BULLETIN 6412

OCCURRENCE AND QUALITY OF GROUND WATER IN STEPHENS COUNTY, TEXAS

By

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Texas Water Commission

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FOREWORD

Ground-water studies that are currently being conducted by the staff of the Texas Water Commission in a block of counties in north-central Texas were begun in March 1962 to meet a growing need for more detailed and more accurate ground-water information in this area than was available from other sources. As initially planned, the investigations that are underway will be conducted in the following counties: Archer, Clay, Montague, Throckmorton, Young, Jack, Jones, Shackelford, Stephens, Palo Pinto, Taylor, Callahan, Eastland, Coleman, and Brown Counties. As work progresses on this project, it is probable that other counties adjoining the initial block selected will be added to the scope of the project.

In the 15 counties that are included in the present study, several towns with municipal water supplies are served by ground water or have water wells as a standby source of water supply. In addition to meeting municipal needs for water, ground water is often the sole source supplying domestic, farm, and ranch needs for water in much of the area. In recognizing the significance of ground water as a water resource in this area, the Water Commission was aware also of the vital need for obtaining information on the depth to which usable-quality water occurs, as the basis for providing adequate and equitable protection for these water supplies in the extensive petroleum development that continues in the area.

The area under study is underlain by Pennsylvanian and Permian rocks that either crop out at the surface or underlie Cretaceous and alluvial sediments at shallow depths. Ground water occurs erratically in most of the area in shallow discontinuous zones of low permeability in Pennsylvanian and Permian rocks, in sands and fractured limestones in the relatively thin Cretaceous sediments, and in Pleistocene to Recent alluvial sediments that are found at the surface in parts of most of the counties included in the study. Initially these investigations were to provide additional data for use by the Water Commission in making recommendations to the Railroad Commission and oil industry on the depth to which usable-quality water should be protected. It was recognized early in the course of the investigations, however, that the scope of the programs should be enlarged to provide information for landowners and others interested in water-resources development. Sufficient information should be provided to assure optimum development of the ground-water supplies available.

The Texas Water Commission has been considering the present program for several years, although personnel have not been available to initiate such a long range study. The scope, objectives, and methods of study to be employed have been part of the planning of the Texas Water Commission, and when funds become available the investigations were included in the Agency's ground-water program. In January 1962, funds allocated to the Texas Water Commission by the Texas Water Pollution Control Board for the purpose of investigation and prevention of ground-water pollution made possible the beginning of the present program. These funds were allocated to the Water Commission by the Pollution

Control Board under provisions of the Act that created the Pollution Board and that directs the Texas Water Commission to "... investigate and ascertain those situations in which the underground waters of the State are being polluted or are threatened with pollution, and it shall report all findings to the Board together with its recommendations in regard thereto."[1]

It was determined that these studies could be most feasibly conducted on a county-by-county basis, and the initial investigations were begun in Stephens, Young, and Brown Counties. Reports from the results of the investigations in each of the 15 counties will be prepared and published by the Texas Water Commission as the field studies are completed.

TEXAS WATER COMMISSION

John J. Vandertulip
John J. Vandertulip
Chief Engineer

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[1] 57th Legislature, 1961, Article 7621d.

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ABSTRACT

Stephens County is located within the outcrop area of upper Pennsylvanian and lower Permian formations in north-central Texas. An erosional remnant of Cretaceous rocks is present in the southeastern part of the county. This unit is probably a part of the Travis Peak Formation of the Trinity Group, and is an outlier to the Callahan Divide, which separates the Brazos River Valley from the Colorado River Valley. Pleistocene to Recent alluvial sediments occur along the streams in Stephens County.

Ground water occurs erratically in shallow discontinuous zones of low permeability, and most of the well development is located in the southeastern portion of the county. More than 85 percent of the water wells in the Cisco Group (upper Pennsylvanian) are completed in the Graham Formation, and the Graham Formation supplies over 48 percent of all the wells completed in the county.

The chemical quality of ground water is variable in Stephens County. This might be expected because of the erratic occurrence of ground water. However, trends in the variation of constituents were used to establish the base quality of ground water in different areas of the county. Some of the water samples contained a high concentration of chloride, which did not coincide with the normal variation or base quality changes of ground water. Water wells containing water having a high choride content are treated in this report as apparently contaminated or possibly contaminated wells. In many cases historical records to prove alteration of chemical quality are lacking.

The disposal of oil-field brine is an important source of chemical alteration of the native-quality water. In some areas, the vegetation has been killed because the soil has become impregnated with salt.

Reported brine production for 1961 in Stephens County was 5,796,313 barrels. Approximately 84 percent of the brine was disposed of into injection wells, and about 16 percent was disposed of into surface pits. Less than 1 percent was disposed of by other methods.

OCCURRENCE AND QUALITY OF GROUND WATER IN STEPHENS COUNTY, TEXAS

INTRODUCTION

Purpose and Scope

The economic vitality of north-central Texas, coupled with the lack of readily obtainable surface-water supplies of good quality, has made it apparent that additional information regarding the occurrence and availability of ground water was essential to a clear evaluation of the area's potential water-resources development. Thus, the purpose of the study in Stephens County was two-fold: to obtain, through field study, information regarding the occurrence and chemical quality of ground water for use by landowners and others interested in water-resources development in the county; and to provide sufficient information for the Texas Water Commission and other agencies responsible for protection of water quality in the county so that water-quality-protection programs can be both adequate for protection of the water available and equitable when applied to industries operating in the county.

The objectives of the Stephens County study were to obtain supplementary basic data to better delineate underground formations containing usable water, the depth of this water, and its chemical quality; to supplement available data on brines produced with oil and gas and the location and method of their disposal, with field observations and spot quantative and qualitative checks; to review surface casing and brine regulations of this agency in the light of field observation to determine where revisions are needed; to evaluate the results of chemical analyses of water from wells and springs in the county in order to establish a base condition of water quality where possible and to pinpoint areas of contamination where it has occurred; and to prepare a report for the use of landowners, the Texas Water Commission, and other State and Federal agencies.

The project was planned to accomplish the following: the collection of records in the field regarding water wells and springs; the study of subsurface data from wells where available; the measurement of elevations above sea level and establishment of topographic control by selected means; obtaining information on brines produced with oil, and methods of brine disposal; the study of surface and shallow subsurface geology significant to the understanding of the occurrence of ground water; and preparation of a report presenting the results of the study, together with pertinent basic data and illustrations reflecting ground-water occurrence in the county.

The study was made during the period 1962-63 under the administrative direction of John J. Vandertulip, Chief Engineer, and L. G. McMillion, director, Ground Water Division, and under the direct supervision of Donald C. Draper, coordinator of the Quality Protection Program.

Method of Investigation

In conducting the detailed ground-water investigation of Stephens County, the following items of work were performed.

A complete inventory of 385 wells and springs was conducted in 1962 to determine the manner in which water wells were constructed and, where possible, to determine the depth and aquifer in which the wells were completed. Elevations were established on most wells and springs with the aid of topographic maps and altimeter from grade elevations furnished by the Texas Highway Department. These elevations together with water levels measured in 169 wells were used, where possible, to determine the direction of ground-water movement in subsurface formations.

Chemical analyses were obtained to determine the water-quality characteristics of the ground water in Stephens County. The laboratory analyses of water samples were made by the State Department of Health and the U. S. Geological Survey under interagency and cooperative agreements with the Commission. Approximately 150 electric logs were studied as an aid in understanding the subsurface geologic conditions pertinent to the occurrence of ground water in the county. Oil-field brine disposal practices were observed, and existing analyses of oil-field brines were studied and tabulated.

Previous Investigations

Several reports containing general information on the geology of north-central Texas are available; however, no detailed ground-water investigation of Stephens County has been made prior to this study. Samuell (1937) recorded the inventory of 96 wells and included drillers' logs of 13 oil wells, logs of 49 test wells, and partial chemical analyses of 95 water samples from wells along with partial chemical analyses of water samples from streams and tanks in Stephens County.

A preliminary report of the ground-water conditions in north-central Texas was made by Gard and others (1956, unpublished report) with the then Texas Board of Water Engineers.

More recent ground-water investigations in small areas of the county have been made by Grimes (1960, unpublished report) and by personnel of the Texas Water Commission. A recent reconnaissance investigation of the entire Brazos River Basin was made by Cronin and others (1963), but coverage within Stephens County was general. Other reports relating to the geology of the area are listed at the end of this report in the Selected References.

Well-Numbering System

Wells and springs in this report were numbered using a statewide numbering system adopted by the Texas Water Commission. Each well and spring is assigned an individual number to facilitate keeping records on file and locating the well within the State. This system is based on division of the State into quadrangles formed by degrees of latitude and longitude, and repeated division of these quadrangles into smaller ones as illustrated in Figure 1.

The largest quadrangle, a 1-degree quadrangle, is divided into sixty-four 7-1/2 minute quadrangles, each of which is further divided into nine 2-1/2 minute quadrangles. Each 1-degree quadrangle in the State has been assigned a number for identification. The 7-1/2 minute quadrangles are numbered consecutively from left to right beginning in the upper left hand corner of the 1-degree quadrangle, and the 2-1/2 minute quadrangles within the 7-1/2 minute quadrangle are similarly numbered. The first two figures of a well number identify the 1-degree quadrangle, the third and fourth numbers identify the 7-1/2 minute quadrangle, the fifth number identifies the 2-1/2 minute quadrangle, and the last two numbers designate the order in which the well was inventoried within the 2-1/2 minute quadrangle.

Some of the wells for which data are given in this report (Tables 3 and 4) are the same wells for which data are given in an earlier Works Progress Administration report by Samuell (1937). The corresponding numbers assigned to these wells in this and the earlier report are listed in Table 1. Some of the well records included in the earlier report are omitted in this report because the wells were not visited, or could not be located, during the present investigation.

Acknowledgements

Appreciation is expressed to the many farmers, ranchers, well drillers, and oil companies who generously contributed information and cooperated in the collection of field data. Thanks are extended to the Departments of Geology of The University of Texas, Baylor University, and other institutions who have made and currently are making investigations in the area. Appreciation also is expressed to the Breckenridge Chamber of Commerce, the Texas State Department of Health, the Texas Highway Department, the Railroad Commission of Texas, the U. S. Geological Survey, and other State and Federal agencies who furnished information.

GEOGRAPHIC SETTING

Location

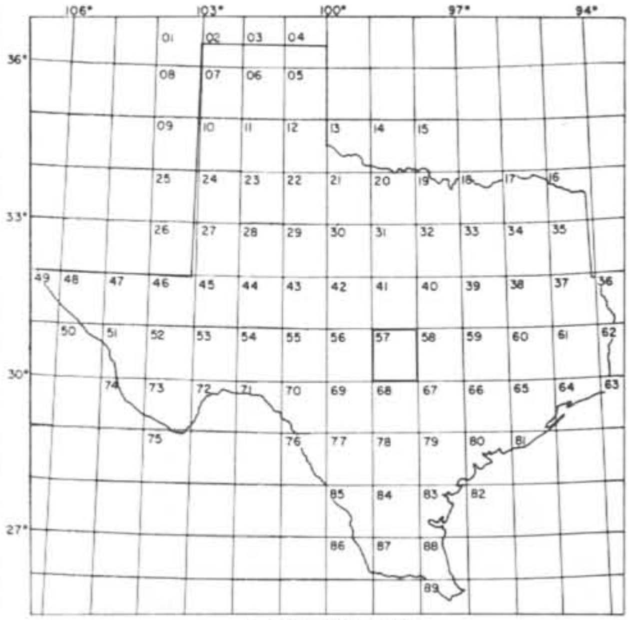
Stephens County comprises an area of 926 square miles, and lies generally between 98°35' and 99°05' west longitude and between 32°30' and 33° north latitude in the plateau region of north-central Texas (Figure 2). Breckenridge, the county seat of Stephens County, is about 100 miles west of Fort Worth at the intersection of U. S. Highways 180 and 183.

Climate

The climate of Stephens County is subhumid, with an average annual rainfall of 27 inches as based on 30-year normals supplied by the U. S. Weather Bureau for the period 1931-60. The maximum annual rainfall was recorded as 46.78 inches at Breckenridge in 1957, and the minimum was recorded as 13.01 inches in 1956. About 75 percent of the monthly distribution of average annual

Table 1.--Well numbers used in this report and corresponding numbers previously used in Stephens County by Samuell (1937)

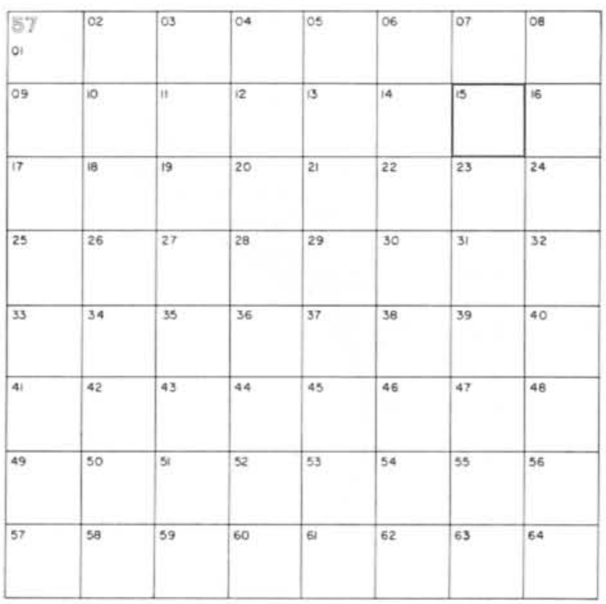
New Number	Old Number	New Number	Old Number	New Number	Old Number
30-08-801	1	31-19-310	73	31-26-504	129
24-801	55	401	69	804	130
32-201	114	402	70	27-101	95
31-03-601	16	20-101	78	102	96
602	17	103	79	201	91
603	18	701	82	202	92
801	15	25-301	112	203	93
10-701	27	902	119	204	94
11-601	20	903	120	301	89
701	23	26-101	109	402	137
801	22	102	110	403	138
17-301	31	103	124	501	139
18-108	28	201	100	502	140
501	63	202	103	503	141
601	66	206	101	513	142
605	67	207	102	701	131
802	99	208	106	702	132
901	97	216	105	703	133
909	64	401	123	704	134
910	65	402	125	801	143
19-301	74	501	126	28-101	85
303	75	502	127	102	84
309	77	503	128		



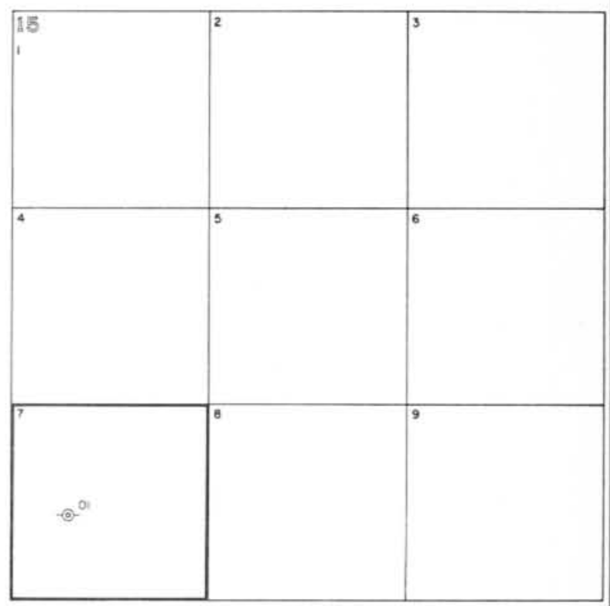
1-degree Quadrangles

Location of Well 57-15-701

57 1-degree quadrangle
15 7 1/2 minute quadrangle
7 2 1/2 minute quadrangle
01 Well number within 2 1/2 minute quadrangle



7 1/2-minute Quadrangles



2 1/2-minute Quadrangles

Figure 1

Well-Numbering System

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Texas Water Pollution Control Board

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Figure 2

Map of Texas Showing Location of Stephens County

Texas Water Commission in cooperation with the Texas Water Pollution Control Board

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rainfall is concentrated during the 7-month growing season of April through October.

