TEXAS WATER DEVELOPMENT BOARD

REPORT 113

# OCCURRENCE AND QUALITY OF GROUND WATER IN THROCKMORTON COUNTY, TEXAS

By

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# OCCURRENCE AND QUALITY OF GROUND WATER IN THROCKMORTON COUNTY, TEXAS


## ABSTRACT

Throckmorton County is in the drainage basin of the Brazos River in north-central Texas. Permian rocks of the Wichita and Clear Fork Groups, dipping gently to the northwest, are found at the surface within the county. Alluvial deposits of Quaternary age are found along the major streams in the county.

Small amounts of ground water, used mostly for household needs and watering livestock, are produced in Throckmorton County from the Moran, Putnam, Admiral, Belle Plains, and Leuders Formations of Permian age and from Quaternary alluvial deposits. This water occurs erratically in zones of generally low permeability on or near the outcrop. More than 87 percent of the wells are completed in the Lueders Formation and Quaternary alluvial deposits.

Water quality in the county varies widely. Although a general range in the native quality of water is apparent, water from some wells contains high concentrations of sodium, calcium, and chloride which do not fall within this general range. This water is from apparently or possibly contaminated wells. Several wells produce water high in nitrate content, indicating the possibility of contamination by sewage or animal wastes.

Methods of disposal of oil-field brines are the probable cause of some of the poorer water quality in Throckmorton County. Disposal of brine is also responsible for extensive soil damage and vegetative kill in some areas of the county. In 1961, 10,664,726 barrels of salt water was reported produced with oil and gas in the county. Of this amount, over 95 percent was reported returned to the subsurface through injection and disposal wells, 4 percent was reported placed into surface pits, and less than 1 percent was reported disposed of by other methods. In 1967, 6,396,766 barrels of salt water was produced with oil and gas in the county. Of this amount, 98.6 percent was injected into the subsurface, 0.2 percent was disposed in unlined surface pits, and 1.2 percent was disposed of by other methods.

# OCCURRENCE AND QUALITY OF GROUND WATER IN THROCKMORTON COUNTY, TEXAS

## INTRODUCTION

### Purpose and Scope

This investigation is one of several ground-water studies that are currently being conducted by the staff of the Texas Water Development Board in a block of 18 counties in north-central Texas to meet a growing need for more detailed and accurate ground-water information in this area. The Board recognizes the significance of ground water in this region and is aware of the vital need for obtaining detailed and accurate information on the depth of occurrence of usable-quality water as the basis for providing adequate and equitable protection for those water supplies. Several towns with municipal water supplies in north-central Texas are served by ground water or have water wells as a standby supply. In addition to meeting municipal needs for water in the area, ground water is often the sole source supplying domestic, farm, and ranch needs. Reports from the results of the investigations in Archer, Brown, Coleman, Montague, Shackelford, Stephens, and Young Counties have been published by the Board (See references at end of text), and reports on each of the remaining counties will be prepared and published as field studies are completed.

This report provides information on the location and extent of fresh water-bearing strata and the chemical quality of all ground water used; the surface and shallow subsurface geology as it relates to the depth and occurrence of ground water; the methods and amounts of oil-field brine disposal and the chemical character of brines; and the effects on water quality that may be caused by surface or subsurface disposal of oil-field brines, inadequate surface casing, or improperly plugged wells in the county.

This study was made under the general direction of John J. Vandertulip, former Chief Engineer; Richard C. Peckham, director, Ground Water Division; Bernard B. Baker, assistant director in charge of Availability Programs; and under the direct supervision of Loyd E. Walker, coordinator, West Texas Investigations.

### Methods of Investigation

During this investigation 143 water wells and springs were located in Throckmorton County, and for these information was compiled on well depth, depth to water in the wells, geologic formations in which the wells are completed, and methods of well construction.

Surface elevations of wells and springs were established with the aid of U.S. Geological Survey topographic maps. These elevations were used in comparing the depths to water and in determining the geologic formation in which the wells are completed.

Water samples were collected for chemical analysis from 125 of the wells and springs, and these analyses were studied to determine the chemical characteristics of the ground water and, where possible, to locate possible areas of pollution.

Various published geologic maps and numerous electric logs of oil and gas tests were studied and used to interpret the geologic conditions relating to the occurrence of ground water.

Oil-field brine disposal practices were observed in the field and available information on areas and amounts of brine production and methods of brine disposal was studied to identify possible connections with present or potential contamination of ground water.

Data from the water well inventory, chemical analyses of ground water and oil-field brines, and the inventory of salt-water production and disposal for the years 1961 and 1967 conducted by the Railroad Commission of Texas were tabulated. Climatological data that are significant to the occurrence and the use of water in the county were compiled, including precipitation, lake-surface evaporation, and temperature range.

### Previous Investigations

Several reports contain information on the geology of north-central Texas, but no detailed study of ground water has been made in Throckmorton County. Rocks in the county have been described and mapped by numerous investigators, although generally without consistent agreement as to formation names and stratigraphic relationships. The surface geology of the county has been mapped by Sellards, Adkins, and Plummer (1932); Hornberger (1937); and Stafford (1960); and remapping is underway by the Bureau of Ecomonic Geology, the University of Texas at Austin, as part of the Abilene and Wichita Falls Sheets of the Geologic Atlas of Texas.

A recent reconnaissance investigation of ground-water resources of the entire Brazos River basin was made by Cronin and others (1963), but the coverage within Throckmorton County was limited, as would be expected in this type of study. Numerous reports relating to the geology of the area are listed in the selected references.

### Well-Numbering System

The numbers assigned to wells and springs in this report conform to the statewide well-numbering system used by the Texas Water Development Board. Each well and spring is assigned a number to facilitate record keeping and locating wells within the State. This system is based on division of the State into quadrangles formed by degrees of latitude and longitude, and repeated division of these quadrangles into smaller ones as illustrated on Figure 2.

The largest quadrangle, a 1-degree quadrangle, is divided into sixty-four 7½-minute quadrangles, each of which is further divided into nine 2½-minute quadrangles. Each 1-degree quadrangle in the State has been assigned a number for identification. The 7½-minute quadrangles are numbered consecutively from left to right beginning in the upper left hand corner of the 1-degree quadrangle, and the 2½-minute quadrangles within each 7½-minute quadrangle are similarly numbered. The first two digits of a well number identify the 1-degree quadrangle, the third and fourth digits identify the 7½-minute quadrangle, the fifth digit identifies the 2½-minute quadrangle, and the last two digits designate the order in which the well was inventoried within the 2½-minute quadrangle. In addition to the 7-digit well number, a 2-letter prefix is used to identify the county. The prefix for Throckmorton County is XZ, and the county lies within the 1-degree quadrangle numbers 20, 21, 30, and 31.

### Acknowledgements

The writer expresses his appreciation to the many ranchers, farmers, oil operators, and other persons who generously gave information and cooperated in the collection of data. Appreciation is also expressed to the Agricultural Stabilization and Conservation County Committee, the U.S. Soil Conservation Service, the Railroad Commission of Texas, the Texas State Department of Health, the Texas Highway Department, the U.S. Geological Survey, and other local and county agencies who furnished information.

## GEOGRAPHY

### Location

Throckmorton County comprises an area of about 913 square miles and lies generally between 98°57′ and 99°28′ west longitude and 32°57′ and 33°23′ north latitude in north-central Texas (Figure 1). Throckmorton, the county seat, is near the center of the county about 73 miles southwest of Wichita Falls and 70 miles northeast of Abilene.

### Climate

The climate of Throckmorton County is subhumid. The average annual rainfall at Throckmorton was 24.83 inches during the period 1924-66, with a maximum of 55.94 inches in 1941 and a minimum of 10.66 inches in 1956. The rainfall for each year from 1924 through 1966 is shown on Figure 3.

The mean temperature for the month of July is 98°F, and that of January is 29°F. The average annual-mean temperature is about 64°F. The first frost in the fall usually occurs about November 6, and the last in the spring about March 31, leaving an annual growing season of about 220 days.

The average annual gross lake-surface evaporation is 75.5 inches based on records for the 26-year period 1940-65. The average annual net lake-surface evaporation (average annual gross lake-surface evaporation less the average annual effective rainfall) is about 51 inches (Figure 4).

Figure 1.—Location of Throckmorton County

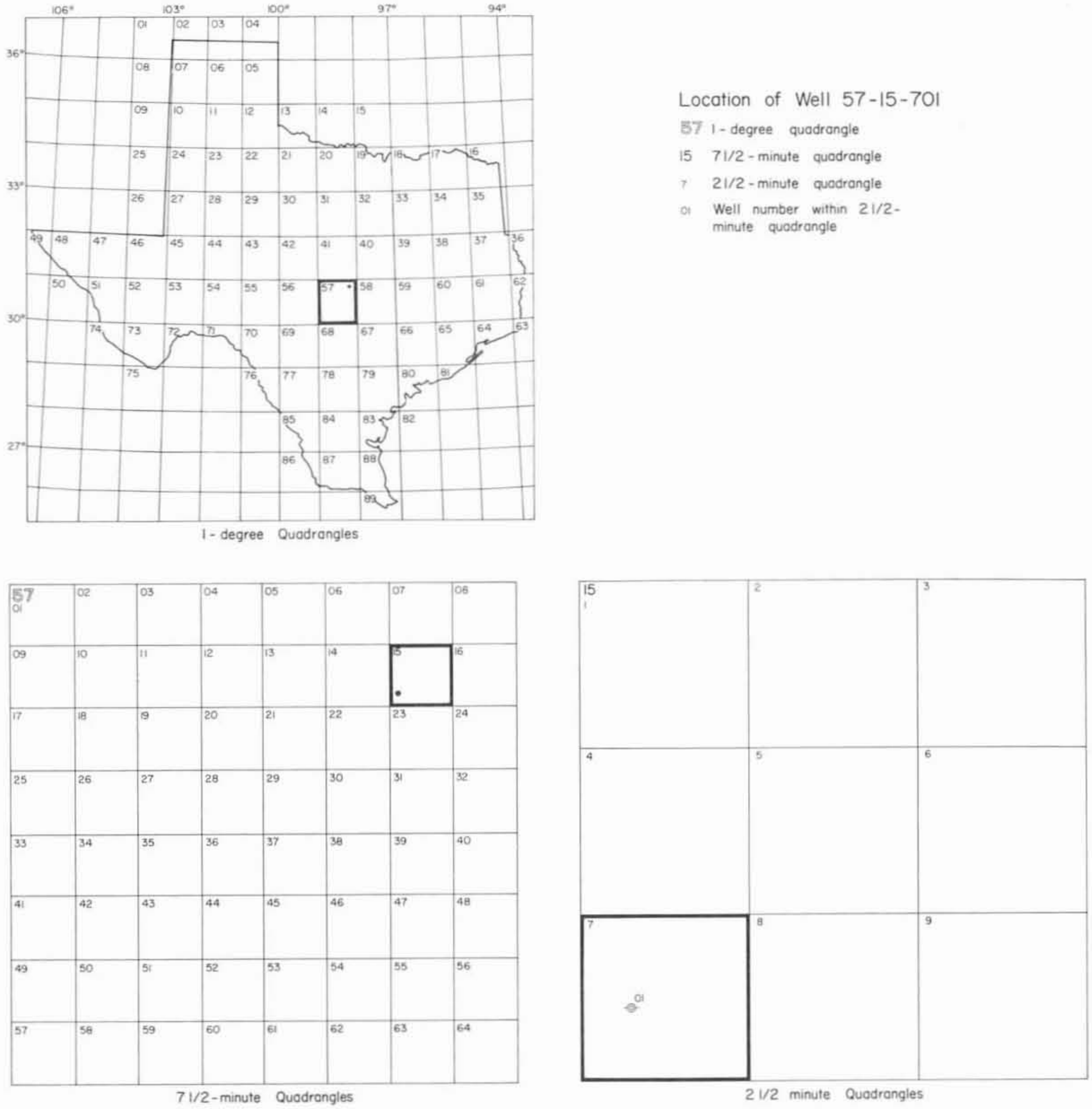



Figure 2.—Well-Numbering System

The average monthly distribution of precipitation and the average monthly distribution of gross and net lake-surface evaporation are shown on Figure 4.

## Topography and Drainage

Throckmorton County is in the Osage Plains section of the Central Lowland physiographic province of Texas. The topography is characterized by gently rolling terrain broken by north-south trending escarpments. There is a range in elevation from less than 1,150 to more than 1,750 feet above mean sea level.

Throckmorton County is in the drainage basin of the Brazos River. A topographic divide trends northwest across the county, passing just south of Throckmorton and crossing the county lines about 10 miles north of the county's southeast corner and about 12 miles south of the northwest corner. Draining the county north of this divide are Millers, Leopard, Boggy, Elm, and Bush Knob Creeks which flow north and east into the Brazos River. Lambs Head, Given, Paint, and Kings Creeks drain the county south of the divide and flow northeast and southeast into the Clear Fork Brazos River.

Throckmorton Reservoir, the municipal water supply for the town of Throckmorton, is on Elm Creek about a mile southwest of the town. The reservoir was constructed in 1918, and was enlarged to a capacity of 1,825 acre-feet in 1940.

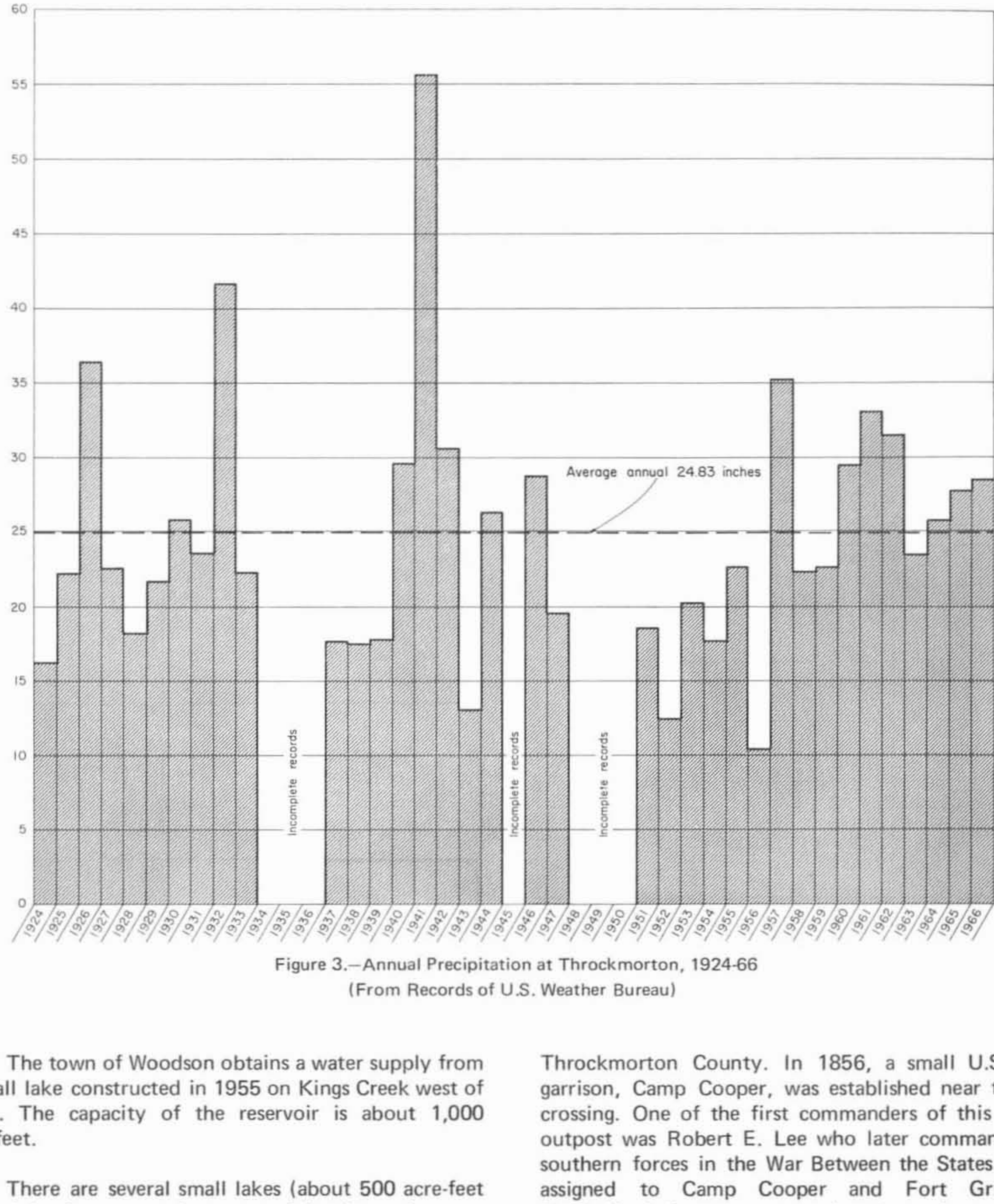



Figure 3.—Annual Precipitation at Throckmorton, 1924-66
(From Records of U.S. Weather Bureau)

The town of Woodson obtains a water supply from a small lake constructed in 1955 on Kings Creek west of town. The capacity of the reservoir is about 1,000 acre-feet.

There are several small lakes (about 500 acre-feet or less) in the county that are used for domestic water supplies.

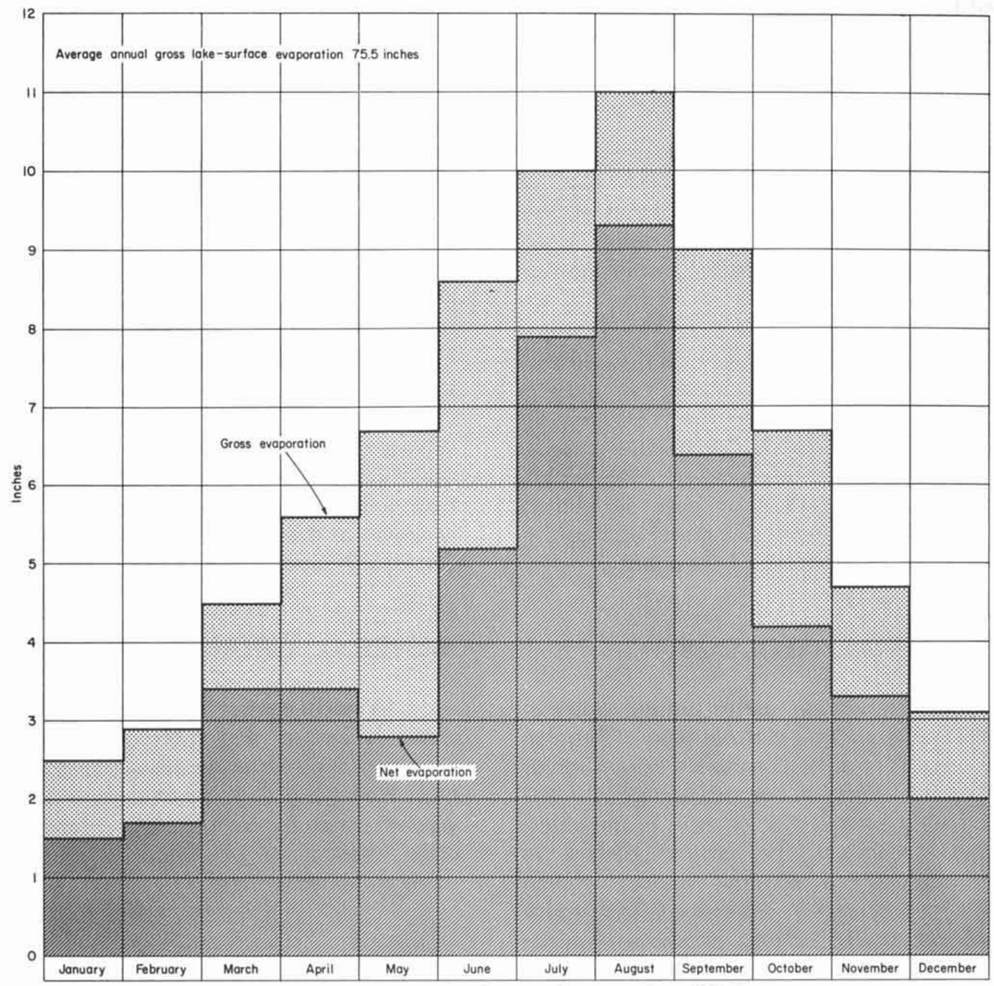
## History, Population, and Economy

Throckmorton County was created from a part of Fannin County in 1858. Only a few ranchers settled along the Clear Fork Brazos River prior to this time because of a continuous danger from hostile indians.

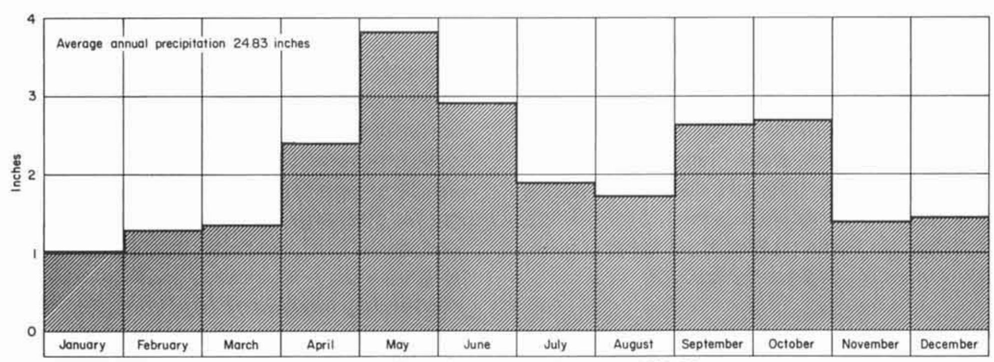
The old California Trail and the Butterfield Overland Stage Line crossed the Clear Fork Brazos River in Throckmorton County. In 1856, a small U.S. Army garrison, Camp Cooper, was established near the river crossing. One of the first commanders of this frontier outpost was Robert E. Lee who later commanded the southern forces in the War Between the States. Troops assigned to Camp Cooper and Fort Griffin in Shackelford County protected early settlers and later guarded the Comanche Indian Reservation located along the Clear Fork Brazos River. Under the protection of these frontier garrisons Throckmorton County was opened for settlement.

