Report 278

OCCURRENCE, QUALITY, AND AVAILABILITY OF GROUND WATER IN CALLAHAN COUNTY, TEXAS

TEXAS DEPARTMENT OF WATER RESOURCES

August 1983

TEXAS DEPARTMENT OF WATER RESOURCES

REPORT 278

OCCURRENCE, QUALITY, AND AVAILABILITY OF GROUND WATER IN CALLAHAN COUNTY, TEXAS

By

Robert D. Price, Loyd E. Walker, and Thomas W. Sieh, Geologists

August 1983

Published and distributed
by the
Texas Department of Water Resources
Post Office Box 13087
Austin, Texas 78711

ABSTRACT

The principal source of fresh to very saline ground water in Callahan County is the Antlers Formation of the Trinity Group of Cretaceous age. Small amounts of fresh to moderately saline water are present in alluvial deposits found along major streams. A limited amount of fresh to brine water also occurs in shallow discontinuous zones of low permeability in Permian limestones and sandstones.

Chemical quality of the ground water varies widely. Dissolved-solids concentrations in ground water from the Antlers ranges from 134 to 16,923 milligrams per liter. Much higher concentrations of dissolved solids are usually present in ground waters derived from Permian rocks.

About 1,900 acre-feet (2.34 hm^3) of ground water, or approximately 1.7 million gallons per day (6.4 million l/d), was used within the county for all purposes during 1978. Of this amount, approximately 52 percent was used for irrigation, about 10 percent for public supply, and about 38 percent for rural domestic and livestock needs. Because of the small amount of pumpage, water-level declines have been restricted to small isolated areas and in most wells the water level has risen during the past few years.

Recharge to the Antlers Formation, derived from precipitation on its outcrop, is estimated at 5,400 acre-feet per year (6.66 hm^3/yr). This represents 1.5 percent of the county's average annual rainfall that reaches the water table and enters storage. It is conservatively estimated that one-half of the total annual effective recharge or about 2,700 acre-feet (3.33 hm^3) can be safely developed from the aquifer on a yearly basis.

During the winter of 1970-71, the quantity of ground water estimated to be stored within the Antlers aquifer in both the Cross Plains and Clyde-Oplin areas of the county was about 836,100 acre-feet (1,031 hm^3). Approximately 627,100 acre-feet (773.2 hm^3) is thought to be recoverable from storage.

TABLE OF CONTENTS

TABLE OF CONTENTS—Continued

TABLE OF CONTENTS—Continued

TABLE OF CONTENTS—Continued

TABLE OF CONTENTS—Continued

TABLE OF CONTENTS—Continued

TABLE OF CONTENTS—Continued

OCCURRENCE, QUALITY, AND AVAILABILITY OF GROUND WATER IN CALLAHAN COUNTY, TEXAS

INTRODUCTION

Location and Extent

Callahan County is located in west-central Texas between 99°05′ and 99°37′ west longitude and 32°05′ and 32°31′ north latitude. It is bordered on the north by Shackelford and Jones Counties, on the west by Taylor County, on the east by Eastland County, and on the south by Coleman and Brown Counties (Figure 1). The county has an areal extent of approximately 856 square miles (2,220 km²). The county seat of government is Baird which is located in the north central part of the county along Interstate Highway 20.

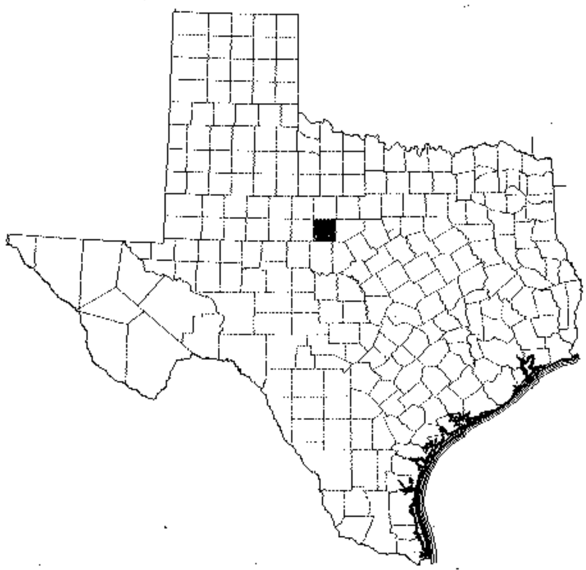


Figure 1.—Location of Callahan County

Purpose and Scope

The general purpose of the study was to determine the occurrence, quality, and, to the extent possible, the quantity of the ground-water resources of the county; and to determine the sources of water suitable for domestic, livestock, public supply, and irrigation uses. The general scope of the study was the collection, compilation, and analysis of data pertaining to the distribution and quality of ground water in Callahan County.

Field work on this study was conducted by Thomas W. Sieh from September 1, 1970 through January 8, 1972, under the general direction of Charles R. Baskin, P.E., Director, Data and Engineering Services Division; Dr. Tommy R. Knowles, P.E., Chief, Data Collection and Evaluation Section; Richard C. Peckham, former Director, Ground Water Division; Bernard B. Baker and Robert L. Bluntzer, former Assistant Directors in charge of Availability Programs; and under the direct supervision of William B. Klemt, Loyd E. Walker, and Robert D. Price, Geologists.

Methods of Investigation

An inventory was made of all municipal, industrial, and irrigation wells; all springs; and a representative inventory of domestic and livestock wells. A total of 497 wells, springs, and test holes were inventoried during this study (Table 5). Water levels were measured in all wells where possible. Information was gathered, when available, on well depths, well construction, date drilled, driller, water-yielding zones, and water-production quantities. Surface elevations of all wells inventoried were determined from topographic maps and electric log well records. Water samples were collected for chemical analysis from 270 selected wells, springs, or test holes during this study. These analyses, as well as 67 analyses performed by commercial or private laboratories, are listed in Table 7. Surface and subsurface geologic data were collected and compiled, placing special emphasis on their relationship to ground water. Additional data were collected and compiled on apparent and potential contamination, oil-field brine disposal, climate, and areas of recharge and discharge. Data were tabulated, analyzed, and the necessary illustrations were prepared for coherent presentation in a report.

Previous Investigations

Several regional reports that include this area have been published prior to this investigation. They are cited in the Selected References.

W. O. George (1940a) collected data on 216 wells, 7 springs, drillers' logs of 11 wells, and 167 water samples for chemical analysis.

A memorandum by W. O. George (1940b) gave information on the occurrence and quality of ground water in the vicinity of the City of Baird.

Cronin and others (1963) of the United States Geological Survey, in cooperation with the Texas Water Commission, conducted a reconnaissance investigation of the ground-water resources of the Brazos River basin.

In 1967, the Texas Water Development Board in cooperation with the United States Geological Survey prepared a reconnaissance investigation of the ground-water resources of the Colorado River basin (Mount and others, 1967).

The Texas Water Development Board also prepared a regional report on the ground-water resources of a part of central Texas which covers part of the study area (Klemt and others, 1975).

Well-Numbering System

The system used in numbering the wells and springs in this report was developed and is used statewide by the Texas Department of Water Resources. It was designed so as to identify each individual well or spring and also to designate its geographical location within the state.

A well number consists of a two-letter county prefix followed by a seven-digit number. The numbers are derived from the system of division and subdivision of the state into quadrangles of degrees and minutes of latitude and longitude (Figure 2). Each largest quadrangle has an assigned two-digit number from 01 to 89 for identification. This largest division, the one-degree quadrangle, is then subdivided into sixty-four 7½-minute quadrangles which are further subdivided into nine 2½-minute quadrangles. Thus, the first two digits in the well number identify the one-degree quadrangle, the third and fourth digits the 7½-minute quadrangle, and the fifth digit the 2½-minute quadrangle. The sixth and seventh digits identify the individual well or spring within the 2½-minute quadrangle.

The two-letter prefix for Callahan County is BX, and the county falls within the one-degree quadrangle numbered 30.

Acknowledgements

Appreciation is expressed to the many landowners, farmers, water well drillers, city, county, and federal officials, and oil operators who assisted in the collection of data for this report by allowing access to lands and furnishing information from files. Grateful acknowledgement is extended to the Taylor Electric Co-op, Inc. and the Soil Conservation Service of the U.S. Department of Agriculture.

Conversion From English To Metric Units

For those readers interested in using the International System (SI) of units, the metric equivalents of English units of measurements are given in parentheses in the text. The English units used in this report may be converted to metric units by the following conversion factors:

From English units	Multiply by	To obtain metric units
acres	0.4047	square hectometers (hm^2)
acre-feet (acre-ft)	0.001233	cubic hectometers (hm^3)
barrel, 42 gallons (bbl)	0.1590	cubic meters (m^3)
cubic feet per second (ft^3/s)	0.02832	cubic meters per second (m^3/s)
feet (ft)	0.3048	meters (m)
feet per mile (ft/mi)	0.189	meters per kilometer (m/km)
gallons (gal)	3.785	liters (l)
gallons per minute (gal/min)	0.06309	liters per second (l/s)

From English units	Multiply by	To obtain metric units
gallons per minute per foot [(gal/min)/ft]	0.207	liters per second per meter [(l/s)/m]
gallons per day per foot [(gal/d)/ft]	12.418	liters per day per meter [(l/d)/m]
gallons per day per square foot [(gal/d)/ft^2]	40.74	liters per day per square meter [(l/d)/m^2]
horsepower, electric (hp)	746	watt (W)
inches (in)	2.54	centimeters (cm)
miles (mi)	1.609	kilometers (km)
million gallons per day (million gal/d)	3.785	million liters per day (million l/d)
square miles (mi^2)	2.590	square kilometers (km^2)

To convert degrees Fahrenheit to degrees Celsius use the following formula:

$$°C = (°F-32) \quad (0.556)$$

GEOGRAPHIC SETTING

Topography and Drainage

Callahan County is located on the boundary between the Central Lowland and the Great Plains Provinces (Carr, 1967, p. 3). The county is divided in half from northwest to southeast by these two physical divisions, with the north part of the county being located in the Osage Section of the Central Lowland Province and the southern one-half being located in the Central Texas Section of the Great Plains Province.

The county has rolling topography from the northeastern to the south central parts with the remainder being relatively level or gently rolling. There are several prominent physiographic features in the county. One is the Callahan Divide which generally separates the county along a line from the northwest to the southeast, and the others are several prominent buttes located in the southeast part of the county. The altitude of the land surface ranges from 1,500 to 2,100 feet (457 to 640 m) above mean sea level.

Callahan County lies within two major drainage systems; the Brazos River basin, which covers the northeast part, and the Colorado River basin, which covers the southwest. Major tributaries in the county are Battle, Deep, and Hubbard Creeks in the Brazos River basin and Pecan Bayou and Greenbriar Creek in the Colorado River basin.

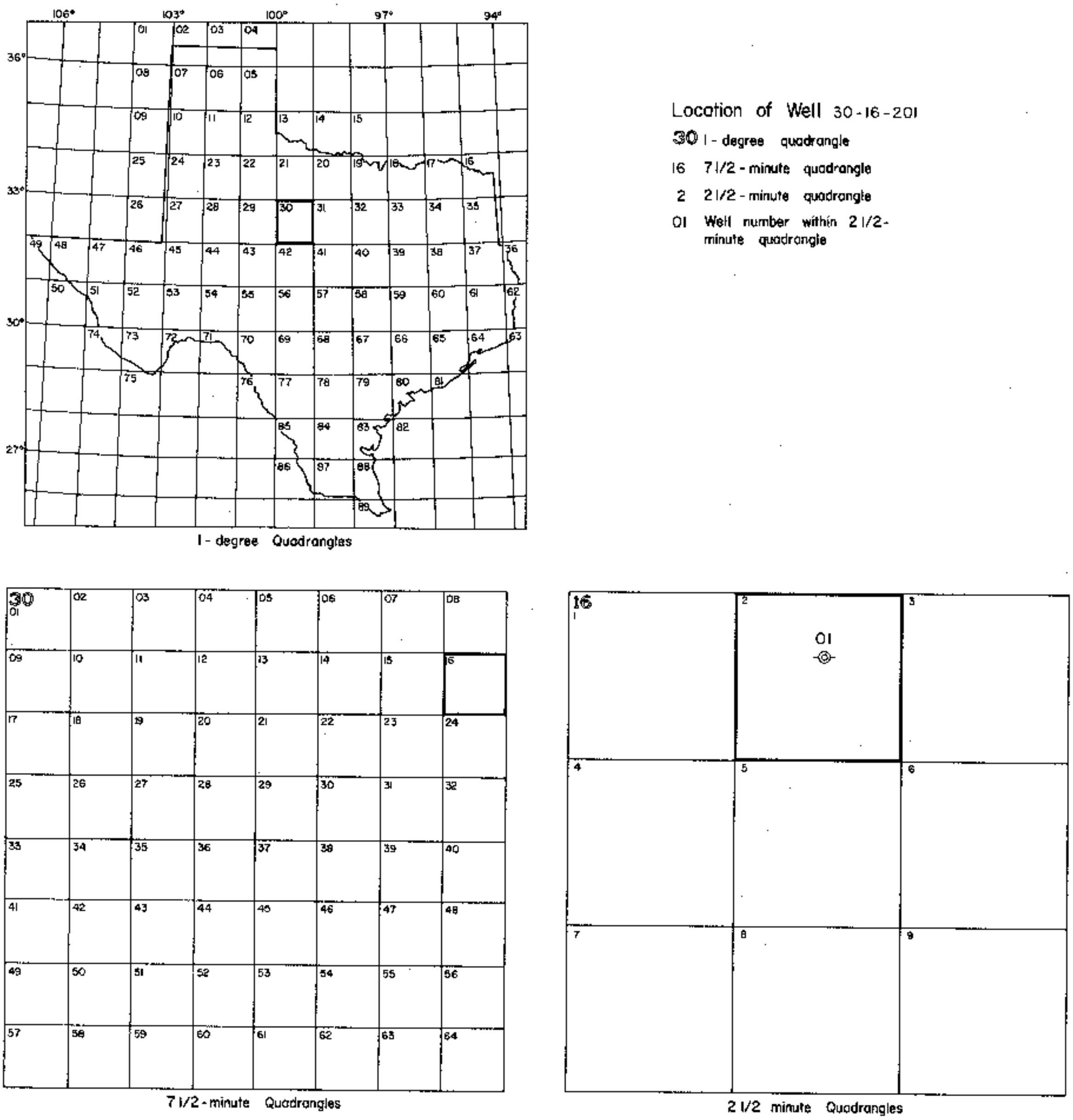


Figure 2.—Well-Numbering System

Climate

The climate of Callahan County is subhumid. The average annual free-air temperature for the period 1931-60 is about 65 °F or 18 °C (Carr, 1967, p. 4). The average minimum temperature for January, the coldest month, is about 33 °F (1 °C). The average maximum temperature for July and August, the warmest months, is 96 °F or 36 °C (Dallas Morning News, 1979, p. 269).

During the period from 1911 through 1974, the average annual precipitation at Putnam was 24.5 inches (or 62.3 cm Figure 3). During the same time interval, the maximum annual precipitation was 39.3 inches (99.8 cm) recorded in 1957, and the minimum was 11.8 inches (30.0 cm) in 1956. The average maximum monthly precipitation of slightly less than 4 inches (10 cm) occurs in

May, and the minimum of slightly over 1 inch (3 cm) occurs in February. These figures are based on National Weather Service records for the period of record at Putnam.

Data collected for the period 1940-65 and compiled by Kane (1967) reflect that the average annual gross lake-surface evaporation is approximately 79 inches (201 cm); however, the average annual net lake-surface evaporation is only 56 inches (142 cm). Figure 4 shows a monthly breakdown of these data and compares it with the average monthly precipitation.

History, Population, and Economy

Callahan County was created from Bexar, Travis, and Bosque Counties in 1858 and was organized with the present boundaries in 1877. The county was named for James H. Callahan, a Texas Ranger (Dallas Morning News, 1979, p. 269). The first county seat of government was Belle Plains, but it later was moved to Baird (Texas State Historical Association, 1976, p. 135).

The population of the county increased from a few pioneer citizens in the mid-1800's to a reported 16,000 in 1924 and had declined to an estimated 9,238 people in 1978. The town of Clyde, with an estimated population of about 2,000, is the largest town in the county. Other towns and communities are Baird, Cross Plains, Putnam, Cottonwood, Pueblo, Denton, Eula, Oplin, and Rowden.

Agribusiness is the principal contributor to the economy. The raising of livestock and poultry along with peanuts, grains, and cotton is valued at 12 million dollars annually. Presently, the production of oil, gas, and stone contributes 3.8 million dollars to the economy each year.

GEOLOGY AS RELATED TO THE OCCURRENCE OF GROUND WATER

Geologic History

Rocks representing various geologic systems underlie and are exposed at the surface of Callahan County (Figures 5, 23, 24, and 25). Listed in ascending order, those systems known to be present in the subsurface are the Precambrian, Cambrian, Ordovician, Mississippian, and the Pennsylvanian. Those represented on the surface, listed from the oldest to the youngest, are the Permian, Cretaceous, and the Quaternary Systems (Figure 5). Description of the hydrologic units and their water-bearing characteristics are given in Table 1. The general lithology of all of the various rock units and their stratigraphic relationship are shown on the above referenced cross-sections. These rocks are composed mainly of limestone, dolomite, shale, and clastics which, for the most part, were deposited in epicontinental seas of relative shallow depth. The sequence of rock types indicates that during their deposition there were repeated transgressions and regressions of the seas.

Geologic data suggest that deposition of sediments during late Cambrian through Mississippian times occurred in broad, relatively shallow seas in this area. There is an absence of some Cambrian and Ordovician, all Silurian and Devonian rocks, and some Mississippian beds. This is due either to nondeposition or removal by erosion and is ample evidence of the repeated advance and retreat of the seas during this vast time period (Taylor, 1978).

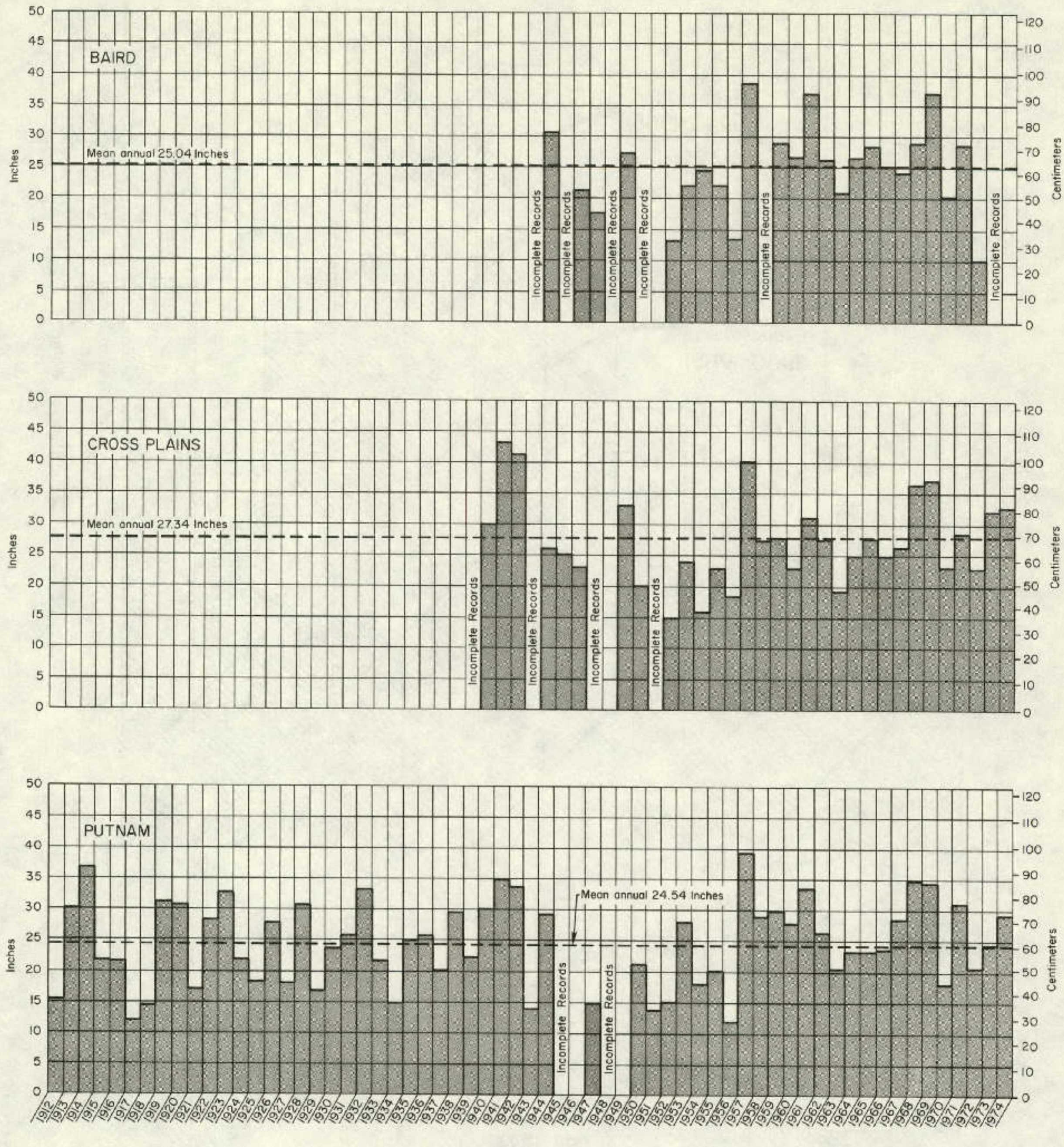


Figure 3

Annual Precipitation at Baird, Cross Plains, and Putnam, Callahan County
(From Records of U.S. Weather Service)

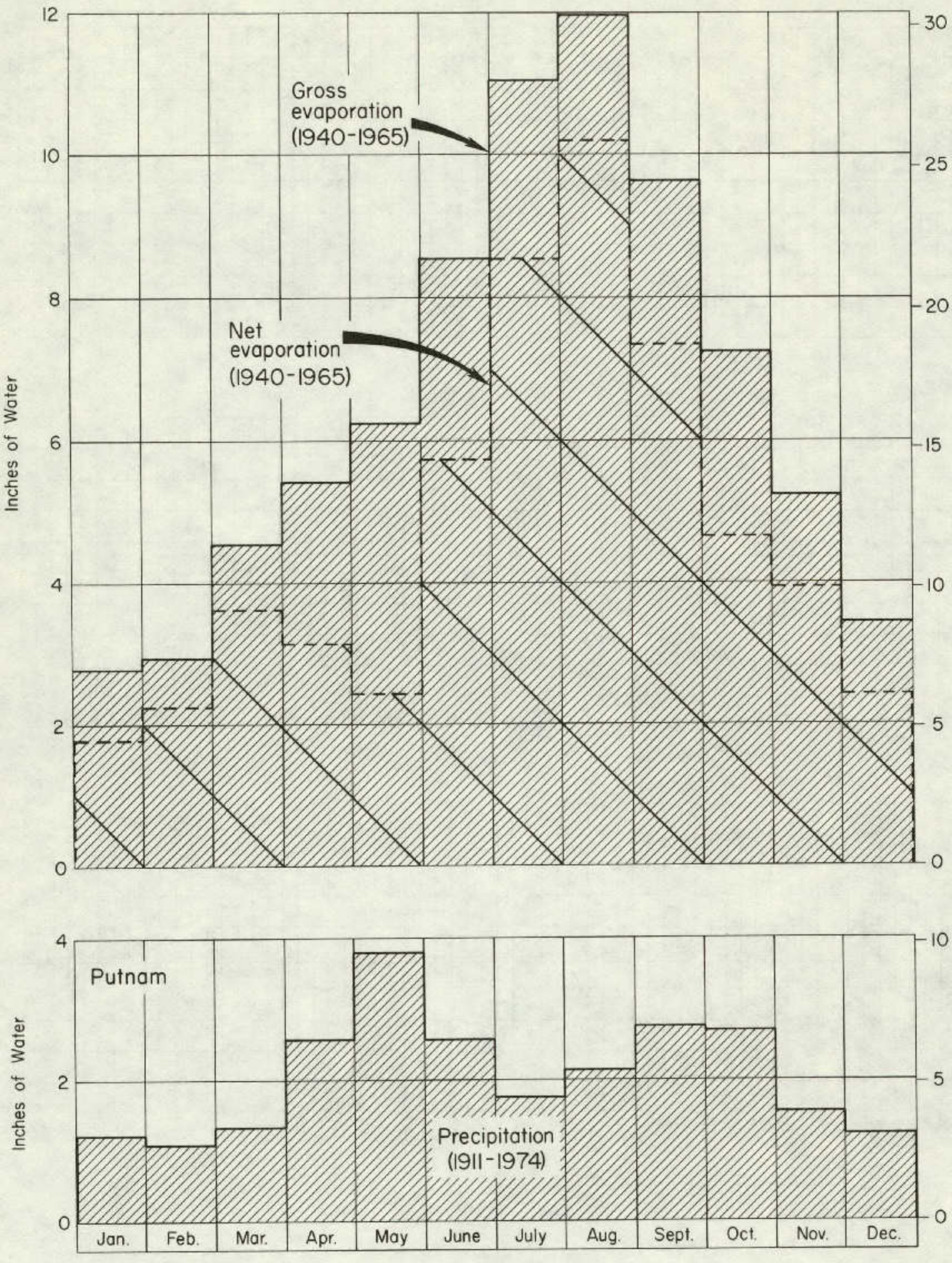


Figure 4

Average Monthly Precipitation at Putnam, and Average Monthly Lake-Surface Evaporation in Callahan County (From Records of U.S. Weather Service, and Kane, 1967)

During late Mississippian or early Pennsylvanian times, epeirogenic movement had begun. Early Pennsylvanian deposits show evidence of shifting environmental conditions with apparently continuous deposition. Evidence points to sea-level changes and subsequent widespread erosion toward the end of early Pennsylvanian time. A general subsidence began during this time and continued, with some minor interruptions, through Permian time. The thick sequences of Middle and Upper Pennsylvanian and Permian deposits found in the Callahan County area are evidence of this. A westward recession of the seas occurred in this area toward the end of the Permian.

Triassic and Jurassic deposits are absent in Callahan County; however, structural and stratigraphic evidence indicates that land tilting and drainage changed by late Jurassic time from a previously westerly or northwesterly direction to a southerly or southeasterly direction. Regional tilt and drainage in this area has remained in this direction since that time.

Early Cretaceous seas advanced from the southeast across the unevenly eroded Permian surface of Callahan County, and the Antlers Formation, which is the marginal or shoreward facies of the Trinity Group, was deposited. As the sea transgressed farther landward, the offshore, or seaward, sediments of the Fredericksburg Group were deposited in the county. Late Cretaceous seas probably also covered this area; however, rocks deposited by them have since been removed by erosion (Taylor, 1978).

Unconformably overlying the rocks of Cretaceous and Permian age throughout Callahan County are semiconsolidated and unconsolidated deposits of clay, sand, and gravel of Quaternary age.

Gravel deposits of probable Pleistocene age form a thin mantle covering scattered parts of extreme northwestern Callahan County (Figure 5). These deposits, some as lag gravel and some with a calcareous cement, are believed to have been laid down as a continuous sheet across the area primarily northwest of the county. They were controlled by terrestrial alluviation and erosion caused by repeated climatic changes associated with the advance and retreat of the great glaciers to the north during this period of time (Van Siclen, 1957). Much of these sediments have since been removed from the area by stream erosion so that today only isolated remnants of the once near-continuous sheet are found capping the low, gently rolling hills (Taylor, 1978).

Recent alluvial deposits are found along the flood plains of many of the main drainage tributaries throughout Callahan County. These sediments were probably derived from Cretaceous rocks along the Callahan Divide (Figure 5). Additionally, much material of the alluvium undoubtedly was derived from the older Pleistocene gravels and from dissected beds of Permian age.

Structure

Major subsurface structural features of central and north-central Texas are shown on Figure 6. Callahan County is located on the west flank of the Bend Flexure which probably had its beginning in late Pennsylvanian or early Permian times as a result of westward land subsidence and regional tilting. Movement continued throughout the Permian and probably into early Mesozoic time. Regional dip of the Permian strata is to the west-northwest at about 40 feet per mile (7.6 m/km). The beds crop out in irregular belts having a north-south trend and becoming successively younger from east to west across the county.

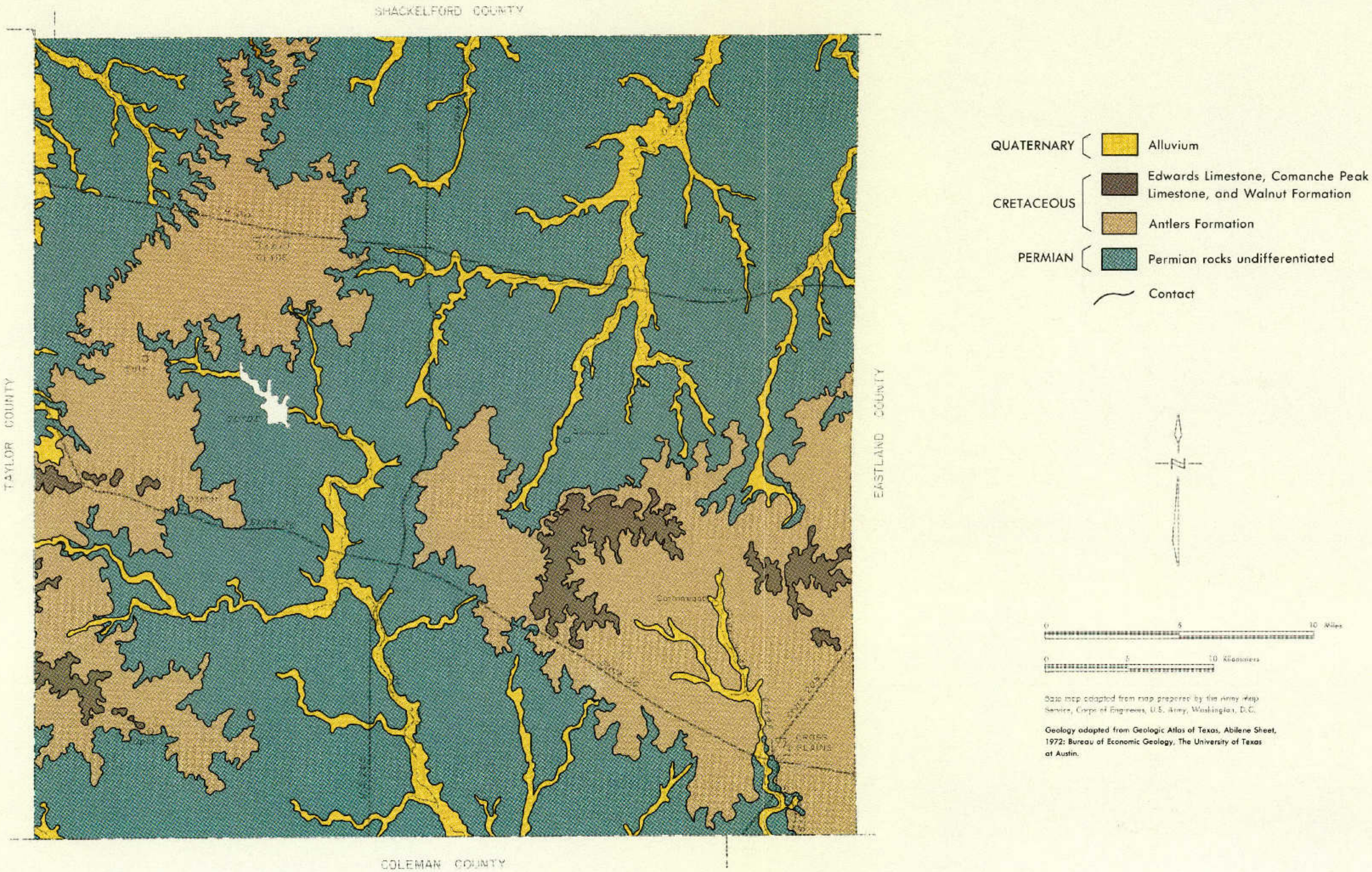


Figure 5

Generalized Geologic Map of Callahan County

Table 1.—Geologic Units and Their Water-Bearing Properties

SYSTEM	SERIES OR GROUP	FORMATION	APPROXIMATE THICKNESS (feet)	LITHOLOGIC CHARACTER	WATER-BEARING CHARACTERISTICS
Quaternary	Recent and Pleistocene	Alluvium	0-30	Surficial floodplain and terrace Alluvium of Pleistocene to Recent age along the streams; consists of gravel, caliche, sand, silt, and clay.	Yields small quantities of fresh to moderately saline water.
——Unconformity——					
Cretaceous	Fredericksburg	Edwards, Comanche Peak, and Walnut	0-80	Edwards is gray to near white, dense to finely crystalline, thin to thick-bedded limestone with thin irregular layers and nodules of dark bluish-gray chert, fossiliferous. Comanche Peak is gray, thin to irregular, wavy-bedded, fossiliferous limestone with thin interbedded claystone, light brown to gray. Walnut is an impure limestone and claystone interbedded, white to light gray to brown, some thin semi-crystalline limestone lenses occur locally with megafossils.	Not known to yield water to wells in the study area.
	Trinity	Antlers	0-185	Upper part cream to near white, very fine to fine-grained sandstone interbedded with claystone, brown to purplish pink, blocky, sandy, and locally calcareous. Middle part claystone as described above. Lower part sandstone as above with conglomerate interbedded. Conglomerate consists of pebbles of chert and quartz with local green clay casts, with some that are argillaceous, sandy, reddish brown and gray.	Yields small to moderate quantities of fresh to very saline water.
——Unconformity——					
Permian	—	—	375-2,040	Units consist mainly of alternating limestone and shale beds, with the upper part containing thicker limestone beds than the lower part. Limestones are generally gray to brown, fine to coarsely crystalline and usually fossiliferous. Shales are of various colors and blocky to fissile. Also present, primarily in the lower part, are some gray to brown, fine to medium-grained sandstones, siltstones, mudstones, conglomerates and thin coal beds.	Yields small quantities of fresh to brine water.
Pre-Permian	—	—	—		Not known to yield water of usable quality.

Yield of wells: small, less than 100 gal/min (gallons per minute) and moderate, 100-1,000 gal/min.

Quality of water as mg/l or ppm (milligrams per liter or parts per million) dissolved solids: fresh, less than 1,000 mg/l or ppm; slightly saline, 1,000 to 3,000 mg/l or ppm; moderately saline, 3,000 to 10,000 mg/l or ppm; very saline, 10,000 to 35,000 ppm; and brine, greater than 35,000 ppm.

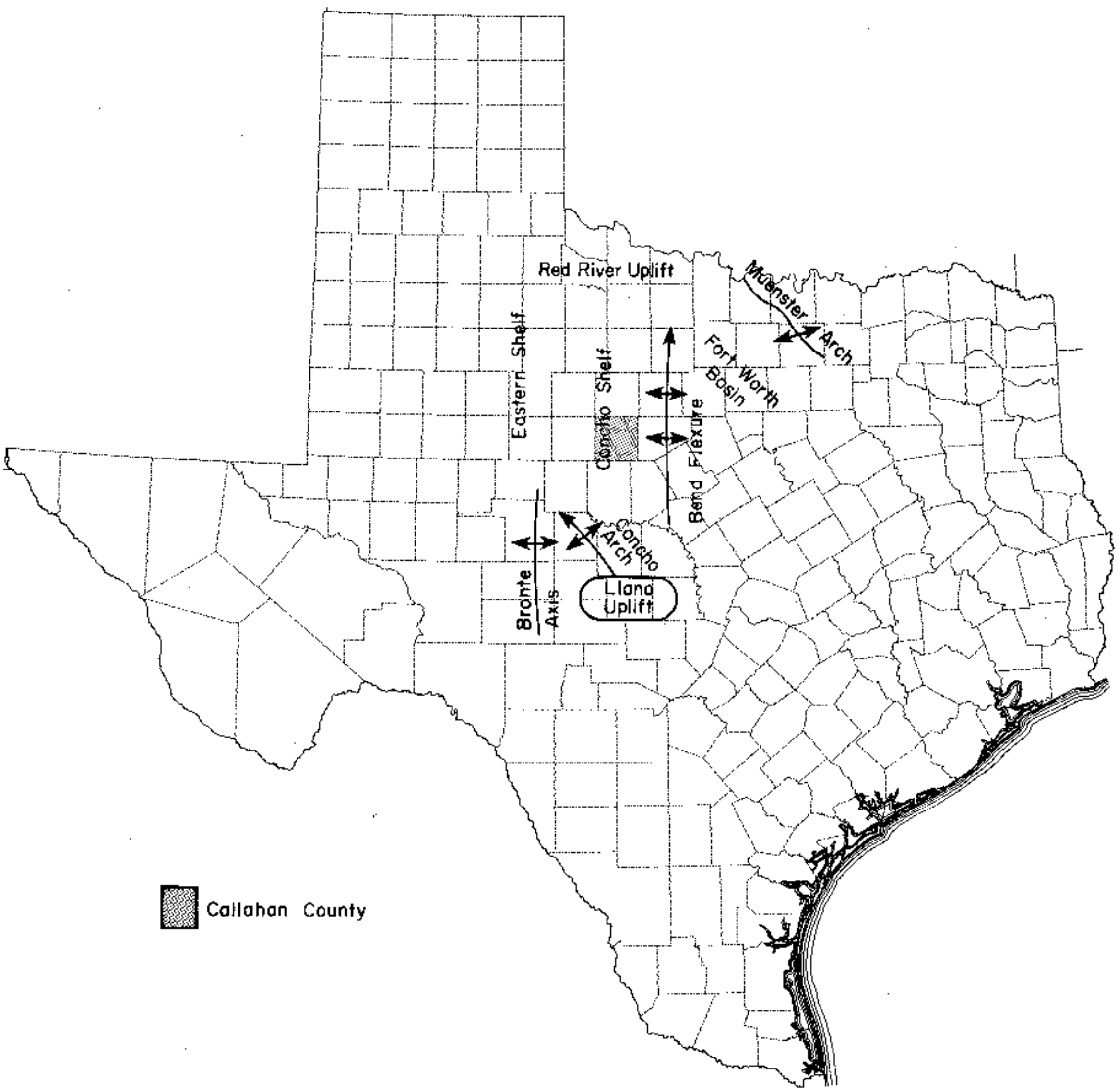


Figure 6.—Major Structural Features in North-Central Texas

Cretaceous deposits of Callahan County overlie the Permian with a marked unconformity caused by post-Permian, pre-Cretaceous uplift, erosion, and tilting to the south and east. According to Farris and others (1963), regional dip on these strata is to the southeast at rates up to 25 feet per mile (4.7 m/km).

Quaternary deposits rest unconformably on Permian rocks and generally assume an attitude equivalent in rate and direction to local topography.

Hydrologic units significant to the occurrence of usable-quality ground water in Callahan County have not been affected appreciably by any of the major structural deformations other than by tilting as previously described.

Stratigraphy of the Water-Bearing Units

In the description of the water-bearing properties of geologic units, the yields of wells are described as follows:

Description	Yield (gallons per minute)
Small	Less than 100
Moderate	100 to 1,000
Large	More than 1,000

In general, the chemical quality of the water is classified according to the dissolved-solids content (Winslow and Kister, 1956, p. 5). A table listing these classifications is found in the chemical quality criteria section of this report.

Pre-Permian Systems

Pre-Permian rocks known to underlie Callahan County are briefly described as follows. Precambrian rocks are composed principally of granite with lesser amounts of schist and gneiss. Mostly dolomitic limestones with some sandstones are present in the Cambrian System. Ordovician and thin Mississippian sediments consist mainly of dolomite, dolomitic limestone, and limestone, with some shale and chert. Rocks of Pennsylvanian age are composed of limestones with some sands, and thick sequences of shales (Figures 23, 24, and 25). Since pre-Permian rocks produce ground waters of a brine quality (dissolved solids greater than 35,000 parts per million), no further discussion will be made of these units. See Table 8 for data on the chemical quality of water in these rocks.

Permian System

The oldest rocks exposed at the surface in Callahan County are of Permian age and are members of the Pueblo Formation which crop out in the extreme eastern part of the county. The youngest Permian rocks are members of the Lueders Formation and are present in extreme northwest Callahan County (Bureau of Economic Geology, 1972). Since many controversies exist within this geologic interval relating to boundaries as well as the names of the systems, series, groups, formations, and members of the formations, this entire interval will be referred to as "Permian rocks undifferentiated" and will be considered as a single hydrologic unit in this report. This is possible since only minor amounts of potable ground water are present in these rocks.

Lithologically, these geologic units consist mainly of alternating limestone and shale beds, with the upper part containing thicker limestone beds than the lower part. Limestones are generally gray to brown, fine to coarsely crystalline, and usually fossiliferous. The shales are of various colors and are blocky to fissile. Some gray to brown, fine- to medium-grained sandstones are present mostly in the lower part. This interval also contains siltstones, mudstones, conglomerates, and thin beds of coal. Individual units of the Permian System crop out in belts of varying widths trending generally in a northeast-southwest direction.

The represented thickness of Permian strata varies from about 375 feet (114 m) at the east line of the county to approximately 2,040 feet (622 m) at the county's west edge. Individual beds dip west-northwest at approximately 40 feet per mile (7.6 m/km).

Minor accumulations of ground water in this hydrologic unit are directly dependent upon the amount of local fracturing and solution channels. For this reason, the unit is not a reliable aquifer. Most wells producing from this unit have small yields and are situated at or near the updip edge of the individual formation or member's outcrop where zones of permeability are locally present. The water-bearing parts of the aquifer are thought to be very limited, occurring near the creeks or drainageways which cross the outcrop of the individual formations or members.

Cretaceous System

The Cretaceous System is represented in Callahan County by the Trinity Group and the overlying Fredericksburg Group. The estimated combined maximum thickness of the two groups is about 265 feet (81 m).

Trinity Group

Within Callahan County, the Trinity Group consists entirely of the Antlers Formation which is the lateral equivalent of the Twin Mountains (Travis Peak of central Texas) and Paluxy Formations present in the Cretaceous System east of Callahan County. In that area, the Glen Rose Formation is present and separates the Antlers into its equivalents. In Callahan County, the Glen Rose Formation is absent and the Twin Mountains and Paluxy Formations coalesce to form the Antlers Formation. In some areas of Callahan County, an upper perched water zone is present in the Antlers. This zone is not hydrologically connected with the lower saturated portion of the Antlers which is the principal aquifer of the county. This water is probably in the Paluxy equivalent.

Within Callahan County, the upper part of the Trinity Group consists of sandstone interbedded with claystone. The lower part of the Antlers contains sandstone interbedded with conglomerate. The outcrop of the Trinity forms the lower slopes of the mesas and buttes of the Callahan Divide located in western and southeastern Callahan County (Figure 5). Data assembled during this study indicate that the maximum thickness of the Antlers is about 185 feet (56.4 m).

Rocks of this age contain most of the usable ground water in Callahan County. The water quality ranges from fresh to very saline; most of the water, however, is slightly saline (Table 7 and Figure 22). Well yields range from small to moderate.

Fredericksburg Group

The Fredericksburg Group is represented by, in ascending order, the Walnut Formation, Comanche Peak Limestone, and the Edwards Limestone. These geologic units form the mesas and buttes which rise above the surrounding land surface in an east to west direction through central Callahan County, and their outcrop defines the approximate location of the Callahan Divide. The Walnut is composed of impure limestone and claystone that is interbedded. The limestone is light gray to brown, semicrystalline lenses which locally contain megafossils. The Comanche Peak Limestone consists of gray, thin to irregular wavy-bedded, fossiliferous limestone. The unit is interbedded with light brown to gray claystone. The Edwards Limestone is gray to near-white, dense to finely crystalline, thick to thin bedded, and fossiliferous. Locally it may contain thin irregular layers and nodules of dark bluish-gray chert (Bureau of Economic Geology, 1972). During the course of this investigation, no evidence was found that suggested the Fredericksburg Group contains usable ground water. The combined thickness of these beds in Callahan County is about 80 feet (24 m).

Quaternary System

The Quaternary System is represented in Callahan County by the Pleistocene and Recent Series. Surficial deposits consisting of sand, gravel, silt, and clay are present north of the Callahan Divide near the Taylor-Callahan County line (Figure 5). These deposits are found in the interstream areas and are possible remnants of older alluvial terraces of Pleistocene age. They rest unconformably on Permian strata and are probably less than 10 feet (3 m) thick. These sediments are not known to contain usable quality water in Callahan County. In addition, more significant deposits of Recent alluvium, which represent the younger Recent Series, are also present within the county.

Recent Alluvium

Alluvial deposits composed of fine sand, silt, clay, and gravel occur in the floodplains of and bordering many of the streambeds of the county. These stream deposits are believed to have been derived from older Pleistocene sediments and from Cretaceous and Permian rocks. The thickness of the alluvium is believed to be no greater than 30 feet (9 m).

The geologic map (Figure 5) outlines the principal deposits of Recent alluvium. Alluvium is also present along numerous tributaries of these streams but is not shown on the geologic map in all cases. Water is produced from the Recent alluvium typically by shallow, dug wells.

Recent alluvium wells usually provide a fairly reliable source of ground water in Callahan County. Water quality ranges from fresh to moderately saline. Yields to wells are small.

GROUND WATER HYDROLOGY

General Principles of Occurrence

In north-central Texas, as well as in Callahan County, the occurrence of ground water is erratic, the aquifers are limited and discontinuous, and well yields are usually small (less than 100 gal/min or 6.31 l/s). A few wells have moderate yields (100 to 1,000 gal/min or 6.31 to 63.1 l/s). Even though these conditions exist, the occurrence of ground water conforms to the same fundamental principles as those in any other area.

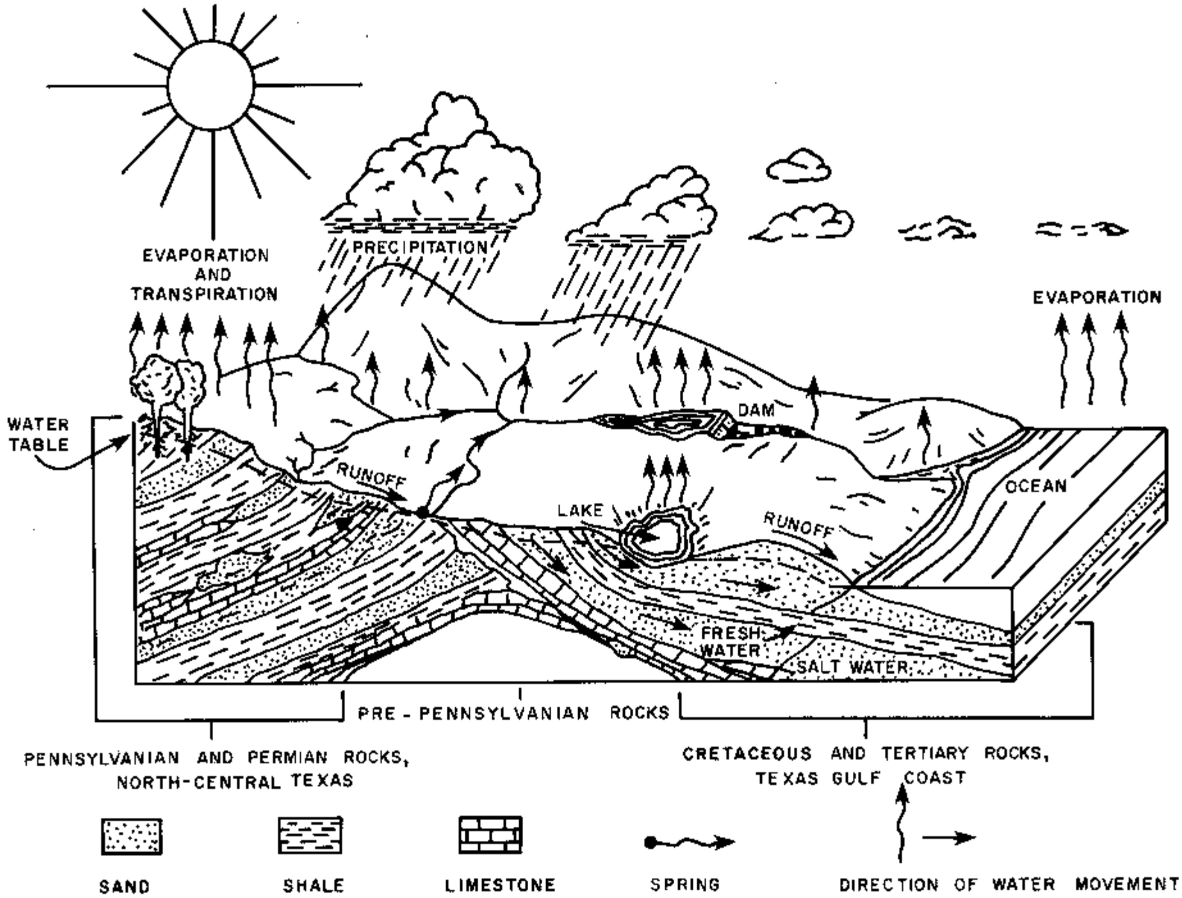


Figure 7.—Hydrologic Cycle

Hydrologic Cycle

Water available for use by man—whether as rain, stream flow, water from wells, or stream discharge—is captured in transit, and after its use, is returned to the hydrologic cycle from which it came. This cycle is illustrated in Figure 7. Graphically, this figure shows the continuing movement of water from the oceans through evaporation to precipitation and its return, either directly or indirectly, to the ocean.

Definition of Ground Water and Related Terms

Ground water is that part of the returning water which has entered the subsurface and filled the void spaces of the porous rocks which are within the zone of saturation. The source of all fresh ground water is precipitation; however, only a small percentage of the precipitation actually becomes ground water.

As water moves downward under the influence of gravity through porous rocks, it first enters the *zone of aeration* or unsaturated voids containing both air and water. Later it enters the *zone of saturation* where all of the pore spaces are filled with water. The upper surface of the zone of saturation is called the *water table,* and the water below the water table is called *ground water.* Occasionally, water in its downward movement encounters impermeable beds above the normal water table, and it is trapped, forming what is referred to as a *perched water table.*

An *aquifer* is a formation, group of formations, or part of a formation that is water bearing (Meinzer, 1923, p. 30). An *aquiclude* is a formation (or unit) 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 (DeWiest, 1965, p. 133-134).

Water-table conditions exist where the upper surface of the zone of saturation is unconfined and is under atmospheric pressure. When water-bearing units (aquifers or aquicludes) dip below nonporous beds in the subsurface, the water is under pressure and is confined. Waters under these conditions are said to be under *artesian conditions.*

Source and Occurrence of Ground Water

Precipitation is the main source of ground water to the aquifers and aquicludes of Callahan County, however, only a small portion of the precipitation actually reaches the water table (Figure 7).

Water occurs and is stored in pores or voids between the rock particles. The two fundamental rock characteristics which are important in the occurrence of ground water are *porosity*, or the ratio of the volume of void space to the total rock volume expressed as a percentage, and *permeability,* which is the ability of a porous material to transmit water. The porosity of a rock is dependent upon the shape, size, sorting, and the amount of cementation of the grains. Clays, silts, and soils which are fine-grained sediments, commonly have high porosity, however, they do not readily transmit water because of the small size of the voids and low permeabilities. Because of their high porosities which range from 40 to 60 percent, the fine-grained sediments are capable of storing large quantities of water.

In aquifers containing sands and gravels which are relatively unconsolidated, ground water occurs in the spaces between the individual particles. In aquifers such as limestones, dolomites, and other more compact and well-cemented rocks, ground water occurs mainly in fractures and cracks caused by force of earth movement or in spaces dissolved by the action of water. Such spaces are known as vugs, caverns, or channels (Taylor, 1978, p. 16).

Recharge, Discharge, and Movement

Replenishment of water to an underground water-bearing formation, or *recharge,* is mainly by natural means. A major controlling factor for recharge is the frequency and the amount of precipitation. Also, seepage from lakes or streams on an aquifer's outcrop aid in natural recharge. The rechargeability of an aquifer depends upon the topography and the amount and kind of vegetative cover on the outcropping rocks, the condition of the soils, and the permeability of the rocks involved. Minor amounts of artificial recharge may be accomplished by running water over an aquifer's permeable outcrop or by pumping water into the water-bearing unit through wells. If recharge does not equal discharge, over a long period of time, the aquifer will be progressively drained. If recharge is greater than discharge, then water will be taken into storage and will progressively fill the aquifer.

Discharge is the process by which water is removed from an aquifer. As in the case of recharge, the discharge of water from a water-bearing unit is also by natural and artificial means.

Natural discharge occurs as flow from springs, effluent seepage, interformational leakage, transpiration by plants, and by evaporation. Artificially, water is discharged through wells by pumping.

The movement of ground water is generally very slow and is from areas of recharge to areas of discharge. The governing factors which determine the rate of movement are the permeability of the aquifer and the hydraulic gradient. With low permeabilities (10 gallons per day per square foot or 407 liters per day per square meter) and a very low gradient of much less than 1 degree, the rate of flow would be less than 1 foot per day (0.305 m/d). Under ideal conditions of high permeabilities and gradient, field tests have reported velocities of greater than 100 feet per day (31 m/d). Todd (1959, p. 53) states, however, that the normal range is from 5 feet per year to 5 feet per day (1.52 m/yr to 1.52 m/d). Artificial discharge through pumping wells can alter the direction of movement and the velocity of the natural flow of ground water. In most areas of north-central Texas, ground-water movement is not constant in rate or direction. This is due to the wide variance in the lithology, extent, porosity, permeability, and structure of the water-bearing units.

Water-Level Fluctuations

Locally, measurements of the depth to water in wells indicate the position of the water table under water-table conditions, or of the potentiometric surface under artesian conditions. When there is no withdrawal, or the influence of pumping is negligible, the measurement is termed a *static water level.* When the measurement is made in a pumping well, the water level is termed a *pumping level.* For water-table aquifers, changes in water levels reflect changes in the ground-water storage. The changes may be on a local or regional basis. Regional changes over a long period of time reflect a change in the recharge-discharge relationship. Often water-level fluctuations of a minor nature are reflections of earthquakes, tidal forces, and changes in atmospheric pressure.

The most significant changes are the result of heavy pumping. Depending on the reservoir characteristics of an aquifer and the rate of withdrawal, various sizes of *cones of depression* are formed around the well bores of pumping wells. These cones are formed by the drawdown of the water table or the potentiometric surface and are in the shape of an inverted cone having its apex at the pumped well (Figure 8, well A). These cones will expand until they encounter a recharge source equal to the discharge rate. If the cone does not encounter a recharge source, it will continue to expand until it encounters the cone of depression of another pumping well, as is the case in highly developed irrigation areas, and may combine with it and form a large, regional cone of depression in the potentiometric surface or the water table (Figure 8, wells A and B).

Hydraulic Properties of Aquifers

The ability of an aquifer to transmit and store water determines the capacity of that aquifer to yield water to wells. These parameters are determined by the porosities and permeabilities of sediments which make up the aquifer. Variations of these parameters, which are dependent on the rock composition, cause the differences in capacities within a single aquifer and between different aquifers. The following definitions are of major importance to the discussion of hydraulic properties of aquifers.

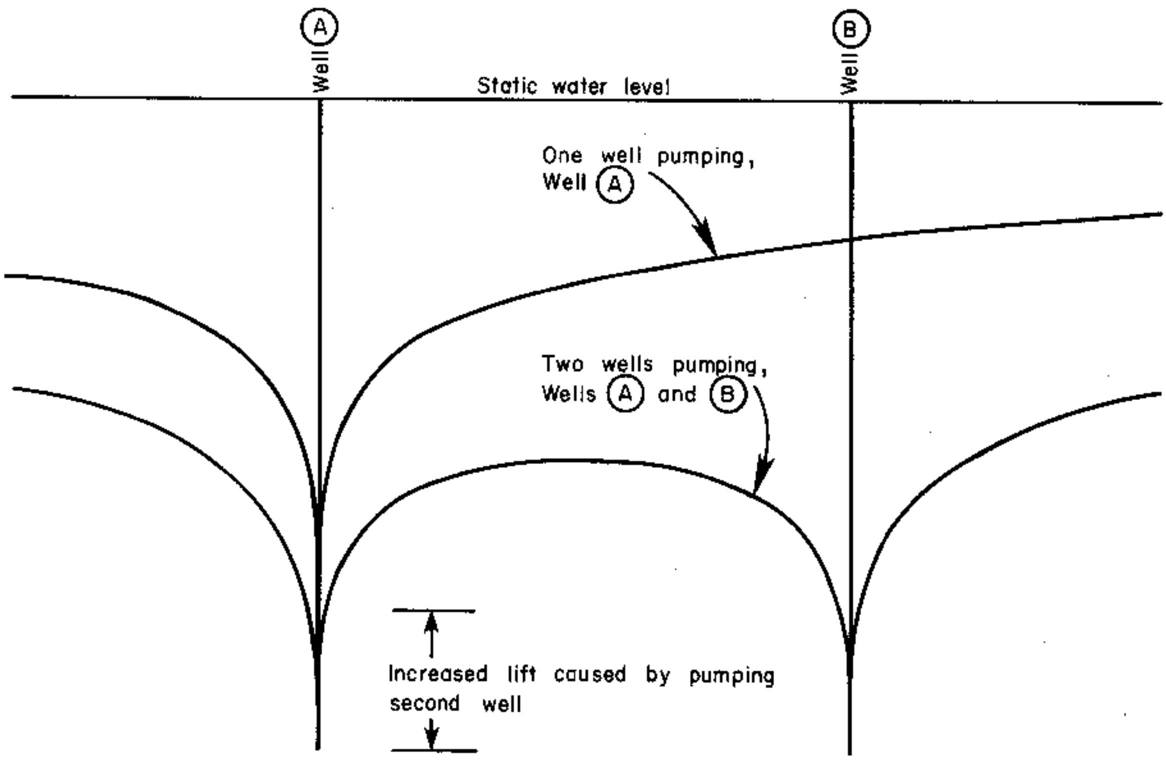


Figure 8.—Idealized Cross Section Showing Drawdown Interference Between Two Pumping Wells

The field *coefficient of permeability* is the flow of water, in gallons per day, at the prevailing temperature through a cross section of 1 square foot of the aquifer under unit hydraulic gradient.