The mean annual temperature for Stephens County, based on 50 years of record, is 65°F. This mean is not a weighted average, but is based on the average of the maximum and minimum daily temperature readings. The range of temperature for this area is from a minimum of -1°F to a maximum of 110°F.

The average annual potential gross evaporation depth for the period 1940-57 is 80 inches; however, the average annual potential net evaporation depth, based on the gross evaporation of 80 inches minus the annual effective rainfall, is 56 inches. The average effective net evaporation (net depth of water actually evaporated) for the county ranges from 53 inches on the eastern edge of the county to 55 inches on the western edge.

Topography and Drainage

The land surface in Stephens County is generally rolling with some hills. The altitude ranges from about 1,000 to 1,650 feet, the total relief being about 650 feet. Prominent elevations include the Gunsight Mountains, Double Mountain, and Evans Peak.

Stephens County lies entirely within the Brazos River drainage system (Plate 1). The western part of the county is drained by Hubbard and Big Sandy Creeks, tributaries to the Clear Fork of the Brazos River, which cuts across the northern part of the county. The central part of the county is drained by Gonzales Creek, which also flows north into the Clear Fork of the Brazos River. The eastern portion of the county drains toward the east into the Brazos River. These eastward-flowing streams, as seen on Plate 1, are: Palo Pinto Creek, Big Caddo Creek, and Big Cedar Creek.

Lake Daniel, with a capacity of 10,000 acre-feet, is located about 8 miles south of Breckenridge on Gonzales Creek (Plate 1). This reservoir provided the municipal water supply for Breckenridge from 1948 until the construction of the Hubbard Creek Reservoir.

Hubbard Creek Reservoir, constructed in 1962 with a capacity of 320,000 acre-feet, is located in the western part of the county. The Reservoir is owned by the West Central Texas Municipal Water District, which was created by the State Legislature in 1955, and provides a new water supply for the cities of Abilene, Albany, Anson, and Breckenridge.

A standby municipal water supply for Breckenridge was served by Lake Grand, located about two miles northeast of Breckenridge (Plate 1). Lake Grand, with a capacity of about 1,000 acre-feet, had to be abandoned as a reservoir because of salt-water contamination, and is now being utilized as a salt-water-disposal basin. Additional discussion of Lake Grand will follow in the section headed Alteration of Native Chemical Quality of Water.

Population and Economy

Stephens County was organized early in 1876, and shortly thereafter Breckenridge was settled and designated the county seat. The population of Stephens

County is 8,885, and that of Breckenridge is 6,273 according to the 1960 Federal census.

Transportation facilities in Stephens County include the U. S. Highways 180 and 183, State Highways 6 and 67, and many paved farm-to-market roads. Breckenridge is served by the Chicago, Rock Island, and Pacific Railroad. The nearest scheduled airline service is at Abilene, which is about 60 miles southwest of Breckenridge.

Cattle raising is the principal agricultural industry, and the raising of sheep, goats, swine, poultry, and dairying are other important sources of income. The principal crops are oats, wheat, grain, sorghum, cotton, and peanuts. In 1961 the total acreage under cultivation was 67,793 acres, while the total grazing land was 503,207 acres. Approximately 200 acres of cultivated land is irrigated.

Oil continues to provide a very important source of income in Stephens County. Drilling began in 1910, and oil production began in 1916. The Breckenridge oil boom began in 1920, with an associated increase in population. A conservative estimate of the population of Breckenridge on January 1, 1920 was around 1,500, whereas 1 year later the population was over 30,000. In 1952 Stephens County produced 2,415,646 barrels of oil. Most of the oil is produced from rocks of Pennsylvanian age at depths of 2,000 to 4,000 feet, but some production has been from strata of Mississippian and Ordovician age below 4,000 feet. Other natural resources include natural gas, gravel, sand, clay, limestone, and thin beds of coal.

OCCURRENCE AND QUALITY OF GROUND WATER

Ground water occurs quite erratically in Stephens County in relatively shallow, discontinuous zones of low permeability in Pennsylvanian and Permian rocks, and in the Pleistocene to Recent alluvial sediments found at the surface along most of the streams.

As can be seen from the geologic map (Figure 3) and from the map showing the location of wells and springs (Plate 1), ground-water development is principally in the Graham Formation, Cisco Group, of the upper Pennsylvanian. Water-well development is largely confined to the southeastern part of Stephens County.

Most of the ground water in Stephens County is used for domestic and livestock purposes; however, some of the ground water is used for waterflooding and other oil-field purposes, and one well furnishes water of sufficient quantity and quality for irrigation.

In ensuing sections of the report, conditions of ground-water occurrence in the following major geologic units are discussed: the Canyon and Cisco Groups of the upper Pennsylvanian System, the Wichita Group of the lower Permian System, the Trinity Group of Cretaceous age, and alluvial sediments of Quaternary age (Table 2). The stratigraphic relationships of these rock units are illustrated in Figures 4 and 5, and their areas of outcrop on Figure 3. The complex depositional history of north-central Texas is discussed in more detail in the Appendix.

Table 2.--Geologic formations and their lithic descriptions, Stephens County

System	Group	Formation	Member	Lithologic character	Approximate maximum thickness (ft.)
Quaternary				Surficial flood-plain and terrace alluvium of Pleistocene to Recent age along the streams; consists of sand, gravel, silt, and clay.	?
—Unconformity—					
Cretaceous	Trinity			Conglomerate, sand, silt, and shale.	35
—Unconformity—					
Permian	Wichita	Moran	Sedwick Limestone Santa Anna Shale Gouldbusk Limestone Dothan Limestone Watts Creek Shale	Shale, with some limestone, sandstone, and siltstone.	?
		Pueblo	Camp Colorado Limestone Salt Creek Bend Shale Stockwether Limestone Camp Creek Shale	Thin limestone beds, separated by shale units. Siltstone, sandstone, and coal beds are also present.	100-200
Pennsylvanian	Cisco	Harpersville	Saddle Creek Limestone Waldrip Shale Crystal Falls Limestone Quinn Clay	Numerous lenticular sandstone and conglomerate deposits, thin limestones, shale, siltstone, and thin coal beds.	200-275
		Thrifty	Breckenridge Limestone Blach Ranch Limestone Ivan Limestone Avis Sandstone	Numerous lenticular sandstone deposits, thin limestones, shale, and siltstone, with some thin coal beds.	115-215
		Graham	Wayland Shale Gunsight Limestone South Bend Shale Bunger Limestone Gonzales Creek Limestone Finis Shale	do	550
	Canyon	Home Creek Limestone		Massive, blue-gray, bioclastic limestone.	34
		Colony Creek Shale		Lenticular sandstone, calcareous shale, siltstone, and silty shale.	66
		Ranger Limestone		Irregularly bedded nodular, to massive limestone, and shale.	57
		Placid Shale		Shale, sandstone, siltstone, and a few thin calcareous sandstones, and limestones.	158
		Winchell Limestone		Massive, bioclastic limestone and shale	43
		Wolf Mountain Shale		Soft, fossiliferous shale, with interbedded sandstone lentils, and limestone beds.	275
		Posideon	Wiles Limestone Fambro Sandstone	Limestones, shale, mudstones, and lenticular sandstones.	75
		Palo Pinto Limestone		Irregularly bedded crystalline limestone, dark gray in color. Fossiliferous.	25
	Strawn	Keechi Creek Shale		Shale, sandstone, and limestone units.	?

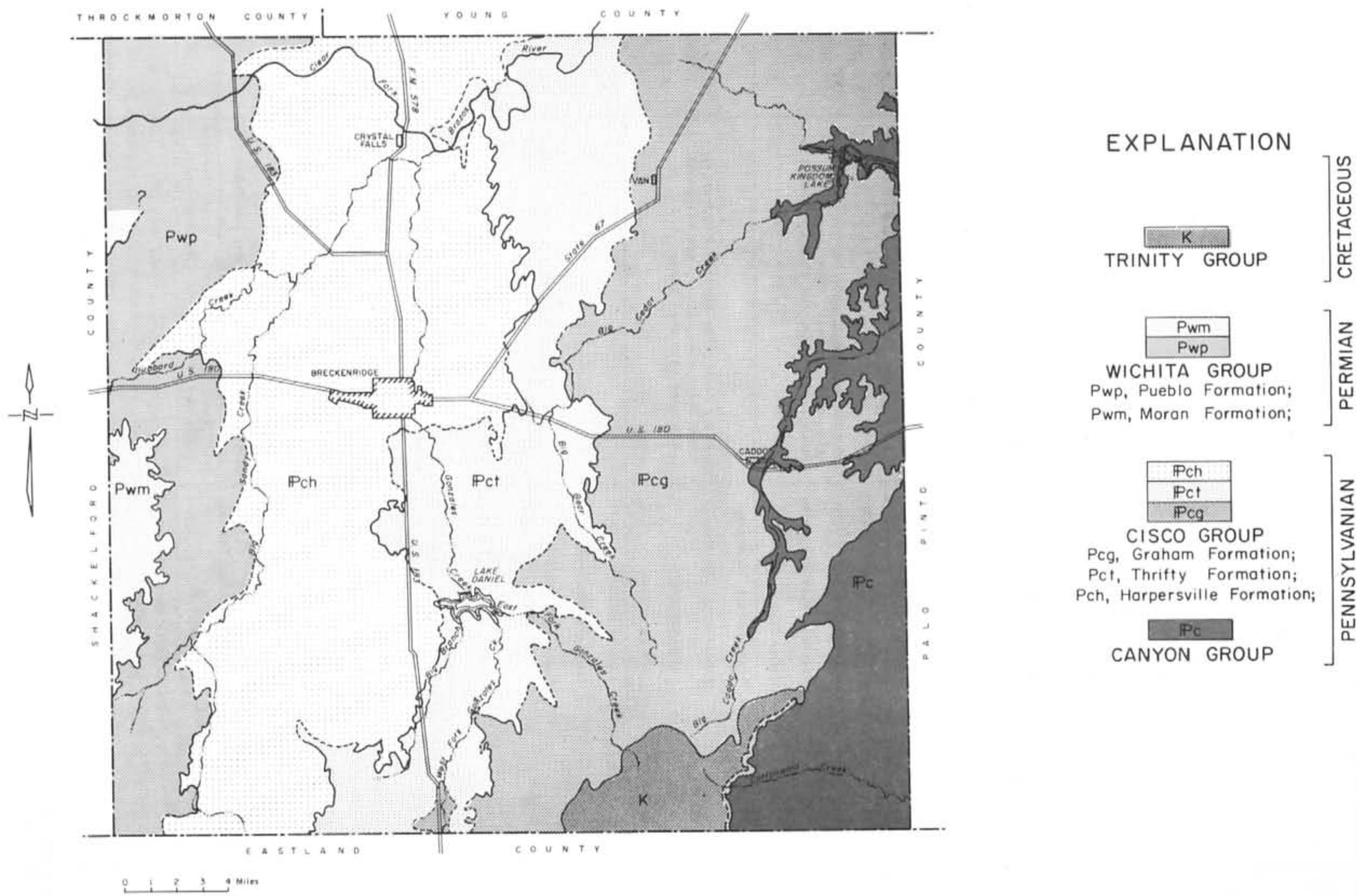

Figure 3

Geologic Map of Stephens County

Texas Water Commission in cooperation with the Texas Water Pollution Control Board

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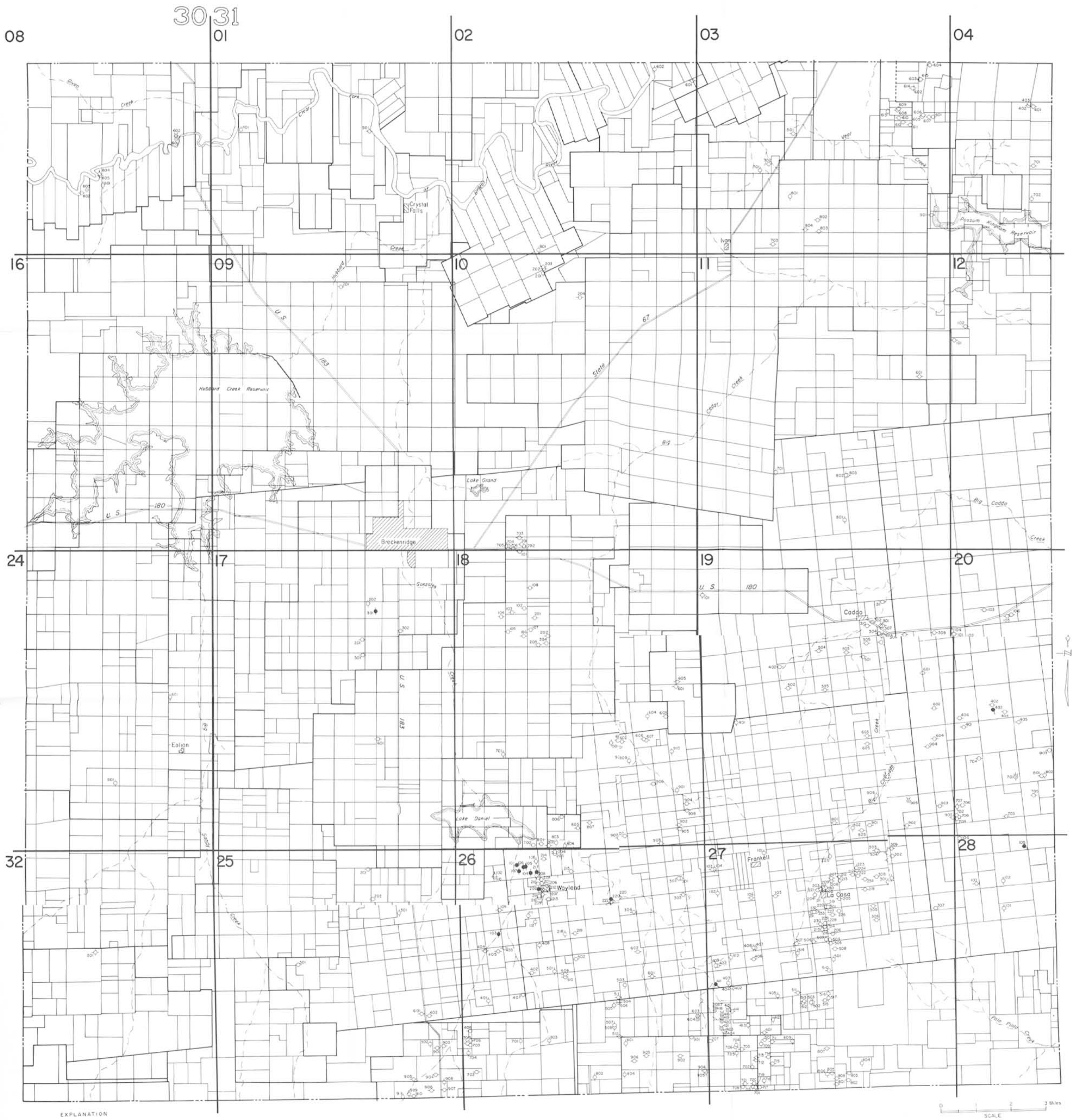