Throckmorton County was officially organized in 1879 with Williamsburg (now abandoned) as its county seat. Soon afterward the town of Throckmorton was established and the seat of county government moved there.

According to the census of 1860, the population of Throckmorton County was 124. By the year 1900,




Average Monthly Lake-Surface Evaporation, Throckmorton County, 1940-65




Average Monthly Precipitation at Throckmorton, 1924-66

Figure 4

## Average Monthly Precipitation at Throckmorton and Average Monthly Lake-Surface Evaporation in Throckmorton County

(From Kane, 1967, and Records of U.S. Weather Bureau) population increased to 1,750. The discovery of oil in 1924 and subsequent exploration brought the population to an all-time high of 5,253 in 1930. Since that time, the population has declined, and in 1967 the county had an estimated 2,735 people with 1,226 of them residing in the town of Throckmorton.

The economy of the county depends primarily on agriculture and the production of oil and gas. Most of the agricultural income is from the production of beef cattle. The farming consists largely of raising small grains, cotton, and hay, primarily in the eastern part of the county.

The major industry of Throckmorton County is the production of oil and gas. There has been a continuous development since the first discovery in 1924. According to Texas Railroad Commission records, 2,622,700 barrels of oil was produced in 1965, with a total oil production since 1924 of over 64 million barrels. The production of sand and gravel also contributes significantly to the economy of the county.

## GENERAL GEOLOGY

Formations that contain usable ground water in Throckmorton County are near-surface rocks of Permian and Quaternary age (Table 1). The Pueblo Formation of the Wichita Group of Permian age, cropping out in the extreme southeastern part of the county, is the oldest rock unit that occurs at the ground surface in Throckmorton County. Progressively younger Permian rocks crop out to the west in a series of north-south trending bands across the county as shown on the geologic map (Figure 9), while Quaternary alluvium is generally confined to stream valleys.

The Moran Formation, which crops out in the southeast part of the county, is the oldest stratigraphic unit known to contain water of usable quality in the county. Other units that contain usable-quality ground water are the Putnam, Admiral, Belle Plains, and Leuders Formations, and the alluvial deposits that occur along major streams (Figure 9). Older rocks which occur in the subsurface are listed in Table 1, and their stratigraphic relationships are shown on Figures 12 and 13.

The principal, large, buried structural features affecting the attitude of strata in north-central Texas are illustrated on Figure 5. These structures include the Bend flexure, Red River uplift, Muenster arch, Fort Worth basin, eastern Midland shelf, Concho arch, and Concho shelf.

Throckmorton County is on the Concho shelf where rocks of Pennsylvanian and Permian age form a westward-dipping homocline. Geological formations underlying the county dip west-northwest about 40 feet per mile, excluding the channel-fill sandstones that occur in the Permian rocks and the surficial deposits of Quaternary alluvium.

On the geologic map, delineation of Permian formations is based largely on the previous mapping of numerous traceable limestone beds in the county by Hornberger (1937). These mapped beds were assigned to the various formations according to the nomenclature used by Stafford (1960) and based on the formation definitions of Moore (1949) and Eargle (1960). Mapping of the Quaternary alluvium on Figure 9 is from Stafford (1960) with some modification based on field observation.

Not all of the limestone beds that were used by Moore and Eargle in defining these Permian formations have been found traceable on the ground across Throckmorton County, so that the position of formation boundaries in some areas is questionable as indicated by dashed boundary lines on Figure 9. More refined mapping of the surface geology in Throckmorton County is presently (1970) underway by the Bureau of Economic Geology, The University of Texas at Austin, as a part of the Abilene and Wichita Falls Sheets of the Geologic Atlas of Texas.

## GENERAL GROUND-WATER HYDROLOGY

In north-central Texas, the occurrence of ground water is erratic, and there are no large, continuous, prolific ground-water aquifers such as those found in the High Plains and Gulf Coast regions of Texas. However, ground water in north-central Texas conforms to the same fundamental principles of occurrence as that in other areas of the State.

### Hydrologic Cycle

The hydrologic cycle is the sum total of processes and movements of the earth's moisture from the sea, through the atmosphere to the land, and eventually, with numerous delays en route, back to the sea. All water occurring in Throckmorton County is from precipitation. The water available for use—whether as direct precipitation, streamflow, water from wells, or spring discharge—is captured in transit, and after its use and reuse is returned to the hydrologic cycle. This cycle is graphically illustrated in Figure 6 which shows the continuing movement of water from the oceans through evaporation to precipitation and its return either directly or ultimately to the ocean.

### Source, Occurrence, and Movement of Water

The geologic history of sedimentary deposition and erosion is a primary factor controlling the occurrence and movement of ground water in the north-central Texas area. The rocks found in the shallow subsurface range from sporadic, uncemented, clastic beds to the more widespread and more continuous beds

Table 1.—Stratigraphic Units and Their Water-Bearing Properties in Throckmorton County

| SYSTEM | GROUP | FORMATION | MEMBER | APPROXIMATE THICKNESS (FEET) | PREDOMINANT CHARACTER OF ROCKS | WATER-BEARING CHARACTERISTICS |
|---|---|---|---|---|---|---|
| Quaternary | | Alluvium | | 0 to 20 | Gravel, sand, silt, sandy silt, and clay; usually deposited along rivers and major tributaries, although some gravels are found on higher plateaus. | Yields fresh to slightly saline water in small quantities to wells. |
| Permian | Clear Fork | Arroyo | | — | Thin limestone beds and thick shales. | Not known to yield usable-quality water in Shackelford County. |
| | Wichita | Lueders | | 90 | Massive to thin limestone beds with thin shale breaks. | Yields fresh to slightly saline water in small quantities to wells in the outcrop. |
| | | Clyde | Talpa Limestone<br>Grape Creek Limestone | 220 | Thin to massive limestone beds alternating with shale and marl. | Not known to yield usable-quality water in Shackelford County. |
| | | Belle Plains | Bead Mountain Limestone<br>Valera Shale<br>Jagger Bend Limestone<br>Voss Shale<br>Elm Creek Limestone<br>Jim Ned Shale | 325 | Limestones and thick to thin shales. | Yields fresh to slightly saline water in small quantities to wells in the outcrop. |
| | | Admiral | Overall Limestone<br>Wildcat Creek Shale<br>Hords Creek Limestone<br>Lost Creek Shale | 165 | Thin-bedded limestones and thick shales. | Do. |
| | | Putnam | Coleman Junction Limestone<br>Santa Anna Branch Shale | 85 | Thin limestone beds and thick shales with some thin lenticular sandstones. | Do. |
| | | Moran | Sedwick Limestone<br>Gouldbusk Limestone<br>Ibex Limestone<br>Watts Creek Shale | 275 | Thin limestone beds, massive shales, and channel-fill sandstones. | Do. |
| | | Pueblo | Camp Colorado Limestone<br>Salt Creek Bend Shale<br>Stockwether Limestone<br>Camp Creek Shale | 220 | Thin limestone beds, massive shales, and channel-fill sandstones. | Not known to yield usable-quality water in Shackelford County. |
| --?---?-- | | | | | | |
| Pennsylvanian | Cisco | | | 1,050 | Thin limestone beds, massive shales, and channel-fill sandstones. | Do. |
| | Canyon | | | 800 | Massive to thin limestone beds interbedded with massive shales and thin lenticular sandstones. | Do. |
| | Strawn | | | 1,600 | Thick units of shale, limestone, and sandstone. | Do. |
| | Bend | | | 175 | Thick shale units with some sand and conglomerate. | Do. |
| Mississippian | | | | 200 | Limestone and shale beds. | Do. |
| Ordovician | Ellenburger | | | — | Massive limestone. | Do. |

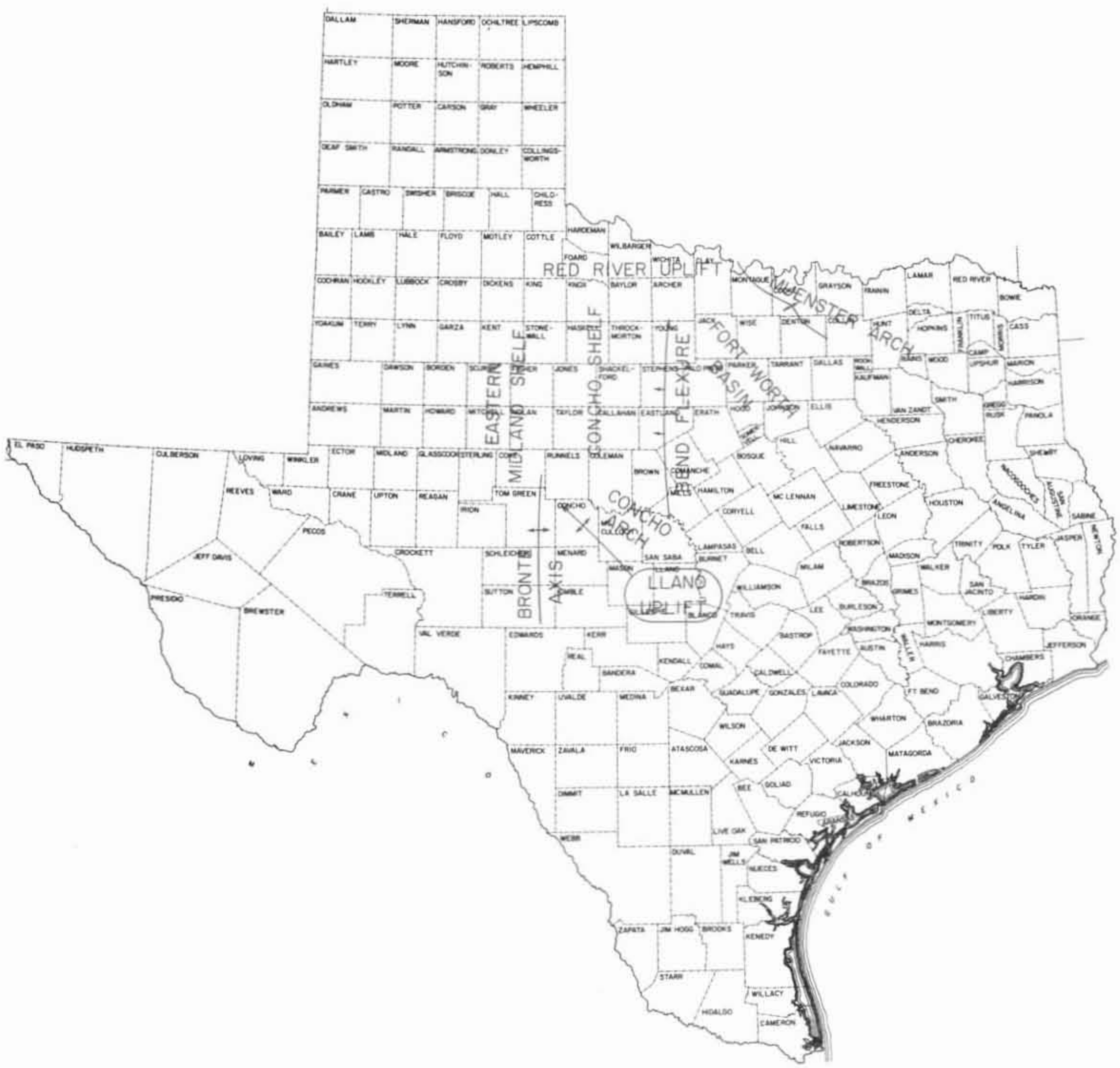



Figure 5

Major Structural Features in North-Central Texas

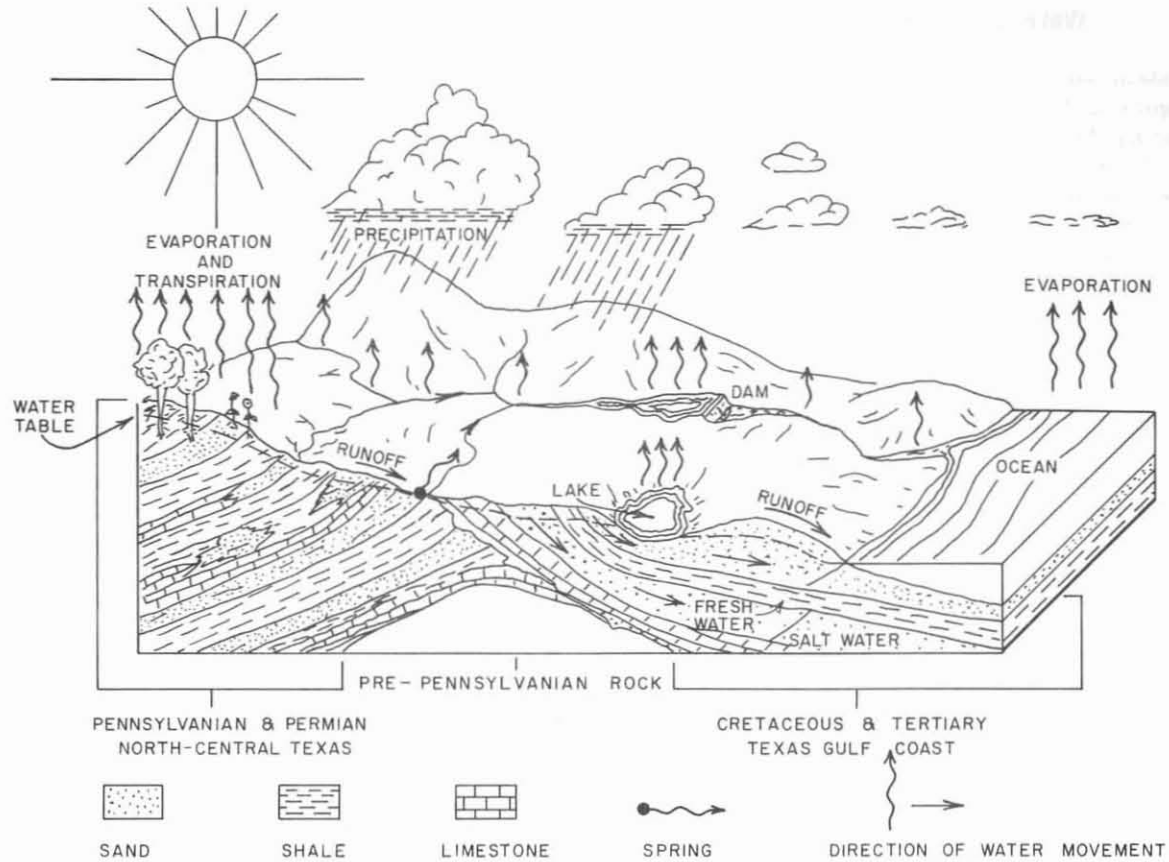



Figure 6.—Hydrologic Cycle

of cemented or compacted shale, sandstone, and limestone. In uncemented rocks, such as sand, gravel, and clay, water occurs in the spaces between individual particles; whereas, in cemented or compacted sedimentary rocks, it occurs cheifly in cracks and fissures produced by earth movement or contraction and in openings formed by solution where the rocks are soluble. If these openings are isolated, the movement of ground water is hindered. However, most openings are interconnected and permit ground water to move through them. The essential factor is that ground water of usable quality is continually moving from the point at which it entered the ground-water body, called the recharge area, to points of discharge, generally at lower elevations, either in stream drainage or through wells.

Recharge is the process by which water is added to an underground water-bearing formation, whether by precipitation on the outcrop of the formation or by seepage from surface streams or lakes on the outcrop. Factors that limit the amount of recharge received by a formation are the amount and frequency of precipitation, the area and extent of the outcrop, the topography, the type and amount of vegetation, the condition of the soil in the outcrop area, and the capacity of the formation to accept recharge. Discharge is the process by which water is removed from the formation, either through surface drainage or through wells.

The direction and rate of movement of water through a porous medium, such as an underground geologic formation, is influenced by a variety of factors, which include the nature of the formation itself, the external pressures applied on it, and the fundamental physical laws of gravity and momentum. These factors also include surface tension, friction, atmospheric pressure where the formation encounters the earth's surface, paths of differential permeability, effects of heavy local withdrawals or injection of water, and climatic changes affecting rates of recharge. In Throckmorton County ground-water movement is not constant in either direction or rate. The environment through which it moves is a heterogeneous complex of sedimentary deposits varying in porosity, permeability, and angle of repose. Thus it is not easy, and frequently not possible in the light of present knowledge, to determine precisely the route water will take from the point of recharge to the points of discharge at the ground surface. In the area of this study, however, this route is probably circuitous and of relatively short geographic extent. As a consequence, a landowner, whether private or public, has a particular need for understanding the hydrologic factors affecting the occurrence of ground water. Only by a careful discriminating study of the geologic environment of his immediate locality can he determine the availability of ground water for beneficial use, or the means required to protect available ground water from pollution.

### Water-Level Fluctuations

Measurements of water levels in wells show locally the depths to the water table (the piezometric surface in artesian aquifers). Although static conditions may never occur, the term *static level* is sometimes used to describe a measured water level in a well that is relatively uninfluenced by pumping. The term *pumping level* is sometimes used to describe a measured water level in a well that is relatively influenced by pumping. Changes in water levels are important in evaluation of aquifers, and may be due to local or regional influences. Changes in water levels are of significance over both long and short time intervals. The most significant changes result from imbalance of the recharge-discharge relationship.

Concentrated pumpage also can produce significant changes in water levels. The water table near a pumped well is drawn down into the shape of an inverted cone with its apex at the pumped well. Development of this cone is dependent upon the hydraulic properties of the aquifer and the pumping rate. The cone of depression expands until it intercepts recharge which is equal to the demand, or it continues to expand as water is withdrawn from storage. In heavily developed irrigation areas, the cone of each well is superimposed upon the cones of adjacent wells, thus creating a regional cone of depression in the water table or piezometric surface.

Changes in atmospheric pressure, tidal forces, and earthquakes can affect changes in water levels, but the fluctuation are usually very small.

## GENERAL CHEMICAL QUALITY OF GROUND WATER

### Chemical-Quality Standards and Criteria

All ground water contains dissolved mineral constituents. The type and concentration depends upon the source, movement, and environment of the ground water. Water derived from precipitation is relatively free of mineral matter, but because water has considerable solvent power, it dissolves minerals from the soil and rocks through which it passes. Therefore, the differences in chemical character of ground water reflect, in a general way, the nature of the geologic formations and the soils that have been in contact with the water. The concentration of dissolved solids generally increases with depth, especially where the movement of the water is restricted. Rocks deposited under marine conditions will contain brackish or highly mineralized water unless flushing by fresh water has been accomplished. This flushing action will occur in the outcrop area and to a limited distance downdip, depending in part upon the permeability of the rocks.

The chemical quality of ground water that has not been artificially altered is relatively constant, as is the temperature of ground water, which makes it highly desirable for many uses.

In addition to the natural mineralization of water that occurs in its environment, the quality of ground water can also be affected by man. Municipal and domestic sewage systems (including septic tanks), industrial waste, and oil-field brine that is improperly disposed of can enter into ground water and render it unfit for most uses.

Included among the factors determining the suitability of ground water as a supply are the limitations imposed by the intended use of the water. Criteria have been developed to cover most categories of water quality, including bacterial content, physical characteristics, and chemical constituents. Water-quality problems associated with the first two categories can usually be alleviated economically, but the removal of undesirable chemical constituents can be difficult and expensive The source and significance of the principal dissolved-mineral constituents occurring in ground water are summarized in Table 2.