A measure of an aquifer's ability to release water is the *coefficient of transmissibility*, and it is important in computing the amount of water available on a continuous basis. It is defined as the amount of water, in gallons per day, which will flow through a vertical column of aquifer 1 foot wide under a 45-degree slope or gradient (Theis, 1938, p. 889-902).

At a given place in a given direction, the *hydraulic gradient* of a water-bearing unit, is the rate of change of pressure head per unit distance at that place and in that direction (Meinzer, 1923, p. 38). Given a known hydraulic gradient and the coefficient of transmissibility, the amounts of water passing through specific portions of an aquifer can be calculated.

The storage capacity of the pores of a water-bearing unit is important in the calculation of the amounts of water stored in an aquifer. This storage capacity is called the *coefficient of storage* and is the volume of water, per unit of surface area, that will be taken into, or released from storage when the potentiometric surface is raised or lowered by 1 foot (Theis, 1938, p. 394). The term *specific yield* is used when water-table conditions exist, and it is defined as the ratio of the volume of water yielded, to the volume of the aquifer which was dewatered (Stearns, 1927, p. 144). Coefficients of storage in artesian aquifers are very small in comparison to specific yields of water-table aquifers since artesian storage is dependent upon the elastic properties of the aquifer.

Through pumping of a test well and the use of repeated measurements of the water levels in the pumping well and nearby observation wells, the coefficients of storage and transmissibility can be determined. These coefficients are a measure of the aquifer's ability to transmit and store water and can be used to determine proper well spacing, the effects that a pumping well may have on another well, and to predict water-level drawdowns at various distances from a pumping well for a specified time and at a given pumping rate.

The yield in gallons per minute per foot of drawdown of the water level in a well pumping at a constant rate is known as the *specific capacity* of a well. This measurement is another indication of the hydraulic characteristics of a water-bearing unit. Specific capacities must be used with caution since they are affected by methods of well completion, and they change with the rate and the length of pumping.

CHEMICAL QUALITY OF GROUND WATER

General Chemical Quality

Both the constituents and concentrations of dissolved minerals carried in ground water are determined mainly by the types of soil and rocks through which the water percolates. The solvent power of water dissolves some of the minerals from the surrounding rocks as water moves through its environment. Concentration of the various dissolved mineral constituents depends upon the mineral solubility in the water-bearing unit, the length of time the water is in contact with the rock, and the concentration of carbon dioxide present within the water. Therefore, the chemical character of ground water mirrors the general mineral composition of the earth through which it has passed. Usually, dissolved mineral concentrations increase with depth and temperature. The source and significance of dissolved-mineral constituents and properties of water are summarized in Table 2 which has been modified from Doll and others (1963, p. 39-43).

The suitability of ground water for municipal, industrial, irrigation, and other uses is determined by the amount and type of minerals present in the water. Several criteria for water-quality requirements have been developed through the years which serve as guidelines in determining the suitability of water for various uses. Subjects covered by the guidelines are bacterial content; physical characteristics, including color, taste, odor, turbidity, and temperature; and the chemical constituents. Water-quality problems associated with the first two subjects can usually be alleviated economically. The neutralization or removal of most of the unwanted chemical constituents is usually difficult and often very costly.

Usually the main factor which limits or determines the use of ground water is the total dissolved-solids content. An excellent, and very applicable, general classification of waters based on the dissolved-solids concentration in parts per million (ppm) was developed by Winslow and Kister (1956). This classification is as follows:

Description	Dissolved-Solids Content (ppm)
Fresh	Less than 1,000
Slightly saline	1,000 to 3,000

Description	Dissolved-Solids Content (ppm)
Moderately saline	3,000 to 10,000
Very saline	10,000 to 35,000
Brine	More than 35,000

In recent years, most laboratories have begun reporting analyses in milligrams per liter (mg/l) instead of ppm. These units, for practical purposes, are identical unless the dissolved-solids concentration of water reaches or exceeds 7,000 units (ppm or mg/l). The concentrations of chemical constituents reported in this report, other than for oil-field brines (Table 8), are in mg/l. Most of the chemical concentrations are below 7,000 mg/l and, therefore, the units are interchangeable. For the more highly mineralized waters, a density correction should be made using the following formula:

$$\text{Parts per million} = \frac{\text{Milligrams per liter}}{\text{Specific gravity of the water}}$$

A total of 337 chemical analyses of water from selected wells and springs in Callahan County is given in Table 7. The locations of these wells are shown on Figure 22, with wells from which samples were taken being identified by a bar over the well numbers. Concentrations of dissolved solids, sulfates, chlorides, and nitrates from samples collected from selected wells and springs are shown on Figure 9.

Public Supply

As the first step in establishing national standards for drinking water quality under the provisions of the Safe Drinking Water Act of 1974, the U.S. Environmental Protection Agency (EPA) issued drinking water regulations on December 10, 1975. These standards apply, selectively, to all types of public water systems of Texas and the regulations became effective June 1977. Responsibility for enforcement of these standards was assumed by the Texas Department of Health on July 1, 1977. Minor revision of the standards became effective on November 30, 1977.

As defined by the Texas Department of Health, municipal systems are classified as follows:

1. A "public water system" is any system for the delivery to the public of piped water for human consumption, providing such a system has four or more service connections or regularly serves at least 25 individuals daily at least 60 days out of the year.

2. A "community water system" is any system which serves at least four or more service connections or regularly serves 25 permanent type residents for at least 180 days per year.

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

(Adapted from Doll and others, 1963, p. 39-43)

Only analyses which were representative of native ground water were used. Analyses are in milligrams per liter except percent sodium, specific conductance, pH, and SAR.

Constituent or Property	Source or Cause	Significance
Silica (SiO_2)	Dissolved from practically all rocks and soils, commonly less than 30 mg/l. High concentrations, as much as 100 mg/l, generally occur in highly alkaline waters.	Forms hard scale in pipes and boilers. Carried over in steam of high pressure boilers to form deposits on blades of turbines. Inhibits deterioration of zeolite-type water softeners.
Iron (Fe)	Dissolved from practically all rocks and soils. May also be derived from iron pipes, pumps, and other equipment.	On exposure to air, iron in ground water oxidizes to reddish-brown precipitate. More than about 0.3 mg/l stain laundry and utensils reddish-brown. Objectionable for food processing, textile processing, beverages, ice manufacture, brewing, and other processes. Texas Department of Health (1977) drinking water standards state that iron should not exceed 0.3 mg/l. Larger quantities cause unpleasant taste and favor growth of iron bacteria.
Calcium (Ca) and Magnesium (Mg)	Dissolved from practically all soils and rocks, but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in sea water.	Cause most of the hardness and scale-forming properties of water; soap consuming (see hardness). Waters low in calcium and magnesium desired in electroplating, tanning, dyeing, and in textile manufacturing.
Sodium (Na) and Potassium (K)	Dissolved from practically all rocks and soils. Found also in oil-field brines, sea water, industrial brines, and sewage.	Large amounts, in combination with chloride, give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers and a high sodium content may limit the use of water for irrigation.
Bicarbonate (HCO_3) and Carbonate (CO_3)	Action of carbon dioxide in water on carbonate rocks such as limestone and dolomite.	Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot water facilities to form scale and release corrosive carbon-dioxide gas. In combination with calcium and magnesium, cause carbonate hardness.
Sulfate (SO_4)	Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Commonly present in some industrial wastes.	Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts, sulfate in combination with other ions gives bitter taste to water. Texas Department of Health (1977) drinking water standards recommend that the sulfate content should not exceed 300 mg/l.
Chloride (Cl)	Dissolved from rocks and soils. Present in sewage and found in large amounts in oil-field brines, sea water, and industrial brines.	In large amounts in combination with sodium, gives salty taste to drinking water. In large quantities, increases the corrosiveness of water. Texas Department of Health (1977) drinking water standards recommend that the chloride content should not exceed 300 mg/l.
Fluoride (F)	Dissolved in small to minute quantities from most rocks and soils. Added to many waters by fluoridation of municipal supplies.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth, depending on the concentration of fluoride, the age of the child, amount of drinking water consumed, and susceptibility of the individual (Maier, 1950, p. 1120-1132).
Nitrate (NO_3) or Nitrate (as N)	Decaying organic matter, sewage, fertilizers, and nitrates in soil.	Concentration much greater than the local average may suggest pollution. Texas Department of Health (1977) drinking water standards suggest a limit of 45 mg/l (as NO_3) or 10 mg/l (as N). Waters of high nitrate content have been reported to be the cause of methemoglobinemia (an often fatal disease in infants) and therefore should not be used in infant feeding (Maxcy, 1950, p. 271). Nitrate shown to be helpful in reducing inter-crystalline cracking of boiler steel. It encourages growth of algae and other organisms which produce undesirable tastes and odors.
Boron (B)	A minor constituent of rocks and of natural waters.	An excessive boron content will make water unsuitable for irrigation. Wilcox (1955, p. 11) indicated that a boron concentration of as much as 1.0 mg/l is permissible for irrigating sensitive crops; as much as 2.0 mg/l for semitolerant crops; and as much as 3.0 mg/l 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.

Range in Concentrations by Aquifer		
Antlers Formation	**Recent Alluvium**	**Permian Rocks Undifferentiated**
4 — 48	17 — 27	8 — 22
.00 — 4.8	—	—
13 — 435	130 — 356	39 — 358
2 — 234	30 — 130	4 — 142
3 — 650	89 — 690	7 — 276
< 1 — 32	< 1 — 12	< 1 — 5
30 — 840	349 — 476	143 — 434
—	—	—
3 — 560	< 10 — 304	6 — 990
2 — 1,050	28 — 1,700	11 — 840
< .1 — 5.3	.3 — 1.2	.1 — 2.0
< .4 — 135	< .4 — 136	< .4 — 480
< .1 — 2.2	.3 — .7	.2 — .5

Table 2.—Source, Significance, and Concentration of Dissolved-Mineral Constituents and Properties of Water—Continued

Constituent or Property	Source or Cause	Significance
Dissolved solids	Chiefly mineral constituents dissolved from rocks and soils.	Texas Department of Health (1977) drinking water standards recommend that waters containing more than 1,000 mg/l dissolved solids not be used if other less mineralized supplies are available. For many purposes the dissolved-solids content is a major limitation on the use of water. A general classification of water based on dissolved-solids content, in mg/l, is as follows (Winslow and Kister, 1956, p. 5): Waters containing less than 1,000 mg/l of dissolved solids are considered fresh; 1,000 to 3,000 mg/l, slightly saline; 3,000 to 10,000 mg/l, moderately saline; 10,000 to 35,000 mg/l, very saline; and more than 35,000 mg/l, brine.
Hardness as $CaCO_3$	In most waters nearly all the hardness is due to calcium and magnesium. All of the metallic cations other than the alkali metals also cause hardness.	Consumes soap before a lather will form. Deposits soap curd on bathtubs. Hard water forms scale in boilers, water heaters, and pipes. Hardness equivalent to the bicarbonate and carbonate is called carbonate hardness. Any hardness in excess of this is called non-carbonate hardness. Waters of hardness up to 60 mg/l are considered soft; 61 to 120 mg/l, moderately hard; 121 to 180 mg/l, hard; more than 180 mg/l, very hard.
Percent Sodium (% Na)	Sodium in water.	A ratio (using milliequivalents per liter) of the sodium ions to the total sodium, calcium, and magnesium ions. A sodium percentage exceeding 60 percent is a warning of a sodium hazard. Continued irrigation with this type of water will impair the tilth and permeability of the soil.
Sodium-adsorption ratio (SAR)	Sodium in water.	A ratio for soil extracts and irrigation waters used to express the relative activity of sodium ions in exchange reactions with soil (U.S. Salinity Laboratory Staff, 1954, p. 72, 156). Defined by the following equation: $$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}},$$ where Na^{+}; Ca^{++}, and Mg^{++} represent the concentrations in milliequivalents per liter (me/l) of the respective ions.
Residual sodium carbonate (RSC)	Sodium and carbonate or bicarbonate in water.	As calcium and magnesium precipitate as carbonates in the soil, the relative proportion of sodium in the water is increased (Eaton, 1950, p. 123-133). Defined by the following equation: $$RSC = (CO_3^{--} + HCO_3^{-}) - (Ca^{++} + Mg^{++})$$ where CO_3^{--}, HCO_3^{-}, Ca^{++}, and Mg^{++} represent the concentrations in milliequivalents per liter (me/l) of the respective ions.
Specific conductance (micromhos at 25°C)	Mineral content of the water.	Indicates degree of mineralization. Specific conductance is a measure of the capacity of the water to conduct an electric current. Varies with concentration and degree of ionization of the constituents.
Hydrogen ion concentration (pH)	Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxides, phosphates, silicates, and borates raise the pH.	A pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. pH is a measure of the activity of the hydrogen ions. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals. The Texas Department of Health (1977) recommends a pH greater than 7.

Range in Concentrations by Aquifer		
Antlers Formation	Recent Alluvium	Permian Rocks Undifferentiated
134 — 2,874	370 — 3,363	149 — 2,265
92 — 1,650	293 — 1,420	116 — 1,190
2.8 — 73.3	50 — 58.4	3.7 — 57.6
.0 — 17.7	4.7 — 8.4	.1 — 4.2
.0 — 1.8	.0 — .0	.0 — 1.2
224 — 3,480	1,095 — 5,200	270 — 3,150
6.0 — 8.3	7.3 — 7.8	7.3 — 8.2

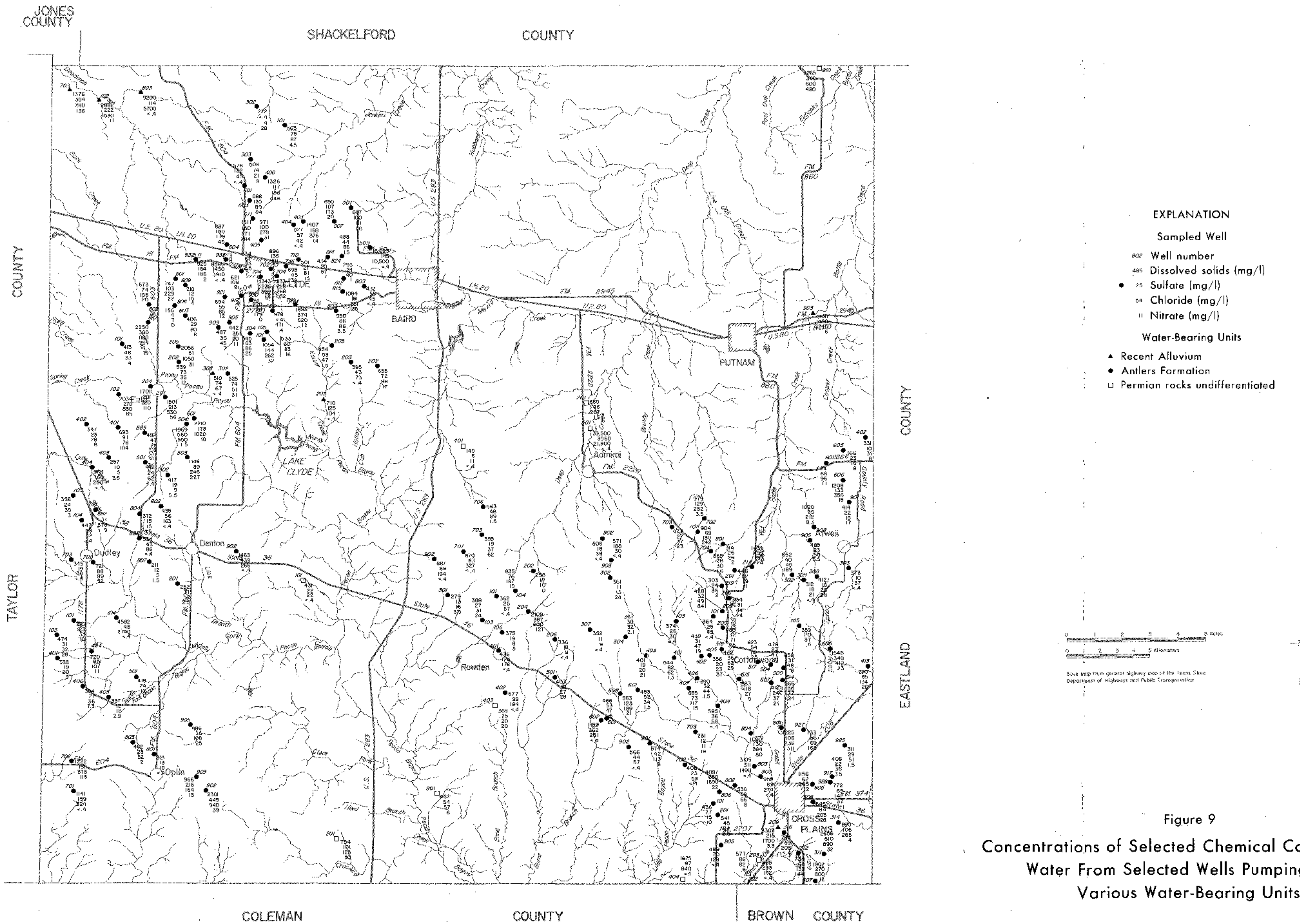


Figure 9

Concentrations of Selected Chemical Constituents in Water From Selected Wells Pumping From Various Water-Bearing Units

3. A "non-community water system" is any public water system which is not a community water system.

Standards which relate to public supplies are of two types: (1) primary and (2) secondary. Primary standards are devoted to constituents and regulations affecting the health of consumers. Secondary standards are those which deal with the esthetic qualities of drinking water. Contaminants for which secondary maximum contaminant levels are set in these standards do not have a direct impact on the health of the consumers, but their presence in excessive quantities may discourage the use of the water.

Primary Standards

Primary standards for dissolved minerals apply to community water systems and are as follows:

Contaminant	Maximum concentration (mg/l)
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	.010
Chromium (Cr^6)	.05
Lead (Pb)	.05
Mercury (Hg)	.002
Selenium (Se)	.01
Silver (Ag)	.05
Nitrate (as NO_3)	45
Nitrate (as N)	10

At the time this report was compiled, analyses were not available for the trace metals as shown above. Except for nitrate content, none of the above contaminant levels for toxic minerals applies to non-community water systems. The maximum of 10 mg/l nitrate as N (about 45 mg/l nitrate as NO_3) applies to community and non-community systems alike.

Maximum fluoride concentrations are applicable to community water systems and they vary with the annual average of the maximum daily air temperature at the location of the system. The following table gives the maximum permissible limits for fluoride based on ranges in the annual average maximum daily air temperature:

Temperature (°F)	Temperature (°C)	Maximum concentration (mg/l)
63.9 - 70.6	17.7 - 21.4	1.8
70.7 - 79.2	21.5 - 26.2	1.6
79.3 - 90.5	26.3 - 32.5	1.4

The annual average maximum daily air temperature within Callahan County varies from 76.2 to 78.2 °F (24.6 to 25.7 °C), therefore, the maximum permissible limit for fluoride for community water systems located within the county would be 1.6 mg/l.

Maximum contaminant limits for organic chemicals are enforced; however, they are applicable only to community water systems. These cover the chlorinated hydrocarbons and chlorophenoxys (Texas Department of Health, 1977, p. 3).

Maximum levels for coliform bacteria, as specified by the Texas Department of Health in 1977, apply to community and non-community water systems. The limits specified are basically the same as in the 1962 Public Health Service Standards which have been widely adopted in most states.

In addition to the previously stated requirements, there are also stringent rules regarding general sampling and the frequency of sampling which apply to all public water systems. Additionally, community water systems are subject to rigid radiological sampling and analytical requirements (Texas Department of Health, 1977, p. 12-15).

Secondary Standards

Recommended secondary standards applicable to all public water systems are given in the following table:

Constituent	Maximum level	
Chloride (Cl)	300	mg/l
Color	15	color units
Copper (Cu)	1.0	mg/l

Constituent	Maximum level	
Corrosivity		non-corrosive
Foaming agents	0.53	mg/l
Hydrogen sulfide (H_2S)	.05	mg/l
Iron (Fe)	.3	mg/l
Manganese (Mn)	.05	mg/l
Odor	3	Threshold Odor Number
pH	>7.0	
Sulfate (SO_4)	300	mg/l
Dissolved solids	1,000	mg/l
Zinc (Zn)	5.0	mg/l

The above secondary standards are recommended limits, except for water systems which are not in existence as of the effective date of these standards. For water systems which are constructed after the effective date, no source of supply which does not meet the recommended secondary standards may be used without written approval by the Texas Department of Health. The determining factor will be whether there is an alternate source of supply of acceptable chemical quality available to the area to be served.

After July 1, 1977, for all instances in which drinking water does not meet the recommended limits and is accepted for use by the Texas Department of Health, such acceptance is valid only until such time as water of acceptable chemical quality can be made available at reasonable cost to the area in question from an alternate source. At such time, either the water which was previously accepted would have to be treated to lower the constituents to acceptable levels, or water would have to be secured from the alternate source.

Domestic and Livestock

Ideally, ground waters used for rural domestic purposes should be as free of contaminants as those used for municipal purposes; however, this is not always economically possible. At present, there are no controls placed on private domestic or livestock wells. In general, the chemical constituents of waters used for domestic purposes should not exceed the concentrations shown in the following table, except in those areas where more suitable supplies are not available (Texas Department of Health, 1977).

Substance	Concentration (mg/l)
Chloride (Cl)	300
Fluoride (F)	1.6*
Iron (Fe)	.3
Manganese (Mn)	.05
Nitrate (as N)	10
Nitrate (as NO_3)	45
Sulfate (SO_4)	300
Dissolved solids	1,000

*Maximum recommended fluoride limit based on annual average of maximum daily air temperature range of 76.2 to 78.2 °F (24.6 to 25.7 °C).

Many areas of north-central Texas do not have and cannot obtain domestic water supplies which meet the recommended standards; however, supplies which do not meet these standards have been used for long periods of time without any apparent ill effects to the user. It is not generally recommended that water used for drinking purposes contain more than a maximum of 2,000 mg/l dissolved solids; however, water containing somewhat higher mineral concentrations has been used where water of better quality was not available.

Water having concentrations of chemical constituents in excess of the Texas Health Department's standards may be objectionable for numerous reasons. Brief explanations for these objections, representative ranges in concentration of chemical constituents within the various water-bearing units of Callahan County, as well as the significance of each constituent are presented in Table 2. More detailed discussions of the water quality of the individual aquifers can be found in later sections of this publication.

Generally, water used for livestock purposes is subject to the same quality limitations as those relating to drinking water for humans; however, the tolerance limits of the various chemical constituents as well as dissolved-solids concentration may be considerably higher for livestock than that which is considered satisfactory for human consumption. The type of animal, the kind of soluble salts, and the respective amount of soluble salts determine the tolerance limits (Heller, 1933, p. 22). In the western United States, cattle may tolerate drinking water containing nearly 10,000 mg/l dissolved solids providing these waters contain mostly sodium and chloride (Hem, 1970, p. 324). Waters containing high concentrations of sulfate are usually considered undesirable for livestock use. Many investigators recommend an upper limit of dissolved solids near 5,000 mg/l as necessary for maximum growth and reproduction. Hem (1970, p. 324) cited a publication of the Department of Agriculture of the state of Western Australia as recommending the following maximum upper limits for dissolved-solids concentration in livestock water:

Animal	Maximum dissolved-solids concentration (mg/l)
Poultry	2,860
Hogs	4,290
Horses	6,435
Cattle (dairy)	7,150
Cattle (beef)	10,000
Sheep (adult)	12,900

Burden (1961) stated that there should be concern for livestock when the nitrate content of their drinking water is as great as 100 mg/l and he further recommended an upper limit of 220 mg/l for waters used for livestock consumption.

Irrigation

The quality of irrigation waters is important in that it determines the results which can be expected from their use. The results, however, are also greatly influenced by the climate, soils, management practices, crops grown, drainage, and the quantity of water applied.

According to the U.S. Salinity Laboratory Staff (1954), the primary factors which determine the quality of water used for irrigation are: (1) the total salt concentration as indicated by the specific conductance; (2) the proportion of sodium and its relationship to other cations (percent sodium); (3) the concentration of boron or other toxic elements; and (4) under certain conditions, the carbonate and bicarbonate content in relationship to concentration of calcium and magnesium. These factors are termed: the salinity, sodium, boron, and the carbonate and bicarbonate ion hazards, respectively (U.S. Salinity Laboratory Staff, 1954, p. 69-82; Wilcox, 1955, p. 11-12; Lyerly and Longenecker, 1957, p. 13-15).

In most waters, the salt concentration is not high enough to impair or retard the growth of plants. It is the salt accumulation in the soil which causes saline conditions that are injurious to plants. However, as the salt concentration in irrigation waters increases, the salinity hazard or the tendency of salts to accumulate in the soil also increases. A field measure used to give an indication of the salt concentration in irrigation water is specific conductance. Using this specific conductance, the U.S. Salinity Laboratory Staff (1954, p. 69-82) designed the classification chart shown in Figure 10 which is an excellent guide in estimating the relative salinity hazard of irrigation waters. It is based in part on various salinity classes which are determined by the conductivity in micromhos per centimeter at 25 °C (or specific conductance in micromhos at 25 °C shown on most chemical analyses in Tables 2 and 7). The salinity-hazard classes (C1, C2, C3, and C4) are shown on the horizontal scale of Figure 10 and a discussion of them is given in Table 3.

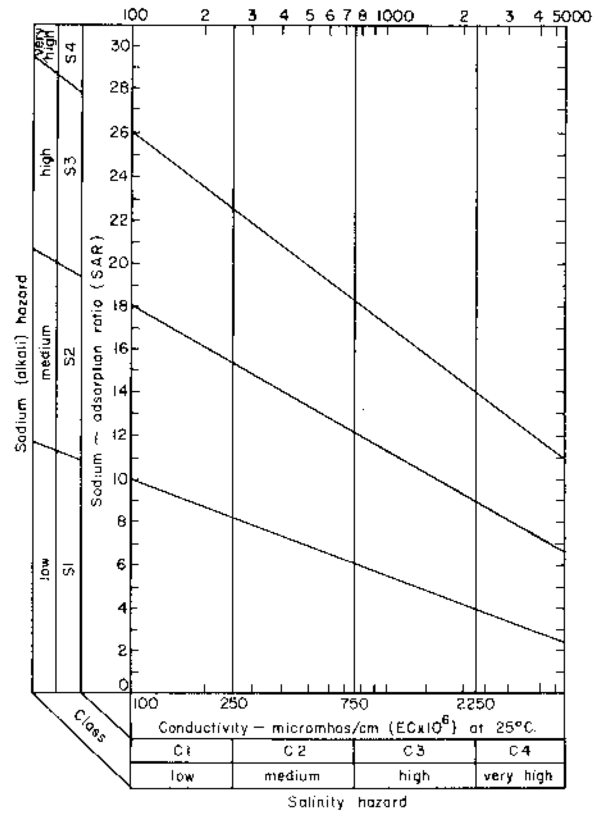


Figure 10.—Diagram for the Classification of Irrigation Waters

Physical conditions of the soil are markedly affected by an increase in exchangeable sodium. For that reason, it is necessary to consider the sodium hazard of irrigation water. Accumulations of sodium in the soil may be injurious to plants sensitive to sodium. The total salt concentration, as well as the sodium-adsorption ratio (SAR), influence the sodium hazard. A high SAR is the cause of soil structure breakdown. Soils tend to form a hard crust and become impermeable to water and air movement. This usually results in crop damage, cultivation difficulties, and drainage problems (Hem, 1959, p. 247). Table 2 shows the equation for calculating the SAR, and Table 7 gives the SAR values which have been calculated for most of the water samples in Callahan County. Using these SAR values and the conductivity, the sodium hazard can be determined from Figure 10. The sodium-hazard classes (S1, S2, S3, and S4) are shown on the vertical scale of Figure 10. A discussion of these classes is also given in Table 3. Under most conditions, irrigation waters containing a percent sodium of less than 60 (Table 7) and a low bicarbonate content are probably satisfactory. The sodium hazard becomes progressively greater as the percent sodium increases above 60.

Excessive boron content will render water unsuitable for irrigation. Table 2 discusses the sensitivity of various crops, the boron limits for these crops, as well as the boron ranges for the various aquifers of Callahan County. Table 7 lists the boron content, where determined, of waters sampled from various aquifers within the county.

Following irrigation, the soil dries and the soil solution becomes progressively more concentrated. This condition creates a tendency for the less soluble compounds to precipitate from solution. Both calcium and magnesium carbonate, being less soluble than sodium carbonate, may precipitate with drying. This precipitation results in an increase in the proportion of sodium in solution. The bicarbonate ion is the source of carbonate which makes the precipitation possible. Conditions favoring precipitation and the extent to which calcium and magnesium carbonates will precipitate are not fully understood. However, waters containing 1.25 to 2.5 me/l (milliequivalents per liter) of residual sodium carbonate (RSC) are considered marginal and those containing greater than 2.5 me/l probably are unsafe for irrigation use. The equation for calculating RSC is given in Table 2, and RSC values for ground waters in Callahan County are shown in Table 7.

Table 3.—Water-Use Limitations of Salinity and Sodium Hazard—Classified Irrigation Waters Shown in Figures 10, 17, and 20 (After Lyerly and Longenecker, 1957, p. 13-15)

Hazard		Classification and Limitations
Salinity	C1)	Low-salinity water—can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required; care should be taken with soils of extremely low permeability.
	C2)	Medium-salinity water—can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.
	C3)	High-salinity water—cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required. Plants selected should have good salt tolerance.
	C4)	Very high-salinity water—may be used occasionally under special conditions. Soils must be permeable and drainage adequate. Highly salt-tolerant crops, only, should be selected. Excess irrigation water must be applied to provide considerable leaching.
Sodium	S1)	Low-sodium water—can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops, such as stone-fruit trees and avocados, may accumulate injurious concentrations of sodium.
	S2)	Medium-sodium water—recommended for use on coarse-textured or organic soils having good permeability. Unless gypsum is present in the soil, this water will present an appreciable sodium hazard in fine-textured soils having high cation-exchange capacity, especially under low-leaching conditions.
	S3)	High-sodium water—requires special soil management (good drainage, high leaching, organic matter additions) as it may produce harmful levels of exchangeable sodium in most soils, although, not necessarily in gypsiferous soils. Chemical amendments may be required for replacement of exchangeable sodium, but this may not be feasible with waters of very high salinity.
	S4)	Very high-sodium water—generally unsatisfactory for irrigation except at low and, possibly, medium salinity, where the solution of calcium from the soil or use of gypsum or other additives may make the use of these waters feasible.

Industrial

Water-quality requirements for an industrial water supply are determined by the type of industry. The main concern to many industries is that the water selected for its supply does not contain corrosive or scale-forming constituents. Both magnesium and calcium affect the hardness and are of major concern in any water to be used in boilers. Excessive amounts of silica and iron cause scale deposits which reduce the efficiency of many industrial processes. Water quality must be rigidly controlled where the water is used in the processing of food, paper, and some chemical-process industries. Mineral impurities affect color, taste, odor, and turbidity; therefore, water with a high content of dissolved solids is usually avoided.

Treatment

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

WELL DEVELOPMENT

History of Well Development in Callahan County

The earliest inhabitants of Callahan County probably settled near springs where they could obtain water supplies from ground-water flows which issued principally from the Cretaceous Antlers Formation. These springs were usually located at or near the outer limits of the outcrop of the water-bearing unit. Several of these springs still flow and were located during this investigation. Other springs flowed from alluvial deposits in the floodplains of the small streams that originate within the county. Additionally, a limited number of springs flowed from some of the more permeable Permian hydrologic units. As the county became more populated, early domestic and livestock supplies were obtained from hand-dug wells. Later, many sand-point wells were probably driven to tap the underlying deposits of Antlers or alluvial sands and gravels. The oldest inventoried domestic well (30-46-201) was hand dug in 1870. Most of the dug wells located during this investigation were completed before 1940. The majority of the 51 domestic or livestock wells, inventoried during this and previous studies, were drilled.

By 1972, a total of 61 public suppy wells were located and had been inventoried. Data presented by George (1940a) suggests that the first county public water system was developed about 1918 and was located in the northeast part of the City of Cross Plains. This system was known as the "settling basin" and originally consisted of seven 25-foot (8 m) wells. These wells produced from the Antlers Formation, were of low yield, and could be pumped for only about 3 hours before the water levels reached the base of the aquifer. After a water-level recovery period, the wells could then be pumped again. Five of these wells are no longer in use.

In addition to the above wells, the City of Cross Plains drilled 28 more wells which are concentrated in three principal areas located approximately 1 mile (1.6 km) east, 1¼ miles (2.0 km) northeast, and 2 miles (3.2 km) northeast of town, respectively. These wells, which also pump from the Antlers, were drilled during the period 1926-64.

Beginning in 1927, the City of Baird started development of its Shady Hill Golf Course well field which is located approximately 3 miles (4.8 km) west of town. These wells pumped from the Cretaceous Antlers aquifer. Development in this field continued through 1939 with a total of nine wells being drilled. Use of this well field was discontinued in August 1949 when the city began using surface water from Lake Baird which is owned by Callahan County Water Conservation and Improvement District Number One. This lake is located on Mexia Creek approximately 2½ miles (4.0 km) southeast of the city. Three of the original wells (30-37-804, 811, and 812) are presently being used as irrigation wells, and the remainder are maintained for emergency use.

Twenty-one public supply wells were drilled by the City of Clyde during the period from about 1939 through 1965. These wells pumped from the Antlers aquifer. They are located throughout the city (Table 7 and Figure 22). Almost all of the wells were in use as of January 1972, at the time that the field inventory was completed for this study; however, during 1972 the city changed to a surface-water supply secured from Lake Clyde, which is located 6 miles (9.6 km) south of the city on North Prong Pecan Bayou. The city wells are now used as a supplemental source of water.

During 1960 and 1961, three 123-foot (37 m) low yield public supply wells were drilled 2 miles (3.2 km) northwest of the community of Denton in west-central Callahan County. These wells furnished municipal water for the Denton Valley Missile Site which was maintained by the U.S. Air Force at Dyess Air Force Base in Abilene. These wells were sold when the facility was deactivated in February 1965.

The development and use of ground water for industrial purposes in the county has been very limited. Six industrial wells, all of which produce from the Antlers Formation, were inventoried during this investigation. The first reported industrial well (30-44-506) was drilled in 1920; however, one was reported as "old" and might have been drilled prior to that date. Four wells were drilled during the period 1961-70.

Of the six industrial wells, water from four wells supplied water for turkey, hog, and cattle feedlots; one for waterflood operations; and one was formerly used by a plumbing firm.

Prior to 1951, the practice of using ground water for irrigation within Callahan County was conducted on a very small scale. Data collected by George (1940a) indicate that there were probably not more than five irrigation wells in the county at that time. Two were used to irrigate gardens and they probably would not presently be classed as irrigation wells. The first recorded irrigation development was by the City of Baird in 1927 (wells 30-37-811 and 812); however, most of the development began in the 1960's.

During this investigation, 153 irrigation wells were inventoried, all of which were producing from the Cretaceous Antlers Formation. A breakdown of the development of irrigation wells within the county is as follows:

Year	Number of irrigation wells drilled	Percent of total
Unknown and 1950 or before	7	4.6
1951 - 1960	12	7.8
1961 - 1970	112	73.2
After 1970	22	14.4

Of the 153 irrigation wells inventoried 95 (62 percent) are located in the Clyde-Oplin area of western Callahan County.

Well Construction

Of 473 wells developed in the Antlers Formation, Quaternary alluvium deposits, and Permian rocks, 108 were hand dug. Most of the others were drilled. Well depths range from 5 to 275 feet (2 to 84 m).

Almost all dug wells are used for domestic or livestock purposes. Generally, most of these wells are from 2.5 to 4 feet (0.8 to 1.2 m) in diameter, although the range is from 1.5 to 14 feet (0.5 to 4 m). The dug wells are lined with bricks, native stone, or concrete rings. More recently drilled domestic and livestock wells are cased with small-diameter (5 to 13 inches or 13 to 33 centimeters) galvanized sheetmetal, steel, or plastic casing. The galvanized metal and plastic casing is perforated opposite the water-bearing zones, and the steel casing is generally torch-slotted.

Industrial, irrigation, and public supply wells usually have diameters of 5 to 24 inches (13 to 61 cm), and recently drilled wells are normally cased to bottom. In most wells, the hole is reamed to 36 inches (91 cm), and prior to the setting of the casing, the casing is torch-slotted opposite the water-bearing zones. Following the setting of the casing on bottom, the hole outside the casing is then filled with small gravel. Only three public-supply wells (30-44-801, 802, and 803) have been developed with casing cemented from the top of the aquifer to the surface and well screens installed opposite the water-bearing zone. Most of the drilled wells are developed by pumping. Many of the older public supply wells of the cities of Baird, Clyde, and Cross Plains are large diameter hand-dug wells which are lined with brick. These wells range in diameter from about 3 to 19 feet (1 to 6 m).

Yields of Wells

During the course of this and previous studies, no lengthy individual well pump tests were run. However, performance tests were conducted during this investigation on 10 irrigation wells which were pumping from the Antlers Formation. Yields on these wells ranged from 9.9 to 70 gal/min (0.62 to 4.4 l/s). These tests are listed in Table 4. This table also contains well yield data on all types of wells on which reliable reports were supplied by well drillers. Yields ranging from 4 to 70 gal/min (0.25 to 4.4 l/s) were reported on wells pumping from the Antlers Formation.

Yields reported by well owners contacted during this study are as follows: Antlers Formation, 1 to 185 gal/min (0.06 to 12 l/s); Quaternary alluvium deposits, "weak" to 5 gal/min (0.32 l/s); and Permian rocks, 1 to 5 gal/min (0.06 to 0.32 l/s) to "strong".

Pump Types and Energy Sources

Most domestic and livestock wells in the county are equipped with jet pumps. Other pump types in common use are centrifugal and submersible. Some windmills are still used to pump water for domestic and livestock purposes. The power or energy source for pumps is generally electricity with the size of the motors ranging from 1/3 to slightly over 2 horsepower (246 to 1,490 W). The 1/3-horsepower (246 W) motor is the most common size in use.

Public supply and industrial wells are generally equipped with submersible and jet pumps. A few wells have turbine-type pumps. Of the wells presently in use in these categories, all are powered by electricity. The motors range from 1/3 to 5 horsepower (246 to 3,730 W) with motors of 1 horsepower (746 W) or less as the most common size.

Of the 153 irrigation wells inventoried, 75 percent are equipped with submersible pumps. Others use jet, turbine, and centrifugal type pumps. The principal power source is electricity with 86 percent of the pumps being equipped with electric motors ranging in size from 1/3 to 10 horsepower (246 to 7,460 W). One well pump was powered by an internal combustion engine.

As a result of low yields in most irrigation wells within the county, water from one to eight wells may be pumped into a surface reservoir. Water collected in this manner is then pumped through sprinkler systems by use of centrifugal pumps, usually powered by electric motors which range from 5 to 25 horsepower (3,730 to 18,600 W). One irrigation system was powered by a farm tractor.

GROUND-WATER PUMPAGE AND UTILIZATION

Figure 11 graphically illustrates the estimated ground-water pumpage from the water-bearing units of Callahan County. Estimates shown were provided to the authors by personnel of the Water Requirements and Uses Section of the Planning and Development Division of the Department. During 1978, approximately 1,900 acre-feet (2.34 hm^3) of ground water was pumped within the county for all uses. This pumpage was used for irrigation, municipal, industrial, and domestic and livestock purposes.

Table 4.—Yields and Other Hydrologic Properties of Selected Wells Completed in the Antlers Formation

Coefficient of transmissivity values are rounded to two significant figures.

Well	Saturated thickness (feet)	Date test began	Yield (gal/min)	Drawdown (feet)	Specific capacity (gal/min/ft)	Estimated coefficient of transmissivity (gal/d/ft)[1]	Estimated coefficient of permeability (gal/d/ft²)[1]	Estimated coefficient of storage[2]	Length of test (hours)
30-36-611[3]	7.3	June 15, 1971	9.9	3.85	2.6	2,600	356	—	2
803[3]	34.8	do	35	4.61	7.6	9,000	259	—	4
804[3]	38.9	—	35	5.10	6.9	8,400	216	—	24
805[3]	33.9	June 15, 1971	11.6	16.88	.68	700	21	—	2
806[4]	18	Oct. 29, 1968	20	15	1.3	1,400	78	—	1
928[3]	31	July 17, 1971	15.2	12	1.27	1,200	39	—	1
929[3]	39	do	9.9	22	.45	400	10	—	1
930[4]	47	Aug. 30, 1970	20	10	.5	1,800	38	—	1
37-503[4]	16	Oct. 6, 1968	15	10	1.5	1,500	94	—	.5
605[4]	12	Sept. 24, 1968	12	12	1.0	1,400	117	—	1
710[3]	34.1	July 22, 1971	26	14.80	1.76	2,400	70	—	24
711[3]	34.5	do	26	18.50	1.41	1,500	42	—	1.5
737[4]	27	July 20, 1970	20	10	2.0	1,900	70	—	1
820[3]	18	June 15, 1971	9.6	13.4	.72	800	44	—	3
824[4]	12	Oct. 8, 1968	10	4	2.5	2,200	183	0.222	.5
44-301[4]	15	Oct. 15, 1968	15	10	1.5	1,600	107	—	1
304[3]	28.3	—	70	8.30	8.4	8,800	311	—	1
402[4]	12	July 5, 1968	4	10	.4	400	33	0.193	1
501[4]	26	Oct. 19, 1968	15	10	1.5	1,400	54	—	1
510[4]	13	Oct. 9, 1973	20	12	1.67	2,200	169	—	.5
703[4]	15	July 16, 1969	10	10	1.0	1,000	67	—	1
704[4]	38	Apr. 14, 1968	14	3	4.7	4,400	116	—	1
705[4]	20	Aug. 13, 1968	10	10	1.0	1,000	50	—	1
710[4]	15	May 15, 1973	25	10	2.5	3,100	207	—	1
805[4]	25	May 2, 1968	15	10	1.5	1,200	48	.209	.5
806[4]	41	Feb. 25, 1969	15	15	1.0	900	22	—	1
45-104[6]	18	Dec. 1966	40	3	13.3	16,600	922	.287	6
52-105[4]	98	July 28, 1969	15	20	.75	800	8	.121	1
107[4]	6	Dec. 8, 1970	5	6	.83	1,000	167	—	.5
501[4]	6	Sept. 26, 1970	5	5	1.0	1,000	167	—	.5
703[4]	12	June 1, 1970	5	10	.5	500	42	—	1
804[4]	12	Mar. 14, 1971	4	10	.4	300	25	—	.5
903[6]	14	Apr. 7, 1965	8	12	.67	700	50	—	2
55-310[7]	32	Apr. 1, 1971	70	20	3.5	3,600	112	.190	.5
608[3]	31.9	July 22, 1971	52.2	27.20	1.96	3,500	110	.200	24

[1]Coefficient of transmissivity values were estimated using data from Myer, 1969; performance tests; and a Department computer program. Permeability values were estimated by dividing the transmissivity values by the saturated thickness. Estimated values based on performance tests conducted for less than three hours should be used with caution.

[2]Coefficient of storage was estimated using data from Morris and Johnson, 1967, Summary of hydrologic and physical properties of rock and soil materials, as analyzed by the hydrologic laboratory of the U.S. Geological Survey 1948-60: U.S. Geol. Survey Water-Supply Paper 1839-D, p. D36-D37.

[3]Well performance test by personnel of the Texas Department of Water Resources.

[4]Well performance test by driller, L. E. Hayhurst.

[5]Well performance test by driller, R. L. McKelvy.

[6]Well performance test by driller, Repps B. Guitar, Jr.

[7]Well performance test by driller, Lester King.

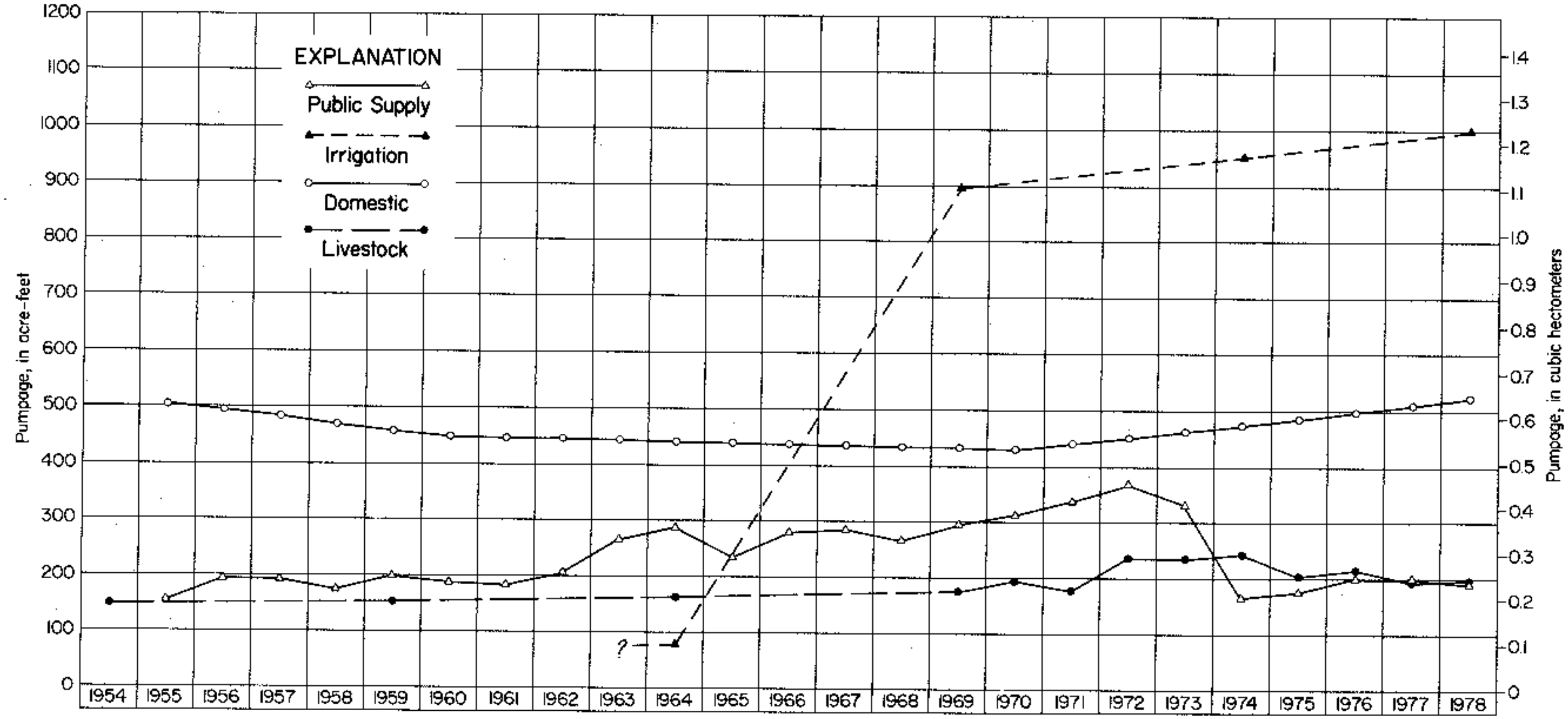


Figure 11

Estimated Pumpage of Ground Water in Callahan County, 1954-78

Irrigation Pumpage

During this investigation, 153 wells were inventoried which were producing or had produced water for irrigation purposes within the county. All of these wells pump or have pumped from the principal aquifer which is the Antlers Formation.

Most of the water is applied to the various crops by sprinkler systems. Since many of the wells are of low yield, often two to eight wells pump into a central earthen tank and the water is redistributed later by an electrically powered centrifugal pump through a multiple sprinkler system. The principal irrigated crop is peanuts with lesser amounts of water being applied to cotton and small grains.

Within Callahan County, irrigation pumpage is confined to two main areas. The largest number of irrigation wells, most of which are of low yield, are located in the Baird-Clyde area in the northwestern part of the county. Fewer but larger yield irrigation wells are located in the Cross Plains area of southeastern Callahan County.

Pumpage data pertaining to irrigation wells drilled prior to 1964 are very limited. In 1940, personnel of the U.S. Geological Survey collected data which indicated that there were probably not more than five irrigation wells in operation at that time (George, 1940a). Pumpage from these wells is believed to have been very minor. Well data collected during this investigation suggest that as many as 26 irrigation wells were possibly in operation by 1964. Total pumpage from all of these wells, prior to 1964, is estimated to have been about 500 acre-feet (0.617 hm^3). Using data provided by Department personnel, irrigation pumpage from the Antlers Formation (100 percent of irrigation pumpage) was estimated at 11,500 acre-feet (14.2 hm^3) for the period 1964-78. The 1978 irrigation pumpage was estimated at 1,000 acre-feet (1.23 hm^3) which represented 52.2 percent of the total pumpage for that year.

Municipal Pumpage

During 1978, slightly less than 200 acre-feet (0.247 hm^3) or about 10 percent of the total ground water pumped within Callahan County was used for public supplies (Figure 11). Estimated municipal pumpage from approximately 61 wells for the period 1955-78 was about 5,700 acre-feet (7.03 hm^3). All of this pumpage was from the Antlers Formation.

Public Water Supply—Cross Plains

Cross Plains is the largest consumer of ground water for municipal needs in the county. Its public supply system was reportedly started about 1918. Pumpage data on the city's water use prior to 1955 are not available. Public supply pumpage in 1978 from the city's 34 active wells (25 at the time of the field inventory for this study) was about 200 acre-feet (0.247 hm^3), and the estimated total pumpage for the period 1955-78 was about 3,000 acre-feet (3.70 hm^3). Cross Plains is the only city within the county which presently secures all of its municipal supply from a ground-water source. All pumpage is from the Antlers Formation.

Public Water Supply—Clyde

The City of Clyde was at one time the second largest consumer of municipal ground-water within the county. Clyde used a ground-water supply during the period 1939-73. Twenty-one wells were drilled; however, the maximum reported active wells were 19. These wells are presently on standby and are now used only during emergencies. Pumpage data for the period 1939-55 are not available. During 1972, the last year in which ground water was used exclusively, pumpage from the city's active wells was about 230 acre-feet (0.284 hm^3). The estimated total ground-water pumpage for the period of record 1955-73 was approximately 2,700 acre-feet (3.33 hm^3) and all pumpage was from the Antlers Formation.

In November 1973, Clyde converted to surface water and began using water from Lake Clyde, located about 4.5 miles (7.2 km) south of the city on Pecan Bayou. This lake has a capacity of 5,748 acre-feet (7.09 hm^3), and the city has a permit to use 1,000 acre-feet per year (1.23 hm^3). During 1978, slightly less than 380 acre-feet (0.469 hm^3) were diverted from the lake. Approximately 90 acre-feet (0.111 hm^3) of this was sold to the Eula Water Supply Corporation which serves the area primarily southwest of Clyde.

Public Water Supply—Baird

During the period 1927 through August 1949, the City of Baird secured its municipal water supply from a well field approximately three miles (4.8 km) west of town. Pumpage data on this field are available only for the period 1941-44. Annual pumpage for these years was 2.14 (0.003), 2.22 (0.003), 2.44 (0.003), and 2.22 acre-feet (0.003 hm^3), respectively (Sundstrom and others, 1947). All of this ground water was pumped from the Antlers Formation. Many of Baird's municipal wells are still maintained for emergency use.

In 1949, the City of Baird joined Callahan County Water Control and Improvement District Number One, and the district later constructed Lake Baird on Mexia Creek approximately 2½ miles (4.0 km) southeast of the city. This lake has an impoundment capacity of 2,070 acre-feet (2.55 hm^3), and the district held a permit to divert 550 acre-feet per year (0.678 hm^3/yr). Ownership of the lake and the diversion rights were transferred to the City of Baird on July 11, 1979. In 1978, approximately 450 acre-feet (0.555 hm^3) of water was diverted from this lake by the city for municipal purposes.

Public Water Supply—Putnam

From 1925 to 1945, the town of Putnam obtained its municipal water from a 10-acre (4.05 hm^3) lake originally constructed by the Texas and Pacific Railroad Company. This lake was located on Live Oak Creek about ½ mile (0.80 km) southeast of town, and it had an impoundment capacity of 81 acre-feet (0.10 hm^3). The town reportedly discontinued use of water from the lake in 1945; however, small quantities of water were used from it when private cisterns and livestock tanks were unable to supply enough water. About 1978, a pipeline was constructed from Lake Cisco in Eastland County and the town presently purchases its municipal supply from the Westbound Water Supply Corporation of Cisco, Texas.

Denton Valley Missile Site Water Supply

A three-well field (wells 30-44-801, 802, and 803) was developed as a municipal supply for the Denton Valley Missile Site during 1960 and 1961. This well field was located 2 miles (3.2 km) northwest of the community of Denton and was maintained by the U.S. Air Force at Dyess Air Force Base in Abilene. This installation was deactivated in February 1965. During 1964, 9.2 acre-feet (0.011 hm^3) was pumped for municipal use by this facility. The total reported ground-water pumpage during the period the missile site was used was slightly more than 28 acre-feet (0.035 hm^3). All of this pumpage was from the Antlers Formation.

Industrial Water Use

Pumpage of ground water for industrial purposes within Callahan County is difficult to estimate. Four of the six wells classed as industrial are located at a commercial turkey farm or a livestock feed lot. Pumpage for these concerns is included with livestock water uses. Well 30-44-709 was used in an oilfield water-flood operation and had an estimated annual pumpage of 2.4 acre-feet (0.003 hm^3). Industrial pumpage for well 30-37-823 is believed to have been insignificant since the well was used by a plumbing firm for only a very short period of time. Total industrial pumpage during 1978 is believed to have been only about 0.2 percent of the total county pumpage.

Domestic and Livestock Use

A total of 251 domestic and livestock wells and 25 springs which produce or have produced water from the water-bearing units of Callahan County were inventoried during this study. Almost all of these wells or springs derive their water from the Antlers Formation.

Reliable estimates of rural ground-water usage for domestic and livestock purposes are difficult to determine; however, water use for these purposes is believed to comprise slightly less than 38 percent of the total county pumpage and is therefore significant. Estimates of pumpage for 1978 for domestic supply are slightly over 500 acre-feet (0.617 hm^3) and for livestock supply about 200 acre-feet (0.247 hm^3). The estimated total ground-water pumpage from domestic and livestock wells for the period 1955-78 is about 11,100 acre-feet (13.69 hm^3) and 4,300 acre-feet (5.30 hm^3), respectively (Figure 11).

AVAILABILITY AND QUALITY OF GROUND WATER

Primary Aquifer

Trinity Group—Antlers Formation

The primary aquifer in Callahan County is the Antlers Formation of the Trinity Group. This formation provided ground water to 94 percent (451 wells and 14 springs) of the 497 wells and springs inventoried during this study. Waters produced from this aquifer were used for all purposes.

Extent of the Aquifer

Cretaceous rocks of the Fredericksburg and Trinity Groups are located primarily in a band lying east-west through the central and southeast part of Callahan County (Figure 5). Erosion has separated their outcrop into two areas, one in the Clyde-Oplin area and one in the Cross Plains area. These erosional remnants are part of a number of outliers of Cretaceous rocks present in Callahan, Coleman, Nolan, Runnels, and Taylor Counties which are commonly referred to as the Callahan Divide. These outliers were once part of a system of Cretaceous rocks which covered all of these counties and the entire area south to the Llano Uplift (Taylor, 1978). Cretaceous rocks in Callahan County cover approximately 280 square miles (725 km^2) or about 33 percent of the surface area of the county. About 155 square miles (401 km^2) of the total outcrop area is located in the Cross Plains area.

