TEXAS
WATER
DEVELOPMENT
BOARD

REPORT 4

GROUND-WATER RESOURCES OF GONZALES COUNTY, TEXAS

November 1965

Second Printing November 1978
by
Texas Department of Water Resources

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GROUND-WATER RESOURCES OF GONZALES COUNTY, TEXAS

By

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United States Geological Survey

Prepared by the U.S. Geological Survey
in cooperation with the
Texas Water Development Board
Gonzales County Commissioner's Court
and the
Guadalupe-Blanco River Authority

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FOREWORD

On September 1, 1965 the Texas Water Commission (formerly, before February 1962, the State Board of Water Engineers) experienced a far-reaching realignment of functions and personnel, directed toward the increased emphasis needed for planning and developing Texas' water resources and for administering water rights.

Realigned and concentrated in the Texas Water Development Board were the investigative, planning, development, research, financing, and supporting functions, including the reports review and publication functions. The name Texas Water Commission was changed to Texas Water Rights Commission, and responsibility for functions relating to water-rights administration was vested therein.

For the reader's convenience, references in this report have been altered, where necessary, to reflect the current (post September 1, 1965) assignment of responsibility for the function mentioned. In other words credit for a function performed by the Texas Water Commission before the September 1, 1965 realignment generally will be given in this report either to the Water Development Board or to the Water Rights Commission, depending on which agency now has responsibility for that function.

Texas Water Development Board

John J. Vandertulip

John J. Vandertulip
Chief Engineer

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GROUND-WATER RESOURCES OF GONZALES COUNTY, TEXAS

ABSTRACT

Gonzales County, in the West Gulf Coastal Plain of south-central Texas, has an area of 1,058 square miles, and had a population of 17,845 in 1960. The economy depends chiefly on agriculture and, to a smaller extent, on the production of oil and gas.

The principal water-bearing formation in the county is the Carrizo Sand, which yields moderate to large quantities of fresh to slightly saline water throughout a large part of its subsurface extent. Small to moderate quantities of such water are obtained from the Wilcox Group, the Queen City Sand, and the Sparta Sand. Other formations yield only small quantities of water for domestic and livestock use.

All the domestic and public supplies, except for the city of Gonzales, and a large part of the livestock supplies are obtained from ground-water sources. About 10 mgd (million gallons per day) of ground water was pumped in 1962; 0.68 mgd was for municipal supply, and 7.3 mgd was for miscellaneous purposes. Only about 0.1 mgd (120 acre-feet) of water was pumped for irrigation in 1962. Of the ground water pumped in 1962, 8.0 mgd was from the Carrizo Sand.

The yields of wells in Gonzales County ranged from a few gallons a minute to as much as 1,200 gpm (gallons per minute), but yields as large as 2,000 gpm can be expected from properly constructed wells screened in that part of the Carrizo that contains fresh to slightly saline water in most of the northeastern and southwestern parts of the county.

Water from wells in the Carrizo, Queen City, and Sparta Sands is satisfactory for domestic use, stock, public supplies, and most industrial uses; some of the water from the Carrizo Sand is of questionable quality for irrigation.

The Carrizo Sand is, by far, the largest potential source of ground water in the county. Computations indicate that the Carrizo could transmit water at the rate of 170,000 acre-feet per year, assuming that the recharge was adequate. However, this rate probably exceeds the rate of recharge to the aquifer in Gonzales County. It is unlikely that large quantities of water will be developed from the Carrizo Sand because of the great depth to the top of the formation and the doubtful quality of much of the water for irrigation.

The potential ground-water development from the Queen City and Sparta Sands could not be evaluated quantitatively. However, yields up to about 600 gpm might be expected from the Queen City Sand and about 200 gpm from the Sparta Sand.

GROUND-WATER RESOURCES OF GONZALES COUNTY, TEXAS

INTRODUCTION

Location and Extent of Area

Gonzales County is in south-central Texas (Plate 1). It is bordered on the northwest by Guadalupe and Caldwell Counties, on the north by Bastrop County, on the northeast by Fayette County, on the east by Lavaca County, on the southeast by De Witt County, and on the southwest by Karnes and Wilson Counties. Gonzales, the county seat, is about 70 miles east of San Antonio and about 60 miles south-southeast of Austin. Gonzales County has an area of 1,058 square miles.

Purpose and Scope of Investigation

This investigation was a cooperative project of the Texas Water Development Board, Gonzales County Commissioner's Court, the Guadalupe-Blanco River Authority, and the U.S. Geological Survey to determine and describe the ground-water resources of Gonzales County and to present information and data that can be used as a guide to the development of the available ground-water supplies. The results of the investigation are described in this report, which includes an analytical discussion of the occurrence and availability of ground water and tabulations of basic data obtained during the investigation.

Determinations were made of the location and extent of the water-bearing formations, the chemical quality of the water they contain, the quantity of water being withdrawn and the effects of these withdrawals on the water levels, the hydraulic characteristics of the important water-bearing formations, and estimates of the quantities of ground water available for development.

The investigation was made under the immediate supervision of A. G. Winslow, district geologist of the U.S. Geological Survey in charge of ground-water investigations in Texas.

Methods of Investigation

The following items of work were included in the investigation of the ground-water resources of Gonzales County:

1. An inventory was made of 216 water wells, including all public supply, irrigation, and industrial wells, and many of the domestic and stock wells.

Their locations are shown on Plate 1, and drillers' logs of 12 water wells are given in Table 4.

2. The electric logs of 96 oil and gas tests were used for correlation purposes and for a study of the water-bearing properties of the formations. The locations of these tests are shown on Plate 1.

3. An inventory was made of the quantities of ground water used for public supply, irrigation, and industry; estimates were made of the quantities of ground water used for domestic, livestock, and recreational purposes. Also, an inventory was made of the quantity of surface water used for public supply.

4. Pumping tests were made in four wells to determine the hydraulic characteristics of the water-bearing sands.

5. Measurements of water levels were made in wells and compared with available records of past fluctuations of water levels.

6. Climatological records were collected and compiled (Figure 1).

7. Analyses of water collected during this and previous investigations were used to determine the chemical quality of the water (Table 5).

8. A geologic map was compiled from field notes and from maps accompanying published and unpublished reports of geologic or mineral resources investigations in parts of the county (Plate 1).

9. Three geologic sections were made from electric logs (Plates 2-4).

10. A map showing the extent and thickness of the sands containing fresh to slightly saline water in the Carrizo Sand was made from electric-log data and from the chemical analyses of water samples (Figure 10).

11. Maps showing the altitudes of and the approximate depths to the tops of the Carrizo Sand, the Queen City Sand, and the Sparta Sand were made from electric-log data (Figures 2-4, 9, 11, and 12).

12. The hydrologic data were analyzed to determine the quantity and quality of ground water available for development.

13. Problems related to the development of ground-water supplies in Gonzales County were studied.

Acknowledgments

The author is indebted to the property owners in Gonzales County for supplying information about their wells and for permitting access to their properties, to the well drillers for logs and other information on water wells, and to the officials of the cities and towns, industry, and the State and Federal agencies, especially the Soil Conservation Service of the U.S. Department of Agriculture and the Texas State Highway Department. Considerable help was received from Gary Bowman, geologist with Roland K. Blumberg of Seguin, and from D. Hoye Eargle, U.S. Geological Survey. Valuable records used in this report had been collected previously by W. M. Jarrell, formerly an employee of the then (before February 1962) Texas Board of Water Engineers.

Previous Investigations

The first report on ground water in Gonzales County was an inventory of wells and springs by Frazier (1939). Included in this report were chemical analyses of water, drillers' logs, and a map showing the locations of wells and springs. The public water supplies of Gonzales, Nixon, and Waelder were included in an inventory of the public water supplies in southern Texas by Broadhurst, Sundstrom, and Rowley (1950, p. 82-84). A reconnaissance report on the ground-water resources of the Guadalupe River Basin by Alexander, Myers, and Dale (1964) included information on Gonzales County. Basic data from all these previous investigations are included in this report.

Two reports on regional geology (Deussen, 1924; Sellards and others, 1932) include descriptions of the geologic formations in the report area. Geological reports on parts of Gonzales County include those by Renick (1936), Chelf (1942), Eargle (1959a, 1959b), Harris (1961), King (1961), and Moxham and Eargle (1961).

Reports on the ground-water resources of areas adjacent to Gonzales County include the following, by counties: Caldwell (Rasmussen, 1947), Karnes (Anders, 1960), and Wilson (Anders, 1957).

Economic Development

The economy of Gonzales County is based on agriculture. According to the U.S. Census Bureau, the population of the county was 17,845 in 1960, and the populations of the cities and towns were as follows: Gonzales, 5,829; Nixon, 1,751; Waelder, 1,270; Smiley, 455; Cost, 225; Ottine, 200; and Harwood, 132.

Most of the agriculture in Gonzales County is devoted to the raising of livestock and poultry. According to U.S. Census of Agriculture data, 68,005 acres was under cultivation in 1959, which is about 10 percent of the area of the county. In 1962, about 1,200 acres was irrigated with surface water and about 200 acres with water from wells. Most of the water for livestock is obtained from wells; the rest is obtained from small reservoirs and from streamflow. The principal crops include cotton, grain sorghums, peanuts, corn, flax, watermelons, and vegetables. The county was the first in Texas to develop commercial poultry raising on a large scale.

Oil was discovered in Gonzales County in 1902, and the cumulative production to January 1, 1963 was 538,970 barrels, according to records of the Railroad Commission of Texas. The production of oil in 1962 was 84,166 barrels, and the production of natural gas was 5,154 Mcf (thousand cubic feet). Hydrocarbon liquids produced with the gas totaled 105 barrels. The oil reservoirs range in depth from about 1,400 to 12,000 feet. At the Patterson oil field, about 5 miles east of Nixon, oil is produced from the Carrizo Sand at a depth of about 1,400 feet; in other parts of Gonzales County, the Carrizo Sand is a source of fresh ground water.

Other industries include the production of cottonseed oil, clay and clay products, sand and gravel, and electric power at three hydroelectric plants on the Guadalupe River.

Physiography and Drainage

Gonzales County is in the West Gulf Coastal Plain of Texas (Fenneman, 1938, p. 100). In most of the county, the topography ranges from flat to rolling. However, two prominent lines of hills extend across parts of the county--one along the northwestern boundary from Ottine to about 7 miles northwest of Dewville, and the other along the boundary with Lavaca County.

Most of the county lies in the drainage basin of the Guadalupe River, one of the major rivers in Texas. Two small areas in the eastern and southeastern parts of the county are drained by the Colorado River. The Guadalupe River enters the county from the west near Belmont, and flows eastward to the city of Gonzales, where it is joined by the San Marcos River; from there it flows southeastward into De Witt County. The altitude in Gonzales County ranges from 200 feet where the Guadalupe River enters De Witt County to about 600 feet on the divide between the Guadalupe and San Marcos Rivers, about 4 miles north of Belmont. Most of the southern and southwestern parts of the county are drained by Sandies Creek, which flows southeastward and enters the Guadalupe River near Cuero in De Witt County; most of the northern and northeastern parts of the county are drained by Peach Creek, which flows southward, entering the Guadalupe River about 10 miles southeast of Gonzales.

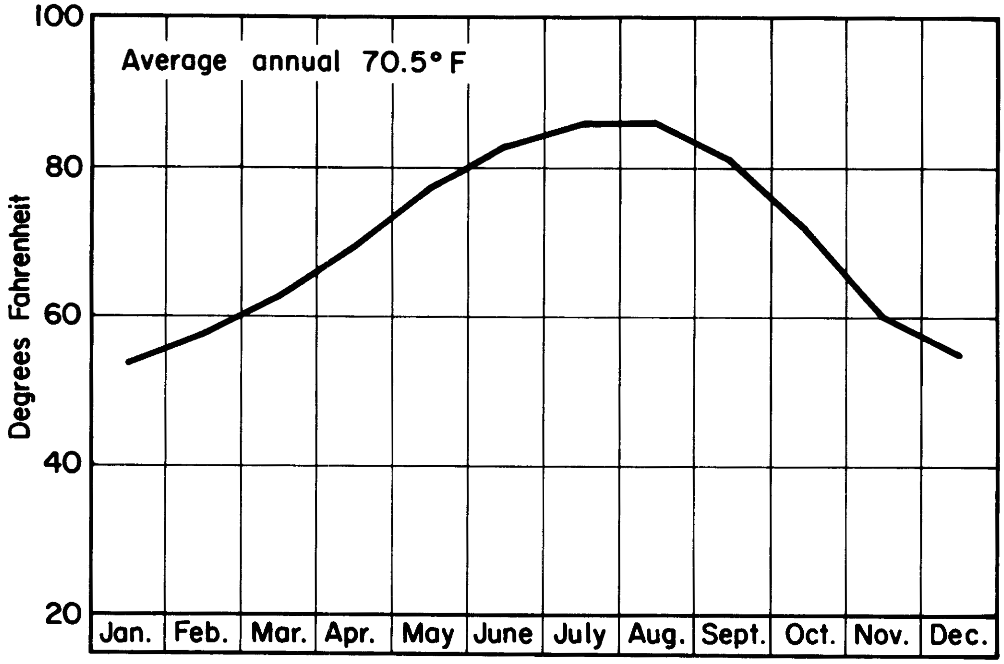
Prominent physiographic features in Gonzales County are the flood plains and terraces along the Guadalupe and San Marcos Rivers (Plate 1). The flood plains and low stream terraces comprise a belt 2 to 5 miles wide along the Guadalupe River southeast of Gonzales and a belt 1 to 2 miles wide along the river west of Gonzales. They are about 1 mile wide along the San Marcos River. The alluvial deposits along both rivers are very fertile farmland, some of which is irrigated with water from the rivers.

Climate

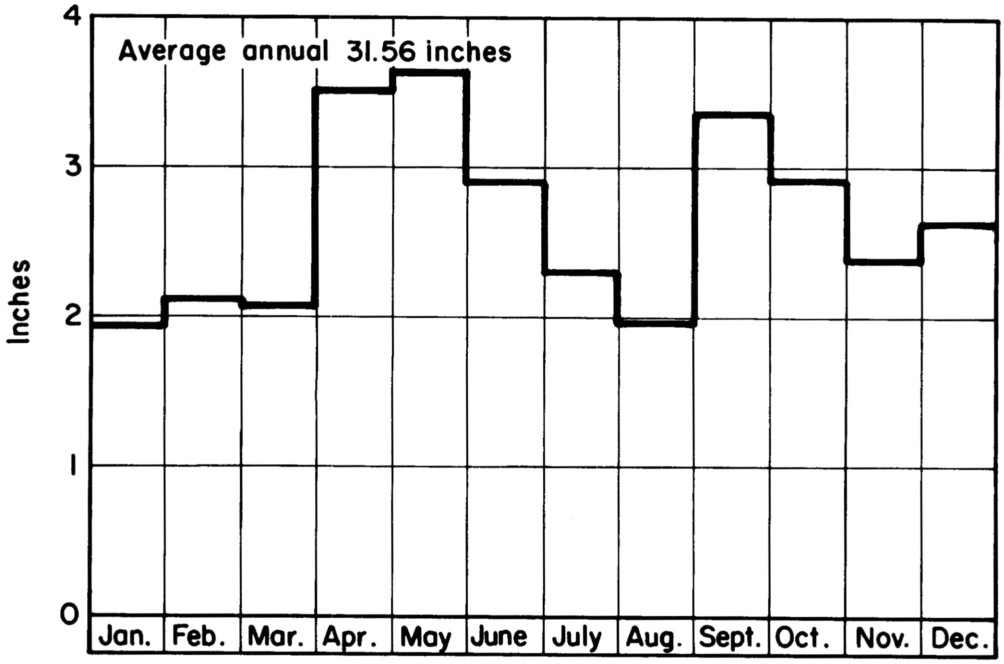
The records of the U.S. Weather Bureau at the city of Gonzales provide the most complete climatological data for the county. The annual precipitation at Gonzales during the period 1910-62 averaged 31.56 inches and ranged from 11.78 inches in 1954 to 54.50 inches in 1919. The average monthly precipitation for the same period was lowest during January, February, March, and August, and highest during April and May (Figure 1). The occasions of far-above average rainfall usually are due to tropical storms during the summer or fall. Records show that 19.94 inches of rain fell during July 1936.