For many purposes the dissolved-solids content constitutes a major limitation on the use of water. A general classification of water by Winslow and Kister (1956, p. 5) based on dissolved-solids content in mg/l (milligrams per liter) is as follows:

| DESCRIPTION | DISSOLVED-SOLIDS CONTENT (MG/L) |
|---|---|
| Fresh | Less than 1,000 |
| Slightly saline | 1,000 to 3,000 |
| Moderately saline | 3,000 to 10,000 |
| Very saline | 10,000 to 35,000 |
| Brine | More than 35,000 |

The U.S. Public Health Service has established standards for drinking water to be used on common carriers engaged in interstate commerce. The standards are designed primarily to protect the traveling public and are often used to evaluate public water supplies. According to these standards, chemical constituents should not be present in the water supply in excess of the listed concentrations except where other more suitable supplies are not available. Some of the standards adopted by the U.S. Public Health Service (1962, p. 7-8) are as follows:

## Table 2.—Source and Significance of Dissolved-Mineral Constituents and Properties of Water

| CONSTITUENT OR PROPERTY | SOURCE OR CAUSE | SIGNIFICANCE |
|---|---|---|
| Silica ($SiO_2$) | Dissolved from practically all rocks and soils, commonly less than 30 mg/l. High concentrations, as much as 100 mg/l, generally occur in highly alkaline waters. | Forms hard scale in pipes and boilers. Carried over in steam of high pressure boilers to form deposits on blades of turbines. Inhibits deterioration of zeolite-type water softeners. |
| Iron (Fe) | Dissolved from practically all rocks and soils. May also be derived from iron pipes, pumps, and other equipment. More than 1 or 2 mg/l of iron in surface waters generally indicates acid wastes from mine drainage or other sources. | On exposure to air, iron in ground water oxidizes to reddish-brown precipitate. More than about 0.3 mg/l stains laundry and utensils reddish-brown. Objectionable for food processing, textile processing, beverages, ice manufacture, brewing, and other processes. U.S. Public Health Service (1962) drinking-water standards state that iron should not exceed 0.3 mg/l. Larger quantities cause unpleasant taste and favor growth of iron bacteria. |
| Calcium (Ca) and magnesium (Mg) | Dissolved from practically all soils and rocks, but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in sea water. | Cause most of the hardness and scale-forming properties of water; soap consuming (see hardness). Waters low in calcium and magnesium desired in electroplating, tanning, dyeing, and in textile manufacturing. |
| Sodium (Na) and potassium (K) | Dissolved from practically all rocks and soils. Found also in ancient brines, sea water, industrial brines, and sewage. | Large amounts, in combination with chloride, give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers and a high sodium content may limit the use of water for irrigation. |
| Bicarbonate ($HCO_3$) and carbonate ($CO_3$) | Action of carbon dioxide in water on carbonate rocks such as limestone and dolomite. | Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot water facilities to form scale and release corrosive carbon dioxide gas. In combination with calcium and magnesium, cause carbonate hardness. |
| Sulfate ($SO_4$) | Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Commonly present in mine waters and in some industrial wastes. | Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts, sulfate in combination with other ions gives bitter taste to water. Some calcium sulfate is considered beneficial in the brewing process. U.S. Public Health Service (1962) drinking-water standards recommend that the sulfate content should not exceed 250 mg/l. |
| Chloride (Cl) | Dissolved from rocks and soils. Present in sewage and found in large amounts in ancient brines, sea water, and industrial brines. | In large amounts in combination with sodium, gives salty taste to drinking water. In large quantities, increases the corrosiveness of water. U.S. Public Health Service (1962) drinking-water standards recommend that the chloride content should not exceed 250 mg/l. |
| Fluoride (F) | Dissolved in small to minute quantities from most rocks and soils. Added to many waters by fluoridation of municipal supplies. | Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth, depending on the concentration of fluoride, the age of the child, amount of drinking water consumed, and susceptbility of the individual. (Maier, 1950) |
| Nitrate ($NO_3$) | Decaying organic matter, sewage, fertilizers, and nitrates in soil. | Concentration much greater than the local average may suggest pollution. U.S. Public Health Service (1962) drinking-water standards suggest a limit of 45 mg/l. Waters of high nitrate content have been reported to be the cause of methemoglobinemia (an often fatal disease in infants) and therefore should not be used in infant feeding. Nitrate has been shown to be helpful in reducing inter-crystalline cracking of boiler steel. It encourages growth of algae and other organisms which produce undesirable tastes and odors. |
| Dissolved solids | Chiefly mineral constituents dissolved from rocks and soils. Includes some water of crystallization. | U.S. Public Health Service (1962) drinking-water standards recommend that waters containing more than 500 mg/l dissolved solids not be used if other less mineralized supplies are available. Waters containing more than 1000 mg/l dissolved solids are unsuitable for many purposes. |
| Hardness as $CaCO_3$ | In most waters nearly all the hardness is due to calcium and magnesium. All the metallic cations other than the alkali metals also cause hardness. | Consumes soap before a lather will form. Deposits soap curd on bathtubs. Hard water forms scale in boilers, water heaters, and pipes. Hardness equivalent to the bicarbonate and carbonate is called carbonate hardness. Any hardness in excess of this is called non-carbonate hardness. Waters of hardness as much as 60 ppm are considered soft; 61 to 120 mg/l, moderately hard; 121 to 180 mg/l, hard; more than 180 mg/l, very hard. |
| Specific conductance (micromhos at 25°C) | Mineral content of the water. | Indicates degree of mineralization. Specific conductance is a measure of the capacity of the water to conduct an electric current. Varies with concentration and degree of ionization of the constituents. |
| Hydrogen ion concentration (pH) | Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxides, and phosphates, silicates, and borates raise the pH. | A pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. pH is a measure of the activity of the hydrogen ions. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals. |

| SUBSTANCE | CONCENTRATION (MG/L) |
| --- | --- |
| Chloride (Cl) | 250 |
| Iron (Fe) | .3 |
| Manganese (Mn) | .05 |
| Nitrate ($NO_3$) | 45 |
| Sulfate ($SO_4$) | 250 |
| Total dissolved solids | 500 |

Water having concentrations of chemical constituents in excess of the recommended limits may be objectionable for many reasons. According to Maxcy (1950, p. 271), water containing nitrate in excess of 45 mg/l has been related to the incidence of infant cyanosis (methemoglobinemia or "blue baby" disease). A high nitrate concentration is often, but not always, indicative of pollution from organic matter, commonly human or livestock wastes. Iron and manganese in excessive concentrations cause reddish-brown or dark-gray precipitates, which stain clothing and plumbing fixtures. Sulfate in water in excess of 250 mg/l may produce a laxative effect, and water containing chloride exceeding 250 mg/l may have a salty taste. Fluoride in concentrations of about 1 mg/l may reduce the incidence of tooth decay, but excessive concentrations may cause teeth to become mottled (Dean, Arnold, and Elvove, 1942, p. 1155-1159). The optimum fluoride content is determined by the air temperature in the area, which influences the amount of water consumed and consequently the amount of fluoride intake.

Hardness in water is caused principally by calcium and magnesium. Excessive hardness causes increased consumption of soap and induces the formation of scale in hot water heaters and water pipes. The following table shows the commonly accepted standards and classificaions of water hardness:

| HARDNESS RANGE (MG/L) | CLASSIFICATION |
| --- | --- |
| 60 or less | Soft |
| 61 to 120 | Moderately hard |
| 121 to 180 | Hard |
| More than 180 | Very hard |

Water that is suitable for industrial use may not be acceptable for human comsumption, and different standards may apply. Ground water used for industry may be classified into four principal categories: cooling water, boiler water, process water, and water used for secondary recovery of oil by water injection.

Although cooling water is usually selected on the basis of its temperature and source of supply, its chemical quality is also significant. Any characteristic that may adversely affect the heat-exchange surfaces is undesirable. Substances such as magnesium, calcium, iron, and silica may cause the formation of scale. Another objectionable feature that may be found in cooling water is corrosiveness caused by calcium and magnesium chlorides, sodium chloride in the presence of magnesium, acids, and oxygen and carbon dioxide gases.

Boiler water used for production of steam requires high quality-of-water standards, since extreme temperature and pressure conditions intensify the problems of corrosion and incrustation. Under these conditions the presence of silica is particularly undesirable as it forms a hard scale or incrustation.

Water coming in contact with, or incorporated into, manufactured products is termed "process water" and is subject to a wide range of quality requirements. These requirements involve physical, biological, and chemical factors. Water used in the manufacture of textiles must be low in dissolved-solids content and free of iron and manganese, which could cause staining. The beverage industry normally requires water free of iron, manganese, and organic substances.

Water used for injection in the secondary recovery of oil is generally that water taken from the oil reservoir. However, this water—usually brine—must generally be supplemented in order to meet the requirements of volume. Careful control must be exercised over the injected water with regard to suspended solids, dissolved gases, microbiological growths, and mineral constituents. Suspended solids in the water, of course, can cause plugging of the reservoir. Hydrogen sulfide, carbon dioxide, and oxygen all have corrosive effects on well equipment, and oxygen reacting with the metallic ions, primarily iron ($Fe^{++}$), will cause plugging of the reservoir Organisms such as iron bacteria, algae, and fungi have an effect of plugging the reservoir or pumping equipment, and the sulfate reducers have a corrosive effect.

Insofar as the mineral constituents are concerned, iron and manganese are undesirable as they cause plugging in injection wells. Sulfates are of interest from a standpoint of deposition. Water that is high in sulfate should not be mixed with water containing appreciable amounts of barium, because this would result in formation of barium sulfate with a very low solubility. The pH value is also significant when corrosion control and the solubilities of calcium carbonate and iron are considered. The higher the pH, the more difficult it is to maintain iron in solution and to keep calcium scale from forming.

## Treatment of Water

Water that does not meet the requirements of a municipal or industrial user commonly can be treated by various methods so that it will become usable. Treatment methods include softening, aeration, filtration, cooling, dilution or the blending of poor and good quality waters, and addition of chemicals. The limiting factor in treatment is cost. Each water may require a different treatment method which should be designed for that particular water and its intended use. However, once a treatment is established it probably will not have to be changed as the chemical characteristics of uncontaminated ground water remain fairly constant.

## OCCURRENCE AND QUALITY OF GROUND WATER

Throckmorton County lies within the surface outcrop of the Wichita and Clear Fork Groups of Permian age. These rocks, consisting of interbedded limestones and shales with some lenticular sandstones, contain fresh to slightly saline water erratically in shallow, discontinuous zones of generally low permeability. Unconsolidated alluvial deposits of Quaternary age overlie the Permain rocks along the major streams of the county, and also yield small amounts of fresh to slightly saline water to wells. The occurrence of fresh to slightly saline water in formations of Permain age is limited mainly to the areas of outcrop or a very short distance downdip from the outcrop. However, fresh to slightly saline water is not known to occur below the Moran Formation of the Wichita Group in the county. The geologic units as used in this report are shown in Table 1, and their stratigraphic and structural relationships are shown on the cross sections on Figures 12 and 13.

Most of the water wells in Throckmorton County are used for domestic and livestock supplies. Many of the wells, especially the older ones, are hand dug and are lined with fieldstone or concrete rings. There are a few drilled wells that are cased with oil-field casing or with galvanized well casing. Most wells that are presently in use are equipped with windmills or small electric jet pumps which produce less than 10 gpm (gallons per minute). Of the 143 wells and springs inventoried during this investigation, 80 were being used to provide domestic and livestock water supplies and one was being used for public supply. Ten wells had been drilled for irrigaton purposes but were abandoned because of inadequate amount of water. The locations of all wells and springs visitied during this investigation are shown on Figure 9.

Water samples were collected for chemical analysis from 123 wells and two springs in the county. The content of dissolved solids in these samples ranged from 165 to 7,000 mg/l. The following table shows the number of analyses within certain ranges of dissolved-solids content:

The wide variation in the chemical quality is also reflected in the concentrations of some of the principal chemical constituents in the samples. Bicarbonate concentrations ranged from 7 to 810 mg/l. Sulfate ranged from less than 4 to 3,220 mg/l and the chloride concentration ranged from 4 to 3,370 mg/l. Some of the wells with an unusually high dissolved-solids and chloride content are probably contaminated and are discussed in later sections of this report. Analyses of water samples from wells in the county are shown in Table 4. The locations of wells sampled, well depth, and the chloride, sulfate, and dissolved-solids contents are shown on Figure 11.

### Permian System

#### Wichita Group

Rocks of the Wichita Group consist of the Pueblo, Moran, Putnam, Admiral, Belle Plains, Clyde, and Leuders Formations.

##### Pueblo Formation

The Pueblo Formation occurs in the subsurface throughout most of Throckmorton County but outcrops in a limited area in the extreme southeastern part of the county and in adjoining areas of western Young County (Figure 9). Rocks of this formation include limestone, shales, and sandstones that occur from the top of the Saddle Creek Limestone Member in the Cisco Group to the top of the Camp Colorado Limestone Member of the Pueblo (Table 1). No fresh to slightly saline water is known to be produced from rocks of this formation.

##### Moran Formation

The Moran Formation consists of thick shales, thin limestones, and lenticular sandstones that occur from the top of the Camp Colorado Limestone Member of the Pueblo Formation to the top of the Sedwick Limestone

| RANGE IN DISSOLVED SOLIDS (MG/L) | NUMBER OF ANALYSES | PERCENT OF TOTAL ANALYSES | CUMULATIVE PERCENT |
|---|---|---|---|
| 500 or less | 15 | 12.00 | 12.00 |
| 501 to 1,000 | 41 | 32.80 | 44.80 |
| 1,001 to 1,000 | 22 | 17.60 | 62.40 |
| 1,501 to 2,000 | 13 | 10.40 | 72.80 |
| 2,001 to 3,000 | 11 | 8.80 | 81.60 |
| Over 3,000 | 23 | 18.40 | 100.00 |

Member of the Moran (Table 1). Small amounts of fresh to slightly saline water are found in isolated permeable zones in or near the outcrop of these rocks in Throckmorton County.

Three wells, 21-64-301, 30-08-301, and 30-08-302, formerly produced water from the Moran. Analyses of water samples from these wells show a wide variation in chemical quality (Table 4). Dissolved solids ranged from 368 to 2,000 mg/l. Bicarbonate content ranged from 250 to 397 mg/l, chloride content from 4 to 520 mg/l, and sulfate content from 16 to 700 mg/l.

Water from two of these wells, 21-64-301 and 30-08-301, contained a higher concentration of dissolved solids than is recommended by the U.S. Public Health Service (1962) for drinking water used on interstate carriers. This water was used in the past for domestic and livestock supplies.

### Putnam Formation

The Santa Anna Branch Shale and the Coleman Junction Limestone Members make up the Putnam Formation (Table 1). Locally the shale and limestone are replaced by siltstone and sandstone channels. The amount of sand increases from south to north along the outcrop. Small amounts of fresh to slightly saline water are found in permeable zones of these sandstone channels.

Eight wells and one spring are known to produce water from rocks of the Putnam Formation in Throckmorton County. Chemical analyses of water samples from the spring and seven of the wells show a wide variation in the chemical quality of water from this formation. The dissolved-solids content ranged from 402 to 4,770 mg/l, the chloride content from 30 to 2,590 mg/l, and the sulfate content from 22 to 2,170 mg/l. A particular contrast of chemical constituents is shown in water from two of these wells. Water from well 21-48-601 contains 4,770 mg/l dissolved solids of which 54 percent is chloride, and water from well 21-48-906 contains 3,960 mg/l dissolved solids of which 55 percent is sulfate. Water from wells 21-56-302, 21-56-303, and 21-56-602 and spring 21-56-301 contains high concentrations of nitrate which are probably due to contamination by sewage from nearby septic tanks.

Water from most of the wells completed in this formation is used for domestic and livestock purposes. All the wells except one contain a higher concentration of dissolved solids than is recommended by the U.S. Public Health Service (1962) for drinking water used on interstate carriers.

### Admiral Formation

The rocks that make up the Admiral Formation in Throckmorton County consist of alternating beds of thin limestone and thick shale with some sandstone lenses. The sandstones become more numerous and extensive northward along the outcrop. The formation includes those rocks which occur from the top of the Coleman Junction Limestone Member of the Putnam Formation to the top of the Overall Limestone Member of the Admiral (Table 1).

One well, 21-48-201, is known to derive water from this formation. Analysis of a water sample shows the following concentrations of dissolved minerals: 133 mg/l, magnesium, 1,000 mg/l sodium, 1,590 mg/l chloride, 550 mg/l sulfate, and 3,640 mg/l dissolved solids.

### Belle Plains Formation

The Belle Plains Formation includes the rocks that occur from the top of the Overall Limestone Member of the Admiral Formation to the top of the Bead Mountain Limestone Member of the Belle Plains (Table 1), and consists of limestones interbedded with thick to thin shales, a few sandstones lenses, and anhydrite deposits. At the surface, however, the anhydrite has been leached out.

Five wells yield fresh to slightly saline water from zones of local permeability in the outcrop of the Belle Plains. These wells are hand dug, and only three are currently in use.

Chemical analyses show that water from four of the five wells has mineral concentration below 3,000 mg/l. However, water from well 21-55-402 contained 1,200 mg/l chloride and 3,040 mg/l dissolved solids.

### Clyde Formation

The Clyde Formation includes the thin to massive limestones alternating with thin marls and shales which make up the Grape Creek and Talpa Limestone Members (Table 1). No fresh to slightly saline water is known to be produced from the Clyde Formation in Throckmorton County.

### Lueders Formation

In Throckmorton County, the Lueders Formation is composed of massive to thin limestone beds with thin shale breaks.

Small amounts of fresh to slightly saline water are produced from fractures and solution cavities in the limestone in the outcrop area. During this study, 46 wells and one spring were inventoried which produce or have produced water of usable quality from the Lueders.

Water samples were collected for chemical analysis from 37 of the wells and one spring. These analyses indicate a high degree of variation in the chemical quality of water produced from the limestones. The numbers of analyses within certain ranges of dissolved-solids content are tabulated below:

| RANGE IN DISSOLVED SOLIDS (MG/L) | NUMBER OF ANALYSES | PERCENT OF TOTAL ANALYSES | CUMULATIVE PERCENT |
|---|---|---|---|
| 500 or less | 1 | 2.63 | 2.63 |
| 501 to 1,000 | 9 | 23.68 | 26.31 |
| 1,001 to 1,500 | 9 | 23.68 | 49.99 |
| 1,501 to 2,000 | 3 | 7.90 | 57.89 |
| 2,001 to 3,000 | 5 | 13.16 | 71.05 |
| Over 3,000 | 11 | 28.95 | 100.00 |

One well, 21-45-507, produces very saline water (43,000 mg/l sodium, 90,500 mg/l chloride, and 147,000 mg/l dissolved solids), and was not considered in the following discussions. This apparently contaminated well is located near several water wells which produce relatively good quality water (Table 4).

The ranges in concentration of the predominant dissolved chemicals in the water from the Leuders Formation in Throckmorton County are as follows:

| | | |
|---|---|---|
| calcium | 33 to | 680 mg/l |
| magnesium | 9 to | 318 mg/l |
| sodium | 25 to | 1,350 mg/l |
| bicarbonate | 7 to | 810 mg/l |
| sulfate | 46 to | 2,580 mg/l |
| chloride | 16 to | 1,780 mg/l |
| fluoride | 0.3 to | 22 mg/l |
| nitrate | $<$0.4 to | 110 mg/l |

Although 11 water samples contain over 3,000 mg/l dissolved solids, the predominant chemical constituent is sulfate, which would indicate natural mineralization. Water from well 21-53-501, however, is high in chloride (1,780 mg/l) which indicates apparent contamination by brine.

The high nitrate content of water from wells 21-54-401 (110 mg/l) and 21-54-402 (70 mg/l) is probably due to contamination from a nearby sewage source.

Although many of these wells produce water containing a higher concentration of minerals then recommended by the U.S. Public Health Service (1962), they have been used for years as domestic and livestock supplies.

### Clear Fork Group

The Clear Fork Group consists of the Arroyo Formation in Throckmorton County.

#### Arroyo Formation

The Arroyo Formation consists mainly of thin dolomitic limestone beds alternating with thick shales, with some anhydrite and sandstone lenses. In Throckmorton County the formation is relatively thin and occurs mainly on the topographic divides in the western part of the county (Figure 9). No water is known to be produced from this formation in the county.

## Quaternary System

### Alluvium

Alluvium of Quarternary age, consisting of unconsolidated sand, gravel, silt, and clay, occurs in the terraces and floodplains of the streams in Throckmorton County (Figure 9). Small amounts of alluvium are found along almost all streams in the county, but only in the northeast part of the county, along the Brazos River and its major tributaries, are these deposits known to be significant sources of ground water (Figure 9). Seventy-eight wells were located which produce or have produced small amounts of usable quality water from these deposits.

Water samples were collected for chemical analysis from 38 wells. The results of these analyses, which are given in Table 4, indicate a wide variation in the chemical quality of water produced from alluvial deposits in the county. The number of samples falling within various ranges are as follows:

| RANGE IN DISSOLVED SOLIDS (MG/L) | NUMBER OF ANALYSES | PERCENT OF TOTAL ANALYSES | CUMULATIVE PERCENT |
|---|---|---|---|
| 500 or less | 11 | 15.72 | 15.72 |
| 501 to 1,000 | 27 | 38.57 | 54.29 |
| 1,000 to 1,500 | 12 | 17.14 | 71.43 |
| 1,501 to 2,000 | 7 | 10.00 | 81.43 |
| 2,001 to 3,000 | 6 | 8.57 | 90.00 |
| Over 3,000 | 7 | 10.00 | 100.00 |

The ranges in concentration of the predominant dissolved chemicals in these samples are shown below:

| | | | | |
|---|---|---|---|---|
| calcium | 15 | to | 424 | mg/l |
| magnesium | 6 | to | 351 | mg/l |
| sodium | 7 | to | 1,820 | mg/l |
| bicarbonate | 73 | to | 810 | mg/l |
| sulfate | <4 | to | 3,220 | mg/l |
| chloride | 4 | to | 3,370 | mg/l |
| fluoride | 0.1 | to | 2.8 | mg/l |
| nitrate | <0.4 | to | 336 | mg/l |

Alteration of the chemical quality of native ground water in the alluvium probably has occurred, but historical data necessary for comparison to indicate where and how much alteration has occurred are not available. Some of the higher concentrations of chloride and total dissolved solids in water from wells completed in the alluvium are listed below:

| WELL | DISSOLVED SOLIDS (MG/L) | CHLORIDE (MG/L) |
|---|---|---|
| 20-41-703 | 5,500 | 2,490 |
| 20-41-704 | 3,130 | 1,260 |
| 20-41-708 | 3,770 | 1,220 |
| 20-41-711 | 2,490 | 1,050 |
| 20-41-713 | 2,530 | 780 |
| 20-41-714 | 2,670 | 1,030 |
| 21-40-803 | 5,700 | 3,370 |

Water from several wells contains higher concentrations of specific minerals than the upper limits recommended by the U.S. Public Health Service (1962), as shown by the following: nine wells (12.8 percent) contain water with more than 125 mg/l magnesium; 20 wells (28.6 percent) contain water with more than 250 mg/l sulfate; 32 wells (45.7 percent) contain water with more than 250 mg/l chloride; 34 wells (48.6 percent) contain water with more than 1.2 mg/l fluoride; and 26 wells (37.1 percent) contain water with more than 45 mg/l nitrate.

Although water produced from the alluvial sediments in Throckmorton County often contains large amounts of dissolved minerals, over 50 percent of the wells sampled yield water with less than the 1,000 mg/l maximum content of dissolved solids recommended by the U.S. Public Health Service (1962).

Water from wells 20-41-103, 20-41-106, 20-41-107, 20-41-204, 20-41-205, and 20-41-206 was formerly used for irrigation, but due to small yields these wells are presently unused. Other wells completed in the alluvium are not known to produce enough water for industrial, municipal, or irrigation purposes.

## WATER-QUALITY PROTECTION PROGRAMS

### Surface Casing

The function of the Surface Casing Program of the Ground Water Division of the Texas Water Development Board is to recommend to oil and gas operators and the Railroad Commission of Texas the depth to which usable quality ground water should be protected in drilling for oil and gas. The authority for participation by the Board in the Surface Casing Program is derived from rules promulgated by the Railroad Commission under authority given that agency by statutes dealing with the regulation of drilling and production activities of the petroleum industry.