Geologic Characteristics

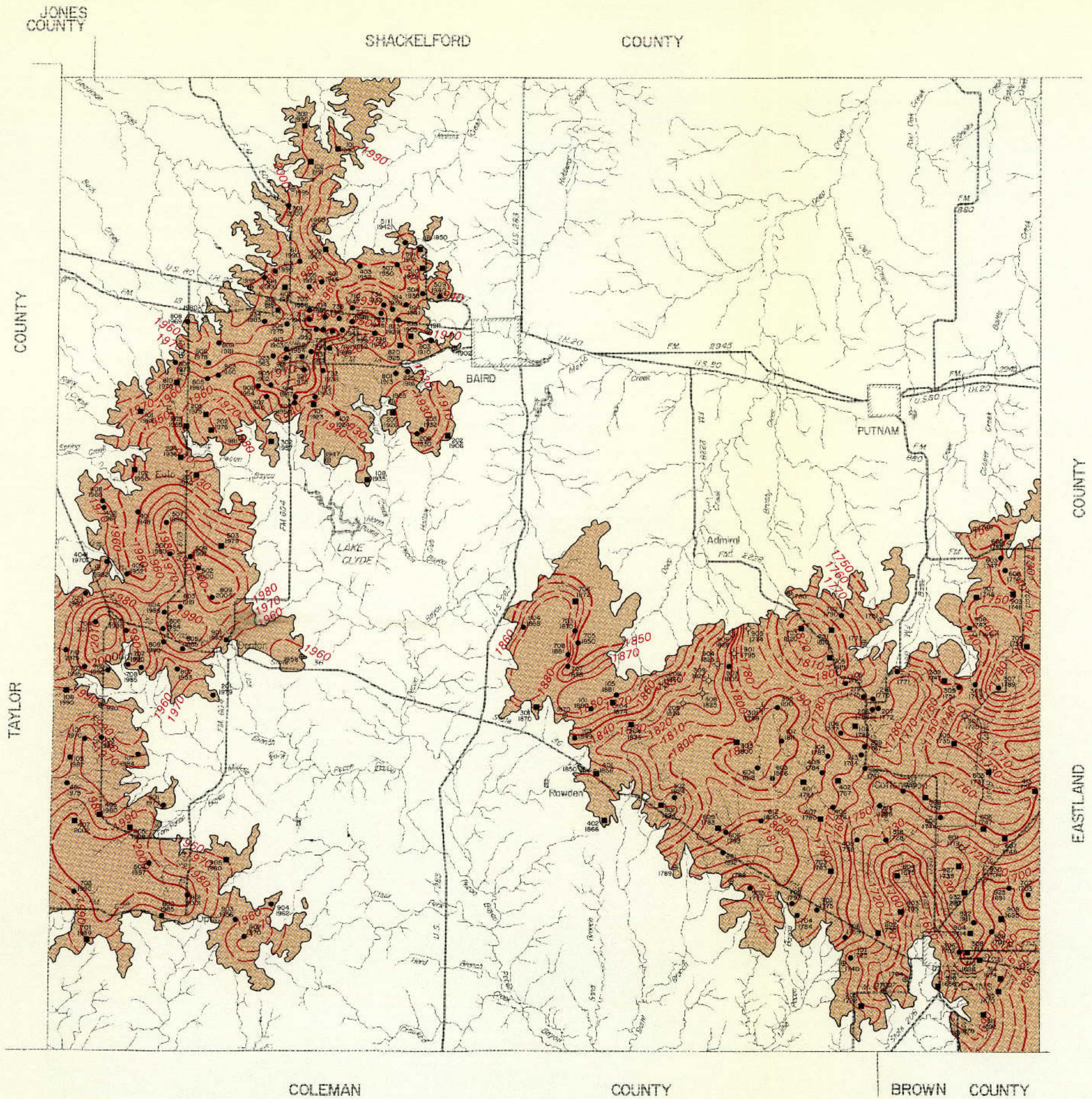
Within Callahan County, the Antlers Formation in its upper part consists of cream to near white, very fine to fine-grained sandstone interbedded with claystone which is brown to purplish pink, blocky, sandy, and locally calcareous. The middle part of the Antlers is also composed of a claystone as previously described. The lower part of the Antlers also contains sandstone but has conglomerate interbedded. The conglomerate consists of pebbles of chert and quartz with local green clay casts (Bureau of Economic Geology, 1972). The Antlers Formation is believed to attain a maximum thickness of about 185 feet (56.4 m) within the county. A marked erosional unconformatory separates the underlying Permian beds from the Antlers Formation which, from a large regional perspective, dips very gently to the southeast at an estimated 25 feet per mile or 7.6 meters per kilometer (Figures 12, 23, 24, and 25).

Figure 12 is a map which depicts the base of the Antlers Formation and attempts to reproduce the old erosional surface upon which Antlers sediments were deposited. The indicated topography, in general, is slightly hilly to rolling with a maximum relief of about 30 feet (9.1 m). The structural lows delineate the old stream patterns which were in existence at the time that the Antlers was deposited. For the most part, pre-Cretaceous streams were flowing from northwest to southeast, and much of the irrigation development appears to correlate with the structural lows which should contain the most permeable and thickest sediments in the Antlers (Figures 12 and 22).

When used in conjunction with a topographic map, Figure 12 can also be used to estimate the depth of possible water wells drilled for ground water in the Antlers Formation. The elevation of the land surface is first estimated from a topographic map at the desired location of a water well. The elevation of the base of the Antlers at the proposed well site is then determined from Figure 12. The value as determined from Figure 12 subtracted from the estimated surface elevation of the subject well will give an approximate depth to the "red beds" or Permian rocks.

Ground-Water Source, Occurrence, and Movement

The primary source of ground water to the Antlers is precipitation falling on its outcrop area or indirectly as seepage from streamflow. Additionally, minor amounts of ground water may be



EXPLANATION

Well

Oil or gas test

Reported well data

Outcrop

Wells and data points used for control
Upper number indicates last three digits of well number
Lower number indicates approximate altitude of the base of the Antlers Formation, in feet above mean sea level

—1840— —

Line showing approximate altitude of the base of the Antlers Formation, in feet
Dashed where control is absent or limited
Interval 10 feet
Datum is mean sea level

Outcrop of the Antlers Formation

0 1 2 3 4 5 Miles

0 1 2 3 4 5 Kilometers

Base map from general highway map of the Texas State Department of Highways and Public Transportation

Geology adapted from Geologic Atlas of Texas, Abilene sheet, 1972: Bureau of Economic Geology, The University of Texas at Austin

Figure 12

Approximate Altitude of the Base of the Antlers Formation

derived from interformational drainage from rocks of Fredericksburg age which may locally overlie the Antlers and contain limited amounts of ground water. Only a small portion of the precipitation which falls, however, actually reaches the water table (Figure 7).

Usable amounts of ground water occur over most of the two outcrop areas of the Antlers Formation (Figure 5). The ground water within the Antlers occurs in the spaces between the individual particles of sand, gravel, and clay. Except in areas where the Fredericksburg Group overlies the Antlers Formation, ground water in the Antlers Formation is found primarily in the basal sands and gravels where permeabilities are usually greater. In two known areas, one northeast of the community of Rowden and the other just north and west of the community of Denton, perched ground water is known to exist in the upper part of the Antlers Formation. In these areas, there are two separate water levels present.

The upper surface of the water table is unconfined in almost all areas of the Antlers and therefore is said to be under water-table conditions. In most areas, the water table is a short distance above the basal sand and gravel.

Movement of ground water is down gradient, from the high to low elevations, at right angles to the contours which denote the configuration of the water table. Ground-water movement is, in general, toward the major streams or their tributaries.

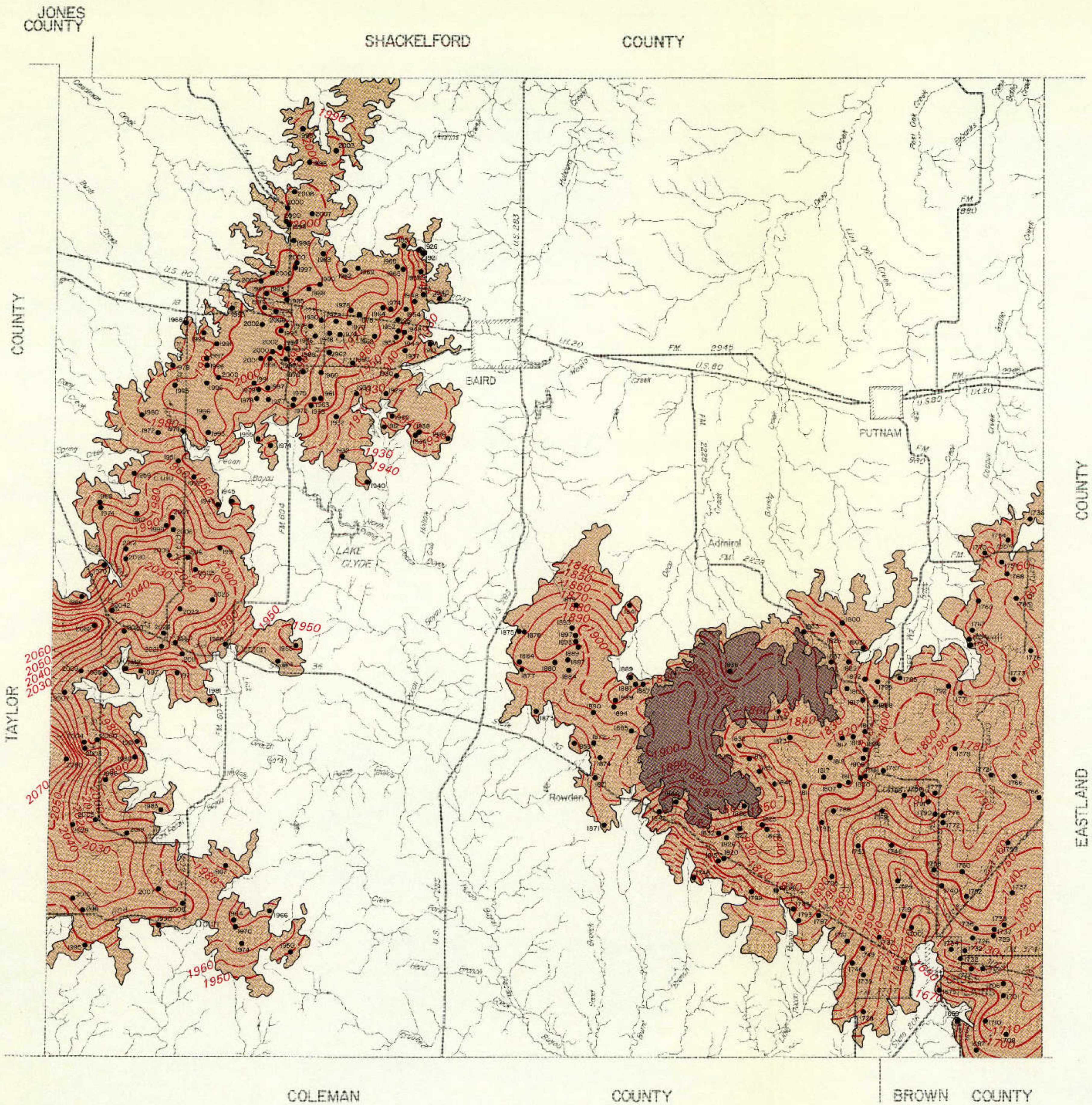
In the Clyde-Oplin area dominant ground-water movement is to the northeast, east, and southeast. Movement is also to the northwest and, locally, to the north and south away from the ground-water highs and toward the surface drainage system.

In the Cross Plains area, dominant ground-water movement is southeast and south. Additionally, some movement is northward into the tributaries of streams which drain that area (Figures 13 and 14).

Changes in Water Levels

A comparison of the water-table maps for the winter of 1940 (Figure 14) and for the winter of 1970-71 (Figure 13) shows water-level rises over almost all of the Clyde-Oplin area and the Cross Plains area. In the Clyde-Oplin area, rises during the period ranged from 0.0 to 11.5 feet (0.0 to 3.51 m) in spring 30-44-404 and well 30-36-602. A slight decline of 1.3 feet (0.40m) was recorded during this period in well 30-52-905. Since the area is one of very limited pumpage, one of the water levels may not have been at static level when measured. In the Cross Plains area, water levels rose from 0.02 foot (0.006 m) in well 30-54-303 to 9.1 feet (2.8 m) in well 30-63-201. Locally, four wells 30-45-902, 30-46-702, 30-53-301, and 30-54-801 reflected declines of 2.1 (0.64), 1.2 (0.37), 1.8 (0.55), and 9.7 feet (3.00 m), respectively. The decline in well 30-54-801 could have been caused by measurement on a pumping level either in 1940 or on the recent measurement. The reasons for the minor declines in the other three wells are unknown.

The hydrographs shown in Figure 15 are records of Antlers Formation water levels from 1940 through 1975. The hydrograph of well 30-55-502 is for the period 1966-75. The two wells with long records both show a general upward trend in water levels with time. Figure 16 compares seasonal water-level fluctuations in observation wells during the period September 1969 to



EXPLANATION

• 1875
Well used for control
Number indicates approximate altitude of water level, in feet above mean sea level

—1870— —
Line showing approximate altitude of water level, in feet
Dashed where control is absent or limited
Interval 10 feet
Datum is mean sea level

Outcrop of the Antlers Formation

Approximate area of perched water table in the upper part of the Antlers Formation

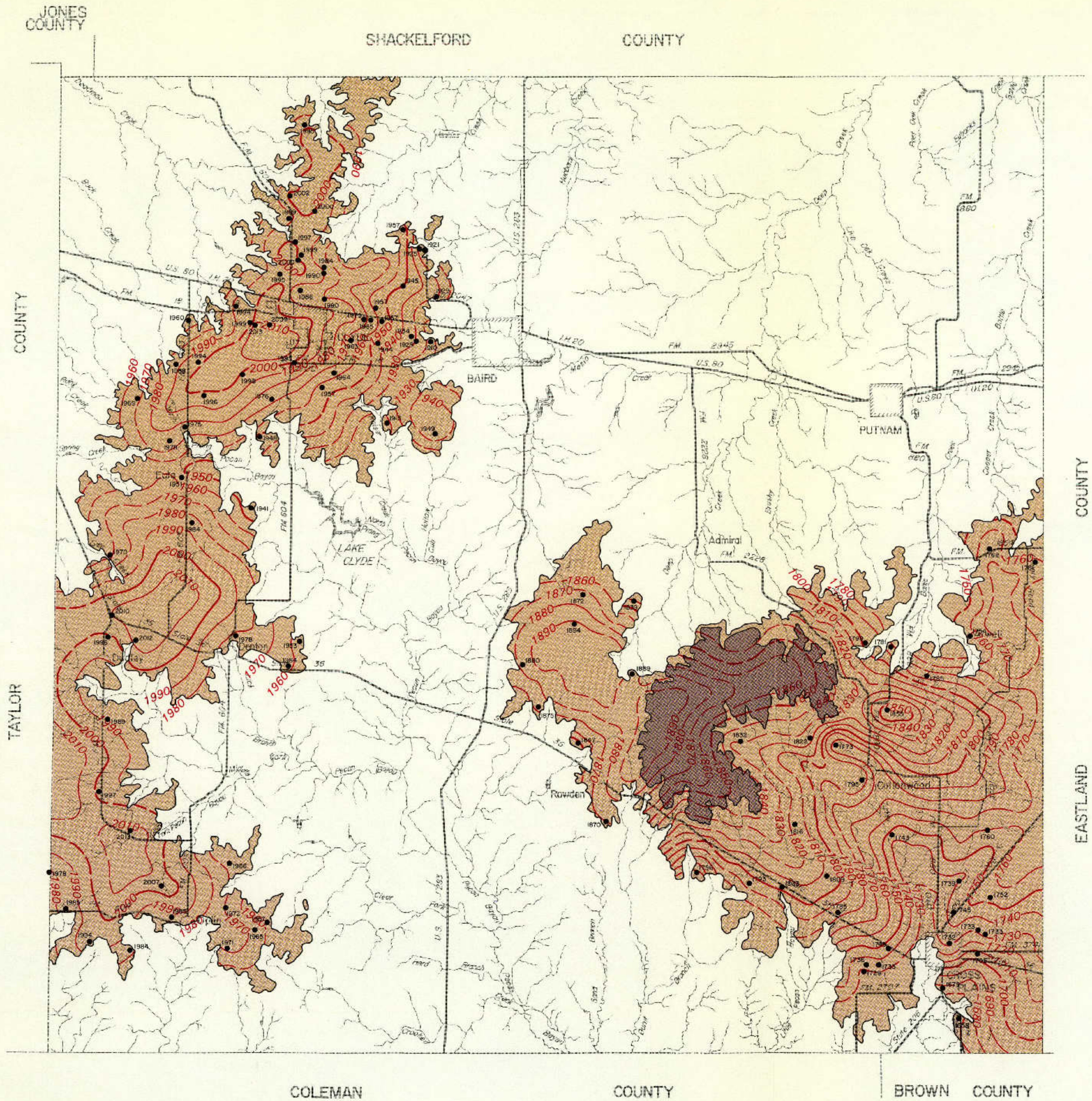
0 1 2 3 4 5 Miles

0 1 2 3 4 5 Kilometers

Base map from general highway map of the Texas State Department of Highways and Public Transportation

Geology adapted from Geologic Atlas of Texas, Abilene sheet, 1972; Bureau of Economic Geology, The University of Texas at Austin

Figure 13
Approximate Altitude of Water Levels in Wells in the Antlers Formation, Fall and Winter 1970-71



EXPLANATION

•1875

Well used for control
Number indicates approximate altitude of water level, in feet above mean sea level

—1870—

Line showing approximate altitude of water level, in feet
Dashed where control is absent or limited
Interval 10 feet
Datum is mean sea level

Outcrop of the Antlers Formation

Approximate area of perched water table in the upper part of the Antlers Formation

Water level data were partially derived from the following source:
George, W.O., 1940, Callahan County, Texas, Records of wells and springs, drillers' logs, water analyses, and map showing locations of wells and springs: Texas Board Water Engineers duplicated rept., 44 p.

0 1 2 3 4 5 Miles
0 1 2 3 4 5 Kilometers

Base map from general highway map of the Texas State Department of Highways and Public Transportation

Geology adapted from Geologic Atlas of Texas, Abilene sheet, 1972: Bureau of Economic Geology, The University of Texas at Austin

Figure 14
Approximate Altitude of Water Levels in Wells in the Antlers Formation, Winter 1940

January 1972 with precipitation at Baird. The hydrographs generally reflect water-level declines due to pumpage and water-level increases following increased rainfall. Additionally, precipitation records (Figure 3) and pumpage changes (Figure 11) are also reflected on the hydrographs of Figure 15, suggesting a quick response to outside influences.

Clearing of much of the water-consuming vegetation (phreatophytes); improved farming practices of terracing, contour plowing, and deep plowing; and general increase in rainfall since 1957 have all possibly been contributing factors to the general rise in water levels.

Recharge and Discharge

The source of all water in storage in the Antlers Formation, as well as the source of recharge, is direct precipitation on its outcrop area. Recharge varies, regionally, with the volume and frequency of precipitation. Other determining factors of recharge are the local permeability of the surface or the nature of the soil mantle, the topography, and the kind and amount of vegetative cover.

Recharge to the Antlers Formation is probably greatest within the county in the areas of outcrop which are composed of loose, friable sand. These areas are highly permeable and usually permit water to infiltrate the soil zone and percolate to the water table. When these localities contain thick cover of oak and mesquite trees, much water is lost during the spring, summer, and fall due to evapotranspiration as the trees derive their needed moisture from the saturated zone. Some of the remaining soils on the Antlers outcrop are fairly tight. However, in areas where the surface is nearly flat and the trees have been cleared, these soils are generally in cultivation. Here, the farming practices of terracing, contour plowing, and deep plowing enable the soils to catch and retain considerable precipitation, allowing some of it to percolate downward to the water table.

Natural recharge rates and quantities are extremely difficult to determine and the reliability of the estimates is often questionable. Data collected during this investigation were not sufficient to determine a reliable estimate of recharge for the Antlers Formation. Therefore, recharge rates developed by Department staff to evaluate the main Trinity Group aquifer of the North-Central Texas area and the Edwards Plateau area near the Llano Uplift were used to estimate the recharge to the Antlers (Texas Water Development Board, 1977).

Within the Brazos, Trinity, and Red River drainage basins, the annual effective recharge to the Trinity Group aquifer was determined, for the most part, using the trough method. Utilizing this method, the transmission capacity of the aquifer was calculated by assuming that water levels were lowered along a line approximately parallel to the outcrop trend and to the top of the aquifer where the top was 400 feet below the land surface. Using these limitations and provided that sufficient water is available from precipitation, it was determined that approximately 1.5 percent of the average annual precipitation falling on the outcrop (effective recharge) can be transmitted through the Trinity Group aquifer to supply the assumed withdrawals on a sustained basis (Price, 1979).

Within and west of the main aquifer in the Brazos, Trinity, and Red River basins, as well as in the Colorado River basin, are outliers of surficial deposits of sand, gravel, and limestone which also contain usable quality ground water. These aquifers are also considered a part of the Trinity

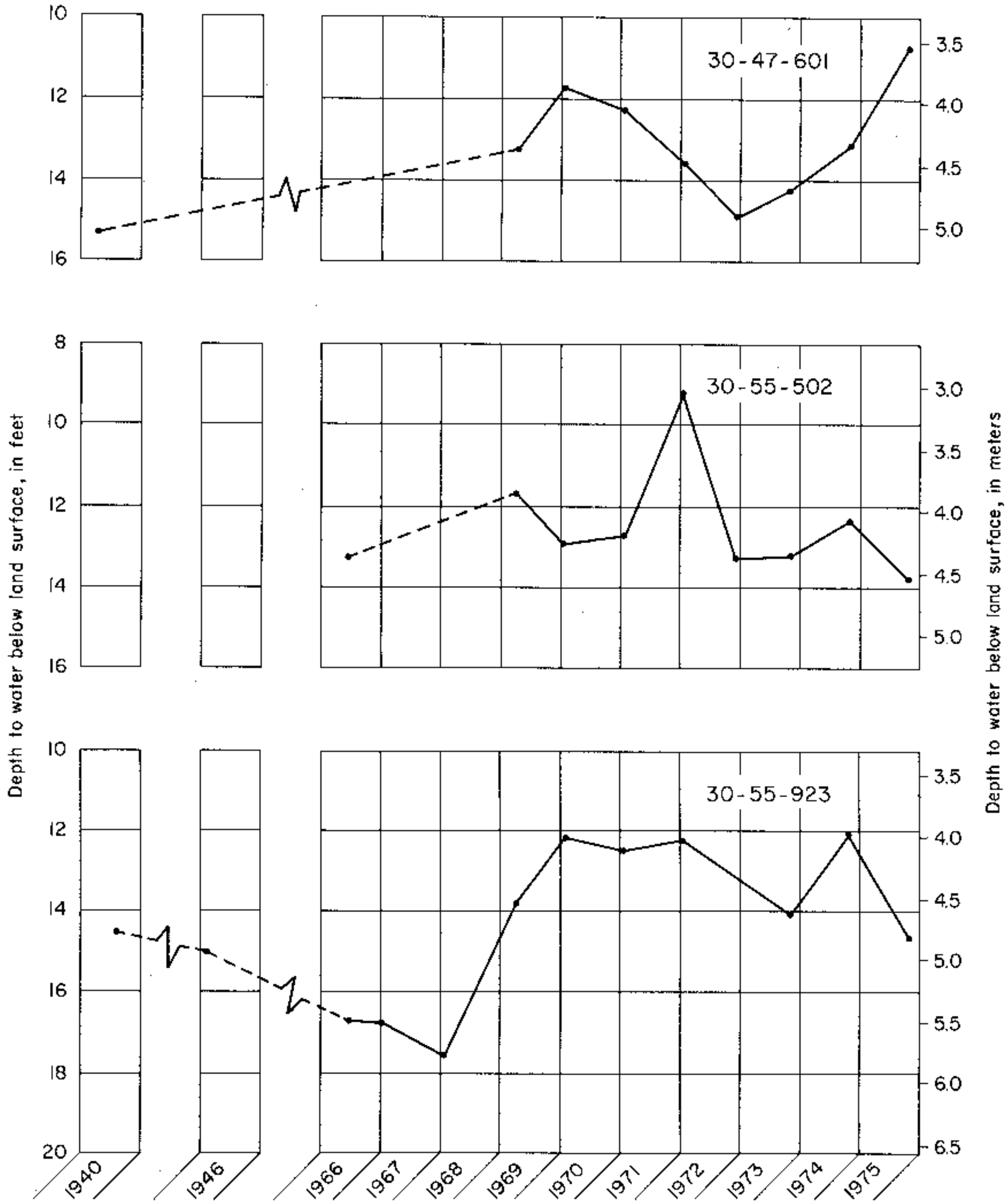


Figure 15

Water-Level Fluctuations in Observation Wells in the Antlers Formation, 1940-75

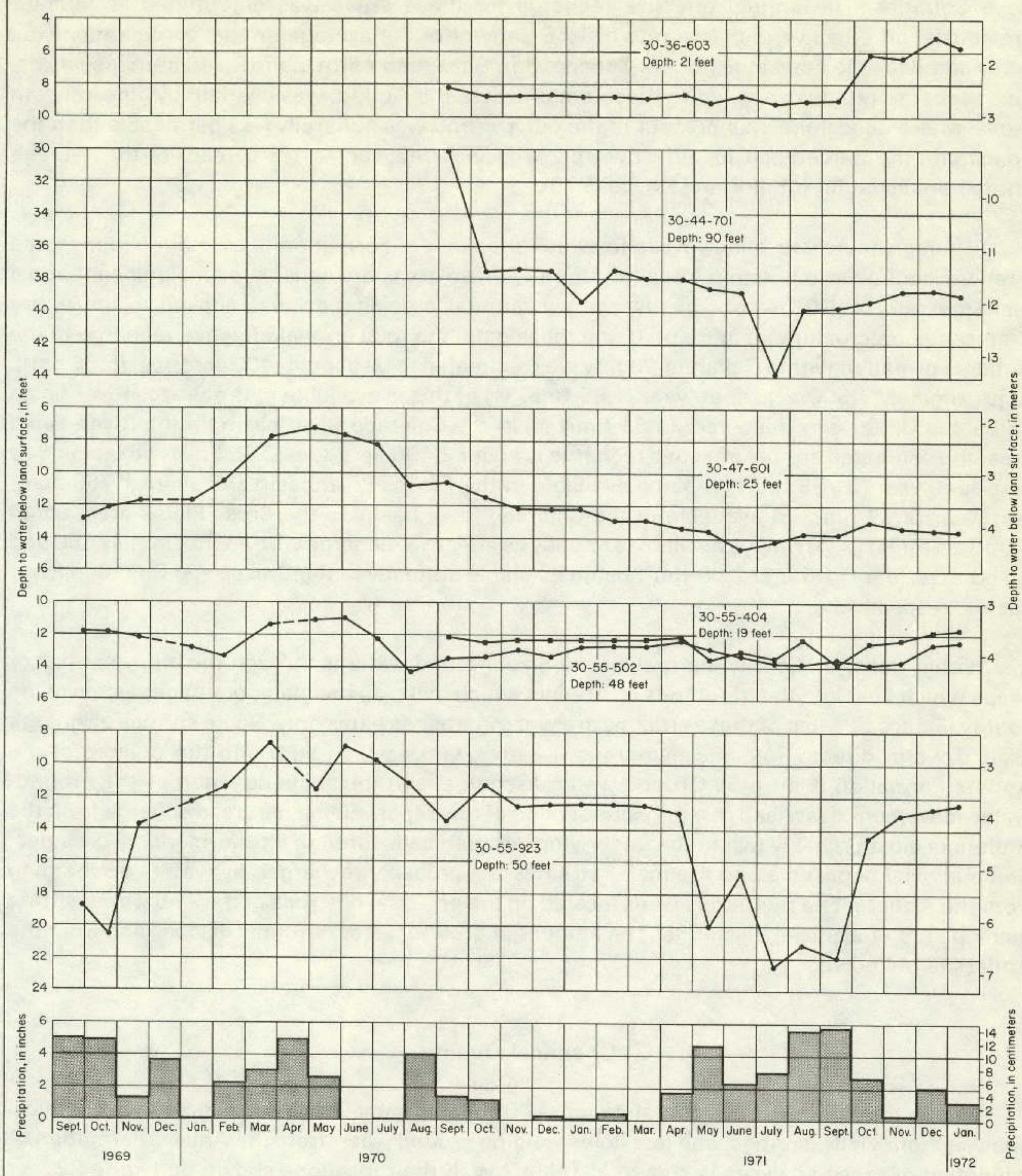


Figure 16

Seasonal Water-Level Fluctuations in Observation Wells in the Antlers Formation and Monthly Precipitation at Baird, September 1969-January 1972

(Precipitation Data From Records of U.S. Weather Service)

Group aquifer. These are located in Callahan, Coleman, Taylor, Runnels, Nolan, Mitchell, and Coke Counties. The annual effective recharge for these areas was determined as follows. Previously, an effective recharge rate of 1.58 percent of the average annual precipitation was determined for the limestones of the Concho, San Saba, and north Llano River drainage basins. This recharge rate was applied to those areas where the Antlers was overlain by limestone. In areas where sandstone was present in the outcrop and was generally less permeable than the limestone, the percentage for effective recharge was reduced to 1.5 percent of the average annual precipitation (Muller and Price, 1979).

Although there are minor areas in which the Antlers Formation is overlain by limestone (Fredericksburg Group) within Callahan County, these areas are considered insignificant and a recharge rate of 1.5 percent of the average annual precipitation was applied to the entire Cretaceous outcrop area (Figure 5). Using these data, the total annual effective recharge to the Antlers Formation within Callahan County was estimated to be about 5,400 acre-feet (6.66 hm^3). Approximately 1,500 acre-feet/year (1.85 hm^3/yr) of this is available in the Brazos River basin and about 3,900 acre-feet/year (4.81 hm^3/yr) in the Colorado River basin. In the Clyde-Oplin area, the estimated annual effective recharge is about 2,400 acre-feet (2.96 hm^3) with about 640 acre-feet/year (0.789 hm^3/yr) being available in the Brazos River basin and about 1,760 acre-feet/year (2.17 hm^3/yr) available in the Colorado River basin. In the Cross Plains area, about 3,000 acre-feet (3.70 hm^3) is available annually as effective recharge with approximately 850 and 2,150 acre-feet (1.05 and 2.65 hm^3) being available annually in the Brazos and Colorado River basins, respectively.

Within Callahan County, natural discharge of ground water is through the many springs or seeps which flow into the tributaries of streams which make up the major drainage system of the county (Figure 5). Most of these streams are wet-weather streams only. Some springs discharge ground water directly into the numerous livestock tanks which surround the outcrop of the Antlers Formation (Figure 5). Ground water discharge is in the same direction as the ground-water movement described in a previous section of this report. Some natural discharge from the Antlers is most probably lost to the underlying Permian beds through interformational drainage. Some alluvial deposits along the major streams are probably recharged by waters discharging from the Antlers. The numerous wells located on the principal outcrops of the Antlers constitute many points of artificial discharge. The amount of ground water naturally discharging from the Antlers is unknown.

Chemical Quality

During this and previous investigations, 308 water samples were collected for chemical analysis from wells, springs, and test holes yielding ground water from the Antlers Formation. A tabulation of these analyses is shown in Table 7 with their locations shown on Figure 22.

For the most part, ground waters derived from the Antlers are of good chemical quality. The majority of samples collected from the aquifer were low in dissolved solids. However, based on the range in dissolved solids, the water would be classed as fresh to very saline. Analyses indicate wide variations in the range of principal chemical constituents in the water. Usually, ground waters obtained from this aquifer contained excessive hardness and, locally, some were high in dissolved iron content. Chloride, sulfate, fluoride, and nitrate concentrations were within recommended limits in the majority of the samples. Additionally, most ground water was suitable for the irrigation of all crops normally grown within the county.

Dissolved-solids contents of fresh to very saline ground waters collected from the Antlers ranged from 134 to 16,923 mg/l. The following table shows a breakdown of the various ranges of dissolved solids.

Range in dissolved solids (mg/l)	Number of analyses	Percent of total analyses
500 or less	139	45
501 to 1,000	110	36
1,001 to 2,000	47	15
2,001 to 3,000	7	2
over 3,000	5	2

Eighty-one percent of the samples collected contained less than 1,000 mg/l dissolved solids and 17 percent contained water which ranged from 1,001 to 3,000 mg/l dissolved solids which would be termed slightly saline in quality. Up to 1,000 mg/l dissolved-solids content is permitted for public supplies (Texas Department of Health, 1977). This is also the suggested upper limit for domestic use; however, waters with higher dissolved-solids content than this have been used for extended periods of time without any apparent ill effects. Normally, ground waters containing greater than 2,000 mg/l are not recommended for drinking purposes.

Concentration ranges of the principal chemical constituents, exclusive of obviously contaminated waters, found in ground waters of the Antlers Formation are as follows:

Constituent	Range (mg/l)
Iron	0.0 to 4.8
Calcium	13 to 435
Magnesium	2 to 234
Sodium	3 to 650
Potassium	<1 to 32

Constituent	Range (mg/l)
Bicarbonate	30 to 840
Sulfate	3 to 560
Chloride	2 to 1,050
Fluoride	< .1 to 5.3
Nitrate	< .4 to 135

It is apparent from these ranges that the quality of Antlers ground water is fairly variable. However, the waters are usually of much better quality than the quality of water found in younger Recent alluvium or older Permian rocks (Table 7).

Ground waters collected from the Antlers Formation had total hardness values ranging from 89 to 6,510 mg/l. Three samples (1 percent) contained 61 to 120 mg/l and, therefore, would be classed as moderately hard. Eight samples (3 percent) ranged from 121 to 180 mg/l and are classified as hard water. The remainder of the samples, or 96 percent of the total, are classified as very hard water.

Iron in comparatively small amounts is derived primarily from the soils and sediments through which the water passes. Upon exposure to air, water containing only a small amount of iron leaves a reddish residue or stain. For this reason, ground waters containing excessive amounts of iron (greater than 0.3 mg/l) are objectionable for domestic and some industrial uses. The iron content was determined on 15 samples collected from the Antlers and ranged from 0.00 to 4.8 mg/l. A total of 13 samples, or 87 percent, contained iron within the recommended limits.

When either chloride or sulfate concentrations are present in amounts above the recommended upper limit of 300 mg/l, ground waters taste either "salty" or "gyppy", respectively. Chloride concentration of Antlers ground water ranged from 2 to 10,500 mg/l with 88 percent of 308 samples collected containing less than the recommended upper limit. The range in sulfate content was from 3 to 1,450 mg/l. Ninety-four percent of the 308 samples analyzed contained less than the recommended upper limit.

Fluoride content of ground waters collected from the Antlers Formation ranged from less than 0.1 to 5.3 mg/l. Based on an annual average maximum daily air temperature within the county, which varies from 76.2 to 78.2 °F (24.6 to 25.7 °C), the maximum recommended upper limit for fluoride would be 1.6 mg/l. A total of 271 of 305 samples collected (92 percent) contained less than the recommended upper limit.

Consumption of ground water containing excessive nitrate can have harmful effects on both humans and livestock. Adult humans can tolerate much more nitrate in drinking water than babies, but prolonged illness and even death can occur when the nitrate concentration is high enough and the water is consumed over a long enough period of time. Burden (1961) concluded that the average lethal dose for a 140-pound adult is between 80 and 300 milligrams of nitrate per kilogram (2.205 pounds) of body weight. Maximum recommended limits for nitrate for humans is an upper limit of 45 mg/l, and the upper limit for livestock water is 220 mg/l; however, there should be concern for animals when the nitrate content reaches 100 mg/l (Texas Department of Health, 1977 and Burden, 1961).

Out of a total of 308 Antlers water samples collected, 28 samples or 9 percent contained nitrate in excess of the recommended upper limit of 45 mg/l (Table 7). The nitrate content in all of the samples ranged from less than 0.4 to 1,050 mg/l.

Many of the well waters that contain excessive amounts of nitrate are possibly contaminated due to the effects of sewage from nearby septic tanks or animal wastes from barnyards. This would account not only for high concentrations of nitrate but would also be an explanation for part of the increase in chloride concentration as the two are associated (Hem, 1959, p. 118).

Boron, necessary for crop growth, is not known to affect the use of water for purposes other than irrigation. Excessive amounts of boron are highly toxic to plants and render water unsuitable for irrigation. A boron concentration as high as 1.0 mg/l is permissible for irrigation of sensitive crops such as deciduous fruit and nut trees; as high as 2.0 mg/l for semi-tolerant crops such as most small grains, cotton, potatoes, and other vegetables; and as high as 3.0 mg/l for tolerant crops such as alfalfa and most root vegetables. The boron content of 204 samples from selected wells in the Antlers Formation ranged from 0.04 to 2.2 mg/l. A tabulation of the boron content of Antlers waters follows:

Range in boron content (mg/l)	Number of analyses	Percent of total analyses
0 to 1.0	202	99
1.1 to 2.0	1	.5
2.1 to 3.0	1	.5
over 3.0	0	0

Main crops grown in Callahan County are peanuts, small grains, and pecans. Pecans are a sensitive crop and can tolerate a boron content up to 1.0 mg/l. Grains are semi-tolerant crops and can stand boron content up to 2.0 mg/l. Peanuts are classed as a tolerant crop and they can stand a boron content up to 3.0 mg/l. Therefore, most irrigation waters pumped from the Antlers Formation can be used without concern for toxicity due to boron.

A widely used system for determining the quality of irrigation waters is shown in Figure 10 and is based on the salinity hazard as measured by the specific conductance and the sodium (alkali) hazard as measured by the SAR (U.S. Salinity Laboratory Staff, 1954, p. 69 - 82). Plots of

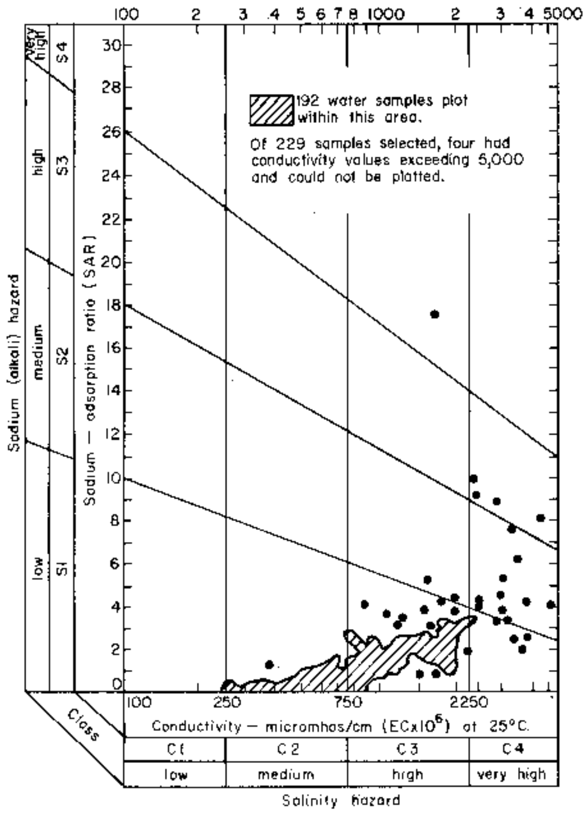


Figure 17.—Classification of Antlers Formation Water Used for Irrigation

representative Antlers Formation waters are shown on Figure 17. All but 39 of the 229 samples of Antlers ground water fall within salinity-hazard classes C2 and C3 and sodium-hazard class S1. The importance of these classes is shown in Table 3.

Of 300 Antlers samples for which percent sodium was calculated, 296 (99 percent) had a percent sodium of 60 or less and 4 samples had a percent sodium greater than 60. Irrigation waters with a percent sodium of 60 or less and a low bicarbonate content are usually satisfactory. When the percentage is greater than 60, the sodium hazard becomes progressively greater.

Following irrigation, the soil dries and the soil solution becomes progressively more concentrated. This condition creates a tendency for the less soluble compounds to precipitate from solution. Both calcium and magnesium carbonate, being less soluble than sodium carbonate, may precipitate with drying. This precipitation results in an increase in the proportion of sodium in solution. The bicarbonate ion is the source of carbonate which makes the precipitation possible. Conditions favoring precipitation and the extent to which calcium and magnesium carbonates will precipitate are not fully understood. However, waters containing 1.25 to 2.5 me/l (milliequivalents per liter) of residual sodium carbonate (RSC) are considered marginal and those containing greater than 2.5 me/l probably are unsafe for irrigation use. The equation for calculating RSC is contained in Table 2, and RSC values for ground waters in Callahan County are shown in Table 7. A total of 293 samples out of 302 considered or 97 percent contained less than 1.25 me/l and, therefore, almost all of the sampled wells pumping from the Antlers produce waters which are satisfactory for irrigation insofar as the RSC is concerned.

Historical Changes in Water Quality

The quality of water derived from the Antlers in Callahan County, as well as from other water-bearing units, varies greatly (Table 7 and Figure 9). Even with this exhibited wide range in quality, some of the waters sampled during this study appear to have been altered. Both natural and artificial means contribute to the alteration of the chemical quality of ground water.

Natural alteration occurs when water dissolves minerals from the rocks through which it percolates or over which it flows. In Callahan County natural alteration is evidenced by locally high concentrations of calcium and magnesium. Many wells also yield water extremely high in bicarbonate. These constituents are probably derived from dolomites and limestones which are present in rocks of Cretaceous age within the county. Ground waters found in Permian undifferentiated and Quaternary or Recent alluvium also contain high concentrations of the above constituents which suggests that much of the waters found in these aquifers may have been derived from the Antlers Formation.

Artificial alteration of ground-water quality may be by biological or chemical means. The positioning of wells near, or downslope from, septic tanks and livestock feedlots or barnyards may result in biological contamination. The presence of an abnormally high nitrate concentration in the water locally is usually suggestive of biological contamination.

Alteration of ground water by chemical means may be associated with the production of oil and gas, or may result from improperly constructed industrial waste-disposal wells. Produced brines as a potential source of ground-water contamination will be discussed in a later section of this report. The locations of several wells and springs which show evidence of possible brine contamination are shown on Figure 21.

Figure 18 contains a series of radial-pattern diagrams which illustrate the relative concentrations of dissolved minerals in native ground water, in water from selected apparently contaminated wells, and in a typical oil-field brine which was produced with oil or gas at a nearby location. The percent of each major chemical constituent—calcium (Ca), magnesium (Mg), chloride (Cl), sodium (Na), potassium (K), sulfate (SO_4), and bicarbonate (HCO_3)—is plotted on radial coordinates and the plots connected. The shape of the patterns thus illustrates the similarities and differences between the chemical analyses. The similarity of the plots on native ground water should be noted. This suggests that much of the ground water present in the minor aquifers may have been derived from discharge from the Antlers Formation. Although several indications of apparent contamination are still evident in Callahan County, efforts have been and are being made by the Texas Railroad Commission and the many petroleum operators to eliminate contamination of the surface water, soil, and ground water by oil-field brines and hydrocarbons.

Changes in native-quality water have occurred in some areas underlain by the Antlers Formation. Historical quality data, when present, are included in Table 7 to indicate the location and the amount of change which has occurred. A total of 52 wells or springs sampled for chemical analysis in earlier investigations were resampled during this investigation. Forty-four of these derived their ground waters from the Antlers. Considering only the Antlers samples, 16 of the recent samples showed essentially no change in chemical quality, and 16 exhibited improvement in overall quality. Nine samples showed only slight to moderate deterioration, and three exhibited significant worsening of quality.

Many wells contain water in which the nitrate concentrations are greater than the upper limit recommended for drinking purposes (Table 7 and Figure 22). Several Antlers wells are also thought to have been altered due to the presence of oil-field brines as the ground water contained an abnormally high content of chloride and dissolved solids, as well as sodium (Table 7, Figures 18

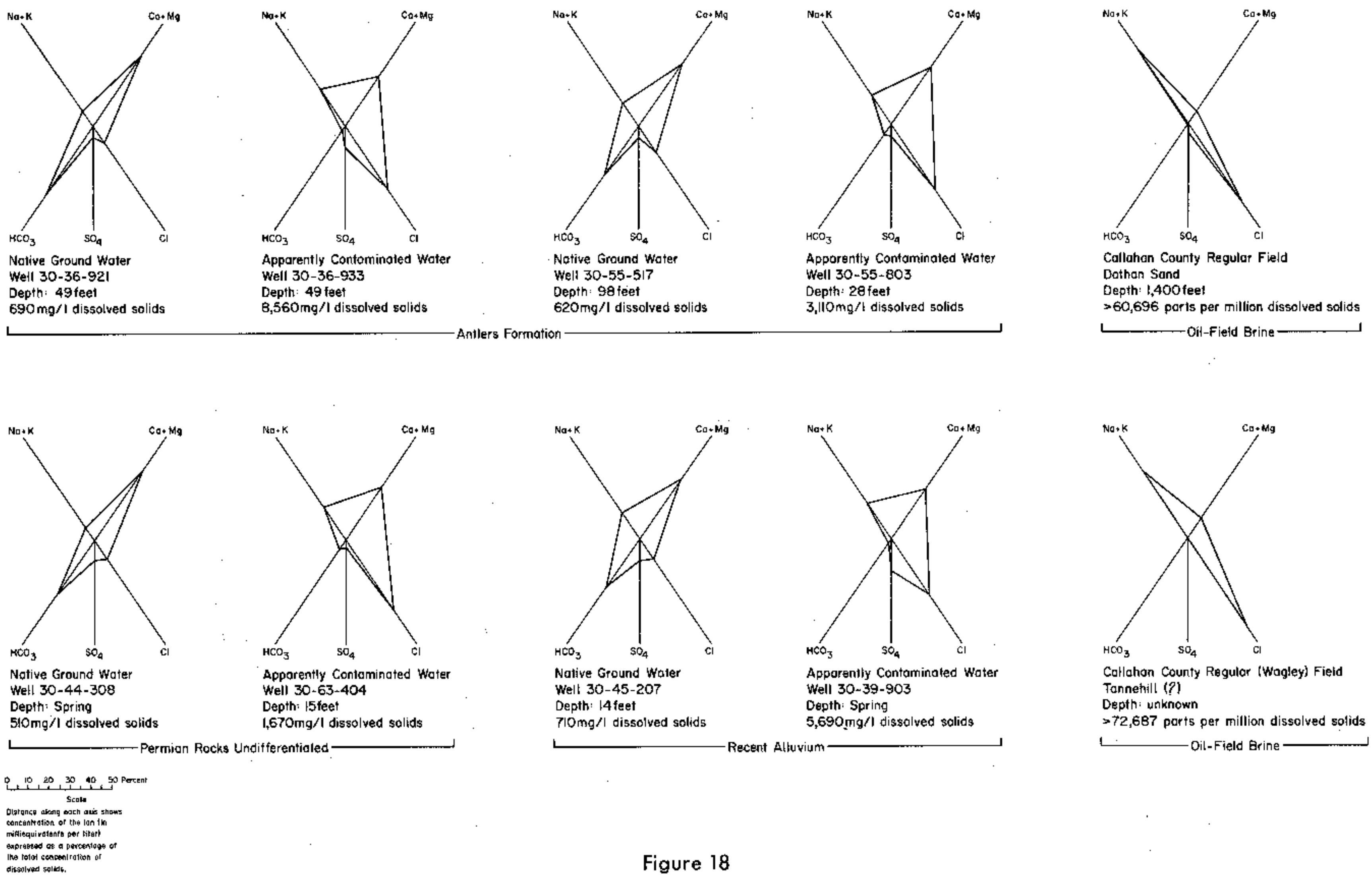


Figure 18

Diagrams of Chemical Analyses of Ground Water and Typical Oil-Field Brines and 22). The dissolved solids, chloride, and nitrate content of apparently contaminated water from 35 wells and 3 springs producing from the Antlers are as follows:

Well	Dissolved solids (mg/l)	Chloride (mg/l)	Nitrate (mg/l)
30-36-603	688	89	84
611	1,511	371	284
810	2,250	860	14
933	8,560	3,910	< .4
37-406	1,326	196	446
509 (Spring)	16,923	10,500	< .4
705	1,895	620	12
740 (Spring)	1,481	580	< .4
815	1,084	281	135
44-102	2,034	830	85
205	2,056	1,050	31
301	671	67	104
401	693	76	104
503	1,146	246	227
504 (Spring)	1,969	550	1.5
601	2,210	1,020	18
702	721	99	52
903	1,667	420	< 20
45-901	1,776	730	< .4
46-703	359	37	62
801	2,717	970	1,050

Well	Dissolved solids (mg/l)	Chloride (mg/l)	Nitrate (mg/l)
30-47-701	904	130	242
52-702	1,222	373	113
902	2,361	940	39
54-102	2,873	1,050	< .4
204	2,109	600	121
605	482	58	108
611	2,287	930	3.5
55-302	652	45	189
801	1,225	236	311
803	3,105	1,490	< .4
804	1,090	264	80
806	4,097	1,690	22
927	733	69	168
63-311	2,656	890	32
312	734	132	144
313	771	100	183
607	1,902	800	12

Ground Water Available for Development

Several hydrologic and economic factors determine the amount of water available for development from the Antlers Formation in the county. The major hydrologic factors are the volume of water in storage, the rate of recharge to the aquifer, and the ability of the aquifer to transmit water. The main economic factors are the number and cost of wells required to produce the maximum amount of water.

The amount of water in storage within the Antlers Formation is determined by the aerial extent of the water-bearing unit, its saturated thickness, and its porosity.

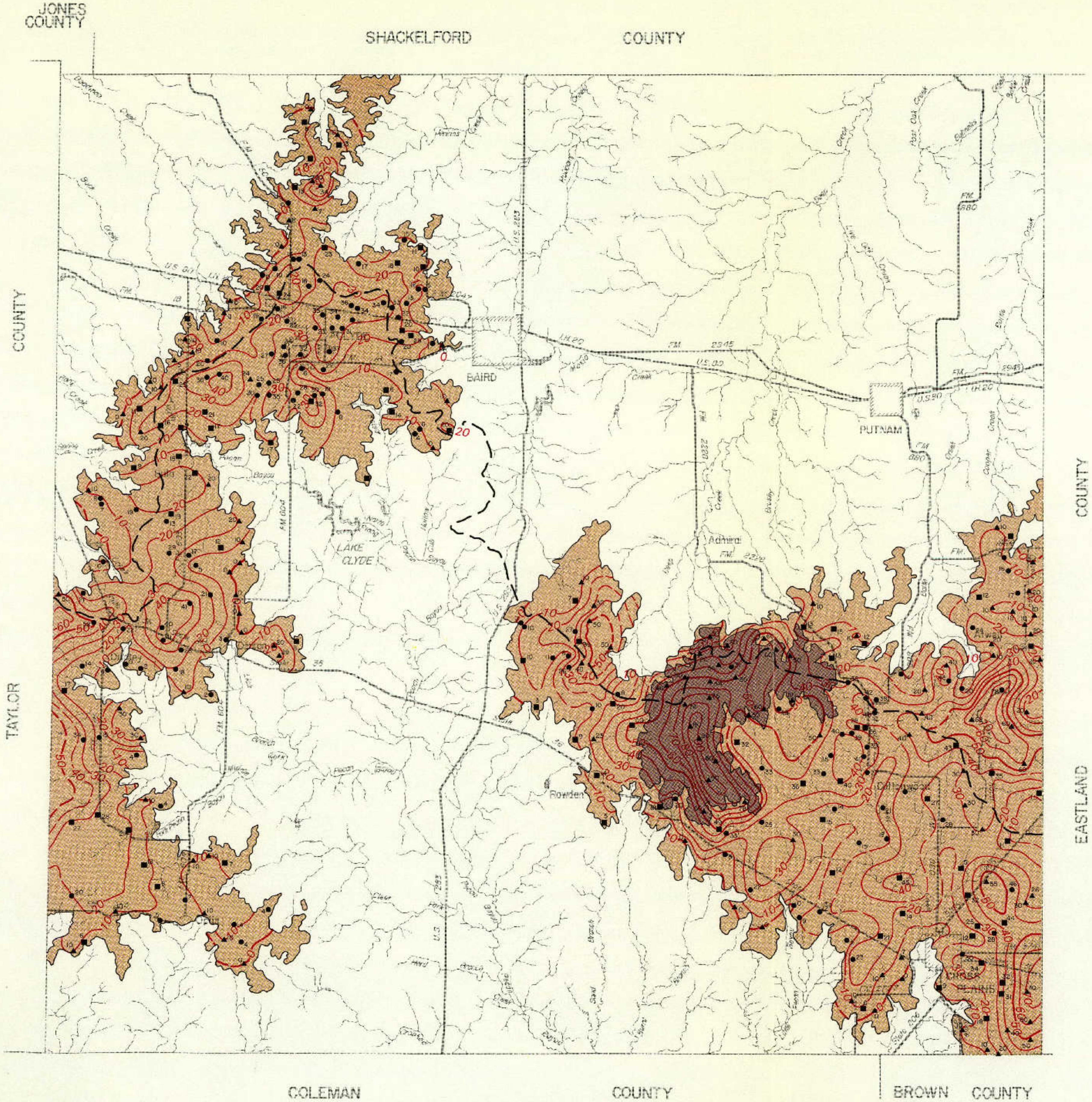
As has been previously stated, the Antlers Formation occurs within the county as two separate deposits which are located in the Clyde-Oplin and Cross Plains areas (Figure 5). These two developments currently support irrigation and municipal pumpage and have potential for limited additional development.

In order to evaluate the future availability of Antlers ground water in Callahan County, a saturated thickness map (Figure 19) was prepared from information shown on the water-table map of the Antlers Formation for the winter of 1970-71 (Figure 13) and the contour map of the base of the Antlers Formation (Figure 12). The total volume of saturated deposits in both the Clyde-Oplin and the Cross Plains areas was computed to be about 4.18 million acre-feet (5,155 hm^3) with about 1.36 million (1,675) and 2.82 million acre-feet (3,479 hm^3) being present in the Clyde-Oplin and Cross Plains areas, respectively. The greatest saturated thickness is present in the Cross Plains area where it reaches an estimated 90 feet (27 m) in an area about 3 miles (4.8 km) northeast of the community of Rowden (Figure 19). There are several other localities in the Cross Plains area where the Antlers has saturated thicknesses which reach or exceed 50 feet (15 m). Within the Clyde-Oplin area, saturated thicknesses are much less. Over most of the area, they are usually on the order of 40 feet (12 m) or less. An exception to this is in an area west-southwest of the community of Denton and near the Taylor County line where the saturated thickness reaches a maximum of about 75 feet (23 m).

Hydrologic and physical properties of the rocks and soils of the Antlers Formation in Callahan County were estimated using stratigraphic tests and drillers' logs compiled for this study together with data derived from previous ground-water studies relating to the Antlers and the Trinity Group. These data indicated that the average specific yield (coefficient of storage since the aquifer is under water-table conditions) of the Antlers is about 20 percent. If this average specific yield is representative, then only about 836,100 acre-feet (1,031 hm^3) is theoretically available from storage in both areas of Antlers outcrop within the county. About 271,800 acre-feet (335 hm^3) is available in the Clyde-Oplin area and about 564,300 acre-feet (696 hm^3) is available in the Cross Plains area. To dewater these areas completely would be impractical because the yields of wells fall off rapidly as the saturated thickness of the aquifer is greatly reduced. It also would require constant year-round pumpage. This is not economically feasible, nor is there a need for the water during the fall and winter months. Therefore, if it becomes necessary to dewater the aquifer, the realistic amount which can be recovered from storage is approximately 75 percent of the amount available from storage or about 627,100 acre-feet (773.2 hm^3) in the outcrop areas of the Antlers within the county. This would amount to about 203,800 acre-feet (251.3 hm^3) in the Clyde-Oplin area and about 423,300 acre-feet (521.9 hm^3) in the Cross Plains area.

The amount of water that can theoretically be developed annually is limited by the amount of effective recharge to the aquifer. During years of drought, discharge can exceed recharge with the deficit being pumped from storage. This condition can exist only temporarily, or until the supply in storage is exhausted. Fortunately droughts are eventually interrupted by years in which precipitation is normal or above normal. During periods in which recharge exceeds discharge, ground water previously removed from storage is partly or completely replaced.

As discussed in a previous section of this report, the total annual effective recharge to the Antlers in Callahan County was estimated to be about 5,400 acre-feet per year (6.66 hm^3/yr). Theoretically, this amount would be available annually for development by wells. However, it would be impractical to intercept all of this water. To do this would require capture by wells of all



EXPLANATION

●30

Well used for control
Number indicates approximate saturated thickness of the Antlers Formation, in feet

■20

Supplemental control point
Number indicates approximate saturated thickness of the Antlers Formation, in feet, derived by using a water level and a reported base of the Antlers Formation

▲10

Supplemental partial control point
Number indicates approximate saturated thickness of the Antlers Formation, in feet, derived by subtracting the altitude of the base of the Antlers Formation (Figure 12) from the altitude of the water level (Figure 13)

—10— —

Line showing approximate saturated thickness of the Antlers Formation
Dashed where control is absent or limited
Interval 10 feet

Outcrop of the Antlers Formation

Approximate area of perched water table in the upper part of the Antlers Formation

Approximate boundary between Brazos and Colorado River drainage systems (Callahan Divide)

0 1 2 3 4 5 Miles

0 1 2 3 4 5 Kilometers

Base map from general highway map of the Texas State Department of Highways and Public Transportation

Geology adapted from Geologic Atlas of Texas, Abilene sheet, 1972: Bureau of Economic Geology, The University of Texas at Austin

Figure 19

Approximate Saturated Thickness of the Antlers Formation, Winter 1970-71

natural discharge. Natural discharge, in part, supports vegetation growth and streamflow. It is possible to capture enough of this discharge during the summer months, however, to reduce all of local streamflow.