The average annual temperature at Gonzales during the period 1948-62 was 70.5°F. The average monthly temperature for the same period was lowest (54°) during January and December and highest (85.2°) during July and August (Figure 1). The growing season is about 270 days.

Thornthwaite (1952, p. 23-35) classified the climate in the conterminous United States by an index of moisture deficiency or surplus, which was obtained from comparisons of the potential evapotranspiration with the precipitation. When precipitation is the same as potential evapotranspiration and water is available as needed, the climate is neither dry nor moist and is called subhumid. Gonzales County is in the dry subhumid belt (Thornthwaite, fig. 30). Precipitation in Gonzales County usually is sufficient for the growing of crops; consequently, there has been very little development of irrigation.



Average monthly temperature, 1948-62



Average monthly precipitation, 1910-62

Figure 1

Monthly Temperature and Precipitation at Gonzales

(From records of U.S. Weather Bureau)

U.S. Geological Survey in cooperation with the Texas Water Development Board and Others

Well-Numbering System

The well-numbering system used in this report is one accepted by the Texas Water Development Board for use throughout the State and is based on latitude and longitude. Under this system, each 1-degree quadrangle in the State is given a number consisting of two digits. These are the first two digits appearing in the well number. Each 1-degree quadrangle is divided into $7\frac{1}{2}$-minute quadrangles which are also given 2-digit numbers from 01 to 64. These are the third and fourth digits of the well number. Each $7\frac{1}{2}$-minute quadrangle is subdivided into $2\frac{1}{2}$-minute quadrangles and given a single digit number from 1 to 9. This is the fifth digit of the well number. Finally, each well within a $2\frac{1}{2}$-minute quadrangle is given a 2-digit number in the order in which it is inventoried, starting with 01. These are the last two digits of the well number. In addition to the 7-digit well number, a 2-letter prefix is used to identify the county. The prefix for Gonzales County is KR. Thus, Well KR-67-43-903 (which supplies water for the city of Smiley) is in Gonzales County (KR), in the 1-degree quadrangle 67 (the numbers of all the wells in Gonzales County begin with 67), in the $7\frac{1}{2}$-minute quadrangle 43, in the $2\frac{1}{2}$-minute quadrangle 9, and was the third well (03) inventoried in that $2\frac{1}{2}$-minute quadrangle.

On the geologic and well-location map in this report (Plate 1), the $7\frac{1}{2}$-minute quadrangles are shown and numbered in the northwest corner of each quadrangle. The 3-digit number shown with the well symbol contains the number of the $2\frac{1}{2}$-minute quadrangle in which the well is located and the number of the well within that quadrangle. For example, the city of Smiley well is numbered 903 in the quadrangle numbered 6743 in the upper left corner.

Definitions of Terms

In the following sections of the report, certain technical terms or terms subject to different interpretations are used. For convenience and clarification, these terms are defined as follows:

Aquiclude.--A geologic formation, group of formations, or part of a formation which, although porous and capable of absorbing water slowly, will not transmit it fast enough to furnish an appreciable supply for a well or spring.

Aquifer.--A geologic formation, group of formations, or part of a formation that is water bearing.

Artesian water.--Ground water that is under sufficient pressure to rise above the level at which it is found in a well; it does not necessarily rise to or above the surface of the ground.

Permeability, coefficient of.--The rate of flow of water in gallons per day through a cross sectional area of 1 square foot under a unit hydraulic gradient.

Piezometric surface.--The imaginary surface to which water will rise in artesian wells and the surface formed by the water table in the outcrop areas. The terms are synonymous in the outcrop area, but the term piezometric surface alone is applicable to artesian areas.

Resistivity.--That property of a material that characterizes its opposition to the flow of electricity. The resistivity of a water-saturated material is a function of both the texture of the material and the contained fluid and is recorded in ohms per square meter per meter (ohms m^2/m). This is a term that pertains to electric logs of wells.

Specific capacity.--The discharge of a well expressed as the rate of yield per unit of drawdown, generally in gallons per minute per foot of drawdown.

Specific conductance (conductivity).--Specific conductance, which is expressed in micromhos per centimeter at 25°C, is a measure of the ability of a solution to conduct electricity. It is approximately proportional to the content of dissolved solids. Herein, it is used in the description of the quality of water.

Spontaneous potential.--The spontaneous potential curve on electric logs indicates the difference in electrical potential across boundaries of different types of material. Spontaneous potential is recorded in millivolts.

Storage, coefficient of.--The volume of water an aquifer releases from or takes into storage per unit of surface area of the aquifer per unit change in the component of head normal to that surface. Under water-table conditions, the coefficient of storage is practically equal to the specific yield, which is defined as the volume of water released from or taken into storage in response to a change in head attributed partly to compressibility of the water and aquifer material in the saturated zone.

Transmissibility, coefficient of.--The number of gallons of water which will move in 1 day through a vertical strip of the aquifer 1 foot wide and having the height of the aquifer when the hydraulic gradient is unity. It is the product of the field coefficient of permeability (gallons per day per square foot, measured at the prevailing water temperature) and the saturated thickness of the aquifer.

Transmission capacity.--The quantity of water which can be transmitted through a given width of an aquifer at a given hydraulic gradient.

Water level; static level; hydrostatic level.--In an unconfined aquifer, the water level is the distance from the land surface to the water table. In a confined (artesian) aquifer, it is the level to which the water will rise either above or below the land surface.

Water table.--The water table is the upper surface of a zone of saturation except where that surface is formed by an impermeable body.

Yield.--The following ratings apply in general discussion of yields of wells in Gonzales County.

Description	Yield (gallons per minute)
Small	Less than 50
Moderate	50 to 500
Large	More than 500

GEOLOGY AS RELATED TO THE OCCURRENCE OF GROUND WATER

Stratigraphic Units and Their Water-Bearing Properties

The geologic formations discussed in this report range in age from Paleocene to Recent. The thickness, lithology, age, and water-bearing properties of the formations are summarized in Table 1. The areal geology and the locations of selected wells are shown in Plate 1. The structure and thickness of the formations as shown on three geologic sections are based on electric logs of wells (Plates 2, 3, and 4).

The rocks consist mainly of alternating beds of sand and clay or shale, which crop out in belts that trend roughly northeast, parallel to the coast. The oldest stratigraphic unit discussed in this report, the Midway Group, crops out about 20 miles northwest of Gonzales County. Southeast of the Midway outcrop, progressively younger formations are exposed. The formations dip to the southeast at an angle slightly greater than the slope of the land surface, and most of the formations thicken in the same direction.

The rocks in Gonzales County have been cut by many normal faults, most of which are in the southeastern half of the county. The major faults generally trend northeastward, approximately parallel to the strike of the formations. Only a few of the faults are shown on the geologic map (Plate 1), as most of them probably do not significantly affect the occurrence of ground water.

Midway Group

The Midway Group of Paleocene age does not crop out in Gonzales County, but it underlies the entire county at depths ranging from about 1,500 feet in Well KR-67-27-501 (Plate 2) in the northwestern part of the county to about 6,600 feet in Well KR-67-38-701. The Midway consists predominantly of clay and silt with a few lenses of sand, and its thickness in Gonzales County, based on electric logs, ranges from about 700 to 960 feet. The electric logs of oil test wells indicate that the Midway Group contains no fresh to slightly saline water in Gonzales County.

Wilcox Group

Rocks of the Wilcox Group, which unconformably overlie the Midway Group, crop out in a small area in northwestern Gonzales County near Ottine (Plate 1). In the report area, the Wilcox is composed of clay, silt, fine- to medium-grained sand and sandstone, sandy shale, and thin beds of lignite. The thickness of the Wilcox ranges from about 1,300 to 3,200 feet, the maximum thickness occurring in the southeastern part of the county where Hoyt (1959, fig. 1, p. 42) reported about 2,000 feet of shale in an erosional channel. The depth to the top of the Wilcox ranges from 265 feet in Well KR-67-27-501 in the northwestern part of the county to probably more than 5,000 feet in Well KR-67-38-801 in the southeastern part of the county (Plate 2). The Wilcox Group yields small to moderate quantities of fresh to slightly saline water to a few wells in and near the outcrop in the northwestern part of the county. Elsewhere in the county, the Wilcox is not tapped by water wells because fresh to slightly saline water is available in sands at shallower depths. The

Table 1.--Stratigraphic units and their water-bearing properties in Gonzales County

System	Series	Group	Stratigraphic unit	Maximum thickness (feet)	Character of rocks	Water-bearing properties
Quaternary	Recent and Pleistocene		Alluvium	70	Clay, silt, sand, and gravel.	Yields small quantities of fresh water to a large number of wells.
Tertiary(?)	Pliocene(?)		Uvalde(?) Gravel	20	Predominantly flint gravel and cobbles; some limestone boulders.	Not known to yield water.
Tertiary	Miocene		Oakville Sandstone	150±	Fine- to medium-grained sand and sandstone, ashy and sandy clay, and beds of bentonitic clay.	Yields small quantities of fresh water for domestic use and stock.
	Miocene(?)		Catahoula Tuff	200±	Predominantly tuff, tuffaceous clay, sandy clay, bentonitic clay, and lenses of sandstone.	Yields small quantities of fresh to slightly saline water for domestic use and stock.
	Oligocene(?)		Frio Clay	350	Bentonitic clay, sand, and sandy silt.	Not known to yield water to wells.
	Eocene	Jackson		950+	Clay, silt, tuffaceous sand, sandstone, bentonitic clay, and volcanic ash.	Locally yields small quantities of fresh to slightly saline water for domestic use and stock.
		Claiborne	Yegua Formation	1,000	Medium to fine sand, silt, clay, gypsum, and beds of lignite.	Yields small quantities of slightly to moderately saline water for domestic use and stock.
			Cook Mountain Formation	750	Clay and shale containing small amounts of sandstone, limestone, glauconite, and gypsum.	Yields small quantities of fresh to moderately saline water for domestic use and stock.
			Sparta Sand	140	Fine to medium sand with some shale.	Yields small to moderate quantities of fresh to slightly saline water to wells in and near the area of outcrop. Water becomes increasingly saline downdip.
			Weches Greensand	150	Glauconitic shale and sand.	Yields small quantities of slightly to moderately saline water to a few wells.
			Queen City Sand	825	Massive to thin-bedded medium to fine sand, and clay.	Yields small to moderate quantities of fresh to slightly saline water to wells.
			Recklaw Formation	390	Glauconitic sand and silty clay in the lower part of formation and clay and some thin beds of sandstone in the upper part.	Yields small quantities of fresh to slightly saline water from sands in lower part of formation.
			Carrizo Sand	880	Fine to coarse, loose, crossbedded sand, and some thin beds of sandstone and clay.	Principal aquifer. Yields moderate to large quantities of fresh to slightly saline water to wells.
		Wilcox		3,200±	Silt, clay, fine to medium sand, sandstone, sandy shale, and thin beds of lignite.	Yields small to moderate quantities of fresh to slightly saline water to wells in and near the outcrop in northwestern part of county.
	Paleocene	Midway		960	Predominantly clay and silt, occasional lenses of sand.	Electric logs of oil-test wells indicate no fresh to slightly saline water in Gonzales County.

electric logs of oil test wells indicate that much of the water in the Wilcox is too highly mineralized for most purposes.

Claiborne Group

The Claiborne Group includes the Carrizo Sand, the Reklaw Member of the Mount Selman Formation, the Queen City Sand Member of the Mount Selman Formation, the Weches Greensand Member of the Mount Selman Formation, the Sparta Sand, the Cook Mountain Formation, and the Yegua Formation, in ascending order. However, D. H. Eargle (written communication, December 1963) has recommended that the Reklaw, Queen City Sand, and Weches Greensand Members be elevated to the rank of formation. He gave the three following reasons for the change. "The three units formerly considered to be members of the Mount Selman Formation are mapped separately on the Geologic Map of Texas (Darton and others, 1937) for a distance of more than 300 miles from the Texas-Louisiana line, north of the Sabine Uplift in northeast Texas, to the San Antonio River in southeast Texas. Anders (1957) has mapped these units for a few more miles southwestward to the Atascosa-Wilson county line, and it is possible to trace them even farther to the southwest. Also, these distinct lithologic units can be recognized with ease on well logs. They are of similar thickness and extent, as are the Sparta Sand, Yegua Formation, and Carrizo Sand, all considered now to be formations. Further, these units have been regarded as formations by many geologists who have mapped and studied them in detail (Ellisor, 1929; Wendlandt and Knebel, 1929; Plummer, 1932; Stenzel, 1938, 1953)." In accordance with the above, the units are raised to rank of formations in the area of this report.

Carrizo Sand

The Carrizo Sand overlies the Wilcox Group unconformably and crops out in a small area along the west edge of Gonzales County (Plate 1). It underlies the county at progressively greater depths southeastward, the maximum depth to the top of the Carrizo being at least 4,400 feet. Much of the Carrizo in the report area consists of beds of massive, commonly crossbedded coarse sand and some minor amounts of sandstone and clay. In general, the sand is loosely cemented, but in some places on the outcrop the sand is firmly cemented with silica, commonly iron stained.

In the subsurface, the Carrizo ranges in thickness from about 385 feet in Well KR-67-27-601 to about 880 feet in Well KR-67-38-701. Part of the variation of the thickness of the Carrizo is due to its unconformable relation with the Wilcox, and part to the difficulty in differentiating the Carrizo from the sands in the overlying Reklaw Formation and the underlying Wilcox Group in some electric logs. The contact between the Carrizo and Wilcox, shown on the cross sections (Plates 2-4), was placed arbitrarily at or near the base of the massive sand overlying the alternating beds of shale and sand of the Wilcox. Hence, the Carrizo Sand, as used in this report, actually may include a part of the Wilcox or a part of the basal sand of the Reklaw, or both; in any event, it appears to be a hydrologic unit.

The altitude of the top of the Carrizo Sand (Figure 2) ranges from about 300 feet above sea level near the outcrop to more than 4,100 feet below sea level in the southeastern part of the county. The irregularities shown on the top of the Carrizo (Figure 2) are due probably to faulting, though only a few of the faults are shown on the map. The dip of the Carrizo averages nearly 200 feet per mile southeastward.