Statewide Rule 13 of the Railroad Commission requires that operators obtain a letter from the Texas Water Development Board regarding the occurrence of fresh-water strata in a field or area in question and that the fresh-water strata be protected to the depth recommended by the Board if the lease or area is not covered by field rules or lease recommendations. Railroad Commission Rule 8 requires that all fresh water be protected in drilling, plugging, or production activities, or disposing of salt water already produced.

In carrying out its duties under Rule 13, the Texas Water Development Board created the Surface Casing Program in the Ground Water Division. The staff of the Surface Casing Program is responsible for maintaining technical data files upon which to base fresh water protection recommendations in all areas of the State, and for preparing these recommendations for operators contemplating drilling oil or gas tests. The recommended depth to which ground water of usable quality should be protected in a given area is based on all pertinent information available to the Surface Casing Program staff at the time the recommendation is given. Recommended depths in any one area may therefore be revised from time to time as additional subsurface information becomes available.

Known depths of wells that produce or have produced water of usable quality, such as domestic, municipal, industrial, livestock, or irrigation wells, are of primary value in determining the depth of usable water. Electric or gamma-ray neutron logs on oil and gas tests are used in many areas to determine the depth to the base of usable quality ground water. Surface elevation is given special consideration when a recommendation is given in an area that has moderate to high surface relief, as is common to portions of Throckmorton County. This consideration is imperative when the slope of the land surface does not conform to the dip of the underlying rocks, because of the danger that poor quality water will cause contamination of surface and ground water by moving along the dip of the beds to fresh-water zones or to points of discharge in stream channels. This information is interpreted in the light of the available knowledge of the geology and ground-water hydrology on the area involved.

During the 6-year period 1963-68, the Surface Casing Program staff prepared 1,154 recommendatins for protection of usable quality ground water for oil and gas tests drilled in Throckmorton County. One hundred and forty-three of these recommendations were prepared during 1968. The depths of these recommendations range from 60 to 100 feet.

## Subsurface Disposal

The Regular Session of the 61st Texas Legislature in 1969 passed Senate Bill 138 (Article 7621b, Vernon's Texas Civil Statutes) which prescribed the permit system for subsurface disposal of municipal and industrial wastes in Texas. This act in effect designated the Texas Water Quality Board as the permit-issuing agency for all injection wells to dispose of "...industrial and municipal waste, other than waste arising out of or incidental to the drilling for or producing or oil or gas...." Section 4(b) of this statute also directed that any person applying to the Railroad Commission for a permit to inject "...waste arising out of or incidental to the drilling for or producing or oil or gas..." shall obtain a letter from the Texas Water Quality Board "...stating that the drilling of the injection well and the injection of such waste into the subsurface stratum will not endanger the fresh water strata in that area and that the formation or strata to be used for such waste disposal are not fresh water sands."

Opinions by the Attorney General of Texas pertinent to the implementation of Article 7621b are to the effect: (1) that "injection well," when correctly interpreted, includes only those wells which are drilled or used for the purpose of disposal and does not include an injection well where the purpose of the well is to increase production from an oil or gas-bearing stratum, and (2) that a determination by Texas Water quality Board is not binding on the Railroad Commission but is merely advisory.

The staff of the Texas Water Quality Board reviews applications to dispose of salt water into subsurface zones and advises the operators and the Railroad Commission of the acceptability of such applications. Waterflood, pilot projects for secondary recovery, and other secondary recovery operations where salt water is injected into subsurface zones which are productive of oil or gas are granted permits by the Railroad Commission without consultation with the Texas Water Quality Board. Also, the inspection of construction and completion of all brine injection systems is a regulatory function of the Railroad Commission.

The above functions designated to the Texas Water Quality Board were formerly responsibilities of the Texas Water Development Board. In the period March 1962 to December 1968, 103 applications to the Railroad Commission for salt-water disposal wells in Throckmorton County were reviewed by the staff of the Subsurface Disposal Program of the Texas Water Development Board. Each of these applications was reviewed on an individual basis with consideration given to geologic and hydrologic data of the area, method of completion of the proposed injection well, volume of salt water to be injected, and injection pressure to be used.

In addition to the salt-water disposal wells, the Railroad Commission, from August 1961 to December 1966, granted permits for 41 projects involving the use of injection wells in water flood, pressure maintenance, and other secondary recovery operations in Throckmorton County. The number of injection wells utilized in these projects ranges from one well in pilot projects for secondary recovery programs to as many as 13 or more injection wells in the larger waterflood projects. Generally, these projects are granted permits which contain provisions for expansion of the water-injection facilities by the use of additional injection wells as the operations expand.

## OIL-FIELD BRINE PRODUCTION AND DISPOSAL

### Quantity and Distribution of Produced Brine

During 1962, the Railroad Commission of Texas, the Texas Water Pollution Control Board, and the Texas Water Commission cooperated in collection and tabulation of information submitted by oil and gas operators concerning the 1961 oil-field brine production and disposal in Texas. The Railroad Commission of Texas and the Texas Water Devlopment Board have cooperated in a similar collection and tabulation of the 1967 oil-field brine production and disposal in Texas which is now being compiled. Table 6 is a summary of the brine production in 1961 and 1967 by oil fields and by arbitrarily defined producing areas in Throckmorton County. The location and extent of the brine-producing areas in the county and the amount of brine production and method of disposal in each area for 1967 are shown on Figure 10.

The total production of oil-field brines reported for 1967 (6,396,766 barrels) was only about 60 percent of the total reported 1961 production (10,664,726 barrels). In 1961, 440,081 barrels or 4.1 percent of the total production was reported disposed into open, unlined surface-disposal pits. However, only 15,216 barrels or 0.2 percent was reported placed into pits for disposal in 1967. This drop is probably due to the no-pit order issued by the Railroad Commission in 1964. In 1961, 10,207,024 barrels or 95.7 percent of the total production of salt water was reported injected into wells for disposal. This includes both pressure maintenance wells and salt-water disposal wells. In 1967, 6,303,192 barrels or 98.6 percent of the total production was reported disposed by injection. In 1961, 17,621 barrels or less than 0.2 percent of the total reported brine production was disposed by other miscellaneous methods, such as dumping into surface drainageways or on road and lease surfaces. In 1967, however, miscellaneous disposal was reported for 78,358 barrels or 1.2 percent of the total brine production.

There have been some significant changes in the distribution of brine production and in the methods of disposal in the county since 1961. Five of the areas (areas 5, 7, 17, 18, and 24) ceased producing brine after 1961. In 1961, some brine was disposed in open surface pits in each of the 32 areas shown on Figure 10 except areas 2, 3, 4, 5, 8, 20, 29, and 32. In 1967, however, disposal of brine in surface pits was reportedly confined to areas 6, 13, 14, 19, and 25 (Figure 10). All other areas were disposing by injection into the subsurface or by other methods.

The greatest use of surface pits apparently occurs in area 19 where a reported 7,380 barrels of brine was disposed by this method in 1967.

### Chemical Quality of Produced Brine

Chemical analyses of some oil-field brines from various producing zones in Throckmorton County are tabulated in Table 5. These analyses show the same ions present in the brines that are present in samples from water wells used for domestic and livestock supplies (Table 4). However, sodium, magnesium, calcium, and chloride ions are present in much greater concentrations in the brines.

Table 4 presents chemical analyses in milligrams per liter, which is the preferred metric system unit. Table 5 presents similar data (from Laxson and others, 1960), but in ppm (parts per million) by weight. Parts per million may be considered equal to milligrams per liter at concentrations less than about 7,000 ppm. At higher concentrations the units are not directly interchangeable, as conversion must take into account the greater differences in density of saline waters.

In the oil-field brines samples (Table 5), the sodium concentration ranges from 23,994 to 51,267 ppm. The chloride concentration ranges from 42,844 to 113,300 ppm. The concentration of magnesium ranges from 427 to 3,790 ppm. The range of total dissolved solids is from 71,445 to 183,112 ppm.

## ALTERATION OF NATIVE QUALITY OF GROUND WATER

Alteration of the chemical quality of ground and surface water, as evidenced by the chemical analyses of water, has occurred locally in Throckmorton County. Although a study of the contamination of surface water was not included in the scope of this report, it is impossible to ignore the interrelationship of ground and surface water. Alteration of the chemical quality of surface water may affect the quality of ground water by downward percolation of the altered water, and alteration of ground-water quality may affect surface water by outflow from springs and by contribution to the base flow of steams (Figure 6).

The alteration of the chemical quality of ground water may be due to both natural and artificial means. Natural alteration occurs when water dissolves minerals from the rocks over which it flows or through which it percolates. In Throckmorton County natural alteration is evidenced by high sulfate concentration (from anhydrite) and high bicarbonate concentration (from limestone and dolomite).

Artificial alteration of the quality of ground water may be either biological or chemical. Biological contamination is usually due to poor well construction and to location of water wells near septic tanks, livestock feedlots, and barnyards. It is usually evidenced by a high nitrate concentration in the water. Several wells in the county seem to be contaminated by one or more of these causes (Table 4).

Alteration of the chemical quality of ground water may also be associated with the operations of the oil and gas industry. Brines produced with oil and gas may commingle with usable-quality water in several ways. Brines placed in shallow surface pits for disposal may contaminate ground water by downward seepage or percolation. Overflow of brines from surface pits may contaminate surface water. Saline water may move up the bore holes of improperly plugged or cased wells into shallow fresh-water zones, due to natural pressure and the pressure of secondary-recovery injection. Ground-water quality may also be altered by lateral and vertical movement of injection fluids from improperly constructed municipal and industrial waste-disposal wells.

The location of 8 wells, apparently contaminated by oil-field brines, and several areas of vegetative kill, apparently the result of discharge of oil-field brine onto the surface or overflow of brine from disposal pits, are shown on Figure 10. Figure 7 shows diagrams of the chemical analyses of water from some of these apparently contaminated wells, native quality or apparently unaltered ground water, and a typical oil-field brine. The diagrams illustrate the chemical similarity between a typical oil-field brine and water from wells which have been contaminated by brine. Only a small amount of brine entering a water supply is necessary to change significantly the chemical character of the water. Although there are many indications of apparent contamination in Throckmorton County, efforts have been and are being made by many petroleum operators to avoid contamination of the soil, surface water, and ground water, especially by curtailing the use of open, unlined surface pits as a means of brine disposal.

Figure 8 consists of photographs of several vegetative-kill areas observed in this study. The areas are found in several locations and range in size from less than one acre to several acres.

Photograph A shows one of several small vegetative-kill areas located about 3½ miles southwest of the town of Throckmorton. In the background are oil-brine separators, tank batteries, and an abandoned surface disposal pit.

Photograph B shows an extensive area of vegetative kill in the Bailes field about 3½ miles southeast of the town of Throckmorton. There are several surface disposal pits in the area.

Photographs C and D were taken in an extensive vegetative-kill area on the southeast edge of the town of Throckmorton. Several abandoned surface disposal pits have been left open in this area and are visible in each photograph.

Photographs E and F show a small vegetative-kill area and a surface disposal pit in use in 1968 containing brine and oil. This area is 1-½ miles north of the community of Elbert.

Photographs G and H show views of a large vegetative-kill area and a surface disposal pit in use in the Greathouse field about 10 miles east of the town of throckmorton. Photograph G shows the extensive area of vegetative kill with the disposal pit, oil well, and tank battery in the left background. Photograph H shows salt water from the nearby separator being discharge into the surface disposal pit.

Photographs I and J are views of an extensive vegetative-kill area about 12 miles southwest of the town of Throckmorton. A water-oil separator, tank battery, and several producing oil wells are located on a bluff overlooking the flood plain of the Clear Fork Brazos River. Brine and oil flow intermittently from a standpipe on the separator onto the land suface. The oil and salt water have flowed down the bluff have caused the kill area on the valley floor.

Photograph K shows an area of vegetative kill and an abandoned oil well about 5 miles west of Woodson in the Florence field.

Photograph L was taken in the Dickie field, inside the city limits of Woodson. The pictures show a producing oil well, a tank battery, and a large surface disposal pit in use in 1968. There is a small area of vegetative kill around the pit.

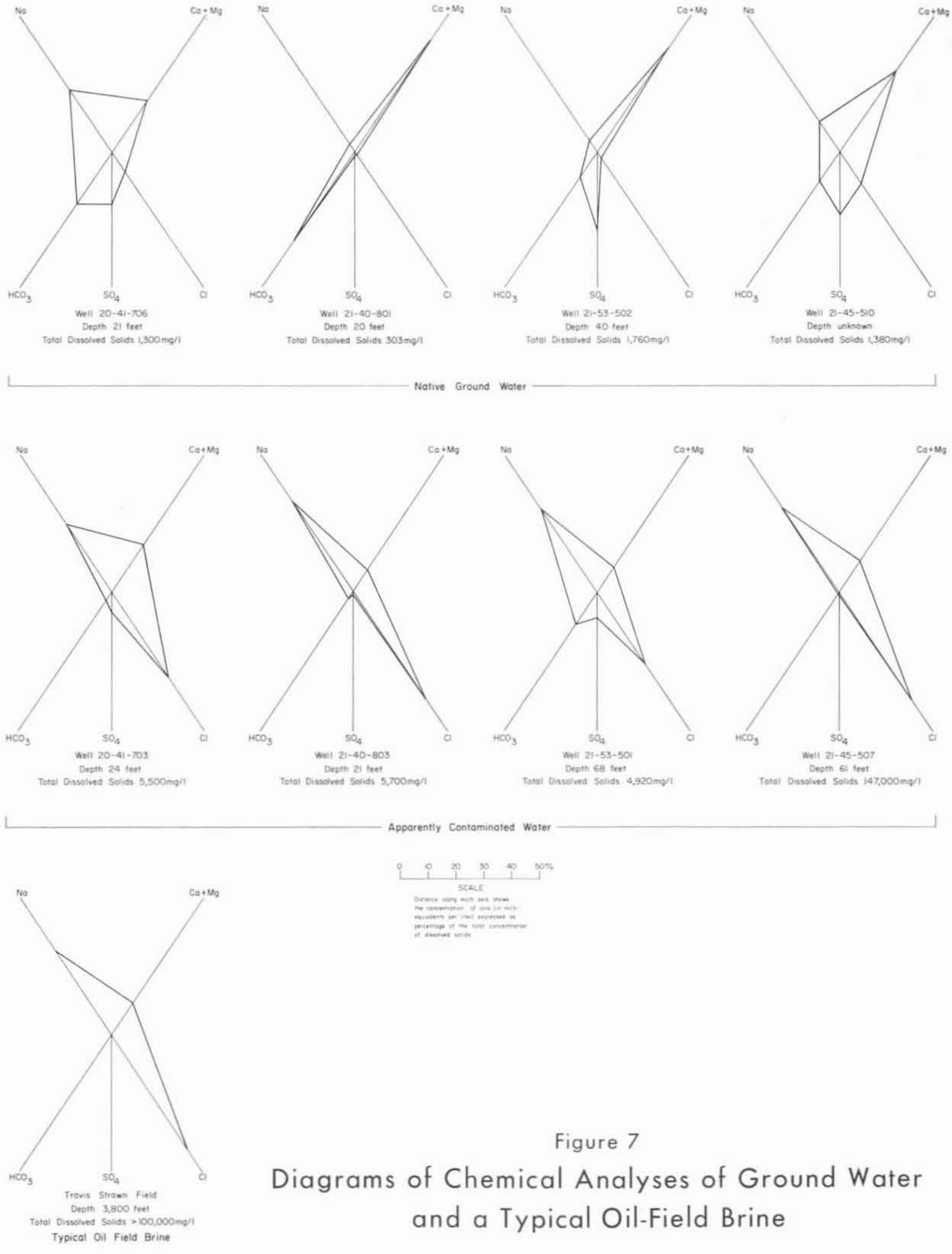



Figure 7
Diagrams of Chemical Analyses of Ground Water and a Typical Oil-Field Brine

A. Vegetative-kill area in Diane field, section 248, BBB & C Survey, 3½ miles southwest of Throckmorton. View is southeast.

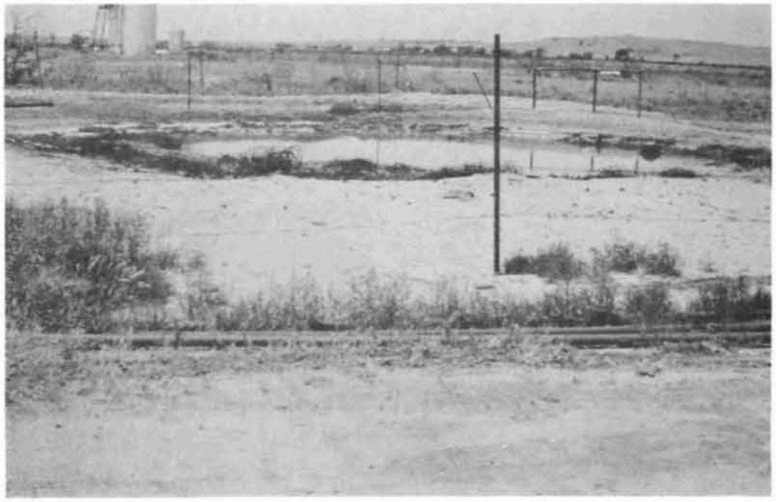
B. Extensive vegetative-kill area in the Bailes field, section 292, BBB & C Survey, 3½ miles southeast of Throckmorton. View is west.

Figure 8.—Photographs of Surface Disposal Pits and Vegetative-Kill Areas, 1968

C. Vegetative-kill area and open abandoned surface disposal pits in the Coon field, section 286, BBB & C Survey, ½ mile southeast of Throckmorton. View is west.

D. Abandoned surface disposal pits in the same area as photograph C. Water in pit is precipitation that is salty to the taste. Note phreatophytes (saltcedars) in pits. View is north.

Figure 8.—Photographs of Surface Disposal Pits and Vegetative-Kill Areas, 1968—Continued



E. Surface disposal pit which contains salt water and oil. Location is section 2133, TE & L Survey, 1½ miles north of Elbert. View is west.

F. Same area as photograph E. View is south.

Figure 8.—Photographs of Surface Disposal Pits and Vegetative-Kill Areas, 1968—Continued

G. Vegetative-kill area in section 2178, TE & L Survey, 10 miles east of Throckmorton. Note oil well surface equipment and surface disposal pit in left background. View is east.

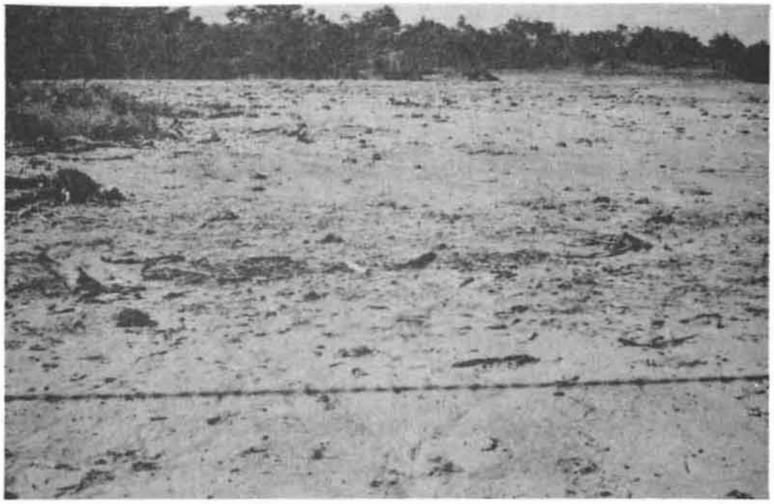
H. Same location as photograph G. View shows salt water from nearby separator being discharged into surface pit. View is southeast.

Figure 8.—Photographs of Surface Disposal Pits and Vegetative-Kill Areas, 1968—Continued

I. Extensive vegetative-kill area along tributary of Clear Fork Brazos River, 12 miles southwest of Throckmorton in the C. W. Marques Survey. Note tank battery and separator (black tower) in background. The ditch in center background (dark-stained area) is apparently used to dispose of salt water and oil waste from separator. View is northeast.

J. Same area as photograph I. View is from the bluff near the separator. Note oil and water puddle in foreground and the eroded trench in left background. View is southwest.

Figure 8.—Photographs of Surface Disposal Pits and Vegetative-Kill Areas, 1968—Continued



K. Area of vegetative kill surrounding an abandoned oil well in the Florence field, section 693, TE & L Survey, 5 miles west of Woodson. View is south.

L. Oil-field brine disposal pit located in section 686, TE & L Survey, adjacent to the town of Woodson. Note oil around edge of pit. View is southeast.