EXPLANATION

In Use / Unused — Domestic and Stock Wells

Industrial Wells

Irrigation Wells

Flowing Wells

Spring

Plate 1

Map Showing Locations of Wells and Springs, Stephens County

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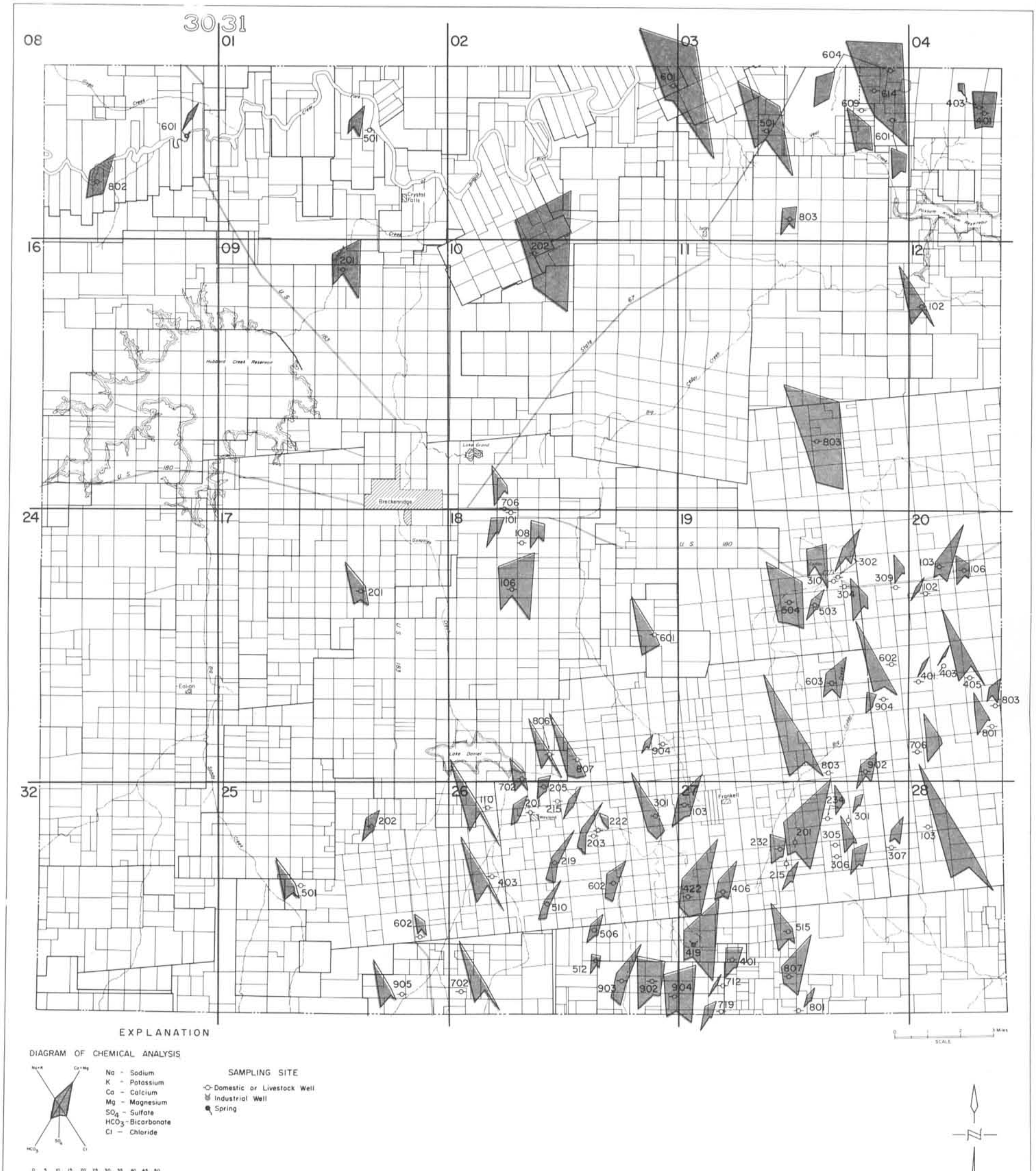

Plate 2

Map Showing Base Chemical Quality of Ground Water in 1962, Stephens County

Texas Water Commission in cooperation with the Texas Water Pollution Control Board

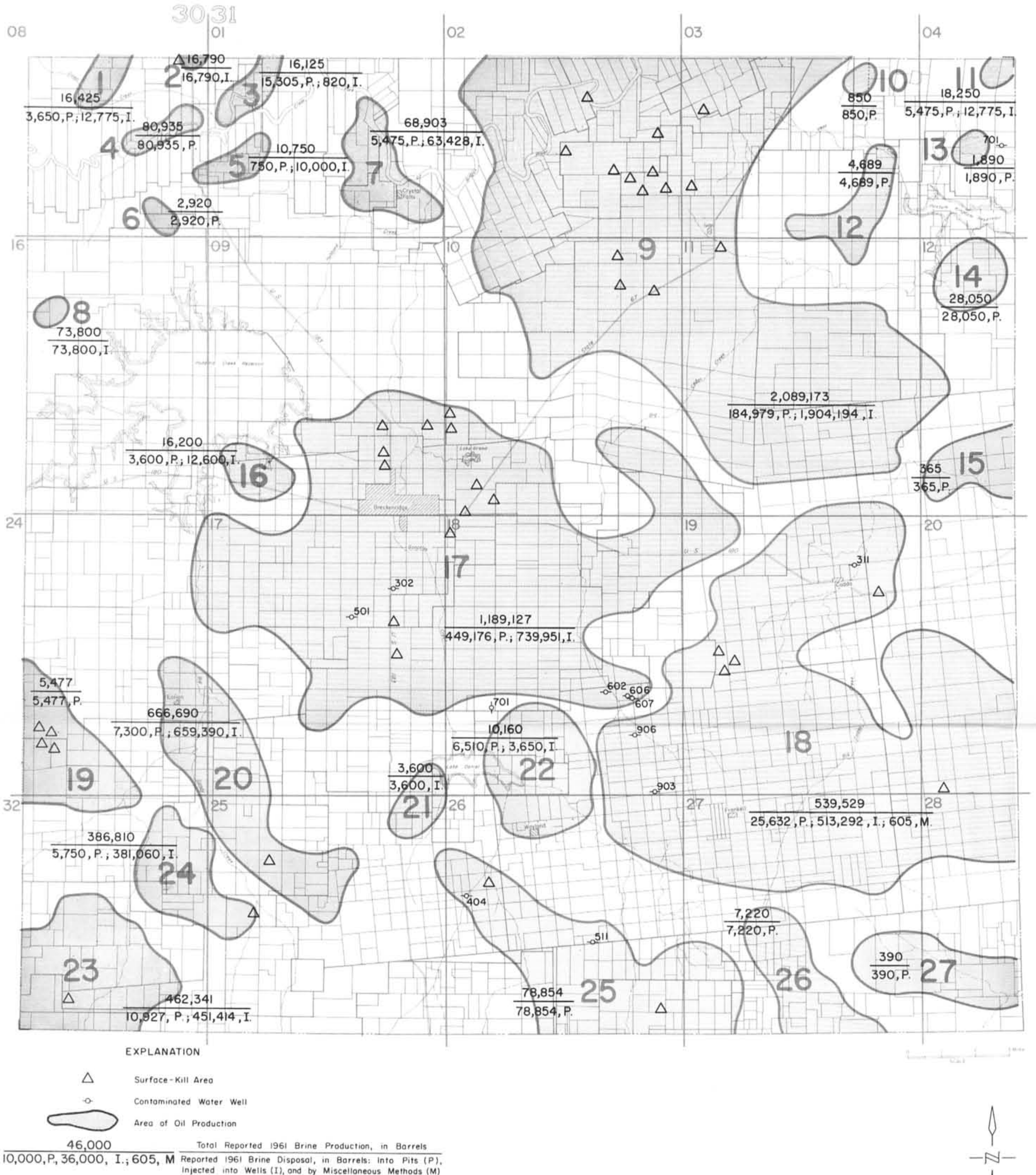

Plate 3

Map Showing Location and Amounts of Reported 1961 Brine Disposal, Surface-Kill Areas, and Contaminated Water Wells, Stephens County

Texas Water Commission in cooperation with the Texas Water Pollution Control Board

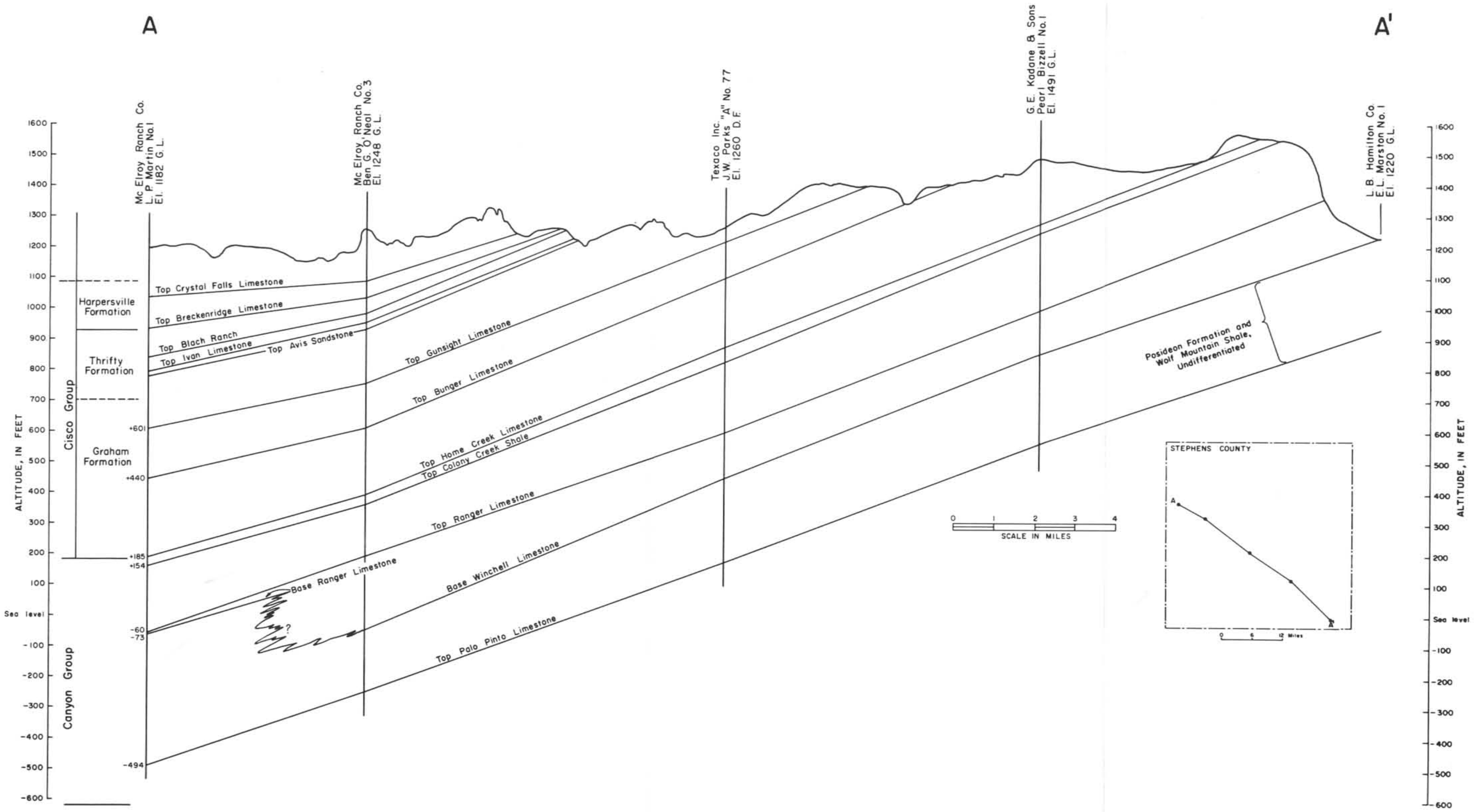

Figure 4
Geologic Section A-A', Stephens County

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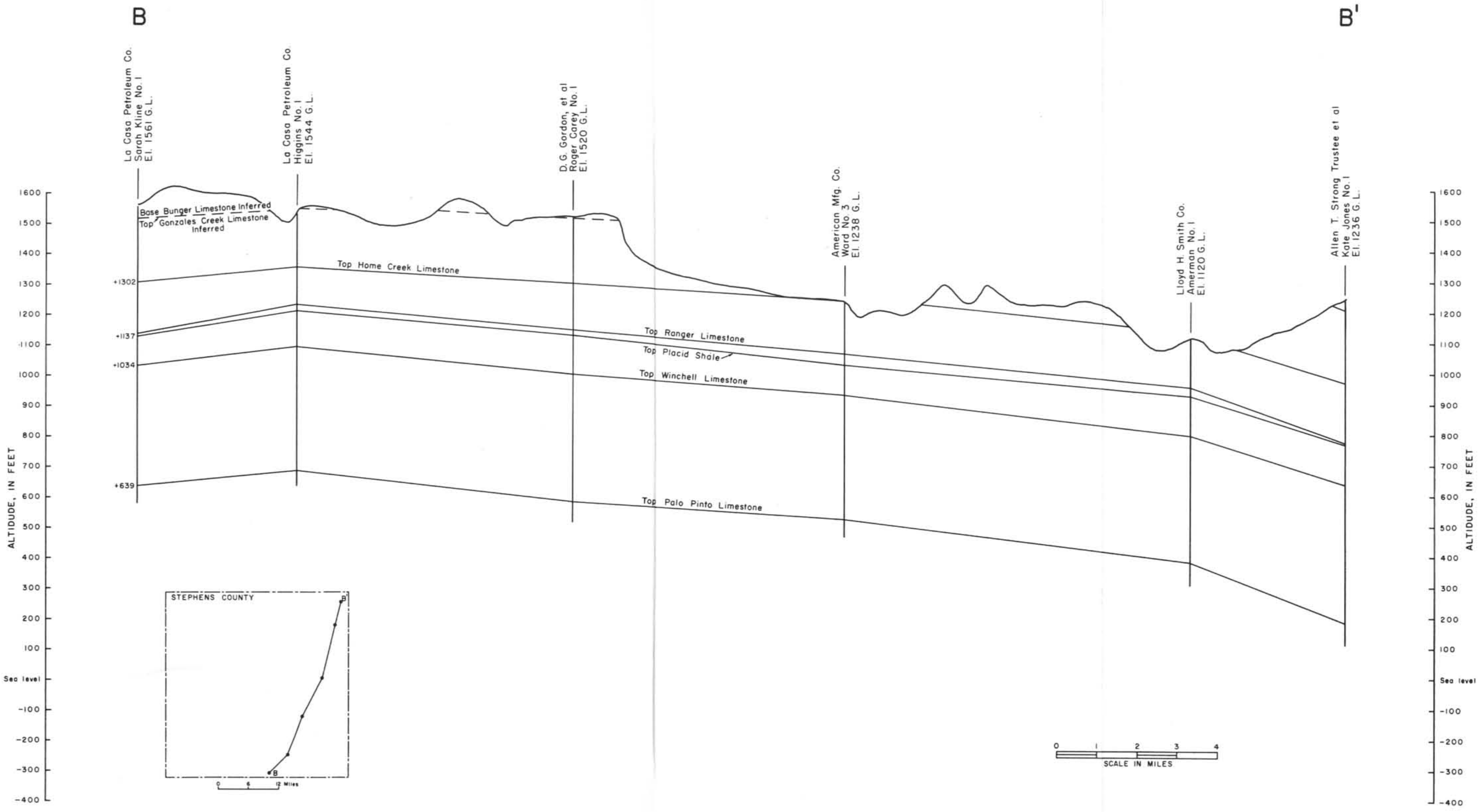

Figure 5
Geologic Section B-B', Stephens County

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The mode of occurrence of ground water in the county is discussed by group and formation where possible in the following sections. Certain general hydrologic principles that govern the occurrence and movement of ground water are discussed in the section on Ground-Water Hydrology in the Appendix. This discussion may be helpful to an understanding of the problems both in finding and developing ground-water resources in Stephens County.

Just as there is a wide range in the depth and mode of occurrence of ground water in the county, so is there a wide range in the chemical character of the water in the various formations in which it is found. The quality of water particular to each of the geologic units defined is discussed in detail in the following sections, and in the Appendix is a discussion of water-quality criteria for beneficial uses, which will be helpful in interpreting the data on analyses from wells in different parts of the county discussed in this text and tabulated in Table 4. Although the water-quality criteria contained in the Appendix provide useful guidelines, this investigation has shown use being made of ground water with mineral concentrations exceeding these criteria.

As can be seen from Table 4, the principal constituents of ground water are silica, calcium, magnesium, sodium, bicarbonate, sulfate, chloride, fluoride, and nitrate.

The silica and bicarbonate content is relatively constant throughout the county. The silica content is low, seldom in excess of 25 ppm (parts per million), whereas the bicarbonate content is generally high and usually ranges from about 200 to 600 ppm. The calcium generally ranges from 0 to 300 ppm, with most samples having less than 100 ppm. Magnesium, like calcium, is generally low with most of the samples containing less than 50 ppm. Magnesium generally increases with an increase in calcium, but only nine samples had magnesium in excess of 100 ppm.