The largest use of ground water in Callahan County is for irrigation (Figure 11), which is confined mainly to the spring and summer months. Year-round pumping for this purpose is both uneconomical and unnecessary. During the fall and winter months much natural discharge would not be captured. However, it does not seem unreasonable to assume that half of the annual effective recharge to an aquifer can be economically captured on an annual basis. If this assumption is correct, then approximately 2,700 acre-feet (3.33 hm^3) could be economically captured annually by pumping wells. In 1978, an estimated 1,900 acre-feet (2.34 hm^3) was pumped for all uses within the county. Thus, approximately 800 acre-feet per year (0.986 hm^3/yr) of additional ground water could be realistically developed from the Antlers Formation within the county.

Even though additional amounts of water could be developed from the Antlers in Callahan County under conditions existing at the time of this study, maximum development would require numerous low-capacity wells. The saturated part of the formation is relatively thin over much of the area (Figure 19), and in these areas, the formation will not produce large quantities of water from single wells. Only in the areas of thickest saturation should wells be expected to produce larger volumes.

Many areas of the Antlers have a very limited areal extent as well as very little saturated thickness. This is especially true in the northern part of the Clyde-Oplin area. During prolonged drought with reduced recharge and declining water levels due to the inability of the aquifer to transmit large volumes of water, well yields may decline and, if the drought is of very long duration, wells may fail. This would normally be expected to occur first in the areas with less saturated thickness (Figure 19).

Possible Areas of Future Development

Generally, the most desirable areas for development of ground-water supply from the Antlers coincide with those areas of greatest saturated thickness (Figure 19). In these areas, the basal sands and gravels which are thickest and most permeable are generally associated with the structural lows or "valleys" in the erosional surface upon which the Antlers was deposited (Figure 12). The most promising areas for future irrigation or municipal development are generally those in which the saturated thickness exceeds 30 feet (9 m), although reliable irrigation wells have been developed in areas having less than this amount. In times of drought, excessive pumping may result in failure of wells having a thin saturated thickness. Within Callahan County, the Cross Plains area has greater possibilities for future irrigation or municipal development since greater saturated thicknesses are present. Locations in the Clyde-Oplin area could be selectively chosen, however.

Therefore, when selecting sites for future irrigation or municipal wells, Figures 22 and 19 should be used to select areas of greater saturated thickness and limited well development. Less care is required for selecting sites for domestic and livestock wells, but it is advisable to drill through the entire section of the Antlers Formation at a location having the greatest saturated thickness.

Other Water-Bearing Units

In addition to the primary aquifer, minor amounts of ground water also occur in Permian rocks and in Recent alluvium of Quaternary age.

The amounts of ground water used from these hydrologic units, as well as that available for possible future development, is considered to be small and insignificant. Well yields are also of questionable reliability. Ground water derived from these sources is known to be used for domestic or livestock purposes only.

Permian Rocks Undifferentiated

As previously stated, hydrologic units yielding only minor amounts of ground water from this system were collectively considered to be producing from the Permian rocks undifferentiated aquifer. The geologic characteristics of this aquifer are discussed in a previous section entitled "Geology as Related to the Occurrence of Ground Water."

Only 14 wells and 3 springs which yielded water from this hydrologic unit were inventoried during this study. These amounted to about 3 percent of the total number of wells and springs inventoried (Table 7 and Figure 22).

Extent of the Aquifer

Permian rocks crop out over most of the surface area of Callahan County (Figure 5). Two separate outcrops of the Cretaceous Antlers Formation cover a fairly extensive area of the Permian. Additionally, insignificant deposits of Recent alluvium, found along the tributaries of the major drainage system, also cover small areas of its surface. Individual members of the aquifer which dip west-northwest at approximately 40 feet per mile (7.6 m/km), crop out in belts of various widths trending in a northeast-southwest direction (Figures 23, 24, and 25).

Ground-Water Source, Occurrence, and Movement

Ground water found in Permian rocks is derived mainly by the infiltration of stream runoff, precipitation on the outcrop, and by limited interformational leakage from water-bearing deposits of Quaternary and Cretaceous age which overlie the individual limestone units. Precipitation is probably the major source of ground water found in the few sandstone members.

Occurrences of ground water in this hydrologic unit are believed to be confined to local zones of permeability in fractures and solution channels at or near the outcrop. The areas most favorable for well development are near the major streams and their tributaries.

Water present in Permian rocks is generally thought to be under water-table conditions. However, in some remote cases, there may be ground water under artesian conditions. The movement of ground water within the aquifer is downdip and toward discharge areas. Natural discharge areas are unknown. Several domestic and livestock wells are pumping from this aquifer and some movement is toward these areas of discharge.

Changes in Water Levels

Limited historical data are available on the Permian rocks undifferentiated aquifer concerning water-level fluctuations. However, six wells completed in various members of the hydrologic unit were measured in the spring and fall of 1940 and again in the spring of 1971. Five wells exhibited a net rise in water level during this period, ranging from 2.57 feet (0.78 m) in well 30-61-201 to 16.37 feet (4.99 m) in well 30-46-401. This was an average annual rise in water level of 0.08 foot (0.02 m) and 0.54 foot (0.16 m), respectively. One well (30-54-403) reflected a net decline in water level of 3.26 feet (0.99 m) or 0.11 foot per year (0.03 m/yr) during this same period (Table 5).

Recharge and Discharge

Recharge to the Permian rocks undifferentiated aquifer is dependent on rainfall. Much of the recharge is from streams which cross the aquifer's individual units. Interformational leakage from Cretaceous and Quaternary deposits overlying the Permian rocks provides additional recharge. Precipitation falling directly on the very limited outcrop of the individual units of the aquifer provides some recharge. Information is lacking to provide an estimate of the amount of recharge; however, it has exceeded discharge as reflected by the net rise in water levels since 1940 in five of six wells (Table 5).

Only two areas of natural discharge from this aquifer are known. These are springs 30-44-308 and 30-53-101 which were flowing an estimated 1 and 8 gal/min (0.063 and 0.505 l/s), respectively. Undoubtedly, there are other unknown areas of natural discharge. Artificial discharge is through the limited number of wells which pump from the aquifer.

Chemical Quality

Twenty-one representative samples of ground water from Permian rocks were collected for chemical analysis during this and previous investigations. These samples were collected from 13 selected wells, 1 test hole, and 3 springs located within the county. Only limited amounts of ground water are available from the individual members which make up this hydrologic unit. The water quality is variable, and the wells are scattered throughout the county. The dissolved-solids content of the samples ranged from 149 to 39,500 mg/l and the waters are classed as fresh to brine. The following table shows the number of analyses within certain ranges of dissolved-solids content:

Range in dissolved-solids (mg/l)	Number of analyses	Percent of total analyses
500 or less	7	33
501 to 1,000	7	33

Range in dissolved-solids (mg/l)	Number of analyses	Percent of total analyses
1,001 to 2,000	5	24
2,001 to 3,000	1	5
over 3,000	1	5

Variations in the chemical quality are reflected in the concentrations of some of the principal chemical constituents found in the samples. Sulfate concentrations ranged from 6 to 3,960 mg/l and chloride from 11 to 21,900 mg/l. In both cases, 81 percent of the samples contained less than 300 mg/l. Fluoride content ranged from 0.1 to 2.0 mg/l with 95 percent of the samples being below the recommended upper limit of 1.6 mg/l. Nitrate ranged from less than 0.4 to 480 mg/l with 38 percent of the samples containing above the maximum recommended value of 45 mg/l. Total hardness ranged from 116 to 15,600 mg/l, and 95 percent of the samples contained ground waters which were classed as very hard. For concentrations of the above constituents in individual wells, as well as other constituents, consult Table 7.

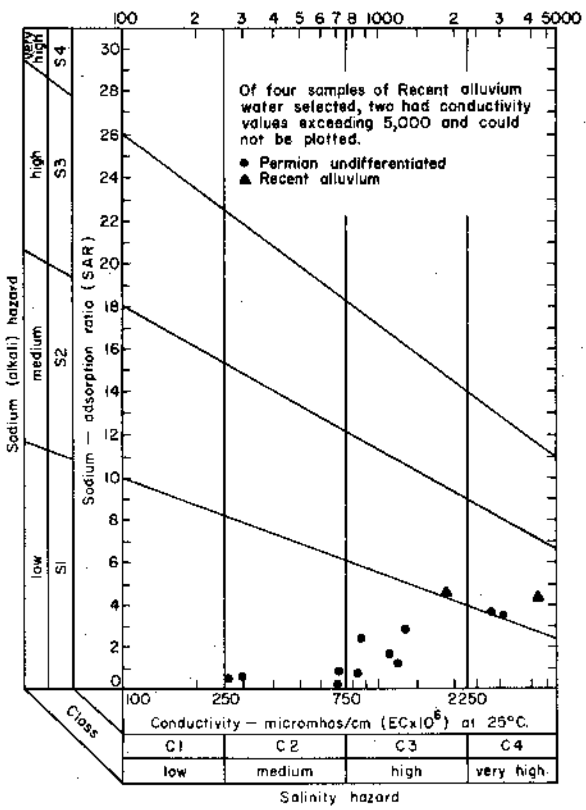


Figure 20.—Classification of Water From Recent Alluvium and Permian Rocks Used for Irrigation

Even though the quantity of ground water in Permian beds is believed to be inadequate for irrigation purposes, the water is of suitable quality for such use. Figure 20 gives the classes of the waters, Table 3 describes the classes and restrictions, and Table 2 contains other chemical parameters used to determine the suitability of ground waters for irrigation.

Recent Alluvium

The Recent alluvium of Quaternary age is a fairly reliable source of minor amounts of ground water for domestic and livestock purposes. The alluvial deposits are found in the flood-plains of the major tributaries of streams which make up the surface drainage system of Callahan County. The "Geology as Related to the Occurrence of Ground Water" section of this report discusses the geologic characteristics and extent of the aquifer.

A total of eight wells and three springs, or about 2 percent of the wells and springs which were inventoried during this study, produced ground water from this aquifer.

Ground-Water Source, Occurrence, and Movement

The source of the ground water is precipitation that falls directly on the alluvium outcrop and discharge from other water-bearing units into the alluvial deposits along the streams. Principal occurrences of ground-water supplies in the alluvial deposits are usually found near the major streams. Movement of the ground water found in Recent alluvium is usually toward the main stream channel where it is discharged.

Changes in Water Levels

Generally, water-level fluctuations within the Recent alluvium vary greatly with rainfall and with the rise and fall of water in the streams. During periods of runoff following rainfall, a temporary rise in the water level occurs due to seepage from the stream into the aquifer. However, when the runoff has passed, the water level in the stream is again below that in the aquifer and the water flows back into the stream.

A total of five wells provided historical data regarding possible water-level changes in the Recent alluvium. These were measured during the spring and fall of 1940 and again in the winter of 1970 and the spring of 1971. Four of the wells exhibited a net rise in water level during this period, ranging from 0.85 foot (0.26 m) in well 30-47-906 to 4.60 feet (1.40 m) in well 30-63-209. The average annual rise in water level in these wells was 0.03 foot (0.01 m) and 0.15 foot (0.05 m), respectively. Well 30-63-103 reflected a net decline in water level of 2.12 feet (0.65 m) or 0.07 foot per year (0.02 m/yr) during this same period (Table 5).

Recharge and Discharge

Recharge to the Recent alluvium is partly from stream runoff and flooding which results from precipitation upstream. Recharging from stream runoff is usually temporary since most of this recharge is bank storage only and the water flows back into the streams after the runoff recedes. However, during flooding, water often covers the entire floodplain, and at this time considerable recharge takes place. Much recharge also is received by seepage from the Antlers Formation which occasionally is in direct contact with the Recent alluvium (Figure 5). Data are not available to estimate the amount of annual effective recharge.

Natural discharge from the Recent alluvium is directly into the main channels of the tributaries of the major streams within the county. Three Recent alluvium springs were located and inventoried during this investigation. Many areas of natural discharge were undoubtedly not located; however, the three springs had estimated flows of 3 (0.189), 5 (0.315), and 10 gal/min (0.631 l/s). The limited number of wells which pump from the Recent alluvium provide artificial discharge from the aquifer.

Chemical Quality

Eight wells and three springs were located which produce or have produced water of usable quality from the Recent alluvium in Callahan County. Eight water samples were collected during this or previous studies on four wells and two springs. The results of these analyses are tabulated in Table 7.

Water from wells or springs deriving their water from Recent alluvium is of much poorer quality than that found in other water-bearing units of the county. The range in the dissolved-solids content of water collected during this and previous studies was from 370 to 9,200 mg/l. These waters would be classed as fresh to moderately saline. Only 25 percent of the samples contained 1,000 mg/l or less. The number of samples falling within various ranges are shown as follows:

Range in dissolved-solids (mg/l)	Number of analyses	Percent of total analyses
500 or less	1	12.5
501 to 1,000	1	12.5
1,001 to 2,000	1	12.5
2,001 to 3,000	2	25
over 3,000	3	37.5

Ranges in concentration of the major chemical constituents which follow reflect the wide variations in the chemical quality of Recent alluvium ground waters:

Constituent	Range (mg/l)
Calcium	130 to 1,150
Magnesium	30 to 497
Sodium	89 to 1,810
Bicarbonate	194 to 476
Sulfate	$<$ 10 to 1,450
Chloride	28 to 5,700
Fluoride	.3 to 1.7
Nitrate	$<$ .4 to 136
Total hardness	293 to 4,270

The quality of Recent alluvium ground waters can be generally summarized as follows. Thirty-eight percent of the samples contained greater than 300 mg/l sulfate and 62 percent contained greater than 300 mg/l chloride. These samples would have "gyppy" or "salty" tastes, respectively. Fourteen percent of the samples contained both fluoride and nitrate above the recommended limits of 1.6 and 45 mg/l, respectively. Water from all of the samples would be classed as very hard.

Chemical analyses of four water samples collected from wells developed in the Recent alluvium were available for use in determining its suitability for irrigation; however, only two samples were within the limits of salinity and sodium hazards shown on Figure 20. These two samples fall within salinity hazard classes C3 and C4 and sodium hazard class S2. The importance of these classes is shown on Table 3. The Recent alluvium does not contain sufficient volumes of ground water to permit large-scale irrigation.

SURFACE-CASING RECOMMENDATIONS FOR WATER-QUALITY PROTECTION

The Texas Department of Water Resources provides recommendations to oil and gas operators and the Railroad Commission of Texas concerning the depth to which usable quality ground water should be protected in drilling for oil and gas. The authority for participation by the Department in this surface-casing program is derived from rules promulgated by the Railroad Commission under authority given that agency by statutes dealing with the regulation of drilling and production activities of the petroleum industry.

Statewide Rule 13 of the Railroad Commission of Texas requires that operators obtain a letter from the Texas Department of Water Resources recommending the depth to which fresh-water strata should be protected when drilling for oil or gas if the lease or area is not covered by field rules or lease recommendations. The Railroad Commission's Rule 8 requires that all fresh-water strata be protected in drilling, plugging, or production activities.

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

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

PRODUCTION AND DISPOSAL OF OIL-FIELD BRINE

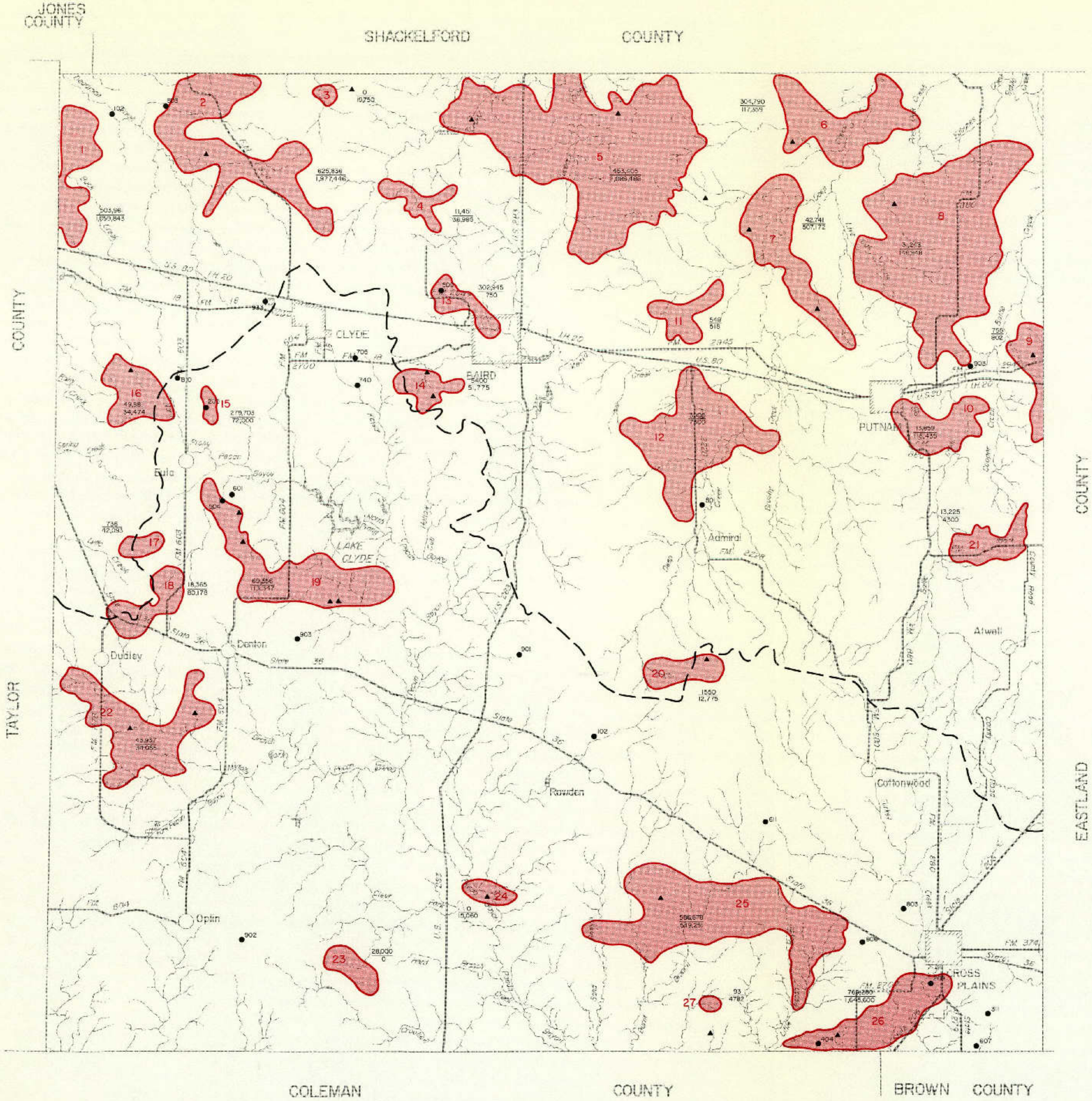
Areas of Disposal, Disposal Methods, and Quantities

In 1962, and again in 1968, the Railroad Commission of Texas and the Texas Department of Water Resources or its predecessor agencies cooperated in the statewide collection and tabulation of information submitted by oil and gas operators concerning the 1961 and 1967 oil-field brine production and the methods used for its disposal. Figure 21 delineates the areas of disposal, quantities of brine disposal, and methods of disposal within the county. The areas of disposal, listed numerically 1 through 27 on Figure 21, were determined by outlining the areas of greatest concentration of producing oil and gas wells. No attempt is made to separate the individual oil or gas fields; however, care was taken not to include parts of a field in more than one area. Statistics on brine disposal for individual oil and gas fields for the years 1961 and 1967 are tabulated in Table 8 by area.

Brine is disposed by injection, surface pits, or miscellaneous methods. Waters disposed by injection are placed into the subsurface through the salt-water injection wells of a waterflood operation, through salt-water disposal wells, or those injected into a non-producing subsurface zone of a presently producing oil well. Waters listed under pits are those which are placed into open surface disposal pits. Waters listed under miscellaneous disposal are those which are disposed of by any other method, mainly through hauling by trucks to salt-water disposal or waterflood injection wells in other areas.

As of January 1, 1968, disposal of brine into pits had been discontinued in areas 1 through 5, 7, 8, 10 through 15, 17, 18, 20 through 24, 26, and 27. Disposal into pits had been drastically reduced in all other areas except areas 16 and 19 where considerable amounts were still being disposed of by this method (Table 8).

The alternate method of disposal, in most cases, has been by injection. A comparison of the volume and methods of disposal in 1961 and 1967 shows that total brine production in the county has increased but the total quantity of brine disposal in surface pits has decreased (Table 8). The total brine production in Callahan County in 1961 was about 5.52 million barrels (887,700 m^3) compared to over 8.74 million barrels (1.39 million m^3) produced in 1967. The amount disposed of in pits during 1961 was about 237,500 barrels (37,760 m^3) or 4.30 percent of the total as compared to almost 13,500 barrels (2,146 m^3) or 0.15 percent of the total in 1967. Disposal by injection into wells in 1961 was about 5.28 million barrels (839,600 m^3) or 95.67 percent and in 1967 was about 8.73 million barrels (1.39 million m^3) or 99.84 percent. Miscellaneous disposal in 1961 and 1967 was 1,664 barrels (264.6 m^3) and 183 barrels (29.1 m^3), respectively. This was 0.03 percent of the total in 1961 and 0.01 percent of the total in 1967. For a comparison of the various methods of disposal, area by area and field by field, for 1961 and 1967 consult Figure 21 and Table 8.



EXPLANATION

Salt water disposal well

Apparently contaminated water well or spring

Area of 1961 and 1967 reported brine production (These areas are separated into specific oil and gas fields in Table 8.)

1961 Total reported brine production, in barrels

1967 Total reported brine production, in barrels

Approximate boundary between Brazos River and Colorado River drainage systems

Figure 21

Location and Amounts of Reported 1961 and 1967 Brine Production, Known Salt-Water Disposal Wells, and Apparently Contaminated Water Wells

Chemical Quality of Produced Brines

Table 9 is a tabulation of the chemical analyses of some oil-field brines in Callahan County. The brines have, for the most part, the same ions present that are present in water from wells used for municipal, industrial, irrigation, and livestock supplies. However, the calcium, chloride, magnesium, and sodium ions are present in much greater concentrations in the brines. The content of dissolved solids is also much higher in the brines, ranging from 60,500 to 195,000 ppm. The concentrations of various ions in the tabulated brines range as follows:

Calcium (Ca)	1,700 to 15,100 ppm
Chloride (Cl)	33,800 to 109,000 ppm
Magnesium (Mg)	352 to 2,856 ppm
Sodium (Na)	20,010 to 49,400 ppm

Produced Brine as a Potential Source of Ground-Water Contamination

Ground water is often subjected to contamination from various sources, and a major potential source of contamination is the improper disposal of oil-field brines. Prior to the advent of the statewide no-pit order, instigated by the Texas Railroad Commission, and which became effective on January 1, 1969, there was possibly considerable ground-water pollution caused by the disposal of produced brines in open, unlined surface-disposal pits. Even though much evaporation took place in these pits, if soil conditions were conducive, there was considerable percolation or seepage of these brines downward, to the water table, resulting in the contamination of the native ground water. Occasional overflow of brines from these surface pits may also have contaminated surface waters. When these brines mix with native ground water, there is usually a marked increase in the concentrations of chloride and sodium ions in the ground water. These increases are reflected in the analyses of some of the waters in Callahan County (Table 7). Figure 21 depicts the location of wells in Callahan County which are apparently contaminated.

Contamination may also result when there is leakage from old, abandoned and improperly plugged oil tests, or from improperly cased producing oil wells. In cases such as these, the brines may move up the bore holes of improperly plugged or cased wells into the shallow fresh-water zones, due to both natural pressure in the brine-producing formations and the pressure created by secondary recovery injection operations. The Texas Railroad Commission now has limited funds available for plugging abandoned oil and gas wells or tests which may be leaking brines to the surface or subsurface. Much work has been done by the Texas Railroad Commission and oil operators to alleviate contamination problems resulting from brine produced with oil and gas.

SUMMARY AND CONCLUSIONS

Within Callahan County, the primary aquifer is the Antlers Formation of Cretaceous age. Its major development covers an area of approximately 280 square miles (725 km^2) which is located in the western and southwestern parts of the county (Figure 5). This water-bearing unit yields small to moderate quantities of usable-quality ground water which generally varies from fresh to slightly saline. However, in local areas, moderate to very saline ground waters were also located (Table 7). A total of 94 percent of all wells and springs inventoried during this study derived their ground waters from this aquifer.

Some individual members and formations of Permian age, collectively called the Permian rocks undifferentiated aquifer, also contain small supplies of ground water. Well yields from these zones are of questionable reliability. The quality of ground water collected from this aquifer ranges from fresh to brine. These waters are used for domestic and livestock purposes only.

Surficial Quaternary floodplain and terrace deposits (Recent alluvium aquifer), found along streams and their tributaries, also provide small quantities of fresh to moderately saline ground waters. These waters are also used for domestic and livestock purposes only.

During 1978, approximately 1,900 acre-feet (2.34 hm^3) of ground water was pumped for all uses from the various aquifers. More than 95 percent of this is estimated to have been derived from the Antlers aquifer. Only minor amounts of pumpage, used for domestic and livestock purposes, were derived from other aquifers. Pumpage for irrigation and municipal purposes (100 percent from the Antlers) accounted for about 52 and 10 percent, respectively. Practically all domestic and livestock withdrawals were also from the Antlers water-bearing unit. Pumpage for these two categories amounted to an estimated 38 percent of the total while that for industrial purposes accounted for only 0.2 percent. Almost all of this was also from the Antlers Formation.

Based on an estimated recharge rate of 1.5 percent of the average annual precipitation of 25.64 inches (65.13 cm) for all the stations within the county, the annual effective recharge to the Antlers Formation was calculated to be about 5,400 acre-feet (6.66 hm^3). Of this, about 2,400 acre-feet (2.96 hm^3) is considered to be available in the Clyde-Oplin area and about 3,000 acre-feet (3.70 hm^3) in the Cross Plains area.

Using a storage coefficient of 20 percent, 836,100 acre-feet (1,031 hm^3) of ground water was estimated to be in transient storage within the Cretaceous Antlers Formation in Callahan County. Of this amount, 271,800 acre-feet (335 hm^3) and about 564,300 acre-feet (696 hm^3) are available in the Clyde-Oplin and Cross Plains areas, respectively. If 75 percent of these amounts are considered to be economically recoverable, then about 203,800 acre-feet (251.3 hm^3) and 423,300 acre-feet (521.9 hm^3) can be withdrawn from these same areas.

Since only insignificant amounts of ground water are available from the Permian rocks undifferentiated and Recent alluvium aquifers, no attempt was made to estimate the annual effective recharge or the amount of ground water in storage for either of these water-bearing units.

Water-level data collected on all three of the aquifers in the county indicate that, in general, there was a rise in water levels in all three water-bearing units for the period from the winter of 1940 through the winter of 1970-71. Measurements in the Antlers aquifer indicated that water levels experienced net rises in the Clyde-Oplin area from 0.0 to 11.5 feet (0.0 to 3.51 m). In the Cross Plains area, Antlers water levels show net rises ranging from 0.02 foot (0.006 m) to 9.1 feet

(2.8 m). Water-levels in the Permian rocks exhibited net rises during the same period, ranging from 2.57 feet (0.78 m) to 16.37 feet (4.99 m). Historical water-level data relating to the Recent alluvium during the subject period also indicated net water-level rises ranging from 0.85 foot (0.26 m) to 4.60 feet (1.40 m).

Chemical analyses of water samples of this and previous investigations indicate that, for the most part, ground waters derived from the Antlers aquifer are of good quality. In the majority of the samples, dissolved solids were low. Usually, the samples contained excessive hardness, and locally, some waters were high in dissolved iron content. The content of the chemical constituents of chloride, sulfate, fluoride, and nitrate, in the majority of the samples, were within recommended limits. Additionally, ground waters were suitable for irrigation of all crops normally grown within the county. Generally, ground waters derived from Permian rocks and Recent alluvium are suitable for domestic and livestock uses.

Alteration of native-quality ground water in several wells in Callahan County has resulted, presumably, from the disposal of oil-field brines into unlined surface pits or from abandoned oil or gas tests which are leaking. In some cases, there has also been alteration of native-quality ground water by excess nitrate in areas where wells have been located improperly with respect to septic tanks or animal barn-yards. Care should be exercised in the future to properly locate wells with respect to these potential sources of pollution. Most brine contamination sources are thought to have been eliminated by the statewide no-pit order issued by the Railroad Commission of Texas. However, since contamination in ground water may continue for long periods of time after the sources are removed, it would be advisable to set up a program for periodic resampling of selected wells to check the amounts and extent of the contamination.

In order to further evaluate the future effects of irrigation or municipal pumpage from the Antlers aquifer, a network of observation wells should be established in Callahan County in which water levels are to be measured and recorded annually by personnel of the Texas Department of Water Resources. Some water level observation wells are presently measured; however, coverage is considered inadequate.

SELECTED REFERENCES

Abilene Geological Society Guidebook, 1955, Study of the lower Permian and upper Pennsylvanian rocks in the Brazos and Colorado River valleys of west central Texas, together with a preliminary report on the structural development of west central Texas.

BJ Services, Inc., 1960, The chemical analyses of brines from some fields in north and west Texas: Am. Inst. Mining, Metall., and Petroleum Engineers, 17 p.

Boone, P. A., 1968, Stratigraphy of the basal Trinity (lower Cretaceous) sands of central Texas: Baylor Univ., Baylor Geol. Studies Bull. 15, 64 p.

Brown, L. F., Jr., 1959, Problems of stratigraphic nomenclature and classification, upper Pennsylvanian, north central Texas: Am. Assoc. Petroleum Geologists, v. 43, p. 2866-2871.

Bruin, J., and Hudson, H. E., Jr., 1961, Selected method for pumping test analysis: Illinois State Water Survey Rept. 25, 54 p.

Burden, E. H. W. J., 1961, The toxicology of nitrates, with particular reference to the potability of water supplies: The Analyst, Proc. of the Soc. Anal. for Chem., v. 86, no. 1024, p. 429-433.

Bureau of Economic Geology, 1972, Geologic Atlas of Texas, Abilene sheet: Univ. Texas at Austin, Bur. Econ. Geology map.

Carr, J. T., Jr., 1967, The climate and physiography of Texas: Texas Water Devel. Board Rept. 53, 27 p.

Cheney, M. G., 1929, Stratigraphic and structural studies in north-central Texas: Univ. Texas Bull. 2913, 29 p.

________1940, Geology of north-central Texas: Bull. Am. Assoc. Petroleum Geologists, v. 24, no. 1, p. 65-118.

Cheney, M. G., and Goss, L. F., 1952, Tectonics of central Texas: Am. Assoc. Petroleum Geologists Bull., v. 36, no. 12, p. 2237-2265.

Cronin, J. G., Follett, C. R., Shafer, G. H., and Rettman, P. L., 1963, Reconnaissance investigation of the ground-water resources of the Brazos River basin, Texas: Texas Water Comm. Bull. 6310, 163 p.

Cummins, W. F., 1890, The Permian of Texas and its overlying beds: Texas Geol. Survey 1st Ann. Rept., p. 183-197.

________1893, Notes on the geology of northwest Texas: Texas Geol. Survey 4th Ann. Rept., pt. 1, p. 177-238.

Cummins, W. F., and Lerch, O., 1891, Report on the geology of northwestern Texas: Texas Geol. Survey Ann. Rept. 2, p. 73-77, 321-325.

Dallas Morning News, 1979, Texas almanac and state industrial guide, 1980-1981: A. H. Belo Corp., 704 p.

Davis, D. A., 1938, Records of wells, drillers' logs, water analyses, and map showing location of wells in Brown County, Texas: Texas Board Water Engineers duplicated rept., 25 p.

DeWiest, R. J. M., 1965, Geohydrology: New York, John Wiley and Sons, Inc., p. 133-134.

Doll, W. L., Meyer, G., and Archer, R. J., 1963, Water resources of West Virginia: West Virginia Dept. Nat. Resources, Div. Water Resources, 134 p.

Eardley, A. J., 1951, Structural geology of North America: New York, Harper and Brothers, 624 p.

Eaton, F. M., 1950, Significance of carbonates in irrigation waters: Soil Sci., v. 59, p. 123-133.

Farris, J. R., and others, 1963, Field conference on the geology of west-central Texas: Hardin-Simmons Univ. Geol. Soc. Fourth Ann. Field Trip, 84 p.

Fisher, W. L., and Rodda, P. U., 1966, Nomenclature revision of basal Cretaceous rocks between the Colorado and Red Rivers, Texas: Univ. Texas, Bur. Econ. Geology Rept. of Inv. 58, 20 p.

______1967, Lower Cretaceous sands of Texas, stratigraphy and resources: Univ. Texas, Bur. Econ. Geology Rept. of Inv. 59, 116 p.

Frye, J. C., Swineford, A., and Leonard, A. B., 1948, Correlation of Pleistocene deposits of the central Great Plains with the glacial section: Jour. Geology, v. 56, no. 6, p. 501-525.

George, W. O., 1940a, Callahan County, Texas - Records of wells and springs, drillers' logs, water analyses, and map showing locations of wells and springs: Texas Board Water Engineers duplicated rept., 44 p.

______1940b, Memorandum on the ground-water conditions in the vicinity of Baird, Texas: Texas Board Water Engineers duplicated rept., 30 p.

George, W. O., and Hastings, W. W., 1951, Nitrate in the ground water of Texas: Am. Geophys. Union Trans., v. 32, no. 3, p. 450-456.

Gordon, C. H., 1913, Geology and underground waters of the Wichita region, north-central Texas: U.S. Geol. Survey Water-Supply Paper 317, 88 p.

Hayward, O. T., and Brown, L. F., Jr., 1967, Comanchean (Cretaceous) rocks of central Texas: Soc. of Econ. Paleontologists and Mineralogists, the Permian Basin section, Pub. 67-8, p. 31-48.

Heller, V. G., 1933, The effect of saline and alkaline waters on domestic animals: Oklahoma Agr. and Mech. Coll. Expt. Sta. Bull. 217, 23 p.

Hem, J. D., 1959, Study and interpretation of the chemical characteristics of natural water: U. S. Geol. Survey Water-Supply Paper 1473, 1st ed., 269 p.

Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water: U.S. Geol. Survey Water-Supply Paper 1473, 2nd ed., 363 p.

Holmquest, H. J., Jr., 1955, Structural development of west-central Texas: Abilene Geol. Soc. Guidebook, 1932 p.

Imlay, R. W., 1944, Correlation of lower Cretaceous formations of the Coastal Plain of Texas, Louisiana, and Arkansas: U. S. Geol. Survey, Oil and Gas Inv. Prelim. chart no. 3.

Johnson, E. E., 1966, Ground water and wells: Edward E. Johnson, Inc., 440 p.

Jones, T. S., 1953, Stratigraphy of the Permian basin of West Texas: West Texas Geol. Soc., 63 p.

Kane, J. W., 1967, Monthly reservoir evaporation rates for Texas, 1940 through 1965: Texas Water Devel. Board Rept. 64, 111 p.

Klemt, W. B., Perkins, R. D., and Alvarez, H. J., 1975, Ground-water resources of part of central Texas with emphasis on the Antlers and Travis Peak Formations: Texas Water Devel. Board Rept. 195, v. 1 and 2, 594 p.

Laxson, Roland, and others, 1960, Resistivities and chemical analyses of formation waters from the west-central Texas area: West Central Texas Section Soc. Petroleum Engineers of Am. Inst. Mining, Metall., and Petroleum Engineers, 21 p.

Lee, W., Nickell, C. O., Williams, J. S., and Henbest, L. G., 1938, Stratigraphic and paleontologic studies of the Pennsylvanian and Permian rocks in north-central Texas: Univ. Texas Pub. 3801, 247 p.

Loehr, R. C., 1969, Animal wastes—A national problem: Jour. Sanitary Eng. Div. of A.S.C.E., v. 95, no. SA2 (Apr.), p. 189-221.

Lohman, S. W., 1972, Ground-water hydraulics: U. S. Geol. Survey Prof. Paper 708, 70 p.

Lozo, F. E., and Stricklin, F. L., Jr., 1956, Stratigraphic notes on the outcrop basal Cretaceous, central Texas: Trans. Gulf Coast Assoc. Geol. Soc., v. 6, p. 67-78.

Lyerly, P. J., and Longenecker, D. E., 1957, Salinity control in irrigation agriculture: Texas Agr. Expt. Sta. Bull. 876, 20 p.

Maier, F. J., 1950, Fluoridation of public water supplies: Am. Water Works Assoc. Jour., v. 42, pt. 1, p. 1120-1132.

Maxcy, K. F., 1950, Report on the relation of nitrate concentrations in well waters to the occurrence of methemoglobinemia: Natl. Research Council Bull. Sanitary Eng. and Envir., p. 265, app. D.

Meinzer, O. E., 1923, Outline of ground-water hydrology, with definitions: U. S. Geol. Survey Water-Supply Paper 494, 71 p.

Morris, D. A., and Johnson, A. I., 1967, Summary of hydrologic and physical properties of rock and soil materials, as analyzed by the hydrologic laboratory of the U. S. Geological Survey 1948-60: U. S. Geol. Survey Water-Supply Paper 1839-D, p. D36-D37.

Mount, J. R., Rayner, F. A., Shamburger, V. M., Jr., Peckham, R. C., and Osborne, F. L., Jr., 1967, Reconnaissance investigation of the ground-water resources of the Colorado River basin, Texas: Texas Water Devel. Board Rept. 51, 107 p.

Muller, D. A., and Price, R. D., 1979, Ground-water availability in Texas - Estimates and projections through 2030: Texas Dept. Water Resources Rept. 238, 77 p.

Myer, B. N., 1969, Compilation of results of aquifer tests in Texas: Texas Water Devel. Board Rept. 98, p. 6-7.

Preston, R. D., 1969, Occurrence and quality of ground water in Shackelford County, Texas: Texas Water Devel. Board Rept. 100, 68 p.

Price, R. D., 1978, The occurrence, quality, and availability of ground water in Jones County, Texas: Texas Dept. Water Resources Rept. 215, 236 p.

________1979, An evaluation of the present and future municipal and industrial ground-water resources in the West Central Texas area: Unpublished data in files of Texas Dept. Water Resources.

Sellards, E. H., Adkins, W. S., and Plummer, F. B., 1932, The geology of Texas, v. 1, Stratigraphy: Univ. Texas Bull. 3232, 1007 p.

Stafford, P. T., 1958, Stratigraphy of the Wichita Group in part of the Brazos River valley, north Texas: U. S. Geol. Survey Bull. 1081-G, p. 261-280.

________1960, Geology of the Cross Plains quadrangle, Brown, Callahan, Coleman, and Eastland Counties, Texas: U. S. Geol. Survey Bull. 1096-B, 72 p.

Stearns, N. D., 1927, Laboratory tests on physical properties of water-bearing materials: U. S. Geol. Survey Water-Supply Paper 596f, p. 144.

Sundstrom, R. W., Broadhurst, W. L., and Dwyer, Mrs. B. C., 1947, Public water supplies in central and north-central Texas: Texas Board Water Engineers duplicated rept., 237 p.

Taylor, H. D., 1978, The occurrence and quality of ground water in Taylor County, Texas: Texas Dept. Water Resources Rept. 224, 135 p.

Texas Department of Health, 1977, Drinking water standards governing drinking water quality and reporting requirements for public water supply systems, Adapted by the Texas Board of Health July 1, 1977, Revised November 30, 1977: Texas Dept. Health, Div. of Water Hygiene duplicated rept., 17 p.

Texas State Historical Association, 1976, The handbook of Texas, A supplement: Texas State Historical Association, Austin, v. III, 1145 p.

Texas Water Development Board, 1977, Continuing water resources planning and development for Texas: Texas Water Devel. Board planning rept. (Draft), v. 1 and 2, 1043 p.

Theis, C. V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage: Am. Geophys. Union Trans., pt. 2, p. 519-524.

________1938, The significance and nature of the cone of depression in ground-water bodies: Econ. Geology, v. 33, no. 8, p. 889-902.

Thompson, D. R., 1967, Occurrence and quality of ground water in Brown County, Texas: Texas Water Devel. Board Rept. 46, 143 p.

Todd, D. K., 1959, Ground-water hydrology: New York, John Wiley and Sons, Inc., 336 p.

U. S. Public Health Service, 1962, Public Health Service drinking-water standards: Public Health Service Pub. 956, 61 p.

U. S. Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkali soils: U. S. Dept. Agriculture Handb. 60, p. 69-83.

Van Siclen, D. C., 1957, Cenozoic strata of the southwestern Osage Plains of Texas: Jour. Geology, v. 65, no. 1, p. 47-60.

Walker, L. E., 1967, Occurrence and quality of ground water in Coleman County, Texas: Texas Water Devel. Board Rept. 57, 102 p.

Walton, W. C., 1962, Selected analytical methods for well and aquifer evaluation: Illinois State Water Survey Bull. 49, 81 p., 4 pls.

Wilcox, L. V., 1955, Classification and use of irrigation waters: U. S. Dept. Agriculture Circ. 969, 19 p.

Winslow, A. G., Doyel, W. W., and Gaum, C. H., 1954, Ground-water resources of Jones County, Texas: Texas Board Water Engineers Bull. 5418, 29 p.

Winslow, A. G., and Kister, L. R., Jr., 1956, Saline-water resources of Texas: U. S. Geol. Survey Water-Supply Paper 1365, 105 p.

Table 5.--Records of Selected Wells, Springs, and Test Holes

All wells are drilled unless otherwise noted in remarks column.
Water-bearing unit : Qal, Quaternary or Recent Alluvium; Kca, Antlers Formation; P, Permian rocks undifferentiated.
Water levels : Reported water levels are given in feet, measured water levels are given in feet and hundreths.
Method of lift and type of power: B, bucket or bailer; C, cylinder; Cf, centrifugal; E, electric; G, gasoline, butane or diesel engine; H, hand or hand pump; J, jet; N, none; R, reciprocating; Sub, submersible; T, turbine; W, windmill. Number indicates horsepower.
Use of water : D, domestic; Ind, industrial; Irr, irrigation; P, public supply; S, livestock; N, none.
Altitude of land surface was determined from topographic maps, or was surveyed.

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-28-703	T. C. Miller	--	--	18	--	--	Qal	1,747	7.25	Mar. 30, 1971	J, E	D, S	Dug well. Salt water reported to leak into well following rain.
* 803	J. M. Morrisett	--	--	15	--	--	Qal	1,810	11.51 8.80	Mar. 2, 1940 Mar. 5, 1971	N	N	Dug well. Well 60 in Callahan County report. [4]
* 31-910	Worley Jones	--	--	31	--	--	P	1,405	22.81 16.50	Aug. 2, 1940 Mar. 16, 1971	J, E 1/3	D, S	Dug well. Reported to be a strong supply. Well 204 in Callahan County report. [4]
36-101	Dr. John L. Estes	--	1930	21	--	--	P	1,775	17.60	Mar. 5, 1971	C, W	S	Dug well. Water coming from cracks in limestone.
* 102	Ralph McAdams	--	--	Spring	--	--	Qal	1,760	(+)	Mar. 8, 1971	J, E 1/2	D, S	Estimated flow rate 10 gal/min. Water is from alluvium in contact with Permian limestone. Spring has been dug out to accomodate pump.
* 301	Hiram Cook	--	--	Spring	--	--	Kca	2,000	(+)	Sept. 8, 1970	Flows	S	Estimated flow rate 2 gal/min. Water seeps from Antlers sand.
* 302	Mrs. Homer Kennard	--	1934	35	--	--	Kca	2,025	30.47 26.82	Feb. 15, 1940 Dec. 10, 1970	C, W	S	Dug well. Well 81 in Callahan County report. [4]
* 303	Wallace Johnson	--	1940	25	--	--	Kca	2,020	11.72	do	C, W	D, S	Dug well. Reported yield 5 gal/min. Sand and gravel reported from 10 to 25 feet.
* 501	A. E. Dyer	--	--	30	--	--	P	1,925	17.18 14.14	Feb. 22, 1940 Mar. 5, 1971	N	N	Dug well. Well 66 in Callahan County report. [4]
* 601	Hiram Cook	--	--	Spring	--	--	Kca	2,000	1.30 1.57	Sept. 8, 1970 Jan. 14, 1971	Cf, G	D, S	Dug well. Flows about 6 months during the year.
* 602	do	--	1925	13	--	--	Kca	2,000	11.48 2.30 0.00	July 31, 1940 Sept. 8, 1970 Jan. 14, 1971	N	N	Dug well. Well 77 in Callahan County report. [4]
* 603	Jack Clemmer	--	--	21	--	--	Kca	2,010	12.89 8.15 8.71 5.89	July 31, 1940 Sept. 8, 1970 Oct. 15, 1970 Jan. 8, 1972	J, E	N	Dug well. Observation well. Well 75 in Callahan County report. [1] [4]
* 604	Ira Ackers	--	--	57	--	--	Kca	2,024	37.30	Nov. 4, 1970	Sub, E 3/4	D, S	Dug well. Reported yield 20 gal/min. Red beds reported at 57 feet.
* 605	do	Jack Leonard	1957	55	10	55	Kca	2,026	30	do	N	N	Reported yield 8 gal/min. Red beds reported at 55 feet. Abandoned irrigation well.
606	do	do	1957	60	10	60	Kca	2,035	42.80	do	J, E 3/4	N	Reported yield 25 gal/min. Red beds reported at 60 feet. Unused irrigation well.
607	do	do	1957	56	10	56	Kca	2,030	37.12	do	N	N	Reported yield 12 gal/min. Abandoned irrigation well.
608	do	Robert Higgins	1962	50	5	50	Kca	2,018	32.82	do	Sub, E	N	Reported yield 25 gal/min. Well reported to be completed into upper sand member. Unused irrigation well.

See footnotes at end of table.

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
30-36-609	Ira Ackers	Robert Higgins	1962	65	10	65	Kca	2,022	30.89	Nov. 4, 1970	T, E 3	N	Reported yield 50 gal/min. Casing slotted from 43 to 55 feet. Red beds reported at 55 feet. Unused irrigation well.
610	do	Jack Leonard	1957	53	8	53	Kca	2,020	23.13	do	J, E 3/4	N	Reported yield 12 gal/min. Unused irrigation well.
* 611	J. B. Eaton	R. L. McKelvy	1970	36	5	36	Kca	2,021	21.21 22.95	Dec. 10, 1970 June 15, 1971	Sub, E 1/2	Irr	Measured yield 9.9 gal/min. Casing slotted from 20 to 35 feet. Red clay at 31 feet. 2/ 3/
* 612	do	do	1964	40	6	40	Kca	2,020	21.88	Dec. 10, 1970	Sub, E 1/3	D	Estimated yield 10 gal/min. Casing slotted from 20 to 40 feet. Well completed in white sand and gravel.
613	F. L. Dugan	F. L. Dugan	1960	25	--	--	Kca	2,014	14.30	Feb. 25, 1971	J, E 1/2	D, S	Dug well. Limestone at 24 feet. 2/
614	do	--	--	Spring	--	--	Kca	2,000	(+)	do	Flows	S	Estimated flow rate 5 gal/min. Water reported from sand and gravel in contact with Permian limestone.
615	Roy L. Martin	Jack Leonard	1966	36	10	36	Kca	2,020	23.25	Apr. 6, 1971	Sub, E 1/2	Irr	Red beds reported at 36 feet.
616	do	do	1966	35	10	35	Kca	2,020	23.01	do	Sub, E 1	Irr	--
* 801	Paul Shankes	Bob Havens	1946	18	--	--	Kca	2,010	10.51 11.32 9.84	Sept. 8, 1970 Oct. 15, 1970 Jan. 8, 1972	C, E 3/4	D, S	Dug well. Water gravel reported at approximately 13 feet. Observation well. 1/
* 802	C. W. Armstrong	--	old	20	--	--	Kca	1,993	15.44 15.40	Feb. 22, 1940 Dec. 9, 1970	J, E 1/3	D	Dug well. Weak well. Supplies only enough water for house use. Well 114 in Callahan County report. 4/
* 803	C. B. Kniffen	R. L. McKelvy	1970	64	5	64	Kca	2,022	20.40	do	Sub, E 2	Irr	Measured yield 35 gal/min. Casing slotted from 30 to 63 feet. Yellow clay at 62 feet. 2/ 3/
804	do	Jack Leonard	1969	64	10	64	Kca	2,020	25.10 30.18	do June 15, 1971	Sub, E 2	Irr	Measured yield 35 gal/min. Yellow clay reported at 64 feet. 3/
805	do	R. L. McKelvy	1970	67	5	67	Kca	2,023	27.02	Dec. 9, 1970	N	N	Measured yield 11.6 gal/min. Casing slotted from 40 to 66 feet. Yellow clay at 63 feet. Unused irrigation well. 3/
* 806	Harold Mauldin	L. E. Hayhurst	1968	50	8	42	Kca	2,020	24 21.59	Oct. 28, 1968 Jan. 18, 1971	N	N	Reported yield 20 gal/min. Casing slotted from 24 to 28 and 38 to 42 feet. Unused irrigation well. 2/ 3/
807	do	Howard Kniffen	1967	50	8	50	Kca	2,019	17.78	do	N	N	Reported yield 25 gal/min. Yellow clay reported at 50 feet. Unused irrigation well.
* 808	W. E. McCallum	--	1937	16	--	--	Kca	1,975	15.00 6.74	Aug. 1, 1940 Mar. 5, 1971	C, W	D, S	Dug well. Water coming from gravel and clay. Strong supply in wet weather. Well 109 in Callahan County report. 4/
* 809	Wallace W. Henry	R. L. McKelvy	1965	32	9	32	Kca	2,010	18.55	Mar. 17, 1971	Sub, E 1/2	D, S	Estimated yield 10 gal/min. Casing perforated from 22 to 31 feet. Yellow clay at 29 feet. 2/
* 810	Edwin Huddelston	Jack Leonard	1963	40	7	40	Kca	2,010	14.68	Mar. 30, 1971	J, E 1/3	D, S	Red beds reported at 40 feet. Water reported to be very corrosive.
* 901	City of Clyde	--	--	25	--	--	Kca	2,010	19.00	Oct. 5, 1959	T, E	P	Reported yield 75 gal/min.
* 902	Dr. J. E. Mikeska, Jr.	R. L. McKelvy	1965	55	6	55	Kca	2,020	20.12	Sept. 10, 1970	Sub, E 3/4	Irr	Reported yield 23 gal/min.

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-36-903	Dr. J. E. Mikeska, Jr.	R. L. McKelvy	1967	55	6	55	Kca	2,021	27.34 26.11	Sept. 10, 1970 Jan. 13, 1971	Sub, E 3/4	Irr	Reported yield 40 gal/min.
* 904	do	do	1967	57	6	57	Kca	2,025	25.37	Sept. 10, 1970	Sub, E 1	Irr	Reported yield 30 gal/min. Yellow clay and lime at 50 feet.
* 905	C. E. Hicks	Howard Kniffen	1960	35	8	35	Kca	2,000	12.92	Nov. 13, 1970	J, E 1	S	Reported yield 40 gal/min. Casing slotted from 14 to 35 feet. Red beds at 38 feet.
906	Jerald Ball	Jack Leonard	1970	35	8	35	Kca	1,999	8.02	do	Sub, E 2	Irr	Reported yield 70 gal/min. Red beds reported at 35 feet.
907	do	do	1970	35	8	35	Kca	2,004	8.15	do	Sub, E 2	Irr	Reported yield 70 gal/min. Red beds reported at 32 feet.
908	Dick Antilley	Merle Bales	1965	32	8	32	Kca	1,986	7.10	do	Sub, E 2	Irr	Reported yield 80 gal/min. Screened from 8 to 32 feet. Blue shale at 32 feet.
* 909	do	do	1966	32	8	32	Kca	1,987	8.80	do	Sub, E 2	Irr	Reported yield 80 gal/min. Screened from 8 to 32 feet. Water sand from 24 to 32 feet. 2/
* 910	Seth Holden	R. L. McKelvy	1968	55	5	55	Kca	2,020	21.42	Nov. 18, 1970	Sub, E 1/2	D, Irr	Reported yield 25 gal/min. Casing slotted from 30 to 55 feet. Red beds at 55 feet.
911	do	do	1968	55	6	55	Kca	2,012	10.32	do	Sub, E 3/4	Irr	Reported yield 22 gal/min. Red beds reported at 55 feet.
912	do	do	1968	55	6	55	Kca	2,017	16.90 18.18	do Oct. 9, 1974	Sub, E 1	Irr	Reported yield 35 to 40 gal/min. Sand and gravel from 40 to 53 feet. Red beds reported at 53 feet.
913	do	do	1968	58	6	58	Kca	2,018	17.71 19.90	Nov. 18, 1970 Oct. 9, 1974	Sub, E 3/4	Irr	Reported yield 30 gal/min. Sand and gravel from 34 to 55 feet. Casing slotted from 30 to 58 feet. 2/
914	do	do	1966	52	7	52	Kca	2,016	14.81	Nov. 18, 1970	Sub, E 3/4	Irr	Reported yield 25 to 30 gal/min. Casing slotted from 25 to 52 feet. Yellow clay at 47 feet.
* 915	do	Bill Varner	1954	56	7	56	Kca	2,015	19.50	do	Sub, E 1	Irr, D	Reported yield 35 to 40 gal/min.
916	do	R. L. McKelvy	1968	55	6	55	Kca	2,010	12.53	do	Sub, E 3/4	Irr	Reported yield 25 to 30 gal/min. Red beds reported at 55 feet.
* 917	do	do	1967	60	5	60	Kca	2,017	19.82	do	Sub, E 1	Irr	Reported yield 35 gal/min. Casing slotted from 34 to 60 feet. 2/
918	do	do	1968	58	6	58	Kca	2,017	19.30	do	Sub, E 3/4	Irr	Reported yield 25 to 30 gal/min. Casing slotted from 30 to 58 feet. Red beds at 58 feet.
919	Dale Wilson	Jack Leonard	1966	50	5	50	Kca	2,012	11	Dec. 1, 1970	Sub, E 1/2	Irr	Reported yield 20 gal/min.
920	do	do	1966	49	5	49	Kca	2,012	11	do	Sub, E 1/2	Irr	Do.
* 921	do	do	1966	49	5	49	Kca	2,012	10	do	Sub, E 1/3	Irr, S	Reported yield 10 to 15 gal/min. Red beds reported at 49 feet.
922	do	L. E. Hayhurst	1965	47	5	47	Kca	2,011	10	do	Sub, E 3/4	Irr	Reported yield 25 to 30 gal/min. Water reported from two sands. Upper sand reported very weak supply.
923	do	Howard Kniffen	1964	46	8	46	Kca	2,009	9.42	do	N	Irr	Reported yield 15 to 20 gal/min. Casing slotted from ground level to 46 feet. Pump being replaced.