Figure 8.—Photographs of Surface Disposal Pits and Vegetative-Kill Areas, 1968—Continued

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Table 3.--Records of Water Wells and Springs, Throckmorton County

Water-bearing unit : Qal, Quaternary alluvium; Pwl, Lueders Formation; Pwbp, Belle Plains Formation; Pwa, Admiral Formation; Pwp, Putnam Formation; Pwm, Moran Formation.
Method of lift and type of power: A, Auger; B, bucket or bailer; C, cylinder; Cf, centrifugal; E, electric; G, natural gas, butane, or gasoline; H, hand; J, jet; N, none; S, submersible; T, turbine; W, windmill.
Use of water : D, domestic; Ind, industrial; Irr, irrigation; N, none; P, public supply; S, Livestock.

| WELL | OWNER | DRILLER | DATE COMPLETED | DEPTH OF WELL (FT) | CASING: DIAMETER (IN.) | CASING: DEPTH (FT) | WATER-BEARING UNIT | ALTITUDE OF LAND SURFACE (FT) | WATER LEVEL: BELOW LAND-SURFACE DATUM (FT) | WATER LEVEL: DATE OF MEASUREMENT | METHOD OF LIFT | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *20-33-701 | Louis Sykora | Louis Sykora | 1963 | 10 | -- | -- | Qal | 1,240 | 5.8 | Aug. 15, 1967 | N | N | Dug well. |
| * 702 | H. B. Rogers | H. B. Rogers | 1946 | 19 | -- | -- | Qal | 1,230 | 14.4 | Sept. 19, 1967 | N | N | Do. |
| * 41-101 | Juble E. Wells | Pete Haley | 1927 | 29 | -- | -- | Qal | 1,201 | 22.3 | Aug. 15, 1967 | C,W | D | Do. |
| * 102 | Cecil Womack | -- | 1934 | 32 | -- | -- | Qal | 1,169 | 13.4 | Aug. 16, 1967 | C,W | S | Do. |
| * 103 | do | Les Jameson | 1963 | 24 | 7 | 24 | Qal | 1,168 | 15.9 | do | N | N | Drilled for irrigation, but did not produce enough water. |
| * 104 | Louis Sykora | -- | -- | 33 | -- | -- | Qal | 1,202 | -- | -- | T,E | N | Dug well. |
| * 105 | Cecil Womack | -- | -- | 40 | -- | -- | Qal | 1,202 | 29.9 | Aug. 16, 1967 | C,W | D,S | Reported over 100 years old. Dug well. |
| 106 | do | Les Jameson | 1963 | 24 | 7 | 24 | Qal | 1,168 | -- | -- | N | N | Drilled for irrigation, but did not produce enough water. |
| 107 | do | Cecil Womack | 1964 | 38 | 7 | 38 | Qal | 1,171 | -- | -- | N | N | Drilled in bottom of old dug well. Drilled for irrigation, but did not produce enough water. |
| * 108 | J. R. Mixon | J. R. Mixon | 1940 | 10 | -- | -- | Qal | 1,146 | 8.5 | Oct. 20, 1967 | B,H | D,S | Dug well. |
| * 109 | W. Morris Hannis, Sr. | -- | -- | 15 | -- | -- | Qal | 1,147 | 10.7 | Oct. 19, 1967 | E,A | D,S | Do. |
| * 110 | do | -- | -- | 21 | -- | -- | Qal | 1,157 | 18.4 | do | J,E | D,S | Do. |
| * 111 | C. C. Richardson | C. C. Richardson | 1947 | 33 | -- | -- | Qal | 1,175 | 29.5 | Oct. 23, 1967 | J,E | D,S | Do. |
| * 112 | A. B. Edsall | -- | 1960 | 72 | 5 | -- | Qal | 1,175 | 31.1 | do | N | N | Seismograph hole. |
| * 203 | Ethelene Easley | Les Jameson | 1964 | 46 | 10 | 46 | Qal | 1,187 | -- | -- | J,E | D,S | |

See footnote at end of table.

Table 3.--Records of Water Wells and Springs, Throckmorton County--Continued

| WELL | OWNER | DRILLER | DATE COMPLETED | DEPTH OF WELL (FT) | CASING: DIAMETER (IN.) | CASING: DEPTH (FT) | WATER-BEARING UNIT | ALTITUDE OF LAND SURFACE (FT) | WATER LEVEL: BELOW LAND-SURFACE DATUM (FT) | WATER LEVEL: DATE OF MEASUREMENT | METHOD OF LIFT | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20-41-204 | Cecil Womack | Les Jameson | 1963 | 24 | 7 | 24 | Qal | 1,168 | -- | -- | N | N | Drilled for irrigation, but did not produce enough water. |
| 205 | do | do | 1963 | 24 | 7 | 24 | Qal | 1,168 | -- | -- | N | N | Do. |
| 206 | do | do | 1963 | 24 | 7 | 24 | Qal | 1,168 | -- | -- | N | N | Do. |
| * 207 | Tom Cooke | Dr. Harrold | -- | 33 | -- | -- | Qal | 1,195 | 23.8 | Sept. 20, 1967 | J,E | D,S | Dug well. |
| * 401 | Mark Campbell | -- | -- | 31 | -- | -- | Qal | 1,147 | 20.9 | Oct. 10, 1967 | N | N | Do. |
| * 402 | F. Dwight Hamilton | -- | -- | 26 | -- | -- | Qal | 1,148 | 21.8 | Oct. 18, 1967 | C,W | N | Do. |
| 403 | J. M. Pace et al. | -- | -- | 20 | -- | -- | Qal | 1,146 | -- | -- | C,W | N | Rains washed sand into well. Dug well. |
| * 404 | A. W. Mitchell | A. W. Mitchell | 1947 | 29 | -- | -- | Qal | 1,147 | 21.8 | Oct. 18, 1967 | J,E | D,S | Dug well. |
| * 405 | W. P. Manuel | -- | -- | 14 | -- | -- | Qal | 1,135 | 8.4 | do | N | N | Do. |
| * 406 | do | -- | -- | 27 | -- | -- | Qal | 1,148 | 21.9 | do | J,E | S | Do. |
| * 407 | do | -- | -- | 27 | -- | -- | Qal | 1,142 | 17.7 | do | J,E | D,S | Do. |
| * 408 | do | -- | 1935 | 28 | -- | -- | Qal | 1,141 | 14.2 | do | J,E | D,S | Do. |
| * 409 | Marvin Hickey | -- | -- | 13 | -- | -- | Qal | 1,138 | 9.3 | Oct. 19, 1967 | C,W | S | Do. |
| * 410 | A. W. Mitchell | -- | -- | 15 | -- | -- | Qal | 1,137 | 10.1 | do | C,W | N | Do. |
| * 411 | W. Elbert Curtis, Jr. | -- | -- | 24 | -- | -- | Qal | 1,145 | 19.9 | do | N | N | Do. |
| * 412 | N. L. B. Davis | -- | -- | 19 | -- | -- | Qal | 1,151 | 16.8 | Oct. 20, 1967 | J,E | D,S | Do. |
| * 413 | D. W. Pace | -- | -- | 36 | -- | -- | Qal | 1,146 | 22.8 | Oct. 18, 1967 | B,H | D,S | Do. |
| * 414 | A. B. Edsall | S. M. Edsall | 1925 | 23 | -- | -- | Qal | 1,159 | 18.7 | Oct. 23, 1967 | C,W | S | Do. |

See footnote at end of table.

Table 3.--Records of Water Wells and Springs, Throckmorton County--Continued

| WELL | OWNER | DRILLER | DATE COMPLETED | DEPTH OF WELL (FT) | CASING DIAMETER (IN.) | CASING DEPTH (FT) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT) | WATER LEVEL BELOW LAND-SURFACE DATUM (FT) | WATER LEVEL DATE OF MEASUREMENT | METHOD OF LIFT | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *20-41-415 | A. B. Edsall | A. B. Edsall | 1960 | 32 | -- | -- | Qal | 1,165 | 30.3 | Oct. 23, 1967 | J,E | S | Dug well. |
| * 416 | Mrs. O. C. Cribbs | -- | -- | 27 | -- | -- | Qal | 1,146 | 21.0 | Dec. 6, 1967 | J,E | D,S | Do. |
| * 417 | do | Harmon Cribbs et al. | 1934 | 21 | -- | -- | Qal | 1,139 | 11.9 | do | N | N | Do. |
| * 701 | W. J. Timmons | W. J. Timmons | 1946 | 21 | -- | -- | Qal | 1,139 | 15.3 | Aug. 23, 1967 | J,E | D,S | Do. |
| * 702 | W. Elbert Curtis, Jr. | -- | -- | 23 | -- | -- | Qal | 1,165 | 18.3 | Oct. 19, 1967 | J,E | D,S | Do. |
| * 703 | J. C. Smith | -- | 1961 | 24 | 10 | -- | Qal | 1,154 | 13.6 | Oct. 20, 1967 | T,E | D | |
| * 704 | Mrs. Ruby Lilly | -- | 1961 | 24 | 10 | -- | Qal | 1,154 | -- | -- | J,E | P.S | Used by Mrs. Lilly and the First Baptist Church. |
| * 705 | Bob D. Bailes | Bob D. Bailes | 1963 | 32 | 7 | -- | Qal | 1,164 | 16.2 | Oct. 20, 1967 | J,E | D,S | |
| * 706 | do | -- | -- | 21 | -- | -- | Qal | 1,150 | 14.4 | do | C,W | N | Dug well. |
| * 707 | do | -- | -- | 15 | -- | -- | Qal | 1,141 | 10.4 | do | J,E | D,S | Do. |
| * 708 | Elbert Keeter | -- | -- | 31 | -- | -- | Qal | 1,144 | 19.8 | do | B,H | N | Do. |
| * 709 | R. R. Roberts | R. R. Roberts | -- | 20 | -- | -- | Qal | 1,144 | 14.5 | Oct. 23, 1967 | J,E | D,S | Do. |
| * 710 | J. W. Roberts | J. W. Roberts | -- | 23 | 6 | -- | Qal | 1,144 | -- | -- | C,E | D,S | |
| * 711 | Lyndel Manuel | -- | -- | 30 | -- | -- | Qal | 1,146 | -- | -- | J,E | D,S | |
| * 712 | W. P. Manuel | W. H. Manuel et al. | 1940 | 24 | -- | -- | Qal | 1,153 | 7.3 | Oct. 20, 1967 | N | N | Dug well. |
| * 713 | W. A. Keeter | W. A. Keeter | 1957 | 24 | -- | -- | Qal | 1,155 | 9.2 | do | J,E | D,S | Do. |
| * 714 | do | do | 1942 | 22 | -- | -- | Qal | 1,163 | 14.0 | do | N | N | Do. |
| * 715 | Venus Hulse | -- | 1964 | 31 | 5 | -- | Qal | 1,152 | 18.6 | Oct. 21, 1967 | N | N | |

See footnote at end of table.

Table 3.--Records of Water Wells and Springs, Throckmorton County--Continued

| WELL | OWNER | DRILLER | DATE COMPLETED | DEPTH OF WELL (FT) | CASING: DIAMETER (IN.) | CASING: DEPTH (FT) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT) | WATER LEVEL: BELOW LAND-SURFACE DATUM (FT) | WATER LEVEL: DATE OF MEASUREMENT | METHOD OF LIFT | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *20-41-716 | G. E. Sorgee | -- | 1964 | 40 | 8 | -- | Qal | 1,152 | -- | -- | J,E | D,S | |
| * 717 | Leo Ramsey | -- | 1964 | 16 | 10 | -- | Qal | 1,150 | 10.8 | Nov. 21, 1967 | N | N | |
| * 805 | W. J. Timmons | W. J. Timmons | 1911 | 20 | -- | -- | Qal | 1,138 | 18.1 | Aug. 23, 1967 | C,W | S | Dug well. |
| * 49-401 | James Meng | Claude Covey | 1960 | 30 | 16 | -- | Qal | 1,141 | -- | -- | C,W | S | |
| *21-37-901 | Frank Allen | -- | 1952 | 47 | 6 | -- | Pwl | 1,343 | -- | -- | J,E | D,S | |
| 902 | do | Frank Allen | 1908 | 60 | 5 | -- | Pwl | 1,342 | 16.3 | Oct. 9, 1967 | C,W | S | |
| * 903 | do | -- | -- | 31 | -- | -- | Pwl | 1,335 | 26.0 | Nov. 14, 1967 | J,E | S | Dug well. |
| * 904 | W. R. Moore and Son | Elmer Glenn | 1942 | 65 | 4 | -- | Pwl | 1,370 | 20.0 | Oct. 9, 1967 | C,W | S | |
| * 40-801 | Don Buckalew | -- | 1949 | 20 | -- | -- | Qal | 1,181 | 15.7 | Sept. 19, 1967 | J,E | D,S | Dug well. |
| 802 | do | Buster Tolson | 1961 | 39 | 8 | -- | Qal | 1,188 | 22.0 | do | C,W | N | |
| * 803 | do | do | 1961 | 21 | 7 | -- | Qal | 1,163 | 7.8 | do | C,W | N | |
| * 805 | do | -- | -- | 13 | -- | -- | Qal | 1,170 | 8.4 | Nov. 14, 1967 | C,W | S | Dug well. |
| * 806 | Polk County School Lands | -- | -- | 25 | -- | -- | Qal | 1,177 | 13.5 | Dec. 1, 1967 | C,W | S | Do. |
| * 807 | do | Drover Roberts | -- | 19 | -- | -- | Qal | 1,172 | 13.1 | do | J,E | D,S | Do. |
| * 808 | John T. Davis, Jr. | -- | -- | 15 | -- | -- | Qal | 1,177 | 14.3 | Dec. 1, 1967 | C,W | N | Do. |
| * 809 | Polk County School Lands | -- | -- | 18 | -- | -- | Qal | 1,176 | 14.8 | Nov. 17, 1967 | N | N | Do. |
| * 901 | Don Buckalew | Ernest Knezek | 1967 | 33 | 36 | -- | Qal | 1,185 | 22.3 | Sept. 19, 1967 | N | N | Owner plans to use well for domestic supply. |
| 902 | do | Buster Tolson | 1961 | 31 | 7 | -- | Qal | 1,184 | -- | -- | N | N | |

See footnote at end of table.

Table 3.--Records of Water Wells and Springs, Throckmorton County--Continued

| WELL | OWNER | DRILLER | DATE COMPLETED | DEPTH OF WELL (FT) | CASING: DIAMETER (IN.) | CASING: DEPTH (FT) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT) | WATER LEVEL: BELOW LAND-SURFACE DATUM (FT) | WATER LEVEL: DATE OF MEASUREMENT | METHOD OF LIFT | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *21-40-903 | Don Buckalew | Buster Tolson | 1961 | 68 | 4 | -- | Qal | 1,203 | 41.8 | Sept. 19, 1967 | C,W | N | |
| 904 | do | -- | 1946 | 20 | -- | -- | Qal | 1,169 | 14.4 | do | S,E | S | Dug well. |
| * 45-201 | Taylor Allen | -- | -- | Spring | -- | -- | Pwl | 1,340 | -- | -- | N | N | Flow began in 1960. |
| * 202 | do | -- | 1947 | 23 | 5 | -- | Pwl | 1,353 | 6.0 | Aug. 24, 1967 | N | N | |
| * 203 | do | -- | 1947 | 35 | 5 | -- | Pwl | 1,351 | 11.1 | do | C,W | S | |
| * 204 | do | -- | 1956 | 88 | 5 | -- | Pwl | 1,337 | 4.2 | Oct. 9, 1967 | N | N | |
| * 205 | Frank Allen | -- | 1954 | 35 | 7 | -- | Pwl | 1,361 | 20.7 | do | C,W | S | |
| * 206 | do | -- | -- | 35 | 7 | -- | Pwl | 1,360 | -- | -- | C,W | S | |
| * 301 | Swenson Land and Cattle Company | -- | -- | -- | 7 | -- | Pwl | 1,402 | 18.8 | Aug. 25, 1967 | C,W | S | |
| * 302 | Frank Allen | -- | -- | 35 | 6 | -- | Pwl | 1,353 | -- | -- | C,W | S | |
| * 303 | do | -- | -- | 35 | 4 | -- | Pwl | 1,358 | 20.7 | Oct. 9, 1967 | C,W | S | |
| 304 | W. R. Moore and Son | Doris Dickson | 1950 | 65 | 5 | -- | Pwl | 1,393 | 22.5 | Oct. 10, 1967 | C,W | S | |
| * 305 | do | Elmer Glenn | 1943 | 65 | 6 | -- | Pwl | 1,394 | 25.9 | do | C,E | S | |
| * 306 | do | do | 1945 | 60 | 5 | -- | Pwl | 1,390 | 12.1 | do | C,W | S | |
| * 307 | do | -- | 1914 | 60 | 5 | -- | Pwl | 1,402 | 27.0 | do | C,W | S | |
| * 308 | do | Doris Dickson | 1954 | 65 | 5 | -- | Pwl | 1,402 | 30.6 | Nov. 14, 1967 | C,W | S | |
| * 401 | Taylor Allen | -- | -- | 65 | 5 | -- | Pwl | 1,360 | 18.0 | Aug. 24, 1967 | C,W | S | |
| * 501 | Mack Cooke | -- | -- | 35 | 5 | -- | Pwl | 1,365 | 13.4 | do | N | N | |
| * 502 | do | Elmer Glenn | -- | 75 | 14 | -- | Pwl | 1,368 | -- | -- | T,E | D,S | |
| 503 | do | -- | 1905 | -- | 7 | -- | Pwl | 1,367 | -- | -- | N | N | |

See footnote at end of table.

Table 3.--Records of Water Wells and Springs, Throckmorton County--Continued

| WELL | OWNER | DRILLER | DATE COMPLETED | DEPTH OF WELL (FT) | CASING: DIAMETER (IN.) | CASING: DEPTH (FT) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT) | WATER LEVEL: BELOW LAND-SURFACE DATUM (FT) | WATER LEVEL: DATE OF MEASUREMENT | METHOD OF LIFT | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21-40-504 | Swenson Land and Cattle Company | -- | -- | -- | 6 | -- | Pwl | 1,372 | 22.2 | Aug. 25, 1967 | C,W | N | |
| * 505 | do | -- | -- | -- | 7 | -- | Pwl | 1,372 | 22.7 | do | C,W | S | |
| 506 | Mack Cooke | -- | -- | 44 | 7 | -- | Pwl | 1,383 | 24.0 | Aug. 24, 1967 | N | N | |
| * 507 | do | -- | 1960 | 61 | 5 | -- | Pwl | 1,378 | 33.6 | do | C,H | N | |
| * 508 | do | -- | -- | 42 | 4 | -- | Pwl | 1,370 | 18.0 | do | N | N | Seismograph hole. |
| * 509 | C. P. Baker and Son | -- | -- | 60 | 5 | -- | Pwl | 1,369 | 21.0 | Dec. 19, 1967 | C,W | S | |
| * 45-510 | G. E. Williamson, estate | -- | -- | -- | 5 | -- | Pwl | 1,370 | 26.8 | do | C,W | S | |
| * 801 | Swenson Land and Cattle Company | -- | -- | -- | 7 | -- | Pwl | 1,416 | 16.2 | Aug. 25, 1967 | C,W | S | |
| 802 | do | -- | -- | -- | 7 | -- | Pwl | 1,416 | 15.9 | do | N | N | |
| 803 | do | Earl G. Wright | 1966 | 60 | 8 | -- | Pwl | 1,416 | -- | -- | T,E | N | Drilled for irrigation, but not enough water. |
| * 804 | do | do | 1966 | 60 | 8 | -- | Pwl | 1,416 | 15.8 | Aug. 25, 1967 | T,E | N | Do. |
| 805 | do | do | 1966 | 60 | 8 | -- | Pwl | 1,416 | -- | -- | T,E | N | Do. |
| 806 | do | do | 1966 | 60 | 8 | -- | Pwl | 1,416 | -- | -- | T,E | N | Do. |
| * 807 | do | -- | -- | -- | 7 | -- | Pwl | 1,428 | 11.6 | Aug. 25, 1967 | N | N | |
| * 808 | do | -- | -- | 32 | -- | -- | Pwl | 1,446 | 4.9 | do | C,W | N | Dug well. |
| * 48-201 | Don Buckalew | Ernest Knezek | 1967 | 57 | 18-5/8 | -- | Pwa | 1,187 | 20.1 | Dec. 6, 1967 | N | N | |
| * 301 | A. B. Edsall | S. M. Edsall | -- | 24 | -- | -- | Qal | 1,173 | 21.8 | Oct. 23, 1967 | C,W | S | Dug well. |
| * 302 | Jerry Ann Portwood | -- | 1921 | 27 | -- | -- | Qal | 1,172 | 25.7 | Dec. 1, 1967 | C,W | N | Do. |

See footnote at end of table.

Table 3.--Records of Water Wells and Springs, Throckmorton County--Continued

| WELL | OWNER | DRILLER | DATE COMPLETED | DEPTH OF WELL (FT) | CASING DIAMETER (IN.) | CASING DEPTH (FT) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT) | WATER LEVEL BELOW LAND-SURFACE DATUM (FT) | WATER LEVEL DATE OF MEASUREMENT | METHOD OF LIFT | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *21-48-601 | Mark Campbell | Junker Oil Co. | -- | 91 | 9 | -- | Pwp | 1,205 | 55.6 | Oct. 10, 1967 | N | N | Drilled as oil test, plugged back for livestock water. |
| * 901 | Lester Johnson | -- | -- | 22 | -- | -- | Qal | 1,172 | 16.7 | Oct. 20, 1967 | J,E | D,S | Dug well. |
| * 902 | Wilburn Johnson | -- | -- | 20 | -- | -- | Qal | 1,175 | 11.4 | do | J,E | D,S | Do. |
| * 903 | Hester Johnson | -- | -- | 21 | -- | -- | Qal | 1,158 | 17.0 | do | J,E | D,S | Do. |
| * 904 | Linn Seedig | -- | -- | -- | -- | -- | Qal | 1,152 | -- | -- | C,W | D,S | |
| * 905 | W. E. Bruton | -- | -- | 18 | -- | -- | Qal | 1,160 | 11.6 | Nov. 20, 1967 | J,E | D,S | Dug well. |
| * 906 | Ray Perkins | -- | 1958 | -- | -- | -- | Pwp | 1,154 | -- | -- | J,E | D,S | |
| * 907 | Frank McCarson | Frank McCarson | 1943 | 22 | -- | -- | Qal | 1,173 | 21.2 | Dec. 1, 1967 | J,E | D,S | Dug well. |
| * 53-201 | Swenson Land and Cattle Company | -- | -- | -- | 6 | -- | Pwl | 1,481 | 30.4 | Aug. 25, 1967 | C,W | S | |
| * 202 | do | -- | -- | -- | 5 | -- | Pwl | 1,505 | 37.8 | do | C,W | S | |
| * 203 | do | -- | -- | -- | 6 | -- | Pwl | 1,505 | 29.1 | do | C,W | S | |
| * 401 | Fritz Steinfath | Fritz Steinfath | 1926 | 16 | -- | -- | Pwl | 1,495 | 9.4 | Nov. 21, 1967 | C,W | S | Dug well. |
| * 402 | do | -- | 1965 | 31 | 8-5/8 | -- | Pwl | 1,498 | 13.3 | do | N | N | |
| * 403 | R. D. Johnson | -- | -- | -- | -- | -- | Pwl | 1,497 | -- | -- | C,W | S | |
| * 501 | Swenson Land and Cattle Company | -- | -- | 68 | 8 | -- | Pwl | 1,555 | 39.2 | Aug. 25, 1967 | N | N | |
| * 502 | do | Earl G. Wright | -- | 40 | 8 | 39.5 | Pwl | 1,538 | -- | -- | C,W | S | |
| * 54-401 | R. C. Pirtle, Jr. | -- | -- | -- | -- | -- | Pwl | 1,659 | 2.6 | Aug. 30, 1967 | J,E | D,S | Dug well. |

See footnote at end of table.