The average fluoride content of all analyses of ground water in Stephens County was 0.9 ppm, and 31 percent of the samples had a fluoride content of 1.0 ppm or more.

In 15 water analyses, about 6 percent of the total, the nitrate content exceeded 45 ppm. Six of these analyses were from wells over 100 feet in depth.

The average sulfate content of the 240 recent analyses in Stephens County is 164 ppm. Thirty-five percent of the analyses have greater than average sulfate content.

No direct relationship was apparent between the chemical quality of the water and the depth of the wells in Stephens County. The water quality was found to be highly variable in most cases, which might be expected because of the erratic occurrence of ground water in the water-bearing formations.

Pennsylvanian System

Canyon Group

The oldest rocks exposed in Stephens County are in the Canyon Group (upper Pennsylvanian), which has been divided into eight formations, all of which are exposed in Stephens County. These formations in ascending order are: Palo Pinto Limestone, Posideon, Wolf Mountain Shale, Winchell Limestone, Placid

Shale, Ranger Limestone, Colony Creek Shale, and Home Creek Limestone. The stratigraphic relationships of these formations with older and younger beds, together with a description of the water-bearing characteristics of each formation, are found in Table 2.

The Canyon Group is exposed in the southeastern corner and along the eastern margin of Stephens County, and westward upstream along Big Caddo and Big Cedar Creeks to about 5 to 7 miles west of the Palo Pinto-Stephens County line (Figure 3).

The Canyon Group is generally composed of thick bioclastic limestone beds and intervening shales, mudstone, thin limestones, and lenticular sandstones and siltstones. Ground water in the Canyon Group generally occurs erratically within the fractured limestones and in the lenticular sandstones and siltstones. The Colony Creek Shale is the principal water-bearing unit in the Canyon Group in Stephens County. The recharge to the Colony Creek is probably through thick lenticular sandstones that occur in the outcrop. The Colony Creek ranges in thickness from about 35 to over 60 feet, and the formation is composed of calcareous shales and siltstones with a thick, cross-bedded, fine-grained sandstone occurring in the upper part of the formation.

A few wells penetrate the Palo Pinto Limestone and the Posideon Formation, representing the lowermost Canyon rocks in the county; but most of the water supplying these wells probably comes from overlying younger strata. The Palo Pinto Limestone, Posideon Formation, Winchell Limestone, and the Ranger Limestone are not considered significant water-bearing formations in the Canyon. Interbedded sandstone lentils in the Wolf Mountain Shale and the Placid Shale produce limited quantities of water in local areas, and some limited well development is found in the Home Creek Limestone.

Most of the ground water from the Canyon Group, supplying 126 wells in Stephens County, is used for domestic or livestock purposes. Of these, approximately 75 wells are completed in the Colony Creek Shale. Three wells producing from the Canyon Group are used for waterflood or other oil-field purposes.

The quality of ground water from the Canyon Group ranges within relatively wide limits, probably as the result of lithologic differences in the formations in which ground water occurs. The water is generally suitable for livestock purposes, and in many areas is suitable also for domestic use. Total dissolved solids in samples of water from the Canyon Group analyzed in the course of this investigation ranged from 269 to 5,314 ppm. The chloride concentration in these samples ranged from 6 to 2,980 ppm, and averaged 358 ppm. Of the 86 samples analyzed, however, approximately 67 percent had chloride concentrations that were below this average. Water samples from the Canyon Group were generally high in bicarbonate.

In the Colony Creek Shale the range in chloride in the samples analyzed was from 14 to 1,320 ppm. The average chloride concentration for the 55 samples from the Colony Creek was 220 ppm, with 67 percent of these samples having chloride concentrations below 175 ppm. The range in total dissolved solids in samples from the Colony Creek was from 324 to 2,936 ppm. The average total dissolved solids in the Colony Creek samples was 938 ppm, with 69 percent of the samples tested having less than 950 ppm total dissolved solids.

Depths of wells in the Canyon Group in Stephens County range from shallow dug wells to 450 feet. Wells in the Palo Pinto Limestone and Posideon Formation range from 225 to 365 feet, in the Wolf Mountain Shale from 225 to 629 feet, in the Placid Shale from 22 to 450 feet, in the Colony Creek Shale from 12 to 340 feet, and in the Home Creek Limestone from 20 to 69 feet. The average depth of wells in the Colony Creek Shale is about 121 feet and in the Wolf Mountain Shale about 355 feet. The water in the formations represented in the Canyon Group in Stephens County becomes generally more saline downdip from the outcrop. It was not possible to map the base of fresh water in the Canyon Group with available data. There does not appear to be a direct relationship between the depths of wells completed in the Canyon and the chloride concentration of the samples that were analyzed during the course of this investigation.

Cisco Group

The Cisco Group, which is the group of rocks overlying the Canyon, crops out in the central portion of Stephens County, generally in a northeast-southwest direction. The Group extends over 75 percent of the surface area of the county, and has an outcrop width of about 22 miles (Figure 3).

The Cisco Group in Stephens County consists of thin limestones and sandstones, with some siltstone, shale, and thin beds of coal. Like the underlying Canyon Group, the Cisco contains many lenticular sand bodies, most of which are channel-fill deposits; however, these lenticular sand bodies are more numerous in the Cisco Group. Most of the ground water occurs in these lenticular sandstones and siltstones, and some ground water occurs in the fractured limestones. These lenticular sand bodies occur erratically at various horizons within the Cisco Group

The Cisco Group is divided into the Graham, Thrifty, and Harpersville Formations in ascending order. A discussion of the three principal formations of the Cisco Group follows.

Graham Formation

The base of the Graham Formation in the Brazos River Valley has been described by Lee and others (1938, p. 12-16) as the base of a deep sandstone-filled channel deposit known as the Kisinger Channel. In other areas, however, the top of the Home Creek Limestone, whenever present, marks the base of the Graham Formation (Table 2). The thickness of the Graham Formation is about 600 feet in Young County, to the north, and is probably about the same in Stephens County.

The Graham Formation is the most highly developed ground-water-bearing formation in Stephens County, and probably contains the most abundant supply of water. More than 180 wells in Stephens County are completed in various horizons within the Graham Formation. More than 85 percent of the water wells in the Cisco Group are completed in the Graham Formation, and the Graham Formation supplies water to over 48 percent of all the wells completed in the county. Most of the water produced from the Graham Formation is used for domestic and livestock purposes, and nine wells furnish water for waterflood operations. Sixty-six of the wells observed in this study, completed in the Graham Formation, are either abandoned or are not being used.

Water quality in the Graham Formation in Stephens County is highly variable, and there appears to be no relationship between well depth and quality of the water. In many cases, there is a mixture of water from two or more water-producing horizons in order to obtain a better supply.

Alteration of the native quality may have occurred in some areas, but historical records to show where or how much alteration has occurred are limited in number. Some of the wells for which there are historical records are no longer being used or have been abandoned, and as a consequence no new samples could be taken in this investigation. Chloride concentrations ranged from 13 to 5,160 ppm in the 109 wells sampled for analysis. The average chloride concentration was 529 ppm with only about 28 percent of the samples having a chloride content of more than 250 ppm. These ranges do not include those analyses where water-quality alteration had apparently occurred.

The range in total dissolved solids in the samples was from 260 to 8,440 ppm. The average total dissolved solids was 1,550 ppm with only about 32 percent of the wells having more than the average. About 54 percent of the wells have dissolved solids more than 1,000 ppm.

The range in depth of the wells completed in the Graham Formation is from 18 to 330 feet, and the average depth is 139 feet. About 54 percent of the wells in the Graham are deeper than 139 feet. Near Wayland are numerous flowing water wells, or wells in which the water level is near the surface. The depths of these flowing wells are generally about 150 feet.

Thrifty Formation

The Thrifty Formation includes strata from the base of the Avis Sandstone Member to the top of the Breckenridge Limestone Member (Table 2). The Thrifty rests unconformably upon the Graham Formation, the Avis Sandstone member being deposited on the widely and deeply dissected Wayland Shale (Lee and others, 1938, p. 54). The thickness of the Thrifty ranges in the county from 117 feet near Rocky Mound to 215 feet near Graham (Lee and others, 1938, p. 54).

Twenty-six wells are listed in Table 3 as having been completed in the Thrifty Formation, of which 7 have been abandoned or are not being used. Most of the other wells are used for domestic purposes, with 6 wells being used for livestock.

Water quality in the Thrifty Formation is variable with chlorides ranging from 49 to 2,000 ppm in the 22 samples collected. The average chloride concentration was 409 ppm with about 41 percent of the samples having more than the average. The range in total dissolved solids is from 528 to 3,992 ppm, and the average is 1,292 ppm with about 41 percent of the samples having more than the average.

The wells in the Thrifty Formation range in depth from 20 to 375 feet, and the average depth is 109 feet. About 89 percent of the wells are 150 feet or less in depth.

Harpersville Formation

The Harpersville Formation includes the strata from the top of the Breckenridge Limestone Member to the top of the Saddle Creek Limestone Member, an interval of about 200 to 275 feet (Plummer and Moore, 1922, p. 160-162). Lee and others (1939, p. 61-63) described this sequence as "...part of a chaotic series of thin limestones, relatively thin lenticular sandstones, variegated sands and clay shales, and thin coals."

Only one well, 31-01-401, appears to be completed in the Harpersville, but it was never used because of poor water quality. This well was sampled from a bailer shortly after drilling, and the chloride content was 3,720 ppm. The well, drilled to a depth of 133 feet, was abandoned shortly after being drilled. Although it is not known what the water quality is in this portion of the Harpersville, the water quality from this well is not believed to be representative.

Water-well development in the Harpersville Formation, as in the Thrifty Formation, is not extensive because ground water occurs erratically in lenticular sandstone and siltstone bodies, which may not yield a sufficient quantity or adequate quality of ground water, and because of the limited need of water in less populated areas of the county.

Summary of Well Yields and Construction in the Pennsylvanian System

Well yields in the Canyon and Cisco Groups of the Pennsylvanian System are variable because of the lenticular nature of most of the water-bearing units within the formations. The maximum yield from the wells equipped with windmills is about 2 to 3 gpm (gallons per minute). Most of the wells that utilize windmills are completed with 5- to 7-inch steel or galvanized iron casing, either set at total depth and perforated or set above the water producing zone with the bottom few feet of the hole not cased. A 2-inch tubing of galvanized iron is generally employed to carry the water to the surface, with wooden sucker rods operating the working barrel. The casing is generally bonded to the bore hole with concrete near the surface, and a concrete curb stabilizes the foundation.

Wells that are equipped with windmills are generally used to furnish water to livestock, and a few furnish water for domestic use. Because of the nonuniform pumping rate, those windmills that supply water for domestic use have overhead storage tanks.

The other drilled wells generally are equipped with electric or small gasoline-operated pumps. Most of the pumps are either pump or jack or jet type, and some of the deeper wells utilize submersible-type pumps. The yield of the wells varies, not only as the result of the porosity, permeability, and thickness of the water-bearing units, but also because of the size of the pump and motor. Drilled wells used for domestic purposes are usually equipped with a pressure tank.

Drilled wells utilizing electric or gasoline-operated pumps are completed with 5- to 7-inch steel or galvanized iron casing, either set to total depth with perforations or set above the water-producing zone with the bottom few feet uncased. Some of the water wells are recompleted, abandoned oil-test holes, and these wells are completed with 7- to 10-inch, steel, oil-field pipe.

Most of the dug wells are lined with field stone to prevent caving, with the upper section of the lining cemented. Galvanized corrugated steel casing of the same type used in culverts was used in a few of the dug wells.

The maximum yield of the wells used for oil-field waterflooding in Stephens County varies from 5 to 10 gpm.

Permian System

Wichita Group

The Wichita Group in the Brazos River Valley includes the rocks from the top of the Saddle Creek Limestone Member of the Harpersville Formation to the top of the Lueders Limestone. The Wichita Group consists of seven formations, of which only the lower two are present in Stephens County. These two formations are, in ascending order: Pueblo and Moran Formations. The outcrop of the Wichita Group occupies the western margin of Stephens County. The Wichita Group extends over 15 percent of the surface area of the county.

Pueblo Formation

The Pueblo Formation, as presently defined, includes the strata from the top of the Saddle Creek Limestone Member to the top of the Camp Colorado Limestone Member (Table 2); its outcrop in western Stephens County generally trends in a north-south direction (Figure 3). The lower half of the Pueblo is distinctly sandy in character, whereas the upper half is principally shale and mudstone. The lower portion, like the underlying Harpersville, is quite variable, containing numerous lenticular sandstones, shale, and thin limestones. The Pueblo Formation ranges in thickness from about 100 to 200 feet. No water wells are known to be completed in the Pueblo in Stephens County.

Moran Formation

Only the lower portion of the Moran Formation outcrops in extreme western Stephens County (Figure 3). The Moran is composed primarily of shale with some limestone, sandstone, and siltstone. No water wells are known to be completed in the Moran in Stephens County.

Cretaceous System

Trinity Group

The rocks of the Trinity Group unconformably overlie rocks of Pennsylvanian and Permian age in north-central Texas. In southeastern Stephens County, an isolated erosional remnant of the Trinity occupies about 10 to 15 square miles (Figure 3).

Less than 35 feet of the Trinity is present in Stephens County. The basal 2 to 10 feet consists of conglomerate interbedded with sandstone (Stafford, 1960, p. 277). The Trinity sands supply shallow dug wells in this area, and may contribute ground water to wells completed in older strata.

About 10 wells have been completed in the Trinity Group, and most of these are shallow dug wells, of which about half are either abandoned or are not being used. About 10 additional wells have been drilled through the Trinity in this area and are completed in older strata such as the Graham Formation and Home Creek Limestone. About half of these wells have been abandoned or are not in use. The water in the Trinity is utilized for domestic and livestock purposes.

The water in the Trinity Group is variable in quality. The chlorides in the 6 dug wells sampled for analysis range from 20 to 775 ppm, with 5 of the wells having a chloride content of 355 ppm or less. The dissolved solids range from 335 to 2,189 ppm in the 6 wells, with 3 of the wells having dissolved solids of 966 ppm or less.

The range in depth of the 10 water wells completed in the Trinity is from 14 to 41 feet; 4 of the wells are 30 feet deep. The base of fresh water in the Trinity is believed to be about 41 feet, but the Trinity may be supplying some ground water to the Graham Formation and Home Creek Limestone, which underlie the Trinity in the area. The base of fresh water could not be determined because of the erratic occurrence of channel sands in the formations that occur below the Trinity.

Well yields from the Trinity Group in Stephens County are determined by the depth of the well and the thickness of water-bearing sand or conglomerate in the vicinity of the well. The diameter of the hole also affects well yields; most of the wells are dug, having a diameter of 2 or 3 feet. Because the Trinity is relatively thin in Stephens County and most of the wells are shallow dug wells, the yield is generally low depending upon the amount of discharge and recharge. The area of Trinity outcrop is geographically high in Stephens County--the elevation is about 1,300 feet--so the recharge must come from rainfall.

Most of the dug wells are lined with field stone to prevent caving, and the upper portion of the lining is cemented. A few of the dug wells have galvanized corrugated steel casing of the same type as used in culverts. The wells are usually equipped with a pulley and a rope, or chain, attached to a bucket or bailer.

Quaternary System

Alluvium

Surficial deposits of alluvium and terrace gravel, sand, silt, and clay occur along the streams and in the valleys in Stephens County. According to Stafford (1960, p. 277) these deposits are probably Pleistocene to Recent in age, and were derived from rocks of the Pennsylvanian, Permian, and Cretaceous Systems. Most of these sediments are the result of stream deposition, although some are of windblown origin. Most of the deposits are probably lenticular and relatively thin in most places, generally not exceeding 60 feet.

More than 30 wells have been drilled or dug in these deposits, of which about 12 have been abandoned or are not being used. Most of the wells supply water for domestic or livestock use, but two wells supply water for industrial use, and one well is pumped principally for irrigation.

The water quality is highly variable in the wells producing from these deposits. The chlorides range from 11 to 944 ppm in the 16 wells sampled for analysis, 9 of which have chlorides less than 90 ppm. The range in dissolved solids is from 228 to 2,772 ppm, with 11 wells having 725 ppm or less.