The Carrizo Sand is the principal water-bearing formation in the county, yielding moderate to large quantities of fresh to slightly saline water to wells, except in an area about 2½ to 5 miles wide along the De Witt and Lavaca county lines and in the vicinity of Gonzales, where the water is too highly mineralized for most uses. In and near the outcrop, the water in the Carrizo is under water-table conditions; downdip the water is under sufficient artesian pressure to cause wells to flow in most places.

Reklaw Formation

The Reklaw Formation conformably overlies the Carrizo Sand, and the dip of the Reklaw is about the same as that of the Carrizo. In Gonzales County, the lower part of the formation consists principally of glauconitic sand, in places thick bedded, and silty clay. This basal sand probably is equivalent to the Newby Glauconitic Sand Member of Stenzel (1938, p. 65-71). The upper part of the Reklaw is composed mainly of clay and silt, although several thin beds of sandstone have been observed in the area of outcrop. The upper part probably correlates with the Marquez Shale Member described by Stenzel (1938, p. 71-78). Where the complete section is present, the Reklaw ranges in thickness from about 200 to 390 feet.

The lower part of the Reklaw yields small quantities of fresh to slightly saline water to wells that tap it at depths of less than 400 feet. No wells are known that obtain water from the upper part.

Queen City Sand

The Queen City Sand overlies the Reklaw Formation conformably and crops out in a northeastward-trending belt about 2 to 4 miles wide (Plate 1). The Queen City is composed of massive to thin-bedded medium to fine sand and clay. On fresh exposure, the Queen City ranges from light gray to orange and brown, but soon weathers to various shades of red, tan, and brown. The thickness of the Queen City ranges from about 400 to 825 feet, where the entire section is present. The dip of the Queen City is southeastward at a fairly uniform rate, ranging from about 150 feet in the northeastern part of the county to about 200 feet in the southwestern part. The top of the Queen City reaches a maximum depth of more than 3,000 feet below sea level near the De Witt county line (Figure 3).

The Queen City Sand yields small to moderate quantities of fresh to slightly saline water to wells in the area of outcrop and downdip for a distance of about 5 to 8 miles (Figure 3). Farther downdip, the Queen City yields water too highly mineralized for most purposes. Yields of as much as 200 gpm (gallons per minute) have been reported; however, where the sands are thick, larger yields may be expected from properly constructed wells.

Weches Greensand

The Weches Greensand conformably overlies the Queen City Sand and crops out in a northeastward-trending belt 1 to 2 miles wide across the county (Plate 1). The Weches consists principally of fossiliferous glauconitic shale and sand. The thickness of the Weches ranges from 0 to 150 feet and averages about 100 feet in Gonzales County. A few wells tapping the Weches yield small quantities of slightly to moderately saline water for stock uses.

Sparta Sand

The Sparta Sand, conformably overlying the Weches Greensand, crops out in a belt about 1 mile wide trending northeastward across the entire county (Plate 1). The Sparta consists of fine- to medium-grained sand with some shale. The thickness of the formation ranges from 0 to about 140 feet and averages about 100 feet in Gonzales County. The dip of the Sparta is southeastward at about 200 feet per mile. The top of the Sparta is penetrated by wells at altitudes ranging from more than 200 feet above sea level near the area of outcrop to more than 2,800 feet below sea level near the De Witt county line (Figure 4).

In the outcrop and for a few miles downdip, the Sparta yields small to moderate quantities of fresh to slightly saline water to wells. The water supplies for Waelder and Cost are obtained from wells tapping the Sparta Sand. The downdip (southeast) limit of fresh to slightly saline water is shown in Figure 4. Downdip from this line, the water becomes increasingly more saline until it is unfit for most uses. A flowing well, KR-67-44-602, about 10 miles downdip from the outcrop, yields very saline water from the Sparta.

Cook Mountain Formation

The Cook Mountain Formation overlies the Sparta Sand and crops out in a belt 2 to 7 miles wide across the central part of Gonzales County (Plate 1). It consists of fossiliferous clay and shale, and contains a few lenses of sandstone and limestone and small amounts of glauconite and gypsum. The thickness of the formation ranges from 0 to about 750 feet. The Cook Mountain yields small quantities of fresh to moderately saline water to a few wells in the county for domestic use and for livestock.

Yegua Formation

The Yegua Formation crops out in a belt about 2 to 6 miles wide across the central part of Gonzales County (Plate 1). It is composed of medium to fine sand, clay, silt, small amounts of gypsum, and beds of lignite. The Yegua has a maximum thickness of about 1,000 feet. In Gonzales County, the Yegua yields small quantities of slightly to moderately saline water for domestic use and for livestock.

Jackson Group

The Jackson Group conformably overlies the Yegua Formation and crops out in a belt 3 to 7 miles wide that is southeast of the adjacent outcrop of the Yegua (Plate 1). The Jackson consists of clay, silt, tuffaceous sand, sandstone, bentonitic clay, and some volcanic ash, and has a maximum thickness in Gonzales County of at least 950 feet and possibly as much as 1,200 feet. At some places in the county, sands in the Jackson yield small quantities of fresh to slightly saline water for domestic use and for livestock.

Frio Clay

The Frio Clay, unconformably overlying the Jackson Group, does not crop out in Gonzales County because it is overlapped by the Catahoula Tuff (Plate 1). The Frio consists of bentonitic clay, sand, and sandy silt. In the southeastern part of Gonzales County near the De Witt county line, the Frio is about 350 feet thick. The Frio Clay is not known to yield water to wells in Gonzales County.

Catahoula Tuff

The Catahoula Tuff overlaps both the Frio Clay and the upper part of the Jackson Group and crops out in Gonzales County in a belt from $\frac{1}{2}$ to $3\frac{1}{2}$ miles wide that roughly parallels the De Witt county line (Plate 1). In this report, the Catahoula Tuff also includes the Catahoula Sandstone, which crops out in the eastern corner of Gonzales County.

In Gonzales County, the Catahoula Tuff consists predominantly of tuff, tuffaceous clay, sandy clay, bentonitic clay, and lenses of sandstone. The thickness of the Catahoula ranges from 0 to about 200 feet. The Catahoula yields small quantities of fresh to slightly saline water to wells in the county for domestic and livestock use; downdip in adjacent counties, it supplies moderate to large quantities of water for public supply and irrigation.

Oakville Sandstone

The Oakville Sandstone overlies the Catahoula Tuff and crops out along the eastern and southeastern boundary lines of Gonzales County (Plate 1). The Oakville consists of fine- to medium-grained sand and sandstone, ashy and sandy clay, and beds of bentonitic clay. Only part of the Oakville is present in Gonzales County, and its thickness in the report area probably does not exceed about 150 feet.

The Oakville Sandstone yields small quantities of fresh water to wells in Gonzales County for domestic and livestock use. Downdip in adjacent counties where the full thickness is present, it yields large quantities of fresh to slightly saline water for irrigation and municipal uses.

Uvalde(?) Gravel

Gravel deposits are present on the high divides and cuestas in much of Gonzales County. The distribution of these deposits is not shown on the geologic map (Plate 1). Near Ottine they are present at an elevation of about 120 feet above the flood plain of the San Marcos River. The Uvalde(?) Gravel consists mostly of gravel, but cobbles are abundant and it contains a number of boulders. The gravels and cobbles are composed of dark-colored flint or quartz, but the boulders are composed of limestone. In general, the gravels are uncemented, although some are slightly cemented and others are firmly cemented. The cementing material generally is calcium carbonate; however, at some places where the gravel deposits overlie formations rich in iron, the cementing material is iron oxide. At most outcrops in Gonzales County, the gravel deposits are less than 5 feet thick; however, the maximum thickness is about 20 feet.

The Uvalde(?) Gravel is used extensively as a road ballast. The formation is not known to yield water to wells in Gonzales County, but at some places it contributes to recharge by retarding runoff.

Alluvium

The flood-plain and alluvial-terrace deposits along the San Marcos and Guadalupe Rivers in Gonzales County are wide (Plate 1) and extensively cultivated. They are composed of sand, silt, clay, and gravel, and range in thickness from 0 to 70 feet; however, the average thickness is about 30 feet. The alluvial deposits yield small quantities of fresh water to a large number of shallow wells in Gonzales County. These supplies, however, are not always dependable during periods of drought.

GROUND-WATER HYDROLOGY

Source and Occurrence of Ground Water

The occurrence of ground water as it applies to Gonzales County is discussed briefly here. The general principles of the occurrence and movement of ground water in all types of rocks have been described by many workers, including Meinzer (1923, p. 2-142), Meinzer and others (1942, p. 385-478), Tolman (1937), Leopold and Langbein (1960), and Baldwin and McGuinness (1963).

The source of ground water is precipitation on the surface of the earth. A large part of the precipitation runs off or is consumed by evapotranspiration, or is stored in the soil later to be evaporated or transpired. A small part of the water infiltrates through the soil and subsoil and moves downward to the water table and becomes recharge. Factors affecting recharge include the intensity and amount of rainfall, the slope of the land surface, the type of soil, the permeability of the aquifer, the quantity of water in the aquifer, and the rate of evapotranspiration.

In the sandy outcrop areas, ground water is unconfined and is said to be under water-table conditions. Downdip from the recharge area, the aquifer may be overlain by less permeable material and the water becomes confined, when it is then said to be under artesian conditions.

Water under artesian conditions will, if not disturbed by man's withdrawals, rise to an elevation equal to its elevation in the recharge area less the loss in head due to friction caused by movement of the water through the aquifer. Where the elevation of the land surface is considerably below the general level of the area of outcrop, the pressure may be sufficient to cause the water to rise a considerable distance in a well or even to flow. Flowing wells are more common at lower altitudes, especially in the valleys of the larger streams.

Ground water moves slowly (tens to hundreds of feet a year) under the influence of gravity from areas of recharge to areas of discharge. It is discharged naturally through springs, by transpiration where the water table is close enough to the surface that it may be reached by the roots of the plants, and by seepage through semiconfining beds or along faults into another aquifer having a lower head, or to the land surface. The artificial discharge is that from flowing or pumped wells. It is described in the following section on the development of ground water.

Development of Ground Water

All the domestic and municipal supplies in Gonzales County (except for the city of Gonzales) and a large part of the livestock supplies are obtained from ground-water sources. Most of the pumpage is from the area between Leesville, Nixon, and Smiley; a small amount is from the vicinity of Ottine. Elsewhere in the county, only minor amounts of water are used.

In 1962, about 10 mgd (million gallons per day) or 11,000 acre-feet of ground water was used in Gonzales County (Table 2). Of this amount, 680,000 gpd (gallons per day), or about 7 percent, was for public supply, and more than 7.3 mgd, or 73 percent, was for miscellaneous purposes, which includes water pumped or allowed to flow into small reservoirs and water from uncontrolled flowing wells. Only small amounts of ground water were used for irrigation in Gonzales County; about 120 acre-feet of water was pumped to irrigate about 200 acres. The rest of the water, about 19 percent, was used for domestic and livestock purposes.

Table 2 shows that 80 percent of the ground water pumped in 1962 was from the Carrizo Sand and less than 10 percent was from the Queen City Sand and Sparta Sand. The rest of the pumpage, or 1.3 mgd, was from the other formations, most of which individually furnished only small amounts of water.

Carrizo Sand

Wells tapping the Carrizo Sand in the vicinity of Nixon and Smiley yielded about 5.1 mgd in 1962, or about 50 percent of the ground water produced in Gonzales County. The town of Nixon used 0.5 mgd, Smiley, 0.03 mgd; the remaining 4.57 mgd was for miscellaneous purposes. Most of the discharge was from flowing wells, but the public supply wells at Nixon and Smiley are equipped with turbine pumps. The depths of 15 flowing wells in the vicinity of Nixon and Smiley ranged from 1,150 to 2,530 feet, and the yields ranged from 5 to 400 gpm.

The discharge of 15 wells tapping the Carrizo Sand in the vicinity of Ottine was about 1.3 mgd in 1962. The depths of the wells ranged from 151 to 600 feet. In 1963, the flows of 10 of these wells ranged from 5 to 180 gpm. In 1962, about 57,000 gpd was pumped for Ottine and the Texas Rehabilitation Center; the remaining 1.24 mgd was used to supply small reservoirs and a fish hatchery.

The discharge of 19 wells tapping the Carrizo in the vicinity of Leesville was about 1.1 mgd in 1962. The depths of the wells ranged from 312 to 872 feet. In 1963, the flows of 13 of these wells ranged from 15 to 170 gpm; the yields

Table 2.--Use of ground water in Gonzales County, 1962

Use	Carrizo Sand		Queen City Sand and Sparta Sand		Other aquifers		Total	
	Mgd	Acre-feet per year	Mgd	Acre-feet per year	Mgd	Acre-feet per year	Mgd	Acre-feet per year
Public supply	0.60	673	0.08	90	--	--	0.68	760
Irrigation	.10	112	--	--	--	--	.10	110
Domestic	.10	112	.30	336	1.00	1,121	1.40	1,600
Livestock	.20	224	.15	168	.30	336	.65	730
Miscellaneous	7.00	7,847	.30	336	--	--	7.30	8,200
Totals*	8.0	9,000	.83	930	1.3	1,500	10	11,000

* Figures are approximate because some of the pumpage was estimated. Totals are rounded to two significant figures.

of the pumped wells ranged from 20 to 1,200 gpm. Most of the water is used to supply small reservoirs and for livestock.

In 1962, about 0.5 mgd was obtained from 24 wells tapping the Carrizo Sand in the areas north, west, and southwest of the city of Gonzales. All the pumped water was for domestic and livestock supplies, except for about 10,000 gpd, which was used to supply water for several families in Harwood. The flows of 19 of the 24 wells ranged from 1 to 1,000 gpm.

In the city of Gonzales, Well KR-67-37-201, which taps the Carrizo Sand, yielded water that was too highly mineralized for municipal use; consequently, the city obtains its water supply from the Guadalupe River. No known supplies of ground water have been developed from the Carrizo Sand in Gonzales County in the areas northeast, east, and southeast of the city of Gonzales, principally because water suitable for domestic and livestock use can be obtained from shallower aquifers.

Queen City Sand and Sparta Sand

In 1962, about 0.83 mgd was obtained from the Queen City Sand or the Sparta Sand in Gonzales County. Although available data are meager, probably more than 400,000 gpd was pumped from the Queen City Sand. Wells KR-67-22-501 and KR-67-22-502, tapping the Sparta Sand, supplied Waelder with about 60,000 gpd. These wells are 510 and 520 feet deep, respectively, and each had a reported yield of about 230 gpm. The community of Cost pumped an average of about 20,000 gpd in 1962 from Well KR-67-36-604, which taps the Sparta Sand. This well is 530 feet deep and had a reported yield of 15 gpm. About 450,000 gpd was pumped for domestic and livestock needs and 300,000 gpd was pumped or allowed to flow into small reservoirs.

Changes in Water Levels

Long-term records of water-level fluctuations in wells in Gonzales County are not available; however, in July 1963, personnel of the then Texas Water Commission measured water levels in 23 selected wells. The same wells will be measured annually by personnel of the Texas Water Development Board as a part of the statewide observation-well program. In 7 of these observation wells, water levels were measured also in 1959, and the changes in water level since that time are shown in the following table.