Table 3.--Records of Water Wells and Springs, Throckmorton County--Continued

| WELL | OWNER | DRILLER | DATE COMPLETED | DEPTH OF WELL (FT) | CASING DIAMETER (IN.) | CASING DEPTH (FT) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT) | WATER LEVEL BELOW LAND-SURFACE DATUM (FT) | WATER LEVEL DATE OF MEASUREMENT | METHOD OF LIFT | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *21-54-402 | R. C. Pirtle, Jr. | -- | -- | -- | -- | -- | Pwl | 1,648 | 0.1 | Aug. 30, 1967 | N | N | Dug well. |
| * 55-201 | Norman McCluskey | -- | 1955 | 40 | 5 | -- | Qal | 1,311 | 6.2 | Sept. 20, 1967 | J,E | N | |
| * 401 | J. L. Carpenter | -- | -- | 14 | -- | -- | Pwbp | 1,404 | 8.3 | Dec. 7, 1967 | J,E | D,S | Dug well. |
| * 402 | E. C. Bruton | -- | -- | 20 | -- | -- | Pwbp | 1,411 | 11.9 | do | J,E | N | |
| * 501 | Thomas Boyd | -- | -- | 23 | -- | -- | Pwbp | 1,399 | 13.9 | Dec. 8, 1967 | J,E | D,S | Dug well. |
| * 502 | John Brockman | -- | -- | 20 | -- | -- | Qal | 1,303 | 5.1 | Jan. 26, 1968 | J,E | D,S | Do. |
| * 601 | Raymond Wright | Raymond Wright | 1951 | 19 | -- | -- | Qal | 1,251 | 9.2 | Sept. 20, 1967 | J,E | D,S | Do. |
| * 56-301 | Rufus Perry | -- | -- | Spring | -- | -- | Pwp | 1,263 | (+) | -- | C,G | D,S | Known locally as "Mexican Springs." |
| * 302 | R. A. McNutt | -- | 1927 | 28 | -- | -- | Pwp | 1,291 | 20.3 | Nov. 20, 1967 | J,E | D,S | Dug well. |
| * 303 | J. E. Jennings | -- | -- | 60 | 4-1/2 | -- | Pwp | 1,254 | -- | -- | J,E | D,S | |
| * 601 | Van Franklin Moses | -- | -- | 28 | -- | -- | Pwp | 1,248 | -- | -- | J,E | D,S | Dug well. |
| * 602 | Jess Barr | Red Glenn | 1947 | 60 | 4 | -- | Pwp | 1,246 | 14.7 | Nov. 21, 1967 | N | N | |
| * 603 | W. A. Babb | -- | -- | 36 | -- | -- | Pwp | 1,251 | 14.3 | do | C,W | N | Dug well. |
| 604 | do | -- | -- | -- | -- | -- | Pwp | 1,252 | -- | -- | B,H | N | Do. |
| * 63-101 | Tom Richards | -- | -- | 11 | -- | -- | Pwbp | 1,410 | 8.7 | Dec. 8, 1967 | B,H | D,S | Do. |
| * 102 | Tom Parrot | -- | -- | 19 | -- | -- | Pwbp | 1,350 | 11.7 | Dec. 7, 1967 | C,W | N | Do. |
| * 64-301 | T. P. Holland et al. | -- | -- | 19 | -- | -- | Pwm | 1,386 | 1.5 | Dec. 8, 1967 | N | N | Do. |
| *30-08-301 | Lee Cumpton | -- | -- | 20 | -- | -- | Pwm | 1,211 | 10.0 | Jan. 16, 1968 | C,W | N | Do. |
| 302 | Carl Sullivan | -- | -- | 22 | -- | -- | Pwm | 1,215 | 8.7 | Jan. 15, 1968 | N | N | Do. |

* See Table 4 for chemical analysis.

Table 4.--Chemical Analyses of Water From Wells and Springs, Throckmorton County

(Analyses are in milligrams per liter except specific conductance and pH)

Analyses performed by Texas State Department of Health.

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Moran Formation | | | | | | | | | | |
| 21-64-301 | T. P. Holland et al. | 19 | Dec. 8, 1967 | 10 | 249 | 37 | 390 | 250 | 700 | 487 | 1.9 | <0.4 | 2,000 | 770 | 2,850 | 7.2 |
| 30-08-301 | Lee Cumpton | 20 | Jan. 16, 1968 | 17 | 211 | 65 | 304 | 388 | 355 | 520 | 1.0 | 8.5 | 1,670 | 790 | 2,660 | 7.7 |
| 302 | Carl Sullivan | 22 | Jan. 15, 1968 | 18 | 111 | 15 | 6 | 397 | 16 | 4 | .9 | 2.0 | 368 | 338 | 624 | 7.4 |
| | | | | | | Putnam Formation | | | | | | | | | | |
| 21-48-601 | Mark Campbell | 91 | Oct. 10, 1967 | 10 | 173 | 114 | 1,500 | 478 | 145 | 2,590 | 1.1 | 3.0 | 4,770 | 900 | 7,500 | 7.7 |
| 906 | Ray Perkins | -- | Nov. 20, 1967 | 18 | 305 | 171 | 740 | 437 | 2,170 | 328 | 1.6 | 12 | 3,960 | 1,470 | 4,600 | 7.3 |
| 56-301 | Rufus Perry | Spring | do | 18 | 92 | 18 | 63 | 283 | 35 | 78 | .8 | 95 | 540 | 306 | 872 | 7.5 |
| 302 | R. A. McNutt | 28 | do | 17 | 93 | 21 | 151 | 289 | 45 | 217 | 1.4 | 80 | 770 | 317 | 1,300 | 7.7 |
| 303 | J. E. Jennings | 60 | do | 18 | 119 | 57 | 161 | 266 | 101 | 217 | 1.7 | 341 | 1,150 | 530 | 1,720 | 7.9 |
| 601 | Van Franklin Moses | 28 | Nov. 10, 1967 | 17 | 119 | 72 | 141 | 397 | 56 | 350 | .8 | 44 | 1,000 | 590 | 1,780 | 7.6 |
| 602 | Jess Barr | 60 | Nov. 21, 1967 | 8 | 137 | 72 | 155 | 395 | 406 | 131 | .5 | 88 | 1,190 | 640 | 1,720 | 7.9 |
| 603 | W. A. Babb | 36 | do | 14 | 88 | 28 | 23 | 386 | 22 | 30 | .7 | 5.5 | 402 | 334 | 686 | 7.8 |
| | | | | | | Admiral Formation | | | | | | | | | | |
| 21-48-201 | Don Buckalew | 57 | Dec. 6, 1967 | 9 | 146 | 133 | 1,000 | 401 | 550 | 1,590 | 1.3 | 16.5 | 3,640 | 910 | 5,640 | 8.0 |
| | | | | | | Belle Plains Formation | | | | | | | | | | |
| 21-55-401 | J. L. Carpenter | 14 | Dec. 7, 1967 | 22 | 97 | 85 | 288 | 433 | 252 | 405 | 3.0 | 55 | 1,420 | 590 | 2,240 | 7.6 |
| 402 | E. C. Bruton | 20 | do | 24 | 296 | 167 | 530 | 245 | 590 | 1,200 | 1.6 | 110 | 3,040 | 1,430 | 4,600 | 8.0 |
| 501 | Thomas Boyd | 23 | Dec. 8, 1967 | 20 | 113 | 113 | 345 | 461 | 276 | 540 | 4.4 | 88 | 1,730 | 750 | 2,704 | 7.7 |
| 63-101 | Tom Richards | 11 | do | 9 | 101 | 6 | 73 | 137 | 45 | 112 | .5 | 155 | 570 | 279 | 916 | 7.9 |
| 102 | Tom Parrot | 19 | Dec. 7, 1967 | 17 | 86 | 45 | 36 | 486 | 24 | 33 | 1.1 | < .4 | 481 | 399 | 823 | 7.6 |

See footnotes at end of table.

Table 4.--Chemical Analyses of Water From Wells and Springs, Throckmorton County--Continued

| WELL | OWNER | DEPTH OF WELL (FT) | DATE OF COLLECTION | SILICA ($SiO_2$) | CAL-CIUM (Ca) | MAGNE-SIUM (Mg) | SODIUM (Na) | BICAR-BONATE ($HCO_3$) | SUL-FATE ($SO_4$) | CHLO-RIDE (Cl) | FLUO-RIDE (F) | NI-TRATE ($NO_3$) | DIS-SOLVED SOLIDS | TOTAL HARD-NESS AS $CaCO_3$ | SPECIFIC CONDUCT-ANCE (MICROM-HOS AT 25° C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lueders Formation | | | | | | | | | |
| 21-37-901 | Frank Allen | 47 | Oct. 9, 1967 | 15 | 124 | 73 | 198 | 403 | 251 | 311 | 0.8 | 18 | 1,190 | 610 | 1,960 | -- |
| 903 | do | 31 | Nov. 14, 1967 | 16 | 122 | 80 | 194 | 432 | 238 | 315 | .7 | 17 | 1,200 | 630 | 1,940 | 7.4 |
| 904 | W. R. Moore and Son | 65 | do | 16 | 112 | 69 | 183 | 346 | 250 | 281 | .8 | 26 | 1,110 | 560 | 1,790 | 8.0 |
| 45-201 | Taylor Allen | Spring | Aug. 24, 1967 | 17 | 680 | 95 | 242 | 338 | 1,680 | 368 | 1.5 | <.4 | 3,250 | 2,080 | 3,700 | 7.2 |
| 202 | do | 23 | do | 15 | 620 | 154 | 175 | 331 | 1,880 | 256 | 1.8 | <.4 | 3,270 | 2,180 | 3,550 | 7.4 |
| 203 | do | 35 | do | 18 | 580 | 160 | 168 | 325 | 1,840 | 204 | 1.7 | <.4 | 3,130 | 2,120 | 3,400 | 7.4 |
| 204 | do | 88 | Oct. 9, 1967 | <.4 | 330 | 115 | 329 | 9 | 1,190 | 540 | .7 | <.4 | 2,510 | 1,300 | 3,440 | 5.9 |
| 205 | Frank Allen | 35 | do | 17 | 453 | 93 | 297 | 329 | 1,380 | 362 | 1.9 | <.4 | 2,770 | 1,510 | 3,350 | 7.4 |
| 206 | do | 35 | do | 16 | 159 | 86 | 194 | 367 | 436 | 296 | 1.2 | <.4 | 1,370 | 750 | 2,100 | 7.7 |
| 301 | Swenson Land and Cattle Company | -- | Aug. 25, 1967 | 13 | 102 | 58 | 111 | 404 | 231 | 114 | 1.2 | .4 | 830 | 494 | 1,310 | 7.7 |
| 302 | Frank Allen | 35 | Oct. 9, 1967 | 15 | 127 | 69 | 194 | 442 | 264 | 252 | 1.2 | 9.5 | 1,150 | 600 | 1,860 | 7.4 |
| 303 | do | 35 | do | 17 | 151 | 81 | 239 | 387 | 458 | 291 | 1.6 | <.4 | 1,430 | 710 | 2,190 | 7.4 |
| 305 | W. R. Moore and Son | 65 | Oct. 10, 1967 | 14 | 97 | 62 | 114 | 394 | 220 | 138 | 1.3 | <.4 | 840 | 497 | 1,380 | 7.4 |
| 306 | do | 60 | do | 14 | 97 | 57 | 103 | 437 | 175 | 100 | 1.3 | 19 | 780 | 479 | 1,340 | 7.8 |
| 307 | do | 60 | do | 14 | 74 | 42 | 54 | 395 | 90 | 48 | 1.1 | <.4 | 520 | 360 | 850 | 8.0 |
| 308 | do | 65 | Nov. 14, 1967 | 1 | 56 | 34 | 146 | 20 | 191 | 258 | 1.0 | <.4 | 700 | 279 | 1,250 | 6.4 |
| 401 | Taylor Allen | 65 | Aug. 24, 1967 | 15 | 600 | 164 | 261 | 338 | 2,130 | 198 | 1.7 | <.4 | 3,540 | 2,160 | 3,750 | 7.3 |
| 501 | Mack Cooke | 35 | do | 6 | 93 | 30 | 66 | 143 | 241 | 89 | .4 | 9.0 | 600 | 356 | 968 | 7.1 |
| 1/ 502 | do | 75 | do | 19 | 356 | 318 | 665 | 328 | 2,580 | 471 | 22 | 11.5 | 4,600 | 2,200 | 5,150 | 7.4 |
| 505 | Swenson Land and Cattle Company | -- | Aug. 25, 1967 | 25 | 154 | 122 | 215 | 262 | 620 | 339 | .8 | 3.0 | 1,610 | 890 | 2,380 | 7.5 |

See footnotes at end of table.

Table 4.--Chemical Analyses of Water From Wells and Springs, Throckmorton County--Continued

| WELL | OWNER | DEPTH OF WELL (FT) | DATE OF COLLECTION | SILICA ($SiO_2$) | CAL-CIUM (Ca) | MAGNE-SIUM (Mg) | SODIUM (Na) | BICAR-BONATE ($HCO_3$) | SUL-FATE ($SO_4$) | CHLO-RIDE (Cl) | FLUO-RIDE (F) | NI-TRATE ($NO_3$) | DIS-SOLVED SOLIDS | TOTAL HARD-NESS AS $CaCO_3$ | SPECIFIC CONDUCT-ANCE (MICROM-HOS AT 25° C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21-45-507 | Mack Cooke | 61 | Aug. 24, 1967 | <0.4 | 10,000 | 2,070 | 43,000 | 28 | 1,560 | 90,500 | 1.9 | <0.4 | 147,000 | 33,500 | <12,000 | 6.9 |
| 508 | do | 42 | do | 4 | 33 | 9 | 25 | 101 | 46 | 16 | .3 | < .4 | 178 | 117 | 320 | 7.3 |
| 509 | C. P. Baker and Son | 60 | Dec. 19, 1967 | 19 | 530 | 261 | 580 | 394 | 1,870 | 1,020 | 1.3 | 6.5 | 4,480 | 2,390 | 5,490 | 7.1 |
| 510 | G. E. Williamson estate | -- | do | 20 | 209 | 82 | 146 | 366 | 520 | 224 | .8 | < .4 | 1,380 | 860 | 2,010 | 7.5 |
| 801 | Swenson Land and Cattle Company | -- | Aug. 25, 1967 | 12 | 230 | 155 | 188 | 209 | 1,180 | 178 | 1.2 | < .4 | 2,050 | 1,210 | 2,540 | 7.3 |
| 804 | do | 60 | do | < .4 | 112 | 117 | 179 | 7 | 840 | 189 | 1.0 | 3.5 | 1,450 | 760 | 2,010 | 5.8 |
| 807 | do | -- | do | 16 | 144 | 73 | 152 | 375 | 430 | 188 | 1.1 | < .4 | 1,190 | 660 | 1,750 | 7.6 |
| 808 | do | 32 | do | 15 | 610 | 89 | 130 | 320 | 1,610 | 145 | 1.2 | 3.5 | 2,760 | 1,890 | 3,040 | 7.4 |
| 53-201 | do | -- | do | 19 | 560 | 239 | 393 | 329 | 2,060 | 570 | 2.0 | 4.0 | 4,010 | 2,380 | 4,590 | 7.4 |
| 202 | do | -- | do | 19 | 620 | 98 | 242 | 342 | 1,640 | 288 | 2.2 | < .4 | 3,080 | 1,940 | 3,540 | 7.4 |
| 203 | do | -- | do | 20 | 610 | 155 | 235 | 344 | 1,790 | 330 | 2.2 | < .4 | 3,310 | 2,170 | 3,690 | 7.4 |
| 401 | Fritz Steinfath | 16 | Nov. 21, 1967 | 19 | 336 | 65 | 55 | 271 | 880 | 41 | 1.3 | 3.5 | 1,530 | 1,110 | 1,860 | 7.6 |
| 402 | do | 31 | do | <1 | 63 | 39 | 49 | 129 | 245 | 45 | .4 | 4.0 | 510 | 319 | 805 | 7.7 |
| 403 | R. D. Johnson | -- | do | 14 | 620 | 131 | 88 | 321 | 1,800 | 117 | 1.9 | < .4 | 2,930 | 2,090 | 3,000 | 7.4 |
| 501 | Swenson Land and Cattle Company | 68 | Aug. 25, 1967 | 47 | 180 | 96 | 1,350 | 2/ | 660 | 1,780 | .7 | < .4 | 4,920 | 850 | 7,470 | 7.9 |
| 502 | do | 40 | Aug. 30, 1967 | 16 | 376 | 75 | 70 | 361 | 1,000 | 48 | 1.3 | < .4 | 1,760 | 1,250 | 2,080 | 7.4 |
| 54-401 | R. C. Pirtle, Jr. | -- | do | 15 | 149 | 14 | 124 | 343 | 154 | 135 | 1.0 | 110 | 870 | 430 | 1,310 | 7.4 |
| 402 | do | -- | do | 15 | 147 | 16 | 132 | 353 | 167 | 138 | 1.0 | 70 | 860 | 433 | 1,350 | 7.6 |
| | | | | | | | Alluvium | | | | | | | | | |
| 20-33-701 | Louis Sykora | 10 | Aug. 15, 1967 | 9 | 47 | 38 | 106 | 417 | 73 | 53 | 1.7 | 16 | 550 | 273 | 904 | 7.7 |
| 702 | H. B. Rogers | 19 | Sept. 19, 1967 | 16 | 45 | 47 | 68 | 416 | 51 | 17 | 2.2 | 36 | 490 | 305 | 806 | 7.7 |

See footnotes at end of table.

Table 4.--Chemical Analyses of Water From Wells and Springs, Throckmorton County--Continued

| WELL | OWNER | DEPTH OF WELL (FT) | DATE OF COLLECTION | SILICA ($SiO_2$) | CAL-CIUM (Ca) | MAGNE-SIUM (Mg) | SODIUM (Na) | BICAR-BONATE ($HCO_3$) | SUL-FATE ($SO_4$) | CHLO-RIDE (Cl) | FLUO-RIDE (F) | NI-TRATE ($NO_3$) | DIS-SOLVED SOLIDS | TOTAL HARD-NESS AS $CaCO_3$ | SPECIFIC CONDUCT-ANCE (MICROM-HOS AT 25° C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20-41-101 | Juble E. Wells | 29 | Aug. 15, 1967 | 17 | 64 | 44 | 283 | 590 | 166 | 214 | 2.8 | 7.0 | 1,080 | 340 | 1,740 | 7.7 |
| 102 | Cecil Womack | 32 | Aug. 16, 1967 | 19 | 34 | 14 | 159 | 464 | 59 | 23 | 2.1 | 28 | 570 | 143 | 894 | 7.9 |
| 103 | do | 24 | do | 18 | 37 | 18 | 138 | 403 | 59 | 32 | 1.1 | 35 | 540 | 165 | 857 | 7.6 |
| 104 | Louis Sykora | 33 | Aug. 15, 1967 | 18 | 66 | 18 | 157 | 448 | 70 | 42 | 1.3 | 115 | 710 | 238 | 1,051 | 7.7 |
| 105 | Cecil Womack | 40 | Aug. 16, 1967 | 18 | 47 | 19 | 209 | 487 | 95 | 65 | 1.3 | 62 | 760 | 198 | 1,181 | 7.6 |
| 108 | J. R. Mixon | 10 | Oct. 20, 1967 | 18 | 137 | 57 | 330 | 447 | 489 | 288 | 1.2 | 13.0 | 1,550 | 580 | 2,300 | 7.7 |
| 109 | W. Morris Hannis, Sr. | 15 | Oct. 19, 1967 | 10 | 96 | 106 | 380 | 410 | 580 | 388 | 1.5 | <.4 | 1,760 | 680 | 1,670 | 7.9 |
| 110 | do | 21 | do | 20 | 52 | 58 | 93 | 428 | 100 | 60 | .7 | 51 | 650 | 370 | 1,040 | 7.6 |
| 111 | C. C. Richardson | 33 | Oct. 23, 1967 | 13 | 40 | 40 | 116 | 405 | 63 | 64 | 1.6 | 19 | 560 | 266 | 938 | 7.7 |
| 112 | A. B. Edsall | 72 | do | 6 | 52 | 17 | 145 | 234 | 41 | 203 | .4 | 5.5 | 590 | 200 | 1,065 | 7.3 |
| 203 | Ethelene Easley | 46 | Aug. 15, 1967 | 20 | 67 | 12 | 133 | 407 | 70 | 53 | .7 | 31 | 590 | 218 | 945 | 7.6 |
| 207 | Tom Cooke | 33 | Sept. 20, 1967 | 21 | 54 | 47 | 188 | 510 | 86 | 102 | 2.4 | 110 | 860 | 327 | 1,360 | 7.6 |
| 401 | Mark Campbell | 31 | Oct. 10, 1967 | 21 | 129 | 32 | 122 | 590 | 51 | 95 | .8 | 85 | 830 | 453 | 1,300 | 7.6 |
| 402 | F. Dwight Hamilton | 26 | Oct. 18, 1967 | 21 | 95 | 14 | 48 | 412 | 15 | 12 | .8 | 5.0 | 413 | 295 | 677 | 7.7 |
| 404 | A. W. Mitchell | 29 | do | 18 | 68 | 25 | 130 | 411 | 60 | 92 | 1.0 | 22 | 620 | 274 | 1,033 | 7.5 |
| 405 | W. P. Manuel | 14 | do | 27 | 202 | 106 | 730 | 640 | 840 | 790 | 1.6 | 2.5 | 3,010 | 940 | 4,360 | 7.2 |
| 406 | do | 27 | do | 12 | 96 | 26 | 38 | 401 | 31 | 23 | .8 | 50 | 474 | 345 | 770 | 7.9 |
| 407 | do | 27 | do | 20 | 71 | 42 | 60 | 372 | 33 | 31 | .3 | 132 | 570 | 349 | 905 | 7.3 |
| 408 | do | 28 | do | 17 | 95 | 20 | 34 | 368 | 19 | 20 | .2 | 60 | 446 | 321 | 773 | 7.7 |
| 409 | Marvin Hickey | 13 | Oct. 19, 1967 | 15 | 66 | 21 | 58 | 307 | 63 | 40 | 1.4 | <.4 | 415 | 253 | 700 | 7.6 |
| 410 | A. W. Mitchell | 15 | do | 19 | 83 | 30 | 281 | 510 | 109 | 288 | .8 | <.4 | 1,060 | 330 | 1,900 | 7.7 |
| 411 | W. Elbert Curtis, Jr. | 24 | do | 23 | 79 | 32 | 196 | 570 | 24 | 184 | 1.3 | 5.0 | 820 | 332 | 1,500 | 7.3 |

See footnotes at end of table.