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
30-36-924	Dale Wilson	Jack Leonard	1966	46	5	46	Kca	2,009	10	Dec. 1, 1970	Sub, E 3/4	Irr	Reported yield 25 to 30 gal/min.
925	do	Howard Kniffen	1965	46	8	46	Kca	2,010	8.0	do	J, E 1	Irr	Reported yield 30 to 35 gal/min. Casing slotted from 31 to 46 feet.
926	do	C. B. Kniffen	1965	46	8	46	Kca	2,009	9.20	do	Sub, E 1	Irr	Reported yield 35 gal/min.
927	Ray H. Walker	Ed L. Chapman	1965	30	5	21	Kca, P	1,991	15.41	Dec. 4, 1970	N	N	Water reported from sand and gravel from 8 to 21 feet and limestone from 28 to 28.5 feet. Unused irrigation well. Open hole from 20 to 30 feet. 2/
* 928	Ed Moore	R. L. McKelvy	1969	47	5	47	Kca	2,001	15.21	do	Sub, E 1	Irr	Measured yield 15.2 gal/min. Casing slotted from 20 to 47 feet. Yellow clay at 47 feet. 2/ 3/
929	do	L. E. Hayhurst	1970	55	5	55	Kca	1,996	12.92	do	J, E 1-1/2	Irr	Measured yield 10 gal/min. 3/
* 930	do	do	1970	53	5	53	Kca	1,991	6 9.90	Aug. 30, 1970 Dec. 4, 1970	J, E 1/2	D, Irr	Reported yield 20 gal/min. Casing slotted from 6 to 20 and 37 to 53 feet. Yellow clay at 53 feet. 3/
* 931	George Sewell	R. L. McKelvy	1968	53	5	53	Kca	2,034	41.75	Jan. 25, 1971	Sub, E 1/3	D, S	Reported yield 5 to 10 gal/min. Slotted from 35 to 53 feet. Red clay at 53 feet. 2/
* 932	E. Q. Echols	E. Q. Echols	1955	18	--	--	Kca	2,000	7.05	Apr. 6, 1971	J, E 3/4	D, S	Dug well. Water reported from sand and clay from 0 to 4 feet.
* 933	T. W. McKoy	L. E. Hayhurst	1971	49	5	49	Kca	2,025	27.50	Apr. 12, 1971	J, E 1/3	D, S	Slotted from 19 to 49 feet. Water reported to have become salty soon after well completed.
934	O. C. Garner, Jr.	R. L. McKelvy	1965	50	6	50	Kca	2,030	28.21	Mar. 1, 1971	J, E 1/2	D	Reported yield 11 gal/min. Slotted from 30 to 50 feet. Yellow clay at 47 feet. 2/
* 37-101	Mrs. Homer Kennard	--	1934	21	--	--	Kca	2,011	7.50	Dec. 10, 1970	J, E 1/2	D, S	Dug well. Reported to be strong supply. Limestone reported at 21 feet.
102	Elizabeth Dugan Estate	--	1920	29	--	--	Kca	2,020	22.15	Feb. 25, 1971	C, W	D	Dug well. Water sand and gravel reported from 24 to 29 feet.
401	Frankie Darnell	R. L. McKelvy	1964	48	8	48	Kca	2,012	21.65	Dec. 4, 1970	N	N	Slotted from 28 to 48 feet. Sand and gravel reported from 39 to 46 feet. Unused irrigation well. 2/
402	W. T. Haraway	Howard Kniffen	1958	37	6	37	Kca	1,997	13.70	Jan. 25, 1971	J, E 3/4	D, S	Sand and gravel reported from 8 to 37 feet.
* 403	W. H. Walker	R. L. McKelvy	1965	33	6	33	Kca	1,985	17.37	do	J, E 1	D, S	Reported yield 10 gal/min. Slotted from 20 to 33 feet. 2/
* 404	do	--	--	Spring	--	--	Kca	1,962	(+)	do	Flows	S	Estimated flow rate 10 gal/min. Reported 5 to 6 feet of sand which is in contact with Permian clays.
* 405	A. D. Ash	W. D. Clark	1966	50	7	50	Kca	2,022	34.44	Feb. 2, 1971	J, E 1/2	D, S	Reported yield 20 to 25 gal/min. Perforated from 28 to 50 feet. Sand and gravel reported from 37 to 50 feet. 2/
* 406	Mrs. A. C. Klepper	--	1940	23	--	--	Kca	2,022	21.91 14.81	July 31, 1940 Feb. 25, 1971	J, E 1/2	S	Dug well. Water reported from sand at 18 to 22 feet. Well 79 in Callahan County report. 4/
* 501	Lee Hickerson	--	1918	13	--	--	Kca	1,928	3.35 1.80	July 31, 1940 Dec. 4, 1970	Cf, G	S	Dug well. Water reported from sand and gravel the base of which is at 13 feet. Well 85 in Callahan County report. 4/

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
30-37-502	Lee Hickerson	--	--	Spring	--	--	Kca	1,921	(+)	Dec. 4, 1970	Flows	S	Estimated flow rate 2 gal/min. Water from sand and conglomerate in contact with Permian limestone. Spring 86 in Callahan County report. 4/
503	Roy Phemister	L. E. Hayhurst	1968	26	5	26	Kca	1,956	10 10.11	Oct. 6, 1968 Jan. 26, 1971	N	N	Estimated yield 15 gal/min. Perforated from 10 to 26 feet. Yellow clay at 26 feet. Unused irrigation well. 3/
504	do	do	1968	18	5	18	Kca	1,952	8 8.90	Sept. 28, 1968 Jan. 27, 1971	N	N	Estimated yield 10 gal/min. Perforated from 8 to 18 feet. Gravel reported from 8 to 11 feet. Unused irrigation well.
505	do	do	1968	24	5	24	Kca	1,955	10 8.77	Sept. 24, 1968 Jan. 26, 1971	N	N	Estimated yield 12 gal/min. Perforated from 10 to 24 feet. Yellow clay at 22 feet. Unused irrigation well. 3/
506	do	do	1968	43	5	43	Kca	1,955	7.5	Sept. 28, 1968	N	N	Estimated yield 12 gal/min. Perforated from 8 to 42 feet. Yellow lime at 35 feet. Unused irrigation well. 2/
* 507	Oscar Brown	R. L. McKelvy	1965	40	6	40	Kca	1,990	22.05	Feb. 2, 1971	Sub, E 1/3	D, S	Estimated yield 28 gal/min. Slotted from 30 to 40 feet. Yellow clay at 40 feet. 2/
508	do	do	1967	35	5	35	Kca	1,984	18.83	do	Sub, E 1/2	Irr	Reported yield 20 gal/min. Slotted from 25 to 35 feet.
* 509	S. L. Canada	--	--	Spring	--	--	Kca	1,940	(+)	Feb. 25, 1971	Flows	N	Estimated flow rate 1 gal/min. Water from gravel which is in contact with Permian clays. Located in large vegetative kill area.
510	do	S. L. Canada	1960	20	--	--	Kca	1,948	9.70	do	J, E 1/3	D	Dug well. Reported yield 5 to 10 gal/min. Water sand reported from 12 to 20 feet. Red clay reported at 20 feet.
511	Jack T. Kidd	R. L. McKelvy	1969	35	8	35	Kca	1,973	14.21	Mar. 28, 1971	J, E 1/2	S	Casing slotted from 23 to 35 feet. Yellow clay at 31 feet. 2/
701	City of Clyde	--	1939	45	--	--	Kca	1,992	19 15.67 16.80	Oct. 5, 1959 Nov. 6, 1970 Oct. 9, 1974	Sub, E 3/4	P	Dug well. Reported yield 35 gal/min. Well pumped only during summer.
* 702	do	--	1947	41	--	--	Kca	1,989	19 15.01 14.47	Oct. 5, 1970 Nov. 6, 1970 Oct. 9, 1974	Sub, E 2	P	Dug well. Reported yield 50 gal/min. This well is the best municipal supply well in Clyde.
703	do	--	1952	26	--	--	Kca	1,994	19	Oct. 5, 1959	T, E	P, D	Dug well. Reported yield 75 gal/min.
* 704	do	--	1956	50	8	50	Kca	1,998	17	Nov. 6, 1970	Sub, E 2	P	Reported yield 20 gal/min.
* 705	E. A. Connel, Jr.	--	--	29	--	--	Kca	1,983	22.97 23.02	Sept. 9, 1970 Jan. 8, 1972	N	N	Dug well. 1/
706	Dr. J. E. Mikeska, Jr.	R. L. McKelvy	1966	37	6	37	Kca	1,985	23	May 3, 1966	N	N	Well destroyed. Sand and gravel reported from 23 to 37 feet. Former public supply well.
707	Eddie Konczak	do	1965	47	7	47	Kca	1,996	20.80	Nov. 4, 1970	Sub, E 3/4	Irr, D	Reported yield 35 gal/min. Slotted from 20 to 47 feet. 2/
* 708	do	do	1964	54	8	54	Kca	1,998	22	do	Sub, E 3/4	Irr, D	Reported yield 35 gal/min. Perforated from 16 to 54 feet.
709	do	do	1968	51	7	51	Kca	1,998	21.50	Nov. 4, 1970	N	N	Reported yield 35 gal/min. Slotted from 25 to 51 feet. Yellow clay at 48 feet. Unused irrigation well.

See footnotes at end of table.

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-37-710	Harold Holden	R. L. McKelvy	1968	57	7	57	Kca	1,997	19.30	Nov. 6, 1970	Sub, E 1	Irr	Measured yield 26 gal/min. Perforated from 25 to 57 feet. 3/
711	do	do	1968	55	6	55	Kca	1,992	16.45	do	Sub, E 1	Irr	Measured yield 26 gal/min. Red beds reported at 52 feet. 3/
712	do	do	1968	53	7	53	Kca	1,994	17.90	do	Sub, E 1	Irr	Reported yield 40 gal/min. Sand and gravel from 25 to 53 feet.
713	do	do	--	54	6	54	Kca	1,994	17.80	do	Sub, E 1	Irr	Reported yield 40 gal/min. Red beds reported at 52 feet.
* 714	City of Clyde	do	1965	55	8	55	Kca	1,998	18.17	do	Sub, E 2	P	Reported yield 40 to 50 gal/min. Slotted from 25 to 54 feet. 3/
* 715	do	do	1965	55	8	55	Kca	1,995	18	do	Sub, E 3/4	P	Reported yield 15 to 20 gal/min. Slotted from 26 to 55 feet. Temperature 62°F. 3/
716	do	Merle Bales	1961	50	6	50	Kca	1,994	18	do	T, E 3	P	Reported yield 20 gal/min. Used only during drouth.
717	do	do	1961	50	5	50	Kca	1,994	18	do	T, E 3	P	Do.
718	do	J. M. Rea	1954	41	--	--	Kca	1,996	21	do	T, E 3	P	Dug well. Reported yield 30 gal/min.
719	do	Howard Kniffen	1960	50	6	50	Kca	1,997	20.00	do	Sub, E 3/4	P	Reported yield 20 gal/min.
720	do	do	1960	50	6	50	Kca	1,995	17.60	do	Sub, E 3/4	P	Reported yield 25 gal/min.
721	do	A. L. Varner	1963	57	11	50	Kca	1,991	13.32	do	Sub, E 3/4	P	Reported yield 15 to 20 gal/min. Sand and gravel from 14 to 50 feet.
722	do	do	1963	50	8	41	Kca	1,992	13.68	do	Sub, E 3/4	P	Reported yield 15 to 20 gal/min. Sand and gravel 10 to 40 feet. 3/
723	do	R. L. McKelvy	1967	45	8	45	Kca	1,996	17	do	Sub, E 1	P	Reported yield 15 to 20 gal/min.
* 724	do	--	1939	26	--	--	Kca	1,992	19 15.80	Oct. 5, 1959 Nov. 6, 1970	Sub, E 3/4	P, D	Dug well. Reported yield 35 gal/min. Well 94 in Callahan County report. 4/
725	do	R. L. McKelvy	1960	45	8	45	Kca	1,987	15.01	do	Sub, E 3/4	P	Reported yield 17 gal/min.
726	do	do	1964	50	8	50	Kca	1,987	15.42	do	Sub, E 3/4	P	Reported yield 30 to 40 gal/min.
727	do	do	1963	50	8	50	Kca	1,992	17.01	do	Sub, E 1	P	Reported yield 45 gal/min.
728	do	do	1965	57	8	57	Kca	1,997	17.30	do	Sub, E 2	P	Reported yield 40 to 50 gal/min. Slotted from 28 to 56 feet. Yellow clay at 52 feet. 3/
729	do	do	1965	55	8	55	Kca	1,997	21.10	do	Sub, E 3/4	P	Reported yield 15 to 20 gal/min. Red beds reported at 52 feet.
* 730	Joe L. Jones	do	1967	49	5	49	Kca	1,995	16.40	Nov. 18, 1970	Sub, E 1	Irr	Reported yield 30 gal/min. Slotted from 32 to 49 feet. Yellow clay at 47 feet. Temperature 63°F. 3/

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-37-732	Charles Bailey	R. L. McKelvy	1965	44	7	44	Kca	1,980	19.90	Dec. 4, 1970	Cf, G 1	N	Reported yield 20 gal/min. Slotted from 31 to 44 feet. Red beds at 42 feet. Unused irrigation well. 2/
* 733	Glen Crosby	do	1967	90	5	90	Kca	2,030	50	Dec. 9, 1970	J, E 1	D	Reported yield 30 gal/min. Sand and gravel from 65 to 82 feet. 2/
734	John L. Estes, Jr.	A. L. Varner	1963	125	9	125	Kca	2,042	77.84	do	T, E 3	Irr	Reported yield 40 gal/min. Slotted from 90 to 112 feet. Shale and rock from 112 to 125 feet.
735	Ralph Ramerez	R. L. McKelvy	1965	40	6	40	Kca	1,955	5.80	Jan. 18, 1971	N	N	Casing slotted from 10 to 40 feet. Red clay at 30 feet. Former public supply well. 2/
* 736	L. O. Mitchell	do	1967	61	8	61	Kca	2,006	26.74	Jan. 25, 1971	Sub, E 3/4	Irr	Estimated yield 30 gal/min. Slotted from 30 to 61 feet. Yellow clay at 61 feet.
737	Clyde Church of Christ	L. E. Hayhurst	1970	43	5	43	Kca	1,992	13 15.45	July 20, 1970 Jan. 26, 1971	Sub, E 3/4	Irr	Reported yield 20 gal/min. Slotted from 12 to 43 feet. Red clay at 40 feet. 2/ 3/
738	Glen Curtiss	R. L. McKelvy	1968	61	6	61	Kca	1,995	32.50	Feb. 2, 1971	Sub, E 1/2	S	Perforated at 30 to 61 feet. Sand and gravel from 42 to 55 feet. 2/
739	Boyd Briscoe	do	1967	50	5	50	Kca	1,990	16.26	Mar. 30, 1971	J, E 1/2	D	Reported yield 30 gal/min. Sand from 12 to 24 feet and 35 to 47 feet. 2/
* 740	Callahan County	--	--	Spring	--	--	Kca	1,930	(+)	Apr. 6, 1971	--	N	Estimated flow rate 100 to 200 gal/min.
* 741	A. L. Varner	Jack Leonard	1964	50	8	50	Kca	1,995	15.26	June 15, 1971	Sub, E 1	D, Irr	Measured yield 32 gal/min. Well completed into Permian clay.
* 801	Baird City Schools	Jack R. Barnes	1960	63	13 7	23 63	Kca	1,957	26.40 23	Nov. 18, 1960 Oct. 28, 1961	Sub, E 3/4	Irr	Reported yield 15 gal/min. Screened from 23 to 43 feet. Formerly public supply for missile site. 2/
* 802	do	do	1960	63	13 7	23 63	Kca	1,957	27.02	Jan. 26, 1971	Sub, E 3/4	Irr	Estimated yield 15 gal/min. Screened from 23 to 43 feet. Formerly public supply for missile site.
* 803	T. P. R. R. Company	--	--	Spring	--	--	Kca	1,910	(+) (+) (+)	Sept. 20, 1939 Oct. 9, 1970 Nov. 14, 1971	Flows	S	Estimated flow rate 2 gal/min. Water flowing from sand which is in contact with Permian limestone. Well 53 in Callahan County report. 4/
* 804	City of Baird	--	1930	22	--	--	Kca	1,944	10.36 6.93	Apr. 9, 1940 Nov. 19, 1970	Sub, E 2	Irr	Dug well with cement walls which are 10 by 54 feet. Reported yield 25 gal/min. Well 1 in Callahan County report. 3/ 4/
805	do	Works Projects Administration	1939	55	--	--	Kca	1,955	24 15.20 18.21	Apr. 17, 1940 Nov. 19, 1970 Oct. 9, 1974	N	N	Dug well with cement walls which are 15 by 35 feet. Clay and shale from 36 to 55 feet. Stand-by public supply. Last used in 1949. Well 2 in Callahan County report. 4/
806	do	--	1927	49	--	--	Kca	1,969	29.52 19.28	Apr. 26, 1940 Nov. 19, 1970	N	N	Dug well. Reported yield 10 gal/min. Stand-by public supply. Last used in 1949. Well 4 in Callahan County report and Well 8 in Public Water Supplies report. 4/ 5/
* 807	do	--	1929	39	--	--	Kca	1,965	29.69 11.54	Aug. 24, 1940 Nov. 19, 1970	N	N	Dug well. Reported yield 15 gal/min. Stand-by public supply. Last used in 1949. Well 5 in Callahan County and Public Water Supplies reports. 4/ 5/
808	do	--	1930	40	--	--	Kca	1,970	39.48 17.74	Apr. 17, 1940 Nov. 19, 1970	N	N	Dug well. Reported yield 15 gal/min. Red beds reported at 38 feet. Last used as public supply in 1949. Well 7 in Callahan County report. 4/

See footnotes at end of table.

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
30-37-809	City of Baird	--	1927	43	--	--	Kca	1,972	36.60 19.52	Apr. 17, 1940 Nov. 19, 1970	N	N	Dug well. Reported yield 35 gal/min. Well will not pump at this rate very long. Stand-by public supply. Last used in 1949. Well 8 in Callahan County report. 4/
810	do	Works Projects Administration	1939	36	--	--	Kca	1,971	37.28 20	Aug. 23, 1940 Nov. 19, 1970	N	N	Dug well. Reported yield 20 gal/min. Well completed into clay at 36 feet. Stand-by public supply. Last used in 1949. Well 9 in Callahan County report. 4/
811	do	--	1927	43	--	--	Kca	1,966	36.85 17.60 21.38	Apr. 17, 1940 Nov. 19, 1970 Oct. 9, 1974	Sub, E 2	Irr	Dug well. Reported yield 35 gal/min. Red beds reported at 40 feet. Last used as public supply in 1949. Well 10 in Callahan County report. 4/
* 812	do	--	1927	44	--	--	Kca	1,969	34.08 22	Apr. 19, 1940 Nov. 19, 1970	Sub, E 1	Irr	Dug well. Reported yield 35 gal/min. Red beds reported at 40 feet. Last used as public supply in 1949. Well 11 in Callahan County report. 4/
813	John L. Estes, Jr.	Merle Bales	1960	125	6	125	Kca	2,040	76.22	Dec. 9, 1970	Sub, E 2	Irr, S	Reported yield 20 gal/min.
* 814	do	A. L. Varner	1963	150	8	150	Kca	2,060	97.26	do	Sub, E 2	S, Irr	Reported yield 40 gal/min. Slotted 96 to 130 feet. 3/
* 815	Glen Rocky	--	--	26	--	--	Kca	1,955	17.51	Jan. 18, 1971	J, E 1/3	D	Dug well. Temperature 62°F.
* 816	do	Glen Rocky	1967	28	--	--	Kca	1,958	13.50	do	Cf, E 3/4	Irr	Dug well. Reported yield 7 to 8 gal/min. Sand and gravel reported from 10 to 28 feet.
817	do	Jack Leonard	1961	45	24 7	10 45	Kca	1,961	17.62 17.50	do Oct. 9, 1974	Sub, E 1/3	Irr	Reported yield 8 to 10 gal/min. Slotted from 25 to 45 feet. Red beds reported at 45 feet.
818	do	R. L. McKelvy	1967	45	5	45	Kca	1,950	16	Jan. 18, 1971	J, E 1	Irr	Measured yield 9.6 gal/min. Slotted from 30 to 45 feet. Red beds reported at 45 feet. 3/
819	do	Jack Leonard	1962	41	24 7	15 41	Kca	1,967	19.70	do	Sub, E 1/3	Irr	Reported yield 8 gal/min. Slotted from 17 to 41 feet.
820	do	Howard Kniffen	1961	32	7	32	Kca	1,957	11.51	do	Sub, E 1/3	Irr	Measured yield 9.6 gal/min. Slotted from 17 to 32 feet. Red clay reported at 32 feet. 3/
821	do	Jack Leonard	1961	32	24 7	15 32	Kca	1,957	12 15.69	do Oct. 9, 1974	Sub, E 1/3	Irr	Measured yield 8.4 gal/min. Slotted from 17 to 32 feet.
822	do	do	1961	32	24 7	15 32	Kca	1,957	12.50 13.00	Jan. 18, 1971 June 15, 1971	J, E 1/3	Irr	Do.
823	Jack Flores	R. L. McKelvy	1965	73	6	73	Kca	2,002	45.04	Jan. 25, 1971	Sub, E 1/2	N	Casing slotted from 50 to 73 feet. Yellow clay at 73 feet. Abandoned industrial well.
* 824	Don E. Boles	L. E. Hayhurst	1968	27	5	27	Kca	1,968	14 13.70	Dec. 8, 1968 Jan. 25, 1971	Sub, E 1/2	D, S	Reported yield 10 gal/min. Perforated from 13 to 27 feet. 2/ 3/
825	S. O. Tucker	R. L. McKelvy	1965	75	--	--	Kca	1,936	18	Sept. 1965	N	N	Test was not completed. Water in sand and gravel at 18 to 20 feet. No water below 20 feet. 2/
826	Bobby Kennedy	--	--	18	--	--	Kca	1,940	11.80	Apr. 6, 1971	J, E 1/3	D, S	Dug well. Red clay reported at 18 feet.
827	City of Baird	Works Projects Administration	1940	34	--	--	Kca	1,940	26.0	Feb. 29, 1940	N	N	Abandoned test well. Well 24 in Callahan County report. 2/ 4/
* 39-903	John P. Mask	--	--	Spring	--	--	Qal	1,540	(+)	Apr. 12, 1971	Flows	N	Estimated flow rate 3 gal/min. Reported to be a salt water seep, which started flowing in spring of 1971. Water flowing from 1 to 2 feet of gravel.

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-44-101	N. H. Stephensen	Jack Leonard	1960	36	11	36	Kca	2,005	24.80	Feb. 5, 1971	J, E 1	D, S	Reported yield 8 gal/min. Red beds reported at 36 feet. Water reported from sand and gravel.
* 102	Mrs. R. G. Edwards	--	1924	28	--	--	Kca	1,978	18.80	Mar. 17, 1971	J, E 1/4	D, S	Dug well. Reported yield 5 gal/min. Sand and gravel 26 to 28 feet.
* 201	Eula Public School	Eula Public School Trustees	1937	26	--	--	Kca	1,960	8.42 4.89	Jan. 11, 1971 Oct. 9, 1974	J, E 1	P	Dug well. Estimated yield 18 gal/min. Water reported from sand at 15 to 30 feet. 2/
* 202	C. M. Hobbs	--	1945	30	--	--	Kca	2,006	12.98	Feb. 2, 1971	J, E 1/2	D, S	Dug well. Water reported from sand. Red beds reported at about 30 feet.
203	Loyd Barr	Jack Leonard	1966	50	5	50	Kca	1,980	6.10	Feb. 25, 1971	J, E 1/2	D, S	Reported yield 10 gal/min. Slotted from 10 to 50 feet. Sand and gravel reported from 10 to 15 feet.
* 204	Bill Farely	--	1930	24	--	--	Kca	1,960	8.80	Mar. 4, 1971	J, E 1/3	D, S	Dug well. Reported yield 10 gal/min. Water sand reported from 18 to 24 feet.
* 205	Don E. Bennett	--	1910	30	--	--	Kca	2,005	15.80	Mar. 5, 1971	J, E 1/2	D, S	Dug well. Sand and gravel reported from 20 to 30 feet.
206	Lee Smith	--Smith	1891	28	--	--	Kca	1,984	11.56	Mar. 17, 1971	J, E 1/3	D, S	Dug well. Pack sand with gravel reported at 16 to 28 feet.
* 301	Frank Blalock	L. E. Hayhurst	1968	38	6	38	Kca	1,988	23 16.41	Oct. 15, 1968 Nov. 2, 1970	J, E 1/3	D, S	Reported yield 15 gal/min. Perforated from 20 to 38 feet. 2/ 3/
* 302	Lyndon Key	Hilton Tarrant	1923	28	--	--	Kca	1,985	11.45	do	J, E 1/2	D, S	Dug well. Water reported from sand and gravel. Red beds reported at 28 feet.
* 303	C. W. Hinds	--	1929	32	--	--	Kca	1,976	27.60 20.60	Mar. 2, 1940 Nov. 2, 1970	J, E 1/3	D	Dug well. Very weak supply. Water reported from sand at 12 to 15 feet. Limestone at 15 feet. Well 119 in Callahan County report. 4/
* 304	Harold Holden	R. L. McKelvy	1969	35	7	35	Kca	1,982	6.72	Nov. 6, 1970	Sub, E 1	Irr	Measured yield 70 gal/min. Sand and gravel from 13 to 35 feet. Reported to be best well in the area. 2/ 3/
* 305	Dick Antilley	Howard Kniffen	1960	32	8	32	Kca	1,990	11.72	Nov. 13, 1970	J, E 1	D, S	Reported yield 20 gal/min. Screened from 10 to 32 feet. Blue shale reported at 32 feet.
306	C. E. Hicks	Merle Bales	1965	40	8	40	Kca	1,986	9.25	do	J, E 1	Irr, S	Reported yield 60 gal/min. Slotted from 14 to 38 feet. Could not complete into Permian because of sand caving.
* 307	do	Bridwell Oil Co.	1956	43	8	43	Kca	1,982	7.02	do	T, E 3	Irr	Reported yield 90 gal/min. Slotted from 18 to 43 feet. Red clay at 42 feet. 2/
* 308	C. E. Campbell	C. E. Campbell	1970	Spring	--	--	P	1,960	(+)	Nov. 17, 1970	Flows	S	Estimated flow 1 gal/min. Seep is 15 feet below ground level. Water reported from white clay.
* 401	Jack J. Hill	R. L. McKelvy	1965	58	6	58	Kca	2,006	38.59	Jan. 6, 1971	J, E 1/2	D, S	Reported yield 5 gal/min. Slotted from 40 to 58 feet. 2/
* 402	Doyle Lenz	L. E. Hayhurst	1968	56	6	56	Kca	2,010	37 35.55	July 5, 1968 Jan. 8, 1971	C, W	D, S	Reported yield 4 gal/min. Casing perforated from 35 to 53 feet. 2/ 3/
* 403	Holley Ivey	Jean McGarrell	1962	77	5	77	Kca	2,010	7.97	Feb. 5, 1971	J, E 1/2	D, S	Reported yield 20 gal/min. Water reported from two sands at 25 and 70 feet.
* 404	W. E. Carter	--	--	Spring	--	--	Kca	1,970	(+) (+)	Aug. 1, 1940 Feb. 5, 1971	Flows	S	Water seeping from sand at undetermined rate. Spring located at contact of Permian rocks and Antlers sands. Well 402 in Callahan County report. 4/

See footnotes at end of table.

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
30-44-405	Ervin Welch	L. E. Hayhurst	1963	30	6	30	P	1,908	11.20	Mar. 1, 1971	C, W	S	Reported to be very weak well and of poor quality. Water reported from limestone at 15 to 30 feet.
406	Callahan County	--	--	Spring	--	--	Qal	1,919	(+)	Mar. 17, 1971	Flows	S	Estimated flow rate 5 gal/min. Water flowing from sandy clay.
407	Holly Ivey	Jean McCarrell	1962	80	5	80	Kca	2,042	21.42	do	Sub, E 1/3	S	Dug well. Two water strata reported at 20 and 70 feet. Red beds reported at 78 feet.
408	W. M. Lockridge	R. L. McKelvy	1966	47	6	47	Kca	2,000	34 30.10	Apr. 8, 1966 Mar. 17, 1971	J, E 1/2	D	Slotted from 30 to 47 feet. Red beds at 40 feet.
409	Lanny Denman	L. E. Hayhurst	1974	80	5	80	Kca	2,030	38.61	Oct. 9, 1974	Sub, E	Irr	Yield reported at 30 gal/min.
* 501	E. F. Beyer	do	1968	80	5	80	Kca	2,060	54 51.41	Oct. 20, 1968 Nov. 2, 1970	J, E 3/4	D	Reported yield 15 gal/min. Perforated from 50 to 78 feet. 2/ 3/
* 502	C. E. Campbell	C. E. Campbell	1968	22	36	22	Kca	2,022	17 16.40	Nov. 17, 1970 Jan. 6, 1971	J, E 1	D	Reported yield 20 gal/min. Slotted from 12 to 22 feet. Water reported from upper sand member. 2/
* 503	J. S. Bentley	--	1947	42	6	42	Kca	2,021	30.00	Jan. 11, 1971	J, E 1	D, S	Reported yield 15 gal/min. Red beds reported at 42 feet.
* 504	Rufus Miller	--	--	Spring	--	--	Kca	1,945	(+)	do	Flows	S	Estimated flow rate 100 gal/min or greater. Water reported from lower sand member. Flow began in 1955.
* 505	W. T. Gardner	--	1940	30	--	--	Kca	2,018	11.22	Feb. 5, 1971	J, E 1/3	D, S	Reported yield 10 gal/min. Red clay reported at 30 feet.
* 506	do	--Gardner	1920	25	--	--	Kca	2,014	8.20	do	J, E 1/3	D, Ind	Dug well. Estimated yield 6 gal/min. Red clay reported at 25 feet. Supplies water for a turkey farm.
507	do	L. E. Hayhurst	1970	32	5	32	Kca	2,010	14 11.40	May 30, 1970 Feb. 5, 1971	J, E 3/4	Ind	Estimated yield 6 gal/min. Slotted from 13 to 32 feet. Yellow clay at 24 feet. Supplies water for a turkey farm. 2/
508	Claudell Joy	do	1973	47	5	47	Kca	2,020	8.86	Oct. 9, 1974	N	N	Owner's well No. 1. Unused irrigation well. Yield reported at 25 gal/min.
509	do	do	1973	27	5	27	Kca	2,020	5.92	do	N	N	Owner's well No. 2. Unused irrigation well. Yield reported at 20 gal/min.
510	do	do	1973	25	5	25	Kca	2,015	6.24	do	N	N	Owner's well No. 3. Unused irrigation well. Yield reported at 20 gal/min. 3/
511	do	do	1973	26	5	26	Kca	2,020	5.54	do	N	N	Owner's well No. 4. Unused irrigation well. Yield reported at 13 gal/min.
* 601	Rufus Miller	--	--	14	--	--	Kca	1,948	7.64 2.73	Feb. 21, 1940 Jan. 11, 1971	C, W	D, S	Dug well. Well 125 in Callahan County report. 4/
* 701	Highway 36 Church of Christ	Howard Kniffen	1959	90	6	90	Kca	2,060	30.08 38.97	Sept. 9, 1970 Jan. 8, 1972	J, E 1/2	P	Water gravels reported at 30, 60, and 90 feet. 1/
* 702	Tommy Smith	L. E. Hayhurst	1968	35	5	26	Kca	2,016	16.22	Jan. 6, 1971	J, E 1/2	D	Estimated yield 3 gal/min. Perforated 16 to 26 feet. Water sand at 19 to 26 feet. 2/
* 703	Frank D. Chrane	do	1969	66	6	66	Kca	2,061	51 51.85	July 16, 1969 Jan. 8, 1971	J, E 1/2	S	Reported yield 10 gal/min. Perforated from 50 to 66 feet. Test originally drilled to 70 feet. 2/ 3/
* 704	Earl Zimmerle	do	1968	131	6	131	Kca	2,145	97 98.72	Apr. 14, 1968 Feb. 5, 1971	Sub, E 1/2	S	Reported yield 14 gal/min. Slotted from 111 to 131 feet. Test originally drilled to 138 feet. 2/ 3/

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-44-705	Annie Mosier	L. E. Hayhurst	1968	51	5	51	Kca	2,015	30 29.29	Aug. 13, 1968 Feb. 5, 1971	J, E	D	Reported yield 10 gal/min. Perforated at 30 and 51 feet. 2/ 3/
706	Burt Northcutt, Jr.	A. L. Varner	1964	45	8	45	Kca	2,038	18 18.20	Mar. 7, 1964 Feb. 16, 1971	Sub, E 1	S	Sand and gravel at 18 to 31 feet and sand 34 to 40 feet. 2/
707	J. D. Crawford	--	--	Spring	--	--	Kca	1,990	(+)	Mar. 19, 1971	Flows	S	Water reported seeping from sand in contact with a fossiliferous limestone.
708	do	--	--	17	--	--	Kca	2,002	15.09	do	N	N	Dug well. Limestone at 17 feet.
709	Marvin Lewis	--	--	150	6	150	Kca	--	80	Aug. 21, 1971	Sub, E	Ind	Reported yield 12 gal/min. Reported to pump 50 barrels a day to supply water-flood operation.
* 710	Jim Culpepper	L. E. Hayhurst	1973	106	5	106	Kca	2,060	74 48.82	May 15, 1973 Oct. 10, 1974	Sub, E	Irr	Yield reported at 25 gal/min. Sand and gravel reported at 70 to 85 feet. 3/
801	Michael B. Williams	Jack R. Barnes	1961	123	13 7	84 123	Kca	2,095	84	Oct. 28, 1960	J, E 3/4	S	Measured yield 7 gal/min. Screened from 84 to 103 feet. Formerly public supply for Denton Missile site.
* 802	do	do	1960	123	13 7	84 123	Kca	2,092	73.00 70	do Jan. 7, 1971	J, E 3/4	S	Measured yield 7 gal/min. Screened from 84 to 103 feet. Formerly public supply for Denton Missile site.
803	do	do	1961	123	13 7	84 123	Kca	2,084	62.38	do	N	N	Measured yield 7 gal/min. Screened from 84 to 103 feet. Formerly public supply for Denton Missile site. 2/
* 804	Jimmy Partin, III	Robert Higgins	1967	153	8	153	Kca	2,120	35 26.70	Oct. 4, 1967 Jan. 8, 1971	Sub, E 1/2	S	Reported yield 20 gal/min. Slotted from 30 to 45 feet and 90 to 150 feet. 2/
805	Casto Smith	L. E. Hayhurst	1968	46	6	46	Kca	2,025	15 13.56	May 2, 1968 Jan. 11, 1971	J, E 1/2	Irr	Estimated yield 15 gal/min. Slotted 20 to 46 feet. Purple and white clay at 40 to 50 feet. 2/ 3/
* 806	L. H. Lilly	do	1969	90	5	90	Kca	2,075	50 49.72	Feb. 25, 1969 Jan. 11, 1971	J, E 1	D, S	Estimated yield 15 gal/min. Perforated 50 to 90 feet. Yellow clay at 91 feet. 2/ 3/
* 807	Herman Scott	do	1969	41	5	41	Kca	1,990	20 19.20	Nov. 11, 1969 Feb. 8, 1971	J, E 1/2	S	Estimated yield 10 gal/min. Screened from 16 to 41 feet. 2/
* 808	A. E. Robertson	J. D. McCarrell	1963	60	6	60	Kca	2,040	23.70	Feb. 17, 1971	Sub, E 1-1/2	Irr	Reported yield 40 gal/min. Sand and gravel from 47 to 60 feet. 2/
809	J. C. Tucker	L. E. Hayhurst	1968	60	6	60	Kca	2,065	40 39.30	May 16, 1968 Mar. 1, 1971	J, E 1/2	S	Estimated yield 10 gal/min. Slotted from 40 to 60 feet. Red beds at 61 feet. 2/
* 810	John Loven	Jack Leonard	1962	76	--	--	Kca	2,040	30.30	do	J, E 1	D	Dug well. Reported yield 10 gal/min. Water reported to be coming from strata of sand and gravel. Red beds reported at 76 feet.
901	W. E. Connel	L. E. Hayhurst	1969	20	5	20	Kca	1,978	8 10.30	July 11, 1969 Jan. 1, 1971	J, E 1/3	D, S	Estimated yield 5 gal/min. Perforated 8 to 20 feet. Sand and gravel from 8 to 13 feet. 2/
* 902	M. C. Gulledge	Lester King	1957	105	5	105	Kca	1,990	75.85	Feb. 16, 1971	Sub, E 1	D, S	Reported yield 30 to 40 gal/min. Sand and gravel reported from 80 to 105 feet. Red beds reported at 105 feet.
* 903	A. E. Kendrick	--	1921	13	--	--	Kca	1,960	6.52 5.11	Apr. 30, 1940 Mar. 4, 1971	N	N	Dug well which has not been used in 20 years. Well 413 in Callahan County report. 4/
* 45-101	Mel Green	Howard Kniffen	1962	55	6	55	Kca	1,978	22.65	Nov. 4, 1970	J, E 3/4	Ind	Reported yield 50 gal/min. Water sand and gravel reported from 45 to 55 feet.

See footnotes at end of table.

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
30-45-102	Mel Green	Howard Kniffen	1966	60	6	60	Kca	1,973	22.30	Nov. 4, 1970	J, E 3/4	D, Ind	Reported yield 50 gal/min. Red beds reported at 50 feet. Provides water for hog and cattle feed-lot.
103	D. C. Rogers, Jr.	R. L. McKelvy	1966	42	7	42	Kca	1,980	21 18.97	Dec. 1966 Nov. 17, 1970	Sub, E 1	Irr	Estimated yield 27 gal/min. Perforated from 25 to 42 feet. Sandy clay at 38 feet. 2/
104	do	do	1966	52	7	52	Kca	1,983	26 22.60	Dec. 1966 Nov. 17, 1970	Sub, E 1	Irr	Estimated yield 40 gal/min. Perforated from 27 to 52 feet. Sandy clay at 44 feet. 3/
* 105	do	do	1966	61	7	61	Kca	1,988	25.02	do	Sub, E 1	Irr	Estimated yield 32 gal/min. Perforated from 32 to 61 feet. Red clay at 55 feet.
106	do	do	1967	50	7	50	Kca	1,982	22.12	do	Sub, E 1	Irr	Reported yield 27 gal/min. Perforated from 25 to 50 feet.
107	Dr. R. W. Evans	do	1964	48	6	48	Kca	1,965	32.82	Feb. 2, 1971	J, E 1/2	S	Reported yield 20 to 30 gal/min. Slotted from 30 to 48 feet. Blue shale at 45 feet. 2/
108	Archie Nichols	--	--	Spring	--	--	Kca	1,940	(+)	Mar. 30, 1971	C, W	D, S	Estimated flow rate 2 gal/min. Water flowing from Antlers sand at contact with Permian limestone.
* 201	Dr. M. C. McGowen	--	1935	31	--	--	Kca	1,932	19.00 19.99	Feb. 7, 1940 Dec. 1, 1970	N	N	Dug well. Well completed into clay. Well 127 in Callahan County report. 4/
* 202	R. L. Griggs, Jr.	--	1890	34	--	--	Kca	1,940	14.32	do	J, E 1/2	D, S	Dug well. Estimated yield 10 gal/min. Red clay at 34 feet.
* 203	W. T. Barnes	L. E. Hayhurst	1970	46	5	46	Kca	1,958	20.30	Feb. 2, 1971	Sub, E 1/2	D	Estimated yield 1 gal/min. Slotted from 18 to 46 feet. 2/
* 205	Wayne Hilcher	R. L. McKelvy	1962	20	8	20	Kca	1,946	5.52	Feb. 25, 1971	J, E 1/2	D	Reported yield 5 gal/min. Yellow clay at 20 feet.
206	Elmer Crossland	L. E. Hayhurst	1970	44	5	44	Kca	1,955	20 20.60	Sept. 18, 1970 Apr. 6, 1971	J, E 1/3	D	Estimated yield 1 gal/min. Sand from 5 to 25 feet. Slotted from 20 to 44 feet.
* 207	Archie Nichols	Archie Nichols	1934	14	--	--	Qal	1,872	8.50	Mar. 30, 1971	Cf, G	S	Reported yield 5 gal/min. Sand and gravel reported from 12 to 14 feet.
* 901	Dr. J. E. Mikeska, Jr.	--	--	24	6	24	Kca	1,892	16.19	Sept. 10, 1970	N	N	Cased dug well.
* 902	Elisk Gilliam	--	--	23	--	--	Kca	1,890	10.49 12.55	Sept. 5, 1940 Sept. 22, 1970	C, W	S	Dug well. Reported yield 10 gal/min. Well 417 in Callahan County report. 4/
903	Bill Varner	--	--	Spring	--	--	Kca	1,875	(+)	Apr. 28, 1971	Flows	S	Estimated flow rate 5 to 20 gal/min. Reported to flow year round. Water flows from sand in contact with Permian clay.
904	do	Jack Leonard	1967	42	5	42	Kca	1,908	30	do	Sub, E 1/2	S	Reported yield 15 gal/min. Slotted from 30 to 42 feet. 2/
* 46-201	Maggie Walker	--	1870	40	--	--	P	1,601	20.90	Mar. 16, 1971	J, E 1/2	D, S	Reported yield 5 gal/min. Cracked cistern used as well for 50 years. Water reported from clay and limestone.
202	Jim Hatchett	--	1900	27	--	--	P	1,595	16.12 11.26	Sept. 5, 1940 Mar. 24, 1971	N	N	Dug well. Well 209 in Callahan County report. 4/
* 401	Claude Flores	--	1876	65	--	--	P	1,813	34.37 18.00	Sept. 5, 1940 Mar. 5, 1971	N	N	Dug well. Reported to be strong supply. Water reported from limestone and shale at unknown depths. Well 133 in Callahan County report. 4/

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-46-501	Robert Eubanks	A. L. Varner	1971	40	--	--	P	1,604	8.00	May 6, 1971	N	N	Water reported from a sandy shale at 20 to 25 feet. Water is extremely saline. Abandoned test hole. 2/
* 701	Dr. J. E. Mikeska, Jr.	R. L. McKelvy	1965	53	9	53	Kca	1,915	22.98 23.50 23.80	Mar. 24, 1970 Sept. 10, 1970 Nov. 12, 1973	C, W	S	Estimated yield 5 gal/min. Slotted from 25 to 53 feet. 1/
* 702	Morgan Stokes	--	--	91	--	--	Kca	1,970	76.10 77.30	Sept. 5, 1940 Sept. 22, 1970	J, E 1/3	N	Dug well. Well 303 in Callahan County report. 4/
* 703	C. M. Eller, Sr.	R. L. McKelvy	1965	76	6	76	Kca	1,940	50 45	1965 Oct. 14, 1970	Sub, E 3/4	Irr, D	Measured yield 12 gal/min. Perforated from 40 to 75 feet. 2/
704	do	do	1968	75	8	75	Kca	1,945	47.05	do	C, W	D	Reported yield 12 gal/min.
705	Charles M. Eller, Jr.	do	1966	70	9	70	Kca	1,915	26	do	C, W	S	Estimated yield 15 gal/min. Slotted from 48 to 72 feet. Yellow clay at 65 feet. 2/
* 706	Andy Myers	--	1920	20	--	--	Kca	1,892	12.92	do	Cf, E 1/3	D, S	Dug well. Sand and gravel at 10 to 20 feet. Red clay at 20 feet.
707	Dave Pillars	A. L. Varner	1964	75	7	75	Kca	1,910	25.70	do	Sub, E	N	Water sand from 31 to 52 feet. Red shale 52 to 61 feet. Unused irrigation well.
708	do	R. L. McKelvy	1965	48	5	48	Kca	1,913	24.53	do	Cf, E 1/2	S	Slotted from 20 to 48 feet. Water sand and gravel from 26 to 32 feet. 2/
* 801	W. O. Wylie	--	--	17	--	--	Kca	1,848	9.25 7.34	Sept. 5, 1940 Mar. 5, 1971	N	N	Dug well. Water from sand and gravel. Well 305 in Callahan County report. 4/
* 902	County of Callahan	--	--	Spring	--	--	Kca	1,966	(+) (+)	Mar. 21, 1940 Sept. 23, 1970	Flows	N	Estimated flow 35 gal/min. Water from white sand in contact with blue clay. Temperature 68°F. Well 308 in Callahan County report. 4/
* 903	Bob Beckham	A. L. Varner	1965	266	6	265	Kca	2,070	234.1	Jan. 13, 1971	C, W	S	Reported yield 2 to 5 gal/min. Water sand from 245 to 265 feet. 2/
* 47-601	E. R. Battle	Fred Sprawls	1920	25	--	--	Kca	1,783	15.31 13.29 13.15	Mar. 19, 1940 Mar. 5, 1969 May 7, 1974	J, E 1/3	D, S	Dug well. Well 316 in Callahan County report. 1/ 4/
602	Raymond Sprawls	A. L. Varner	1970	34	7	32	Kca	1,772	16 14.83	July 1970 Jan. 14, 1971	Sub, E 1/2	Irr	Reported yield 35 gal/min. Slotted from 15 to 25 feet. Red beds reported at 28 feet.
* 603	do	do	1970	30	7	30	Kca	1,772	16 15.03	July 1970 Jan. 14, 1971	Sub, E 1-1/2	Irr	Reported yield 25 gal/min. Slotted from 15 to 25 feet. Red clay at 25 to 41 feet. Well completed to 30 feet. 2/
* 604	do	do	--	23	--	--	Kca	1,772	14 15.44	Sept. 17, 1970 Jan. 14, 1971	Sub, E 1-1/2	Irr, D, S	Dug well. Measured yield 60 gal/min. Ten feet of water sand present in well.
* 605	W. W. Scott	J. W. Huff	1964	19	--	--	Kca	1,767	12.67	Oct. 6, 1970	C, E 1	D, S	Dug well. Water sand from 13 to 19 feet. Temperature 69°F.
* 606	G. A. Reece	R. L. McKelvy	1966	45	6	45	Kca	1,787	18.52	do	J, E 1	D, S	Pack sand from 23 to 35 feet. 2/
* 701	Weldon Gary	--	--	45	--	--	Kca	1,855	29.94	Sept. 21, 1970	C, W	S	Dug well. Open hole from 4 to 45 feet.
* 702	do	--	--	Spring	--	--	Kca	1,800	(+)	do	Flows	S	Estimated flow rate 30 gal/min. Water flowing from fine to coarse grained sand which is in contact with a Permian limestone.
* 703	Loyd Gary	A. L. Varner	1951	118	5	118	Kca	1,900	66.78	do	C, W	D, S	Blue shale reported at 80 feet.

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-47-704	LaReata Ranch	Lester King	1966	134	6	134	Kca	1,907	85.31	Oct. 1, 1970	Sub, E 3/4	D	Reported yield 5 gal/min. Temperature 69°F.
* 705	do	--	--	114	6	114	Kca	1,933	100.65	Oct. 7, 1970	C, W	S	Red beds reported at 114 feet. Well 309 in Callahan County report. 4/
* 801	do	--	--	18	--	--	Kca	1,810	10.77 7.38	Aug. 2, 1940 Oct. 1, 1970	C, W	D, S	Dug well. Well 310 in Callahan County report. 4/
* 901	Jerry Dehlinger	Jack Leonard	1966	50	12	50	Kca	1,798	36.02	Sept. 24, 1970	Sub, E 1-1/2	Irr	Reported yield 65 gal/min. Water sand from 27 to 50 feet.
902	do	do	1966	50	12	50	Kca	1,798	33.90	Sept. 23, 1970	Sub, E 1-1/2	Irr	Reported yield 100 gal/min. Water sand from 27 to 50 feet.
903	do	do	1966	50	12	50	Kca	1,798	32.68	do	Sub, E 1-1/2	Irr	Reported yield 100 gal/min.
904	do	do	1968	60	12	60	Kca	1,798	32.19	do	Sub, E 1-1/2	Irr	Reported yield 65 gal/min. Water sand from 27 to 50 feet. Slotted 20 to 60 feet.
* 905	Dwight Black	--	1950	21	--	--	Kca	1,765	11.79	Oct. 1, 1970	J, E 1	D, S	Dug well. Yield reported to be strong. Pack sand from 8 to 21 feet.
* 906	S. A. Black estate	--	1935	16	--	--	Qal	1,764	10.45 9.60	Mar. 19, 1940 Oct. 1, 1970	C, W	N	Dug well. Well 315 in Callahan County report. 4/
907	Foy Jobe	--	--	18	--	--	Kca	1,766	5.95	do	B, H	D, S	Dug well.
* 908	J. L. Marinelli	Vernon Phillips	1966	33	8	33	Kca	1,776	8.85	Oct. 6, 1970	J, E 1/2	S	Slotted from 12 to 33 feet. Red beds from 33 to 35 feet. Well originally drilled to 35 feet. 2/
* 48-402	Morris L. Morgan	Morris L. Morgan, Sr.	1918	17	--	--	Kca	1,745	9.50	do	H	S	Dug well. Reported yield 5 to 10 gal/min.
705	D. L. Sessions	--	1955	55	--	--	Kca	1,810	34.00	Mar. 15, 1971	J, E	S	Dug well. Red bed reported at 55 feet. Water from sand and gravel.
* 52-101	C. W. Carter	C. W. Carter	1949	121	6	121	Kca	2,090	85.62	Dec. 3, 1970	Sub, E 3/4	Irr	Reported yield 12 gal/min. Slotted 87 to 120 feet. Black shale at 120 feet. 2/
* 102	do	do	1950	110	6	110	Kca	2,085	82.39	do	Sub, E 1	D, Irr	Reported yield 14 gal/min. Slotted 87 to 110 feet. Black shale at 110 feet.
103	do	Jack Leonard	1962	36	--	--	Kca	2,020	20 20.00	Sept. 25, 1962 Dec. 3, 1970	N	N	Well has been destroyed. Sand and gravel 20 to 35 feet. Yellow clay at 35 feet. 2/
* 104	Gordon Hass	P. A. Kirk	1955	16	6	16	Kca	1,970	8.71	do	J, E 1/3	D	Water coming from sand and gravel. Water reported to have become salty this summer. Several vegetative-kill areas located above well.
* 105	S. O. Barton	L. E. Hayhurst	1969	130	5	130	Kca	2,100	20 20.07	July 29, 1969 Feb. 8, 1971	Sub, E 3/4	D, S	Reported yield 15 gal/min. Slotted from 20 to 30 feet and 100 to 120 feet. Upper sand formation has very little water. Originally drilled to 135 feet. 2/ 3/
106	R. D. Whitford	--	1920	50	--	--	Kca	2,040	33.10	Mar. 1, 1971	C, W	D, S	Dug well. Reported yield 5 gal/min. Water reported from sand and gravel at 35 to 50 feet.
107	C. W. Barnard	L. E. Hayhurst	1970	17	5	17	Kca	1,998	8 9.80	Dec. 8, 1970 Mar. 1, 1971	J, E 1/2	D	Estimated yield 5 gal/min. Casing slotted from 8 to 17 feet. Yellow lime at 14 to 18 feet. 2/ 3/
* 201	Leroy Crawford	--	--	16	--	--	Kca	1,995	13.90	Mar. 19, 1971	Sub, E 1/2	D, S	Dug well. Open hole at 14 to 16 feet. Limestone at 16 feet.

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-52-401	Stella Johnson	Jack Barnes	1960	112	13 7	82 112	Kca	2,080	52	June 24, 1961	Sub, E 2	Irr	Formerly public supply for Oplin Missile site. Reported yield 8 gal/min. Screened from 82 to 112 feet. Shale at 105 feet. 2/
402	do	do	1960	112	13 7	82 112	Kca	2,104	82 76	do Jan. 11, 1971	Sub, E 2	Irr	Formerly public supply for Oplin Missile site. Reported yield 8 gal/min. Screened from 82 to 112 feet.
403	do	do	1960	112	13 7	82 112	Kca	2,100	82	Jan. 7, 1971	Sub, E 2	Irr	Formerly public supply for Oplin Missile site. Reported yield 8 gal/min. Screened from 82 to 112 feet.
* 404	Ola Roberts	--	--	19	--	--	Kca	2,000	12.03 11.78	Sept. 9, 1970 Jan. 8, 1972	R	N	Dug well. 1/
* 405	Walter Preston	--	--	32	--	--	Kca	2,030	16.82 11.01	Apr. 30, 1940 Jan. 8, 1971	J, E 1/2	D, S	Dug well. Well 437 in Callahan County report. 4/
* 406	John Armor	--Rogers	1950	101	6	101	Kca	2,080	72.14	Mar. 1, 1971	J, E 1/2	D, S	Water reported coming from a seep at 40 feet and water sand from 80 to 100 feet.
407	Roy Armor	do	1950	90	6	90	Kca	2,090	60.80	do	C, W	D, S	Reported yield 8 gal/min. Water reported from seep at 45 feet. Water sand reported at 70 to 88 feet.
* 501	Ira Crawford	L. E. Hayhurst	1970	16	5	16	Kca	1,993	8 10.00	Sept. 26, 1970 Feb. 5, 1971	J, E 1/2	S	Estimated yield 5 gal/min. Casing slotted 7 to 16 feet. 2/ 3/
* 701	Luther McCrea	--	1924	15	--	--	Kca	2,005	11.01 9.91	Sept. 6, 1940 Jan. 6, 1971	N	N	Dug well. Sand reported at 11 to 16 feet. Well 434 in Callahan County report. 4/
* 702	Lowell Johnson	--	--	49	--	--	Kca	2,025	29.49	do	J, E 1/3	D, S	Dug well. Water coming from sand and gravel at unknown depth.
703	do	L. E. Hayhurst	1970	70	5	70	Kca	2,052	42.33	do	C, W	S	Reported yield 5 gal/min. Slotted from 47 to 70 feet. Red beds at 62 feet. 2/ 3/
* 801	Guy Williams	do	1969	37	8	37	Kca	2,023	15 15.41	Mar. 24, 1969 Dec. 3, 1970	J, E 1/3	S	Estimated yield 6 gal/min. Slotted from 15 to 35 feet. Lime from 22 to 37 feet. 2/
802	Leon Barr	do	1970	20	5	20	Kca	2,004	16 13.76	Nov. 20, 1970 Feb. 16, 1971	N	N	Estimated yield 2 gal/min. Perforated 15 to 20 feet. Yellow clay at 22 feet. 2/
* 803	Stella Yost	--	1940	35	--	--	Kca	2,035	27.97 27.50	Apr. 30, 1940 Mar. 1, 1971	J, E 1/3	D, S	Dug well. Reported yield 5 gal/min. No water reported below 33 feet. Well 431 in Callahan County report. 4/
804	Alvin Cox	L. E. Hayhurst	1971	59	5	59	Kca	2,052	43	Mar. 14, 1971	J, E	D	Reported yield 4 gal/min. Slotted from 40 to 59 feet. Originally drilled to 65 feet. 2/ 3/
901	Carl Dunlap	Repps Guitar, Jr.	1965	20	6	20	Kca	1,978	14.15 14.62	Dec. 17, 1970 Jan. 8, 1972	C, W	N	Perforated from 12 to 20 feet. Water coming from sand and gravel. 1/
* 902	Guy Williams	L. E. Hayhurst	1969	65	5	65	Kca	2,009	33 35.00	Apr. 4, 1969 Jan. 6, 1971	J, E 1/2	S	Reported yield 3 gal/min. Slotted 33 to 65 feet. 2/
* 903	Carl Dunlap	Repps B. Guitar, Jr.	1965	30	9	30	Kca	1,978	8 8.50	Apr. 7, 1965 Jan. 6, 1971	J, E 1/2	N	Estimated yield 8 gal/min. Perforated 14 to 20 feet. Sand and gravel reported from 14 to 22 feet. Test originally drilled to 50 feet and completed at 30 feet. Unused irrigation well. 2/ 3/
904	Marvin Rutland	L. E. Hayhurst	1970	40	4	40	Kca	1,982	15.55	do	C, W	S	Reported yield 3 gal/min. Perforated from 15 to 40 feet.

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-52-905	J. O. Williams	--	--	37	--	--	Kca	1,997	31.34 30.00	Sept. 6, 1940 Mar. 19, 1971	C, E	S	Dug well. Open hole from 4 to 37 feet. Well 430 in Callahan County report. 4/
906	Mrs. Clint McIntyre	Mury Bales	1952	45	6	45	Kca	1,958	7.81	do	C, W	S	Water sand reported at 20 to 45 feet.
* 53-101	Henry Seale	--	1950	Spring	--	--	P	1,840	(+)	do	Flows, J, E 1/2	D	Spring which has been dug out to 8 feet. Estimated flow rate 8 gal/min.
* 301	Alton Hornsby	--	--	7	--	--	Kca	1,878	2.88 4.64	Sept. 5, 1940 Sept. 22, 1970	N	N	Dug well. Open hole from 3 to 8 feet. Well 418 in Callahan County report. 4/
* 901	Hall Ranch	--	--	Spring	--	--	P	1,670	(+)	Mar. 25, 1971	Flows	S	Estimated yield 1 gal/min. Reported to flow year round.
* 54-101	Robert McClain	Lester King	1966	88	8	88	Kca	1,920	30.22	Sept. 22, 1970	J, G 3	S	Reported yield 60 gal/min. Slotted from 30 to 45 and 86 to 88 feet. Test originally drilled to 90 feet. Temperature 69°F. 2/
* 102	do	do	1969	31	8	31	Kca	1,880	7.82	do	J, E 1/2	D, S	Reported yield 10 gal/min. Sand from 2 to 31 feet. Well completed in sand.
* 103	H. J. Gibbs	W. D. Clark	1970	70	6	70	Kca	1,905	46.53	do	J, E 1/3	D, S	Reported yield 6 gal/min. Perforated from 50 to 70 feet. Water sand from 49 to 56 feet. 2/
* 104	Bob Dye	R. L. McKelvy	1966	70	6	70	Kca	1,944	50.18	Oct. 7, 1970	Sub, E 1/2	D	Reported yield 16 gal/min. Water sand from 45 to 70 feet.
105	Russell H. Dye	Dick Marrow	1970	102	6	102	Kca	1,951	62.28	Oct. 14, 1970	Sub, E 1/2	D	Reported yield 10 gal/min. Perforated from 62 to 102 feet. 2/
* 106	John F. Downs	--	1916	30	--	--	Kca	1,887	13.44	Jan. 13, 1971	J, E 1/2	S	Dug well. Reported yield 10 gal/min.
201	W. M. Price	--	--	23	--	--	Kca	1,910	21.03 18.80	Mar. 21, 1940 Oct. 9, 1970	C, W	N	Dug well. Reported yield 2 gal/min. Well 302 in Callahan County report. 4/
* 202	do	--	1946	26	--	--	Kca	1,900	12.52	Oct. 13, 1970	Cf, E 1	D, S	Dug well. Reported yield 5 gal/min. Water reported from sand and gravel.
203	do	--	--	Spring	--	--	Kca	1,887	(+)	do	Flows	S	Estimated flow at 5 to 10 gal/min. Water reported flowing from a fine, white sand.
* 204	W. L. Lawrence	R. L. McKelvy	1961	120	6	120	Kca	1,935	50.40	Oct. 14, 1970	J, E 1/2	D, S	Reported yield 3 gal/min. Water sands reported at 60 and 90 feet. Red beds reported at 100 feet.
* 206	Bob Beckham	Bill Varner	1937	200	5	160	Kca	2,138	173.50	Mar. 11, 1971	C, W	S	Reported potential yield 75 gal/min. Completed in upper part of Antlers sand.
207	do	Bud Goble	--	220	6	220	Kca	2,111	135.00	do	C, W	S	Reported potential yield 75 gal/min. Upper water sand reported from 200 to 220 feet.
* 302	Caldwell Ranch	Cecil Gobel	1950	190	5	190	Kca	2,005	31.53 37.78	Mar. 6, 1969 Jan. 12, 1971	Sub, E 1/3	D, S	Estimated yield 4 gal/min. Temperature 66°F.
* 303	Ray Fairacloth	William Varner	1939	119	5	119	Kca	1,919	87.22 87.20	Apr. 4, 1940 Sept. 21, 1970	N	N	Water reported from 99 to 119 feet. Well 327 in Callahan County report. 4/
* 304	A. A. Holley	--Murdock	--	120	6	120	Kca	1,910	54.40	Sept. 23, 1970	C, W	D, S	Estimated yield 5 to 6 gal/min. Casing reported collapsed from 110 to 120 feet.
305	Bob Beckham	Bud Goble	1936	186	6	186	Kca	1,994	135.30	Mar. 11, 1971	C, W	S	Sand reported from 152 to 184 feet. Slotted from 163 to 184 feet.
306	do	William Varner	1928	120	4	120	Kca	2,048	74.09	do	C, W	S	Well reported completed in sand and gravel 90 to 120 feet.