Well	Geologic source	Depth of well, in feet	Depth to water below or above (+) land-surface datum, in feet		Change, in feet, 1959-63
			1959	1963	
KR-67-19-901	Wilcox Group	230	32.8	36.6	-3.8
27-701	Carrizo Sand	180	14.1	17.3	-3.2
34-803	Queen City Sand	54	44.6	48.4	-3.8
35-701	Carrizo Sand	630	+ 7.5	+ 7.8	+0.3
37-203	do	2,175	+87	+80	-7
43-901	do	2,050	+56	+54	-2
44-201	do	2,190	+90	+83	-7

The changes in water levels since 1959 are due mainly to changes in withdrawal rates, although changes in wells in the outcrop area may reflect changes in the rate of recharge. Most of the wells listed in the table are in the artesian part of the aquifer, and the decline of water levels merely represents a decrease in pressure in the system. The aquifers, for all practical purposes, are still as full of water as they ever were.

The water levels in 10 wells were measured in 1938 and again in 1962. In 4 of these wells, the water levels declined 1.3 to 14.2 feet, and in 6 they rose from 1.1 to 66.1 feet. Little significance can be attributed to these changes in water levels over the 25-year period as no particular trend can be inferred. Actually, the large changes in water levels in some of the wells may be due to changes in the physical condition of the well caused by deepening or by leaking casing. For example, the casing in Well KR-67-35-803, in which the water level has risen 42.6 feet since 1938, reportedly was corroded, and the high water level probably represents a different aquifer from that in which the well was originally completed.

Aquifer Tests

Aquifer tests were made in four wells in Gonzales County to determine the coefficients of transmissibility and storage of the Carrizo Sand, the principal aquifer. The results of these tests are shown in the following table.

Well	Coefficient of transmissibility (gpd/ft)	Coefficient of storage	Interval screened (ft)
KR-67-27-701	47,000	--	118 - 180
35-201	39,000	--	--
401	65,000	--	254 - 732
42-904	40,000	1.6×10^{-4}	1,336 - 1,394

The data from the tests were analyzed by use of the Theis nonequilibrium method as modified by Cooper and Jacob (1946) and the Theis recovery method (Wenzel, 1942). The coefficients of transmissibility determined from the tests in Gonzales County ranged from 39,000 to 65,000 gpd per foot and averaged about 50,000 gpd per foot. The coefficient of storage obtained from the test of Well KR-67-42-904 was 0.00016, which compares reasonably well with the average coefficient of storage (0.00019) as determined in four wells in the Carrizo Sand in Wilson and Atascosa Counties (Anders, 1957, table 3).

The coefficients of transmissibility and storage may be used to predict future drawdown of water levels caused by pumping. Figure 5 shows the theoretical relation between drawdown of water level and distance from the center of pumping for different coefficients of transmissibility. The calculations of drawdown were based on a withdrawal of 1 mgd (million gallons per day) for 1 year from an extensive aquifer having a storage coefficient of 0.0002 and coefficients of transmissibility as shown. The figure shows that the amount of drawdown will increase with the decrease in the coefficient of transmissibility. For example, at a point 5,000 feet from the discharging well, the drawdown will

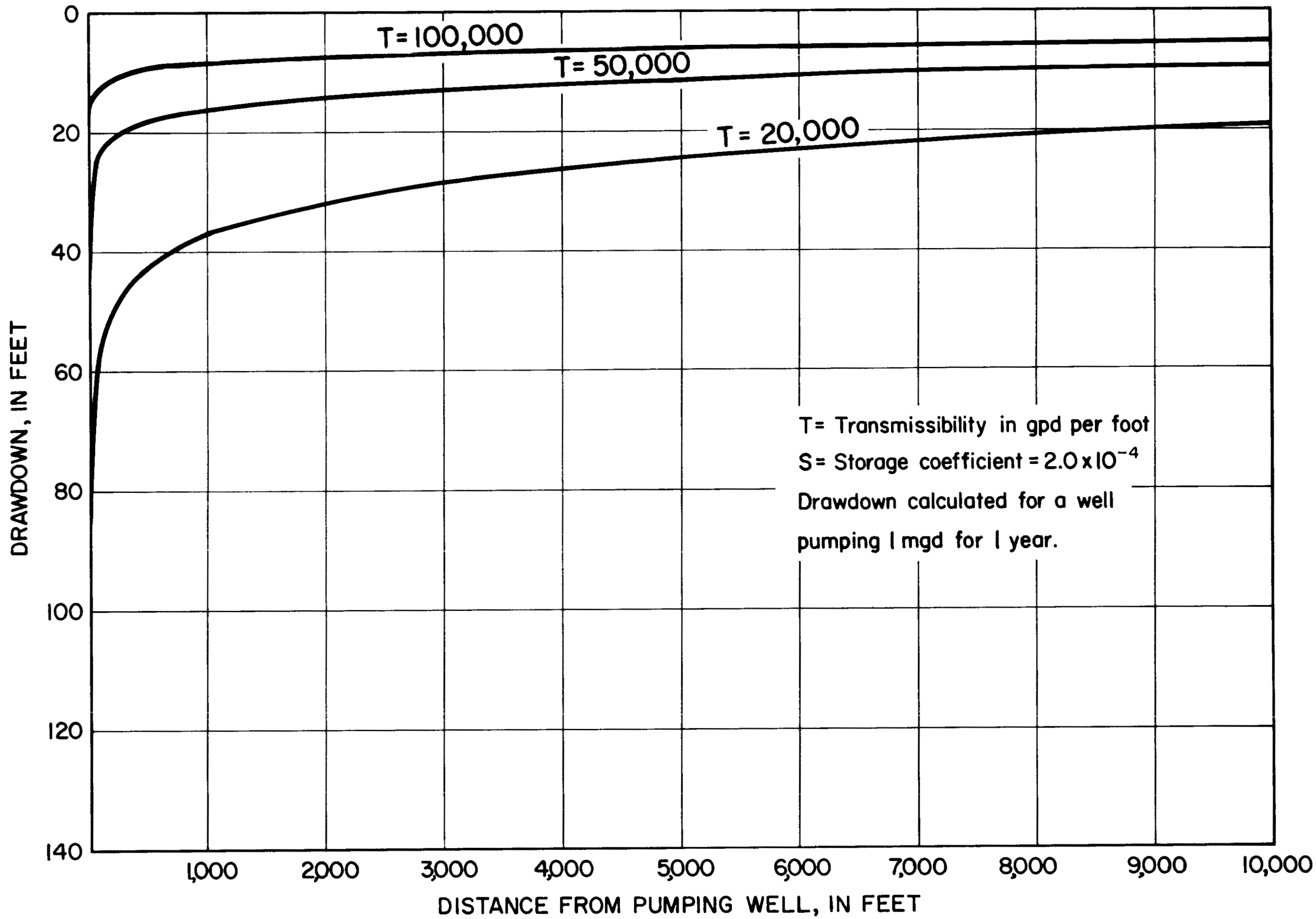


Figure 5

Relation Between Drawdown, Distance, and Transmissibility in an Infinite Aquifer

U.S. Geological Survey in cooperation with the Texas Water Development Board and Others

be 6 feet 1 year after the start of pumping, if the coefficient of transmissibility is 100,000 gpd per foot; 11 feet, if the coefficient of transmissibility is 50,000 gpd per foot; and 24 feet, if the coefficient of transmissibility is 20,000 gpd per foot.

Figure 6 shows the relation between drawdown, distance, and time in a well pumping from an artesian aquifer of infinite areal extent. Pumping is assumed to be at a constant rate of 1,000 gpm, the storage coefficient is 0.0001, and the coefficient of transmissibility is 50,000 gpd per foot. The figure shows that the rate of drawdown decreases with time. For example, at a point 1,000 feet from the pumped well, the drawdown will be 19 feet after 30 days of pumping, 22 feet after 90 days, 25 feet after 1 year, 28 feet after 3 years, and 31 feet after 10 years.

Pumping from wells drilled close together may create cones of depression that intersect, thereby causing additional lowering of the piezometric surface or water table. The intersection of cones of depression, or interference between wells, will result in lower pumping levels (and increased pumping costs) and may cause serious declines in yields of the wells. If the pumping level is lowered below the top of the well screen, that part of the aquifer will become dewatered, and the yield of the well will decrease with the decrease in thickness of the saturated part of the aquifer. The proper spacing of wells to minimize interference can be determined from the aquifer test data.

Construction of Wells

Almost all the water wells in Gonzales County are drilled wells, the few exceptions being those wells about 30 feet deep that were dug in the alluvial deposits along the Guadalupe and San Marcos Rivers. The casings range in diameter from 4 to 16 inches. Casings 4 to 6 inches in diameter are commonly used in wells drilled for domestic and stock supplies; the larger casings are necessary to accommodate the deep-well turbine pumps that supply larger quantities of water for public supply and irrigation needs. In many wells, large-diameter casing is set in the upper part of the well and 4- or 6-inch casing is set in the lower part. In most wells, slotted casings are installed opposite the water-bearing sands, but, in a few wells, screens are used for this purpose, and the wells are gravel packed. A number of unsuccessful oil and gas test wells have been plugged back to the base of the aquifer and completed as water wells by gun-perforating the casing opposite the water-bearing sands.

USE OF SURFACE WATER

Surface water, principally from the Guadalupe River, is used in Gonzales County for public supply, for irrigation, and for the generation of electricity. In order to provide for the equitable distribution and use of the water in the streams of the State, the Texas Water Rights Commission has the authority to issue permits for the diversion of water from streams at specified locations. The point of diversion, the rate of withdrawal, the amounts of land to be irrigated, and, in some cases, the time of year that these withdrawals may be made also are specified by the Commission.

Records of the Texas Water Rights Commission show that 2,100 acre-feet of water a year may be diverted from the Guadalupe River for the irrigation of 1,200 acres in Gonzales County. In 1962, the city of Gonzales pumped

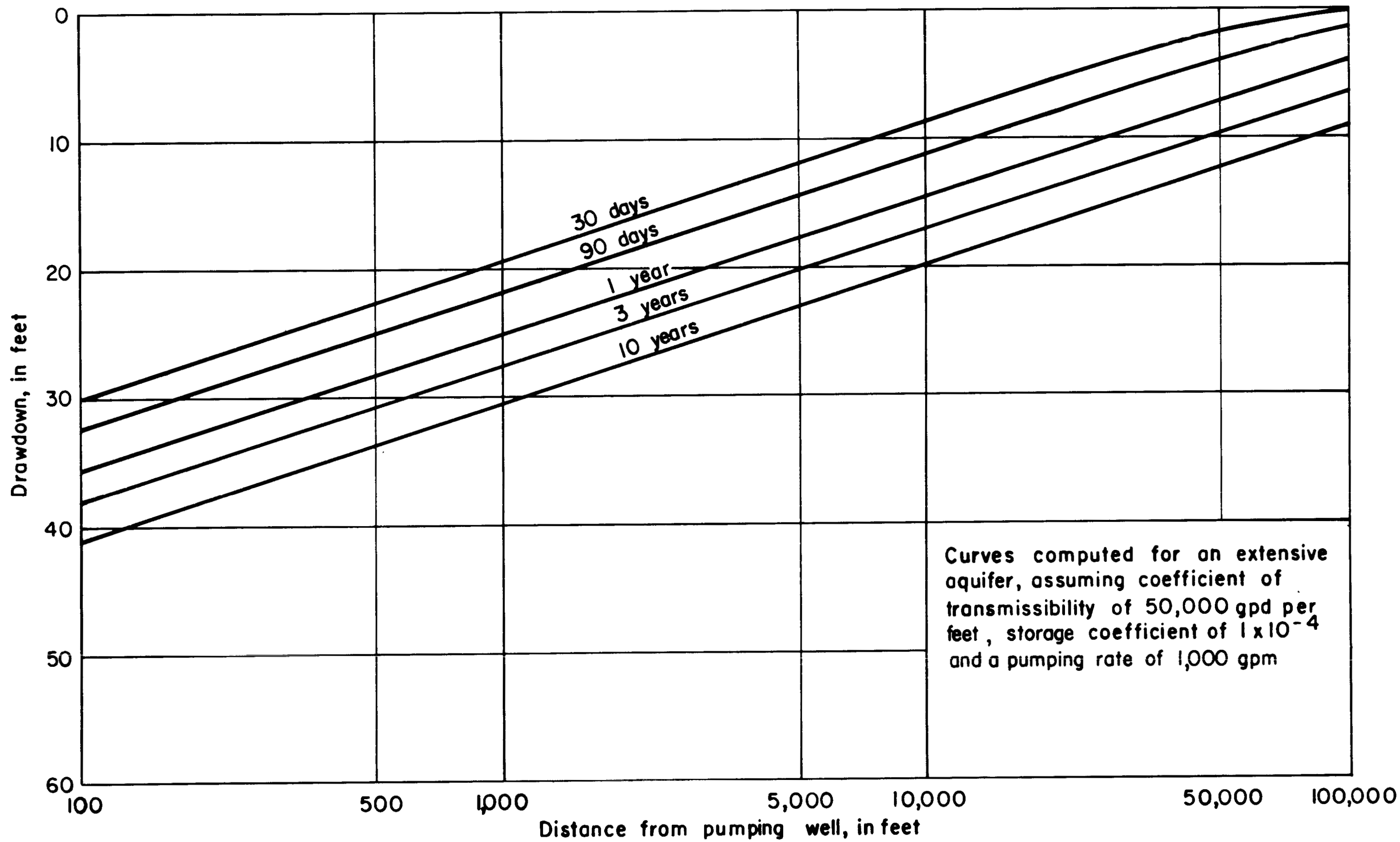


Figure 6

Relation Between Drawdown, Distance, and Time

U.S. Geological Survey in cooperation with the Texas Water Development Board and Others

353,710,000 gallons (1,085 acre-feet) of water from the river. Electricity is generated at three hydro-electric plants on the Guadalupe River in the county. The water used by these plants is not consumed, but remains in the river for use downstream.

QUALITY OF GROUND WATER

The chemical constituents of ground water originate principally from the soil and rocks through which the water moves; most of the differences in the chemical character of the water in Gonzales County therefore reflect the differences in the mineral content of the geologic formations with which the water has been in contact. Generally, the chemical content of ground water increases with depth. The temperature of the water, which near the land surface is generally about the same as the mean air temperature of the region, also increases with depth. Analyses of water from 138 wells in the report area are given in Table 5, and the temperatures of the water samples are given in Table 3.

The major factors that determine the suitability of a water supply are the limitations imposed by the contemplated use of the water. Various criteria of water-quality requirements have been developed, which include bacterial content; physical characteristics, such as temperature, odor, color, and turbidity; and, chemical constituents. Usually, the bacterial content and the undesirable physical properties can be lessened economically, but the removal of undesirable chemical constituents may be difficult and expensive. For many purposes, the dissolved-solids content is a major limitation on the use of the water. A general classification of water based on dissolved-solids content follows (Winslow and Kister, 1956, p. 5):

Description	Dissolved-solids content (parts per million)
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 and periodically revises standards of drinking water to be used on common carriers engaged in interstate commerce. These standards, designed to protect the traveling public, may be used also to evaluate domestic and public water supplies. According to the standards, chemical constituents in a public water supply should not exceed the concentrations listed in the following table, except where other more suitable supplies are not available (U.S. Public Health Service, 1962, p. 7-8).