Table 4.--Chemical Analyses of Water From Wells and Springs, Throckmorton County--Continued

| WELL | OWNER | DEPTH OF WELL (FT) | DATE OF COLLECTION | SILICA ($SiO_2$) | CAL-CIUM (Ca) | MAGNE-SIUM (Mg) | SODIUM (Na) | BICAR-BONATE ($HCO_3$) | SUL-FATE ($SO_4$) | CHLO-RIDE (Cl) | FLUO-RIDE (F) | NI-TRATE ($NO_3$) | DIS-SOLVED SOLIDS | TOTAL HARD-NESS AS $CaCO_3$ | SPECIFIC CONDUCT-ANCE (MICROM-HOS AT 25° C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20-41-412 | N. L. B. Davis | 19 | Oct. 20, 1967 | 20 | 44 | 33 | 198 | 459 | 99 | 119 | 1.6 | 28 | 770 | 246 | 1,250 | 7.7 |
| 413 | D. W. Pace | 36 | Oct. 18, 1967 | 17 | 148 | 68 | 189 | 342 | 178 | 320 | .5 | 187 | 1,280 | 650 | 2,060 | 7.6 |
| 414 | A. B. Edsall | 23 | Oct. 23, 1967 | 15 | 33 | 37 | 85 | 418 | 38 | 16 | 1.6 | 15 | 447 | 234 | 750 | 7.6 |
| 415 | do | 32 | do | 13 | 51 | 32 | 154 | 500 | 65 | 75 | 1.8 | 10 | 650 | 259 | 1,089 | 7.7 |
| 416 | Mrs. O. C. Cribbs | 27 | Dec. 6, 1967 | 14 | 62 | 24 | 163 | 570 | 34 | 66 | .7 | 2.0 | 650 | 254 | 1,076 | 7.9 |
| 417 | do | 21 | do | 12 | 34 | 7 | 79 | 205 | 56 | 45 | .6 | 2.5 | 338 | 113 | 546 | 7.7 |
| 701 | W. J. Timmons | 21 | Aug. 23, 1967 | 19 | 424 | 351 | 1,380 | 423 | 3,220 | 1,110 | 2.3 | 315 | 7,000 | 2,500 | 7,760 | 7.4 |
| 702 | W. Elbert Curtis, Jr. | 23 | Oct. 19, 1967 | 19 | 126 | 61 | 455 | 340 | 352 | 600 | 1.4 | 88 | 1,870 | 570 | 2,900 | 7.5 |
| 703 | J. C. Smith | 24 | Oct. 20, 1967 | 18 | 400 | 227 | 1,240 | 401 | 620 | 2,490 | 1.8 | 336 | 5,500 | 1,930 | 7,880 | 7.3 |
| 704 | Mrs. Ruby Lilly | 24 | do | 17 | 217 | 144 | 710 | 445 | 331 | 1,260 | 2.1 | 231 | 3,130 | 1,130 | 4,910 | 7.5 |
| 705 | Bob D. Bailes | 32 | do | 15 | 89 | 40 | 340 | 460 | 267 | 281 | 1.4 | 55 | 1,310 | 386 | 2,090 | 7.6 |
| 706 | do | 21 | do | 20 | 97 | 65 | 277 | 620 | 396 | 128 | 1.5 | 10 | 1,300 | 510 | 1,950 | 7.7 |
| 707 | do | 15 | do | 17 | 65 | 38 | 286 | 451 | 155 | 260 | 2.0 | 47 | 1,090 | 318 | 1,800 | 7.7 |
| 708 | Elbert Keeter | 31 | do | 15 | 145 | 160 | 1,020 | 640 | 870 | 1,220 | 1.8 | 19 | 3,770 | 1,020 | 5,540 | 7.4 |
| 709 | R. R. Roberts | 20 | Oct. 23, 1967 | 17 | 71 | 54 | 373 | 510 | 264 | 316 | 1.9 | 48 | 1,400 | 400 | 2,230 | 8.0 |
| 710 | J. W. Roberts | 23 | do | 19 | 102 | 133 | 590 | 500 | 395 | 890 | 1.6 | 38 | 2,420 | 800 | 3,810 | 7.6 |
| 711 | Lyndel Manuel | 30 | Oct. 19, 1967 | 19 | 186 | 152 | 520 | 399 | 345 | 1,050 | 1.0 | 24 | 2,490 | 1,090 | 4,060 | 7.5 |
| 712 | W. P. Manuel | 24 | Oct. 20, 1967 | 24 | 51 | 15 | 42 | 278 | 10 | 31 | .8 | 5.5 | 316 | 188 | 535 | 7.5 |
| 713 | W. A. Keeter | 24 | Nov. 20, 1967 | 18 | 218 | 98 | 530 | 382 | 409 | 780 | .7 | 283 | 2,530 | 950 | 3,750 | 7.4 |
| 714 | do | 22 | do | 19 | 166 | 76 | 700 | 370 | 412 | 1,030 | 1.0 | 88 | 2,670 | 730 | 4,150 | 7.8 |
| 715 | Venus Hulse | 31 | Nov. 21, 1967 | 6 | 89 | 101 | 409 | 285 | 466 | 459 | 1.0 | 200 | 1,870 | 640 | 2,760 | 7.4 |
| 716 | G. E. Sorgee | 40 | do | 15 | 72 | 43 | 235 | 394 | 130 | 275 | 1.4 | 38 | 1,000 | 360 | 1,680 | 7.8 |
| 717 | Leo Ramsey | 16 | do | 6 | 222 | 199 | 760 | 431 | 1,990 | 500 | 1.5 | 2.5 | 3,890 | 1,370 | 4,650 | 7.4 |

See footnotes at end of table.

Table 4.--Chemical Analyses of Water From Wells and Springs, Throckmorton County--Continued

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20-41-805 | W. J. Timmons | 20 | Aug. 23, 1967 | 18 | 196 | 156 | 600 | 560 | 1,160 | 449 | 2.3 | 168 | 3,020 | 1,130 | 3,920 | 7.4 |
| 49-401 | James Meng | 30 | Sept. 1, 1967 | 15 | 136 | 66 | 241 | 494 | 155 | 419 | .5 | 5.0 | 1,280 | 610 | 2,150 | 7.7 |
| 21-40-801 | Don Buckalew | 20 | Sept. 19, 1967 | 20 | 50 | 39 | 9 | 354 | 7 | 4 | .4 | <.4 | 303 | 285 | 531 | 7.7 |
| 803 | do | 21 | do | <.4 | 249 | 84 | 1,820 | 328 | <4 | 3,370 | .5 | <.4 | 5,700 | 970 | 9,380 | 7.1 |
| 805 | do | 13 | Nov. 14, 1967 | 15 | 74 | 122 | 700 | 810 | 479 | 720 | 1.5 | 41 | 2,550 | 690 | 3,860 | 7.6 |
| 806 | Polk County School Lands | 25 | Dec. 1, 1967 | 17 | 91 | 100 | 448 | 750 | 336 | 379 | 1.5 | 20 | 1,860 | 640 | 2,800 | 7.8 |
| 807 | do | 19 | do | 14 | 64 | 74 | 122 | 453 | 122 | 133 | .7 | 68 | 820 | 465 | 1,320 | 7.6 |
| 808 | John T. Davis, Jr. | 15 | Dec. 1, 1967 | 12 | 41 | 6 | 7 | 146 | 11 | 10 | 1.5 | 5.5 | 165 | 129 | 299 | 7.3 |
| 809 | Polk County School Lands | 18 | Nov. 17, 1967 | 12 | 58 | 48 | 174 | 427 | 155 | 138 | .8 | 13 | 810 | 342 | 1,340 | 7.3 |
| 901 | Don Buckalew | 33 | Sept. 19, 1967 | 17 | 46 | 29 | 267 | 810 | 70 | 57 | 1.6 | <.4 | 890 | 234 | 1,430 | 8.0 |
| 903 | do | 68 | do | <.4 | 19 | 15 | 175 | 73 | 5 | 272 | .1 | 15 | 520 | 108 | 1,046 | 6.7 |
| 904 | do | 20 | do | 17 | 95 | 29 | 175 | 314 | 133 | 227 | .6 | 51 | 860 | 348 | 1,490 | 7.6 |
| 48-301 | A. B. Edsall | 24 | Oct. 23, 1967 | 10 | 46 | 77 | 310 | 680 | 13 | 379 | 1.6 | <.4 | 1,170 | 433 | 2,120 | 7.4 |
| 302 | Jerry Ann Portwood | 27 | Dec. 1, 1967 | 30 | 96 | 75 | 151 | 650 | 34 | 228 | .8 | <.4 | 940 | 550 | 1,660 | 7.5 |
| 901 | Lester Johnson | 22 | Oct. 20, 1967 | 22 | 86 | 25 | 66 | 317 | 42 | 91 | 1.2 | 38 | 530 | 319 | 900 | 7.5 |
| 902 | Wilburn Johnson | 20 | do | 20 | 15 | 47 | 140 | 376 | 60 | 83 | 1.9 | 80 | 630 | 233 | 1,031 | 7.7 |
| 903 | Hester Johnson | 21 | do | 16 | 81 | 51 | 386 | 454 | 153 | 465 | 1.4 | 55 | 1,430 | 410 | 2,390 | 7.7 |
| 904 | Linn Seedig | -- | Nov. 20, 1967 | 18 | 61 | 69 | 464 | 620 | 238 | 444 | 2.7 | 105 | 1,700 | 437 | 2,640 | 7.7 |
| 905 | W. E. Bruton | 18 | do | 23 | 146 | 64 | 402 | 381 | 247 | 620 | .9 | 95 | 1,790 | 630 | 2,880 | 7.4 |
| 907 | Frank McCarson | 22 | Dec. 1, 1967 | 18 | 109 | 57 | 249 | 384 | 65 | 474 | .6 | 8.5 | 1,170 | 510 | 2,040 | 7.4 |
| 55-201 | Norman McCluskey | 40 | Sept. 20, 1967 | 16 | 54 | 19 | 22 | 161 | 37 | 44 | .6 | 33 | 305 | 215 | 528 | 7.4 |
| 502 | John Brockman | 20 | Jan. 26, 1968 | 12 | 94 | 48 | 88 | 361 | 62 | 183 | .6 | <.4 | 670 | 433 | 1,160 | 7.7 |
| 601 | Raymond Wright | 19 | Sept. 20, 1967 | 15 | 245 | 197 | 580 | 346 | 179 | 1,600 | .7 | <.4 | 2,990 | 1,420 | 5,090 | 7.5 |

1/ Sample contains 15 mg/l iron, <0.05 mg/l manganese, 2.8 mg/l boron.
2/ Analysis for bicarbonate affected by presence of 165 mg/l ammonia in the water sample.

Table 5.--Chemical Analyses of Oil-Field Brines, Throckmorton County

(Analyses are in parts per million except pH.)

Data from Laxson and others, 1960.

| PRODUCING ZONE | FIELD | AVERAGE DEPTH OF WELL | AREA SHOWN ON FIGURE 10 | CALCIUM (CA) | MAGNESIUM (MG) | SODIUM (NA) | BICARBONATE ($HCO_3$) | SULFATE ($SO_4$) | CHLORIDE (CL) | DIS-SOLVED SOLIDS | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | PERMIAN SYSTEM | | | | | | | |
| Bluff Creek | Burch cook sand | 1,275 | 22 | 5,960 | 2,352 | 35,604 | 56 | 0 | 72,500 | 116,416 | 6.4 |
| Cook sand | Burch | 1,312 | 22 | 6,160 | 2,156 | 37,513 | 76 | 0 | 75,500 | 121,329 | 6.6 |
| | | | | PENNSYLVANIAN SYSTEM | | | | | | | |
| Canyon sand | Woodson | 2,320 | 32 | 15,000 | 760 | 45,400 | 114 | 149 | 98,700 | -- | 5.7 |
| Strawn | Woodson | 2,600 | 32 | 13,750 | 1,587 | 40,900 | 142 | 185 | 98,500 | -- | 6.2 |
| Strawn | Dickie | 3,065 | 28 | 10,960 | 2,290 | 47,050 | 148 | 11 | 98,517 | -- | 6.7 |
| Strawn | Travis | 3,800 | 2 | 11,280 | 1,748 | 43,160 | 116 | 68 | 91,500 | -- | 6.2 |
| Strawn | Manning-Harrington | 3,950 | 11 | 16,650 | 1,690 | 51,267 | 135 | 70 | 113,300 | -- | 6.3 |
| Caddo | Woodson | 3,900 | 21 | 10,680 | 3,418 | 42,980 | 35 | 12 | 95,070 | -- | 5.6 |
| Caddo | Marshall N. | 3,958 | 16 | 12,803 | 3,790 | 50,603 | 23 | 9 | 111,800 | -- | 5.8 |
| Caddo | Lunsford | 4,126 | 19 | 13,740 | 3,790 | 47,600 | 339 | 33 | 108,700 | -- | 6.1 |
| Bend Conglomerate | Batchelor | 4,672 | 16 | 5,330 | 721 | 29,074 | 312 | 783 | 55,600 | -- | 6.2 |
| | | | | MISSISSIPPIAN SYSTEM | | | | | | | |
| Mississippian | McKnight | 4,025 | 19 | 3,410 | 724 | 26,500 | 353 | 754 | 48,300 | -- | 7.5 |
| Mississippian | Dickie | 4,800 | 28 | 3,092 | 708 | 24,670 | 404 | 680 | 44,400 | -- | 6.5 |
| Mississippian | Richards Ranch | 4,600 | 25 | 3,045 | 427 | 23,994 | 354 | 781 | 42,844 | -- | 7.1 |
| Mississippian | Warren | 4,514 | 30 | 4,080 | 815 | 24,750 | 332 | 698 | 47,300 | -- | 7.3 |
| Mississippian | Woodson | 4,500 | 32 | 4,030 | 751 | 24,650 | 150 | 1,052 | 48,900 | 79,531 | -- |

Table 6.--Reported Oil-Field Brine Production and Disposal in 1961 and 1967, Throckmorton County
(Quantities reported in barrels)

| AREA SHOWN ON FIGURE 10 | FIELD[1/] | BRINE PRODUCTION 1961 | BRINE PRODUCTION 1967 | DISPOSAL INTO PITS 1961 | DISPOSAL INTO PITS 1967 | INJECTION INTO WELLS 1961 | INJECTION INTO WELLS 1967 | MISCELLANEOUS 1961 | MISCELLANEOUS 1967 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | County regular | 18,980 | 41,270 | 18,980 | 0 | -- | 41,270 | 0 | 0 |
| | Area Total | 18,980 | 41,270 | 18,980 | 0 | -- | 41,270 | 0 | 0 |
| 2 | Lendra (Strawn) | 39,360 | 285,900 | 0 | 0 | 39,360 | 285,900 | 0 | 0 |
| | Travis (Strawn) | 87,360 | 176,949 | 0 | 0 | 87,360 | 176,949 | 0 | 0 |
| | Travis (Strawn 3300) | 386,000 | 127,750 | 0 | 0 | 386,000 | 127,750 | 0 | 0 |
| | County regular | 50,232 | 43,767 | 0 | 0 | 50,232 | 27,342 | 0 | 16,425 |
| | Area Total | 562,952 | 634,366 | 0 | 0 | 562,952 | 617,941 | 0 | 16,425 |
| 3 | Miller Creek | 10,950 | 13,140 | 0 | 0 | 10,950 | 13,140 | 0 | 0 |
| | Area Total | 10,950 | 13,140 | 0 | 0 | 10,950 | 13,140 | 0 | 0 |
| 4 | Tier (Strawn) | 94,840 | 224,723 | 0 | 0 | 94,840 | 224,723 | 0 | 0 |
| | County regular | 45,140 | 78,770 | 0 | 0 | 45,140 | 78,770 | 0 | 0 |
| | Area Total | 139,980 | 303,493 | 0 | 0 | 139,980 | 303,493 | 0 | 0 |
| 5 | County regular | 549,325 | 0 | 0 | 0 | 549,325 | 0 | 0 | 0 |
| | Area Total | 549,325 | 0 | 0 | 0 | 549,325 | 0 | 0 | 0 |
| 6 | Curtis (upper Caddo) | 953 | 697 | 953 | 697 | 0 | 0 | 0 | 0 |
| | King | 3,650 | 0 | 3,650 | 0 | 0 | 0 | 0 | 0 |
| | King (upper Caddo) | 1,394 | 511 | 1,394 | 511 | 0 | 0 | 0 | 0 |
| | Area Total | 5,997 | 1,208 | 5,997 | 1,208 | 0 | 0 | 0 | 0 |
| 7 | County regular | 3,650 | 0 | 3,650 | 0 | 0 | 0 | 0 | 0 |
| | Area Total | 3,650 | 0 | 3,650 | 0 | 0 | 0 | 0 | 0 |
| 8 | Oinks (Strawn) | 44,975 | 0 | 0 | 0 | 44,975 | 0 | 0 | 0 |
| | Oinks (lower Strawn) | 48,475 | 28,683 | 0 | 0 | 48,475 | 28,683 | 0 | 0 |
| | P.C.S.L. (Mississippian) | 3,650 | 4,380 | 3,650 | 0 | 0 | 4,380 | 0 | 0 |
| | County regular | 155,950 | 108,503 | 0 | 0 | 155,950 | 108,503 | 0 | 0 |
| | Area Total | 253,050 | 141,566 | 3,650 | 0 | 249,400 | 141,566 | 0 | 0 |
| 9 | Elbert (lower Strawn) | 27,281 | 41,990 | 1,000 | 0 | 26,281 | 41,990 | 0 | 0 |
| | County regular | 0 | 36,500 | 0 | 0 | 0 | 36,500 | 0 | 0 |
| | Area Total | 27,281 | 78,490 | 1,000 | 0 | 26,281 | 78,490 | 0 | 0 |
| 10 | Bryle Northwest (lower Caddo) | 0 | 730 | 0 | 0 | 0 | 730 | 0 | 0 |
| | Swenson 170 (lower Caddo) | 7,300 | 3,554 | 7,300 | 0 | 0 | 3,554 | 0 | 0 |
| | Swenson 170 (upper Caddo) | 18,250 | 3,567 | 18,250 | 0 | 0 | 3,567 | 0 | 0 |
| | Tom (Caddo 4765 feet) | 0 | 45,600 | 0 | 0 | 0 | 0 | 0 | 45,600 |
| | Valda (Caddo) | 176,295 | 147,355 | 0 | 0 | 176,295 | 147,355 | 0 | 0 |
| | County regular | 0 | 3,237 | 0 | 0 | 0 | 3,237 | 0 | 0 |
| | Area Total | 201,845 | 204,043 | 25,550 | | 176,295 | 158,443 | -- | 45,600 |
| 11 | Bessie | 15,000 | 0 | 15,000 | 0 | 0 | 0 | 0 | 0 |
| | Kelton (Strawn) | 75,607 | 295,415 | 3,607 | 0 | 72,000 | 295,415 | 0 | 0 |
| | Manning-Harrington (Caddo) | 5,110 | 0 | 0 | 0 | 5,110 | 0 | 0 | 0 |
| | Manning-Harrington (Strawn) | 1,461,998 | 0 | 0 | 0 | 1,461,998 | 0 | 0 | 0 |
| | Mills (Caddo) | 15,750 | 36,000 | 15,000 | 0 | 750 | 36,000 | 0 | 0 |
| | Mills (Strawn 3550) | 0 | 5,400 | 0 | 0 | 0 | 5,400 | 0 | 0 |
| | Throckmorton (Caddo) | 0 | 96,867 | 0 | 0 | 0 | 96,867 | 0 | 0 |
| | Throckmorton (basal Canyon) | 0 | 53,122 | 0 | 0 | 0 | 53,122 | 0 | 0 |
| | Throckmorton north (Caddo) | 87,600 | 0 | 0 | 0 | 87,600 | 0 | 0 | 0 |
| | Throckmorton north (basal Canyon) | 109,500 | 0 | 0 | 0 | 109,500 | 0 | 0 | 0 |
| | WRW (Caddo 4650) | 0 | 0 | 0 | 0 | 0 | 4,000 | 0 | 0 |
| | County regular | 88,330 | 115,000 | 5,475 | 0 | 82,855 | 115,000 | 0 | 0 |
| | Area Total | 1,858,895 | 605,804 | 39,082 | 0 | 1,819,813 | 605,804 | 0 | 0 |
| 12 | Bachman (Caddo) | 72,000 | 0 | 0 | 0 | 72,000 | 0 | 0 | 0 |
| | Bachman East (Caddo) | 38,175 | 14,600 | 7,300 | 0 | 30,875 | 14,600 | 0 | 0 |
| | Bachman East (Caddo M.) | 18,250 | 0 | 0 | 0 | 18,250 | 0 | 0 | 0 |
| | Bachman East (Conglomerate) | 11,370 | 0 | 0 | 0 | 11,370 | 0 | 0 | 0 |
| | Bachman East (Mississippian) | 40,150 | 0 | 0 | 0 | 40,150 | 0 | 0 | 0 |
| | Bruton (Caddo 4150 feet) | 0 | 15,000 | 0 | 0 | 0 | 15,000 | 0 | 0 |
| | C. G. G. (Conglomerate) | 1,200 | 0 | 1,200 | 0 | 0 | 0 | 0 | 0 |
| | C. G. G. (lower Conglomerate) | 7,300 | 0 | 0 | 0 | 7,300 | 0 | 0 | 0 |
| | Ewalt | 43,800 | 0 | 0 | 0 | 43,800 | 0 | 0 | 0 |
| | Ewalt North (Marble Falls) | 20,805 | 0 | 0 | 0 | 20,805 | 0 | 0 | 0 |
| | Ewalt South (Caddo) | 31,755 | 34,000 | 0 | 0 | 31,755 | 34,000 | 0 | 0 |
| | PM (Caddo) | 7,070 | 0 | 0 | 0 | 7,070 | 0 | 0 | 0 |
| | Sunwood (Caddo) | 54,000 | 0 | 0 | 0 | 54,000 | 0 | 0 | 0 |
| | Sunwood (Conglomerate) | 60,590 | 0 | 0 | 0 | 60,590 | 0 | 0 | 0 |
| | Sunwood South (Caddo) | 0 | 1,863 | 0 | 0 | 0 | 1,863 | 0 | 0 |

See footnote at end of table.