The range in depth of the 31 wells completed in these deposits is from 6 to 70 feet, with the average depth being 28 feet. About 61 percent of the wells are less than 25 feet deep. Some of the alluvium may supply ground water to the underlying strata. The base of fresh water is believed to be about 60 feet, depending upon the thickness of the deposit and the nature of the underlying strata. The actual base of fresh water was not determined because of the erratic occurrence of channel sands in the formations that occur below the alluvium.

Well yields from the alluvium in Stephens County are similar to yields from wells in the Trinity Group. The thickness and nature of the water-bearing units in the vicinity of a particular water well, and the well diameter and depth, affect the yield. Most of the shallow dug wells are from 2 to 4 feet in diameter.

One drilled well, 30-08-803, has a casing diameter of 12 inches and a depth of 47 feet. The well is equipped with a turbine pump, and the capacity of the well is 500 gallons per minute, according to the owner. This is the most exceptional well in Stephens County, as it is the only well being used principally for irrigation, and is also the well with the largest yield in the county.

Most of the dug wells are lined with field stone to prevent caving, and the upper portion of the lining is cemented. A few of the dug wells have galvanized corrugated steel casing of the same type as used in culverts.

The yield is small in many of the wells completed in the alluvium.

SURFACE CASING

The function of the Surface Casing Section in the Ground Water Division of the Texas Water Commission is to recommend to members of the oil and gas industry and the Railroad Commission of Texas the depth to which ground water should be protected in drilling tests for oil and gas. The authority for participation by the Texas Water Commission in the surface casing program is derived from rules promulgated by the Railroad Commission under authority given that agency by the statutes dealing with regulation of drilling and production activities of the oil industry.

Statewide Rule 12a of the Railroad Commission requires that operators obtain a letter from the Texas Water Commission recommending the depth to which fresh-water strata should be protected when drilling a new lease or area if the lease or area is not covered by field rules or lease recommendations. Rule 20 of the Railroad Commission requires that all fresh-water strata be protected in drilling or production activities.

In carrying out its duties under Rule 12a, the Texas Water Commission created the Surface Casing Section in the Ground Water Division. The staff of the Surface Casing Section is responsible for maintaining technical-data files upon which to base fresh-water-protection recommendations in all areas of the State, and for preparing these recommendations on application by operators contemplating drilling test wells. The depth to which ground water should be protected in a given area is based on all pertinent information available to the Surface Casing Section staff at the time the recommendation is given. Recommended depths in any one area may therefore be revised when additional subsurface information becomes available. Known depths of water wells being used or depths of wells known to contain water of usable quality, such as domestic, municipal, industrial, livestock, or irrigation wells, are of great value. Electric or gamma-ray neutron logs run on oil and gas tests are used in many areas of the State to determine the depth at which the base of usable quality ground water occurs. Surface elevation is considered when a recommendation is given in an area that has moderate to high surface relief, as is common in the north-central Texas counties. This consideration of elevations is imperative when the area is dissected by streams, 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 emerge at lower elevations. All of this information is interpreted in the light of the best knowledge of the geology and ground-water hydrology available on the area involved.

Because of the erratic occurrence of ground water in Stephens County, which was described in the preceding sections of this report, known depths of water wells are given special weight in preparing surface-casing recommendations in the county. Usefulness of electric logs in this geologic environment is limited because of the lack of continuous zones in the shallow subsurface that can be correlated over the area, and the difficulty in interpreting water quality from such logs where the aquifer materials range so widely from sands to gravels to limestones over relatively short distances. In the northern part of the county, the Surface Casing Section gives particularly close attention to surface elevations in addition to information on water wells because of the dissection of the surface rocks in this area by the Clear Fork of the Brazos.

In Stephens County a county-wide depth recommendation is not feasible because the depth of surface-casing protection, which would be required in those areas of the county where deep water wells are found, would be an excessive requirement in many other parts of the county. The preceding section of this report describes the occurrence of ground water of usable quality in a number of formations at depths ranging from the surface to over 500 feet. Thus, the results of this study confirm that surface-casing recommendations in this county should be made on a well-to-well or lease-to-lease basis in order to provide adequately for water protection without imposing unnecessary burdens for excessive protection in those areas where deep protection is not needed.

During the 5-year period from 1958 to 1962 inclusive, the Surface Casing staff prepared 515 recommendations for protection of usable-quality ground water for oil and gas tests in Stephens County. Eighty-seven recommendations were prepared during 1963. The depths of these recommendations range from 100 to 550 feet.

OIL-FIELD BRINE PRODUCTION AND DISPOSAL

Quality and Distribution of Produced Brine

The 1961 inventory of salt-water production throughout the State, conducted by the Railroad Commission of Texas and the Texas Water Commission and reported by oil companies and operators, shows that a total of 5,796,313 barrels of oil-field brine was produced in Stephens County in 1961. Of this total, 936,169 barrels were disposed of into surface pits, and 4,859,539 barrels were disposed of into injection wells. An additional 605 barrels were disposed of by other methods, such as hauling, spraying on roads, leases, etc.

The tabulation of brine production and disposal in 1961 by oil field and by arbitrarily defined major producing areas is recorded in Table 5. Plate 3, which shows the location and amounts of reported brine disposal, areas of contamination, and apparently contaminated water wells, was drawn by outlining the areas of greatest concentration of producing oil wells. No attempt was made to define individual oil fields, but areas of extensive production were outlined on an arbitrary basis to show the relative concentration of production.

The major areas of surface contamination, or areas in which the vegetation has been killed, are shown on Plate 3, in addition to those water wells from which water sampled for chemical analysis indicated alteration of the chemical quality of the native water.

Chemical Quality of Produced Brine

The chemical quality of brines produced along with oil in Stephens County is presented in Table 5, which is a tabulation of chemical analyses. As can be seen, the ions normally present in most samples from water wells (Table 4) are present in the brines, but significant ions such as sodium (Na) and chloride (Cl) are present in greater abundance.

Sodium concentrations in the brine samples ranged from 20,910 to 57,034 ppm. The average was about 39,060 with about 56 percent of the 39 samples having a sodium content of more than 40,000 ppm. The chlorides ranged from 14,500 to 123,700 ppm. The average of the chlorides was 81,153 ppm, with about 54 percent having a chloride content of more than 87,000 ppm.

ALTERATION OF NATIVE CHEMICAL QUALITY OF WATER

Although a study of contamination of surface water in Stephens County was not contemplated in the scope of this project, it is important to note that ground and surface water are interrelated. If the chemical quality of surface water is significantly altered, some of the ground water in that area may be affected through vertical percolation; and of course stream quality can be affected by altered ground water, which contributes to the base flow of the stream.

In 1952 a preliminary survey was conducted on oil-field brine production and disposal in the area drained by the upper part of the Brazos River by the Texas State Department of Health and the Texas Game and Fish Commission. Their report, a copy of which is on file in the Austin office of the Texas Water

Commission, indicates, based on sample analyses in the area, that salt-water pollution in Stephens County was the most severe in the entire upper Brazos River watershed at that time. (Supplemental Report, unpublished, 1952b, p. 19).

By 1953, after another survey was conducted by the same agencies, it was reported that many of the operators of oil and gas leases were disposing the produced brines into injection wells (First Annual Report, unpublished, 1953, p. 6).

In 1960 an investigation was made by the Railroad Commission of Texas on a problem of salt-water pollution in the vicinity of Breckenridge, where it was found that salt water was entering the drainage of Lake Grand and Gonzales Creek (Parker and Smith, 1960).

Big Branch Dam or Lake Grand Dam was built in the early 1920's for mining, irrigation use, and standby municipal supply. The lake, with a reservoir capacity of about 1,000 acre-feet, is located about 2 miles northeast of Breckenridge (Plate 1). The lake became contaminated with salt water soon after it was constructed and apparently no use has been made of the lake subsequently except for the storage of salt water.

During this field study, it was observed that much of the area around the lake has been denuded of vegetation apparently because the soil has been impregnated with salt. In May of 1963, it was observed that there were numerous seep areas below the dam. A sample taken from the water seeping out below the dam on June 14, 1960 tested 40,000 ppm chlorides (Parker and Smith, 1960, unpublished report). The seepage below the dam runs for about a mile in a draw, tributary to Gonzales Creek, and then appears to go underground. No water wells are present in the area to determine whether alteration of the chemical quality of ground water has occurred.

During the present investigation, it was observed that a buried pipeline from a separator on one lease empties brine directly into a draw, which empties into Lake Grand. Other leases were observed to have surface pits in use, with badly leaking earthen dams and large areas where vegetation had been killed.

In some areas where surface pits are no longer being used, large "kill" areas of salt-impregnated soil and salt deposits formed from evaporation continue to contribute to pollution of surface water as rainfall and runoff leaches the salt from the soil.

Another area that exhibits surface contamination is around Ivan in northeastern Stephens County. In this area, soil contamination is indicated by the lack of vegetation, although the areal extent of the "kill" is smaller than the area east of Breckenridge. Salt water is put into surface pits in the Ivan area, which in many cases were observed to leak around the earthen dams.

A few of the water wells in Stephens County that exhibit apparent alteration of native quality as the result of contamination by oil-field brine are shown on Plate 3, and Figure 6 compares diagrams of these contaminated wells with native-quality ground water and a typical oil-field brine. Other water wells exhibit apparent quality alteration, but historical records of chemical quality were not available for comparison.

The source of contamination in wells 31-19-311, 31-17-302, and 31-17-501 appears to be a nearby salt-impregnated "kill" area. In some other cases of

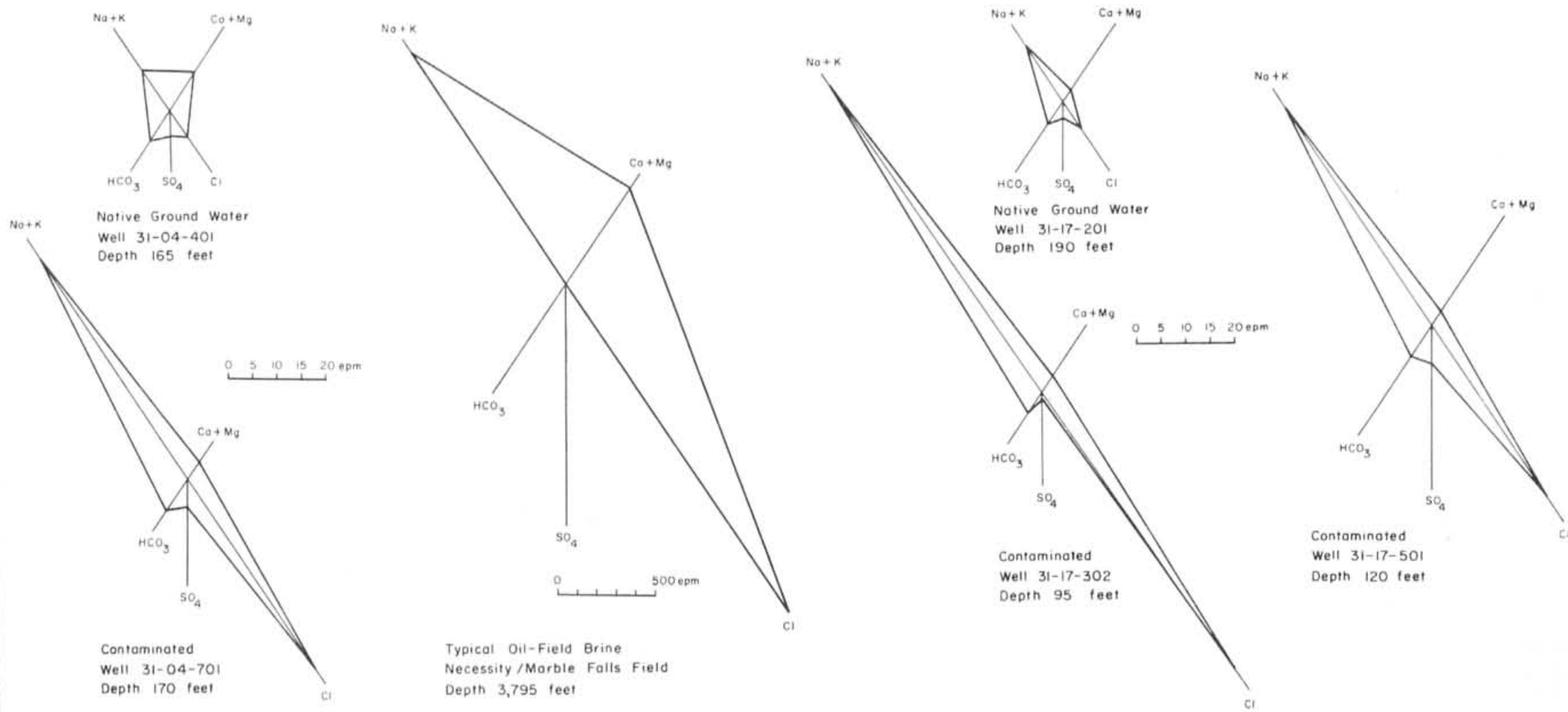

Figure 6

Diagrams of Chemical Analyses of Water from Contaminated Wells, Showing Comparison with Native-Quality Ground Water and a Typical Oil-Field Brine

Texas Water Commission in cooperation with the Texas Water Pollution Control Board

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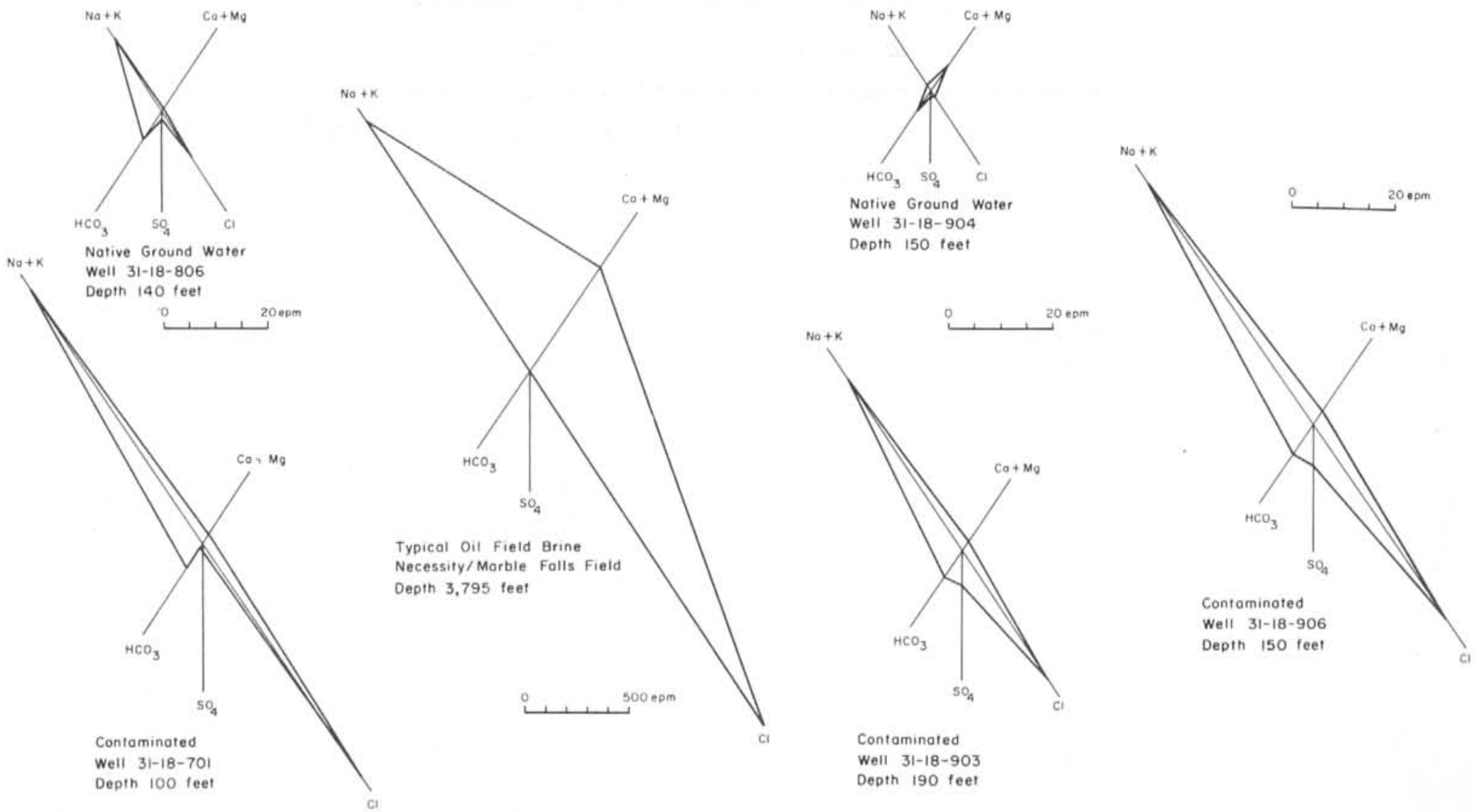

