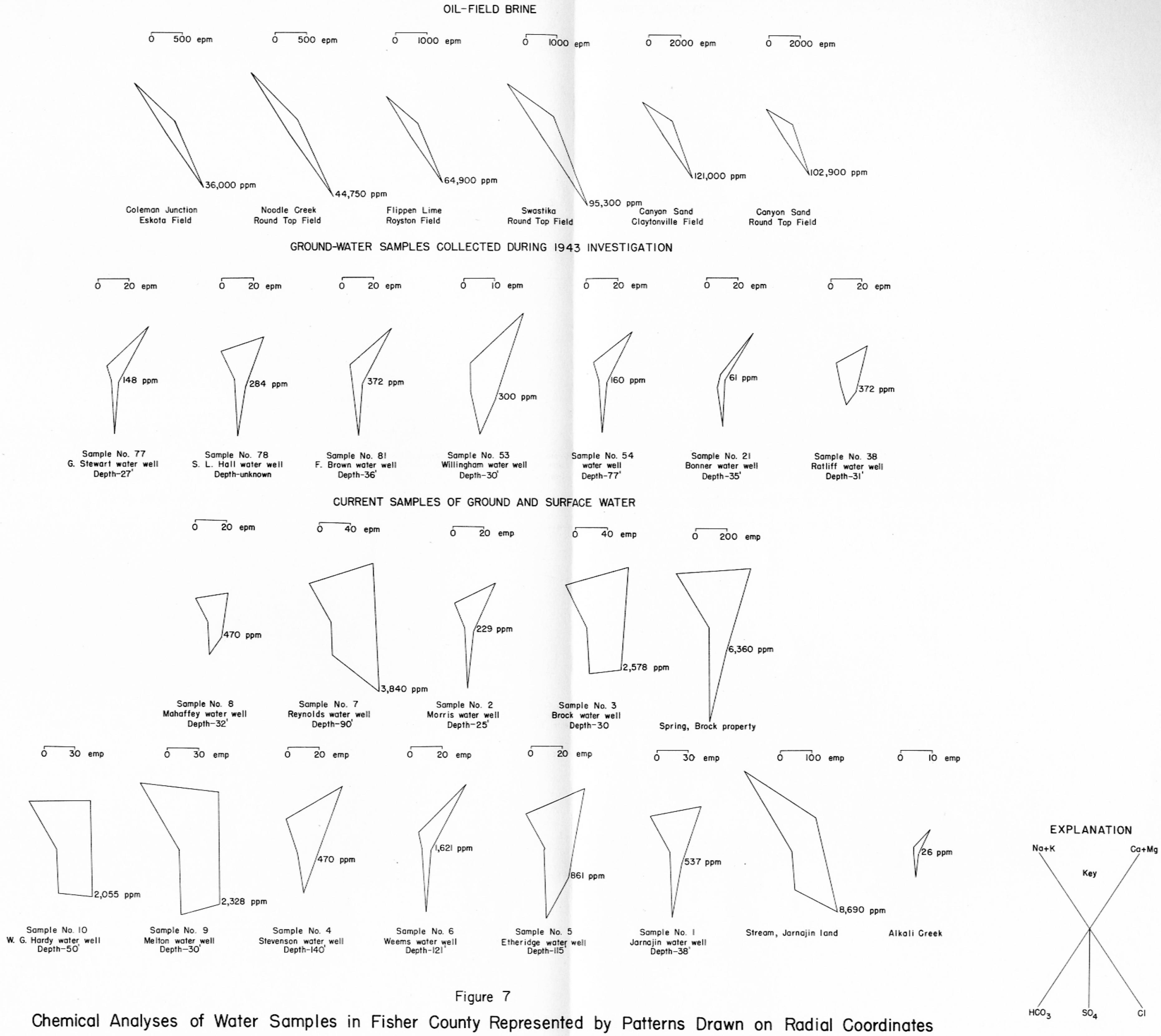

Figure 7

Chemical Analyses of Water Samples in Fisher County Represented by Patterns Drawn on Radial Coordinates

(Analyses plotted in equivalents per million; chloride concentration, in parts per million, indicated)

Texas Water Commission

(For location of samples, see Plate I)

4. A reevaluation of current methods of land management and cultivation practices should be made to include the possibility of ditching and draining or pumping ground water from some of these "water-logged" areas.

5. A comprehensive study of static water levels of brine in producing oil wells should be initiated in conjunction with an evaluation of surface-casing practices in order to determine those areas which are most likely sources of brine contamination. Studies should be continued to establish criteria for well completion which will provide effective confinement of brine below the base of usable water.

6. Unlined surface pit disposal of produced brine should be discontinued and all shallow subsurface disposal of brine, annulus injection, and injection into the Coleman Junction Limestone and associated zones mentioned in this report should be discontinued pending the results of additional study. This action should be taken to avoid increasing pressures and therefore the hydraulic head of brine in these horizons.

7. Plugging reports on file at the Railroad Commission for abandoned oil wells or tests in the vicinity of these areas of damage should be studied to determine the adequacy of well plugging with respect to the deep, high-pressure brine aquifers present in this region. Test-drilling programs to determine ground-water quality should be conducted adjacent to selected wells in order to determine if upward movement and lateral migration of brine is occurring. If such migration is found to occur, similar conditions of leakage may exist in other areas where wells or abandoned holes are completed or plugged by methods similar to those used in wells which are found to be leaking.

8. A complete study should be made of current practices of well completion and plugging of oil tests in this area. In the future, substantial cement plugs should be placed in all deep abandoned bore holes to confine all brine occurring under artesian pressure in deep aquifers. This would include plugs above the Coleman Junction Limestone and probably above the Elm Creek or Jagger Bend Limestones. All new oil and gas wells should be completed in a manner which would assure that brine from the Coleman Junction Limestone and associated zones is sealed off from overlying strata.

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

APPENDIX

DETAILED SUMMARY OF CURRENT INVESTIGATION

Below are brief summaries of the conditions noted at each of the areas inspected during this study. The location of each site is shown on Plate 1. Complete chemical analyses of samples from water wells and streams mentioned in these discussions are shown in Table 4.

<u>Map Reference Numbers</u>

1. Owner: W. G. Hardy

   Location: H & TC Survey, Block 2, Section 28:
   3 miles NW of Roby.

Approximately 20 acres of cotton land have become unproductive as a result of mineral concentrations in the soil on the Hardy farm. Small unproductive spots were first noticed by Mr. Hardy about 3 years ago and have spread considerably during the current growing season. All of the unproductive acreage occurs in topographically low areas which reportedly remain wet and muddy at all times. Analyses of soil samples from this area reportedly showed a high calculated NaCl content.

Mr. Hardy has one water well 50 feet deep which was drilled in 1961, cased to total depth, perforated, gravel packed, and with a reported 1961 water level of about 8 feet below land surface. Ground elevation at the well site was estimated to be 10 to 15 feet above ground elevation of the unproductive cotton land. A 1961 analysis of a sample of Mr. Hardy's water well showed a chloride concentration of 2,055 ppm, sulfate concentration of 2,141 ppm, and 6,495 ppm total dissolved solids. The well produces water from alluvial material and, although very salty, the water is used for livestock water and household purposes other than drinking.

2. Owners: Dick Melton, C. R. Webb, and M. Jarnagin

   Location: All located in adjacent Sections within Bastrop
   County School Land Survey, T. H. Cosby, and
   H & TC Surveys: 2 miles NW of Roby.

Property owned by the above persons is discussed as one area since the farms adjoin each other and the problem is similar in each case. A total of 35 to 40 acres of cultivated land on the three farms has become barren as a result of soil damage. These spots reportedly remain "water logged" during most of the year.

The largest unproductive area, totaling about 20 acres, occurs on land owned by Mr. Jarnagin, located in the northwest corner of the T. H. Cosby Survey. Small barren spots were reportedly first noted about 3 years ago but the areas increased significantly in size during the past year.

An intermittant tributary of Alkali Creek, which flows northeast through this area, has reportedly contained highly saline water during recent years. During the past summer, Mr. Jarnagin stated that the creek banks often were white with "salt deposits." Most of the vegetation near this stream, including large mesquite trees, has been killed as an apparent result of its intolerance to saline ground water. An analysis of a water sample of this stream, taken on Mr. Jarnagin's land, indicated 8,690 ppm chloride, 6,335 ppm sulfate, and 24,148 ppm total dissolved solids. A brief inspection of this stream revealed that the water is relatively fresh at a point on the western edge of the Webb property, but that the quality decreases rapidly to the northeast.