Substance	Concentration (ppm)
Chloride (Cl)	250
Fluoride (F)	(*)
Iron (Fe)	.3
Manganese (Mn)	.05
Nitrate (NO_3)	45
Sulfate (SO_4)	250
Total dissolved solids	500

*When fluoride is present naturally in drinking water, the concentration should not average more than the appropriate upper limit shown in the following table.

Excessive concentrations of fluoride in water may cause teeth of young children to become mottled. The U.S. Public Health Service (1962, p. 41) states that the optimum fluoride level for a given community depends on climatic conditions because the amount of water (and consequently the amount of fluoride) ingested by children is primarily influenced by air temperature.

Annual average of maximum daily air temperatures (computed for a minimum of 5 years) (°F)	Recommended control limits of fluoride concentrations (ppm)		
	Lower	Optimum	Upper
50.0 - 53.7	0.9	1.2	1.7
53.8 - 58.3	.8	1.1	1.5
58.4 - 63.8	.8	1.0	1.3
63.9 - 70.6	.7	.9	1.2
70.7 - 79.2	.7	.8	1.0
79.3 - 90.5	.6	.7	.8

During the 5-year period 1958-62, the annual average of the maximum daily air temperatures at Gonzales ranged from 80.0 to 84.0°F, and the 5-year average was 81.3°F. Consequently, the recommended control limits of fluoride concentrations in the report area range from 0.6 to 0.8 ppm (parts per million). Of the 102 water samples analyzed for fluoride, 13 contained amounts greater than 0.8 ppm.

Concentrations of nitrate in excess of 45 ppm in water used for infant feeding have been related to the incidence of infant cyanosis (methemoglobinemia, or "blue baby" disease), a reduction of the oxygen content in the blood constituting a form of asphyxia (Maxcy, 1950, p. 271). High concentrations of nitrate may be an indication of pollution from organic matter. Of the 123 water samples analyzed for nitrate, 8 contained amounts of more than 45 ppm.

Excessive concentrations of iron and manganese in water cause reddish-brown or dark-gray precipitates that discolor clothes and stain plumbing fixtures. Iron appears to be a problem in parts of Gonzales County; of 40 iron determinations, 26 were in excess of 0.3 ppm.

Water having a chloride content exceeding 250 ppm may have a salty taste. Such concentrations are common in Gonzales County in the deeper parts of the principal aquifers where the water is slightly or moderately saline, and at shallow depths in some of the less important water-bearing formations.

Sulfate in water in excess of 250 ppm may produce a laxative effect. High concentrations of sulfate are common in much of the slightly and moderately saline water in the report area.

Calcium and magnesium are the principal constituents in water that cause hardness. Excessive hardness causes increased consumption of soap and induces the formation of scale in hot water heaters and pipes. A commonly accepted classification of water hardness is given in the following table:

Hardness range (ppm)	Classification
60 or less	Soft
61 - 120	Moderately hard
121 - 180	Hard
More than 180	Very hard

The hardness as calcium carbonate in 136 water samples ranged from 3 to 1,880 ppm; however, the hardness was less than 60 ppm in samples collected from 19 of 34 wells in the Carrizo Sand, the principal aquifer in the county.

Water used for industry may be classified into three categories--process water, cooling water, and boiler water. Process water is the term used for the water incorporated into or in contact with the manufactured products. The quality requirements for this use may include physical and biological factors in addition to chemical factors. Water for cooling and boiler uses should be noncorrosive and relatively free of scale-forming constituents. The presence of silica in boiler water is undesirable because it forms a hard scale of encrustation, the scale-forming tendency increasing with the pressure in the boiler. The following table shows the maximum suggested concentrations of silica for water used in boilers (Moore, 1940, p. 263):

Concentration of silica (ppm)	Boiler pressure (pounds per square inch)
40	Less than 150
20	150 - 250
5	251 - 400
1	More than 400

The silica content in the water samples from 124 wells in the report area ranged as follows: from 8.8 to 20 ppm in 73 samples, from 21 to 40 ppm in 32 samples, and from 41 to 84 ppm in 19 samples.

Several factors other than the chemical quality are involved in determining the suitability of water for irrigation purposes. The type of soil, adequacy of drainage, crops grown, climatic conditions, and quantity of water used all have important bearing on the continued productivity of irrigated land.

A classification commonly used for judging the quality of a water for irrigation was proposed in 1954 by the U.S. Salinity Laboratory Staff (1954, p. 69-82). The classification is based on the salinity hazard as measured by the electrical conductivity of the water and the sodium hazard as measured by the SAR (sodium-adsorption ratio). The relative importance of the dissolved constituents in irrigation water is dependent upon the degree to which they accumulate in the soil--more of the mineral content of the water will accumulate in tight soils than in more permeable soils under similar conditions. Sodium can be a significant factor in evaluating quality of irrigation water because a high SAR of the water will cause the soil structure to break down by deflocculating the colloidal soil particles. Consequently, the soil can become plastic, thereby lessening the aeration and availability of the water. This is especially true in fine-textured soils. Wilcox (1955, p. 15) states that the system of classification of irrigation waters proposed by the Laboratory Staff "...is not directly applicable to supplemental waters used in areas of relatively high rainfall." He indicates (p. 16) that generally water can be used safely for supplemental irrigation if its conductivity is less than 2,250 micromhos per centimeter at 25°C and its SAR is less than 14. The SAR value and the conductivity of samples from wells tapping the Carrizo Sand and Queen City Sand are shown in Figure 7.

Another factor used in assessing the quality of water for irrigation is the the RSC (residual sodium carbonate) in the water. Excessive RSC will cause the water to be alkaline, and the organic content of the soil will tend to dissolve. The soil becomes a grayish black and the land areas affected are referred to as "black alkali." Wilcox (1955, p. 11) states that laboratory and field studies have resulted in the conclusion that water containing more than 2.5 epm (equivalents per million) RSC is not suitable for irrigation. Water containing from 1.25 to 2.5 epm is marginal, and water containing less than 1.25 epm RSC probably is safe. However, it is believed that good irrigation practices and proper use of soil amendments might make it possible to use the marginal water successfully for irrigation. Furthermore, the degree of leaching will modify the permissible limit to some extent (Wilcox, Blair, and Bower, 1954, p. 265). The RSC exceeded 2.5 epm in 46 samples collected in Gonzales County, the maximum being 26.0 epm.

An excessive boron content will make water unsuitable for irrigation. Wilcox (1955, p. 11) indicates that a boron concentration of as much as 1.0 ppm is permissible for irrigating sensitive crops, as much as 2.0 ppm for semitolerant crops, and as much as 3.0 for tolerant crops. Crops sensitive to boron include most deciduous fruit and nut trees and navy beans; semitolerant crops include most small grains, potatoes, and some other vegetables, and cotton; and tolerant crops include alfalfa, most root vegetables, and the date palm. Boron does not seem to be a significant problem in Gonzales County. Of 17 boron determinations, only 3 were greater than 1 ppm and all were less than 2 ppm.

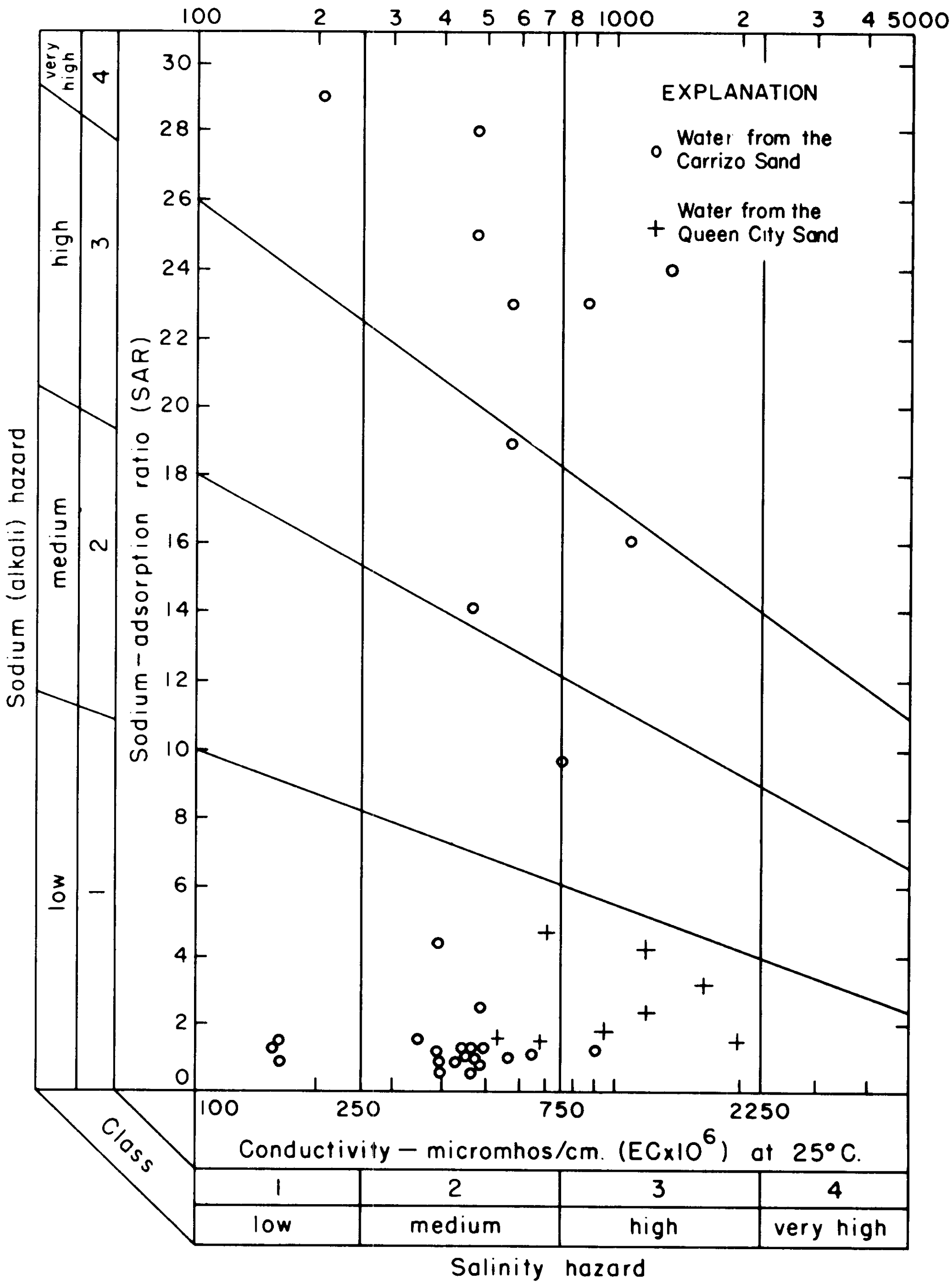


Figure 7

Diagram for the Classification of Irrigation Waters

(After United States Salinity Laboratory Staff, 1954, p. 80)

U.S. Geological Survey in cooperation with the Texas Water Development Board and Others

Nearly all of Gonzales County is underlain by sands containing fresh to slightly saline water and extending to various depths (Figure 8). The base of the fresh to slightly saline water was determined from a study of electric logs and chemical analyses of water samples. The apparent resistivity of sand beds containing slightly saline water based on the long normal and lateral curves is about 10 ohms m^2/m. Figure 8 shows that the base of fresh to slightly saline water extends to a depth of as much as 4,250 feet below sea level in the southwestern part of the county along the line marking the downdip limit of fresh to slightly saline water in the Carrizo Sand. Southward from this line, the base of fresh to slightly saline water shifts upward nearly vertical. In this part of the county, fresh to slightly saline water occurs at a depth ranging from about 200 to more than 600 feet below sea level.

Carrizo Sand

Most of the water from the Carrizo Sand in Gonzales County is suitable for domestic use, livestock, and public supplies, and most industrial uses; its use for irrigation is questionable in some instances. Water from 33 of the 35 wells sampled was fresh (less than 1,000 ppm dissolved solids); samples of water from 2 wells, 1,750 and 2,175 feet deep, KR-67-37-201 and KR-67-37-203 in and near Gonzales, were slightly saline, containing dissolved solids of 1,820 and 2,330 ppm, respectively. The greatest depth from which fresh water was obtained was 2,530 feet in Well KR-67-43-903, which supplies water for the city of Smiley.

In general, the water from the Carrizo Sand is suitable for irrigation. In a few localized areas, however, the water from the Carrizo is of doubtful suitability for irrigation, according to the classification of the U.S. Salinity Laboratory Staff (1954, fig. 11). The SAR of the water from the Carrizo Sand ranged from 0.7 to 103, and the specific conductance ranged from 149 to 3,960 micromhos. Of the 34 samples for which SAR and specific conductance data are available, 30 had SAR values of less than 30 (Figure 7); of these samples, 21 had SAR values less than 14 and specific conductance less than 2,250 micromhos. The RSC in water from 35 wells in the Carrizo Sand ranged from 0.00 to 26.0 epm, and that in 21 samples was less than 2.5 epm.

As mentioned previously, the system of classification of irrigation waters proposed by the Laboratory Staff probably is not directly applicable to Gonzales County where precipitation is fairly high and ground water would be a supplemental supply. Where water from the Carrizo is of questionable suitability for irrigation, such items as the type of soil, local conditions of drainage, the type of crop, the method of application of water, and the economics of the use of soil amendments need to be considered.

Queen City Sand

In Gonzales County, water from the Queen City Sand is used only for domestic and livestock needs. However, 15 of the 18 samples collected from wells tapping the Queen City were fresh water and meet most of the standards for public supply.

Chemical analyses of samples from 8 wells less than 500 feet deep indicate that water to this depth would be suitable for irrigation. In these samples the SAR values ranged from 1.5 to 4.7; conductivities ranged from 553 to 1,950 micromhos; and, RSC values ranged from 0.00 to 1.67. Analyses of water from 7 wells, which range in depth from 500 to 1,150 feet, indicate that water from depths greater than 500 feet would be unsuitable for irrigation. In these samples the SAR values ranged from 28 to 81; conductivities ranged from 751 to 3,350 micromhos; and, RSC values ranged from 3.18 to 10.9.

Sparta Sand

Water from wells tapping the Sparta Sand is used for public supplies at Waelder and Cost and for domestic and livestock needs. Samples were collected from 13 wells that tap the Sparta Sand in Gonzales County. In water from 7 of these wells, the dissolved-solids content ranged from 560 to 1,090 ppm--most of the constituents were within the limits suggested by the Public Health Service for public supplies. Of these 7 wells, the water from 5 (400 to 600 feet deep) was suitable for irrigation, and that from the 2 other wells contained excessive amounts of sodium and bicarbonate. In water from the 6 remaining wells the dissolved-solids content ranged from 1,250 to 11,200 ppm--or from slightly to very saline. The depth of 1 well is 345 feet and the depths of 5 wells range from 500 to 1,200 feet. These analyses indicate that water below the depths of 500 or 600 feet is unsuitable for most uses, but part of the high dissolved-solids content may be contamination from the saline-water sands that overlie the Sparta. The movement of highly mineralized water through corroded casing is possible in four wells that were drilled before 1930. In two of these wells, casing was not set opposite the sands containing slightly to moderately saline water.