Figure 6-- Continued

Diagrams of Chemical Analyses of Water from Contaminated Wells, Showing Comparison with Native-Quality Ground Water and a Typical Oil-Field Brine

Texas Water Commission in cooperation with the Texas Water Pollution Control Board

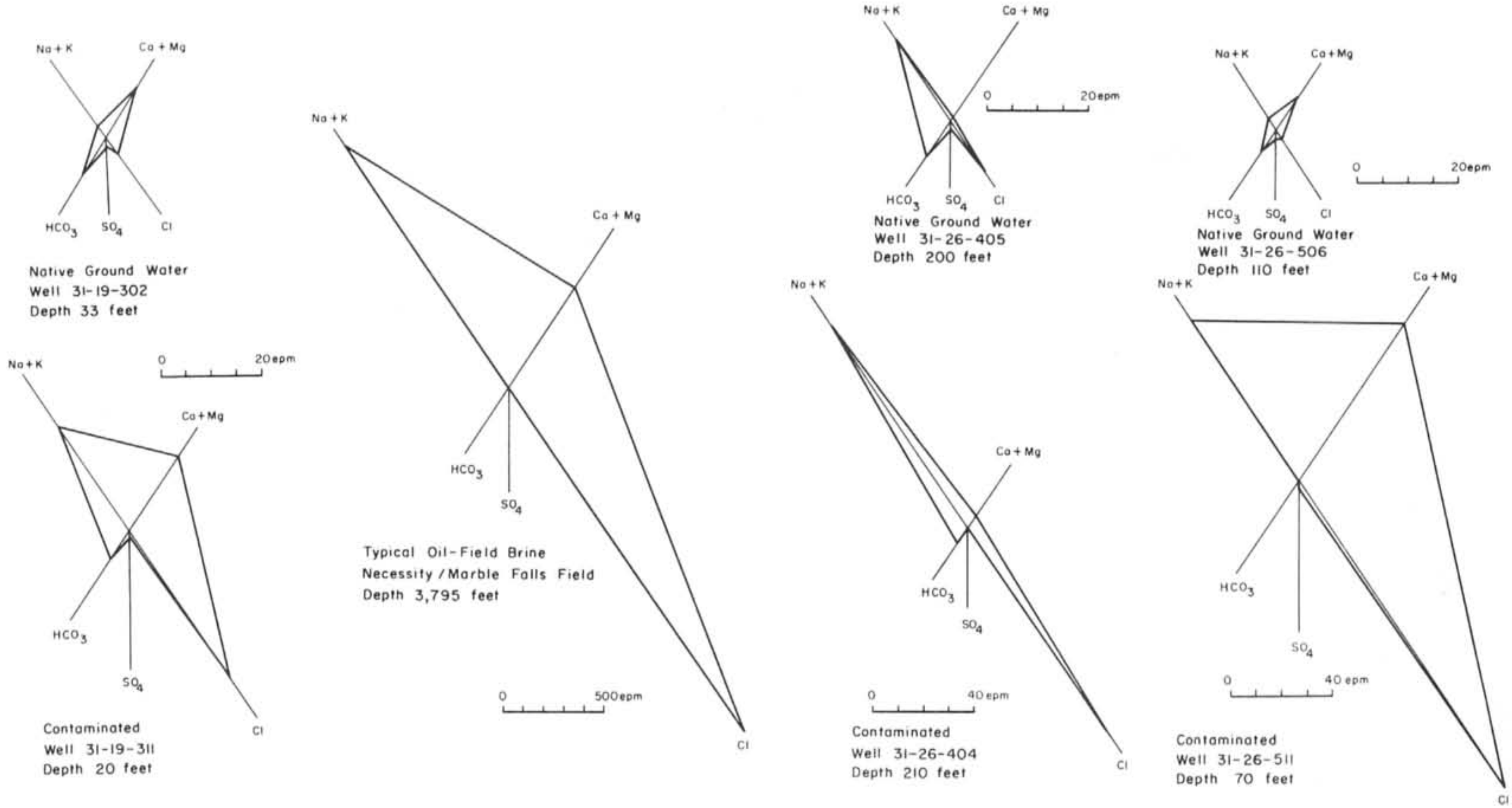

Figure 6-- Continued

Diagrams of Chemical Analyses of Water from Contaminated Wells, Showing Comparison with Native-Quality Ground Water and a Typical Oil-Field Brine

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apparent water-quality alteration the source was not apparent, and shallow salt-water injection operations or unplugged or improperly plugged abandoned oil and gas wells may be contributing to ground-water mineralization.

Most of the surface pits observed during this study in Stephens County were unlined. These pits may serve to dispose of more fluid through seepage than evaporation. In such pits, salinity reduces the rate of evaporation. The average annual net evaporation depth for water having a saline concentration of 75,000 ppm is 49 inches in Stephens County, whereas a salinity concentration of 250,000 ppm reduces the average evaporation depth to 35 inches. These figures are intended only to illustrate the order of magnitude involved. They cannot be used to determine actual depth of water evaporation from a specific point for a specific period of time, because they are based on the assumption that the fresh water evaporation rates remain constant and that a free water surface is available for evaporation at all times. Frequently there is a film of oil on the surface of these pits that also substantially reduces the rate of evaporation.

Since dissolved salts in a pit are not evaporated, the fluid holding these minerals in solution becomes more concentrated. If the pits were lined and the salt water was not allowed to overflow the sides of the dikes, the salt would precipitate after the saturation point was reached; some method would have to be employed to haul away this precipitate in order to continue use of the pits for temporary storage.

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Table 3.--Records of wells and springs, Stephens County

Water-bearing unit : All, Pleistocene to recent alluvium; CC, Colony Creek; G, Graham; Har, Harpersville; HC, Home Creek; P, Posideon; PP, Palo Pinto; PS, Placid Shale; R, Ranger; Th, Thrifty; Tr, Trinity; W, Winchell; WM, Wolf Mountain Shale.
Water levels : Reported water levels given in feet; measured water levels given in feet and tenths; P, indicates pumping level.
Method of lift and type of power : B, bucket or bailer; C, cylinder; Cf, centrifugal; E, electric; G, natural gas, butane, or gasoline; H, hand, J, jet; N, none; S, submersible; T, turbine; W, windmill; Number indicates horsepower.
Use of water : D, domestic; Ind, industrial; Irr, irrigation; S, stock; N, none.

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
*30-08-601	Southwestern Gas Products Co.	Luke Ledbetter	1961	170	8	30	All	1,161	27.5P	Mar. 31, 1962	C,E, 3/4	Ind, D	Pumps 2-1/2 gpm.
* 602	do	do	1961	70	10	30	All	1,158	53.9P	do	C,E, 3/4	Ind, D	Pumps 1-1/2 gpm.
* 801	D. G. Stover	D. G. Stover	1883	36	48	36	All	1,144	32.4	Feb. 9, 1937	N	N	Rock-lined dug well.
* 802	Lester Clark	--	1945	47	4	47	All	1,162	35	--	C,E, 1/4	D,S	
* 803	do	--	1958	47	12	47	All	1,156	32.0	Mar. 13, 1962	G,T, 36	Irr	Pumps 500 gpm.
804	R. W. Tipton	A. W. Tipton	1926	45	4	45	All	1,156	34.5	Mar. 16, 1962	C,W	N	
* 805	do	-- Doty	1961	48	4	48	All	1,156	35.1	May 31, 1962	J,E, 1/3	D,S	
24-601	W. D. McCain Heirs	--	1885?	15	48	15	All	--	--	--	N	N	Last used about 10 or 12 years ago. Rock-lined dug well.
* 801	P. B. Loving	P. B. Loving	1895	35	27	35	All	--	18.1	Feb. 16, 1937	--	--	Unable to locate. Assumed abandoned. Rock-lined dug well.
32-201	Henry Compton	Belding & McKeelvain	1934	375	--	--	Th	1,300	--	--	N	N	Oil test. Water sand 16-ft. thick from 216 to 235. 10 bailers of water reported in 12 hours.
*31-01-401	Weldon Powers	John Ed Conner	1962	133	N	N	Har	1,166	--	--	N	N	Abandoned after drilling. Water too salty. Sampled by bailer on April 19, 1962.
* 501	W. D. Boyd	Tom Hefner	1937?	36	--	36	All	1,113	29.7	Mar. 31, 1962	J,E, 1/3	D,S	
* 02-601	Mrs. J. T. McDonald	--	--	60	--	60	Th or All	1,133	26.3	July 17, 1962	J,E, 1/2	D	
602	Claude Curry	John Huffman	--	35	5	35	All	1,064	28.5	do	N	N	Last used about 2 years ago. Water reported to have become too salty.
* 801	B. H. Trammell	--	1885?	24	--	24	Th	1,132	22.9	July 21, 1962	C,W	N	
* 03-501	Mrs. Elon Rickles	-- Dickson	1941	144	5	144	G	1,147	50.6	Apr. 6, 1962	C,W	S	

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of Water	Remarks
*31-03-601	Ed Ford	--	1915	150	5	150	G	1,139	76	--	C,W	S	
* 602	do	--	1934	148	5	148	G	1,148	107.0	Mar. 17, 1937	N	N	
* 603	H. J. Wesley	-- Grover	1915	166	--	--	G	1,146	83.0	do	N	N	
* 604	S. E. Copeland	-- McGowan	1900?	160	5	160	G	1,143	145	--	C,E, 1-1/2	S	
* 605	Ed Ford	John Pemberton	1952	160	5	160	G	1,143	76	--	C,E, 1-1/2	D,S	
* 606	do	--	1915	160	5	160	G	1,143	83.2	Apr. 6, 1962	C,W	D,S	
607	Do	--	1912	150	5	150	G	1,140	82.4	do	C,W	S	
608	Mrs. S. E. Burgess	-- Gallegar	1910	127	6	127	G	1,143	75	--	C,W	S	
* 609	do	Tom Watkins	1948	132	6	132	G	1,143	75	--	J,E, 1	D,S	
* 610	Ben Burgess	--	1942	160	7	160	G	1,141	--	--	S,E, 1	D,S	
611	Mrs. S. E. Burgess	-- Gallegar	1910	127	6	127	G	1,136	75	--	C,W	S	Not being used when visited. Pump not connected.
612	do	John Pemberton	--	180	7	180?	G	1,141	--	--	C,E	S	Not being used when visited. Pump not connected. Water sands at 45, 90, and 145 ft.
613	do	-- Gallegar	1910	127	6	127	G	1,142	75	--	N	N	
* 614	Ed Ford	Luke Ledbetter	1959	140	6	140	G	1,148	103.3P	Apr. 5, 1962	C,E, 3/4	D,S	
* 615	H. J. Wesley	John Pemberton	1944	150	4	150	G	1,146	119.4	do	C,W	D,S	
701	J. B. Rickles	--	1880?	40	--	40	G	1,133	13.2	Nov. 8, 1962	N	N	Rock-lined dug well.
702	do	--	1880?	20	--	20	All	1,114	14	--	J,E, 1/2	D	Do.
703	A. H. Davis	Roy Micheal	1951	103	5	103	G	1,134	49.6	Apr. 6, 1962	C,W	S	Water has never been used. Pump not connected.
801	W. D. Dollar	--	1920	167	5	121	G	1,147	--	--	C,W	N	
* 802	Edmond Corbett	Roy Micheal	1951	126	5	126?	G	1,156	--	--	C,E, 1/2	D,S	
* 803	do	do	1953	126	5	126?	G	1,163	--	--	C,E, 1/2	S	
* 804	J. B. Collins	do	1950	105	5	105	G	1,148	--	--	J,E, 1-1/2	D,S	

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*31-03-901	H. F. Cook	H. F. Cook	1962	22	36	22	All	1,027	10.5	Apr. 7, 1962	J,E, 1-1/4	D	Galvanized casing. Dug well at location of spring.
* 04-401	W. A. Gragg	Nate Harlan	1937	165	5	150	G	1,233	147.8	Aug. 22, 1962	C,W	D,S	
402	Mrs. Emili C. Jones	do	1938	130	6	130	G	1,229	--	--	C,W	D,S	
* 403	do	John Pemberton	1938	140	5	140	G	1,229	65	--	C,E, 3/4	D,S	
* 701	Lloyd Potts	Frank Lewis	--	170	4	150	G	1,205	79.1	Apr. 7, 1962	J,E, ?	D,S	
702	Kenneth New	Luke Ledbetter	1959	189	5	189	G	1,112	78.8	Aug. 21, 1962	N	N	Abandoned in May, 1962. Water became salty.
* 09-201	Mrs. Ada Ball	John Ed Conner	1956	43	4	43	All	1,119	13.4	Mar. 24, 1962	C,W	D,S	
* 10-201	B. H. Trammell	--	1880?	24	--	24	Th	1,136	7.7	July 21, 1962	N	N	Rock-lined dug well. No longer used. Water became salty in 1954.
* 202	Jack Black	--	1947	20	--	20	Th	1,131	7.0	do	J,E, 3/4	D	Rock-lined dug well.
* 203	do	--	1943	28	--	28	Th	1,137	12.6	do	J,E, 3/4	D	Do.
* 204	do	--	1920	20	--	20	All	--	--	--	C,E, 1/3	S	Concrete-lined dug well in center of creek bottom.
* 701	Travis Robbins	Pete Echols	1945	98	5	92	Th	1,326	63	--	C,W	D	Water sand 92 to 112 ft.
* 702	Mrs. J. E.	Ed Sawyers	1950	120	7	120	Th	1,331	62	--	C,E, 1/2	D	Do.
703	Travis Robbins	do	1951	120	7	120	Th	1,343	62	--	C,W	S	Tight sand 92 to 112 ft.
* 704	David Cahill	do	1947	150	5	150	Th	1,323	50	--	C,E, 1/3	D	
705	Mrs. Sloan Baker	--	1947	150	--	--	Th	1,323	--	--	N	N	Abandoned in 1952 because of poor supply.
* 706	Thurman Latham	--	1950	109	6	109	Th	1,330	--	--	C,E, 1/2	D	
* 11-601	E. E. Mitchell	--	1936	127	5	127	CC	1,162	98.3	June 28, 1962	C,E, 1/2	D,S	Water level measured in abandoned well about 20 ft. east of this well.
* 701	D. W. Deaver	-- Fincher	1906	56	8	56	G	--	26	--	--	--	Unable to locate. Assumed abandoned.
* 801	C. M. Caldwell	do	1896	72	6	72	G	--	39.5	Mar. 18, 1937	--	--	Do.
802	G. D. Devenport	-- Hayden	1956	102	N	N	CC	1,266	--	--	N	N	Abandoned in 1957 because of weak supply.