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing		Water bearing unit	Altitude of land surface (ft)	Water level		Method of lift	Use of water	Remarks
					Diameter (in.)	Depth (ft)			Below land-surface datum (ft)	Date of measurement			
* 30-54-307	Bob Beckham	William Varner	1947	56	8	56	Kca	1,985	20.47	Mar. 11, 1971	Sub, E 1/2	S	Well completed in upper sand unit.
* 401	Weldon Gary	Jake Childers	1955	60	6	60	Kca	1,876	5.26 5.51	Sept. 18, 1970 Jan. 12, 1971	J, E 1	D, S	Water reported from sand at 5 to 20 feet.
* 402	Olin English	--	1920	16	--	--	Kca	1,882	11.54 11.10	Sept. 5, 1940 Mar. 9, 1971	C, W	D, S	Dug well. Yield reported to be strong. Well 366 in Callahan County report. 4/
* 403	Walter B. Black, Jr.	--	1917	12	--	--	P	1,855	3.89 7.15	Sept. 5, 1940 Mar. 9, 1971	J, E 1/2	D, S	Dug well. Reported strong supply. Water reported from fractures in limestone. Well 367 in Callahan County report. 4/
* 501	Elizabeth Burks	Curtis Alford	1955	123	6	123	Kca	1,925	83.10	Oct. 7, 1970	J, E 3/4	D, S	Reported yield 10 gal/min. Sand and gravel reported from 99 to 101 feet.
502	Lee Caldwell	Merle Bales	1964	78	8	78	Kca	1,897	56 51.61	1964 Mar. 15, 1971	C, W	S	Reported yield 5 gal/min. Slotted from 58 to 73 feet. 2/
* 601	J. C. Childers	J. C. Childers	1964	38	13	10	Kca	1,840	20.40 20.24	Sept. 4, 1970 Jan. 8, 1972	J, E 1/2	D	Reported yield 8 gal/min. Open hole from 10 to 28 feet. 1/ 2/
* 602	do	--	--	Spring	--	--	Kca	1,815	(+) (+)	do Jan. 12, 1971	Flows	S	Estimated flow rate 5 gal/min. Water coming from sand in contact with Permian clay.
* 603	John I. Crawley	J. E. Woods	1955	70	6	70	Kca	1,870	35.10	Sept. 23, 1970	J, E 3/4	D, S	Reported yield 10 gal/min. Twenty-five feet of water sand reported.
* 604	do	W. D. Clark	1969	70	6	70	Kca	1,882	30.60	do	Sub, E 1/2	Irr	Reported yield 12 gal/min. Water sands reported at 24 to 30 feet and 57 to 64 feet. 2/
* 605	Glen Wooten	--	1945	60	6	60	Kca	1,845	25	Oct. 9, 1970	J, E 1/2	D	Reported yield 15 gal/min. Ten feet of water sand reported.
606	do	Jake Dallas	1964	94	8	94	Kca	1,873	46.70	Oct. 7, 1970	W, C	S	Reported potential yield 100 gal/min. Water sand and gravel reported from 48 to 80 feet. 2/
607	do	--	1920	55	6	55	Kca	1,986	32.86	do	W, C	S	Reported to be a weak well. Well completed in upper sand member.
* 608	do	--	1900	65	--	--	Kca	1,875	47.55	do	W, C	S	Dug well. Temperature 69°F.
609	do	Jake Dallas	1964	85	8	85	Kca	1,866	33.60	do	N	N	Reported potential yield 80 gal/min. Blue clay reported at 83 feet.
610	do	--	1920	155	6	150	Kca	1,965	98.80	do	W, C	S	Well completed in upper sand member.
* 611	Edgar Albricht	Eddie Woods	1964	90	6	90	Kca	1,890	47.66	Feb. 17, 1971	C, E	D, S	Reported yield 10 gal/min. Bad water reported at 45 to 50 feet.
* 612	do	do	1970	100	6	100	Kca	1,900	74.55	do	C, W	S	Reported yield 9 gal/min. Water reported from lower water sand. Upper sand cemented off 45 to 52 feet. 2/
* 613	J. O. Williams	Stephen Fortune	--	65	5	65	Kca	--	28.28	Oct. 10, 1974	Sub, E	Irr	Reported yield 75 gal/min.
614	do	do	1971	70	5	70	Kca	--	30 33.95	July 16, 1971 Oct. 10, 1974	Sub, E	Irr	Reported yield 20 gal/min.
* 801	Mrs. Fred Heyser	--	--	15	--	--	Kca	1,759	2.93 12.60	Apr. 16, 1940 Mar. 9, 1971	N	N	Old dug well filled with debris. Well 364 in Callahan County report. 4/
* 901	O. M. Holland	--	--	40	6	40	Kca	1,822	14.42 14.30	Sept. 15, 1970 Jan. 12, 1971	J, E	D	Reported strong supply.

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-54-902	Dr. R. H. Tull	J. C. Childers	1964	28	6	28	Kca	1,805	10.17 6.17	1964 Jan. 12, 1971	Cf, E 3	Irr	Reported yield 60 gal/min. Perforated from 13 to 28 feet. Red beds reported at 28 feet. Temperature 69°F. 2/
* 55-101	H. H. Chaney	W. D. Clark	1964	100	6	100	Kca	1,880	61.02	Sept. 18, 1970	J, E 1/3	D	Estimated yield 100 gal/min. Red beds reported at 100 feet.
* 102	do	Neal Dillard	1964	85	8	85	Kca	1,874	55.48	do	J, E 1/2	S	Yield reported at 100 gal/min. Red beds reported at 85 feet. Former irrigation well.
* 103	Emmit Price	--Nardyke	1905	84	5	84	Kca	1,885	63.28 62.22	Apr. 4, 1940 Sept. 21, 1970	J, E 1/3	D, S	Reported yield 5 gal/min. Well 326 in Callahan County report. 4/
104	Red Duncan	W. D. Clark	1971	110	9	110	Kca	1,893	74.90	Mar. 11, 1971	Sub, E 1	D, S	Reported yield 30 gal/min. Sand and gravel reported from 100 to 110 feet. Red beds reported at 110 feet. 2/
105	A. L. Varner	A. L. Varner	1967	218	7	218	Kca	1,970	155.14	Mar. 24, 1971	Sub, E 1	S	Reported to have been pumped at 100 gal/min for 4 hours. Water sand and gravel at 150 to 180 feet. 2/
106	J. T. Howard	do	1965	125	7	125	Kca	1,870	52.87	do	Sub, E 1/2	D, S	Reported yield 12 gal/min. Slotted from 63 to 95 feet. 2/
107	Dayton McInnis	W. D. Clark	1974	92	6	92	Kca	1,895	55.82	Oct. 8, 1974	Sub, E	Irr	Pack sand with gravel 53 to 84 feet.
108	do	do	1974	92	6	92	Kca	1,895	58.15	do	Sub, E	Irr	Sand and gravel 36 to 82 feet.
* 201	N. G. Wilcoxen	Cecil Gobel	1954	88	3	80	Kca	1,842	35	Sept. 15, 1970	C, W	D, S	Open hole from 80 to 88 feet.
* 202	Edwin & Everett Wilcoxen	--	--	175	7	175	Kca	1,880	77.65 77.02	do Jan. 14, 1971	N	N	Well 311 in Callahan County report. 4/
203	Charles Sowell	Lester P. King	1966	131	7	131	Kca	1,875	70	Sept. 15, 1970	Sub, E 5	Irr	Reported yield 185 gal/min. Slotted from 85 to 115 feet.
204	do	A. L. Varner	1966	135	8	135	Kca	1,865	65	do	Sub, E 3	Irr	Reported yield 100 gal/min. Water sand from 74 to 117 feet.
205	do	do	1966	95	7	95	Kca	1,857	60	do	Sub, E 3	Irr	Reported yield 100 gal/min. Water sand from 60 to 88 feet.
* 206	do	do	1966	105	7	105	Kca	1,853	55	do	Sub, E 3	Irr	Reported yield 100 gal/min. Water sand from 60 to 95 feet. Red beds at 95 feet. 2/
* 207	do	do	1966	130	8	130	Kca	1,877	74	do	Sub, E 3	Irr, D	Reported yield 100 gal/min. Water sand from 24 to 105 feet.
* 208	Mrs. M. R. Lovell	Eddie Woods	1964	60	6	60	Kca	1,850	33.30 33.51	Sept. 18, 1970 Jan. 13, 1971	J, E 1/3	D	Reported yield 5 gal/min. Yellow clay at 60 feet.
* 209	W. D. Clark	W. D. Clark	1967	60	6	60	Kca	1,827	21.50	Sept. 21, 1970	Sub, E 3/4	D, S	Reported yield 18 gal/min. Slotted from 30 to 60 feet. Red beds at 60 feet.
210	do	do	1967	58	5	58	Kca	1,825	18.12	do	N	N	Reported yield 20 gal/min. Slotted from 28 to 58 feet. Unused irrigation well.
211	do	do	1967	58	5	58	Kca	1,825	18.72	do	N	N	Reported yield 20 gal/min. Unused irrigation well.
* 212	do	do	1967	60	10	60	Kca	1,824	19.62	do	Sub, E 1-1/2	Irr	Reported yield 100 gal/min. Red beds reported at 60 feet.
213	do	do	1967	67	6	67	Kca	1,824	19	do	Sub, E 3/4	Irr	Reported yield 30 gal/min. Perforated from 37 to 60 feet. 2/

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing		Water bearing unit	Altitude of land surface (ft)	Water level		Method of lift	Use of water	Remarks
					Diameter (in.)	Depth (ft)			Below land-surface datum (ft)	Date of measurement			
30-55-214	W. D. Clark	W. D. Clark	1967	58	8	58	Kca	1,824	18.66	Sept. 21, 1970	Sub, E 1-1/2	Irr	Reported yield 100 gal/min. Slotted from 37 to 67 feet.
* 215	Jack Smith	Cecil Gobel	1954	150	5	150	Kca	1,880	70	Sept. 17, 1970	J, E 1	D, S	Reported yield 60 gal/min. Red beds reported at 150 feet.
216	do	Jake Childers	1964	155	7	155	Kca	1,870	64.22 61.80	Sept. 18, 1970 Jan. 13, 1971	Sub, E 5	Irr	Reported yield 185 gal/min. 2/
* 217	J. N. Nisbett	Curtis Alford	1963	30	5	30	Kca	1,801	16.17	Oct. 19, 1970	C, H	S	Reported yield 10 gal/min. Perforated from 20 to 30 feet. Limestone at 30 feet. 2/
218	N. A. Yarbough	A. L. Varner	1966	75	8	75	Kca	1,815	16	do	T, E 10	Irr	Reported yield 185 gal/min.
* 219	A. L. Varner	do	1970	135	7	135	Kca	1,890	76	Mar. 24, 1971	Sub, E 1/2	S	Measured yield 25 gal/min. Water sand and gravel 89 to 115 feet.
220	do	do	1970	135	11	135	Kca	1,890	76.10 72.74	do June 15, 1971	N	N	Test pumped by driller at 132 gal/min for 48 hours. Water sand and gravel at 89 to 115 feet. Unused irrigation well.
221	Leonard Mosely	do	1971	100	6	100	Kca	1,940	30	July 20, 1971	J, E 1/2	S	Slotted from 50 to 90 feet. 2/
* 302	Mrs. J. T. Hewes	--	1900	90	6	90	Kca	1,837	45.10	Sept. 24, 1970	J, E 1/3	D, S	Reported yield 5 gal/min. Slotted from 50 to 90 feet. Red clay reported at 90 feet.
* 303	Nathan Foster	--	--	130	4	130	Kca	1,855	81.80	do	C, W	S	Well casing reported to have caved at 100 feet. Well 318 in Callahan County report. 4/
* 304	Dr. A. J. Pope	--	--	80	8 6	6 80	Kca	1,935	56.29	Oct. 19, 1970	C, W	S	Well 319 in Callahan County report. 4/
* 305	Mrs. W. T. McClure	--Thate	1963	275	9 7	173 275	Kca	2,020	241.80	Mar. 11, 1971	N	N	Reported yield 120 gal/min. Slotted from 220 to 275 feet. Unused public supply well.
306	do	--	--	160	6	160	Kca	2,000	124.50	Mar. 15, 1971	C, W	S	Reported yield 8 gal/min. Reported to be completed in upper sand member.
307	Nathan Foster	Kit Carson	1964	132	5	132	Kca	1,919	60 51.71	Aug. 1964 Mar. 24, 1971	C, W	S	Reported yield 5 gal/min. Well completed in upper sand member. 2/
* 308	Marcus A. Tatom	Vernon Phillips	1971	112	8	112	Kca	1,855	70	Mar. 22, 1971	Sub, E 5	Irr	Estimated yield 80 gal/min. Water sand reported at 83 to 112 feet. Test originally drilled to 117 feet.
* 309	Robert Brashear	Lester King	1971	100	8	100	Kca	1,840	48.50 69.00	May 6, 1971 July 22, 1971	Sub, E 5	Irr	Measured yield 44 gal/min. Slotted from 53 to 93 feet. 2/
310	do	do	1971	100	7	100	Kca	--	56.06	Oct. 8, 1974	Sub, E	Irr	Water from sand and gravel 55 to 89 feet. 3/
* 311	do	do	1971	98	7	98	Kca	--	50.30	do	Sub, E	Irr	Water sand 53 to 83 feet.
* 401	Claude C. Joy	--Gobel	1952	80	6	80	Kca	1,833	22.47 13.89	Sept. 10, 1970 Jan. 13, 1971	J, E 1	D, S	Perforated from 25 to 80 feet. Water reported at 25 feet.
* 402	do	W. D. Clark	1967	80	8	80	Kca	1,847	31.05 40.46	Sept. 10, 1970 Jan. 14, 1971	Sub, E 1-1/2	N	Red beds reported at 80 feet. Unused irrigation well.
* 403	do	Jack Leonard	1967	80	8	80	Kca	1,860	32 50.32	Sept. 10, 1970 Jan. 14, 1971	Sub, E 2	Irr	Reported yield 90 gal/min.
404	do	W. D. Clark	1967	80	8	80	Kca	1,865	32 60.16	Sept. 10, 1970 Jan. 14, 1971	Sub, E 3	Irr	Do.

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-55-405	Claude C. Joy	W. D. Clark	1967	80	8	80	Kca	1,851	32 52.60	Sept. 10, 1970 Jan. 14, 1971	Sub, E 2	Irr	Reported yield 90 gal/min.
* 406	Dan L. Childress	Glen Vaughn	1955	30	6	30	Kca	1,798	10.30	Oct. 1, 1970	J, E 1/3	D	Reported yield 12 gal/min. Slotted from 22 to 30 feet. Blue clay at 24 feet. 2/
* 407	O. O. Sandifer	Eddie Woods	1965	30	6	30	Kca	1,810	14.79	do	J, E 2	D, S	Reported yield 12 gal/min. Water sand from 14 to 30 feet. Blue clay from 30 to 34 feet.
* 408	J. B. Green	Jake Dallas	1967	40	7	40	Kca	1,768	14.58	Mar. 9, 1971	J, E 1/2	D, S	Reported yield 10 gal/min. Perforated from 24 to 33 feet. 2/
409	C. M. Kinnard	W. D. Clark	1965	58	7	58	Kca	1,840	23.16	Mar. 11, 1971	J, E 1/3	S	Measured yield 4 gal/min. Slotted from 50 to 60 feet. 2/
501	W. W. Robinson	--	1915	16	--	--	Kca	1,800	13.0	Mar. 8, 1960	N	N	Water sand from 13 to 16 feet. Dug well now destroyed.
502	W. A. Gill	Lester King	1966	48	6	48	Kca	1,801	13.84 12.76 12.30	Apr. 29, 1966 Jan. 14, 1971 Nov. 7, 1974	Sub, E	D	Perforated from 32 to 40 feet. 1/ 2/
* 503	C. J. Bush	--Norkey	1927	108	6	108	Kca	1,855	77.51 78.45 77.76	Mar. 29, 1966 Sept. 4, 1970 Nov. 7, 1974	Sub, E	S	Perforated from 73 to 108 feet. 1/
* 504	Lester Bush	--Murdock	--	91	6	91	Kca	1,850	64.58 65.80	do Jan. 12, 1971	Sub, E 1/2	D, S	Perforated from 56 to 91 feet. Temperature 72°F.
505	Glen E. Winfrey	W. D. Clark	1969	75	8	75	Kca	1,801	30.59	Jan. 13, 1971	Sub, E 2	Irr	Reported yield 75 gal/min. Perforated from 35 to 75 feet.
506	do	do	1969	85	8	85	Kca	1,840	39.30	do	Sub, E 2	Irr	Reported yield 75 gal/min. Perforated from 45 to 85 feet.
* 507	do	do	1969	65	8	65	Kca	1,800	21.81	do	Sub, E 1/2	Irr	Reported yield 30 gal/min. Perforated from 25 to 65 feet. Temperature 70°F.
508	do	do	1969	85	8	85	Kca	1,832	40.51	Jan. 14, 1974	Sub, E 2	Irr	Reported yield 50 gal/min. Perforated 45 to 85 feet. Water reported from sand and gravel at 60 to 75 feet.
* 509	do	do	1969	98	8	98	Kca	1,845	58.22 61.40	Jan. 13, 1971 Oct. 8, 1974	Sub, E 3	Irr	Reported yield 100 gal/min. Perforated from 58 to 98 feet.
510	do	do	1969	83	8	83	Kca	1,830	51.78	Jan. 13, 1971	Sub, E 1/2	Irr	Measured yield 20 gal/min. Perforated from 43 to 83 feet.
511	do	do	1969	73	8	73	Kca	1,827	43.14	do	Sub, E 2	Irr	Measured yield 24 gal/min. Perforated from 33 to 73 feet.
* 512	do	--Morrow	1970	99	8	99	Kca	1,840	50.10	do	Sub, E 3	Irr	Measured yield 48 gal/min. Perforated from 59 to 99 feet.
513	do	do	1970	98	8	98	Kca	1,838	57.11 59.91	Sept. 11, 1970 Oct. 8, 1974	Sub, E 3	Irr	Reported yield 65 gal/min. Perforated from 56 to 96 feet.
* 514	do	W. D. Clark	1969	85	6	85	Kca	1,830	41.62 40.43	Sept. 11, 1970 Jan. 12, 1971	J, E 1/2	D	Reported yield 35 gal/min.
* 515	Richard Smith	R. L. McKelvy	1965	35	6	35	Kca	1,777	7.76 7.61	Sept. 17, 1970 Jan. 12, 1971	J, E 1/3	D, S	Reported yield 5 gal/min. Slotted from 17 to 35 feet. Blue shale at 29 feet. 2/
* 516	Norman Coffey	J. E. Woods	1967	31	6	31	Kca	1,815	15.08	Sept. 23, 1970	J, E 1/3	D	Sand and clay reported from 0 to 30 feet.

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-55-517	Mrs. Bryan Bennett	A. L. Varner	1965	98	6	98	Kca	1,835	50.10	Oct. 15, 1970	J, E 1	D, S	Reported strong well. Water sand reported at 60 to 85 feet. 2/
518	Troy Lamb	Jack Leonard	1966	24	9	24	Kcs	1,748	12 2.10	Apr. 30, 1966 Mar. 9, 1971	Sub, E 1/3	S	Screened from 16 to 24 feet. Blue shale at 20 feet. 2/
602	Mike Cunningham	--	--	110	6	110	Kcs	1,855	95.41 42.60	Aug. 2, 1940 Oct. 19, 1970	C, W	S	Former school supply. Well 320 in Callahan County report. 4/
603	Mrs. W. T. McClure	--Woods	1951	70	8	70	Kca	1,865	30.65	do	C, W	S	Reported strong well. Red beds reported at 70 feet.
604	do	do	1951	120	6	120	Kca	1,830	63.90	do	J, E 1	D, S	Water reported from sand and gravel.
* 605	do	Dale Taylor	1969	180	5	180	Kca	1,867	95.30	do	J, E 1	D, S	Red clay reported at 130 feet.
607	Arvin Brasher	Lester King	1971	130	5	130	Kca	1,870	111.30	Mar. 15, 1971	Sub, E 3/4	D, S	Reported yield 12 gal/min. Slotted from 112 to 122 feet. Red shale at 122 feet. 2/
608	S. E. Page	do	1971	83	8	83	Kca	1,818	40.50	May 6, 1971	Sub, E 5	Irr	Measured yield 53 gal/min. Slotted from 40 to 80 feet. Water sand and gravel reported from 42 to 74 feet. 2/ 3/
609	do	do	1971	82	7	82	Kca	1,810	38.15	Oct. 6, 1971	Sub, E 3	Irr	--
610	do	Texas Department of Water Resources	1971	83	4	83	Kca	1,815	46.79 39.31	Sept. 16, 1971 Oct. 6, 1971	N	N	Originally drilled for an observation well. Slotted 42 to 83 feet. 2/
611	do	do	1971	82	4	82	Kca	1,818	42.94 39.88	Sept. 16, 1971 Oct. 6, 1971	N	N	Originally drilled for an observation well. Slotted 40 to 82 feet.
* 702	Howard Cox	Lester King	1966	45	7	45	Kca	1,805	18.32	Mar. 24, 1970	J, E 1	D, S	Perforated from 20 to 40 feet. 2/
* 703	Kenneth Foller	J. E. Woods	1967	90	5	90	Kca	1,855	60.04	Oct. 1, 1970	J, E 1	D	Water sand reported from 65 to 72 feet. Red beds reported at 72 feet.
704	Kenneth Whithurst	L. E. Hayhurst	1970	46	5	46	Kca	1,807	18 12.67	Nov. 28, 1970 Feb. 16, 1971	--	D, S	Reported yield 5 gal/min. Slotted from 18 to 46 feet. Sand and gravel from 12 to 23 ft.
705	do	--	--	Spring	--	--	Kca	1,787	(+)	do	Flows	S	Estimated flow rate 15 gal/min. Water flowing from sand and gravel in contact with limestone. Estimated yield 2 gal/min.
706	Oran Bains, Jr.	W. D. Clark	1971	50	5	50	Kca	1,788	27.15	Mar. 9, 1971	N	N	Slotted from 22 to 29 feet. Red clay at 29 feet. 2/
* 708	G. W. Childers	Stephen Fortune	1971	50	5	50	Kca	--	27.20	Oct. 8, 1974	Sub, E	Irr	--
* 801	M. F. Dill	--	--	50	--	--	Kca	1,797	39.00	Sept. 18, 1970	J, E 1/3	D, S	Dug well. Open hole in very tight pack sand from 4 to 50 feet.
* 802	Fred F. Davis	Fred F. Davis	1965	15	--	--	Kca	1,745	7.62	Oct. 27, 1970	J, E 1/3	D, S	Dug well. Pack sand from 7 to 15 feet.
* 803	G. B. Booth	--	1930	28	--	--	Kca	1,733	14.23	do	H	D	Dug well. Water coming from two sands starting at 16 feet.
* 804	Sam Ingram	Jake Dallas	1967	65	8	65	Kca	1,740	29.62	do	J, E 1/2	D	Reported yield 1 gal/min. Slotted from 35 to 65 feet. Water coming from seep at 35 to 37 feet.
* 805	Douglas Ingram	--	--	17	--	--	Kca	1,709	8.60	Mar. 25, 1971	J, E 1/2	D, S	Dug well. Temperature 63°F.

See footnotes at end of table.

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-55-806	Lilly MacMillian	--	1930	20	--	--	Kcs	1,761	15.60	Mar. 25, 1971	J, E 1/4	D	Dug well. Reported yield 3 gal/min. Water recently became very saline and unusable.
901	City of Cross Plains	--	1950	60	7	60	Kcs	1,778	30 45.60	Oct. 5, 1959 Oct. 21, 1970	J, E 1	P	Reported yield 6 gal/min.
902	do	--	1950	60	6	60	Kcs	1,780	30 47.05	Oct. 5, 1959 Oct. 21, 1970	J, E 1	P	Reported yield 6 gal/min. Red beds reported at 60 feet.
903	do	--	1950	60	8	60	Kcs	1,781	30 49.32 46.46	Oct. 5, 1959 Oct. 21, 1970 Oct. 7, 1974	Sub, E 1	P	Reported yield 6 gal/min.
904	do	--	1950	60	6	60	Kcs	1,774	30 47.60	Oct. 5, 1959 Oct. 21, 1970	J, E 2	P	Reported yield 10 gal/min. Slotted from 40 to 55 feet.
* 905	do	--	1950	60	6	60	Kcs	1,767	30 44	Oct. 5, 1959 Oct. 21, 1970	Sub, E 3/4	P, S	Reported yield 35 gal/min. Slotted from 40 to 55 feet.
906	do	--	1950	60	7	60	Kcs	1,760	30 32	Oct. 5, 1959 Oct. 21, 1970	J, E 1	P	Reported yield 10 gal/min.
907	do	--	1950	65	7	65	Kcs	1,756	30 19.00	Oct. 5, 1959 Oct. 21, 1970	N	P	Reported yield 5 gal/min. Slotted from 40 to 55 feet. Standby source.
908	do	Jake Dallas	1950	65	7	65	Kcs	1,755	21	do	Sub, E 1	P	Reported yield 15 gal/min.
909	do	--	1950	65	7	65	Kcs	1,760	21.44	do	J, E 1-1/2	P	Reported yield 8 gal/min. Slotted from 40 to 55 feet. Red beds reported at 65 feet.
910	do	--	1950	65	7	65	Kcs	1,760	21	do	J, E 1-1/2	P	Reported yield 10 gal/min. Slotted from 40 to 55 feet.
911	do	Jake Dallas	1964	70	7	70	Kcs	1,765	36.86	do	Sub, E 1/2	P	Reported yield 10 gal/min. Red beds reported at 65 feet.
* 912	do	E. E. Thate	1940	48	10 8	48 28	Kcs	1,762	30 22.81	Sept. 4, 1940 Oct. 21, 1970	N	N	Reported yield 6 gal/min. Perforated 28 to 48 feet. Unused public supply well. Well 342 in Callahan County report. 4/
913	do	Jake Dallas	1964	70	7	70	Kcs	1,750	16.99	do	Sub, E 1/2	P	Reported yield 10 gal/min. Slotted from 40 to 60 feet. Red shale at 60 feet. 3/
914	do	do	1964	70	7	70	Kcs	1,750	18.05	do	Sub, E 3/4	P	Reported yield 10 gal/min. Water sand and gravel reported at 40 to 60 feet.
* 915	do	do	1964	70	7	70	Kcs	1,748	12	do	Sub, E 1/2	P	Reported yield 10 gal/min. Slotted from 40 to 60 feet.
916	do	do	1964	70	7	70	Kcs	1,748	18.50	do	Sub, E 1/2	P	Reported yield 10 gal/min. Red shale reported at 65 feet.
* 917	do	do	1964	70	7	70	Kcs	1,748	17.41 18	Mar. 3, 1969 Oct. 21, 1970	Sub, E 1/2	P	Reported yield 35 gal/min. Red beds reported at 70 feet.
* 918	do	--	1926	50	--	--	Kcs	1,764	28.90	do	J, E 1-1/2	P	Dug well. Lined with brick from 35 feet to surface. Open hole from 35 to 50 feet. Well 338 in Callahan County report and Well 2 in Public Water Supplies report. 4/ 5/
* 919	do	--	1926	49	8	49	Kcs	1,764	28.10	do	J, E 1	N	Perforated casing set below water level. Unused public supply well. Well 339 in Callahan County report. 4/

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
* 30-55-920	City of Cross Plains	City of Cross Plains	1938	44	--	--	Kca	1,764	30.90 27.50 29.05	Sept. 4, 1940 Oct. 21, 1970 Oct. 7, 1974	N	N	Dug well. Reported yield 10 gal/min. Open hole from 30 to 44 feet. Unused public supply well. Well 340 in Callahan County report. 4/
* 921	do	Ben Welch	1926	48	8	48	Kca	1,763	21	Oct. 21, 1970	J, E 1-1/2	N	Reported yield 10 gal/min. Water sand reported at 23 to 45 feet. Unused public supply well. Well 341 in Callahan County report. 4/
* 922	do	E. E. Thate	1940	47	8 10	27 47	Kca	1,758	22.44	do	J, E 1-1/2	P	Reported yield 10 gal/min. Sand reported from 29 to 47 feet. Well 336 in Callahan County report. 4/
* 923	do	--	--	50	--	--	Kca	1,747	15 30 16.73 16.68 12.56 12.09	Feb. 1946 Oct. 5, 1959 Apr. 29, 1966 Nov. 29, 1966 Nov. 16, 1970 Nov. 7, 1974	J, E 2	P	Dug well. Reported yield 15 gal/min. 1/
* 924	do	--	--	50	--	--	Kca	1,745	30 12.21	Oct. 5, 1959 Oct. 21, 1970	J, E 1/2	P	Dug well. Reported yield 15 gal/min.
* 925	Harvey Wilcoxen	Lester King	1970	85	8	85	Kca	1,761	24.21	Oct. 19, 1970	Sub, E	Irr	Reported yield 4 gal/min. Slotted from 30 to 70 feet. 2/
926	do	do	1970	85	8	85	Kca	1,766	35	do	Sub, E	Irr	Reported yield 40 gal/min. Slotted from 30 to 70 feet.
* 927	Thomas E. Buck	Parker Baum	1964	40	3	40	Kca	1,775	15.45	do	Cf, E 1/3	D, S	Reported yield 3 gal/min. Water reported from sand and gravel at 20 to 40 feet.
* 928	Morris Thomas	Lester King	1970	60	8	60	Kca	1,746	17.34	do	J, E 1/2	D	Reported yield 10 gal/min. Slotted from 30 to 50 feet. 2/
931	Ben Odom	Eddie Woods	1968	30	6	30	Kca	1,766	16.71	Mar. 25, 1971	H, B	D	Water sand reported from 25 to 30 feet.
932	O. B. Evanson	Jake Dallas	1971	60	8	60	Kca	1,780	28.60	do	J, E 1-1/2	S	Red beds reported at 60 feet.
933	Dick Vestal	Lester King	1970	50	5	50	Kca	1,781	40	June 29, 1971	Sub, E 1	Irr	Measured yield 27 gal/min.
* 56-413	W. R. Erwin	--	1940	25	--	--	Kca	1,780	14.25	Oct. 27, 1970	C, W	D, S	Dug well. Water sand from 20 to 25 feet.
702	Glenn Winfrey	W. D. Clark	1973	56	5	56	Kca	1,753	13.19	Oct. 7, 1974	Sub, E	Irr	Owner's well no. 1. Sand and gravel 12 to 52 feet.
* 703	do	do	1973	50	5	50	Kca	1,753	10.50	do	Sub, E	Irr	Owner's well no. 2.
704	do	do	1973	56	5	56	Kca	1,754	14.24	do	Sub, E	Irr	Owner's well no. 3.
705	do	do	1973	51	5	51	Kca	1,756	15.30	do	Sub, E	Irr	Owner's well no. 4.
706	do	do	1974	57	5	57	Kca	1,758	15.73	do	Sub, E	Irr	Owner's well no. 5.
707	do	do	1974	62	5	62	Kca	1,760	19.80	do	Sub, E	Irr	Owner's well no. 6.
* 61-201	Oran Baines	W. C. Baines	1917	27	--	--	P	1,770	14.27 11.70	Sept. 6, 1940 Mar. 19, 1971	N	N	Dug well. Reported yield 5 gal/min. Water reported from fractures in limestone. Well 421 in Callahan County report. 4/
* 63-101	L. M. Hodges	Lester King	1967	55	5	55	Kca	1,758	12.07	Feb. 15, 1971	J, E 1/3	D, S	Sand reported 12 to 35 feet. 2/

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
30-63-102	P. B. Long	--	--	13	--	--	Qal	1,675	8.64 6.36	Sept. 4, 1940 Feb. 17, 1971	C, W	N	Dug well. Unused livestock supply. Well 357 in Callahan County report. 4/
103	Mary Hattie Long	--	--	12	--	--	Qal	1,665	4.70 6.82	Sept. 4, 1940 Feb. 17, 1971	N	N	Dug well. Reported weak supply. Well 358 in Callahan County report. 4/
* 201	James Hickman	--	1934	28	--	--	Kca	1,751	22.20 13.14	Sept. 4, 1940 Oct. 13, 1970	C, W	S	Dug well. Yield reported at 4 gal/min. Open hole from 12 to 28 feet. Well 356 in Callahan County report. 4/
* 202	J. O. Freeman	--	--	150	6	150	P	1,719	130	Jan. 13, 1971	C, E 1/2	D, S	Reported yield 1 gal/min. Water reported from a limestone.
* 203	Alford Franke	E. D. Schfard	1934	90	8	60	P	1,670	53.88	Feb. 15, 1971	C, G	D, S	Water reported from limestone from 55 to 90 feet. Open hole from 60 to 90 feet.
204	Cross Plains Riding Club	Vernon Phillips	1958	30	6	30	Qal	1,682	7.74	Feb. 17, 1971	J, E 1/3	P	Water reported from sand and gravel.
* 205	Traves Sanders	M. E. Howell	1930	13	--	--	Kca	1,735	7.40	do	J, E	S	Dug well. Water reported from sand. Red beds reported at 13 feet.
208	Mrs. R. B. Belyeu	--	1930	16	--	--	Kca	1,711	9.30	Mar. 15, 1971	N	N	Dug well. Reported to be strong supply. Water reported from sand. Water has odor.
* 209	Clyde Kelly	--	--	17	--	--	Qal	1,668	14.00 9.40	Apr. 4, 1940 Mar. 15, 1971	N	N	Dug well. City dump located 100 yards north and up slope from this well. Well 349 in Callahan County report. 4/
303	City of Cross Plains	--	1945	62	8	62	Kca	1,771	30 42	Oct. 5, 1959 Oct. 21, 1970	J, E 2	P	Reported yield 4 gal/min. Standby municipal source.
* 304	do	--	1945	50	8	50	Kca	1,776	30 44.20	Oct. 5, 1959 Oct. 21, 1970	N, E 2	N	Do.
305	do	--	1941	61	8	61	Kca	1,772	30 39	Oct. 5, 1959 Oct. 21, 1970	J, E 3/4	P	Reported yield 15 gal/min. Red beds reported at 60 feet. Used only during summer months.
306	do	--	1941	66	8	66	Kca	1,768	30 36.72	Oct. 5, 1959 Oct. 21, 1970	J, E 2	P	Reported yield 4 gal/min. Used during summer months and for emergencies.
307	do	Jake Dallas	1963	70	7	70	Kca	1,773	43	do	Sub, E 1/2	P	Reported yield 15 gal/min. Slotted at 45 to 60 feet. Pumped continuously.
* 308	do	do	1963	70	7	70	Kca	1,773	42	do	Sub, E 3/4	P	Reported yield 8 gal/min. Water sand reported from 45 to 60 feet. Well pumped continuously.
* 309	Dale Crawford	Curtis Alford	1962	80	5 9	80 40	Kca	1,772	44.70 41.69	Mar. 3, 1969 Jan. 14, 1971	J, E 1/2	D	Perforated from 50 to 70 feet.
310	Fred Wilson	do	1963	63	6	63	Kca	1,761	36.79 27.17 25.98	Sept. 4, 1970 Oct. 15, 1970 Jan. 8, 1972	J, E	N	Perforated from 51 to 63 feet. 1/
* 311	Dan Applin	Jake Dallas	1965	40	5	40	Kca	1,732	23.01	Oct. 13, 1970	J, E 1/2	D, S	Reported strong supply. Two water sands reported.
* 312	C. M. Garrett	do	1966	48	8	48	Kca	1,680	21.80	do	Sub, E 1/2	D, S	Reported very strong supply.
* 313	do	T. C. Thorn	1890	60	6	60	Kca	1,682	24.09 22.47	Sept. 4, 1940 Oct. 13, 1970	J, E 1/2	N	Formerly supplied large poultry farm. Well 351 in Callahan County report. 4/
* 314	H. R. Miner	Jack Leonard	1970	62	6	62	Kca	1,735	30	Oct. 27, 1970	Sub, E 1	D	Reported yield 6 gal/min.

See footnotes at end of table.

Table 5.--Records of Selected Wells, Springs, and Test Holes--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Casing: Diameter (in.)	Casing: Depth (ft)	Water bearing unit	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
30-63-315	H. R. Miner	--	1951	72	5	72	Kca	1,730	29.27	Oct. 27, 1970	C, W	S	Reported yield 10 gal/min. Red beds at 60 feet.
* 316	Mrs. Ed Long	--	1904	19	--	--	Kca	1,685	10.07 10.18	Apr. 4, 1940 Oct. 27, 1970	C, W	D, S	Dug well. Open hole from 6 to 19 feet. Well 350 in Callahan County report. 4/
317	Oral Joy	Parker Baum	1955	28	6	28	Qal	1,651	21.90	Mar. 15, 1971	J, E 1/2	D, S	Reported yield 5 gal/min. Clay, sand and gravel reported from 0 to 28 feet. Red beds reported at 28 feet.
318	Red Grider	Eddie Woods	1964	35	8	35	Kca	1,735	26.60	June 3, 1971	C, W	S	--
* 404	G. L. Klutz	--	--	15	--	--	P	1,705	12.50	Mar. 25, 1971	N	N	Dug well.
* 607	J. H. Balkum	--	1920	25	--	--	Kca	1,701	13.82	Oct. 13, 1970	J, E 1/3	D	Dug well. Open hole from 16 to 25 feet.

* For chemical analysis of water, see Table 7.
1/ Observation well--for water-level hydrographs on selected wells, see Figures 15 and 16.
2/ For drillers' log of well, see Table 6.
3/ For results of pumping tests, yields, and specific capacities of wells, see Table 2.
4/ George, W. O., 1940, Callahan County Texas--Records of wells and springs, drillers' logs, water analyses, and map showing locations of wells and springs: Texas Board Water Engineers duplicated report.
5/ Sundstrom, R. W., and others, 1947, Public water supplies in central and north-central Texas: Texas Board Water Engineers duplicated report.

Table 6.—Drillers' Logs of Selected Water Wells, Oil and Gas Tests, and Stratigraphic Tests

Well 30-36-611

Owner: J. B. Eaton
Driller: R. L. McKelvy

	Thickness (feet)	Depth (feet)
Brown sand	3	3
Red clay	11	14
Sand and gravel (dry)	7	21
Sand and gravel (water)	10	31
Red clay	3	34
Yellow clay	2	36
Yellow lime	—	36

Well 30-36-613

Owner: F. L. Dugan
Driller: F. L. Dugan

	Thickness (feet)	Depth (feet)
Top soil, clay	4	4
Sand and red clay	11	15
Water sand and gravel	9	24
Limestone	—	24

Well 30-36-803

Owner: C. B. Kniffen
Driller: R. L. McKelvy

	Thickness (feet)	Depth (feet)
Brown sandy clay	5	5
Mixed sandy shale	26	31
Red sand	14	45
Sand and large gravel	17	62
Yellow clay	2	64

Well 30-36-806

Owner: Harold Mauldin
Driller: L. E. Hayhurst

	Thickness (feet)	Depth (feet)
Sand	1	1
Red clay	5	6
Gravel	9	15
Sand	3	18
Gravel	3	21
Sand	2	23
Purple clay	1	24
Sand and gravel	4	28
Purple clay	10	38
Sand and gravel (water)	4	42
Purple and white clay	1	43
Conglomerate rock	2	45
White clay	2	47
Conglomerate rock	1	48
Sandstone	5	53
Lime	3	56

Well 30-36-809

Owner: Wallace W. Henry
Driller: R. L. McKelvy

	Thickness (feet)	Depth (feet)
Brown sand with gravel	4	4
Red clay	1	5
Red sand (medium)	6	11
Red sand with water show	3	14
Red sand with very small gravel (dry)	5	19
Red sand (fine) with water	5	24
White sand with small gravel (water producing)	5	29
Yellow clay	2	31
Yellow lime	1	32

Well 30-36-909

Owner: Dick Antilley
Driller: Murl Bales

	Thickness (feet)	Depth (feet)
Red clay	8	8
Water sand	14	22
Conglomerate	2	24
Water sand and gravel	8	32
Blue shale	3	35

Well 30-36-913

Owner: Seth Holden
Driller: R. L. McKelvy

	Thickness (feet)	Depth (feet)
Top sand	3	3
Red subsoil	1	4
Pack sand	19	23
Red clay	11	34
Sand and gravel	21	55
Yellow clay	3	58
Yellow lime	—	58

Well 30-36-917

Owner: Seth Holden
Driller: R. L. KcKelvy

	Thickness (feet)	Depth (feet)
Sandy top	1	1
Red shale	4	5
Brown sand	17	22
Red shale	12	34
Sand and gravel	24	58
Yellow clay and lime	2	60

Table 6.—Drillers' Logs of Selected Water Wells, Oil and Gas Tests, and Stratigraphic Tests—Continued

	Thickness (feet)	Depth (feet)
Well 30-36-927		
Owner: Ray H. Walker Driller: Ed L. Chapman		
Sand	5	5
Caliche	3	8
Sand	12	20
Sand and gravel	2	21
Clay (gray)	7	28
Limestone	1	29
Red clay	1	30
Well 30-36-928		
Owner: Ed Moore Driller: R. L. McKelvy		
Brown sand	8	8
Caliche	5	13
Pack sand	13	26
Sand and large gravel	21	47
Yellow clay	—	47
Well 30-36-931		
Owner: George Sewell Driller: R. L. McKelvy		
Top sand	5	5
Red clay	4	9
Pack sand	22	31
Brown sand	11	42
Sand and gravel	11	53
Red clay	—	53
Well 30-36-934		
Owner: O. C. Garner, Jr. Driller: R. L. McKelvy		
Brown sand	4	4
Yellow clay	2	6
Brown sand	26	32
Sand and gravel (water)	15	47
Yellow clay	3	50
Well 30-37-401		
Owner: Frankie Darnell Driller: R. L. McKelvy		
Brown sand	6	6
Red clay	3	9
Brown sand	12	21
Yellow clay	5	26

	Thickness (feet)	Depth (feet)
Well 30-37-401—Continued		
Brown sand	13	39
Sand and gravel (water)	7	46
Yellow clay	1	47
Yellow rock	1	48
Well 30-37-403		
Owner: W. H. Walker Driller: R. L. McKelvy		
Sand	5	5
Yellow clay	7	12
Red clay	6	18
Sand	8	26
Sand and gravel	7	33
Lime	—	33
Well 30-37-405		
Owner: A. D. Ash Driller: W. D. Clark		
Sand	3	3
Red clay	21	24
Gray clay	13	37
Pack sand	11	48
Loose lime gravel	2	50
Red bed	4	54
Rock	1	55
Well 30-37-506		
Owner: Roy Phemister Driller: L. E. Hayhurst		
Topsoil	1	1
Brown clay	3	4
White clay	6	10
Sand	5	15
White clay	3	18
Sand and gravel	3	21
White clay	4	25
Yellow and white clay	5	30
Sandrock	5	35
Yellow lime with layered clay	7	42
Red clay	4	46
Blue shale	4	50

Table 6.—Drillers' Logs of Selected Water Wells, Oil and Gas Tests, and Stratigraphic Tests—Continued

	Thickness (feet)	Depth (feet)
Well 30-37-507		
Owner: Oscar Brown Driller: R. L. McKelvy		
Sand, brown	32	32
Sand and gravel (water)	8	40
Yellow clay	3	43
Lime	—	43
Well 30-37-511		
Owner: Jack T. Kidd Driller: R. L. McKelvy		
Sand	2	2
Sandy	4	6
Red shale	5	11
Sand rock	6	17
Red sand (water)	6	23
Sand and gravel	8	31
Yellow clay	4	35
Yellow lime	—	35
Well 30-37-707		
Owner: Eddie Konczak Driller: R. L. McKelvy		
Top sand	2	2
Red sand	2	4
Brown sand	18	22
Water formation	2	24
Sand with rock layers	16	40
Water formation (large gravel)	6	46
Red bed	1	47
Well 30-37-714		
Owner: City of Clyde Driller: R. L. McKelvy		
Topsoil, black	6	6
Brown sand	11	17
Sand and gravel (dry)	7	24
Sand and gravel (water)	29	53
Well 30-37-715		
Owner: City of Clyde Driller: R. L. McKelvy		
Topsoil, black	8	8
White sand	3	11
Brown sand	11	22
Sand and gravel (water show)	6	28
Well 30-37-715—Continued		
Sand and large gravel (water)	8	36
Soft limestone	1	37
Sand and gravel	14	51
Red clay	4	55
Well 30-37-722		
Owner: City of Clyde Driller: A. L. Varner		
Soil	7	7
Caliche	3	10
Sand and gravel	8	18
Rock	1	19
Sand and gravel	21	40
Clay	10	50
Well 30-37-728		
Owner: City of Clyde Driller: R. L. McKelvy		
Topsoil	5	5
Caliche	2	7
White pack sand	9	16
Soft limestone	1	17
Brown sand	8	25
Sand and gravel (water)	12	37
Soft limestone	2	39
Sand and gravel (water)	13	52
Yellow clay	5	57
Well 30-37-730		
Owner: Joe L. Jones Driller: R. L. McKelvy		
White sand	6	6
Mixed clay	11	17
Pack sand	15	32
Sand and gravel	15	47
Yellow clay	2	49
Well 30-37-732		
Owner: Charles Bailey Driller: R. L. McKelvy		
Sand	2	2
Red clay	2	4
Yellow clay	8	12
Rock	1	13
Brown sand	2	15

Table 6.—Drillers' Logs of Selected Water Wells, Oil and Gas Tests, and Stratigraphic Tests—Continued

	Thickness (feet)	Depth (feet)
Well 30-37-732—Continued		
Rock	2	17
Brown sand	14	31
Water formation (large gravel)	11	42
Red bed	2	44
Well 30-37-733		
Owner: Glen Crosby Driller: R. L. McKelvy		
Top sand	4	4
Pack sand, clay	10	14
Pack sand, white	51	65
Sand and gravel	17	82
Sandy shale	8	90
Well 30-37-735		
Owner: Ralph Ramerez Driller: R. L. McKelvy		
Topsoil, black	5	5
Caliche	8	13
Brown rock	4	17
Sand and gravel	4	21
Yellow clay	6	27
Water formation	3	30
Red clay	10	40
Well 30-37-737		
Owner: Clyde Church of Christ Driller: L. E. Hayhurst		
Soil	2	2
Caliche	13	15
Sand and gravel	25	40
Red clay	5	45
Well 30-37-738		
Owner: Glen Curtiss Driller: R. L. McKelvy		
Brown sand	3	3
Clay	2	5
Brown sand	25	30
Yellow clay	6	36
White sand	6	42
White sand and gravel	5	47
Sand and gravel (water)	8	55
Yellow clay	6	61

	Thickness (feet)	Depth (feet)
Well 30-37-739		
Owner: Boyd Briscoe Driller: R. L. McKelvy		
Brown sand	4	4
Yellow clay	2	6
Red sandy shale	6	12
Brown sand	12	24
Red clay	11	35
Red sand	12	47
Yellow clay and lime	3	50
Well 30-37-801		
Owner: Baird City Schools Driller: Jack R. Barnes		
Soil and clay	5	5
Clay with sandstone	18	23
Conglomerate with breaks	7	30
Conglomerate, tight	15	45
Hard limestone	18	63
Well 30-37-814		
Owner: John L. Estes, Jr. Driller: A. L. Varner		
Sand	1	1
Clay	18	19
Lime	1	20
Shale	35	55
Sand	7	62
Shale	22	84
Sand	12	96
Sand and gravel	34	130
Rock	9	139
Shale	11	150
Well 30-37-824		
Owner: Don E. Boles Driller: L. E. Hayhurst		
Sand	1	1
Red clay	3	4
Sand	11	15
Sand and gravel (water)	11	26
Yellow clay	9	35

Table 6.—Drillers' Logs of Selected Water Wells, Oil and Gas Tests, and Stratigraphic Tests—Continued

	Thickness (feet)	Depth (feet)
Well 30-37-825		
Owner: S. D. Tucker Driller: R. L. McKelvy		
Brown sand	18	18
Sand and gravel (seep)	2	20
Red and yellow clay	16	36
Yellow lime with blue streaks	29	65
Blue shale	10	75
Well 30-37-827		
Owner: City of Baird Driller: Works Projects Administration		
Red clay	1	1
Sandy yellow clay	6	7
Yellow sand	4	11
White sand	2	13
Small gravel	1	14
White chalk and sand	1	15
Sandy yellow clay	1	16
Red sand and small gravel	1	17
Red and yellow sand	2	19
Red sand and gravel (water)	6	25
Coarse water gravel	5	30
Rock	4	34
Well 30-44-201		
Owner: Eula Public School Driller: School Trustees		
Clay and caliche	12	12
Sand and clay	3	15
Sand	10	25
Water sand	5	30
Well 30-44-301		
Owner: Frank Blalock Driller: L. E. Hayhurst		
Sand	1	1
Red clay	6	7
Sand	6	13
White clay	1	14
Sand	5	19
Gravel	5	24
White clay	2	26
Conglomerate	1	27
Well 30-44-301—Continued		
Yellow clay and rock	1	28
Sand and gravel	10	38
Yellow clay	2	40
Well 30-44-304		
Owner: Harold Holden Driller: R. L. McKelvy		
Topsoil	3	3
Red clay	10	13
Sand and gravel (large)	22	35
Well 30-44-307		
Owner: C. E. Hicks Driller: Bridwell Oil Company		
Red clay with some sand	14	14
Sand and gravel	28	42
Red clay	1	43
Well 30-44-401		
Owner: Jack J. Hill Driller: R. L. McKelvy		
Top soil	1	1
Caliche	14	15
Sand and gravel with lime shells	29	44
Sandstone	1	45
—	1	46
Sand and gravel (water)	12	58
Red bed	—	58
Well 30-44-402		
Owner: Doyle Lenz Driller: L. E. Hayhurst		
Sand	1	1
Red clay	1	2
Caliche	12	14
Sand	7	21
Conglomerate rock	5	26
Sand	9	35
Purple and white clay	5	40
Sand and gravel	5	45
Sand rock	1	46
Sand and gravel	3	49
Red clay	7	56

Table 6.—Drillers' Logs of Selected Water Wells, Oil and Gas Tests, and Stratigraphic Tests—Continued

	Thickness (feet)	Depth (feet)
Well 30-44-501		
Owner: E. F. Beyer Driller: L. E. Hayhurst		
Sand	2	2
Red and white clay	5	7
Purple and white clay	23	30
Sand	19	49
White clay	5	54
Sand and gravel (water)	26	80
Red bed	—	80
Well 30-44-502		
Owner: C. E. Campbell Driller: C. E. Campbell		
Topsoil, black	5	5
Red clay	10	15
Water sand (white, sugar)	7	22
Red bed	—	22
Well 30-44-507		
Owner: Winfrod Gardner Driller: L. E. Hayhurst		
Sand	7	7
Red clay	1	8
Sand and gravel	16	24
Yellow clay	10	34
Well 30-44-702		
Owner: Tommy Smith Driller: L. E. Hayhurst		
Topsoil	2	2
Red clay	5	7
Sand	8	15
Red clay	4	19
Sand (water)	7	26
Red clay	4	30
Yellow clay	5	35
Well 30-44-703		
Owner: Frank D. Chrane Driller: L. E. Hayhurst		
Caliche	6	6
Red clay	20	26
Sandstone	13	39
Sandy clay	11	50
Sand and gravel (water)	16	66
Yellow lime	4	70

	Thickness (feet)	Depth (feet)
Well 30-44-704		
Owner: Earle Zimmerle Driller: L. E. Hayhurst		
Topsoil	2	2
Caliche	13	15
Pack sand	5	20
White and red clay, sandy	33	53
Black lime rock	1	54
Red clay	4	58
White sandy clay	4	62
Red clay	3	65
Pack sand	23	88
Sand rock	14	102
Red clay	5	107
Sand and gravel (water)	18	125
Red clay	3	128
Sand and gravel (water)	7	135
Red clay	3	138
Well 30-44-705		
Owner: Annie Mosier Driller: L. E. Hayhurst		
Topsoil	1	1
Red clay	2	3
Sand	5	8
Purple and white clay	10	18
Sand	16	34
Purple clay	3	37
Sand and gravel (water)	7	44
Red clay	4	48
Sand rock	1	49
Sand	1	50
Purple clay	2	52
Limestone	1	53
Purple and white clay	4	57
Limestone	1	58
Purple and white clay	17	75
Well 30-44-706		
Owner: Burt Northcutt, Jr. Driller: A. L. Varner		
Soil	10	10
Sandy	8	18
Sand and water gravel	13	31
Clay	3	34

Table 6.—Drillers' Logs of Selected Water Wells, Oil and Gas Tests, and Stratigraphic Tests—Continued

	Thickness (feet)	Depth (feet)
Well 30-44-706—Continued		
Sand	6	40
Rock	13	53
Well 30-44-803		
Owner: Michael B. Williams Driller: Jack R. Barnes		
Topsoil	4	4
Sticky clay	21	25
Clay and caliche	25	50
Sandy clay	8	58
Sand and clay	11	69
Sand and gravel	15	84
Hard sand	2	86
Sand	17	103
Sand and lime shale	20	123
Well 30-44-804		
Owner: Jimmy Partin, III Driller: Robert Higgins		
Soil	1	1
Caliche	3	4
Lime	4	8
Sandy clay	22	30
Sand (water)	5	35
Sandstone	33	68
Lime rock	2	70
Sandy clay	40	110
Clay	20	130
Rock lime	2	132
Water sand and gravel	2	134
Basin clay	19	153
Well 30-44-805		
Owner: Casto Smith Driller: L. E. Hayhurst		
Topsoil	1	1
Red clay	3	4
White sandy clay	10	14
Sand and gravel	8	22
Sand rock	2	24
Sand	5	29
Sand rock	1	30
Sand and gravel	10	40
Purple and white clay	10	50
Well 30-44-806		
Owner: L. H. Lilly Driller: L. E. Hayhurst		
Sand	1	1
Red clay	4	5
Sandstone	3	8
Purple and white clay	26	34
Sandstone	3	37
Pack sand	18	55
Conglomerate rock	2	57
Sandstone	17	74
Conglomerate rock	2	76
Sand (water)	15	91
Yellow clay	1	92
Well 30-44-807		
Owner: Herman Scott Driller: L. E. Hayhurst		
Red clay	6	6
Sand	8	14
Sand and gravel	16	30
Gravel and clay	7	37
Purple and white clay	4	41
Lime	1	42
Well 30-44-808		
Owner: A. E. Robertson Driller: J. C. McCarrell		
Topsoil	1	1
Red clay	9	10
White sand	18	28
Red clay	6	34
Sand rock	13	47
Sand and gravel	13	60
Red bed clay	1	61
Well 30-44-809		
Owner: J. C. Tucker Driller: L. E. Hayhurst		
Topsoil	1	1
Red clay	2	3
Pack sand	21	24
Red clay	13	37
Sand rock	1	38
Pack sand	6	44
Sand and gravel (water)	11	55

Table 6.—Drillers' Logs of Selected Water Wells, Oil and Gas Tests, and Stratigraphic Tests—Continued

	Thickness (feet)	Depth (feet)
Well 30-44-809—Continued		
Sand rock	1	56
Sand and gravel (water)	5	61
Red bed	—	61
Well 30-44-901		
Owner: W. E. Connel Driller: L. E. Hayhurst		
Topsoil	2	2
White clay	6	8
Sand and gravel (water)	5	13
Yellow lime	3	16
Yellow clay	4	20
Well 30-45-103		
Owner: D. C. Rogers, Jr. Driller: R. L. McKelvy		
Top sand	4	4
Yellow clay	3	7
Pack sand	19	26
Sand and gravel	12	38
Sandy clay	2	40
Yellow clay	2	42
Well 30-45-107		
Owner: Dr. E. W. Evans Driller: R. L. McKelvy		
Top sand	2	2
Clay	2	4
Brown sand	24	28
Water formation (dry)	5	33
Sand and gravel (water)	8	41
Yellow clay	4	45
Blue shale	3	48
Rock	—	48
Well 30-45-203		
Owner: W. T. Barnes Driller: L. E. Hayhurst		
Sand	1	1
Brown clay	1	2
Sand	24	26
Yellow clay	5	31
Lime	18	49

	Thickness (feet)	Depth (feet)
Well 30-45-904		
Owner: Bill Varner Driller: Jack Leonard		
Topsoil	4	4
Clay	22	26
Sandy clay	7	33
Sand and gravel	7	40
Blue shale	2	42
Well 30-46-501		
Owner: Robert Eubanks Driller: A. L. Varner		
Soil	5	5
Blue shale	15	20
Sandy shale (salt water)	5	25
Blue shale	15	40
Well 30-46-703		
Owner: C. N. Eller, Sr. Driller: R. L. McKelvy		
Brown sand	10	10
Pack sand	15	25
Light sandstone	25	50
White sand and gravel with water	20	70
Red bed	2	72
Red sand	2	74
Red bed	2	76
Well 30-46-705		
Owner: Charles M. Eller, Jr. Driller: R. L. McKelvy		
Surface and clay	8	8
Pack sand	14	22
Sand and gravel	3	25
Pack sand	10	35
Sand and gravel	10	45
Sand and clay	5	50
Fine sand	2	52
Clay and gravel	5	57
Fine sand	8	65
Yellow clay red bed	5	70

Table 6.—Drillers' Logs of Selected Water Wells, Oil and Gas Tests, and Stratigraphic Tests—Continued

	Thickness (feet)	Depth (feet)
Well 30-46-708		
Owner: Dave Pillars Driller: R. L. McKelvy		
Brown sand	3	3
Yellow sand	2	5
Brown sand	9	14
White sand	1	15
Sandy shale	11	26
White sand with gravel	6	32
Red bed	16	48
Well 30-46-903		
Owner: Bob Beckham Driller: A. L. Varner		
Soil	4	4
Rock	56	60
Shells and shale	20	80
Sand	15	95
Red rock	115	210
Sand	25	235
Clay	10	245
Sand (water)	20	265
Clay	1	266
Well 30-46-904[1]		
Owner: C. M. Caldwell Driller: Star Oil Company		
Surface rock	22	22
Shale and rock streaks	13	35
Hard sandy shale	65	100
Yellow shale	30	130
Sandy shale	40	170
Red shale	20	190
Gravel	45	235
Red shale	60	295
Well 30-46-905[1]		
Owner: Edgar Smith Driller: Ike Drilling Company		
Soil	1	1
Caliche	24	25
Gravel	10	35
Lime	3	38
Brown shale	37	75
Well 30-46-906[1]		
Owner: T. W. Eastham Driller: A. R. McElreath, Jr.		
Soil	5	5
Yellow clay	7	12
Yellow gravel	13	25
Red clay	22	47
Red bed	11	58
Yellow clay	2	60
Well 30-47-603		
Owner: Raymond Sprawles Driller: A. L. Varner		
Topsoil	2	2
Clay	8	10
Sandy and sand rock	5	15
Water sand and gravel	10	25
Red clay	16	41
Well 30-47-606		
Owner: G. A. Reece Driller: R. L. McKelvy		
Topsoil and pack sand	18	18
Water sand	5	23
Pack sand	12	35
Clay	7	42
Red bed	3	45
Well 30-47-908		
Owner: J. L. Marinelli Driller: Vernon Phillips		
Sand	8	8
Gray clay	4	12
Sand and gravel	21	33
Red bed	2	35
Well 30-52-101		
Owner: C. W. Carter Driller: C. W. Carter		
Lime, caliche	38	38
Sand and gravel (little water)	2	40
Limestone (little or no water)	40	80
Sand and gravel	40	120
Black shale	1	121

See footnote at end of table.