Other Formations

Water samples were collected from three wells tapping the Wilcox Group in and near Ottine. Fresh water, suitable for irrigation, was obtained from Well KR-67-19-901, 230 feet deep. Slightly saline water unsuitable for irrigation was obtained from Well KR-67-28-202, 1,548 feet deep, and Well KR-67-28-203, 1,601 feet deep.

Water from 7 wells, 93 to 393 feet deep, tapping the basal sand of the Reklaw Formation was fresh to slightly saline, and contained iron ranging from 1.5 to 67 ppm. The hardness of the water from the wells less than about 200 feet deep ranged from 201 to 1,020 ppm; from a well 250 feet deep it was 115 ppm; and from a well 393 feet deep, which also taps the Carrizo Sand, it was only 58 ppm.

The Weches Greensand is not known to yield fresh water to wells in Gonzales County. Water samples were obtained from Well KR-67-22-402, 32 feet deep, and Well KR-67-35-601, 100 feet deep, were slightly saline, very hard, and unsuitable for most uses. The iron content of one sample was 4.9 ppm.

The geologic formations younger than the Sparta Sand (Table 1) yield only small quantities of water to wells in Gonzales County principally for domestic and livestock use. Water from the Cook Mountain Formation was fresh to moderately saline; from the Yegua Formation, fresh to moderately saline; and, from the Jackson Group, fresh to slightly saline. The Catahoula Tuff, Oakville Sandstone, and the alluvium all yielded fresh water. Shallow wells that tap both the alluvium and underlying formations yielded fresh to moderately saline water.

Temperature of Ground Water

The temperature of ground water near the land surface is generally about the same as the mean air temperature of the region and increases with depth. The mean air temperature in Gonzales County probably is about 70°F. The temperature of the water in the Carrizo Sand ranged from 74°F in Well KR-67-27-701, which is 180 feet deep, to 114°F in Well KR-67-44-402, which is 2,425 feet deep, a gradient of about 1.8°F per 100 feet of depth. The temperature of the water in the Wilcox Group ranged from 72°F in Well KR-67-19-901, which is 230 feet deep, to 101°F in Well KR-67-28-202, which is 1,548 feet deep, a gradient of nearly 2°F per 100 feet of depth.

AVAILABILITY OF GROUND WATER FOR FUTURE DEVELOPMENT

The availability of water for future development from the aquifers in Gonzales County is dependent upon several hydrologic and economic factors. Among the hydrologic factors, the most important are the ability of the aquifers to transmit water, the amount of water in storage, and the rate of recharge to the aquifers. Economic factors include the cost of wells--in some places this factor is very important because of the great depth to the top of the aquifers.

Wilcox Group

The Wilcox Group in Gonzales County is tapped by only a few wells, principally in or near the area of outcrop, due mainly to the presence of the overlying Carrizo Sand, which is capable of yielding the needed quantities of water. Consequently, it is difficult to evaluate quantitatively its potential.

Electric logs of oil tests indicate that the Wilcox contains fresh to slightly saline water in the area of outcrop and downdip to a line that extends roughly from the southwestern corner of the county northeastward to about Gonzales, thence eastward to the county line. Within this area, the thickness of the sands containing fresh to slightly saline water ranges over rather wide limits within a short distance. Available data indicate that the saturated sand sand is thickest in the western part of the county where electric logs show as much as 830 feet of sand containing fresh to slightly saline water about 8 miles miles northeast of Nixon. In this part of the county, the saturated sand thickness probably averages about 250 feet; in the eastern part of the county where few data are available, the sand thickness may be somewhat less.

On this basis, the Wilcox Group seemingly is capable of furnishing considerably larger quantities of water than are now being produced from it.

Carrizo Sand

The Carrizo Sand is the principal source for the development of ground water in Gonzales County. Figure 9 shows the downdip limit of fresh to slightly saline water in the Carrizo Sand and the approximate depth to the top of the aquifer. This depth is about 1,800 feet in the vicinity of Gonzales, in the central part of the county, and as much as 3,800 feet in the southwestern part of the county. The thickness of the sands in the Carrizo that contain fresh to slightly saline water is shown in Figure 10. The saturated thickness is slightly more than 900 feet in the vicinity of Waelder and about 800 feet in the Nixon-Smiley area. Between these two areas, the thickness decreases rapidly until it is less than 100 feet at Gonzales. The map also shows in a general way, by the thickness of these sands, those parts of the county where the largest yields may be expected. From a study of Figure 10 and of the performance of wells that tap the Carrizo in the county, it is believed likely that yields of as much as 2,000 gpm can be obtained from properly constructed wells screened in that part of the Carrizo that contains fresh to slightly saline water in most of the northeastern and southwestern parts of the county.

The Carrizo Sand in Gonzales County contains an estimated 80 million acre-feet of fresh to slightly saline water in storage. This figure itself is not significant, however, because much of the water will not drain freely to wells.

One of the principal factors in determining the amount of water available is the ability of an aquifer to transmit water to wells. In order to estimate the amount of water that may be available from the Carrizo, a set of theoretical computations was made. It was assumed that a line of wells was installed about midway between the center line of the Carrizo outcrop and the downdip limit of fresh to slightly saline water (Figure 10). The line of wells would be about 46 miles long and extend from a point on the southwest county line about 1.4 miles northwest of Nixon, to a point on the northeast county line about 4½ miles northeast of Waelder, and it was assumed that the wells were pumped in such a way that water levels along the line of wells were lowered to 400 feet below the land surface. It was assumed that during the pumping period, no water was recharged to the aquifer except along the centerline of the outcrop area (line of recharge) and that recharge was adequate to keep the altitude of the water levels the same everywhere along the line of recharge. On the basis of the hydraulic gradient that would be established, it was computed that about 170,000 acre-feet of water per year (150 mgd) would be transmitted toward the line of discharge. In addition to this, during the period of lowering of the water levels to 400 feet, about 47,000 acre-feet of water would be released from storage. This indicates that the Carrizo Sand in Gonzales County could be pumped indefinitely at the rate of about 170,000 acre-feet per year; however, this rate probably exceeds the rate of recharge to the aquifer in Gonzales County. It is estimated that at least half of this amount, or 85,000 acre-feet per year, can be supplied by recharge. It should be realized that if the water levels are lowered excessively, the hydraulic gradient at the interface between the slightly and the moderately saline water would be reversed, and ultimately a very slow intrusion of water of higher salinity would occur especially in the southeastern part of the county.

Another problem is the threat of contamination of the water in the Carrizo Sand from saline-water-bearing sands above or below the Carrizo. Wells tapping the Carrizo Sand are cased through the overlying saline-water-bearing sands, and in some of the older wells the casing may corrode opposite these sands, thus permitting entrance of the saline water.

A potential source of contamination of the water in the Carrizo Sand is by the movement of brines from underlying sands through improperly cased oil wells or from improperly plugged oil tests. In recent years, the Texas Water Development Board has made recommendations, to the oil operators, of the depths to which water-bearing formations are to be protected by casing, and the Oil and Gas Division of the Railroad Commission of Texas is responsible for the protection of the water-bearing formations. No contamination of this type has been reported or observed in the county.

It is unlikely that large quantities of water will be developed from the Carrizo Sand in the southeastern part of Gonzales County, chiefly because of the great depth to the top of the formation (Figure 10) and the doubtful quality of much of the water for irrigation.

Queen City Sand

Water from the Queen City Sand is used only for domestic and livestock needs in Gonzales County. Because there are no large-capacity wells tapping this aquifer in the county, it is difficult to evaluate its potential development. Figure 11 shows the downdip limit of fresh to slightly saline water in the Queen City Sand and, by contours, the map shows the approximate depth to the top of the aquifer in Gonzales County. As shown on the map (Figure 11), most of the fresh to slightly saline water occurs where the depth to the top of the aquifer is less than 1,200 feet.

The thickness of the sands containing fresh to slightly saline water in the Queen City varies greatly within short distances. The thickness ranges from 0 at the downdip limit of the extent of fresh to slightly saline water (Figure 3) to a maximum of 290 feet and averages about 130 feet. Based on the sand thickness and the rather limited areal extent of fresh to slightly saline water, the quantity of water potentially available in the Queen City is relatively small, considerably less than that from the Carrizo Sand or the Wilcox Group. Wells drilled to the Queen City should be properly cased to prevent the entrance of saline water from the overlying formations.

Sparta Sand

The extent of fresh to slightly saline water in the Sparta Sand and the approximate depth to the top of the aquifer in Gonzales County are shown on Figure 12. The contour lines show that the Sparta contains fresh to slightly saline water in the area of outcrop and for a distance downdip that ranges from about 2 miles southwestward, where the top of the aquifer is less than 300 feet deep, to about 7 miles northeastward, where the top of the aquifer is almost 1,200 feet deep. The thickness of the sands containing fresh to slightly saline water in the Sparta Sand in Gonzales County is about 100 feet.

Data are not sufficient to evaluate quantitatively the potential development of the Sparta Sand. However, on the basis of the performance of the city wells at Waelder, previously discussed, and the generally uniform hydrologic properties of the aquifer, yields of as much as 200 gpm probably can be obtained anywhere within the extent of the fresh to slightly saline water. Wells drilled to the Sparta Sand should be properly cased to prevent the entrance of saline water from the overlying sands.

Other Formations

The geologic formations younger than the Sparta Sand (Table 1) yield only small quantities of water to domestic and livestock wells. With a few exceptions, the quality of the water from these wells ranges from slightly to moderately saline and is not suitable for public supply, industrial, or irrigation use. Data are not available to permit a quantitative appraisal of the potential of these units; however, very little additional development is anticipated because of the low yields of the wells and the generally poor chemical quality of the water.

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Table 4.--Drillers' logs of wells in Gonzales County

Well 67-22-503

Owner: City of Waelder. Driller: --

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	47	47	Rock	2	272
Sand (water)	21	68	Shale and gumbo	10	282
Shale	46	114	Rock	2	284
Rock, hard	1	115	Shale	51	335
Shale	6	121	Rock	2	337
Rock	2	123	Shale and gumbo	14	351
Gumbo	46	169	Rock	2	353
Rock	1	170	Shale and gumbo	2	355
Gumbo	3	173	Rock	1	356
Shale	2	175	Shale and gumbo	13	369
Gumbo	17	192	Coal	8	377
Rock	2	194	Shale	20	397
Shale	6	200	Gumbo	25	422
Shale and rock	7	207	Shale	24	446
Rock, hard	5	212	Sand (water)	47	493
Shale	3	215	Gumbo	6	499
Rock, hard	1	216	Sand	21	520
Shale and gumbo	33	249	Sand and rock	33	553
Rock	1	250	Gumbo	15	568
Shale and gumbo	7	257	Rock	2	570
Rock	1	258	Gumbo	4	574
Shale	12	270	Rock	1	575

(Continued on next page)

Well 67-22-503--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Shale and soapstone	39	614	Sand	30	680
Sand	24	638	Rock, sandy	2	682
Shale, sandy	12	650	Sand (water)	28	710

Well 67-27-701

Owner: W. B. Soefje. Driller: J. Malatek.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Surface soil	4	4	Gravel	11	60
Gumbo	41	45	Sand	120	180
Soil, sandy	4	49			

Well 67-28-203

Owner: Texas Elk's Childrens Hospital. Driller: Layne-Texas Co.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil and gravel	4	4	Sand, hard	4	792
Clay, sandy, and gravel	50	54	Sand	14	806
Sand and sandy clay	78	132	Shale and sandy shale	170	976
Rock, sandy	3	135	Sand, hard	3	979
Shale, sandy	8	143	Shale	14	993
Sand	112	255	Shale and sand	57	1,050
Shale, sandy	12	267	Sand	35	1,085
Sand	55	322	Shale and sandy shale	50	1,135
Shale, sandy	162	484	Shale	35	1,170
Sand and shale, hard	30	514	Sand, shale breaks	365	1,535
Sand	146	660	Sand	44	1,579
Shale, sand breaks	85	745	Shale	22	1,601
Shale	43	788			

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

Well 67-29-101

Owner: M. C. Butcher. Driller: M. H. Hanson.

Clay and rock	40	40	Shale, hard, sandy with shell	120	500
Clay	20	60	Shale, sandy with sand streaks	150	650
Shale	80	140	Rock	2	652
Sand	50	190	Sand with hard streaks	8	660
Shale	80	270	Sand	75	735
Shale and shell	70	340	Shale, sandy	5	740
Sand	40	380			

Well 67-31-701

Owner: Houston Munson, Jr. Driller: John Maresh.

Surface soil	10	10	Rock	10	90
Clay, white	10	20	Sand	30	120
Shale, light blue	60	80			

Well 67-35-401

Owner: Quien Sabe Ranch. Driller: R. McCollough.

Surface soil	3	3	Rock	2	147
Gravel and clay	33	36	Sand and rock	73	220
Rock, hard	2	38	Shale and lignite	11	231
Shale and rock, sandy	26	64	Sand	49	280
Rock	12	76	Shale, hard, sandy lignite	14	294
Shale, sandy	18	94	Shale and sand streaks	31	325
Shale, sticky	8	102	Sand, coarse (water)	27	352
Sand, hard, and rock	43	145	Sand, hard	36	388

(Continued on next page)

Well 67-35-401--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand, shale and lignite----	27	415	Sand, fine, and gravel-----	71	647
Lignite--------------------	4	419	Shale----------------------	4	651
Sand, coarse, loose--------	110	529	Sand, coarse (water)-------	17	668
Sand, hard, boulders-------	43	572	Rock-----------------------	2	670
Sand, hard, and rocks------	4	576	Sand, coarse (water)-------	62	732

Well 67-35-802

Owner: Lloyd Cook. Driller: A. R. Thierry.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Surface sand---------------	4	4	Shale, brown---------------	2	400
Clay, red------------------	36	40	Shale, sandy---------------	190	590
Shale, sandy---------------	120	160	Shale, hard, brown---------	91	681
Sand, black----------------	38	198	Shale, soft, white---------	109	790
Shale, brown---------------	66	264	Shale, hard, brown---------	30	820
Sand, brown----------------	46	310	Sand, white----------------	80	900
Rock-----------------------	5	315	Rock, hard-----------------	12	912
Shale and rock-------------	83	398	Sand-----------------------	88	1,000

Well 67-37-201

Owner: City of Gonzales. Driller: Layne-Texas Co.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil and clay--------------	10	10	Clay, blue, tough----------	44	178
Sand, coarse---------------	9	19	Clay, blue and shale-------	22	200
Shale and clay-------------	43	62	Sand and shale-------------	23	223
Clay, blue, and shale layers------------------	49	111	Clay, blue, and shale------	66	289
Clay-----------------------	23	134	Rock-----------------------	1	290