A 38 foot deep water well drilled for livestock-watering purposes by Mr. Jarnagin in 1961 reportedly encountered highly saline water in shallow zones. This water well is located about 100 feet south of the stream sample point. A 40 foot deep well drilled by Mr. Webb in 1962 for domestic supply reportedly did not produce usable water. Analysis of a 30 foot deep well on the Melton farm, obtained in 1959, showed 2,328 ppm chloride, 3,120 ppm sulfate, and 8,536 ppm total dissolved solids.

Water levels in wells on the Jarnagin and Webb properties varied from 4 to 6 feet below land surface. Ground water has also risen about 3 feet in a concrete-lined storm cellar on the Jarnagin property. The areas of soil damage as well as stream channels are generally topographically low.

There is no oil or gas production in this immediate area, although records indicate several oil tests have been drilled on nearby property. Numerous seismic holes were drilled on the farms during past years.

3. Owners: Sam Etheridge and Tom Hargrove

Location: Sections 64 and 65, Block 2, H & TC Survey:
12 miles NW of Roby.

Isolated barren spots totaling about 5 acres were noted on the Etheridge farm. These areas reportedly began to appear in 1959, but became enlarged in 1961. The spots occur mostly in topographic depressions near the base of a hill slope along Spring Creek. They reportedly remain "water logged" most of the time.

A 115 foot water well, drilled in 1941, furnishes livestock water for the farm. An analysis of the water indicated 861 ppm chloride, 2,180 ppm sulfate, and 4,630 ppm total dissolved solids.

There is no oil production in this region, although several dry tests are located in adjacent sections to the east.

Similar barren spots were reported on the nearby Hargrove farm which was not investigated.

4. Owners: W. C. Hardy, D. Nowlin, and Floyd Weems

Location: Sections 55 and 56, Block 2, H & TC Survey; Section 36, Block 3, H & TC Survey: 8 miles NW of Roby.

Several unproductive areas in cotton fields occur on the Nowlin and Hardy farms. Mr. Nowlin reported that one large spot remained "water logged" throughout the year.

Two water wells on the Nowlin farm, one 20 feet deep and the other 90 feet deep, are covered and no longer used; therefore no samples or water-level measurements could be obtained.

A total of about 30 acres of cotton land are affected by soil damage on the Weems farm. Mr. Weems reported that the areas remain muddy most of the year and that cotton attained a stand in these areas but died soon after an early summer rain. Most of the spots are along the base of hill slopes or in topographic depressions.

Several water wells are present on the Weems land, including a 121 foot deep well drilled in 1961 which is used for household purposes. The static water level was 16.7 feet below land surface. According to Mr. Weems, water levels in this area have risen about 10 feet since 1934. Most of the ground water is produced above a depth of 60 feet from stream-deposited alluvium. An analysis of the water showed 162 ppm chloride, 2,123 ppm sulfate, and 3,120 ppm total dissolved solids.

There is no oil production in the area, although deep tests were drilled in sections northwest and northeast of the Weems property.

5. Owners: T. C. Justice and James Cave

Location: Sections 115 and 117, H & TC RR Survey, Block 3: 7 miles SW of Roby.

Small barren areas have been noted on these farms for several years. An open trench silo was constructed on the Cave farm in 1961 and the water level has risen so that silo remains partly full of water. All vegetation in the immediate area of the excavation has died. No information was available on water wells or ground-water quality at these localities, although it was reported that water for domestic use is obtained from a shallow water well on the Cave property.

This area is located on the northwest edge of the Claytonville oil field.

6. & 7. Owners: J. H. Morris, Alton McCain, and Ira Brock

Location: Sections 190, 204, and 208, H & TC Survey, Block 3: 5 to 7 miles SW of Roby.

The problem encountered on each of these farms was also apparently the result of soil damage. An intermittant stream, flowing south into Cottonwood Creek, was bordered by barren cotton land on the Morris property. An abandoned

20 foot deep water well within this stream meander belt had a measured water level of 3 feet below land surface.

Unproductive cotton acreage was reported on the McCain property; however, this area was not located during the present investigation.

Approximately 3 to 5 acres of cultivated land on the Ira Brock property (site number 7) have become barren during the past year. The areas occur on a hill slope adjacent to Cottonwood Creek. Mr. Brock has a 30 foot deep water well which reportedly has been used for livestock-watering purposes from about 20 years. The water level in this well was measured at 10 feet below land surface; an analysis of this water showed a chloride concentration of 2,578 ppm, sulfate concentration of 2,959 ppm, and 8,761 ppm total dissolved solids. A small spring issuing from Permian strata exposed along the stream crossing Mr. Brock's land, and also adjacent to the unproductive spots, had a chloride concentration of 6,360 ppm, sulfate concentration of 29,248 ppm, and 51,985 ppm total dissolved solids.

This area is located on the southeast margin of the Claytonville oil field. There are several producing oil wells on the property and at least one surface disposal pit constructed near cottonwood Creek.

8. Owner: E. R. O'Donald

Location: Section 256, Block 3, H & TC Survey:
8 miles SW of Roby.

An area covering about 7 acres has been damaged on the O'Donald farm. At the present time, salt cedars cover most of the affected area.

Alluvial and Permian strata are exposed along a stream-cut escarpment which strikes east through the damaged area. Seepage of ground water from the side of the cliff has resulted in mineral precipitates along the exposure. This phenomenon was first noted in 1958 by Mr. O'Donald, although the affected areas have become much larger since 1961.

There are no water wells on the property and no oil production in the area; however, there is some oil production to the south and numerous abandoned wells and dry holes in the general area.

9. Owners: Fred Stevenson and Albie Kolb

Location: Sections 30 and 31, El Paso County School
Land Survey: 3-1/2 miles SW of Roby.

Approximately 25 acres of cotton land have become barren on the Stevenson farm. Reportedly, small spots began to appear in 1957, but these areas enlarged considerably during the 1962 growing season. The largest area occurred near the base of a hill slope, and adjacent to surface drainage. In these low areas, water reportedly stands above land surface at all times.

Two water wells on the Stevenson land were drilled in 1940 to a depth of 140 feet. The current water level measured in one well was 57 feet below land surface datum. Both of these wells are located in areas estimated to be 20 to 40 feet topographically higher than areas of soil damage.

The Kolb farm was not visited during the study as the owner could not be located; however, the problem on this land was reported to be similar to that on the adjacent Stevenson land.

There is no current oil or gas production in this immediate area; however, the farms are surrounded by a number of dry holes and abandoned wells.

10. Owner: Ellis Sumerlin

Location: Blocks 13 and 14, Section 305, Gillespie County School Land Survey: 4-1/2 miles SW of Roby.

About 5 acres of cotton land have been affected on the Sumerlin farm. No water wells have been drilled on the land.

There is no oil production in the area although several dry holes are present in the area. A dry hole drilled about 5 years ago is located on the Sumerlin farm within the affected area.

11. Owner: Thurmond Terry

Location: Blocks 87 and 94, Section 304, Gillespie County School Land Survey: 8 miles SW of Roby.

An estimated 20 acres of cotton land is currently unproductive on the Terry farm. The areas are generally confined to narrow bands trending south-southeast which terminate at an intermittant creek which flows northeast. Most of these spots are presently covered by salt cedar.

An old water well, drilled to a depth of 140 feet, furnished livestock water until recently when it was abandoned because of "excessive salt". A water well drilled in 1962 to a depth of 20 feet near the creek also reportedly produced water too highly mineralized for livestock use.

Although water levels could not be measured in the wells, the water level in an invaded cistern located on a hill top near the deeper of the two water wells was 12 feet below land surface.

There is no oil or gas production in this area, but several dry holes are located in nearby sections.

12. Owner: Dub Harvey

Location: Section 5, Block 2, T & P RR Co. Survey: 10 miles SSW of Roby.

A large part of the Harvey property is affected by soil damage and most of the area currently supports only salt cedar. No water wells have been drilled on this property.

Areas of current oil production are located east and southwest of the farm. Several dry holes and abandoned wells are also present in areas near the Harvey farm.

13. Owner: J. T. Mahaffey

Location: Section 15, T. H. Cosby Survey: 4 miles NE of Roby.

A water well drilled by Mr. Mahaffey in 1961 to a depth of 36 feet reportedly produced water too salty for livestock use. A spring, located in a small creek near the water well, and which was used for livestock water, had reportedly become extremely "salty" during the past summer. Mr. Mahaffey also reported that the banks of the creek had become "white with salt crystals."

The measured water level in the newly-drilled well was 13 feet below land surface. Neither the spring nor the water well were yielding excessively mineralized water (see analyses, Table 4); however, recent heavy rains have apparently resulted in considerable dilution.

Several oil fields are located about 2 miles north of the property and several dry holes are present in the general area.