Table 6.--Reported Oil-Field Brine Production and Disposal in 1961 and 1967, Throckmorton County--Continued

| AREA SHOWN ON FIGURE 10 | FIELD | BRINE PRODUCTION | | DISPOSAL INTO PITS | | INJECTION INTO WELLS | | MISCELLANEOUS | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1961 | 1967 | 1961 | 1967 | 1961 | 1967 | 1961 | 1967 |
| | Troy (lower Caddo) | 1,200 | 0 | 1,200 | 0 | 0 | 0 | 0 | 0 |
| | Troy (upper Caddo) | 0 | 39,420 | 0 | 0 | 0 | 39,420 | 0 | 0 |
| | Troy (Conglomerate) | 365 | 0 | 365 | 0 | 0 | 0 | 0 | 0 |
| | Troy (lower Conglomerate) | 0 | 3,650 | 0 | 0 | 0 | 3,650 | 0 | 0 |
| | Troy (Mississippian) | 2,500 | 0 | 2,500 | 0 | 0 | 0 | 0 | 0 |
| | County regular | 681,214 | 74,602 | 4,760 | 0 | 673,175 | 72,777 | 3,279 | 1,825 |
| | Area Total | 1,091 744 | 183,135 | 17,325 | 0 | 1,071,140 | 181,310 | 3,279 | 1,825 |
| 13 | County regular | 90 | 3,738 | 90 | 238 | 0 | 3,500 | 0 | 0 |
| | Area Total | 90 | 3,738 | 90 | 238 | 0 | 3,500 | 0 | 0 |
| 14 | Ben Rob (Caddo and Mississippian) | 0 | 62,050 | 0 | 0 | 0 | 62,050 | 0 | 0 |
| | Bohner-Kimbrell (Caddo) | 365 | 102,200 | 365 | 0 | 0 | 102,200 | 0 | 0 |
| | Bryle (lower Caddo) | 32,560 | 0 | 0 | 0 | 32,560 | 0 | 0 | 0 |
| | Bryle (upper and lower Caddo) | 0 | 49,824 | 0 | 0 | 0 | 49,824 | 0 | 0 |
| | Bryle (upper Caddo) | 20,880 | 0 | 0 | 0 | 20,880 | 0 | 0 | 0 |
| | Bryle East (lower Caddo) | 34,400 | 18,250 | 0 | 0 | 34,400 | 18,250 | 0 | 0 |
| | Bryle East (middle Caddo) | 0 | 2,920 | 0 | 0 | 0 | 2,920 | 0 | 0 |
| | Bryle East (upper Caddo) | 36,500 | 43,800 | 0 | 0 | 36,500 | 43,800 | 0 | 0 |
| | Bryle Northeast (upper and lower Caddo) | 0 | 20,075 | 0 | 0 | 0 | 20,075 | 0 | 0 |
| | Bryle South | 7,045 | 0 | 0 | 0 | 7,045 | 0 | 0 | 0 |
| | Bryle South (upper Caddo) | 0 | 29,565 | 0 | 0 | 0 | 29,565 | 0 | 0 |
| | Bryle West (Caddo 4690 feet) | 0 | 7,200 | 0 | 0 | 0 | 7,200 | 0 | 0 |
| | Burk Gregory (Caddo) | 41,975 | 0 | 0 | 0 | 41,975 | 0 | 0 | 0 |
| | C. E. H. (Mississippian) | 0 | 10,000 | 0 | 0 | 0 | 10,000 | 0 | 0 |
| | Curry (Caddo) | 18,550 | 36,500 | 0 | 0 | 18,550 | 36,500 | 0 | 0 |
| | Diane (Conglomerate) | 95 | 0 | 95 | 0 | 0 | 0 | 0 | 0 |
| | County regular | 17,356 | 229,837 | 1,800 | 550 | 15,556 | 228,235 | 0 | 1,052 |
| | Area Total | 209,726 | 612,221 | 2,260 | 550 | 207,466 | 610,619 | 0 | 1,052 |
| 15 | Jumbo (Caddo) | 1,098 | 0 | 0 | 0 | 1,098 | 0 | 0 | 0 |
| | McKnight North (Caddo) | 3,000 | 7,300 | 3,000 | 0 | 0 | 7,300 | 0 | 0 |
| | Throckmorton East (Mississippian) | 3,285 | 0 | 0 | 0 | 3,285 | 0 | 0 | 0 |
| | County regular | 143,530 | 53,350 | 0 | 0 | 143,530 | 53,350 | 0 | 0 |
| | Area Total | 150,913 | 60,650 | 3,000 | | 147,913 | 60,650 | -- | -- |
| 16 | B. C. P. (Caddo) | 5,475 | 5,500 | 5,475 | 0 | 0 | 5,500 | 0 | 0 |
| | Batchler (Caddo) | 0 | 494 | 0 | 0 | 0 | 494 | 0 | 0 |
| | Batchler (lower Caddo) | 1,218 | 0 | 0 | 0 | 1,218 | 0 | 0 | 0 |
| | Batchler (Strawn) | 21,169 | 34,936 | 0 | 0 | 21,169 | 34,936 | 0 | 0 |
| | Bee Cee (lower Caddo) | 10,160 | 0 | 10,160 | 0 | 0 | 0 | 0 | 0 |
| | Bee Cee (upper Caddo) | 31,676 | 27,272 | 12,440 | 3,285 | 19,236 | 23,987 | 0 | 0 |
| | Greathouse (upper Caddo) | 128,665 | 0 | 0 | 0 | 128,665 | 0 | 0 | 0 |
| | Greathouse (Conglomerate) | 10,805 | 17,035 | 0 | 0 | 10,805 | 17,035 | 0 | 0 |
| | Greathouse (Mississippian) | 11,095 | 0 | 0 | 0 | 11,095 | 0 | 0 | 0 |
| | Greathouse North (Conglomerate) | 0 | 5,143 | 0 | 0 | 0 | 5,143 | 0 | 0 |
| | Greathouse Southwest | 96 | 0 | 96 | 0 | 0 | 0 | 0 | 0 |
| | County regular | 19,783 | 17,646 | 15,165 | 0 | 4,618 | 17,646 | 0 | 0 |
| | Area Total | 240,142 | 108,026 | 43,336 | 3,285 | 196,806 | 104,741 | 0 | 0 |
| 17 | Gentry (Caddo) | 16,000 | 0 | 16,000 | 0 | 0 | 0 | 0 | 0 |
| | Gentry (Pennsylvanian) | 182 | 0 | 182 | 0 | 0 | 0 | 0 | 0 |
| | Matthews Ranch (Caddo) | 18,250 | 0 | 18,250 | 0 | 0 | 0 | 0 | 0 |
| | Area Total | 34,432 | 0 | 34,432 | 0 | 0 | 0 | 0 | 0 |
| 18 | Poverty Ridge (Caddo) | 9,125 | 0 | 9,125 | 0 | 0 | 0 | 0 | 0 |
| | Area Total | 9,125 | 0 | 9,125 | 0 | 0 | 0 | 0 | 0 |
| 19 | Bailes | 16,440 | 212,412 | 0 | 0 | 16,440 | 212,412 | 0 | 0 |
| | Condron (Caddo) | 33,580 | 23,000 | 16,425 | 3,000 | 17,155 | 20,000 | 0 | 0 |
| | Condron (Mississippian) | 0 | 225,000 | 0 | 0 | 0 | 225,000 | 0 | 0 |
| | Condron (Palo Pinto) | 365 | 720 | 0 | 0 | 365 | 730 | 0 | 0 |
| | G. B. (Caddo) | 0 | 12,045 | 0 | 0 | 0 | 12,045 | 0 | 0 |
| | G. B. (Strawn) | 30,295 | 5,794 | 4,380 | 0 | 25,915 | 5,794 | 0 | 0 |
| | Gober (Marble Falls) | 86,140 | 7,456 | 1,095 | 0 | 85,045 | 0 | 0 | 7,456 |
| | Leach (Marble Falls) | 29,200 | 14,600 | 29,200 | 0 | 0 | 14,600 | 0 | 0 |
| | Liles (upper Caddo) | 59,005 | 36,000 | 0 | 0 | 59,005 | 36,000 | 0 | 0 |
| | Liles (Marble Falls) | 10,099 | 36,500 | 0 | 0 | 10,099 | 36,500 | 0 | 0 |
| | Lunsford (Caddo) | 18,250 | 0 | 0 | 0 | 18,250 | 0 | 0 | 0 |
| | McKnight (Caddo) | 651,313 | 170,879 | 0 | 0 | 651,313 | 170,879 | 0 | 0 |
| | McKnight (Mississippian) | 2,774 | 0 | 0 | 0 | 2,774 | 0 | 0 | 0 |
| | Mobile (upper Strawn) | 1,800 | 0 | 1,800 | 0 | 0 | 0 | 0 | 0 |

See footnote at end of table.

Table 6.--Reported Oil-Field Brine Production and Disposal in 1961 and 1967, Throckmorton County--Continued

| AREA SHOWN ON FIGURE 10 | FIELD[1/] | BRINE PRODUCTION | | DISPOSAL INTO PITS | | INJECTION INTO WELLS | | MISCELLANEOUS | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1961 | 1967 | 1961 | 1967 | 1961 | 1967 | 1961 | 1967 |
| | Overcash (Caddo) | 9,490 | 3,650 | 9,490 | 0 | 0 | 3,650 | 0 | 0 |
| | Parmenter (upper Caddo) | 7,300 | 21,900 | 0 | 0 | 7,300 | 21,900 | 0 | 0 |
| | Parrot-Atkinson (Mississippian) | 18,250 | 24,820 | 0 | 0 | 18,250 | 24,820 | 0 | 0 |
| | Stephens-Shankle | 14,600 | 0 | 0 | 0 | 14,600 | 0 | 0 | 0 |
| | Wright | 3,660 | 0 | 0 | 0 | 3,660 | 0 | 0 | 0 |
| | County regular | 356,892 | 422,216 | 46,650 | 4,380 | 306,637 | 411,836 | 3,605 | 6,000 |
| | Area Total | 1,349,453 | 1,217,002 | 109,040 | 7,380 | 1,236,808 | 1,196,166 | 3,605 | 13,456 |
| 20 | Greathouse South (Mississippian) | 10,024 | 11,948 | 0 | 0 | 10,024 | 11,948 | 0 | 0 |
| | County regular | 700 | 0 | 0 | 0 | 700 | 0 | 0 | 0 |
| | Area Total | 10,724 | 11,948 | 0 | 0 | 10,724 | 11,948 | 0 | 0 |
| 21 | Jerald Cecil (Caddo) | 3,885 | 13,505 | 3,885 | 0 | 0 | 13,505 | 0 | 0 |
| | Schlittler | 40,635 | 19,384 | 0 | 0 | 40,635 | 19,384 | 0 | 0 |
| | Tuttle | 88,695 | 0 | 0 | 0 | 88,695 | 0 | 0 | 0 |
| | Woodson East (Caddo 4600) | 0 | 6,205 | 0 | 0 | 0 | 6,205 | 0 | 0 |
| | Woodson N. E. (Caddo) | 3,650 | 0 | 3,650 | 0 | 0 | 0 | 0 | 0 |
| | Woodson N. E. (lower Caddo) | 0 | 14,600 | 0 | 0 | 0 | 14,600 | 0 | 0 |
| | County regular | 362,726 | 177,931 | 2,250 | 0 | 360,476 | 177,931 | 0 | 0 |
| | Area Total | 499,591 | 231,625 | 9,785 | 0 | 489,806 | 231,625 | 0 | 0 |
| 22 | Burch (Cook) | 93,685 | 0 | 0 | 0 | 93,685 | 0 | 0 | 0 |
| | County regular | 7,965 | 18,060 | 2,490 | 0 | 5,475 | 18,060 | 0 | 0 |
| | Area Total | 101,650 | 18,060 | 2,490 | 0 | 99,160 | 18,060 | 0 | 0 |
| 23 | County regular | 408 | 131,400 | 408 | 0 | 0 | 131,400 | 0 | 0 |
| | Area Total | 408 | 131,400 | 408 | 0 | 0 | 131,400 | 0 | 0 |
| 24 | County regular | 15,174 | 0 | 6,660 | 0 | 8,514 | 0 | 0 | 0 |
| | Area Total | 15,174 | 0 | 6,660 | 0 | 8,514 | 0 | 0 | 0 |
| 25 | Brown-Harrington (Caddo) | 730 | 0 | 730 | 0 | 0 | 0 | 0 | 0 |
| | Bramlett (Mississippian) | 0 | 128,155 | 0 | 0 | 0 | 128,155 | 0 | 0 |
| | Irwin (Mississippian) | 21,900 | 0 | 0 | 0 | 21,900 | 0 | 0 | 0 |
| | Irwin North (Mississippian) | 7,851 | 0 | 0 | 0 | 7,851 | 0 | 0 | 0 |
| | McKeichan East (Mississippian) | 0 | 18,250 | 0 | 0 | 0 | 18,250 | 0 | 0 |
| | McKeichan (Mississippian) | 30,000 | 0 | 0 | 0 | 30,000 | 0 | 0 | 0 |
| | McKeichan (Strawn) | 19,975 | 36,500 | 12,775 | 0 | 7,200 | 36,500 | 0 | 0 |
| | McKeichan (lower Strawn) | 6,000 | 0 | 0 | 0 | 6,000 | 0 | 0 | 0 |
| | Morrison (Conglomerate) | 68,150 | 0 | 0 | 0 | 68,150 | 0 | 0 | 0 |
| | Murphy (Strawn) | 3,500 | -- | 0 | 0 | 3,500 | 0 | 0 | 0 |
| | Richards Ranch (2800) | 10,950 | -- | 10,950 | 0 | -- | 0 | 0 | 0 |
| | County regular | 947,057 | 1,038,562 | 65,487 | 2,555 | 881,570 | 1,036,007 | 0 | 0 |
| | Area Total | 1,116,113 | 1,221,467 | 89,942 | 2,555 | 1,026,171 | 1,218,912 | 0 | 0 |
| 26 | Florence (Caddo) | 1,460 | 0 | 1,460 | 0 | 0 | 0 | 0 | 0 |
| | Florence (Mississippian) | 73,000 | 0 | 0 | 0 | 73,000 | 0 | 0 | 0 |
| | Herron | 2,900 | 0 | 2,900 | 0 | 0 | 0 | 0 | 0 |
| | County regular | 10,950 | 30,450 | 0 | 0 | 10,950 | 30,450 | 0 | 0 |
| | Area Total | 88,310 | 30,450 | 4,360 | 0 | 83,950 | 30,450 | 0 | 0 |
| 27 | Hughes Odell (Mississippian) | 1,200,091 | 0 | 91 | 0 | 1,200,000 | 0 | 0 | 0 |
| | Mudge-Sloan | 0 | 25,550 | 0 | 0 | 0 | 25,550 | 0 | 0 |
| | Medes (Conglomerate) | 400 | 0 | 400 | 0 | 0 | 0 | 0 | 0 |
| | Nevins Southwest (Gardner) | 0 | 47,450 | 0 | 0 | 0 | 47,450 | 0 | 0 |
| | Sloan (Mississippian) | 12,600 | 73,000 | 0 | 0 | 12,600 | 73,000 | 0 | 0 |
| | County regular | 183,275 | 7,300 | 45 | 0 | 183,230 | 7,300 | 0 | 0 |
| | Area Total | 1,396,366 | 153,300 | 536 | 0 | 1,395,830 | 153,300 | 0 | 0 |
| 28 | Dickie | 328,000 | 0 | 0 | 0 | 328,000 | 0 | 0 | 0 |
| | Dickie (Canyon) | 5,200 | 5,475 | 4,500 | 0 | 700 | 5,475 | 0 | 0 |
| | Dickie (Strawn) | 2,465 | 91 | 2,100 | 0 | 365 | 91 | 0 | 0 |
| | County regular | 74,122 | 78,470 | 390 | 0 | 73,732 | 78,470 | 0 | 0 |
| | Area Total | 409,787 | 84,036 | 6,990 | 0 | 402,797 | 84,036 | 0 | 0 |
| 29 | Malcolm (Mississippian) | 52,750 | 14,600 | 0 | 0 | 52,750 | 14,600 | 0 | 0 |
| | Area Total | 52,750 | 14,600 | 0 | 0 | 52,750 | 14,600 | 0 | 0 |
| 30 | John Anderson (Caddo) | 7,905 | 41,329 | 0 | 0 | 708 | 41,329 | 7,197 | 0 |
| | John Anderson (Mississippian | 41,070 | 965 | 0 | 0 | 37,530 | 965 | 3,540 | 0 |
| | John Anderson South (Mississippian) | 2,028 | 14,700 | 2,028 | 0 | 0 | 14,700 | 0 | 0 |
| | Area Total | 51,003 | 56,994 | 2,028 | 0 | 38,238 | 56,994 | 10,737 | 0 |

See footnote at end of table.

Table 6.--Reported Oil-Field Brine Production and Disposal in 1961 and 1967, Throckmorton County--Continued

| AREA SHOWN ON FIGURE 10 | FIELD[1/] | BRINE PRODUCTION | | DISPOSAL INTO PITS | | INJECTION INTO WELLS | | MISCELLANEOUS | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1961 | 1967 | 1961 | 1967 | 1961 | 1967 | 1961 | 1967 |
| 31 | Higgs (Mississippian) | 11,650 | 21,369 | 0 | 0 | 11,650 | 21,369 | 0 | 0 |
| | County regular | 10,220 | 34,000 | 365 | 0 | 9,855 | 34,000 | 0 | 0 |
| | Area Total | 21,870 | 55,369 | 365 | 0 | 21,505 | 55,369 | 0 | 0 |
| 32 | Dick Scott (Mississippian) | 14,600 | 18,283 | 0 | 0 | 14,600 | 18,283 | 0 | 0 |
| | Wagner (Mississippian) | 0 | 87,600 | 0 | 0 | 0 | 87,600 | 0 | 0 |
| | Woodson-Allison (Mississippian) | 103,660 | 21,685 | 0 | 0 | 103,660 | 21,685 | 0 | 0 |
| | Woodson East (Mississippian) | 42,290 | 30,797 | 0 | 0 | 42,290 | 30,797 | 0 | 0 |
| | County regular | 0 | 21,000 | 0 | 0 | 0 | 21,000 | 0 | 0 |
| | Area Total | 160,550 | 179,365 | 0 | 0 | 160,550 | 179,365 | 0 | 0 |
| | Unlocated county regular | 21,900 | 0 | 0 | 0 | 21,900 | 0 | 0 | 0 |
| | Total | 21,900 | 0 | 0 | 0 | 21,900 | 0 | 0 | 0 |
| | County totals | 10,664,726 | 6,396,766 | 440,081 | 15,216 | 10,207,024 | 6,303,192 | 17,621 | 78,358 |
| | Percent of total | 100 | 100 | 4.1 | 0.2 | 95.7 | 98.6 | 0.2 | 1.2 |

1/ Oil or gas fields as assigned by the Railroad Commission of Texas.

Table 7.--Oil and Gas Tests Selected as Data-Control Points

| WELL | OPERATOR | LEASE AND WELL | SURVEY | DATE |
|---|---|---|---|---|
| 20-41-113 | Bond Oil Corp. | Patti M. Anderson 1 | Allen Hines | Dec. 30, 1963 |
| 57-501 | Cities Service Oil Co. | H. W. Schlittler 1 | Sec. 1648, T.E. & L. Co. | Feb. 24, 1948 |
| 21-46-901 | Perkins Oil Company | Mabel Richards 1 | Sec. 213, B.B.B. & C.R.R. Co. | -- |
| 47-901 | Jim-Lee Drilling Co. | Fred Smith 1 | Sec. 3082, T.E. & L.Co. | Dec. 1, 1953 |
| 48-501 | Deep Rock Oil Corp. | J. R. Cribbs 1 | Sec. 3014, T.E. & L.Co. | May 30, 1950 |
| 53-204 | Cities Service Oil Co. and Sinclair Oil & Gas Co. | SMS Ranch 1-41 | Sec. 41, B.B.B. & C.R.R. Co. | Mar. 7, 1950 |
| 54-101 | Cities Service Oil Co. and Sinclair Prairie Oil Co. | Swenson 99-1 | Sec. 99, B.B.B. & C.R.R. Co. | June 1, 1949 |
| 61-201 | Continental Oil Co. | Ross Sloan "10" 1 | Sec. 10, A.B. & M. | May 11, 1956 |
| 62-201 | Warren Oil Co. | J. T. Davis 1 | Sec. 163, B.B.B. & C.R.R. Co. | Aug. 31, 1948 |
| 63-103 | Cox Drilling Co. | Virginia A. Cochran 1 | Sec. 252, B.B.B. & C.R.R. Co. | May 29, 1952 |
| 601 | Joe K. Bailey and W. A. Lofton, et al. | R. A. Brown 1 | Sec. 921, T.E. & L. Co. | Mar. 3, 1956 |