(Continued on next page)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well 67-37-201--Continued					
Shale, blue, and clay	186	476	Shale	44	1,532
Sand	64	540	Rock	1	1,533
Shale and clay	10	550	Shale	21	1,554
Shale	60	610	Rock	1	1,555
Shale, hard, sandy	27	637	Shale	7	1,562
Shale, soft	16	653	Rock	1	1,563
Rock	1	654	Shale	89	1,652
Shale, soft	115	769	Gumbo	9	1,661
Rock	2	771	Sand	87	1,748
Shale, hard	97	868	Shale, sandy and shale	47	1,795
Gumbo	2	870	Sand, broken	32	1,827
Shale, sandy	159	1,029	Shale	13	1,840
Rock	1	1,030	Sand	79	1,919
Shale, hard layers	5	1,035	Shale	2	1,921
Shale, sandy	167	1,202	Sand	1	1,922
Shale, hard	37	1,239	Shale	2	1,924
Rock	1	1,240	Sand	17	1,941
Shale, hard layers	40	1,280	Shale	5	1,946
Shale, soft	51	1,331	Sand	22	1,968
Shale, hard layers	21	1,352	Shale	18	1,986
Shale, soft	54	1,406	Sand	40	2,026
Sand, blue	49	1,455	Shale	5	2,031
Sand	31	1,486	Shale and sand	28	2,059
Rock	2	1,488	Shale	14	2,073

(Continued on next page)

Table 4.--Drillers' logs of wells in Gonzales County--Continued

Well 67-37-201--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Shale, sandy	56	2,129	Shale, sandy	83	2,299
Sand	20	2,149	Sand, broken	31	2,330
Shale	49	2,198	Sand	40	2,370
Rock	1	2,199	Rock	2	2,372
Shale	8	2,207	Shale	30	2,402
Rock	2	2,209	Shale, sandy	7	2,409
Shale, hard	7	2,216			

Well 67-42-905

Owner: A. C. Lowe. Driller: A. R. Thierry.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Surface soil	5	5	Rock	1	392
Clay	51	56	Shale	24	416
Rock	2	58	Sand, shells and shale	22	438
Shale, sandy	57	115	Shale, sandy	60	498
Rock	1	116	Rock	2	500
Shale	82	198	Shale and sand	21	521
Sand	38	236	Shale	22	543
Shale, sandy	25	261	Shale, sandy	42	585
Rock	1	262	Sand	45	630
Shale	52	314	Shale, sandy	35	665
Shale, sandy	17	331	Rock	2	667
Sand and shale	41	372	Sand	53	720
Rock	3	375	Shale, sandy, hard streaks	45	765
Shale	16	391	Shale, sticky	22	787

(Continued on next page)

Well 67-42-905--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Shale with lime	48	835	Sand	45	1,226
Shale, hard	154	989	Shale, hard	45	1,271
Rock, brown	1	990	Sand	54	1,325
Shale, hard	79	1,069	Shale	47	1,372
Shale and sand streaks	89	1,158	Sand	153	1,525
Sand, hard	23	1,181			

Well 67-43-401

Owner: Edgar Mercier. Driller: A. R. Thierry.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand	4	4	Shale	71	361
Clay, red	22	26	Rock	3	364
Sand	36	62	Shale, hard	32	396
Shale	50	112	Sand	43	439
Rock	2	114	Shale, sticky	32	471
Shale, hard	72	186	Sand	68	539
Shale, sandy	55	241	Rock, hard	1	540
Sand	49	290			

Well 67-43-601

Owner: Hubert Chandler. Driller: A. R. Thierry.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Gumbo and rock, hard	513	513	Shale, sandy	14	730
Shale, sandy, and rock	67	580	Shale, hard	10	740
Rock	3	583	Shale, sandy	41	781
Shale	45	628	Sand, green	45	826
Shale, hard and rock	88	716	Sand and rock	20	846

(Continued on next page)

Well 67-43-601--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Shale, hard, sticky	23	869	Shale, limy, soft, and sand, white, fine	88	1,383
Shale, hard, sand streaks	71	940	Shale, hard, and sand, fine	22	1,405
Sand, black	50	990	Shale, limy, soft, sand streaks	41	1,446
Shale, hard, sand streaks	15	1,005	Shale and sand, light-brown	43	1,489
Shale, limy, sand streaks	45	1,050	Sand and shale, limy	111	1,600
Sand, fine-grained, white	65	1,115	Sand, coarse-grained in streaks of fine sand	131	1,731
Shale, limy, soft, fine sand, white	67	1,182	Shale and rock	39	1,770
Shale, limy, hard	23	1,205	Sand	113	1,883
Shale, limy	90	1,295			

Well 67-51-102

Owner: Jack Wheat. Driller: A. R. Thierry.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
No record	440	440	Shale, sandy	14	870
Shale	58	498	Sand, brown	85	955
Shale, sticky	22	520	Shale, sandy	12	967
Shale, sandy	114	634	Shale, sandy, hard streaks	67	1,034
Shale, hard, rock	21	655	Shale, hard, sand streaks	45	1,079
Sand, hard streaks	45	700	Lime, hard, shale and sand streaks	22	1,101
Shale, hard	20	720	Sand and lime, brown	23	1,124
Shale, sandy	23	743	Shale, sandy	66	1,190
Shale, sticky	22	765	Sand and shells	33	1,223
Shale, sticky, sand streaks	68	833	Shale, hard, and lime	30	1,253
Shale, hard and sand streaks	23	856	Shale, sandy	5	1,258

(Continued on next page)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well 67-51-102--Continued					
Shale, limy, hard sand streaks	31	1,289	Sand, fine-grained, blue and white	45	1,675
Sand, green, hard	22	1,311	Shale, limy, hard	22	1,697
Sand and shale, hard streaks	139	1,450	Shale, limy, soft, sand and shells	90	1,787
Shale, hard, sand stringers	45	1,495	Shale, hard, limy, sticky	53	1,840
Shale, sandy, brown, hard streaks	22	1,517	Sand, brown and white, streaks of shale	260	2,100
Shale, limy, hard, sandy streaks	113	1,630	Sand, white, hard shale streaks	41	2,141
			Sand	84	2,225

Table 5.--Chemical analyses of water from wells in Gonzales County

Analyses given are in parts per million, except specific conductance, pH, percent sodium, sodium-adsorption ratio, and residual sodium carbonate.

Water-bearing unit: Alluvium, Qa; Carrizo Sand, Tc; Catahoula Tuff, Tct; Cook Mountain Formation, Tcm; Jackson Group, Tj; Oakville Sandstone, To; Queen City Sand, Tqc; Reklaw Formation, Tr; Sparta Sand, Ts; Weches Greensand, Tw; Wilcox Group, Twi; Yegua Formation, Ty.

Well	Depth of well (ft)	Date of collection	Water-bearing unit	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)	Specific conductance (micromhos at 25°C)	pH
67-19-901	230	Apr. 26, 1962	Twi	24	3.3	159	50	*75		326	206	200	0.4	1.0	--	875	602	21	1.3	0.00	1,420	7.4
20-607	410	Feb. 6, 1963	Tc	44	.13	36	11	30	8.3	78	84	51	.3	.0	--	311	135	30	1.1	.00	462	6.1
902	200	Apr. 17, 1963	Tr	26	3.2	79	36	*72		270	131	100	.6	.0	--	578	345	31	1.7	.00	949	7.0
903	93	do	Tr	17	1.5	263	89	*110		260	806	143	.1	.0	--	1,560	1,020	19	1.5	.00	2,010	7.2
904	205	do	Tr	28	2.8	68	7.6	*32		148	81	46	.2	.0	--	361	201	26	1.0	.00	543	7.0
21-301	250	Jan. 24, 1963	Tqc	36	14	255	73	*110		152	732	205	.2	.0	--	1,490	936	20	1.6	.00	1,950	6.3
601	190	Jan. 25, 1963	Tqc	19	--	60	22	*55		258	85	42	.1	.0	--	413	240	33	1.5	.00	675	7.1
602	400	Feb. 6, 1963	Tqc	14	--	28	11	*115		242	89	51	.3	.0	--	427	115	68	4.7	1.67	699	7.6
701	328	June 1, 1959	Tc	20	--	76	33	53	9.6	258	113	88	.2	.5	--	520	325	25	1.3	.00	883	7.1
22-201	470	Jan. 25, 1963	Ts	13	--	78	30	*74		222	187	72	.2	.0	--	564	318	34	1.8	.00	899	6.9
301	600	Apr. 27, 1962	Ts	12	1.2	48	17	*318		164	324	288	.2	2.5	--	1,090	190	78	10	.00	1,800	7.1
a/ 302	400	Oct. 5, 1938	Ts	--	--	86	47	*259		183	377	305	--	--	--	1,164	409	--	--	--	--	--
402	32	Jan. 16, 1963	Tw	16	--	273	84	*262		458	458	520	2.7	3.0	--	1,840	1,030	36	3.5	.00	2,910	6.7
501	510	Dec. 20, 1944	Ts	19	.31	49	20	103	16	208	142	91	.1	1.5	--	542	204	50	3.1	.00	894	7.9
		Apr. 22, 1959	Ts	14	--	52	22	125	7.4	200	166	113	.0	2.0	0.04	625	220	54	3.7	.00	1,020	7.4
906	500	Jan. 24, 1963	Ty	9.1	--	28	5.8	*440		266	446	258	.1	2.9	--	1,320	94	91	20	2.28	2,050	7.4
27-701	180	July 3, 1959	Tc	39	--	12	1.9	24	9.4	0	83	34	--	.0	.00	204	38	40	1.7	.00	328	3.3
801	270	May 29, 1959	Tc	12	--	47	6.1	21	9.5	147	43	23	.1	.2	--	242	142	23	.8	.00	406	6.9
803	30?	Feb. 5, 1963	Qa	19	--	93	19	*20		306	41	26	.4	28	--	398	310	12	.5	.00	735	6.9
903	600?	Apr. 24, 1959	Tc	13	--	48	4.4	19	12	128	46	28	.1	.2	--	242	138	21	.7	.00	399	6.9
905	385	May 18, 1962	Tc	14	.05	14	3.7	*157		361	45	34	.4	.0	--	448	50	87	9.7	4.92	746	7.5
28-202	1,548	Apr. 27, 1962	Twi	18	.07	.8	.6	664	2.6	900	150	408	1.4	2.5	1.6	1,690	4	99	144	14.7	2,770	8.2
203	1,601	Apr. 25, 1962	Twi	17	.06	1.0	.5	695	2.6	972	52	470	1.6	2.2	1.6	1,720	4	99	151	15.8	2,940	8.1
204	262	Aug. --, 1957	Tc	26	--	9.2	2.0	*206		228	12	197	.2	.2	--	538	31	94	16	3.12	1,010	7.3
a/ 205	138	Oct. 14, 1938	Tqc	--	---	99	27	*59		220	127	122	--	--	--	542	356	--	--	--	--	--
405	550?	May 7, 1959	Tc	14	--	50	8.3	29	9.3	170	48	31	.1	.0	--	282	159	27	1.0	.00	473	7.2
501	600	Apr. 25, 1962	Tc	17	.02	1.2	.6	*227		550	4.0	28	1.9	.0	--	550	6	99	40	8.90	905	7.7
502	400	do	Tc	16	.09	2.0	1.2	*170		418	2.0	22	1.8	.0	--	426	10	97	23	6.65	702	7.7

See footnotes at end of table.

Table 5.--Chemical analyses of water from wells in Gonzales County--Continued

Well	Depth of well (ft)	Date of collection	Water-bearing unit	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)	Specific conductance (micromhos at 25°C)	pH
67-28-503	385	Apr. 26, 1962	Tc	16	0.08	1.5	0.5	127	3.2	298	16	19	0.7	0.0	0.39	331	6	97	23	4.77	551	7.8
506	350	Mar. 14, 1963	Tc	17	--	1.5	.0	*113		252	17	17	.5	.0	--	297	4	98	25	4.06	474	7.8
a/ 602	91	Oct. 14, 1938	Tc	--	--	172	63	*105		183	269	345	--	--	--	1,044	689	--	--	--	--	--
a/ 702	56	Sept.19, 1938	Tqc	--	--	--	--	--		207	138	62	--	28	--	499	--	--	--	--	--	--
901	600	Apr. 27, 1962	Tqc	15	.22	.8	.2	*322		660	.0	115	.4	.0	--	780	3	100	81	10.8	1,320	8.0
902	764	May 13, 1959	Tc	14	--	1.8	.7	229	2.3	560	.0	26	3.0	.0	--	557	8	98	36	9.03	899	7.8
29-101	740	Apr. 27, 1962	Tc	30	.42	37	5.8	*33		163	24	20	.2	.0	--	230	116	38	1.3	.35	369	7.0
301	300?	June 16, 1959	Tqc	77	12	80	31	139	17	0	157	352	.2	.0	--	854	327	45	3.4	.00	1,520	3.0
a/ 302	265	Nov. 1, 1938	Ts	--	--	47	16	*64		61	99	122	--	--	--	378	185	--	--	--	--	--
501	400	Sept.19, 1962	Ts	24	--	20	11	*166		152	114	150	.2	.0	--	560	95	79	7.4	.59	977	6.9
a/ 502	556	Sept.29, 1938	Ts	--	--	5	2	*259		342	87	151	.4	--	--	682	21	--	--	--	--	--
701	540	Apr. 25, 1962	Tqc	18	.77	2.5	1.5	*247		446	12	120	.3	.0	--	620	12	98	31	7.07	1,060	8.0
702	600	do	Tqc	15	.19	.8	.5	--		668	.0	112	.4	.0	1.0	785	4	99	70	10.9	1,310	8.2
705	25?	Jan. 18, 1963	Qa	22	--	138	25	*137		412	310	50	.4	16	--	916	448	40	2.8	.00	1,370	6.9
706	100	do	Qa,Tcm	13	--	3.2	3.1	*702		600	.8	382	2.6	.5	--	1,710	21	99	67	19.6	2,860	8.0
707	30?	do	Qa	24	--	95	8.2	*33		340	16	24	.2	16	--	383	270	21	.9	.16	566	7.9
801	30?	Apr. 21, 1959	Ty	70	--	382	182	804	31	211	1,920	900	.3	95	--	4,490	1,700	50	8.5	.00	5,850	7.0
802	100?	Dec. 17, 1962	Ty	18	--	49	15	*626		346	644	418	.3	.2	--	1,940	184	88	20	1.99	2,960	7.3
803	102	do	Ty	34	--	184	27	*194		344	157	380	.3	12	--	1,160	570	43	3.5	.00	1,920	7.4
30-102	90	Apr. 22, 1959	Ty	75	--	113	27	178	7.9	162	116	360	.4	21	--	978	393	49	3.9	.00	1,670	6.8
103	588	Sept.19, 1962	Ts	11	--	4.0	2.5	*421		422	16	405	.7	.0	--	1,070	20	98	41	6.51	1,940	7.8
301	125	Mar. 14, 1963	Tj	21	--	147	23	*430		304	532	418	.1	3.0	--	1,720	462	67	8.7	.00	2,660	7.4
502	80?	Jan. 16, 1963	Tj	45	--	63	9.8	*450		588	14	480	.4	2.5	--	1,350	198	83	14	5.69	2,360	7.0
31-501	64	do	To	59	--	102	3.6	*16		262	19	22	.4	47	--	436	270	11	.4	.00	577	7.1
701	120	Apr. 21, 1959	Tj	70	--	89	4.4	*82		337	37	74	--	.0	--	560	240	43	2.3	.72	824	6.7
34-502	250	Apr. 18, 1963	Tr	16	16	34	7.3	*27		90	23	54	.1	.0	--	218	115	34	1.1	.00	371	6.4
610	328	July 2, 1959	Tc	32	--	3.5	3.2	*31		2	50	25	--	.0	--	146	22	75	29	.00	201	4.8

See footnotes at end of table.