Table 6.—Drillers' Logs of Selected Water Wells, Oil and Gas Tests, and Stratigraphic Tests—Continued

	Thickness (feet)	Depth (feet)
Well 30-52-103		
Owner: C. W. Carter Driller: Jack Leonard		
Black topsoil	3	3
Red clay	13	16
Yellow clay	4	20
Red water sand	3	23
Sand and gravel	12	35
Yellow clay	1	36
Well 30-52-105		
Owner: S. O. Barton Driller: L. E. Hayhurst		
Topsoil	1	1
Purple and white clay	20	21
Sand (water)	9	30
Purple and white clay	24	54
Sand rock	3	57
Purple and white clay	41	98
Pack sand	5	103
Sand and gravel (water)	15	118
Red clay	2	120
Purple and white clay	15	135
Well 30-52-107		
Owner: C. W. Barnard Driller: L. E. Hayhurst		
Sand	1	1
Red clay	5	6
Sand	2	8
Sand and gravel	6	14
Yellow lime	4	18
Well 30-52-401		
Owner: Stella Johnson Driller: Jack Barnes		
Soil and caliche	10	10
Red shale and limerock	10	20
Red and gray shale	15	35
Red shale	20	55
Sand shale	5	60
Red shale and lime	25	85
Sand and clay	5	90
Sand	15	105
Shale	5	110
Brown clay and limerock	5	115

	Thickness (feet)	Depth (feet)
Well 30-52-501		
Owner: Ira Crawford Driller: L. E. Hayhurst		
Topsoil	1	1
Red clay	3	4
Sand	10	14
Purple and white clay	2	16
Yellow clay	2	18
Well 30-52-703		
Owner: Lowell Johnson Driller: L. E. Hayhurst		
Caliche	7	7
Purple and white clay	40	47
Pack sand	15	62
Red bed	8	70
Well 30-52-801		
Owner: Guy Williams Driller: L. E. Hayhurst		
Sand	1	1
Red clay	4	5
Sand	16	21
Sandstone	1	22
Lime	15	37
Well 30-52-802		
Owner: Leon Barr Driller: L. E. Hayhurst		
Topsoil	1	1
Red clay	7	8
Sand	11	19
Yellow clay	3	22
Well 30-52-804		
Owner: Alvin Cox Driller: L. E. Hayhurst		
Caliche	2	2
Clay	14	16
Pack sand	39	55
Purple and white clay	9	64
Lime	1	65

	Thickness (feet)	Depth (feet)
Well 30-52-902		
Owner: Guy Williams Driller: L. E. Hayhurst		
Topsoil	1	1
Red clay	24	25
Pack sand	14	39
Purple and white clay	32	71
Well 30-52-903		
Owner: Carl Dunlap Driller: Repps B. Guitar, Jr.		
Sand and clay	14	14
Sand and fine gravel	8	22
Rock limestone	7	29
Red and blue clay	21	50
Well 30-54-101		
Owner: Robert McClain Driller: Lester King		
Soil	2	2
Sand	28	30
Water sand	10	40
Red (shale?)	10	50
Lime	8	58
Red shale	5	63
Lime	17	80
Blue shale	3	83
Lime	5	88
Blue shale	2	90
Well 30-54-103		
Owner: H. J. Gibbs Driller: W. D. Clark		
Soil	5	5
Sand	25	30
Clay and sand	19	49
Water sand	7	56
Blue shale	14	70
Well 30-54-105		
Owner: Russell H. Dye Driller: Dick Marrow		
Sandy topsoil	2	2
Caliche	6	8
Sandrock and sand	27	35
Red clay	10	45
Well 30-54-105—Continued		
Sand	5	50
Red clay	5	55
White sand	10	65
Water sand	5	70
Lime	5	75
Red bed clay	5	80
Lime with hard streak	22	102
Well 30-54-205[1]		
Owner: C. M. Caldwell Driller: Roxanana Petroleum Corporation and C. O. Moore		
Surface	3	3
Lime	33	36
Sandy shale	30	66
Broken lime	10	76
Sand rock	8	84
Yellow clay	21	105
Sand and gravel	5	110
Yellow clay	30	140
Lime	10	150
Pink shale	15	165
Red rock	28	193
Gray lime	7	200
Broken lime	16	216
Sand rock	9	225
Sand rock cave	22	247
Red bed	7	254
Brown shale	76	330
Well 30-54-309[1]		
Owner: C. M. Caldwell Driller: Broderick and Calvert		
Soil	5	5
Yellow clay	15	20
Sand (fresh water sand)	30	50
Gray shale	30	80
Red bed	15	95
Sand, sandy shale	73	168
Red bed	32	200
Red shale	10	210
Blue shale	30	240
Lime shale	15	255

See footnote at end of table.

Well 30-54-309[1]

Owner: —Caldwell
Driller: C. B. Edgar

	Thickness (feet)	Depth (feet)
Yellow clay and fine sand mix	120	120
Pink clay and fine sand	40	160
Pink shale and fine sand mix	20	180
Coarse orange and clear basal Trinity conglomerate	35	15
Yellow and pink plastic shale and conglomerate	10	225
Red plastic shale	5	230

Well 30-54-602

Owner: Lee Caldwell
Driller: Murl Bales

	Thickness (feet)	Depth (feet)
Topsoil and clay	15	15
Pack sand	15	30
Water sand (dry)	6	36
Pack sand	22	58
Gravel (water)	15	73
Red clay	5	78

Well 30-54-601

Owner: J. C. Childers
Driller: J. C. Childers

	Thickness (feet)	Depth (feet)
Soil	2	2
Sandy shale	20	22
Pack sand	6	28
Blue shale	10	38

Well 30-54-604

Owner: John T. Crawley
Driller: W. D. Clark

	Thickness (feet)	Depth (feet)
Surface	2	2
Caliche	8	10
Rock	1	11
Red bed	9	20
White clay	4	24
Sand and gravel	6	30
White clay	6	36
Rock	1	37
White sandy clay	20	57
Sand and fine gravel	7	64
Clay	6	70

Well 30-54-606

Owner: Glen Wooten
Driller: Jake Dallas

	Thickness (feet)	Depth (feet)
Sand and caliche	48	48
Water sand and gravel	32	80
Red clay	4	84

Well 30-54-612

Owner: Edgar Albricht
Driller: Eddie Woods

	Thickness (feet)	Depth (feet)
Clay and sand	45	45
Sand (seep)	7	52
Clay	28	80
Water (sand and gravel)	20	100
Red bed	2	102

Well 30-54-902

Owner: Dr. R. H. Tull
Driller: J. C. Childers

	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sandy shale	18	20
Sand and gravel	8	28
Red bed	—	28

Well 30-55-104

Owner: Red Duncan
Driller: W. D. Clark

	Thickness (feet)	Depth (feet)
Clay and sand	20	20
Pack sand	70	90
Clay	10	100
Gravel and sand	10	110
Red bed	—	110

Well 30-55-105

Owner: A. L. Varner
Driller: A. L. Varner

	Thickness (feet)	Depth (feet)
Soil	5	5
Caliche	10	15
Sandy shale	50	65
Clay	5	70
Sandy shale	80	150
Water sand and gravel	35	185
Yellow clay	10	195
Lime	3	198
Clay	2	200
Shale and clay	18	218

See footnote at end of table.

Table 6.—Drillers' Logs of Selected Water Wells, Oil and Gas Tests, and Stratigraphic Tests—Continued

Well 30-55-106

Owner: J. T. Howard
Driller: A. L. Varner

	Thickness (feet)	Depth (feet)
Sand	3	3
Red clay	7	10
Yellow clay	40	50
Pack sand	13	63
Water sand	30	93
Red clay	32	125

Well 30-55-206

Owner: Charles Sowell
Driller: A. L. Varner

	Thickness (feet)	Depth (feet)
Topsoil	5	5
Sand rock	10	15
Sand (water seep)	5	20
Sandy shale and sand	40	60
Water sand	35	95
Red mixed and blue shale	20	105

Well 30-55-213

Owner: W. D. Clark
Driller: W. O. Clark

	Thickness (feet)	Depth (feet)
Sand and clay	13	13
Sand	5	18
Red bed	2	20
Sand and gravel	40	60
Red bed	7	67

Well 30-55-216

Owner: Jack Smith
Driller: J. C. Childers

	Thickness (feet)	Depth (feet)
Soil	2	2
Clay	3	5
Sandy clay	25	30
Sand (water)	5	35
Sand and gravel	115	150
Red bed	5	155

Well 30-55-217

Owner: J. N. Nisbett
Driller: Curtis Alford

	Thickness (feet)	Depth (feet)
Soil	2	2
Clay	4	6
Gray sandy	14	20
Water sand	10	30
Lime	1	31

Well 30-55-221

Owner: Leonard Mosely
Driller: A. L. Varner

	Thickness (feet)	Depth (feet)
Soil	5	5
Sandy shale	30	35
Clay	15	50
Water sand (water)	40	90
Red shale	10	100

Well 30-55-307

Owner: Nathan Foster
Driller: Kit Carson

	Thickness (feet)	Depth (feet)
Soil	5	5
Sand rock	5	10
Sand	10	20
Yellow clay	15	35
Hard sand	25	60
Water sand	10	70
Red shale	10	80
Water sand	10	90
Red shale, sandy	10	100
Blue shale	10	110
Water sand	20	130
Red sand (red bed)	2	132

Well 30-55-309

Owner: Robert Brashear
Driller: Lester King

	Thickness (feet)	Depth (feet)
Soil	2	2
Sandy shale	53	55
Water sand	20	75
Sand and gravel (water)	14	9
Red shale	11	100

Well 30-55-406

Owner: Dan L. Childers
Driller: Glen Vaughn

	Thickness (feet)	Depth (feet)
Sand	6	6
Red clay	6	12
Sandstone	4	16
Water sand	8	24
Blue clay	6	30

Well 30-55-408

Owner: J. B. Green
Driller: Jake Dallas

	Thickness (feet)	Depth (feet)
Clay	15	15
White sand	2	17

Table 6.—Drillers' Logs of Selected Water Wells, Oil and Gas Tests, and Stratigraphic Tests—Continued

	Thickness (feet)	Depth (feet)
Well 30-55-408—Continued		
Yellow clay	7	24
Gravel and sand	6	30
Red bed	10	40
Well 30-55-409		
Owner: C. M. Kinnard Driller: W. D. Clark		
Surface	5	5
Sand	8	13
Blue clay	6	19
Sand and gravel	12	31
Light blue clay	7	38
Pack sand with some sand	8	46
Blue clay	2	48
Pack sand	8	56
Clay	2	58
Rock	1	59
Red bed	1	60
Well 30-55-502		
Owner: W. A. Gill Driller: Jake Dallas		
Soil	2	2
Pack sand	18	20
Sand (water)	20	40
Shale	8	48
Well 30-55-515		
Owner: Richard Smith Driller: R. L. McKelvy		
Brown sand	3	3
Yellow clay	2	5
—	9	14
Sand with gravel	6	20
Brown sand	9	29
Blue shale	6	35
Well 30-55-517		
Owner: Mrs. Bryan Bennett Driller: A. L. Varner		
Soil	5	5
Clay	25	30
Pack sand	30	60
Water sand	25	85
Red bed	13	98

	Thickness (feet)	Depth (feet)
Well 30-55-518		
Owner: Troy Lamb Driller: Jack Leonard		
Sandy clay	12	12
Sand and gravel	8	20
Blue shale	4	24
Well 30-55-607		
Owner: Arvin Brasher Driller: Lester King		
Topsoil	2	2
White shale	51	53
Lime	2	55
Yellow shale	3	58
Red clay	17	75
Sand (dry)	15	90
White shale	10	100
Red shale	5	105
Water sand	17	122
Red shale	8	130
Well 30-55-608		
Owner: S. E. Page Driller: Lester King		
Topsoil	2	2
Sandy shale	40	42
Water sand and gravel	32	74
Red shale	11	85
Well 30-55-610		
Owner: S. E. Page Driller: Texas Department of Water Resources		
Sand, brown, topsoil	5	5
Sand, reddish, fine grained, with gray sand streaks	9	14
Sand, dark red, fine grained, with gray-white clay streaks	18	32
Sand, gray, medium grained, and gravel, small with occasional white-gray clay streak	32	64
Clay, green, sandy	2	66
Sand, gray, fine-medium-grained, gray, and gravel with green clay stringers	10	76
Clay, brown, sandy with sand and gravel streaks	3	79
Clay, brown to green with green shale and red to brown sandstone streaks	4.5	83.5

Table 6.—Drillers' Logs of Selected Water Wells, Oil and Gas Tests, and Stratigraphic Tests—Continued

Well 30-55-702

Owner: Howard Cox
Driller: Lester King

	Thickness (feet)	Depth (feet)
Soil	3	3
Sandy shale	17	20
Water sand	10	30
Red shale	15	45

Well 30-55-704

Owner: Kenneth Whithurst
Driller: L. E. Hayhurst

	Thickness (feet)	Depth (feet)
Sand	1	1
Sand and gravel	9	10
White clay	2	12
Sand and gravel	11	23
White clay	5	28
Red shale	20	48

Well 30-55-706

Owner: Oran Bains, Jr.
Driller: W. D. Clark

	Thickness (feet)	Depth (feet)
Clay and sand	22	22
Sand and gravel	7	29
Red clay with yellow clay	31	60

Well 30-55-913

Owner: City of Cross Plains
Driller: Jake Dallas

	Thickness (feet)	Depth (feet)
Caliche and gravel	15	15
Yellow sandy clay	25	40
Sand with some gravel	20	60
Red shale	10	70

Well 30-55-925

Owner: Harvey Wilcoxen
Driller: Lester King

	Thickness (feet)	Depth (feet)
Soil	5	5
Pack sand	25	30
Water sand	40	70
Red shale	15	85

Well 30-55-928

Owner: Morris Thomas
Driller: Lester King

	Thickness (feet)	Depth (feet)
Soil	3	3
Red shale	7	30
Water sand	15	45
Red shale	15	60

Well 30-55-930[1]

Owner: W. R. Erwin
Driller: Humble Oil and Refining Company

	Thickness (feet)	Depth (feet)
Clay	4	4
Gray clay	26	30
Red clay	25	55
White clay	20	75
Red rock	20	95
Sand	5	100
Gray shale	5	105
Red rock	20	125
Gray shale	15	140
Lime	15	155
Red rock	15	170

Well 30-63-101

Owner: L. M. Hodges
Driller: Lester King

	Thickness (feet)	Depth (feet)
Caliche-clay	12	12
Sand	23	35
Red shale	25	60
Blue shale	5	65

Well 30-63-306

Owner: City of Cross Plains
Driller: —

	Thickness (feet)	Depth (feet)
Soil	5	5
Fine white sand	61	66
Red bed	—	66

Well 30-63-314

Owner: H. R. Miner
Driller: Jack Leonard

	Thickness (feet)	Depth (feet)
Caliche and sand	30	30
Water sand, white	10	40
Clay with some sand	10	50
Sand and clay	11	61
Red bed	1	62

[1] Partial drillers' log from an oil or gas test.

Table 7.--Chemical Analyses of Water From Selected Wells, Springs, and Test Holes

(Analyses are in milligrams per liter except percent sodium, specific conductance, pH, SAR, and RSC.)

Water-bearing unit: Qal, Quaternary or Recent alluvium; Kca, Antlers Formation; P, Permian rocks undifferentiated.

Analyses made in 1939 and 1940 were by chemists employed on Work Projects Administration Project 10443. Other analyses performed by Texas Department of Health except where indicated by footnote.

Well	Aquifer	Depth of well (ft)	Date of collection	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	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)	pH	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)
30-28-703	Qal	18	Mar. 30, 1971	21	--	139	53	260	< 1	349	304	280	1.2	136	0.5	1,367	570	1,980	7.8	50.0	4.7	0.0
803	Qal	15	Mar. 2, 1940	--	--	--	--	--	--	--	43	28	--	< 20	--	370	293	--	--	--	--	--
803	Qal	15	Mar. 5, 1971	10	--	1,150	337	1,810	7	194	114	5,700	.4	< .4	.2	9,200	4,270	11,900	7.2	--	--	--
31-910	P	31	Aug. 2, 1940	--	--	186	38	127*	--	275	138	237	.4	240	--	1,101	623	--	--	30.8	2.2	.0
910	P	31	Mar. 16, 1971	17	--	358	65	276	2	242	348	600	.6	480	.4	2,265	1,160	3,150	7.4	34.0	3.5	.0
36-102	Qal	Spring	Mar. 8, 1971	11	--	432	138	418	< 1	200	222	1,530	.7	11	--	2,862	1,650	4,490	7.6	35.6	4.4	.0
301	Kca	Spring	Sept. 8, 1970	19	--	13	14	386	--	670	188	133	5.2	< .4	--	1,088	89	1,700	8.2	90.3	17.7	9.1
302	Kca	35	Feb. 15, 1940	--	--	36	12	6*	--	134	16	17	--	< 20	--	172	137	--	--	8.6	.2	.0
302	Kca	35	Dec. 10, 1970	23	--	74	6	5	7	246	< 4	4	.1	28	.1	272	211	420	7.5	4.7	.1	.0
302	Kca	35	July 25, 1978	22	--	76	11	8	--	247	3	14	< .1	37	--	292	234	467	7.0	6.9	.2	.0
303	Kca	25	Dec. 10, 1970	19	--	79	9	96	< 1	400	74	21	1.6	9	.5	506	235	765	8.1	47.0	2.7	1.8
501	P	30	Feb. 22, 1940	--	--	170	142	271*	--	378	244	660	2.0	120	--	1,794	1,007	--	--	36.9	3.7	.0
601	Kca	Spring	Sept. 8, 1970	31	--	76	22	94	< 1	373	122	45	1.5	< .4	.4	576	282	879	7.5	42.1	2.4	.5
602	Kca	13	July 31, 1940	--	--	82	29	121*	--	378	138	89	--	< 20	--	664	323	--	--	44.8	2.9	.0
602	Kca	13	Sept. 8, 1970	27	--	75	40	141	< 1	488	148	77	2.1	2.5	.6	754	351	1,169	7.6	46.5	3.2	.9
603	Kca	21	July 31, 1940	--	--	286	53	53*	--	214	101	176	--	645	--	1,419	933	--	--	11.0	.7	.0
603	Kca	21	Sept. 8, 1970	19	--	123	23	81	< 1	301	120	89	.5	84	.2	688	403	1,091	7.4	30.4	1.7	.0
604	Kca	57	Nov. 4, 1970	18	--	166	23	104	< 1	407	100	179	1.1	45	.2	837	510	1,360	7.2	30.7	2.0	.0
611	Kca	36	Dec. 10, 1970	18	--	309	40	140	3	397	150	371	.5	284	.3	1,511	940	2,250	7.1	24.5	1.9	.0
612	Kca	40	do	19	--	277	29	205	2	488	210	439	.5	15	.2	1,436	810	2,230	7.4	35.4	3.1	.0
801	Kca	18	Sept. 8, 1970	22	--	120	19	117	< 1	231	103	229	1.0	22	.3	747	380	1,270	7.4	40.2	2.6	.0
802	Kca	20	Feb. 22, 1940	--	--	85	10	40*	--	293	26	33	--	36	--	374	256	--	--	25.6	1.0	.0
802	Kca	20	Dec. 9, 1970	21	--	149	17	70	< 1	331	74	158	.8	20	.2	673	441	1,098	7.5	25.6	1.4	.0
803	Kca	64	do	19	--	99	12	32	< 1	257	29	80	.3	8	.2	406	295	679	7.2	18.9	.8	.0
806	Kca	50	Jan. 18, 1971	8	--	39	7	11	< 1	162	4	7	.2	< .4	.1	157	127	278	7.5	15.8	.4	.1
808	Kca	30	Aug. 1, 1940	--	--	127	86	191*	--	378	494	188	--	--	--	1,271	674	--	--	38.3	3.2	.0
809	Kca	32	Mar. 17, 1971	29	--	58	7	6	< 1	177	12	15	.4	4.4	.1	219	174	345	7.5	6.9	.1	.0
809	Kca	32	July 25, 1978	35	--	56	6	8	--	177	16	14	.4	1.7	--	224	167	341	7.6	9.6	.2	.0
810	Kca	40	Mar. 30, 1971	35	--	267	34	510	2	340	360	860	1.1	14	.6	2,250	810	3,380	7.4	57.8	7.8	.0

See footnotes at end of table.

Well	Aquifer	Depth of well (ft)	Date of collection	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	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)	pH	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)
[1] 30-36-901	Kca	25	Feb. 5, 1946	28	0.05	152	28	121	11	478	123	162	0.6	26	--	3,919	494	12,360	7.3	34.0	2.4	--
902	Kca	55	Sept. 10, 1970	22	--	216	41	187	< 1	600	269	264	1.4	.4	0.3	1,297	710	1,950	7.2	36.5	3.0	0.0
903	Kca	55	do	32	--	112	29	79	< 1	570	32	50	2.8	< .4	.2	618	399	979	7.4	30.1	1.7	1.3
904	Kca	57	do	19	--	104	13	73	< 1	405	67	55	.3	2.5	.1	534	316	841	7.4	33.6	1.7	.3
905	Kca	35	Nov. 13, 1970	24	--	109	13	33	< 1	338	35	50	.6	11	.2	442	325	705	7.4	18.0	.7	.0
909	Kca	32	do	25	--	105	10	60	< 1	403	35	45	.9	7	.2	487	305	765	7.6	30.0	1.4	.5
910	Kca	55	Nov. 18, 1970	20	--	134	14	52	7	348	60	114	.6	13	.2	585	391	949	7.1	22.0	1.1	.0
915	Kca	56	do	24	--	175	15	69	< 1	340	72	194	.4	13	.4	730	499	1,192	7.0	23.1	1.3	.0
917	Kca	60	do	21	--	134	9	76	< 1	365	109	91	.3	1	.1	621	371	969	7.3	30.7	1.7	.0
921	Kca	49	Dec. 1, 1970	24	--	175	19	52	< 1	550	55	85	.5	12	.2	694	520	1,072	7.7	18.0	.9	.0
928	Kca	47	Dec. 4, 1970	26	--	201	27	139	< 1	425	150	293	.8	7	.3	1,054	620	1,640	7.9	33.0	2.4	.0
930	Kca	53	do	19	--	198	17	76	< 1	473	94	179	.4	< .4	.3	817	560	1,290	7.5	22.6	1.3	.0
931	Kca	53	Feb. 17, 1972	21	--	242	35	123	< 1	477	102	373	.5	4.5	.3	1,136	750	1,850	7.8	26.3	1.9	.0
932	Kca	18	Apr. 6, 1971	30	--	153	30	137	2	407	184	186	1.1	2	.3	925	510	1,380	8.1	37.0	2.6	.0
933	Kca	49	Apr. 12, 1971	25	--	1,210	286	1,460	6	428	1,450	3,910	1.3	< .4	1.8	8,560	4,200	9,780	7.3	43.0	9.8	.0
37-101	Kca	21	Dec. 10, 1970	25	--	113	12	73	< 1	349	75	87	1.3	4.5	.3	563	332	889	7.5	32.3	1.7	.0
403	Kca	33	Jan. 25, 1971	26	--	198	44	265	< 1	640	168	376	1.0	14	.3	1,407	680	2,200	7.4	46.0	4.4	.0
404	Kca	Spring	do	25	--	90	22	71	< 1	442	57	42	1.4	< .4	.2	527	316	820	7.9	32.8	1.7	.9
405	Kca	50	Feb. 2, 1971	18	--	184	20	139	--	407	100	278	.7	31	.3	971	542	1,600	7.3	35.8	2.5	.0
406	Kca	23	July 31, 1940	--	--	120	21	141*	--	500	82	134	.9	< 20	--	764	388	--	--	44.3	3.1	.4
406	Kca	23	Feb. 25, 1971	25	--	229	43	84	1	277	83	251	.7	317	.3	1,170	750	1,750	7.1	19.6	1.3	.0
406	Kca	23	July 25, 1978	26	--	240	52	94	--	316	117	196	.6	446	--	1,326	815	1,620	7.5	20.1	1.4	.0
501	Kca	13	July 31, 1940	--	--	94	16	48*	--	372	48	35	--	< 20	--	424	300	--	--	--	--	--
501	Kca	13	Dec. 4, 1970	19	--	153	24	82	2	490	104	107	.6	.4	.2	733	479	1,134	7.7	27.0	1.6	.0
501	Kca	13	July 25, 1978	18	--	138	18	60	--	427	100	61	.6	1.6	--	607	417	867	7.5	23.8	1.2	.0
507	Kca	40	Feb. 2, 1971	20	--	160	21	58	13	301	107	173	.2	20	.2	690	487	1,164	7.2	20.6	1.1	.0
509	Kca	Spring	Feb. 25, 1971	2	--	1,890	432	3,920	9	49	145	10,500	.8	< .4	--	16,923	6,510	> 12,000	6.4	56.7	21.1	.0
702	Kca	41	Nov. 6, 1970	33	--	183	29	106	< 1	436	135	191	1.4	37	.4	896	580	1,460	7.3	28.6	1.9	.0
704	Kca	50	do	26	--	190	32	164	2	361	220	268	1.1	52	.4	1,133	610	1,740	7.7	37.0	2.8	.0
705	Kca	29	Sept. 9, 1970	25	--	341	48	258	2	437	374	620	.5	12	.3	1,895	1,050	2,840	7.2	34.8	3.4	.0
708	Kca	54	Nov. 4, 1970	35	--	129	18	66	< 1	440	48	61	1.1	45	.2	620	395	958	7.4	26.5	1.4	.0
710	Kca	57	July 21, 1966	24	--	133	16	26	2	360	27	81	.4	15	.1	501	399	824	7.4	12.4	.5	.0

See footnotes at end of table.

Table 7.--Chemical Analyses of Water From Selected Wells, Springs, and Test Holes--Continued

Well	Aquifer	Depth of well (ft)	Date of collection	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	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)	pH	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)
30-37-714	Kca	55	Nov. 6, 1970	19	--	131	21	50	< 1	403	47	95	0.7	6	0.1	568	414	938	7.3	20.8	1.0	0.0
715	Kca	55	do	27	--	207	31	111	< 1	470	140	248	1.0	13	.3	1,010	650	1,600	7.4	27.2	1.9	.0
724	Kca	26	Sept. 21, 1939	--	--	166	24	73*	--	451	100	119	.9	36	--	740	515	--	--	23.6	1.4	.0
1/ 724	Kca	26	Feb. 5, 1946	28	0.05	152	28	121	11	478	123	162	.6	26	--	887	494	--	7.3	34.1	2.3	.0
724	Kca	26	Nov. 6, 1970	33	--	260	43	154	2	472	235	369	1.1	14	.2	1,343	830	1,980	7.6	28.8	2.3	.0
730	Kca	49	Nov. 18, 1970	20	--	143	14	92	1	600	34	66	.6	< .4	.3	666	416	1,054	7.3	32.5	1.9	1.5
732	Kca	44	Dec. 4, 1970	4	--	89	32	235	4	279	< 4	471	.1	.4	.1	976	354	1,770	6.9	58.7	5.4	.0
733	Kca	90	Dec. 9, 1970	16	--	121	12	48	< 1	412	30	54	.4	13	.2	498	351	806	7.4	22.8	1.1	.0
736	Kca	61	Jan. 25, 1971	10	--	151	20	78	3	303	45	239	.2	< .4	.2	695	462	1,200	7.6	26.8	1.5	.0
740	Kca	Spring	Apr. 6, 1971	27	--	71	44	403	15	244	220	580	.5	< .4	.7	1,481	358	2,400	7.3	69.9	9.2	.0
741	Kca	50	June 15, 1971	31	--	122	22	26	< 1	418	26	42	.9	13	.1	489	398	773	7.5	--	--	--
801	Kca	63	Aug. 11, 1961	23	.00	120	24	138*	--	358	126	169	.5	40	--	816	398	--	6.6	43.0	3.0	.0
802	Kca	63	Jan. 26, 1971	16	--	83	18	92	5	327	86	86	.5	3.5	.2	550	280	871	7.7	41.0	2.3	.0
803	Kca	Spring	Sept. 20, 1939	--	--	71	12	20*	--	220	36	37	.5	< 20	--	304	228	--	--	16.1	.5	.0
803	Kca	Spring	Oct. 9, 1970	16	--	115	13	24	< 1	329	55	45	.7	< .4	.3	432	341	710	7.6	13.3	.5	.0
804	Kca	22	Nov. 19, 1970	19	--	90	10	37	< 1	268	40	61	.6	2.5	.2	393	269	654	7.3	23.2	.9	.0
807	Kca	39	do	27	--	114	9	23	5	387	20	26	.2	< .4	.2	415	320	654	7.3	13.2	.5	.0
812	Kca	44	do	24	--	60	9	30	< 1	211	24	40	.6	1	.1	293	187	483	7.1	25.8	.9	.0
814	Kca	150	Dec. 9, 1970	17	--	122	9	26	< 1	356	20	57	.3	7	.3	434	341	717	7.5	14.2	.6	.0
815	Kca	26	Jan. 18, 1971	23	--	198	44	107	< 1	272	161	281	.5	135	.1	1,084	680	1,680	7.4	25.6	1.7	.0
816	Kca	28	do	20	--	106	17	42	< 1	237	48	124	.4	3	.1	478	333	816	7.7	21.4	.9	.0
824	Kca	27	Jan. 25, 1971	27	--	118	14	39	< 1	321	44	86	.4	1.5	.1	488	353	799	7.9	19.4	.9	.0
39-903	Qal	Spring	Apr. 12, 1971	22	--	358	497	960	2	314	1,450	2,240	1.7	6	.8	5,691	2,940	7,080	7.5	41.5	7.7	.0
44-101	Kca	36	Feb. 5, 1971	23	--	90	16	36	< 1	328	48	33	1.1	4.3	.3	413	290	638	8.3	21.2	.9	.0
102	Kca	28	Mar. 17, 1971	27	--	370	57	274	< 1	243	270	830	.8	85	.5	2,034	1,160	3,130	7.5	34.0	3.5	.0
201	Kca	26	Jan. 11, 1971	23	--	217	35	268	< 1	320	213	530	.9	56	.3	1,501	690	2,360	7.5	45.9	4.4	.0
202	Kca	30	Feb. 2, 1971	34	--	106	17	63	< 1	400	73	35	1.6	12	.2	539	336	815	7.5	29.0	1.4	.0
204	Kca	24	Mar. 4, 1971	31	--	230	38	319	< 1	343	281	520	2.5	110	.5	1,701	730	2,540	7.3	48.7	5.1	.0
205	Kca	30	Mar. 5, 1971	30	--	435	72	218	--	331	57	1,050	.5	31	--	2,056	1,380	3,440	7.2	25.5	2.5	.0
301	Kca	38	Nov. 2, 1970	21	--	129	22	75	< 1	386	62	67	1.0	104	.1	671	412	1,045	7.2	28.3	1.6	.0
302	Kca	28	do	22	--	114	23	39	< 1	343	74	51	1.4	31	.2	525	382	830	7.4	18.2	.8	.0
303	Kca	32	Mar. 2, 1940	--	--	76	30	195*	--	311	130	165	3.1	132	--	884	313	--	--	57.5	4.7	.0
303	Kca	32	Nov. 2, 1970	29	--	60	32	107	< 1	366	88	69	3.2	23	.4	592	281	918	8.0	45.2	2.7	.3

See footnotes at end of table.

Well	Aquifer	Depth of well (ft)	Date of collection	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	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)	pH	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)
30-44-304	Kca	35	Nov. 6, 1970	26	< 0.02	104	20	61	< 1	321	63	86	1.1	25	0.2	545	341	877	7.4	27.9	1.4	0.0
305	Kca	32	Nov. 13, 1970	33	--	79	15	94	< 1	401	49	51	1.8	1.5	.2	522	258	808	7.4	44.0	2.5	1.3
307	Kca	43	do	31	--	119	28	70	< 1	425	48	107	1.5	9	.3	623	411	1,000	7.4	26.9	1.5	.0
308	P	Spring	Nov. 17, 1970	20	--	130	14	34	< 1	344	74	67	1	< .4	.2	510	384	812	7.3	16.2	.7	.0
401	Kca	58	Jan. 6, 1971	18	--	137	9	86	< 1	346	91	76	.6	104	.3	693	378	1,036	7.6	33.0	1.9	.0
402	Kca	56	Jan. 8, 1971	15	--	105	8	12	< 1	300	23	28	.3	8	.1	347	297	565	8.0	8.1	.3	.0
403	Kca	77	Feb. 5, 1971	20	--	77	9	4	< 1	260	10	5	.2	3.5	.2	257	229	418	7.3	3.6	.1	.0
404	Kca	Spring	Aug. 1, 1940	--	--	106	21	58*	--	348	76	81	.6	< 20	--	533	353	--	--	26.4	1.3	.0
404	Kca	Spring	May 10, 1971	13	--	67	48	233	2	484	163	200	3.5	< .4	.6	968	364	1,520	8.1	58.0	5.3	.6
501	Kca	80	Nov. 2, 1970	13	--	126	12	36	< 1	399	24	62	.5	< .4	.1	471	367	784	7.2	17.7	.8	.0
502	Kca	22	Nov. 17, 1970	45	--	91	30	13	< 1	409	19	9	2.3	5.5	.1	417	349	637	7.4	7.4	.3	.0
503	Kca	42	Jan. 11, 1971	16	--	246	18	114	< 1	384	89	246	.7	227	.3	1,146	690	1,740	7.3	26.5	1.8	.0
504	Kca	Spring	do	4	--	114	69	496	< 1	349	560	550	1.8	1.5	.4	1,969	570	2,910	7.6	65.5	9.0	.0
505	Kca	30	Feb. 5, 1971	35	--	95	24	50	< 1	433	47	25	1	1.5	.2	492	337	742	8.1	24.4	1.1	.3
506	Kca	25	do	28	--	136	29	72	3	464	66	104	.8	21	.1	688	459	1,088	7.4	25.3	1.4	.0
601	Kca	14	Feb. 21, 1940	--	--	81	24	142*	--	348	177	75	--	40	--	710	300	--	--	50.7	3.5	.0
601	Kca	14	Jan. 11, 1971	18	--	244	58	493	< 1	364	178	1,020	1.1	18	.4	2,210	850	3,520	7.5	55.8	7.3	.0
701	Kca	90	Sept. 9, 1970	10	--	208	19	97	< 1	282	31	378	.2	9	.2	892	600	1,600	7.5	26.1	1.7	.0
702	Kca	35	Jan. 6, 1971	23	--	150	30	63	6	427	88	99	.6	52	.1	721	496	1,134	7.4	21.3	1.2	.0
703	Kca	66	Jan. 8, 1971	9	--	111	6	12	< 1	303	19	38	.3	< .4	.1	345	300	581	7.5	7.9	.3	.0
704	Kca	131	Feb. 5, 1971	15	--	139	11	11	< 1	365	58	32	.5	< .4	.1	447	392	714	7.4	5.7	.2	.0
705	Kca	51	do	14	--	90	11	29	< 1	306	24	35	.6	3	.1	358	272	598	7.5	18.9	.7	.0
710	Kca	106	Oct. 10, 1974	14	--	119	9	12	--	332	19	37	.4	15	--	388	334	652	7.5	7.2	.2	.0
710	Kca	106	July 24, 1978	15	--	111	10	20	--	298	27	51	.2	17	--	397	318	635	7.7	12.0	.4	.0
802	Kca	123	Aug. 11, 1961	14	--	98	17	35	1.2	386	19	38	.7	3.0	.04	415	314	723	7.6	19.4	.8	.0
802	Kca	123	Jan. 7, 1971	14	--	103	24	39	< 1	394	25	54	.7	11	.1	465	357	766	7.9	19.2	.8	.0
802	Kca	123	July 25, 1978	7	--	40	20	91	--	124	56	163	.3	< .4	--	438	182	734	8.2	52.1	2.9	.0
804	Kca	153	Jan. 8, 1971	14	--	113	15	6	< 1	383	15	15	.2	4.5	.2	372	343	602	7.9	3.6	.1	.0
806	Kca	90	Jan. 11, 1971	15	--	173	25	53	< 1	359	72	188	.4	3.0	.1	707	540	1,164	7.9	17.7	.9	.0
807	Kca	41	Feb. 8, 1971	21	--	56	7	9	< 1	200	12	5	.2	1.5	.1	211	170	341	7.6	10.3	.3	.0
808	Kca	60	Feb. 17, 1971	21	--	125	13	55	< 1	384	43	86	.7	< .4	.2	534	366	867	7.4	24.6	1.2	.0
810	Kca	76	Mar. 1, 1971	17	--	196	34	141	< 1	560	112	249	.6	15	.4	1,041	630	1,650	7.2	32.7	2.4	.0
902	Kca	105	Feb. 16, 1971	10	--	47	49	413	6	467	439	266	2.6	< .4	1.3	1,463	318	2,180	7.6	73.3	10.0	1.2

See footnotes at end of table.

Table 7.--Chemical Analyses of Water From Selected Wells, Springs, and Test Holes--Continued

Well	Aquifer	Depth of well (ft)	Date of collection	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	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)	pH	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)
30-44-903	Kca	13	Apr. 30, 1940	--	--	178	46	354*	--	384	459	420	1.8	< 20	--	1,667	633	--	--	54.9	6.1	0.0
45-101	Kca	55	Nov. 4, 1970	20	--	184	30	155	2	458	144	262	.6	32	0.2	1,054	580	1,690	7.3	36.6	2.7	.0
105	Kca	61	Nov. 17, 1970	19	--	108	12	68	< 1	336	60	83	.7	16	.2	533	320	865	7.4	31.6	1.6	.0
201	Kca	31	Feb. 7, 1940	--	--	140	16	80*	--	433	75	110	--	20	--	653	415	--	--	29.5	1.7	.0
202	Kca	34	Dec. 1, 1970	23	--	132	14	85	< 1	432	72	98	.6	17	.4	655	389	1,022	7.6	32.3	1.8	.0
203	Kca	46	Feb. 2, 1971	22	< 0.02	98	12	25	< 1	246	43	73	.2	< .4	.1	395	294	655	7.1	15.5	.6	.0
205	Kca	20	Feb. 25, 1971	24	--	88	14	58	< 1	339	53	47	1.1	1.5	.4	454	279	704	7.6	31.1	1.5	.0
207	Qal	14	Mar. 30, 1971	17	--	130	30	89	< 1	432	125	104	.8	< .4	.3	710	446	1,095	7.3	--	--	--
901	Kca	24	Sept. 10, 1970	--	--	178	86	374	--	820	< 4	730	1.1	< .4	--	1,776	800	3,140	7.1	50.5	5.7	.0
902	Kca	23	Sept. 5, 1940	--	--	110	45	63*	--	318	82	170	1.4	< 20	--	647	455	--	--	23.0	1.2	.0
902	Kca	23	Sept. 22, 1970	34	--	124	43	137	2	540	86	194	1.3	< .4	.2	887	486	1,440	7.3	37.9	2.7	.0
46-201	P	40	Mar. 16, 1971	20	--	122	28	78	< 1	205	46	267	.6	1.5	.4	665	420	1,150	7.9	28.7	1.6	.0
401	P	65	Sept. 5, 1940	--	--	209	74	119*	--	153	653	102	.6	165	--	1,397	826	--	--	23.9	1.8	.0
401	P	65	Mar. 5, 1971	8	--	278	120	175	--	189	990	157	.9	208	--	2,029	1,190	2,410	7.4	24.3	2.2	.0
401	P	65	Oct. 9, 1974	12	--	186	23	36	--	209	218	86	.6	172	--	836	560	1,260	7.7	12.3	.6	.0
401	P	65	July 25, 1978	10	--	39	4	9	--	143	6	11	.2	< .4	--	149	116	270	7.9	14.7	.3	.0
501	P	40	May 6, 1971	22	--	1,900	2,640	8,900	42	348	3,960	21,900	1.2	< .4	.4	39,500	15,600	12,000	6.6	--	--	--
701	Kca	53	Sept. 10, 1970	18	--	31	4	8	< 1	88	8	21	< .1	< .4	< .1	134	92	224	6.8	15.5	.3	.0
701	Kca	53	Nov. 12, 1973	19	--	44	10	28	--	35	25	113	.2	< .4	--	256	152	486	6.1	28.7	.9	.0
701	Kca	53	Mar. 24, 1978	21	--	108	26	90	--	30	83	327	< .1	< .4	--	670	377	1,260	6.0	34.2	2.0	.0
702	Kca	91	Sept. 5, 1940	--	--	68	9	28*	--	140	25	88	.1	< 20	--	306	206	--	--	22.8	.8	.0
703	Kca	76	Oct. 14, 1970	16	--	86	8	23	< 1	218	19	37	.3	62	.2	359	249	579	7.2	16.7	.6	.0
706	Kca	20	do	36	--	139	17	34	4	395	48	89	.6	1.5	.2	563	415	899	7.5	14.9	.7	.0
801	Kca	17	Sept. 5, 1940	--	--	513	205	403	--	445	404	970	.6	1,050	--	2,717	2,127	--	--	29.2	3.8	.0
902	Kca	Spring	Mar. 21, 1940	--	--	95	12	16*	--	329	32	15	.1	< 20	--	351	288	--	--	10.8	.4	.0
902	Kca	Spring	Sept. 23, 1970	27	--	150	17	14	< 1	492	18	39	.3	< .4	.2	508	445	807	7.6	6.4	.2	.0
903	Kca	266	Jan. 13, 1971	13	--	125	31	26	< 1	318	188	30	.5	< .4	.1	571	440	840	7.6	11.4	.5	.0
47-601	Kca	25	Mar. 19, 1940	--	--	206	65	257*	--	445	135	590	--	< 20	--	1,491	785	--	--	41.7	3.9	.0
601	Kca	25	Mar. 5, 1969	40	--	104	31	198	--	455	99	214	.9	70.0	--	980	388	1,550	7.4	52.7	4.3	.0
601	Kca	25	Dec. 8, 1972	16	--	78	25	165	--	432	87	136	.9	39.0	--	759	301	1,250	7.4	54.7	4.1	1.1
601	Kca	25	Oct. 8, 1974	16	--	68	24	152	--	417	78	109	1.0	5.0	--	658	268	1,085	7.4	55.2	4.0	1.4
601	Kca	25	Mar. 24, 1978	17	--	68	20	140	--	414	68	96	.9	11	--	624	251	1,038	7.6	54.7	3.8	1.7

See footnotes at end of table.

Table 7.--Chemical Analyses of Water From Selected Wells, Springs, and Test Holes--Continued

Well	Aquifer	Depth of well (ft)	Date of collection	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	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)	pH	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)
30-47-603	Kca	30	Sept. 17, 1970	26	--	140	26	97	5.0	510	73	111	1.2	27.0	0.1	757	457	1,176	7.4	31.3	1.9	.0
604	Kca	23	do	38	--	146	24	123	8	520	71	168	1.2	1.5	.2	836	464	1,320	7.4	36.1	2.4	.0
605	Kca	19	Oct. 6, 1970	30	--	93	12	20	2	329	23	16	.5	8	.2	366	282	580	7.4	13.3	.5	.0
606	Kca	45	do	29	--	177	31	219	2	500	133	356	.8	15	.2	1,208	570	1,950	7.3	45.5	3.9	.0
701	Kca	45	Sept. 21, 1970	11	--	199	31	46	2	353	69	130	.5	242	.2	904	630	1,340	7.4	13.8	.8	.0
702	Kca	Spring	do	17	--	107	62	166	5	520	129	232	1.6	3.5	.5	979	520	1,590	7.7	40.6	3.1	.0
703	Kca	118	do	10	--	122	19	30	2	421	27	37	.4	23	.1	477	382	771	7.5	14.5	.6	.0
704	Kca	134	Oct. 1, 1970	12	--	84	30	12	< 1	377	17	23	.7	< .4	.2	365	334	618	7.4	7.2	.2	.0
704	Kca	134	July 26, 1978	13	--	76	33	16	--	341	28	30	.6	1.6	--	365	326	587	7.7	9.7	.3	.0
705	Kca	114	Aug. 2, 1940	--	--	90	17	25*	--	348	35	20	.1	< 20	--	358	295	--	--	--	--	--
801	Kca	18	do	--	--	48	8	24*	--	159	18	32	.3	< 20	--	224	155	--	--	25.5	.8	.0
801	Kca	18	Oct. 1, 1970	26	--	70	10	25	2	257	26	26	.6	1.5	.2	313	218	500	7.7	19.9	.7	.0
901	Kca	50	Sept. 24, 1970	19	--	82	14	48	5	389	22	15	.9	17	.1	414	264	660	7.4	28.0	1.2	1.1
905	Kca	21	Oct. 1, 1970	38	--	103	26	32	2	406	23	56	.6	5.5	.2	485	366	775	7.7	16.0	.7	.0
906	Qal	16	Mar. 19, 1940	--	--	74	19	24*	--	317	18	18	--	< 20	--	328	262	--	--	16.6	.6	.0
906	Qal	16	Oct. 1, 1970	27	--	107	28	28	2	431	25	44	.6	< .4	.2	474	384	769	7.5	13.7	.6	.0
908	Kca	33	Oct. 6, 1970	26	--	190	32	123	4	520	95	212	.8	8.3	.2	1,020	610	1,610	7.5	--	--	--
48-402	Kca	17	do	17	--	66	24	48	--	336	< 4	65	.5	10	--	399	265	694	7.1	28.4	1.2	.2
402	Kca	17	Oct. 8, 1974	26	--	71	12	29	--	292	10	31	.5	8.0	--	331	228	537	7.4	21.8	.8	.2
52-101	Kca	121	Dec. 3, 1970	11	--	95	21	15	< 1	337	23	33	.3	10	.1	375	323	629	7.6	9.1	.3	.0
102	Kca	110	do	12	< 0.02	91	21	18	< 1	344	20	32	.4	7	.2	371	313	615	8.0	11.1	.4	.0
104	Kca	16	do	16	--	590	193	850	< 1	289	48	2,740	1.2	< .4	.3	4,582	2,280	6,950	7.6	44.9	7.7	.0
105	Kca	130	Feb. 8, 1971	13	--	149	11	10	< 1	405	31	32	.2	28	.2	474	420	760	7.2	4.9	.2	.0
201	Kca	16	Mar. 19, 1971	13	--	85	4	3	< 1	266	11	2	.1	2.5	.2	252	231	408	7.6	2.8	.0	.0
401	Kca	112	June 24, 1961	12	.07	66	29	19	3.8	335	19	20	.6	3.0	.19	338	284	589	7.2	12.5	.4	.0
404	Kca	19	Sept. 9, 1970	22	--	120	50	72	4	510	85	107	1.0	11	.2	722	510	1,150	7.4	23.5	1.3	.0
405	Kca	32	Apr. 30, 1940	--	--	88	16	12*	--	329	15	18	.1	< 20	--	330	285	--	--	8.4	.3	.0
405	Kca	32	Jan. 8, 1971	20	--	127	15	19	< 1	376	38	46	.3	< .4	.2	451	378	728	7.6	9.8	.4	.0
405	Kca	32	July 24, 1978	14	--	98	15	10	--	352	12	12	.3	2.9	--	337	306	539	7.8	6.6	.2	.0
406	Kca	101	Mar. 1, 1971	12	--	88	25	20	< 1	340	27	36	.4	7.3	.2	384	323	640	7.7	11.8	.4	.0
501	Kca	16	Feb. 5, 1971	24	--	75	16	61	< 1	418	24	12	1.1	< .4	.2	420	255	664	7.4	34.3	1.6	1.7
701	Kca	15	Sept. 6, 1940	--	--	185	32	112*	--	445	233	150	2.4	< 20	--	953	595	--	--	29.1	2.0	.0

See footnotes at end of table.

Table 7.--Chemical Analyses of Water From Selected Wells, Springs, and Test Holes--Continued

Well	Aquifer	Depth of well (ft)	Date of collection	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	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)	pH	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)
30-52-701	Kca	15	Jan. 6, 1971	31	--	173	48	176	< 1	455	159	324	5.1	< 0.4	0.2	1,141	630	1,790	7.7	37.8	3.0	0.0
702	Kca	49	do	16	--	260	44	106	< 1	323	150	373	.8	113	.2	1,222	830	1,950	7.6	21.7	1.6	.0
801	Kca	37	Dec. 3, 1970	19	4.8	95	10	7	5	329	13	10	.3	< .4	.1	321	280	510	7.6	5.1	.1	.0
803	Kca	35	Apr. 30, 1940	--	--	50	20	12*	--	220	28	16	< 20	--	--	254	207	--	--	11.2	.3	.0
803	Kca	35	May 10, 1971	14	--	90	21	32	2	336	23	52	.7	2	.2	402	312	674	7.6	18.2	.7	.0
902	Kca	65	Jan. 6, 1971	13	--	388	165	205	3	322	449	940	1.1	39	.3	2,361	1,650	3,570	7.7	21.3	2.1	.0
903	Kca	30	do	24	--	88	50	185	< 1	450	216	164	3.8	13	.2	966	424	1,490	7.8	48.5	3.9	.0
905	Kca	37	Sept. 6, 1940	--	--	142	13	19*	--	293	35	108	.3	25	--	486	408	--	--	9.2	.4	.0
53-101	P	Spring	Mar. 19, 1971	12	--	143	10	7	< 1	434	22	22	.1	< .4	.2	431	399	705	7.3	3.7	.1	.0
301	Kca	7	Sept. 5, 1940	--	--	90	10	35*	--	311	25	42	.2	< 20	--	375	266	--	--	22.3	.9	.0
301	Kca	7	Sept. 22, 1970	16	--	79	7	14	< 1	264	13	16	.2	3.5	--	279	226	462	7.4	11.8	.4	.0
901	P	Spring	Mar. 25, 1971	14	--	88	29	36	2	338	54	57	.6	6	.2	452	340	740	7.6	18.7	.8	.0
54-101	Kca	88	Sept. 22, 1970	11	--	72	12	47	2	275	25	57	.4	< .4	.1	362	227	616	7.7	30.6	1.3	.0
102	Kca	31	do	21	--	72	234	650	< 1	840	425	1,050	5.3	< .4	2.2	2,873	1,140	4,410	7.5	55.3	8.3	.0
103	Kca	70	do	21	--	104	11	19	2	304	27	31	.2	24	.1	388	307	634	7.1	11.9	.4	.0
104	Kca	70	Oct. 7, 1970	13	.52	163	18	123	< 1	477	76	187	.6	19	.3	835	381	1,370	7.5	35.7	2.4	.0
106	Kca	30	Jan. 13, 1971	29	--	97	19	12	< 1	376	19	8	.8	5	.2	375	321	583	7.8	7.5	.2	.0
202	Kca	26	Oct. 13, 1970	30	--	68	7	9	3	243	12	10	.3	< .4	.1	259	199	404	7.4	8.6	.2	.0
204	Kca	120	Oct. 14, 1970	17	--	336	66	309	2	550	387	600	.5	121	.4	2,109	1,110	3,070	7.4	37.7	4.0	.0
206	Kca	200	Mar. 11, 1971	12	--	92	22	5	< 1	360	18	9	.2	< .4	.2	336	322	556	7.5	3.3	.1	.0
302	Kca	190	Mar. 6, 1969	27	--	309	10	15	2	322	30	104	.3	539	--	1,194	810	1,600	7.1	3.9	.2	.0
302	Kca	190	Oct. 8, 1974	12	--	174	6	8	--	372	19	48	.2	116	--	566	462	875	7.6	3.7	.1	.0
302	Kca	190	July 26, 1978	12	--	118	7	5	--	349	11	13	.2	24	--	361	326	561	7.4	3.3	.1	.0
303	Kca	119	Apr. 4, 1940	--	--	108	20	24*	--	390	36	33	--	< 20	--	432	352	--	--	12.9	.5	.0
304	Kca	120	Sept. 23, 1970	13	--	111	19	16	< 1	345	38	41	.3	17	.2	426	357	703	7.8	8.9	.3	.0
304	Kca	120	Oct. 8, 1974	14	--	100	15	16	--	306	38	32	.4	2.1	--	367	311	600	7.7	10.1	.3	.0
307	Kca	56	June 5, 1971	14	--	116	10	5	< 1	379	11	9	.1	< .4	.1	352	332	570	7.7	3.2	.1	.0
401	Kca	60	Sept. 18, 1970	7	--	59	20	37	32	259	< 4	97	.3	1.5	.1	385	230	690	7.5	22.9	1.0	.0
401	Kca	60	Oct. 10, 1974	19	--	126	37	130	--	460	136	169	.9	< .4	--	844	466	1,350	7.7	37.7	2.6	.0
401	Kca	60	July 26, 1978	20	--	110	39	176	--	511	125	176	1.4	< .4	--	899	436	1,240	7.5	46.8	3.6	.0
402	Kca	16	Sept. 4, 1940	--	--	130	56	255*	--	647	144	300	1.9	< 20	--	1,225	554	--	--	50.0	4.7	.0
402	Kca	16	Mar. 9, 1971	22	--	109	29	88	4	287	99	184	.9	< .4	.2	677	394	1,125	7.6	32.6	1.9	.0

See footnotes at end of table.