14. Owner: Raleigh Reynolds

Location: Section 211, Block 1, BBB & CRR Co. Survey: 9 miles NE of Roby.

An area of undetermined extent, probably between 30 and 40 acres, has developed from what once was prime cotton acreage into virtual salt water marsh land presently covered by salt cedars. The area borders an intermittant stream which flows north-northeast into California Creek.

Two livestock water wells on the Reynolds property were abandoned in the spring of 1962 because of increased salt content. A dug well 30 feet deep is within the stream bed. Because of the streamflow resulting from recent heavy rains, the water level in the well stood at the ground surface. The second well, a converted seismic test hole 90 feet deep, is about 200 yards southeast of the shallow well. The analysis of water from this well shows a very high chloride concentration (3,840 ppm) and high total dissolved solids (8,868 ppm), although the sulfate concentration (1,965 ppm) was comparable to that indicated in most water samples in other areas during the current study.

The Reynolds property is located within the Round Top oil field, which is the largest field in Fisher County. There are 13 producing oil wells and several dry holes in the immediate area of the abandoned water wells.

Unlined surface pits, which are still present near tank batteries on the Reynolds property, were used for salt-water disposal in the area prior to 1962 when they were abandoned. At the present time, brine, at the rate of about 100 barrels per day, is being reinjected into the surface casing-long string annulus below a depth of about 160 feet in the Raleigh Reynolds well #1, "B" lease, operated by Sojourner Drilling Company and George A. Donnelly. Injection pressure ranges from 150 to 300 psi according to Mr. Reynolds. Bradenhead injection of brine in this well was begun about 2 years ago.

The presence of highly corrosive saline ground water in this area has caused considerable trouble for oil pipelines operated by Pure Oil Company. Several instances of pipeline breaks and oil leaks were reported by Mr. Reynolds.

15. Owner: W. F. Davison

Location: Section 149, Block 1, HT & B Survey:
1 mile W of McCaulley.

About 10 acres of cotton acreage was found to be barren on the Davison property. The area occurs near the base of a topographic rise. Mineral precipitates were noted on the surface over most of the barren spots. No water wells were located in the area.

There is no current oil or gas production on the property although a dry hole and several abandoned oil wells are located just north of and topographically upslope from the barren area. Numerous producing oil wells, abandoned wells, and dry holes are situated in this general area.

Table 2.--Records of wells in Fisher County

(For location of wells see Plate 1)

Records of wells 51 through 103 adapted from Lang (1944).
Method of lift and type of power : C, cylinder; Cent., centrifical; T, turbine; J, jet; E, electric; G, gasoline; B, butane; N, none; S, submersible; W, windmill.
Use of water : D, domestic; N, none; S, stock; Irr, irrigation.
Water-bearing unit : A, Quaternary alluvium; T, Triassic sandstone; P, Permian rocks.

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing		Water-bearing unit	Water Level		Method of lift	Use of water	Yield (gpm)	Remarks
					Diameter (in.)	Depth (ft.)		Below land surface datum (ft.)	Date of measurement				
* 1	M. Jarnagin	G. W. Rodgers	1961	35	8	35	A	5.7	Sept.12, 1962	J,E	S	--	Water too salty for drinking.
* 2	J. H. Morris	--	Old	20	36	--	A	3.0	Sept.14, 1962	N	N	--	Old well, located in streambed.
* 3	I. Brock	--	1942	30	--	--	A,P	10.0	Sept.13, 1962	C,W	S	--	Goes dry during drought.
* 4	F. Stevenson	--	1940	140	--	--	P	57.0	Sept.14, 1962	C,W	S	--	Converted seismic hole.
* 5	W. S. Etheridge	J. Reap	1941	115	8	--	P	100.0	Sept.12, 1962	C,W	S	--	
* 6	F. Weems	G. W. Rodgers	1961	120	10	28	A	14.7 16.7	-- , 1961 Sept.13, 1962	C,G	D,S	15	All water reportedly above 60 feet.
* 7	(Redus) R. Reynolds	--	1945	90	3	90	P	--	Sept.13, 1962	C,W	N	--	Converted seismic hole. Became too salty for livestock use in January, 1962.
* 8	J. T. Mahaffey	C. C. Justice	1961	36	10	36	A,P	13.0	Sept.13, 1962	N	N	--	Water too salty for domestic use when drilled.
* 9	J. N. Melton	--	--	30	--	--	--	--	--	--	--	--	
* 10	W. G. Hardy	--	1961	50	5	50	A,P	--	--	J,E	D	--	Water used for household purposes other than drinking.
* 11	J. O'Briant	--	--	80	--	--	--	--	--	--	--	--	
* 12	D. Darden	G. W. Rodgers	1955	25	12	25	A	18.0	Oct. 15, 1959	Cent., E	Irr	50	
* 13	B. W. Sumerlin	--	--	36	--	--	--	--	--	--	--	--	
* 14	J. Cummings	--	--	30	--	--	--	--	--	--	--	--	
* 15	A. D. Sumerlin	G. W. Rodgers	1958	50	12	50	A	18.0	Dec. 21, 1959	T,E	Irr	400†	
* 16	do	do	1958	50	12	50	A	20.0	Dec. 21, 1959	T,E	Irr	700	Temp. 68°F. Sampled after pumping several days.
17	do	do	1959	80	12	80	A	21.0	Dec. 21, 1959	T,E	Irr	400†	
18	do	do	1958	50	12	50	A	20.0	Dec. 21, 1959	T,E	Irr	400†	
* 19	J. Cummings	--	--	100	--	--	--	--	--	--	--	--	
20	O. T. Shell	--	--	40	--	--	--	--	--	--	--	--	

See footnotes at end of table

Table 2.--Records of wells in Fisher County--Continued

Well	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	Use of water	Yield (gpm)	Remarks
* 21	J. T. Stewart	--	--	42	--	--	--	--	--	--	--	--	
* 22	B. J. Smith	--	1959	60	--	60	A	29.8	--	--	--	--	
* 23	R. E. Kidd	G. W. Rodgers	1959	34	12	34	A	19.1	Sept. 1, 1960	T,E	Irr	390	
24	C. Webb	C. C. Justice	1961	40	5	--	A	4.0	Sept. 14, 1962	S,E	S	--	Water reportedly very salty.
25	T. Terry	--	--	140	--	--	P	10.0	Sept. 14, 1962	C,W	N	--	Converted seismic hole. Water has reportedly become too salty for use.
26	-- Spruiell	--	--	155	--	--	--	--	--	--	--	--	Converted seismic hole.
* 27	J. Rowlan	G. W. Rodgers	1957	25	12	25	A	17.8	Oct. 15, 1959	C,E	Irr	55	Temp. 67°F. Sampled after pumping 2 days. 1/
28	J. Bruce	do	1955	36	12	36	A	24.0	Aug. 12, 1960	S,E	Irr	35	1/
29	do	B. Wielder	1955	55	12	55	A	24.0	Aug. 12, 1960	T,B	Irr	--	
30	D. R. Nowlin	--	Old	90	--	--	P	--	--	--	N	--	
31	B. Hardgrove	C. W. Rodgers	1957	38	12	38	A	25.2	Oct. 14, 1959	T,E	Irr	125	
32	L. L. Morgan	do	1958	71	8	71	A	30.0	Oct. 14, 1959	T,E	Irr	150	1/
33	J. Rowland	do	1957	25	12	25	A	17.5	Oct. 15, 1959	Cent., E	Irr	55	
34	B. D. Murphy	do	1959	46	12	46	A	19.0	Aug. 12, 1960	T,E	Irr	150	
35	J. Rowland	do	1957	25	12	25	A	17.0	Oct. 15, 1959	Cent., E	Irr	55	
36	D. Lovett	do	1958	55	12	55	A	19.5	Dec. 20, 1959	T,E	Irr	400†	
* 37	M. Blair	do	1959	60	12	--	A	17.4	Dec. 21, 1959	T,NG	Irr	--	
38	O. R. Clark	do	1958	13	6	--	A	19.0	Sept. 1, 1960	Cent., E	Irr	200†	
39	W. A. Wadell	do	1957	32	8	32	A	19.0	Aug. 12, 1960	Cent., E	Irr	150†	1/
40	L. Rasberry	do	1958	30	12	30	A	18.7	Oct. 20, 1959	T,E	Irr	150†	
41	C. H. Carriker	do	1954	50	12	50	A	34.3	Aug. 16, 1960	T,E	Irr	290	1/
42	L. Brown	do	1956	30	6	--	A	13.0	July 12, 1960	Cent., E	Irr	--	1/
* 43	F. Mitchell	G. W. Rodgers	1960	36	16	36	A	16.0	Aug. 4, 1960	S,E	Irr	130	Temp. 67°F. Drawdown 17 feet after pumping 5 days.
44	W. M. Kiser	do	1957	28	12	--	A	10.0	Aug. 12, 1960	Cent., E	Irr	--	
* 45	E. C. Kiser	-- Roberts	1960	30	12	30	A	14.7	Aug. 8, 1960	Cent., E	Irr	120	

See footnotes at end of table.