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of Water	Remarks
*31-11-803	G. D. Devenport	G. D. Devenport	1957	18	--	18	G	1,266	6.1	Apr. 10, 1962	J,E, 1/3	D,S	Rock-lined dug well.
* 12-101	S. G. Copeland	Roy Micheal	1955	150	5	150	CC	1,247	26	--	C,E, 1/2	D,S	
* 102	S. C. do	Luke Ledbetter	1960	137	5	110	CC	1,249	--	--	C,E, 1/2	D,S	
* 17-201	Gilbert Ridings	Buddy Jackson	1954	190?	--	--	G	1,242	61.3	July 20, 1962	J,E, 1/2	D	
202	C. V. Edwards	--	1953	80	--	--	Th	1,264	59.4	July 3, 1962	N	N	Abandoned soon after drilling. Water not good.
* 301	D. C. Edwards estate	--	1918	138	6-5/8	--	G	--	Flows	Mar. 17, 1937	N	N	Still reported to flow in 1962, but not used.
* 302	B. F. Dickson	--	--	95?	6	--	G	1,228	--	--	J,E, 1	D,S	
* 501	Mrs. Myrtle E. Conner	--	1940?	120	--	--	G	1,239	35.6	July 20, 1962	Cf,E, 1	D,S	
601	C. W. Wulfjen, Jr.	-- Doty	1962	120	--	--	Th	1,362	--	--	N	N	Test well. Owner plans to redrill hole with regular cable tool rig for water well.
* 18-101	J. D. Collins	Ed Sawyers	1951	135	7	135	Th	1,332	--	--	C,E, 1	D	
* 102	T. D. Fambrough	Delmar Gentry	1952	120	5	120	Th	1,350	20	--	J,E	D	
* 103	do	--	1920	80	N	--	Th	1,342	18	--	C,W	S	Old oil well plugged back to 80 ft.
* 104	Jack Fambro	--	1949	80	6	80	Th	1,320	15	--	J,E, 1-1/2	D	
* 105	Ellis Hope	Texaco	1923	153?	--	--	Th	1,340	11.1	June 19, 1962	C,W	S	Old oil test Tolbert #4 plugged back to 153?
* 106	do	Damon Gray	1958	100	5	100	Th	1,357	--	--	J,E, 1/2	D	
* 107	C. D. Griggs	Ed Sawyers	1947	128	6	128	Th	1,355	12	--	J,E, 1/2	D	
* 108	C. A. Fore	B. K. Richardson	1910	75	--	--	Th	1,336	34.1	July 17, 1962	B.H	D,S	
* 201	John Vick	Ed Sawyers	1950	100	--	--	Th	1,344	--	--	C,W	S	
202	George Masters	J. V. Hayden	1954	242	5	150	G	1,359	--	--	C,G, 2-1/2	S	

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*31-18-203	George Masters	Ed Sawyers	1947	150	6	4	Th	1,368	17.7	June 18, 1962	B,H	S	
* 204	do	J. V. Hayden	1951	70	5	70	Th	1,359	5.6	do	Cf,G, ?	S	
* 501	L. Williams	--	1918	200	6	--	G	--	82.0	Feb. 10, 1937	N	N	Unable to locate. Assumed abandoned.
* 601	S. T. Swenson	Nel Swenson	1885?	90	6	90	G	1,515	19.4	June 20, 1962	C,E, 1/2	D,S	
* 602	J. D. Cox	Delmar Gentry	1951	200	6	200	G	1,351	65	--	C,E, 3/4	D,S	
* 603	Floyd Vick	-- McLaughlin	1930	120	6	120	G	1,537	14.0	July 18, 1962	C,W	S	
604	do	Unknown	1934	220	--	--	G	1,573	--	--	C,W	N	
* 605	S. T. Swenson	Nel Swenson	1887	35	--	--	G	1,503	14.9	Nov. 15, 1962	C,G, ?	S	
* 606	L. C. Burke	Luke Ledbetter	1960	185	6	185	G	1,377	105	--	S,E, 3	D	
* 607	do	--	1934	210	6	210	G	1,388	116.8	May 1, 1962	C,W	S	
* 701	Mrs. M. M. Carey	-- Buyers	1919	100	6	80	Th	1,281	4.7	Oct. 9, 1962	C, W	N	Last used for domestic and stock in 1955. Sampled from bailer.
* 702	Alex Fambro	--	1905	150	6	50	G	1,292	Flows	May 3, 1962	C,H	D,S	
801	do	-- Miller	1921	150	6	70?	G	1,311	--	--	C,W	S	
* 802	T. C. Fambro	do	1919	60	6	60	G	1,316	21.4	Oct. 10, 1962	C,W	S	
803	do	--	--	125	--	--	G	1,308	4.1	do	N	N	
804	do	--	--	125	--	--	G	1,326	33.4	do	N	N	
* 805	Alex Fambro	--	1920	100	6	60	G	1,322	--	--	C,W	D,S	
* 806	do	-- Miller	1915	140	6	60	G	1,328	44.7	July 13, 1962	C,W	S	
* 807	Jess Fambro	--	1918	150	8	150	G	1,362	75	--	J,E, 1-1/2	D,S	
* 901	C. McCauley	--	--	14	36	14	All	--	3.9	Feb. 10, 1937	N	N	Rock-lined dug well. Unable to locate. Assumed abandoned.
* 902	G. E. Langford	Luke Ledbetter	1961	130	5	130	G	1,464	--	--	C,E, 1/2	D	
* 903	I. C. Peeks	Marvin Sides	1955	190	6	190	G	1,476	--	--	C,E, 3/4	S	

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of Water	Remarks
*31-18-904	Hal Langford	--	1954	150	6	150	G	1,418	14.8	June 15, 1962	C,E, 3/4	S	
905	C. Newham	--	1956	72	5	--	G	1,473	--	--	C,E, ?	N	Not being used now. Pump disconnected. Very weak supply. Owner may drill deeper, later.
* 906	E. D. Morgan	Luke Ledbetter	1961	150	4	150	G	1,423	--	--	J,E, ?	D,S	
907	Alex Fambro	--	1960	150	5	100	G	1,347	--	--	C,W	D,S	Not being used when visited in 1962.
* 908	G. E. Langford	Luke Ledbetter	1961	148	5	148	G	1,427	54.7	Sept. 15, 1962	N	N	Not being used when visited in 1962. Owner plans to install pump later and use for stock. Sampled from bailer.
909	R. S. Taylor	--	1917	200	6	200	G	--	60.0	Feb. 10, 1937	N	N	
* 910	Floyd Vick	--	1901	110	6	110	G	1,615	31.7	July 18, 1962	C,W	N	
19-101	Texaco	Texaco	1921	3,200	18	--	G?	--	--	--	N	N	Abandoned oil test. Black #7 plugged now. Water sand reported between 200 and 300 ft.
* 301	R. M. Rogers	--	--	89	5-1/2	--	CC	1,279	53.5	Feb 15, 1937	N	N	
* 302	Otis Hodges	--	1910	33	36	33	HC	1,241	16.4	Apr. 10, 1962	J,E, 1/2	D,S	Rock-lined dug well.
* 303	R. M. Rogers	--	--	135	6	--	CC	--	65.0	Feb. 17, 1937	N	N	
* 304	D. L. Nelms	John Gray	1957	200	6	141	CC	1,279	12.7	June 12, 1962	J,E, 1/2	D	
* 305	R. J. Carey	do	1958	166	7	70	CC	1,277	20	--	C,W	S	
* 306	Garland Coody	Marvin Sides	1952	175	6	175	CC	1,282	--	--	J,E, 1/2	S	
* 307	R. M. Rogers	--	1950	65	6	65	CC	1,279	14.8	June 12, 1962	J,E, 1/2	D	
* 308	Garland Coody	--	1923	150	4	--	CC	1,221	--	--	J,E, 1/2	D,S	
* 309	J. R. Coody Estate	--	1890	100	6	100	CC	1,337	--	--	J,E, 1/2	D,S	
* 310	J. M. Luttrell	--	1910	24	192	24	HC	1,242	14.0	Apr. 10, 1962	J,E, 1	D	
* 311	J. M. Rogers	Prairie Oil & Gas Co.	1919	20	156	20	HC	1,227	12.9	Apr. 11, 1962	J,E, 1	D,S	
* 401	R. A. Sorgee Estate	Humble Oil Co.	1920	340	6-5/8	--	CC	--	118	Feb. 19, 1937	N	N	Unable to locate. Assumed abandoned.

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*31-19-402	Garland Coody	J. R. Coody	1919	84	5-1/2	84?	G	1,326	37.7	June 13, 1962	C,W	S	
501	R. J. Carey	--	1900?	20	--	--	All	1,274	--	--	C,G,?	D,S	Last used in 1961. Pump not in operation when visited in 1962. Rock-lined dug well.
* 502	do	John Gray	1958	134	7	134	G	1,393	65.7	Aug. 25, 1962	C,W	S	
* 503	Mrs. Albert Smith	-- Proctor	1930	30	24	30	All	1,261	9.4	June 13, 1962	B,H	D,S	Rock-lined dug well. Goes dry when creek goes dry.
* 504	Elmer Hudspeth	Roy Micheal	1952	65	4	65	G	1,339	73.4	Aug. 28, 1962	C,G	D,S	Water level measured in abandoned well located 35 ft. southeast. This well was 74 ft. in depth.
505	Oliver Ledbetter	John Gray & Marvin Sides	1953	239	6	239	PS	1,370	66.1	do	C,W	S	Not in use now. Last used about 1951. Water is reported salty to taste, but stock could drink water.
601	Garland Coody	Marvin Sides	1952	120	6	120	CC	1,402	22.1	Oct. 29, 1962	C,E, 1/3	S	Pump not operating when visited in 1962.
* 602	Mrs. L. C. Link	--	--	141	--	--	CC	1,448	119.9	July 10, 1962	C,W	S	
* 603	Garland Coody	Marvin Sides	1954	120	6	120	G	1,365	26.3	June 13, 1962	J,E, 1/2	S	
* 604	J. R. Coody Estate	--	1940	100	6	100	CC	1,477	--	--	C,E, 3/4	S	
605	R. A. Trower	--	1955	93	5	93	G	1,378	--	--	C,G, 1-1/2	S	Not in use when visited in 1962. Last used in 1957.
801	J. F. Eddleman	John Gray	1950	150	5	150	CC	1,436	--	--	C,E, 5-1/2	D,S	Not in use when visited in 1962.
802	A. O. Templeton	--	1946	--	--	--	--	1,423	--	--	N	N	Abandoned in 1951.
* 803	D. B. Raney	Texas & Pacific Coal & Oil Co.	1921	1,000	7	150	PS?	1,432	40	--	C,E, 1	D,S	Abandoned oil test used for water well. Plug-back depth unknown.
* 901	D. M. Stanford	do	1920	199	7	65	PS	1,449	--	--	S,E, 3/4	D,S	Old gas well cleaned out and plugged back to 199 ft.
* 902	D. B. Raney	--	1953	200	5	200	PS	1,425	--	--	C,E, 1	S	
903	B. C. McNabb	B. C. McNabb	1940	20	66	20	All	1,397	9.4	June 4, 1962	Cf,G	S	Rock-lined dug well.
* 904	Mrs. L. C. Link	--	1949	75	5-1/2	75?	G	1,458	32.2	Sept. 28, 1962	C,W	S	
* 905	W. H. Birdwell	W. H. Birdwell	1960	629	5-1/2	629	WM	1,453	--	--	C,E, 5	W	
906	R. A. Trower	--	1951	118	5	110	CC	1,418	60.4	Aug. 27, 1962	S,E	S	Last used in 1953 because of poor quality. May be used again, but only in emergency.

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*31-19-907	D. D. Vaughn	John Gray	1953	114	--	--	PS	1,412	--	--	C,W	S	
* 20-101	H. C. Thompson	Dick Pope & John Lynn	1924	185	4-1/2	125	CC	1,383	25.3	Aug. 3, 1962	J,E, 3/4	D,S	Well has been reentered, and deepened.
* 102	do	--	1918	140	4-1/2	--	CC	1,365	58.4	do	C,E, 1/2	D,S	
* 103	do	--	1890	35	--	35	G	1,327	15.2	June 13, 1962	B,H	S	Rock-lined dug well.
104	do	Roy Micheal	1953	94	6-1/4	10	G	1,376	34.4	do	N	N	Well was drilled during drought, but has never been used. Will be used in emergency.
* 105	Lee Mitchell	John Gray	1956	368	7	140	WM	1,303	--	--	C,G, 1-1/2	S	
* 106	do	--	1910?	140	6	--	PS	1,293	44.5	June 13, 1962	B,H	D,S	
* 401	Mrs. L. C. Link	--	1952	91	5-1/2	70	CC	1,482	--	--	C,W	D,S	
* 402	do	--	--	61	--	--	HC	1,523	--	--	C,W	S	
* 403	do	--	--	Surface	--	--	HC	1,472	Flows	May 15, 1962	N	D,S	Spring. Water flows.
* 404	do	--	1952	339	5-1/2	339	WM	1,421	--	--	S,E 3/4	S	
* 405	do	--	1952	298	5-1/2	--	WM & P	1,396	--	--	C,W	S	
* 406	do	Luke Ledbetter	1952	72	5-1/2	72	CC	1,476	32.5	July 10, 1962	C,E, 3/4	S	
* 701	Lone Star Gas Co.	Lone Star Gas Co.	1919	365	6-5/8	350	PP	--	--	--	N	N	Unable to locate. Assumed abandoned.
702	D. D. Vaughn	-- Bargsley	1945	152	--	--	PS	1,435	60.5	Sept. 12, 1962	C,W	S	
* 703	Mrs. L. C. Link	Texas & Pacific Oil Co.	1920	273	7	--	WM & P	1,477	--	--	C,W	S	
704	do	--	1948	240	--	--	PS	1,417	130.0	Sept. 28, 1962	C,W	S	
* 705	do	Lone Star Gas Co.	1940	330	7	--	WM & P	1,444	190.1	Sept. 26, 1962	C,W, 3/4	D,S	
* 706	Joe Jackson	Madison Bargsley	1946	90	7	10	PS	1,380	13.7	June 2, 1962	C,W	S	
707	do	Marvin Sides	1955	100	10, 5	8, 100	PS	1,386	4.5	Sept. 12, 1962	N	N	
708	D. D. Vaughn	J. A. Gray	1954	200	--	--	PS	1,431	42.6	do	C,W	S	
* 709	do	do	1940	120	6	110	PS	1,426	--	--	C,W	D,S	

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*31-20-801	Texas & Pacific Coal & Oil Co.	Texas & Pacific Coal & Oil Co.	1920?	225	5	--	WM, P, PP?	1,394	--	--	C,E	D,S	
802	do	do	--	225	--	--	WM, P, PP?	--	--	--	N	N	
* 803	E. W. Hohhertz	--	1900?	22	30	22	PS	1,298	17.4	July 10, 1962	J,E, 1/2	D,S	Rock-lined dug well.
* 25-201	Mrs. O. R. Wallis	-- McHall	1917	12	42	12	All	1,371	10.8	June 16, 1962	C,W	D	Do.
* 202	G. B. Greiner	Luke Ledbetter	1960	75	5-1/2	75	Th	1,365	9	--	J,E, 1/2	D	
* 301	Noble Robertson	Noble Robertson	1936	6	48	6	All	--	4.1	Feb. 8, 1937	N	N	Unable to locate. Assumed abandoned.
* 501	Jesse Garrett	Luke Ledbetter	1962	158	5-1/2	158	Th & G	1,351	26.1	May 28, 1962	S,E, 1/2	D,S	
601	A. R. Knight	Ed Sawyers	1947	247	7	247	G	1,412	--	--	C,E, 1	D,S	
* 602	do	do	1947	330	7	330	G	1,435	--	--	C,E, 1	D,S	
901	J. H. Perry	--	1920	180	6	--	G	1,403	30	--	C,E	D	
902	J. A. Baggett	Bell, McDonald, & Bell Oil Co.	1916	240	6	--	G	--	--	--	N	N	
* 903	S. H. Boles	Tex-O-Kan Oil Co.	1919	140	5	--	G	1,390	.6	June 29, 1962	J,E, 1/2	D,S	Well flows in wet weather.
* 904	Lester Thrope	Plateau Oil Co.	1920	200	6-5/8	170	G	1,442	35	--	C,G, 2-1/2	D,S	
* 905	Mrs. M. H. Thorpe Estate	Brig Owens	1906	206	6	180	G	1,439	42.9	June 29, 1962	J,E, 1/2	D,S	
* 906	G. W. Thorpe	--	1947	205	8	175	G	1,475	68.0	do	J,E, 1/2	D,S	
* 907	do	-- Davis	1928	175	5-1/2	175	G	1,470	55.7	do	J,E, 1/2	D,S	
908	do	--	1917	175	7-1/2	175	G	1,448	50	--	N	N	
909	do	--	1917	175	8	175	G	1,438	34.9	June 29, 1962	N	N	
910	do	--	1917	175	5-1/2	175	G	1,458	--	--	C,W	S	
911	Rapp Estate	--	1917	175	--	--	G	1,424	--	--	C,G, 5	N	Last used in 1957 for industrial supply.
* 26-101	Alex Fambro	--	1910	131	8	--	G	1,292	Flows	Oct. 6, 1962	B,H	S	