Table 7.--Chemical Analyses of Water From Selected Wells, Springs, and Test Holes--Continued

Well	Aquifer	Depth of well (ft)	Date of collection	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	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)	pH	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)
30-54-403	P	12	Sept. 4, 1940	--	--	97	14	34*	--	323	35	18	0.7	55	--	412	299	--	--	19.8	0.8	0.0
403	P	12	Mar. 9, 1971	14	--	105	13	23	< 1	316	38	23	.7	32	0.3	405	316	645	7.7	13.6	.5	.0
403	P	12	July 26, 1978	15	--	102	10	20	--	318	25	20	.7	20	--	369	295	574	7.5	12.8	.5	.0
501	Kca	123	Oct. 7, 1970	12	--	96	21	17	< 1	331	38	27	.5	28	.2	403	325	645	7.5	10.1	.4	.0
601	Kca	38	Sept. 4, 1970	12	--	109	30	22	< 1	379	53	47	.4	6	.2	466	395	760	7.5	10.8	.4	.0
602	Kca	Spring	do	22	--	85	105	182	--	510	262	251	1.7	< .4	--	1,159	650	1,800	7.7	38.1	3.1	.0
603	Kca	70	Sept. 23, 1970	13	--	116	11	16	< 1	375	19	20	.2	21	.2	401	338	653	7.5	9.4	.3	.0
604	Kca	70	do	13	--	85	15	14	2	325	13	16	.2	1	.1	319	273	530	7.4	9.9	.3	.0
605	Kca	60	Oct. 9, 1970	20	--	113	18	16	< 1	240	30	58	.3	108	.1	482	358	761	7.2	8.9	.3	.0
608	Kca	65	Oct. 7, 1970	17	--	131	110	59	7	620	123	189	1.0	21	.6	963	780	1,580	7.5	14.0	.9	.0
611	Kca	90	Feb. 17, 1971	16	--	290	200	250	3	550	323	930	.8	3.5	.3	2,287	1,550	3,480	7.1	26.0	2.7	.0
612	Kca	100	do	12	--	100	26	32	< 1	395	52	34	.4	1.5	.1	453	359	728	7.9	16.3	.7	.0
613	Kca	65	Oct. 10, 1974	13	--	102	12	16	--	333	17	21	.4	9.0	--	354	302	590	7.7	10.3	.3	.0
613	Kca	65	July 26, 1978	14	--	95	12	13	--	340	14	14	.3	5.3	--	334	288	542	7.9	9.0	.3	.0
801	Kca	15	Apr. 16, 1940	--	--	100	57	328*	--	445	497	220	2.1	< 20	--	1,442	485	--	--	59.6	6.4	.0
901	Kca	40	Sept. 15, 1970	15	--	118	52	63	2	530	42	113	.6	8	.2	674	510	1,134	7.2	21.1	1.2	.0
902	Kca	28	do	30	--	85	36	72	2	484	44	57	1.7	< .4	.1	566	362	895	7.7	30.1	1.6	.7
55-101	Kca	100	Sept. 18, 1970	11	--	65	21	39	5	310	25	45	.3	< .4	.1	364	250	612	7.8	25.0	1.0	.1
102	Kca	85	do	10	--	75	25	38	2	357	23	44	.3	1	.1	393	291	667	7.5	22.0	.9	.0
103	Kca	84	Apr. 4, 1940	--	--	--	--	--	--	354	39	56	--	< 20	--	433	--	--	--	--	--	--
103	Kca	84	Sept. 21, 1970	15	--	93	13	27	1	343	26	30	.3	< .4	.1	374	288	617	7.3	17.0	.6	.0
201	Kca	88	Sept. 15, 1970	11	--	112	23	16	< 1	348	92	19	.3	1.0	.1	446	374	692	7.4	8.5	.3	.0
202	Kca	175	Aug. 2, 1940	--	--	96	14	13	--	323	35	18	--	< 20	--	354	299	--	--	8.7	.3	.0
206	Kca	105	Sept. 15, 1970	16	--	99	22	28	< 1	331	37	44	.3	24	.2	434	339	720	7.4	15.2	.6	.0
207	Kca	130	do	12	--	92	19	22	< 1	322	24	28	.3	23	.1	379	308	635	7.5	13.4	.5	.0
208	Kca	60	Sept. 18, 1970	11	--	79	25	41	2	334	32	49	.7	24	.2	428	302	705	7.4	22.8	1.0	.0
209	Kca	60	Sept. 21, 1970	12	--	101	26	42	2	388	32	71	.4	3.5	.2	480	360	802	7.5	20.2	.9	.0
212	Kca	60	do	12	--	102	24	46	--	345	65	72	.5	6	--	497	355	823	7.3	22.1	1.0	.0
215	Kca	150	Sept. 17, 1970	15	--	114	17	24	2	338	27	56	.3	21	.1	442	355	737	7.3	12.8	.5	.0
217	Kca	30	Oct. 19, 1970	11	--	212	68	188	< 1	481	499	195	.8	24	.3	1,435	810	2,000	7.6	33.5	2.8	.0
219	Kca	135	Mar. 24, 1971	13	--	69	9	31	2	237	24	36	.4	2	.2	303	209	500	7.7	24.1	.9	.0
302	Kca	90	Sept. 24, 1970	16	--	158	16	26	< 1	327	40	45	.3	189	.2	652	461	959	7.5	10.9	.5	.0

See footnotes at end of table.

Table 7.--Chemical Analyses of Water From Selected Wells, Springs, and Test Holes--Continued

Well	Aquifer	Depth of well (ft)	Date of collection	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	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)	pH	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)
30-55-303	Kca	130	Aug. 2, 1940	--	--	79	11	32*	--	293	16	39	0.0	< 20.0	--	321	242	--	--	--	--	0.0
303	Kca	130	Sept. 24, 1970	11	--	103	11	22	2	359	10	37	.3	.4	0.1	373	305	628	7.4	13.6	0.5	.0
304	Kca	80	Aug. 2, 1940	--	--	89	12	18	--	336	15	14	--	< 20	--	313	272	--	--	--	--	.0
305	Kca	275	Nov. 18, 1963	--	0.08	80	23	29*	--	342	20	37	.4	.5	--	359	296	720	7.8	17.7	.7	.0
308	Kca	112	Mar. 22, 1971	14	--	116	12	17	2	367	15	28	.2	28	.2	412	340	690	7.6	9.8	.4	.0
309	Kca	100	May 6, 1971	10	--	100	4	10	2	298	18	21	.4	< .4	.2	312	266	520	7.5	7.5	.2	.0
311	Kca	98	Oct. 8, 1974	13	--	106	9	18	--	321	20	30	.4	10.0	--	364	301	600	7.7	11.5	.4	.0
311	Kca	98	July 26, 1978	14	--	100	10	23	--	317	22	31	.4	20	--	376	289	582	7.9	14.7	.5	.0
401	Kca	80	Sept. 10, 1970	18	--	88	22	83	< 1	420	62	62	.6	1.3	.1	544	310	872	7.5	36.7	2.0	.6
402	Kca	80	do	20	--	98	20	32	2	345	31	47	.9	19	.1	439	327	718	7.3	17.4	.7	.0
403	Kca	80	do	16	--	97	16	35	--	379	22	15	.4	30	--	417	307	669	7.6	19.8	.8	.0
405	Kca	80	do	15	--	84	13	26	< 1	278	20	23	.3	37	.2	356	262	579	7.1	17.6	.6	.0
406	Kca	30	Oct. 1, 1970	29	--	74	14	46	< 1	301	32	44	.8	1.5	.1	390	241	629	7.3	29.1	1.2	.0
407	Kca	30	do	27	--	104	27	102	3	439	73	117	1.2	15	.1	685	374	1,098	7.5	37.2	2.3	.0
408	Kca	40	Mar. 9, 1971	25	--	82	33	98	< 1	530	36	58	1.1	< .4	.3	595	342	950	7.4	38.4	2.3	1.8
503	Kca	108	Dec. 8, 1972	12	--	89	17	34	--	345	24	29	.4	17.0	--	392	293	657	7.5	20.2	.8	.0
503	Kca	108	July 26, 1978	13	--	86	17	29	--	343	23	20	.4	7	--	364	286	571	8.0	18.1	.7	.0
504	Kca	91	Sept. 4, 1970	12	--	109	19	45	< 1	411	23	47	.4	20	.3	478	350	782	7.6	21.8	1.0	.0
507	Kca	65	Sept. 11, 1970	12	--	87	26	30	< 1	354	24	37	.5	21	.2	412	325	694	7.5	16.7	.7	.0
509	Kca	98	do	12	--	99	25	37	< 1	397	31	44	.4	6	.2	450	350	744	7.5	18.6	.8	.0
512	Kca	99	do	12	--	129	24	44	--	449	32	58	.4	33	--	553	424	910	7.4	18.5	.9	.0
514	Kca	85	do	12	--	110	27	39	< 1	399	26	62	.4	22	.2	495	385	835	7.4	18.0	.8	.0
514	Kca	85	Oct. 8, 1974	13	--	117	29	45	--	407	50	77	.4	24	--	555	412	915	7.8	19.2	.9	.0
515	Kca	35	Sept. 17, 1970	29	--	75	25	26	3	355	18	27	.7	5	.1	383	290	617	7.5	16.1	.6	.0
516	Kca	31	Sept. 23, 1970	17	--	115	17	28	3	323	36	62	.3	25	.1	462	356	762	7.3	14.4	.6	.0
517	Kca	98	Oct. 15, 1970	11	--	124	27	70	< 1	389	54	119	.7	25	.2	623	419	1,042	7.4	26.5	1.4	.0
605	Kca	180	Oct. 19, 1970	8	--	171	101	244	< 1	486	348	412	.8	23	.3	1,548	850	2,360	7.8	38.6	3.6	.0
702	Kca	45	Oct. 14, 1970	24	--	94	17	32	< 1	343	24	50	.4	< .4	.1	411	306	681	7.3	18.5	.7	.0
702	Kca	45	Oct. 7, 1974	27	--	99	14	31	--	326	23	53	.5	< .4	--	408	305	668	7.6	18.1	.7	.0
703	Kca	90	Oct. 1, 1970	18	--	63	6	9	--	189	12	11	.3	19	--	231	183	375	7.5	9.7	.2	.0
708	Kca	50	Oct. 8, 1974	15	--	74	12	41	--	316	26	24	.9	2.9	--	351	249	580	7.7	27.6	1.1	.4
708	Kca	50	July 26, 1978	22	--	40	9	36	--	209	20	10	1.2	8	--	248	138	385	7.4	36.4	1.3	.6

See footnotes at end of table.

Table 7.--Chemical Analyses of Water From Selected Wells, Springs, and Test Holes--Continued

Well	Aquifer	Depth of well (ft)	Date of collection	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	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)	pH	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)
30-55-801	Kca	50	Sept. 18, 1970	16	--	279	30	74	8	334	106	236	0.7	311	0.3	1,225	820	1,810	7.3	16.2	1.1	0.0
802	Kca	15	Oct. 27, 1970	36	--	112	21	48	2	395	48	66	1.1	8	.2	536	367	845	7.5	22.1	1.0	.0
803	Kca	28	do	26	--	540	118	413	--	420	311	1,490	.4	< .4	--	3,105	1,840	4,750	7.2	32.9	4.1	.0
804	Kca	65	do	13	--	107	66	184	8	484	130	264	.9	80	--	1,090	540	1,740	7.8	42.2	3.4	.0
805	Kca	17	Mar. 25, 1971	18	--	190	31	121	3	473	89	274	.5	< .4	.2	959	610	1,560	7.6	30.3	2.1	.0
806	Kca	20	do	27	--	690	144	570	8	540	680	1,690	.8	22	.1	4,097	2,320	5,570	7.4	34.8	5.1	.0
905	Kca	60	Oct. 21, 1970	16	--	153	24	129	2	392	62	265	.4	12	.1	856	481	1,460	7.2	36.7	2.5	.0
912	Kca	48	Sept. 4, 1940	--	--	134	21	46*	--	409	39	96	.3	< 20	--	557	423	--	--	19.2	.9	.0
912	Kca	48	Oct. 21, 1970	5	--	44	2	6	< 1	110	9	23	.4	1.0	.1	145	120	260	7.6	9.9	.2	.0
915	Kca	70	do	26	--	194	35	188	< 1	367	39	476	1.1	11	.3	1,151	630	1,960	7.3	39.4	3.2	.0
917	Kca	70	Mar. 3, 1969	29	0.06	95	14	36	--	349	22	36	1.3	3.5	--	408	296	675	7.4	21.0	.9	.0
918	Kca	50	Sept. 4, 1940	--	--	85	16	88*	--	378	51	64	.6	21	--	511	280	--	--	40.8	2.2	.6
1/ 918	Kca	50	Feb. 5, 1946	19	.03	99	13	76	6.2	403	48	57	.4	15	--	533	300	--	7.0	--	--	--
919	Kca	49	do	--	--	124	19	129*	--	488	89	110	.7	23	--	734	387	--	--	42.0	2.8	.2
920	Kca	44	do	--	--	198	26	187*	--	567	140	270	.6	< 20	--	1,120	601	--	--	40.4	3.3	.0
921	Kca	48	do	--	--	196	26	140*	--	494	117	250	.5	24	--	996	596	--	--	33.8	2.4	.0
922	Kca	47	do	--	--	171	25	133*	--	531	70	210	.4	20	--	890	531	--	--	35.3	2.5	.0
922	Kca	47	Oct. 21, 1970	16	--	112	12	45	< 1	440	24	28	.7	1.5	.2	456	329	740	7.6	22.9	1.0	.6
923	Kca	50	Dec. 8, 1972	48	--	228	35	102	--	442	107	312	.6	35	--	1,084	710	1,780	7.2	23.7	1.6	.0
923	Kca	50	July 26, 1978	31	--	148	18	78	--	398	49	150	.3	21	--	690	445	1,015	7.5	27.7	1.6	.0
1/ 924	Kca	50	Feb. 5, 1946	19	.03	99	13	76	6	403	48	57	.4	15	--	531	300	--	7.0	34.9	1.9	.5
925	Kca	85	Oct. 19, 1970	4	--	56	19	35	3	229	29	51	.6	1.5	.1	311	218	560	7.4	25.6	1.0	.0
927	Kca	40	do	15	--	150	32	48	< 1	392	56	69	1.1	168	.2	733	510	1,098	7.9	17.1	.9	.0
928	Kca	60	do	25	--	142	17	117	< 1	449	69	142	1.4	37	.3	772	425	1,200	8.1	37.4	2.4	.0
56-413	Kca	25	Oct. 27, 1970	24	--	107	38	132	--	495	85	134	2.1	26	--	791	426	1,250	7.6	40.4	2.7	.0
703	Kca	50	Oct. 7, 1974	13	--	93	26	31	--	399	17	29	.5	23.0	--	428	341	705	7.6	16.6	.7	.0
61-201	P	27	Sept. 6, 1940	--	--	101	28	42*	--	348	86	46	.8	22	--	496	367	--	--	19.9	.9	.0
201	P	27	Mar. 19, 1971	12	--	155	35	67	< 1	427	101	123	.7	50	.3	754	530	1,190	7.5	21.5	1.2	.0
63-101	Kca	55	Feb. 15, 1971	36	--	81	17	49	7	394	27	15	.9	10	.3	436	272	669	7.6	27.5	1.2	1.0
201	Kca	28	Sept. 4, 1940	--	--	98	33	117*	--	500	51	120	1.0	--	--	665	380	--	--	40.1	2.6	.5
201	Kca	28	Oct. 13, 1970	27	--	146	16	24	4	432	45	64	.5	2.5	.2	541	429	865	7.5	10.7	.5	.0
202	P	150	Jan. 13, 1971	17	--	50	29	154	2	377	79	140	.5	2.3	.4	659	243	1,089	7.7	57.6	4.2	1.2
202	P	150	July 26, 1978	22	--	76	28	100	--	371	86	82	.4	.6	--	577	305	844	8.2	41.6	2.4	.0

See footnotes at end of table.

Table 7.--Chemical Analyses of Water From Selected Wells, Springs, and Test Holes--Continued

Well	Aquifer	Depth of well (ft)	Date of collection	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	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)	pH	Percent sodium	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)
30-63-203	P	90	Feb. 15, 1971	19	--	95	45	138	2	346	233	152	0.5	< 0.4	0.5	855	424	1,300	7.9	41.4	2.9	0.0
205	Kca	13	Feb. 17, 1971	28	--	91	24	47	< 1	221	70	128	.8	< .4	.3	499	327	825	7.3	23.8	1.1	.0
209	Qal	17	Apr. 4, 1940	--	--	258	63	583*	--	427	< 10	1,290	.4	< 20	--	2,434	904	--	--	58.4	8.4	.0
209	Qal	17	Mar. 15, 1971	22	--	356	130	690	12	476	215	1,700	.3	3.3	.7	3,363	1,420	5,200	7.6	51.1	7.9	.0
1/ 304	Kca	50	Feb. 5, 1946	11	0.04	227	23	138	12	520	128	283	.2	23	--	1,100	661	--	7.0	30.7	2.3	.0
308	Kca	70	Oct. 21, 1970	17	--	122	19	81	2	182	84	203	.2	28	.2	645	382	1,105	6.9	31.4	1.8	.0
309	Kca	80	Mar. 3, 1968	20	.21	142	19	87	--	265	82	217	.5	< .4	--	698	433	1,190	7.0	30.4	1.8	.0
311	Kca	40	Oct. 13, 1970	21	--	441	81	398	3	570	510	890	.5	32	.2	2,656	1,440	3,840	7.1	37.6	4.5	.0
312	Kca	48	do	12	--	114	23	99	< 1	287	68	132	.5	144	.2	734	379	1,175	7.4	36.1	2.2	.0
313	Kca	60	Sept. 4, 1940	--	--	187	25	35*	--	348	70	100	.3	183	--	771	570	--	--	11.8	.6	.0
314	Kca	62	Oct. 27, 1970	15	--	178	28	106	< 1	379	106	265	.2	4	.2	889	560	1,470	7.4	29.1	1.9	.0
316	Kca	19	Apr. 4, 1940	--	--	116	19	31*	--	378	28	67	--	20	--	466	367	--	--	15.5	.7	.0
316	Kca	19	Oct. 27, 1970	10	--	127	18	44	< 1	342	41	111	.4	< .4	.2	521	389	885	7.5	19.6	.9	.0
316	Kca	19	Oct. 7, 1974	12	--	163	27	74	--	323	86	226	.4	< .4	--	747	520	1,250	7.7	23.7	1.4	.0
316	Kca	19	July 26, 1978	15	--	170	26	77	--	404	59	208	.3	< .4	--	754	530	1,159	7.5	24.0	1.4	.0
404	P	15	Mar. 25, 1971	12	--	333	23	260	5	212	97	840	.2	< .4	.2	1,675	930	2,780	7.5	37.8	3.7	.0
607	Kca	25	Oct. 13, 1970	10	--	259	46	361	7	279	270	800	.7	12	--	1,902	840	3,040	7.4	48.2	5.4	.0

* Concentration includes both sodium (Na) and potassium (K).

1/ Analysis by U.S. Geological Survey.

Table 8.—Reported Oil-Field Brine Production and Disposal, 1961 and 1967

(Quantities reported in barrels)

Area[1]	Field[2]	Brine production 1961	Brine production 1967	Disposal into pits 1961	Disposal into pits 1967	Injection into wells 1961	Injection into wells 1967	Miscellaneous disposal 1961	Miscellaneous disposal 1967
1	Box (Palo Pinto)	213,681	821,480	0	0	213,681	821,480	0	0
	Elmdale (Palo Pinto)	152,400	133,285	0	0	152,400	133,285	0	0
	County regular	137,880	105,078	0	0	137,880	105,078	0	0
	Area Total	503,961	1,059,843	0	0	503,961	1,059,843	0	0
2	Dyer (Flippen)	12,775	0	0	0	12,775	0	0	0
	Dyer (Moran)	0	2,190	0	0	0	2,190	0	0
	Dyer (Strawn)	161,801	88,620	0	0	161,801	88,620	0	0
	Morrisett	27,445	0	0	0	27,445	0	0	0
	Morrisett (Tannehill, lower)	124,885	0	730	0	124,155	0	0	0
	Morrisett (Tannehill, upper)	5,475	0	0	0	5,475	0	0	0
	Morrisett, West (Tannehill, upper)	548	0	548	0	0	0	0	0
	St. Patrick (Hope)	81,700	200,750	0	0	81,700	200,750	0	0
	Seidel (Tannehill, upper)	18,250	0	0	0	18,250	0	0	0
	Three Acres (Flippen)	84,437	999,420	437	0	84,000	999,420	0	0
	Three Acres, South (Gardner)	0	100	0	0	0	100	0	0
	County regular	108,520	686,366	1,560	0	106,960	686,366	0	0
	Area Total	625,836	1,977,446	3,275	0	622,561	1,977,446	0	0
3	County regular	0	19,750	0	0	0	19,750	0	0
	Area Total	0	19,750	0	0	0	19,750	0	0
4	Dykes (Cook)	10,904	35,525	904	0	10,000	35,525	0	0
	County regular	547	1,460	0	0	547	1,460	0	0
	Area Total	11,451	36,985	904	0	10,547	36,985	0	0
5	Clunder (Bluff Creek)	15,000	73,000	0	0	15,000	73,000	0	0
	Colonel (Fry Sand)	31,673	1,095	0	0	31,673	1,095	0	0
	Herr-King (Cross Cut)	60,000	1,137,728	0	0	60,000	1,137,728	0	0
	IX (Conglomerate)	547	186,385	187	0	360	186,385	0	0
	Red Horse (Hope)	108,000	0	0	0	108,000	0	0	0
	Red Horse (Moran)	189,515	108,949	3,000	0	186,515	108,949	0	0
	County regular	48,670	582,331	19,220	0	29,450	582,331	0	0
	Area Total	453,405	2,089,488	22,407	0	430,998	2,089,488	0	0

See footnotes at end of table.

Table 8.—Reported Oil-Field Brine Production and Disposal, 1961 and 1967—Continued

Area[1]	Field[2]	Brine production 1961	Brine production 1967	Disposal into pits 1961	Disposal into pits 1967	Injection into wells 1961	Injection into wells 1967	Miscellaneous disposal 1961	Miscellaneous disposal 1967
6	Wagley (Tannehill Sand)	274,019	91,262	0	0	274,019	91,262	0	0
	County regular	30,771	26,097	350	4	30,421	25,910	0	183
	Area Total	304,790	117,359	350	4	304,440	117,172	0	183
7	Finely (Moran)	26,696	21,900	0	0	26,696	21,900	0	0
	Giddens (1,100′ Cisco and 1,900′ Sand)	1,660	422,932	1,660	0	0	422,932	0	0
	Hendrick (Morris Sand)	0	41,975	0	0	0	41,975	0	0
	Mikapam	365	365	365	0	0	365	0	0
	County regular	14,020	20,000	2,190	0	11,830	20,000	0	0
	Area Total	42,741	507,172	4,215	0	38,526	507,172	0	0
8	Perkins (Caddo)	730	2,160	730	0	0	2,160	0	0
	Suttle (Palo Pinto Sand)	8	0	8	0	0	0	0	0
	County regular	30,505	144,788	4,042	0	26,463	144,788	0	0
	Area Total	31,243	146,948	4,780	0	26,463	146,948	0	0
9	County regular	755	802	755	72	0	730	0	0
	Area Total	755	802	755	72	0	730	0	0
10	Putnam, South (Duffer Lime)	4	730	0	0	0	730	4	0
	County regular	13,855	115,705	350	0	13,505	115,705	0	0
	Area Total	13,859	116,435	350	0	13,505	116,435	4	0
11	Speed-Findley (Cross Plains)	183	0	183	0	0	0	0	0
	County regular	365	518	0	0	365	518	0	0
	Area Total	548	518	183	0	365	518	0	0
12	County regular	3,000	7,300	0	0	3,000	7,300	0	0
	Area Total	3,000	7,300	0	0	3,000	7,300	0	0
13	EGN (King)	725	750	725	0	0	750	0	0
	Lord & Shell (Tannehill)	1,095	0	1,095	0	0	0	0	0
	Myers (Upper Hope)	301,125	0	0	0	301,125	0	0	0
	Area Total	302,945	750	1,820	0	301,125	750	0	0

See footnotes at end of table.

Table 8.—Reported Oil-Field Brine Production and Disposal, 1961 and 1967—Continued

Area[1]	Field[2]	Brine production 1961	Brine production 1967	Disposal into pits 1961	Disposal into pits 1967	Injection into wells 1961	Injection into wells 1967	Miscellaneous disposal 1961	Miscellaneous disposal 1967
14	McCurdy-Blair (Mississippi)	5,400	35,010	0	0	5,400	35,010	0	0
	McCurdy-Blair, East (Mississippi)	0	12,750	0	0	0	12,750	0	0
	County regular	0	4,015	0	0	0	4,015	0	0
	Area Total	5,400	51,775	0	0	5,400	51,775	0	0
15	Brock (Cook)	279,703	72,000	0	0	279,703	72,000	0	0
	Area Total	279,703	72,000	0	0	279,703	72,000	0	0
16	Eula, Northwest (Cook)	19,700	33,833	0	0	19,700	33,833	0	0
	H & H (Cook) Field Unit	25,550	0	0	0	25,550	0	0	0
	Olga (Upper Cook)	2,910	484	1,600	484	1,310	0	0	0
	County regular	1,721	157	0	157	1,721	0	0	0
	Area Total	49,881	34,474	1,600	641	48,281	33,833	0	0
17	J. K. Wadley	736	0	736	0	0	0	0	0
	County regular	0	42,093	0	0	0	42,093	0	0
	Area Total	736	42,093	736	0	0	42,093	0	0
18	Inman (Flippen Sand)	18,365	67,150	365	0	18,000	67,150	0	0
	County regular	0	13,028	0	0	0	13,028	0	0
	Area Total	18,365	80,178	365	0	18,000	80,178	0	0
19	Denton	20,085	12,775	540	12,775	19,545	0	0	0
	Milliorn	2,760	9,490	2,760	0	0	9,490	0	0
	Whitehead (Hope Sand)	335	7,300	335	0	0	7,300	0	0
	County regular	46,176	83,782	551	0	45,625	83,782	0	0
	Area Total	69,356	113,347	4,186	12,775	65,170	100,572	0	0
20	Marge (Jennings Sand)	1,550	9,125	1,550	0	0	9,125	0	0
	Marge E (4040)	0	3,650	0	0	0	3,650	0	0
	Area Total	1,550	12,775	1,550	0	0	12,775	0	0
21	Scranton	13,225	4,300	13,225	0	0	4,300	0	0
	Area Total	13,225	4,300	13,225	0	0	4,300	0	0

See footnotes at end of table.

Table 8.—Reported Oil-Field Brine Production and Disposal, 1961 and 1967—Continued

Area[1]	Field[2]	Brine production 1961	Brine production 1967	Disposal into pits 1961	Disposal into pits 1967	Injection into wells 1961	Injection into wells 1967	Miscellaneous disposal 1961	Miscellaneous disposal 1967
22	Barnes (Cook Lime)	4,500	0	4,500	0	0	0	0	0
	Barnes (Cook Sand)	28,720	5,500	28,000	0	720	5,500	0	0
	Dumont (Cook)	4,800	12,775	4,800	0	0	12,775	0	0
	Loven Ranch	3,012	0	0	0	3,012	0	0	0
	County regular	2,905	15,780	1,825	0	1,080	15,780	0	0
	Area Total	43,937	34,055	39,125	0	4,812	34,055	0	0
23	Oplin, S. E. (Ellenburger)	28,000	0	0	0	28,000	0	0	0
	Area Total	28,000	0	0	0	28,000	0	0	0
24	County regular	0	15,060	0	0	0	15,060	0	0
	Area Total	0	15,060	0	0	0	15,060	0	0
25	A. C. Scott (Cross Plains)	274,175	523,775	18,900	0	255,275	523,775	0	0
	A. C. Scott, N.W. (Cross Plains)	22,250	0	22,250	0	0	0	0	0
	Am-Hard (Cross Plains)	36,750	0	250	0	36,500	0	0	0
	Gregory-Fortune (Cross Plains)	42,520	0	545	0	41,975	0	0	0
	Lucky Strike (Cross Plains)	2,555	0	0	0	2,555	0	0	0
	McGraw (Cross Plains)	97,381	1,066	390	3	96,991	1,063	0	0
	McKinney (Cross Plains)	73,232	20,410	232	0	73,000	20,410	0	0
	War Kirk (Cross Plains)	37,065	0	1,065	0	36,000	0	0	0
	County regular	750	4,000	750	0	0	4,000	0	0
	Area Total	586,678	549,251	44,382	3	542,296	549,248	0	0
26	County regular	765,280	1,645,600	8,345	0	755,570	1,645,600	1,365	0
	Area Total	765,280	1,645,600	8,345	0	755,570	1,645,600	1,365	0
27	County regular	93	4,782	93	0	0	4,782	0	0
	Area Total	93	4,782	93	0	0	4,782	0	0
—	County regular, Unlocated Total	1,363,198	0	84,843	0	1,278,060	0	295	0
	County Total	5,519,936	8,740,486	237,489	13,495	5,280,783	8,726,808	1,664	183
	Percent of Total	100	100	4.30	0.15	95.67	99.84	0.03	0.01

[1] Areas shown on Figure 21.
[2] Oil or gas fields as assigned by the Railroad Commission of Texas.

Table 9.—Chemical Analyses of Oil-Field Brines

(Analyses are in parts per million except pH)

Producing zone	Field[1]	Average well depth (feet)	Area shown on Figure 21	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Dissolved solids	pH
					Permian System						
Dothan Sand[2]	Elmdale	3,350	1	12,059	1,088	—	66	730	52,800	147,300	6.1
do[2]	Regular	1,400	—	1,992	635	20,300	259	3,710	33,800	—	7.4
Tannehill[2 3]	Morrisett	1,609	2	4,159	1,417	28,530	99	6	55,400	—	7.0
do[2]	do	1,623	2	4,128	1,256	27,320	139	6	52,950	—	7.1
do[4]	Red Horse	1,407	5	5,360	1,099	30,785	83	7	60,100	—	7.0
do[4]	Three Acres	—	2	5,720	1,370	34,100	80	655	66,300	119,800	6.5
do[4]	S. E. Clyde	1,312	14	6,520	2,106	25,402	105	680	71,800	—	6.8
do[4]	N. of Baird	—	5	4,750	1,120	27,000	300	0	53,300	92,500	6.3
do[4]	Wagley	—	8	3,673	1,384	21,180	21	19	44,050	—	5.3
do[4]	do	—	8	3,812	1,359	22,280	257	43	44,320	—	6.5
U.Tannehill[4]	Regular	—	—	5,860	1,090	34,600	85	0	66,900	112,000	6.2
L.Tannehill[4]	do	—	—	5,360	1,120	34,800	85	0	66,400	112,000	6.7
Flippen[4]	Wildcat	1,763	—	4,390	1,070	29,400	95	340	50,000	85,000	6.8
do[4]	Three Acres	1,682	2	7,310	1,660	38,000	146	0	76,200	132,800	6.2
Cook Sand[4]	Brock	—	15	4,993	1,333	39,445	78	0	73,500	120,000	7.4
do[4]	Regular	—	—	5,750	1,440	35,290	86	0	69,100	124,800	6.0
					Pennsylvanian System						
King[3]	Morrisett	1,956	2	7,793	1,780	33,270	94	92	70,100	—	6.8
Home Creek[4]	Brock (Cook Sand) and Eula Lower Hope	—	15	3,354	1,143	32,499	312	275	59,000	96,000	6.7
do[4]	do	—	15	2,189	820	32,586	124	40	60,000	95,817	7.2
Winchell[4]	Elmdale	—	1	2,960	1,000	30,750	528	750	54,700	94,500	6.0
Palo Pinto[4]	Box	3,300	1	11,680	2,041	20,010	117	148	81,650	97,649	—
do[4]	Regular	—	—	3,280	1,500	32,600	150	0	60,500	100,800	7.3
Cross Plains[4]	Baum	—	26	4,800	1,205	32,100	70	740	60,980	105,150	6.0
do[4]	Cross Plains (McKinney)	1,530	25	3,920	2,350	31,000	124	45	60,500	97,900	6.25

See footnotes at end of table.

Table 9.—Chemical Analyses of Oil-Field Brines—Continued

Producing zone	Field[1]	Average well depth (feet)	Area shown on Figure 21	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Dissolved solids	pH
				Pennsylvanian System—Continued							
Cross Cut[4]	Herr-King	2,580	5	9,324	2,889	36,650	195	189	79,430	—	6.0
Cisco Sand[3]	Regular	—	—	5,120	1,170	30,400	150	120	60,200	102,800	6.6
Moran Sand[4]	Herr-King	2,350	5	8,767	1,518	32,030	66	329	69,085	111,815	6.15
do[2, 4]	Red Horse	2,680	5	10,880	1,941	39,848	93	69	85,550	—	6.5
do[2, 4]	do	2,700	5	10,085	1,586	36,295	72	110	78,370	—	5.8
Fry Sand[4]	1.5 SE Eula	—	19	2,930	775	30,000	180	2,730	51,700	91,200	7.0
U. Fry[3]	—	—	—	5,800	870	—	220	122	61,370	108,800	6.0
U. Fry[3]	—	—	—	4,300	600	—	292	78	41,245	83,000	6.3
Fry Sand[4]	Regular	—	—	5,960	1,395	34,240	110	36	67,400	118,300	5.9
Jennings Sand[4]	Silver Valley	—	—	15,100	2,160	49,400	290	85	109,000	195,000	6.4
Lake[2]	Red Horse	4,190	5	4,625	706	16,420	47	337	35,200	—	5.2
do[4]	Speed Findley	3,800	8	13,356	2,723	43,661	109	85	98,759	—	6.7
Bend[4]	IX Conglomerate	4,356	5	12,360	2,856	37,330	15	145	95,000	147,700	4.75
Conglomerate[4]	do	4,362	5	10,560	2,180	32,400	66	175	74,900	—	5.3
				Ordovician System							
Ellenburger[3]	Red Horse	4,442	5	2,288	1,388	22,944	480	1,592	42,034	71,280	7.03
do[4]	do	4,396	5	3,240	1,685	22,000	392	1,855	43,300	—	6.6
do[4]	do	4,460	5	2,318	564	23,110	60	1,064	39,300	—	6.8
do[4]	Three Acres	—	2	2,200	554	25,100	393	1,250	43,000	75,300	7.7
do[2]	Red Horse	4,410	5	2,200	400	23,040	81	1,390	39,520	—	7.8
do[2]	Hatchett	4,420	12	6,890	1,752	21,200	50	359	49,700	—	6.8
do[2]	Red Horse	4,442	5	2,735	733	22,260	121	1,685	40,020	—	5.8
do[4]	Oplin	3,875	22	2,100	352	24,900	312	474	42,600	—	7.1
Ellenburger[4]	Oplin SE	4,190	23	1,700	690	22,500	483	1,400	38,500	60,500	7.58

[1]Oil and gas fields as assigned by the Railroad Commission of Texas.
[2]Analyses obtained from BJ Service, Inc., 1960.
[3]Analyses obtained from data accompanying Railroad Commission of Texas' 1967 Salt Water Production and Disposal Questionnaires.
[4]Analyses obtained from Laxson and others, 1960.

Table 10.— Oil and Gas Tests Selected as Data-Control Points in Callahan County and Adjacent Areas

(For location of wells, see Figure 22.)

Well	Operator	Lease name and operators well number	Survey and section number	County	Type of log	Elevation of measuring point	Remarks
30-27-623	Rock Hill Oil Company	D. M. Myatt No. 1	Blind Asylum Lands No. 1	Jones	Electric	1,680	Log on Jones County geological cross section B-B'.
28-802	Hovgard and Fitzgerald	R. D. Damewood No. 1	Section 90, Block 13, T and P RR Company	Callahan	Electric	1,922	—
29-601	E. H. R. Sabens	Green No. A-1	Section 71, Block 13, T and P RR Company	Shackelford	Electric	1,628	Log on Shackelford County geological cross section B-B'.
37-201	A. G. Hill	Maggie Hardy No. 2	Section 24, ET RR Company	Callahan	Electric	1,847	—
38-401	William D. Austin	Synder No. A-1	Section 142, BBB and C RR Company	do	Electric	1,738	—
601	E. L. Finely	E. L. Finely No. 1	Section 68, B. O. A.	do	Drillers'	1,473	A total of 36 feet of Alluvium was encountered in this test.
801	Miami Operating Company, Incorporated	N. L. Finely No. 1	Section 73, B.O.H.	do	Electric	1,506	—
39-901	West Central Drilling Company	W. A. Ramsey No. 1	Section 2277, TE and L RR Company	do	Electric	1,626	—
40-801	Intex Oil Company	A. J. Pippen No. 1	Section 3182, TE and L RR Company	Eastland	Electric	1,652	—
45-204	Copaz Oil and Gas Corporation	Jones No. 1	No. 336, Victoria County School Land	Callahan	Electric	1,965	—
801	Humble Oil and Refining Company	L. J. McFarlane No. 1	Jesse Youngblood No. 248	do	Electric	1,763	—
46-901	Frank Ausanka Trustee and Ab-Tex Drilling Company	C. M. Caldwell No. 2	Section 12, Block 5, SP RR Company	do	Electric	2,152	Base of Antlers Formation at 1,795 feet above sea level, and 357 feet of Cretaceous sediments were encountered in the test.
904	Star Oil Company	C. M. Caldwell No. 1	Section 12, Block 5, SP RR Company	do	Drillers' and Electric	2,058	Base of Antlers Formation at 1,823 feet above sea level. A total of 235 feet of Cretaceous sediments were encountered in the test.
905	Ike Drilling Company	Edgar Smith No. 1	Section 9, Block 5, SP RR Company	do	Drillers'	1,809	Base of Antlers Formation at 1,790 feet above sea level, and 35 feet of Cretaceous sediments were encountered in the test.
906	A. R. McElreath, Jr.	T. W. Eastham No. 1	Section 9, Block 5, SP RR Company	do	Drillers'	1,854	Base of Antlers Formation at 1,829 feet above sea level. A total of 25 feet of Cretaceous sediments were encountered in the test.
51-603	Robinson-Puckett, Inc.	Addie Bishop Pfleuger No. 1	Section 18, Block 6, SP RR Company Survey	Taylor	Electric and Sample	2,284	—
52-601	Anderson-Pritchard Oil Corporation	Tom Windham No. 1	George Hancock Section 369	Callahan	Electric and Sample	1,958	—
53-601	Warren-Bradshaw Exploration Company	Ludie H. Owen No. 1	A-275, George Massengale	do	Electric	1,695	—
54-205	Roxananna Petroleum Corporation and C. O. Moore	C. M. Caldwell No. 3	Section 15, Block 5, SP RR Company	do	Drillers'	2,017	Base of Antlers Formation at 1,824 feet above sea level, and 247 feet of Cretaceous sediments were encountered in the test.
208	Woodson Production Company and Ernestine Callahan	C. M. Caldwell No. 1	Section 14, Block 5, SP RR Company	do	Electric	1,996	Base of Antlers Formation at 1,859 feet above sea level. A total of 137 feet of Cretaceous sediments were encountered in the test.
301	Star Oil Company	C. M. Caldwell No. A-1	Geo Click	do	Electric	2,043	Base of Antlers Formation at 1,798 feet above sea level, and 245 feet of Cretaceous sediments were encountered in the test.
308	Broderick and Calvert	C. M. Caldwell No. 1	Section 15, Block 15, SP RR Company	do	Drillers'	1,993	Base of Antlers Formation at 1,825 feet above sea level. Fresh water reported from 50 to 80 feet. A total of 168 feet of Cretaceous sediments were encountered in the test.

Table 10.— Oil and Gas Tests Selected as Data-Control Points in Callahan County and Adjacent Areas—Continued

Well	Operator	Lease name and operators well number	Survey and section number	County	Type of log	Elevation of measuring point	Remarks
30-54-309	C. B. Edgar	Caldwell No. 1-SWD	Section 13, Block 5, SP RR Company	Callahan	Electric	2,043	Base of Antlers Formation at 1,826 feet above sea level, and 217 feet of Cretaceous sediments were encountered in the test.
55-301	Sunray Oil Company	C. E. Aspin No. 1	Gabriel Padillo	do	Electric	2,000	Base of Antlers Formation at 1,726 feet above sea level. A total of 275 feet of Cretaceous sediments were encountered in the test.
601	Irvin Producing Company and Western Natural Gas	Ben Lester No. 1	Jesse Dyson No. 751	do	Electric	1,799	—
701	Harding Brothers	Cornelouis No. 1	George M. Vigal No. 798	do	Electric	1,801	—
707	Drilling and Exploration Company, Incorporated	Baum-Swafford No. A-1	do	do	Electric	1,802	—
929	Casper Drilling Company	Wright No. 1	Section 751, Jesse Dyson	do	Electric	1,763	—
930	Humble Oil and Refining Company	W. R. Erwin No. 1	do	do	Drillers'	1,804	Base of Antlers Formation at 1,704 feet above sea level, and 100 feet of Cretaceous sediments were encountered in the test.
61-101	Hovgard and Fitzgerald	C. M. Morse No. 1	Section 138, GH and H RR	do	Electric	1,885	—
701	Coronet Oil Company	Morris No. 66-2	Section 66, GH and H	Coleman	Electric	1,752	—
64-205	Henshaw Brothers	Alexander and Plumley No. 1	Section 20, Block 2, ET RR	Eastland	Electric	1,697	—

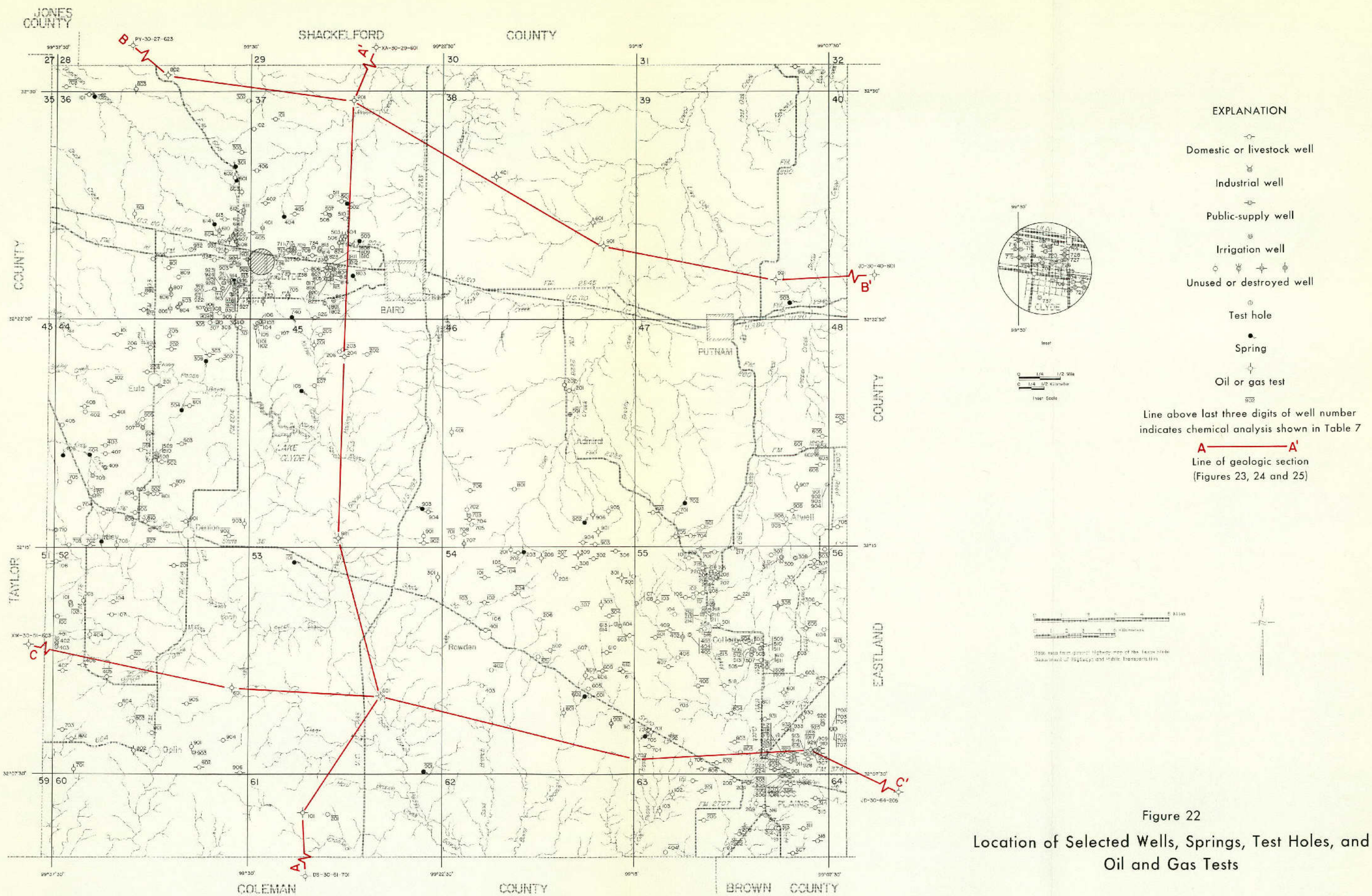


Figure 22

Location of Selected Wells, Springs, Test Holes, and Oil and Gas Tests

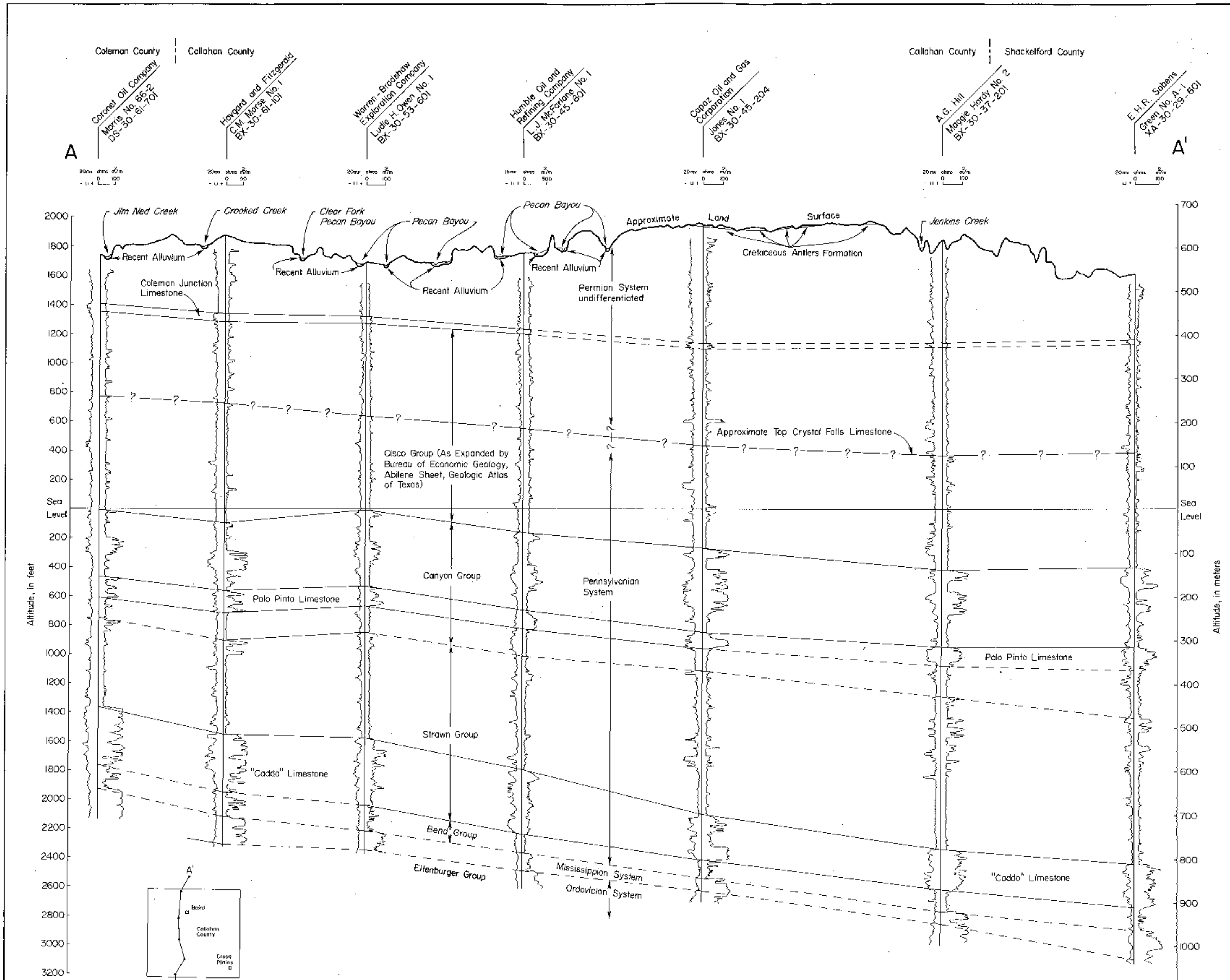


Figure 23

Geologic Section A-A'

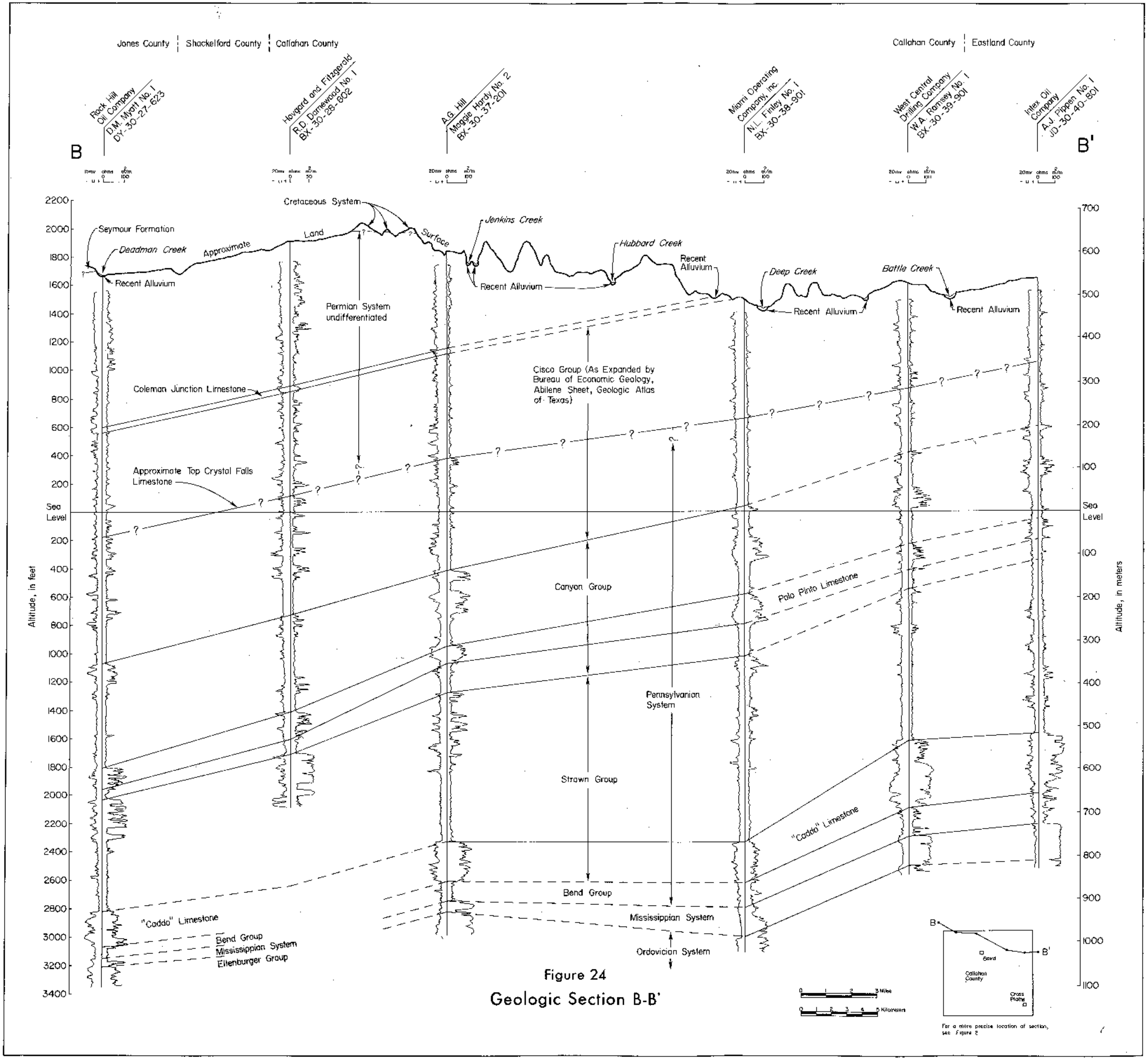


Figure 24
Geologic Section B-B'

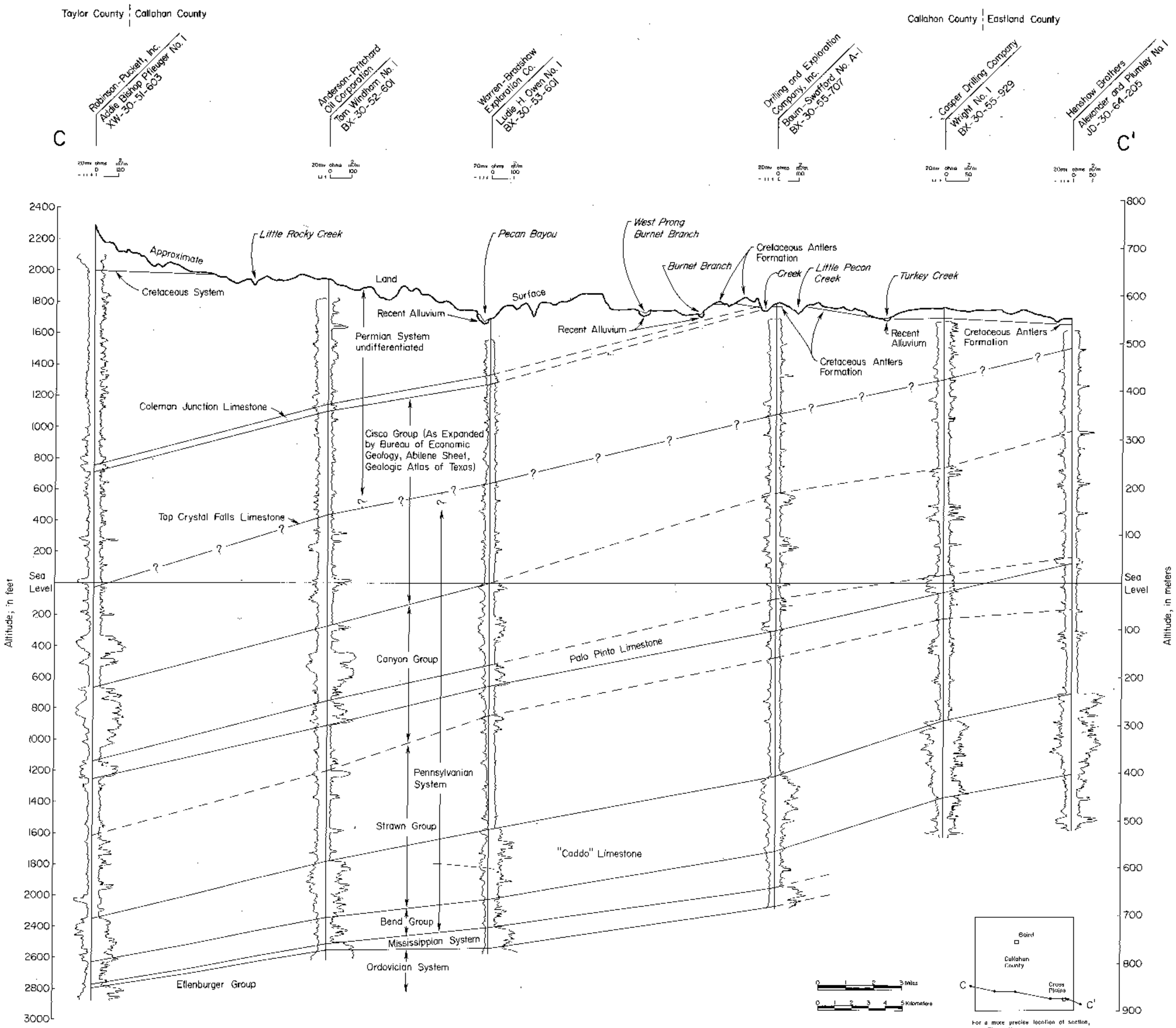


Figure 25

Geologic Section C-C'