Table 2.--Records of wells in Fisher County--Continued

Well	Owner	Driller	Date com-plet-ed	Depth of well (ft.)	Casing: Diam-eter (in.)	Casing: Depth (ft.)	Water-bearing unit	Water Level: Below land surface datum (ft.)	Water Level: Date of measure-ment	Method of lift	Use of water	Yield (gpm)	Remarks
46	G. W. Waldrop	G. W. Rodgers	1957	26	12	26	A	16.8	Aug. 10, 1960	Cent., E	Irr	--	
47	S. Jackson	do	1955	28	12	28	A	10.0	Aug. 23, 1960	T,E	Irr	200†	1/
* 48	-- Redus	do	1959	34	12	34	A	26.7	Aug. 8, 1960	T,E	Irr	250†	
* 49	A. B. Martin	--	--	40	--	--	A,P	--	--	--	--	--	
* 50	S. Jackson	--	--	34	--	--	A	--	--	--	Irr	--	
* 51	F. W. Crum	B. White	1943	49	6	8	T	29.0	--	C,W	D,S	--	Triassic sandstone from 8 to 49 feet.
* 52	T. Hefner	J. Aaron	--	41	8	--	A	27.8	Dec. 20, 1943	C,W	S	--	In creek valley.
* 53	S. Willingham	--	1943	30	--	--	A	24.0	--	C,E	S	--	On bank of Clear Fork of Brazos River.
* 54	--	--	--	77	4	--	P	51.5	Dec. 2, 1943	C,W	S	--	Water level measured while pumping 2 to 3 gpm.
* 55	R. E. Joyce	--	--	100	6	--	T	--	--	C,W	D,S	--	Probably penetrates Permian rocks.
56	W. B. Willingham	J. Aaron	--	170	6	--	T	100.0	--	C,W	S	--	
* 57	R. G. Davenport	--	--	40	--	--	T	--	--	C,W	S	--	
* 58	do	--	--	58	6	--	T	41.0	Nov. 24, 1943	C,W	S	--	
* 59	do	--	1920	62	5	--	T	30.4	Nov. 24, 1943	C,W	S	--	
60	do	--	1940	70	5	--	P	35	--	C	S	--	Water reportedly too highly mineralized for any use.
* 61	do	C. C. Justice	1935	112	5	--	T,P	46.6	Nov. 24, 1943	C,W	S	--	
* 62	do	--	--	90	6	--	--	70.4	Nov. 24, 1943	C,W	S	--	
63	do	--	1941	200	4	--	--	--	--	--	--	--	Seismic test hole; no water.
* 64	J. L. Gilmore	--	--	135	6	--	T	114.6	Dec. 2, 1943	C,W	D,S	--	Water for drinking hauled from this well by neighbors for many years.
* 65	R. G. Davenport	C. C. Justice	--	171	6	--	T	146.0	Nov. 24, 1943	C,W	S	--	
* 66	-- Etheridge	do	--	82	6	--	T	55.6	Nov. 24, 1943	C,W	S	--	
* 67	R. G. Davenport	do	--	110	6	--	T	60.8	Nov. 24, 1943	C,W	S	--	
68	do	--	--	112	--	--	T	--	--	--	N	--	Seismic test hole; low yield.
69	R. Etheridge	--	--	80	--	--	T	--	--	C,W	D,S	--	
* 70	T. R. Bonner	--	--	35	40	--	A	27.0	--	C,E	S	--	Water from gravel in stream valley.

See footnotes at end of table.

Table 2.--Records of wells in Fisher County--Continued

Well	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	Use of water	Yield (gpm)	Remarks
71	--	--	--	50	--	--	P	--	--	C,W	S	--	Discharge pipe incrusted with mineral precipitates.
72	--	Shell Oil Co.	--	207	4†	--	--	--	--	--	--	--	Seismograph test hole. 1/
73	--	do	--	217	4†	--	--	--	--	--	--	--	Do.
74	--	do	--	217	4†	--	--	--	--	--	--	--	Do.
75	--	do	--	205	4†	--	--	--	--	--	--	--	Do.
* 76	A. W. Kingsfield	--	1939	100	4	36	P,A	30.0	--	C,W	S	--	Water produced from Permian sandstone.
* 77	G. Stewart	--	--	27	36	--	P	20.0	--	C,W	S	--	
* 78	S. L. Hall	--	--	--	--	--	A,P	--	--	C,W	S	--	
* 79	City of Roby	--	--	Sump in creek	--	--	A,P	--	--	C,E	N	--	Formerly used for fire protection.
80	--	--	--	25	36	--	--	20.0	--	C,W	S	--	Thick mineral crusts on discharge pipe.
* 81	F. Brown	--	--	36	40	--	--	34.8	Dec. 21, 1943	C,W	S	--	White mineral precipitates on discharge pipe.
* 82	L. Cross	--	1898	35	48	--	A	30	--	C,W	D,S	--	
* 83	City of Rotan	--	--	55	35	--	A	25	--	T,E	P	--	Formerly used as standby well. Furnished drilling water to oil companies.
* 84	M. J. Ashley	--	--	83	6	--	A	48.3	Nov. 26, 1943	C,W	D,S	--	Formerly furnished water for 10 to 20 families during dry seasons.
* 85	W. S. Cleaveland	--	--	87	4	--	P	71	Dec. 16, 1943	C,W	S	--	Mineral deposits on discharge pipe.
* 86	D. Davis	--	1942	80	--	--	A,P	56.5	Nov. 26, 1943	C,W	S	--	Penetrated alluvium and several feet of underlying Permian siltstone.
* 87	C. Ratliff	--	--	31	6	--	A	19.5	Nov. 26, 1943	C,W	S	--	
* 88	--	--	--	28	36	--	A	22.8	Dec. 17, 1943	C,W	S	--	
* 89	-- Canfill	--	1940	34	--	--	A	29.4	Dec. 16, 1943	C,W	S	--	
* 90	do	--	--	79	5	--	A	53.3	Dec. 17, 1943	C,W	S	--	
91	do	--	--	35	--	--	A	31.7	Dec. 16, 1943	--	N	--	
* 92	-- Akers	--	--	31	36	--	A	27.7	Dec. 18, 1943	C,W	S	--	
* 93	-- Key	--	--	12	36	--	A	9.3	Dec. 16, 1943	--	D,S	--	

See footnotes at end of table.

Table 2.--Records of wells in Fisher County--Continued

Well	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	Use of water	Yield (gpm)	Remarks
* 94	-- Phesmeir	--	--	21	40	--	A	11.8	Dec. 18, 1943	--	D,S	--	Formerly supplied several families during dry seasons.
* 95	E. Masters	--	--	22	7	--	A	8.8	Dec. 18, 1943	C,W	D,S	--	Oil test 1/4 mile to southeast reportedly encountered strong salt water flow at 300 feet.
96	Kyle Springs	--	--	Spring	--	--	--	--	--	--	S	--	Spring at contact of Alluvium and Permian.
* 97	Clear Fork of Brazos River	--	--	River	--	--	--	--	--	--	S	--	Sample taken from pool. River not flowing.
* 98	F. O. Turner	--	--	35	40	--	A	28.0	Nov. 26, 1943	-	D,S	--	
99	--	Shell Oil Co.	--	207	--	--	-	--	--	--	--	--	Seismic test hole. 1/
100	--	do	--	200	--	--	--	--	--	--	--	--	Do.
101	--	do	--	207	--	--	--	--	--	--	--	--	Do.
*102	C. Evans	--	--	Spring	--	--	--	--	--	--	S	--	At contact of alluvium and Permian. Temp. 52°F.
*103	W. C. Mitchell	--	--	20	--	--	A	12.8	Dec. 21, 1943	C,W	D,S	--	

1/ See Table 3 for drillers' log.
* See Table 4 for chemical analyses of water.
† Reported yield.

Table 3.--Drillers' logs of wells in Fisher County

Logs of wells 72 through 101 adapted from Lang (1944).