Table 5.--Chemical analyses of water from wells in Gonzales County--Continued

Well	Depth of well (ft)	Date of collection	Water-bearing unit	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)	Specific conductance (micromhos at 25°C)	pH
67-34-803	54	Jan. 15, 1963	Tqc	43	--	58	6.8	*52		220	39	44	0.4	0.5	--	358	172	39	1.7	0.16	553	6.9
902	393	Mar. 13, 1963	Tr,Tc	18	14	19	2.6	*20		44	24	28	.1	.0	--	145	58	42	1.1	.00	221	5.9
903	341	do	Tc	15	--	66	17	*42		220	76	46	.2	.0	--	393	54	28	1.2	.00	630	6.9
35-102	176	Apr. 18, 1963	Tr	16	67	82	24	*76		138	104	173	.4	1.2	--	598	303	35	1.9	.00	960	6.2
103	172	do	Tr	17	2.3	182	55	*107		236	250	325	.4	.5	--	1,050	680	26	1.8	.00	1,710	6.8
201	800	July 2, 1959	Tc	23	--	9.2	2.4	11	8.1	25	21	18	--	.0	0.05	105	33	36	.8	.00	158	5.6
401	732	do	Tc	26	--	3.8	2.2	15	7.3	2	27	22	--	.0	.04	104	19	54	1.5	.00	149	4.8
405	700	Mar. 26, 1959	Tc	20	--	6.0	2.2	*18		11	24	21	--	.0	--	96	24	62	1.6	.00	150	6.1
		June 19, 1959	Tc	--	3.1	--	--	--		7	--	22	--	--	--	--	23	--	--	.00	149	4.9
a/ 502	130	Nov. 22, 1938	Tqc	--	--	140	52	*179		397	449	112	--	--	--	1,127	562	--	--	--	--	--
601	100?	Mar. 15, 1963	Tw	13	4.9	385	223	*286		310	1,250	670	--	.0	--	2,980	1,880	25	2.9	.00	4,010	6.6
803	360	Oct. 11, 1962	Tqc	37	15	86	26	*73		171	184	104	.6	.0	--	595	322	33	1.8	.00	930	6.3
901	1,150	May 1, 1962	Tqc	14	.07	1.2	.3	256	2.7	408	104	82	.4	.2	.65	663	4	99	56	6.61	1,100	8.1
902	440	Oct. 25, 1962	Tqc	13	--	56	29	*153		276	212	102	.3	.2	--	702	259	56	4.1	.00	1,120	7.3
36-101	817	June 1, 1959	Tc	14	--	44	8.8	38	9.2	176	53	31	.1	.0	--	285	146	34	1.4	.00	479	7.1
102	250	Feb. 5, 1963	Tqc	16	--	76	44	*104		234	211	130	.1	.0	--	704	370	38	2.4	.00	1,160	7.5
a/ 301	104	Sept.19, 1938	Ts	--	--	52	49	*315		427	138	370	--	--	--	1,134	330	--	--	--	--	--
302	80	Feb. 5, 1963	Qa,Tcm	23	--	32	11	*402		324	178	385	.4	4.2	--	1,190	125	87	16	2.81	2,030	7.3
501	1,650	Apr. 13, 1959	Tc	16	--	2.8	.6	96	3.6	220	17	18	--	.0	.09	262	9	94	14	3.42	436	7.4
502	283	Mar. 30, 1962	Tcm	27	17	188	110	388	13	168	600	730	.0	1.5	1.3	2,140	922	47	5.5	.00	3,380	6.5
503	400	Oct. 11, 1962	Ts	18	2.8	39	22	*310		189	300	278	.3	.8	--	1,060	188	78	9.8	.00	1,730	6.8
604	530	Apr. 3, 1959	Ts	12	--	4.5	2.7	379	3.8	312	196	275	.1	.2	.92	1,030	22	97	35	4.67	1,810	8.1
802	1,650?	Apr. 13, 1959	Tc	18	--	2.5	.6	*127		288	16	22	.4	.0	--	338	8	97	19	4.55	546	8.0
803	1,800?	Apr. 26, 1962	--	13	.08	7.0	5.5	*290		216	190	208	.2	2.2	--	828	40	94	20	2.74	1,380	7.7
902	900	Oct. 10, 1962	Ts	15	--	2.0	1.3	*790		660	42	810	--	.2	--	1,990	10	99	109	10.6	3,450	8.1
37-201	1,750	Dec. 20, 1944	Tc	--	--	--	--	--		1,440	2	310	--	1.2	--	1,820	--	--	--	12.8	322	7.9
b/	1,940?	Sept.25, 1945	Tc	19.0	2.0	8.5	3.2	110	8.7	1,798.4	5.5	660	--	--	--	3,626	34.5	--	--	12.8	--	8.3
203	2,175	Apr. 14, 1959	Tc	18	--	3.8	1.7	*958		1,610	.2	552	--	.8	--	2,330	16	99	103	26.0	3,960	7.9

See footnotes at end of table.

Table 5.--Chemical analyses of water from wells in Gonzales County--Continued

Well	Depth of well (ft)	Date of collection	Water-bearing unit	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)	Specific conductance (micromhos at 25°C)	pH
67-37-204	100?	Dec. 17, 1962	Ty	11	--	5.5	3.9	*863		648	386	690	--	0.2	--	2,280	30	98	69	10.0	3,650	8.0
205	30?	Dec. 19, 1962	Qa	18	--	98	7.1	*21		274	23	38	0.4	21	--	377	274	15	.6	.00	614	7.0
206	60?	Jan. 24, 1963	Qa	24	2.8	80	18	*279		350	269	220	.5	.0	--	1,060	274	69	7.3	.27	1,660	7.3
301	430	June 4, 1959	Ty	8.8	--	60	18	23	2.3	231	28	38	.3	3.5	--	296	224	18	.7	.00	533	7.6
305	125	Dec. 17, 1962	Ty	25	--	24	7.5	*225		392	123	92	.4	.5	--	683	91	84	10	4.60	1,090	7.2
a/ 402	100	Nov. 29, 1938	Ty	--	--	362	118	*371		329	1,018	615	--	--	--	2,646	1,392	--	--	--	--	--
a/ 501	200	Nov. 28, 1938	Ty	--	--	318	47	*944		183	1,541	910	--	--	--	3,854	990	--	--	--	--	--
601	30?	Dec. 19, 1962	Qa	22	--	91	17	*72		302	94	48	.6	48	--	547	297	34	1.8	.00	851	7.0
701	100?	Sept.21, 1962	Ty	28	--	190	65	*347		340	522	478	.2	.2	--	1,800	742	50	5.6	.00	2,870	6.8
803	90	Oct. 26, 1962	Tj	31	--	64	9.2	*112		334	87	53	.9	.5	--	522	198	55	3.5	1.52	840	7.2
38-401	190	Dec. 18, 1962	Qa,Tj	25	--	126	4.9	*34		318	30	58	.2	42	--	476	334	18	.8	.00	788	7.0
403	40	do	Qa	18	--	122	9.1	*39		310	35	51	.1	79	--	555	342	20	.9	.00	838	6.8
603	60	Jan. 17, 1963	Tct	48	--	92	6.0	*75		366	42	40	1.3	17	--	517	254	39	2.0	.92	781	6.8
802	70	Dec. 18, 1962	Qa?	31	--	111	6.3	*30		346	27	27	.3	21	--	436	303	18	.8	.00	684	6.7
803	30	do	Qa	41	--	118	5.3	*22		330	24	40	.4	15	--	428	316	13	.5	.00	684	6.8
804	30?	do	Qa	26	--	138	7.3	*44		286	43	87	.3	83	--	570	374	20	1.0	.00	936	6.8
805	128	do	Tct	68	--	19	3.6	*278		614	24	97	.4	.0	--	792	62	91	15	8.81	1,200	7.4
901	400?	Apr. 22, 1959	Tj?	84	--	9.6	1.0	293	11	543	.0	158	.4	.0	--	853	28	94	24	8.34	1,300	7.3
903	93	Sept.18, 1962	Tj	24	--	133	4.3	*17		272	23	44	.5	93	--	473	350	9	.4	.00	789	6.7
39-101	100?	Jan. 16, 1963	Tj	25	--	180	4.1	*38		296	32	90	.4	180	--	696	466	15	.8	.00	1,090	7.1
42-604	700	Mar. 13, 1963	Tqc	15	--	2.2	.4	*169		268	76	54	.2	.0	--	449	7	98	28	4.25	751	7.8
902	1,382	Apr. 28, 1962	Tc	17	.64	60	5.1	22	9.8	166	41	39	.1	.0	0.04	278	171	21	.7	0.00	466	6.8
903	1,387	May 15, 1959	Tc	14	.00	46	6.0	26	8.8	157	30	31	.1	.2	.16	249	139	27	1.0	.00	422	7.0
43-101	750	May 28, 1959	Tc	16	--	32	7.7	25	12	94	53	36	.0	.0	--	238	112	30	1.0	.00	391	5.9
404	345	June 4, 1959	Ts	10	--	101	41	256	14	123	514	250	.2	.2	--	1,250	420	56	5.4	.00	1,950	6.9
406	500	Apr. 28, 1962	Tqc	12	.06	3.5	1.4	*289		212	210	178	.2	.0	--	806	14	98	34	3.18	1,350	7.8
501	1,425	Apr. 14, 1959	Tc	12	--	51	5.5	*29		157	37	33	.0	.0	--	260	150	30	1.0	.00	440	7.2

See footnotes at end of table.

Table 5.--Chemical analyses of water from wells in Gonzales County--Continued

Well	Depth of well (ft)	Date of collection	Water-bearing unit	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)	Specific conductance (micromhos at 25°C)	pH
67-43-503	550?	Mar. 13, 1963	Tqc	12	--	8.5	3.7	*766		320	840	400	--	0.0	--	2,190	36	98	56	4.52	3,350	7.8
601	1,883	Apr. 14, 1959	Tc	15	--	30	6.8	*59		199	29	27	--	.2	--	272	103	56	2.5	1.21	460	7.6
801	500?	Apr. 3, 1959	Ts	11	--	5.0	2.6	*1,260		834	588	1,040	--	.5	--	3,320	23	99	114	13.2	5,420	7.9
806	1,995	Mar. 25, 1959	Tc	13	--	39	6.9	34	8.2	175	28	25	--	.0	0.02	240	126	35	1.3	.36	423	7.5
807	132	Mar. 13, 1963	Tcm	34	--	335	89	*386		266	884	640	--	.0	--	2,500	1,200	41	4.9	.00	3,620	6.7
903	2,530	Apr. 13, 1959	Tc	18	--	3.2	.9	192	3.6	416	6.0	58	0.4	.0	.32	487	12	96	25	6.59	828	7.9
44-101	500?	May 14, 1959	Ts	12	--	2.1	1.4	612	3.9	864	222	290	1.6	.5	--	1,570	11	99	80	13.9	2,590	8.2
103	440	Mar. 30, 1962	Tcm	11	2.6	27	21	*1,790		606	18	2,500	--	--	--	4,670	154	96	63	6.85	8,010	7.6
201	2,190	do	Tc	20	.07	1.2	.0	113	1.3	257	14	18	.4	.0	.26	298	3	98	28	4.15	477	8.0
202	120	do	Tcm	14	14	365	131	*326		172	1,340	440	--	1.8	--	2,700	1,450	33	3.7	.00	3,540	6.9
301	120	Sept.21, 1962	Ty	16	--	14	5.4	*1,280		1,110	3.0	1,370	--	.0	--	3,230	57	98	74	17.0	6,740	7.4
401	2,350	Apr. 28, 1962	Tc	18	.13	12	4.8	*71		192	20	18	.2	.0	--	238	50	76	4.4	2.15	392	7.7
402	2,425	Mar. 20, 1959	Tc	18	--	1.5	.4	178	2.4	399	10	35	.9	.0	.44	443	5	98	35	6.44	745	8.0
403	65	Oct. 10, 1962	Tcm	25	15	11	3.4	*83		114	17	78	--	.0	--	280	41	81	5.6	1.04	465	6.5
602	1,200?	do	Ts	17	--	51	17	*4,370		1,010	21	6,270	--	--	--	11,200	197	98	135	12.6	17,400	7.1
901	74	Oct. 25, 1962	Tj	30	--	9.5	1.9	*603		690	45	515	1.1	.2	--	1,540	32	98	46	10.7	2,630	7.9
45-301	50	Oct. 26, 1962	Tj	67	--	49	6.4	*110		33	116	123	.3	82	--	597	149	62	3.9	.00	860	6.5
901	135	Apr. 21, 1959	Tct	53	--	94	3.1	*70		331	61	45	.4	.0	--	530	247	38	1.9	.49	776	6.8
a/ 46-201	--	Oct. 28, 1938	Tct?	--	--	18	4	*501		671	44	395	.0	--	--	1,292	63	--	--	--	--	--
301	230	Jan. 17, 1963	Tj	44	--	54	7.4	*178		334	43	165	.3	.2	--	656	165	70	6.0	2.17	1,120	7.1
401	100	Sept.20, 1962	Tct	35	--	148	6.4	*52		280	38	158	.4	21	--	597	396	22	1.1	.00	1,050	6.7
a/ 501	80	Oct. 28, 1938	Qa,Tj	--	--	68	10	*119		415	28	72	--	--	--	501	211	--	--	--	--	--
51-102	2,225	Mar. 12, 1963	Tc	20	--	5.5	3.3	*291		636	6.8	91	.9	.0	--	767	27	96	24	9.88	1,220	7.5
201	744	do	Ts	13	--	19	16	*3,490		1,540	1.0	4,560	--	--	--	8,860	114	99	142	23.0	14,200	7.5
501	140?	Jan. 15, 1963	Ty	18	--	52	10	*347		434	328	160	.2	1.0	--	1,130	170	82	12	3.70	1,840	7.4
52-301	110?	May 12, 1959	Tj	63	--	218	16	299	28	339	374	448	.3	1.5	--	1,610	610	50	5.3	.00	2,550	6.6
401	170	Mar. 12, 1963	Tj	72	--	282	18	*403		300	512	620	--	.0	--	2,060	778	53	6.3	.00	3,170	6.3

See footnotes at end of table.

Table 5.--Chemical analyses of water from wells in Gonzales County--Continued

Well	Depth of well (ft)	Date of collection	Water-bearing unit	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)	Specific conductance (micromhos at 25°C)	pH
67-52-502	140	Jan. 15, 1963	Tj	68	--	259	25	*360		316	374	610	--	29	--	1,880	749	5.1	5.7	.00	3,070	6.9
601	132	Oct. 10, 1962	Tct	77	--	136	7.2	*149		338	173	166	0.3	.0	--	906	369	47	3.4	.00	1,320	6.7

* Sodium and potassium calculated as sodium (Na).

a/ Analysis made by personnel of the Works Progress Administration under supervision of Bureau of Industrial Chemistry of the University of Texas.

b/ Analysis by Curtis Laboratories, Houston, Texas.