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)

Well 27

Owner: J. Rowlan. Driller: G. W. Rodgers.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil and sand	15	15	Red bed	--	25
Sand and gravel	10	25			

Well 28

Owner J. Bruce. Driller: G. W. Rodgers

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil and clay	24	24	Red bed	--	36
Sand and gravel	12	36			

Well 32

Owner: L. L. Morgan. Driller: C. W. Rodgers

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	28	28	Red sand	20	71
Gravel	20	48	Red bed	--	71
Clay	3	51			

Well 39

Owner: W. A. Wadell. Driller: C. W. Rodgers

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	5	5	Sand and gravel	17	32
Caliche	10	15	Red bed	--	32

Well 41

Owner: C. H. Carriker. Driller: C. W. Rodgers

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	10	10	Sand and gravel	35	50
Sand and soil	5	15	Red bed	--	50

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)

Well 42

Owner: L. Brown. Driller: C. W. Rodgers.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	5	5	Sand and gravel	17	30
Clay	8	13	Red bed	--	30

Well 47

Owner: S. Jackson. Driller: G. W. Rodgers.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	5	5	Sand and gravel	18	28
Clay	5	10			

Well 72

Seismograph test hole, 5 miles southwest of Roby. Drilled by Shell Oil Company. Altitude of land surface, 2,043 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Surface soil	8	8	Red beds and shale	71	118
Gypsum	3	11	Red beds and sand rock	54	172
Sand rock	7	18	Red beds and blue clay	35	207
Red beds and sand rock	29	47			

Well 73

Seismograph test hole, 4-1/2 miles southwest of Roby. Drilled by Shell Oil Company. Altitude of land surface, 1,972 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand and gravel	17	17	Gypsum	24	154
Red beds	9	26	Hard rock	36	190
Gypsum	30	56	Red beds and shale with streaks of hard rock	16	206
Red beds	12	68	Red beds and streaks of shale	11	217
Sand rock	62	130			

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)

Well 74

Seismograph test hole, 4 miles southwest of Roby. Drilled by Shell Oil Company. Altitude of land surface, 1,988 feet.

Surface soil -------------	8	8	Hard rock ---------------	13	179
Gypsum and sand rock -----	27	35	Red beds ----------------	5	184
Red beds -----------------	47	82	Hard rock ---------------	15	199
Red beds, shale and sand rock --------------	36	118	Red beds and streaks of sand rock -------------	18	217
Red beds -----------------	28	146			
Sandy red beds and streaks of gypsum --------------	20	166			

Well 75

Seismograph test hole, 3-1/2 miles southwest of Roby. Drilled by Shell Oil Company. Altitude of land surface, 2,010 feet.

Surface soil -------------	8	8	Gypsum ------------------	6	103
Sand and sand rock -------	18	26	Sand rock ---------------	12	115
Gypsum -------------------	4	30	Red shale ---------------	12	127
Red beds and streaks of sand rock and gypsum ---	67	97	Red beds and shale ------	78	205

Well 99

Seismograph test hole, 4 miles southeast of Roby. Drilled by Shell Oil Company. Altitude of land surface, 1,972 feet.

Surface soil -------------	8	8	Sand, red beds, shale and streaks of rock ---	47	179
Gypsum and sand rock -----	33	41	Hard rock ---------------	9	188
Red beds and shale -------	77	118	Red beds ----------------	19	207
Sand and sand rock -------	14	132			

Well 100

Seismograph test hole, 3-1/2 miles southeast of Roby. Drilled by Shell Oil Company. Altitude of land surface, 1,924 feet.

	Thickness (feet)	Depth (feet)
Hard red clay	37	37
Red beds and streaks of gypsum	59	96
Hard rock	9	105
Red beds and streaks of gypsum	85	190
Red beds and streaks of hard rock	10	200

Well 101

Seismograph test hole, 5-1/2 miles southeast of Roby. Drilled by Shell Oil Company. Altitude of land surface, 1,893 feet.

	Thickness (feet)	Depth (feet)
Surface soil and sandy clay	18	18
Gypsum and sand rock	28	46
Red beds and shale	31	77
Red beds and blue clay	18	95
Red beds and shale	37	132
Red beds and streaks of hard rock	22	154
Hard rock	14	168
Red beds and shale	20	188
Hard rock	5	193
Red beds and shale	14	207

Table 4.--Chemical analyses of water samples in Fisher County.

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

Analyses for wells 51 through 103 adapted from Lang (1944).
All samples analyzed by U. S. Geological Survey except where indicated.

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C.)	pH
* 1	M. Jarnagin	38	Sept.12, 1962	28	534	252	833	168	2,890	537	2.3	133	5,377	2,367	5,800	7.3
* 1a	-- Jarnagin	Stream	do	17	942	790	6,739	630	6,335	8,690	.7	4.4	24,148	560	>12,000	7.4
* 2	J. H. Morris	25±	Sept.14, 1962	9	265	266	348	198	1,976	229	2.0	58	3,351	1,755	3,550	7.4
* 3	Ira Brock	30	Sept.12, 1962	19	726	628	1,347	371	2,959	2,578	.9	133	8,761	4,394	9,910	7.2
* 3a	-- Brock	Spring	do	15	501	5,071	9,154	946	29,248	6,360	6.6	633	51,985	221	>12,000	8.2
* 4	Fred Stevenson	140	Sept.13, 1962	26	461	298	446	338	1,470	470	2.5	1,090	4,601	2,375	5,150	7.4
* 5	W. S. Etheridge	115	Sept.12, 1962	28	603	231	563	111	2,180	861	.8	53	4,630	2,455	5,400	7.4
* 6	Floyd Weems	121	Sept.13, 1962	23	553	209	193	258	2,123	162	.9	16	3,120	2,240	3,504	7.3
* 7	R. Reynolds	90	do	14	1,111	430	1,278	207	1,965	3,840	.5	23	8,868	4,540	10,750	7.1
* 8	J. T. Mahaffey	32	do	3	148	153	367	67	1,009	470	.9	.4	2,217	100	3,080	6.8
* --	Alkali Creek at U. S. Hwy. 180	Stream	Sept.12, 1962	7	132	16	24	76	349	26	.1	1.6	632	393	--	7.1
† 9	J. N. Melton	30	Jan. 16, 1959	--	701	330	1,824	233	3,120	2,328	--	--	8,536	--	--	--
† 10	W. G. Hardy	50	Mar. 29, 1961	--	688	234	1,194	183	2,141	2,055	--	--	6,495	--	--	--
† 11	Jim O'Briant	80	Feb. 20, 1957	--	311	98	896	250	1,020	1,319	--	--	3,894	--	--	--
† 12	D. Darden	31	Aug. 10, 1956	--	320	107	156	256	1,104	149	--	--	2,098	--	--	--
† 13	B. W. Sumerlin	36	Feb. 13, 1957	--	590	516	21	311	2,018	911	--	--	4,367	--	--	--
† 14	Jewell Cummings	30	Mar. 17, 1959	--	506	281	631	345	2,853	381	--	--	4,997	--	--	--
† 15	A. D. Sumerlin	50	Apr. 6, 1959	--	613	186	988	734	1,938	1,293	--	--	5,752	--	--	--
			Sept.22, 1961	--	637	119	785	305	1,899	1,106	--	--	4,851	--	--	--
16	do	50	Aug. 4, 1960	36	675	161	752	220	2,040	1,140	--	86	5,000	2,350	6,350	6.5
† 19	Jewell Cummings	100	Aug. 17, 1959	--	507	108	1,023	49	2,991	553	--	--	--	--	--	--

See footnotes at end of table.

Table 4.--Chemical analyses of water samples in Fisher County--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) 1/	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C.)	pH
† 20	O. T. Shell	40	July 7, 1961	--	256	139	295	262	995	401	--	--	2,272	--	--	--
† 21	J. T. Stewart	42	Sept.11, 1961	--	484	118	549	244	1,563	751	--	--	3,709	--	--	--
† 22	B. J. Smith	60	Sept.25, 1961	--	631	116	285	244	1,467	670	--	--	3,413	--	--	--
† 23	R. E. Kidd	34	Sept.18, 1961	--	112	24	170	360	189	181	--	--	1,036	--	--	--
27	J. Rowlan	25	Aug. 4, 1960	25	585	33	39	120	1,390	16	--	139	2,290	1,600	2,440	6.5
† 37	M. Blair	60	Sept.18, 1961	--	560	104	423	217	1,402	785	--	--	3,491	--	--	--
43	F. Mitchell	36	Aug. 4, 1960	22	94	29	336	332	446	225	--	37	1,350	354	2,070	7.0
45	E. C. Kiser	30	Aug. 8, 1960	23	530	146	743	322	1,940	870	0.7	32	4,440	1,920	5,370	6.8
48	-- Redus	34	do	24	228	59	420	322	734	460	0.8	58	2,140	812	3,130	6.9
† 49	A. B. Martin	40	July 26, 1961	--	572	182	188	262	2,052	167	--	--	3,421	--	--	--
† 50	S. Jackson	34	Sept.11, 1961	--	550	189	741	268	1,967	1,058	--	--	4,773	--	--	--
51	F. W. Crum	49	Dec. 20, 1943	--	126	26	71	262	99	115	--	120	686	422	--	--
52	Tom Hefner	41	do	--	270	131	111	488	877	99	--	0.5	1,730	1,210	--	--
53	Sterling Willingham	30	Dec. 21, 1943	--	386	69	157	310	864	300	--	15	1,940	1,250	--	--
54	--	77	Dec. 2, 1943	--	605	128	106	226	1,770	160	--	16	2,900	2,040	--	--
55	R. E. Joyce	100±	Dec. 20, 1943	--	330	109	80	345	950	122	--	3.8	1,760	1,270	--	--
57	R. G. Davenport	40	Oct. 7, 1943	--	84	46	39	280	164	40	--	34	586	398	--	--
58	do	58	Nov. 24, 1943	--	600	83	63	310	1,590	43	--	9.6	2,540	1,840	--	--
59	do	62	Oct. 7, 1943	--	80	77	51	393	193	69	--	8.4	722	516	--	--
61	do	112	Nov. 24, 1943	--	124	71	253	376	558	185	--	.8	1,380	602	--	--
62	do	90	do	--	84	60	122	396	199	135	--	.2	795	456	--	--
64	Mrs. J. L. Gilmore	135	Dec. 2, 1943	--	42	12	115	367	46	25	--	2.2	434	154	--	--
65	R. G. Davenport	171	Nov. 24, 1943	--	58	26	158	380	179	69	--	.5	678	252	--	--
66	-- Ethridge	82	do	--	216	116	68	325	752	80	--	.8	1,390	1,020	--	--

See footnotes at end of table.

Table 4.--Chemical analyses of water samples in Fisher County--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) 1/	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (Micromhos at 25°C.)	pH
67	R. G. Davenport	110	Nov. 24, 1943	--	228	100	69	284	774	62	--	5.0	1,380	480	--	--
70	T. R. Bonner	35	Dec. 2, 1943	--	534	148	77	404	1,620	61	--	6.8	2,650	1,940	--	--
76	A. W. Kingsfield	100	Nov. 25, 1943	--	558	147	404	112	2,310	268	--	1.0	3,740	2,000	--	--
77	Geo. Stewart	27	do	--	610	111	184	176	1,900	148	--	60	3,100	1,980	--	--
78	S. Lee Hall	--	Oct. 7, 1943	--	362	143	438	164	1,830	284	--	3.5	3,140	1,490	--	--
79	City of Rotan	Spring	do	--	603	166	423	256	2,170	445	--	14	3,950	2,190	--	--
81	F. Brown	36	Dec. 21, 1943	--	576	116	228	197	1,860	161	--	60	3,120	1,910	--	--
82	L. C. J. Cross	35	Sept. 15, 1937	--	350	58	74	265	825	116	0.2	40	1,594	1,113	--	--
83	City of Rotan	55	Sept. 14, 1937	--	504	61	115	299	1,260	78	1.2	110	2,276	1,510	--	--
84	M. J. Ashley	83	Nov. 26, 1943	--	91	11	47	326	26	15	--	74	425	272	--	--
85	W. S. Cleveland	87	Dec. 16, 1943	--	810	232	350	135	1,780	1,220	--	64	4,520	2,980	--	--
86	Doyle Davis	30	Nov. 26, 1943	--	510	112	79	328	739	602	--	22	2,230	1,730	--	--
87	C. A. Ratliff	31	Nov. 26, 1943	--	412	59	264	386	879	372	--	110	2,290	1,270	--	--
88	--	28	Dec. 17, 1943	--	322	47	244	218	453	585	--	65	1,820	997	--	--
89	-- Canfil	34	Dec. 16, 1943	--	252	31	187	575	478	128	--	18	1,380	756	--	--
92	-- Akers	31	Dec. 18, 1943	--	808	199	1,120	188	2,020	2,120	--	18	6,380	2,840	--	--
93	-- Key	12	Dec. 16, 1943	--	84	19	35	370	26	13	--	3.2	370	288	--	--
94	Mrs. -- Phesmeir	21	Dec. 18, 1943	--	77	30	52	341	65	45	--	23	460	316	--	--
95	E. L. Masters	22	do	--	--	--	--	437	243	169	--	94	--	--	--	--
97	Clear Fork of the Brazos River	--	Oct. 7, 1943	--	--	--	--	153	2,550	2,355	--	--	--	--	--	--
98	F. O. Turner	35	Nov. 26, 1943	--	71	19	59	312	32	33	--	58	423	255	--	--
102	Charlie Evans	Spring	Dec. 21, 1943	--	360	99	312	470	376	790	--	112	2,280	1,310	--	--
103	W. C. Mitchell	20	do	--	121	20	99	429	98	57	--	81	687	384	--	--

* Samples analyzed by Texas State Department of Health.
† Samples analyzed by Texas A. & M. College.
1/ Includes both sodium (Na) and potassium (K) in samples 51 through 103.

Table 5.--Selected chemical analyses of oil-field brine produced in Fisher County [1]

(Chemical constituents are in parts per million)

Stratigraphic unit	Field	Average depth	Resistivity at 70°F	Specific gravity	pH	Sodium (Na)	Calcium (Ca)	Magnesium (Mg)	Chloride (Cl)	Sulfate (SO_4)	Bicarbonate (HCO_3)	Dissolved solids
Permian												
Coleman Junction	Eskota	2,200	--	1,051	6.1	20,600	2,490	855	36,100	2,850	470	--
Noodle Creek	do	2,600	--	1.0420	7.9	--	1,691	519	30,495	5,236	329	55,340
Do.	do	--	0.095	1.054	6.5	24,335	2,720	1,104	45,000	900	261	74,100
Do.	do	2,600	--	1.052	7.2	21,800	2,560	677	38,600	1,710	197	--
Do.	Raven Creek	2,648	.11	1.0515	5.64	24,200	3,080	748	42,243	2,229	115	73,615
Do.	Eivens	3,020	.10	1.059	7.1	27,100	3,920	764	49,500	1,900	245	89,400
Do.	Round Top	--	.13	1.055	7.0	25,600	3,315	642	44,750	3,125	256	83,000
Flippen Lime	Royston	3,000	.100	1.079	6.3	33,600	5,880	1,380	64,900	1,475	--	121,500
Do.	Wildcat	3,200	--	1.016	6.6	30,300	8,500	1,945	66,600	707	479	--
Do.	do	3,300	.086	--	--	--	--	--	--	--	--	--
Pennsylvanian												
Swastika	Newman	3,850	0.068	--	--	--	--	--	--	--	--	--
Do.	Pardue	--	.067	--	--	--	--	--	--	--	--	--
Do.	do	--	.065	--	--	--	--	--	--	--	--	--
Do.	do	3,770	.08	1.114	6.4	47,700	10,380	2,120	97,200	900	120	177,300
Do.	do	3,765	--	1.111	6.2	42,650	9,250	1,728	86,400	836	479	--
Do.	Round Top	3,860	--	1.121	6.2	44,700	12,265	1,773	95,300	267	195	--
Do.	do	3,860	.08	1.106	6.8	44,850	11,350	1,665	93,900	198	222	163,200
Do.	do	3,850	--	1.120	6.0	43,750	12,420	1,816	94,430	268	204	--
Do.	Toller	3,820	--	1.124	7.5	41,300	12,750	1,823	95,200	405	147	--
Do.	Wildcat	3,730	.067	--	--	--	--	--	--	--	--	--
Cisco Sand	Eskota	4,465	--	1.090	6.9	36,588	6,049	1,455	70,459	1,035	204	--
Canyon Sand	Blockline	--	.06	1.139	5.4	53,000	16,700	2,340	118,000	0	90	217,300
Do.	Claytonville	5,200	.07	1.141	6.1	54,800	17,300	2,030	121,000	230	135	220,500
Do.	Keener	5,260	.06	1.150	6.3	62,900	17,600	2,140	131,200	0	210	235,000
Do.	Pardue	4,489	--	1.128	6.0	46,100	13,800	2,008	101,200	35	138	--
Do.	do	4,450	.06	1.129	6.1	49,500	16,050	2,280	111,500	0	110	201,400
Do.	Round Top	4,500	.06	1.116	6.2	47,400	13,400	2,120	102,900	50	240	180,600
Canyon Reef	Claytonville	5,700	.055	1.143	5.9	56,200	15,500	2,620	121,900	445	220	223,000
Do.	do	5,700	.055	1.1315	5.74	48,035	14.257	2,271	106,230	468	95	172,151
Do.	Eskota	4,420	.072	1.0978	6.15	40,013	10,557	1,703	84,749	619	171	138,050
Palo Pinto	do	4,400	.068	--	--	40,010	10,557	1,703	84,749	619	171	137,812
Do.	do	4,421	--	1,105	4.0	37,650	10,100	1,914	81,250	521	22	--

Table 5.--Selected chemical analyses of oil-field brine produced in Fisher County--Continued 1/

Strati-graphic unit	Field	Average depth	Resistivity at 70°F	Specific gravity	pH	Sodium (Na)	Cal-cium (Ca)	Magne-sium (Mg)	Chlo-ride (Cl)	Sul-fate (SO_4)	Bicar-bonate (HCO_3)	Dis-solved solids
Palo Pinto	Round Top	4,970	--	1.055	6.7	22,310	2,720	1,011	41,150	1,270	144	--
Do.	do	4,970	0.11	1.056	7.0	28,600	3,650	960	51,700	1,675	360	85,000
Do.	do	4,970	.11	1.050	6.9	24,650	3,100	810	44,600	1,275	530	76,000
Strawn	Celotex	5,136	--	1.097	6.5	41,600	6,822	1,462	79,630	966	206	--
Strawn Sand	Lena Green	5,670	.07	1.144	6.6	56,400	18,850	1,900	125,800	Trace	115	225,400
Strawn	Pardue	5,360	.065	--	--	--	--	--	--	--	--	--
Do.	Bernecker	6,790	--	1.103	6.5	47,600	7,440	1,280	89,000	812	215	157,800
Do.	Ocho Juan	5,900	.052	1.1429	7.0	53,775	14.028	2,982	116,320	141	21	187,267
Do.	Raven Creek	4,800	.07	1.121	6.3	55,700	13,200	1,970	115,000	190	120	188,600
Do.	Sweetwater NW	6,460	.06	--	--	--	--	--	--	--	--	--
Do.	Wildcat	--	.07	1.137	6.5	57,400	16,000	2,580	124,000	240	170	214,100
Ordovician												
Ellenburger	Pardue	5,976	--	1.047	7.5	20,820	2,138	422	35,200	2,190	593	--
Do.	do	6,000	0.14	1.042	7.4	20,100	2,000	535	34,200	2,130	540	63,700
Do.	E. Pardue	6,200	.118	--	--	--	--	--	--	--	--	--
Do.	Pyron	7,340	.111	--	--	22,670	2,072	471	38,297	1,933	506	65,949
Do.	Round Top	--	.15	1.042	7.2	19,200	2,035	379	32,400	2,150	685	63,800
Do.	Young	7,047	--	1.049	7.3	20,790	1,732	415	34,390	2,269	440	--
Do.	Wildcat	--	--	1.052	7.0	22,000	2,490	505	41,700	1,850	405	79,100
Cambrian												
Cambrian	Round Top	6,200	0.151	1.039	7.4	--	1,880	460	31,000	2,140	460	--

1/ Data from "Resistivities and Chemical Analyses of Formation Waters From the West Central Texas Area," prepared by the West Central Texas Section of the Society of Petroleum Engineers of America of AIME.

Table 6.--Records of brine production and disposal in Fisher County for the calendar year 1961

(Reported by operators)

M, Miscellaneous disposal; A, Annulus injection.

Field	Total production (barrels)	To pits (barrels)	To injection wells (barrels)	Top of injection zone (depth, in feet, below ground level)	Maximum injection pressure (pounds per square inch)
ADAS (Canyon Reef)	46,985	10,485	36,500	2,565	Gravity
ADAS, S. (Canyon Reef)	730(M)	730(M)	--	--	--
BENNETT	75	75	--	--	--
BERNECKER (L. Strawn)	25,994	--	25,994	667(A)	300
BONNER (Penn)	8,910	8,910	--	--	--
CARRIKER	0	--	--	--	--
CLAYTONVILLE (Canyon Lime)	11,413	8,349	3,064	260(A)	125
CLAYTONVILLE, SE (5,000' sand)	3,075	3,075	--	--	--
CLAYTONVILLE (5,200' Canyon Sand)	24,611	24,611	--	--	--
COFFIN (Strawn Sand)	725	725	--	--	--
COFFIN (4,100' Canyon Sand)	725	725	--	--	--
DROKE (Caddo Lime)	1,825	1,825	--	--	--
ELSIE MAE (Canyon Sand)	0?	--	--	--	--
ESKOTA	462,911	--	462,911	3,215	Gravity
ESKOTA (Noodle Creek)	299,275	600	298,675	3,122	Gravity
FRANKUS (Strawn Reef)	30,000	--	30,000	285	30 to 60
HARGROVE (Noodle Creek)	2,000(M)	--	--	--	--
HUNSAKER (Strawn)	4,318	4,318	--	--	--
IDA (Strawn)	15,000	15,000	--	--	--
JONISUE BOWDEN (Canyon)	11,695	11,695	--	--	--
JUDY GAIL (Canyon Sand)	10,886	10,886	--	--	--
JUDY GAIL (Swastika)	16,200	--	16,200	66(A)	30 to 45

Table 6.--Records of brine production and disposal in Fisher County for the calendar year 1961--Continued

Field	Total production (barrels)	To pits (barrels)	To injection wells (barrels)	Top of injection zone (depth, in feet, below ground level)	Maximum injection pressure (pounds per square inch)
KEELER WIMBERLY (Canyon Sand)	1,241	1,241	--	--	--
LAWLIS (Goen Lime)	360	360	--	--	--
LENA GREEN (Strawn)	2,880	2,880	--	--	--
LONGWORTH (Flippin Lime)	412	412	--	--	--
NEILL (Goen Lime)	4,069	4,069	--	--	--
NEWMAN (Swastika)	22,188	21,138	1,050	147(A)	100 to 200
OCHO JUAN (Canyon)	5,980	1,766	4,214	--	--
PARDUE (Ellenburger)	1,035,757	--	1,035,757	3,410 or below	Gravity to 400
PARDUE (Canyon)	61,675	--	61,675	3,410 or below	Gravity to 400
PARDUE (Swastika)	389,252	--	389,252	3,410 or below	Gravity to 400
PARDUE, W. (Ellenburger)	45,441	172	45,269	163(A)	80
PERRY RANCH (Canyon)	0	--	--	--	--
RAVEN CREEK (Noodle Creek)	76,256	--	76,256	2,270 or below	Gravity to 500 or 600
RAVEN CREEK (Strawn)	34,407	1,453	32,954	3,056 or below	Gravity to 60
RAVEN CREEK (4,980' Strawn)	26,657	--	26,657	3,056	Gravity
RAVEN CREEK (Canyon)	25,559	3,800	21,759	2,270 or below	Gravity to 600
ROBY (Canyon)	472	472	--	--	--
ROBY, N. (Cisco)	16,584	274	16,310	1,980	50
ROTAN	24,363	24,363	--	--	--
ROUGH DRAW (Noodle Creek)	500	500	--	--	--
ROUND TOP (Canyon)	17,155	4,529	12,626	3,362 or below (5,110 bbls. at 166 A)	10 to 100 95 to 135
ROUND TOP (Palo Pinto Reef)	870,662	2,117	868,545	3,510 or below (6,205 bbls. at 166 A)	Gravity to 100 95 to 135
ROUND TOP (Swastika)	72,459	3,470	68,989	3,362 or below (11,680 bbls. at 166 A)	95 to 135 Gravity

Table 6.--Records of brine production and disposal in Fisher County for the calendar year 1961--Continued

Field	Total production (barrels)	To pits (barrels)	To injection wells (barrels)	Top of injection zone (depth, in feet, below ground level)	Maximum injection pressure (pounds per square inch)
ROYSTON	225,947	117,542	108,405	3,083 or below	Gravity to 300
ROYSTON (Canyon)	24,585	4,510	20,075	3,083 or below	Gravity to 125
SANDY HILL	8	8	--	--	--
SANDY HILL (Strawn)	711	711	--	--	--
SATURDAY (Canyon Sand)	2,403	203	2,200	1,980	50
SWEETWATER (Canyon Sand)	24,813	24,813	--	--	--
SYLVESTER (Goen Lime)	16,350	16,350	--	--	--
SYLVESTER (Strawn)	12,369	12,369	--	--	--
SYLVESTER, S. (Flippen)	1,080	1,080	--	--	--
TOLAR (Canyon)	7,585	360	7,555	3,485 or below	Gravity to 225
TOLAR (Swastika)	338,555	--	338,555	3,485 or below (39,320 bbls. at 170 A)	225 150

<u>County Totals</u>

Total salt water produced in 1961 ------- 4,365,363 barrels
To open surface pits --------------------- 351,516 barrels
To injection wells ---------------------- 4,011,117 barrels
Miscellaneous disposal --------------------- 2,730 barrels

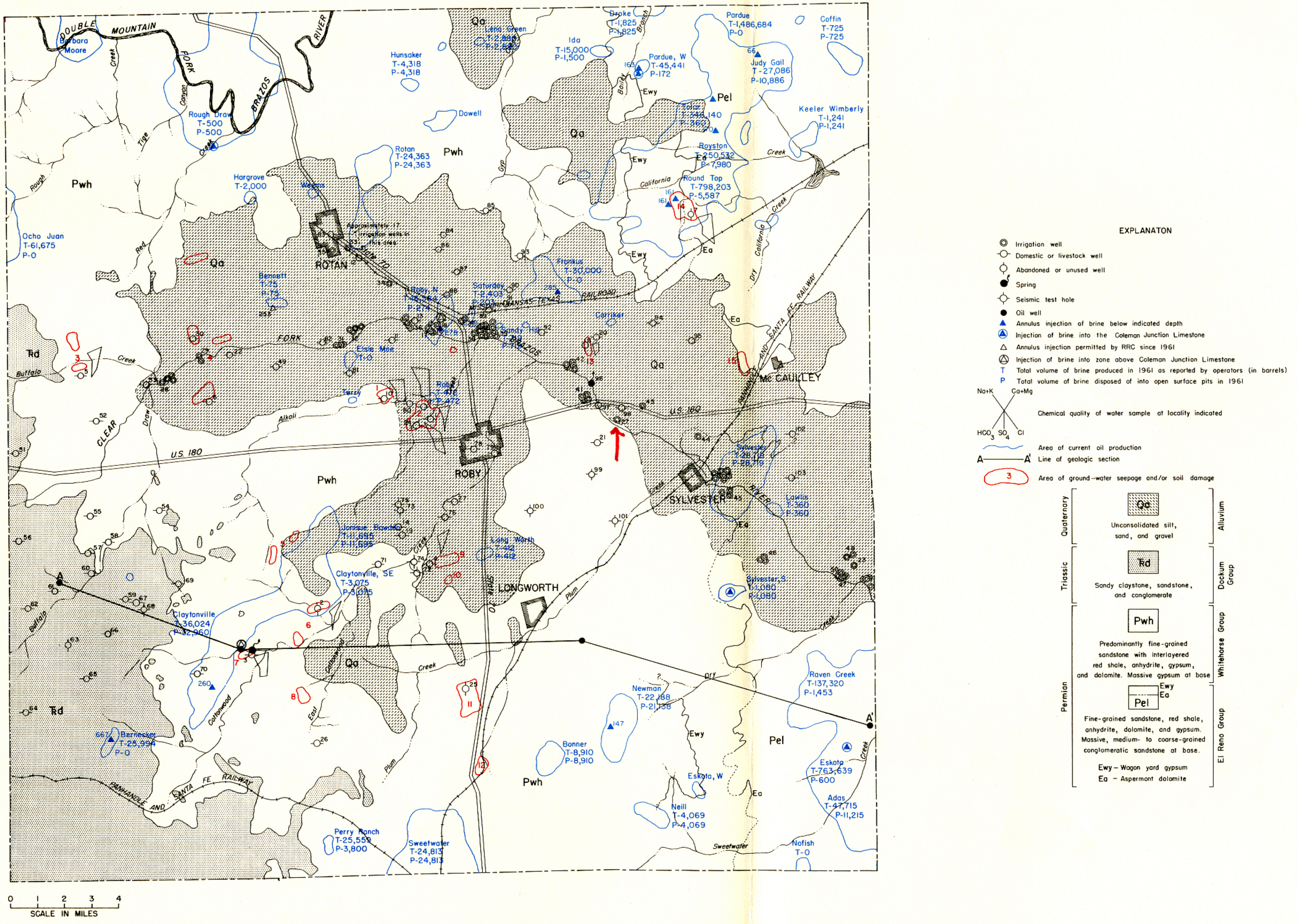
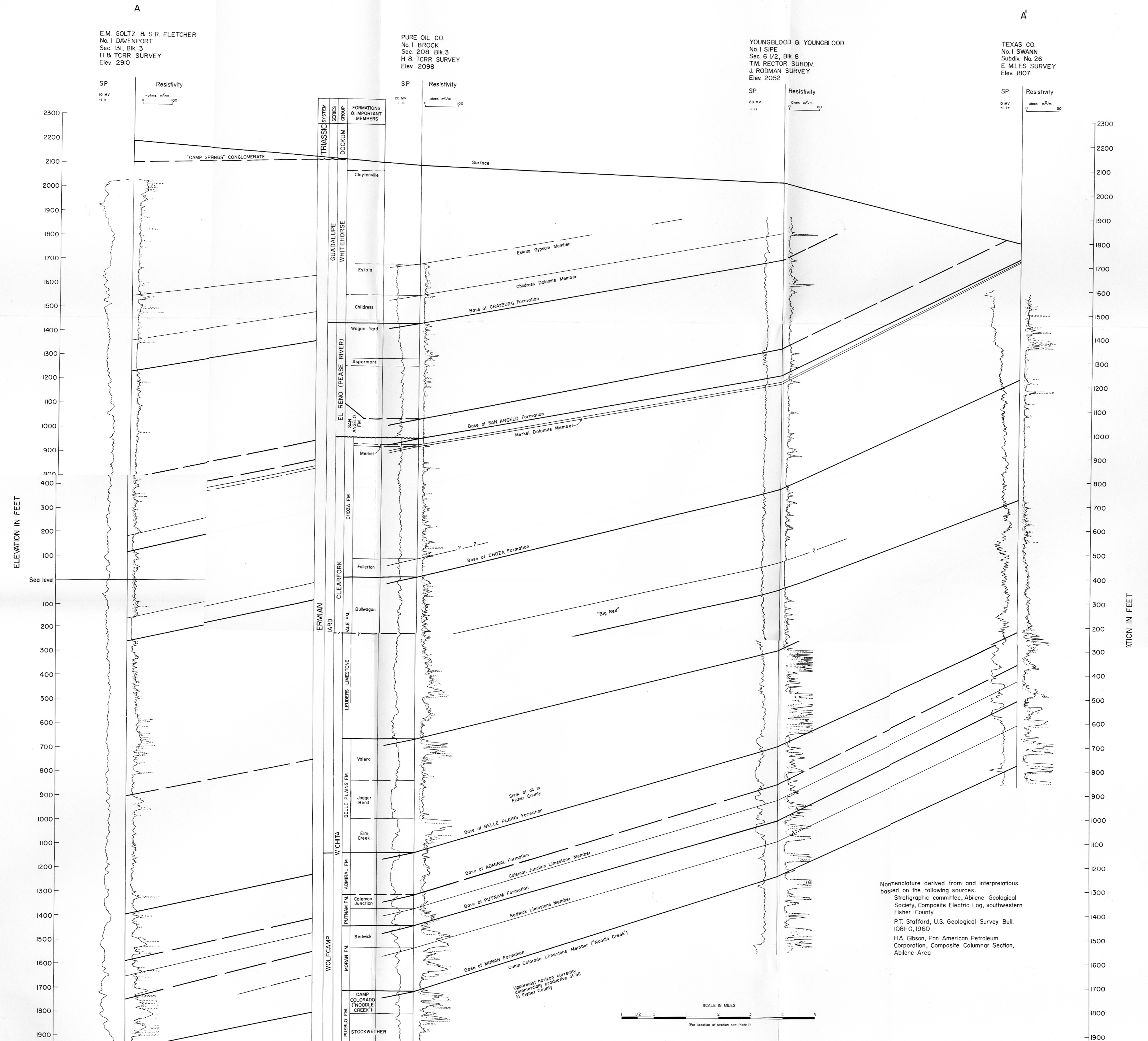


Plate I

Generalized Geologic Map of Fisher County Showing Location of Water Wells, Areas of Current Oil and Brine Production, and Areas of Ground-Water Seepage and Soil Damage

Texas Water Commission



Nomenclature derived from and interpretations based on the following sources:

Stratigraphic committee, Abilene Geological Society, Composite Electric Log, southwestern Fisher County

P.T. Stafford, U.S. Geological Survey Bull. 1081-G, 1960

H.A. Gibson, Pan American Petroleum Corporation, Composite Columnar Section, Abilene Area

Plate 2

Geologic Section A-A', Fisher County

Texas Water Commission