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*31-26-102	Joseph F. Rumsey	Aubrey Ramshire	1925?	135	6	--	G	1,316	29.5	Feb. 8, 1937	N	N	
* 103	Paul Wagley	Prairie Oil & Gas Co.	1920	192	6	192	G	1,328	Flows	Oct. 27, 1962	N	N	
104	T. C. Fambro	--	--	150?	5-1/2	--	G	1,301	Flows	Oct. 6, 1962	N	N	
105	do	Will Gray	1910	150	6-5/8	150	G	1,288	Flows	Nov. 3, 1962	N	N	
106	do	--	--	150?	6-5/8	--	G	1,288	Flows	do	N	N	
107	Alex Fambro	--	--	150?	5-1/2	100?	G	1,289	Flows	do	N	N	
108	do	--	--	150	--	--	G	1,302	3.3	Oct. 6, 1962	N	N	
* 109	E. C. Head	Aubrey Ramshire	1931	135	6	135	G	1,324	25	--	J,E, 2	D,S	
* 110	Joseph F. Rumsey	--	1950	200	6	200	G	1,316	18.8	June 21, 1962	J,E, 1/2	D	
* 111	A. R. Knight	--	--	65	30	65	G	1,320	24.9	July 13, 1962	N	N	Rock-lined dug well.
112	do	--	1930?	150	4	--	G	1,350	26.4	Nov. 15, 1962	N	N	
* 201	O. R. Gilbert	--	1885	185	6	185	G	1,309	--	--	J,E, 3/4	D,S	
* 202	Mrs. Willie Sykes	Sam Miller	1920?	120	7	--	G	1,310	Flows	May 3, 1962	N	N	
* 203	J. W. Jackson	--	1954	160	8	160	G	1,393	10	--	S,E, 1/2	D	
* 204	Alex Fambro	-- Hodges	1920	100	6	50	G	1,325	27.6	July 13, 1962	C,W	D,S	
* 205	do	--	1950	100	6	50	G	1,325	20	--	J,E, 3/4	D,S	
* 206	O. R. Gilbert	Will Gray	1900	180	6	180	G	1,315	6.7	Aug. 9, 1962	N	N	
* 207	Wayland School	Charlie Smoot	1908	180	--	--	G	1,316	4.0	do	N	N	
* 208	T. C. Fambro	Will Gray	1918	165	--	--	G	1,302	4.1	Oct. 6, 1962	N	N	
* 209	G. M. Lauderdale	do	1925	135	6	70	G	1,319	5.4	June 22, 1962	J,E, 1/3	D	
* 210	do	--	1885	120	--	--	G	1,328	10.3	do	C,H	S	
211	do	--	1880	50	42	50	G	1,328	32.0	do	N	N	Rock-lined dug well.
212	do	--	1908	130	--	--	G	1,334	--	--	N	N	
213	P. D. Campbell	--	1895	120	--	--	G	1,329	--	--	B,H	D,S	

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*31-26-214	Alex Fambro	--	1930	152	6	60	G	1,323	11	--	C,W	D,S	
* 215	D. M. Duncan	--	1910	94	--	--	G	1,345	61	--	J,E, 3/4	D,S	
216	E. C. Head	--	1885	180	6	180	G	1,311	5.8	June 21, 1962	C,W	D,S	
217	T. C. Fambro	--	--	165	6-1/2	--	G	1,299	Flows	Oct. 6, 1962	N	N	
218	Troy Turner	J. F. Ford	1895	160	6	80	G	1,380	--	--	C,W	N	
* 219	T. G Gilbert	-- Hayden	1957	115	6	65	G	1,368	28	--	J,E, 3/4	D,S	
220	J. W. Jackson	None	--	Surface	--	--	G	1,351	Flows	Oct. 22, 1963	N	S	Seep spring.
* 221	O. R. Gilbert	--	1919	156	6-5/8	90	G	1,314	30.2	July 7, 1962	J,E, 2	S	
* 222	J. W. Jackson	Dale Trobough	1961	161	8	160	G	1,358	11.5	June 25, 1962	C,E, 1/4	S	
* 301	D. E. Turner	Luke Ledbetter	1959	150	5	150	G	1,473	100	--	S,E, 1	D,S	
* 302	do	--	1940?	125	5	125	G	1,473	115	--	J,E, 3/4	D	
* 303	B. G. Langford	-- Norton	1945	150	5	150	G	1,610	--	--	C,E, 3/4	D	
* 304	C. B. Greenlee	Luke Ledbetter	1962	134	5-1/2	134	G	1,404	37	--	J,E, 1	D,S	
* 401	A. F. Billman	--	1915	158	6	--	G	--	116.5	Feb. 8, 1937	--	--	Unable to locate. Assumed abandoned.
* 402	J. C. Rominger	Aubrey Ramshire	1936	200?	6	149	G	1,363	14.7	July 19, 1962	C,W	S	
* 403	Paul Wagley	Charlie Smoot	1906	198	5	182	G	1,353	20	--	J,E, 1/2	D	
* 404	C. F. Hogan	-- Wagley	1958	210	7-1/2	190	G	1,342	8	--	S,E, 3/4	S	
* 405	K. D. Pilgrim	--	1878	200	4	180	G	1,361	24.0	June 21, 1962	J,E, 1/4	D,S	
406	P. L. Boles	--	1955	210	6	210	G	1,404	35.5	June 29, 1962	N	N	
* 407	Alex Fambro	Jones Drilling Co.	1960	160	5-1/2	160	G	1,388	--	--	C,W	S	
408	A. R. Knight	--	1890?	150	--	--	G	1,388	56.5	July 13, 1962	C,E	N	
* 501	J. K. Pruitt Estate	--	--	77	5	--	G	--	19.5	Feb. 6, 1937	N	N	No new sample collected. Abandoned about 1926

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*31-26-502	R. F. Ledbetter	W. D. Gray	1926	125	5-1/2	125	G	1,422	--	--	J,E, 4-1/4	D,S	
* 503	J. C. Thompson	do	--	70	6	--	G	--	54.0	Feb. 11, 1937	N	N	No new sample collected. Abandoned about 1950.
* 504	T. W. Mills	--	1923	106	10	106	G	1,500	--	--	N	N	
505	do	--	1900	110	6	110	G	--	15	--	N	N	
* 506	do	--	1920	110	6	--	G	1,536	74.2	May 3, 1962	J,E, 3/4	D,S	
507	do	--	1900	150	6	--	G	--	--	--	N	N	
508	do	--	1890	65	6	65	G	--	--	--	N	N	
* 509	Irven A. Gray	Luke Ledbetter	1961	90	8	90	G	1,411	18	--	J,E, 1/2	D,S	
* 510	do	Aubrey Ramshire	1938	160	6	160	G	1,412	18	--	C,E, 1/2	D,S	
* 511	Alfred Cole	--	--	70	5	--	G	1,496	34.2	May 30, 1962	J,E, 1/2	D,S	
* 512	J. D. Ridling	--	1959	138	6	138	G	1,549	--	--	C,E, 1/2	D	
* 601	P. C. Langford	--	1930	110	5	110	G	1,520	30	--	C,W	D,S	
* 602	R. L. Tuton	--	1908	121	N	121	G	1,449	40	--	J,E, 3/4	D,S	
603	G. E. Hall	Ector Water Co.	1962	100	10	14	G	1,557	--	--	S,E, 3/4	Ind	Used for waterflood supply.
* 604	do	do	1962	100	--	--	G	1,558	--	--	S,E, 3/4	Ind	Do.
701	T. L. Boles	--	1945	140	--	--	G	1,414	15.9	June 29, 1962	C,W	N	
* 702	J. R. Perry	--	1910	180	--	--	G	1,452	75	--	C,E, 3/4	D,S	
* 703	W. T. Hinson	Luke Ledbetter	1958	199	6	199	G	1,415	36.2	June 29, 1962	J,E, 1	D,S	
704	A. R. Knight	--	1880	90	6	--	G	1,416	--	--	C,G, 1-1/2	N	
* 705	Gunsight Cementery Assoc.	Luke Ledbetter	1961	215	5-1/2	215	G	1,402	8	--	S,E, 1/4	D	
* 706	J. H. Boles	Archie Kelly	1955	205	4-1/2	205	G	1,423	51.4	June 29, 1962	J,E, 1	D	

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
31-26-801	H. C. Thompson	--	1893	135	--	--	G	1,586	120.1	July 7, 1962	N	N	
802	do	--	1885	145	--	--	G	--	--	--	N	N	
803	do	Will Gray	1918	185	--	--	G	--	18.3	July 7, 1962	N	N	
* 804	M. A. Frost	--	1937	173	--	--	G	--	143.0	Feb. 11, 1937	N	N	Unable to locate. Assumed abandoned.
* 901	A. C. Thompson	--	--	120	6	120	G	1,597	65	--	C,E, 1/3	D,S	
* 902	R. A. Barker Estate	R. A. Barker	1920	30	30	30	Tr	1,608	14.1	June 9, 1962	B,H	D	Rock-lined dug well.
* 903	Mrs. M. E. Frasier Estate	-- Ramsey	1935	150	--	--	G	1,594	--	--	C,W	D,S	
* 904	R. B. Wymer	-- Norton	1950	50	5	50	G	1,552	6.2	Oct. 16, 1962	J,E, 1/2	D,S	
905	do	--	1920	50	5	50	G	1,560	--	--	N	N	
* 906	Mrs. Ola Frasier	-- Wagley	1947	192	--	--	G	1,621	140.6	May 30, 1962	C,E, 3/4	D,S	
* 27-101	Willis Knight	-- Jones	1933	12	40	12	All	--	11.2	Feb. 12, 1937	N	N	Unable to locate. Assumed abandoned. Dug well.
* 102	Mrs. Kit Gardenheim	--	1880	11	48	11	All	--	3.9	Feb. 10, 1937	N	N	Do.
* 103	G. M. Munnerlyn	--	1900?	100	6	100	G	1,517	24	--	J,E, 1/4	D,S	
104	do	Luke Ledbetter	1959	160	N	--	G	1,517	--	--	N	N	
* 105	A. W. Howton	Frank Bargsley	1942	140	5	140	G	1,452	48.8	Sept. 12, 1962	C,E, 1/2	D	
* 106	G. R. Langford	--	1956	150	4	150	G	1,562	116.5	June 14, 1962	J,E, ?	D	
* 201	J. B. Jones	-- Hilliard	1906	65	4-1/2	65	CC	1,487	25.3	May 25, 1962	N	N	
* 202	M. A. Truesdell	A. W. Sechrist	1921	19	78	19	G	1,454	10.5	May 24, 1962	N	N	Concrete-lined dug well.
* 203	J. C. Bradford	Henry Bradford	1906	19	48	19	All	1,447	9.3	Aug. 29, 1962	B,H	S	
* 204	Charlie Bobo	L. A. Sides	1932	100	5	100	CC	1,445	--	--	N	N	
* 205	W. L. Carey	--	1918	140	10	--	CC	1,473	98.7	June 14, 1962	C,W	S	
* 206	D. M. Stanford	--	1948	100	6	12	CC	1,499	27	--	C,E, 3/4	S	
* 207	C. L. Bargsley	Marvin Sides	1953	100	7	20	CC	1,453	51.9	May 24, 1962	J,E, 3/4	D	

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
31-27-208	C. L. Bargsley	--	1920	125	6	125	CC	1,456	--	--	C,W	S	
* 209	M. A. Truesdell	--	1910	18	--	--	All	1,445	14.2	May 24, 1962	J,E, 1/2	D,S	Rock-lined dug well.
* 210	do	--	1956	115	8	18	CC	1,448	10.1	July 19, 1962	J,E, 1	D,S	
211	do	--	1910	18	--	--	All	1,445	13.5	May 24, 1962	N	N	Rock-lined dug well.
* 212	Frank Bargsley	George Register	1955	100	--	--	CC	1,454	--	--	J,E	D	
213	do	Marvin Sides	1915	100	5	100	CC	1,454	--	--	C,W	D,S	
* 214	K. E. McDonald	--	1920	110	5	--	CC	1,471	18.8	June 4, 1962	C,W	D,S	
* 215	do	--	--	20	30	20	All	1,465	10.1	Sept. 9, 1962	N	N	Rock-lined dug well.
* 216	do	--	1945	105	6	--	CC	1,478	36.7	June 4, 1962	J,E, 3/4	D,S	
* 217	New Hope Baptist Church	G. E. Register	1961	110	5	110	CC	1,459	40.1	May 24, 1962	C,E, 1/2	D	Water level measured in abandoned well 50 ft. to northeast.
* 218	Robert Jackson	--	--	100	--	--	CC	1,483	--	--	C,W	S	
* 219	J. B. Jones	--	1947	130	4-1/2	130	CC	1,487	--	--	J,E, 3/4	D,S	
220	do	--	--	25	--	--	G	1,487	23.1	May 25, 1962	N	N	Rock-lined dug well.
* 221	J. C. Bradford	Frank Bargsley	1933	101	6	--	CC	1,451	28.5	Aug. 29, 1962	B,H	S	
* 222	Mrs. Artie Sherrill	Dean Brothers Oil Co.	1952	125	7	125	CC	1,463	--	---	S,E, 1	D,S	
223	do	--	1952	100	5	100	CC	1,457	33.0	May 24, 1962	N	N	
224	do	--	1952	100	5	100	CC	1,456	--	--	N	N	
225	Mrs. Ellen Justice	--	1923	--	--	--	--	1,429	13.4	June 23, 1962	C,W	N	Abandoned oil test. Beck #1. Plug-back depth unknown.
* 226	J. T. Justice	-- Norton	1947	125	--	--	CC	1,499	--	--	C,G, 1-1/2	S	
* 227	do	do	1947	100	5	--	CC	1,494	--	--	C,E, 1/2	D,S	
228	do	-- Jennings	1920	100	--	--	CC	1,489	--	--	N	N	
229	S. A. Davis	--	1910	100	5	100	CC	1,466	12.1	Aug. 22, 1962	N	N	
230	do	-- Norton	1955	100	5	100	CC	1,464	13.1	do	C,G, 1-1/2	S	

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
31-27-231	S. A. Davis	-- Hoover	1915	20	--	--	All	1,452	7.3	Aug. 22, 1962	B,H	S	Rock-lined dug well.
* 232	do	Unknown	1910	100	5	100	CC	1,449	8.5	do	C,W	S	
* 233	do	-- Hoover	1915	20	30	20	All	1,452	3.4	do	B,H	S	Rock-lined dug well.
* 234	Mrs. Ellen Justice	Texas Fidelity Oil Co.	1927	--	--	--	CC	1,465	--	--	C,E, 3/4	S	
* 301	do	--	1936	--	18	--	--	1,485	4.6	June 23, 1962	C,W	N	
* 302	do	Texas & Pacific Coal & Oil Co.	1919	450	8	--	CC,R, PS	1,469	--	--	C,W	S	
* 303	D. M. Stanford	Marshall Pipe & Supply Co.	1957	500	7	500	WM	1,449	200.8	April 19, 1962	C,W	S	
* 304	do	--	1910	21	--	--	All	1,431	10.6	do	B,H	S	Rock-lined dug well.
* 305	R. C. Stuard	Luke Ledbetter	1959	203	5	203	PS	1,521	59.8	May 25, 1962	C,G, 4	S	
* 306	do	--	1908	125	5	125	PS	1,539	49.2	do	C,W	S	
* 307	Joe Jackson	--	1959	50	7	50	R	1,503	6.1	Sept. 11, 1962	C,E, 1/4	D,S	
* 308	Mrs. Ellen Justice	-- Norton	1948	90	--	--	CC	1,471	--	--	C,E, 1/2	S	
* 309	do	--	1915	28	--	--	HC	1,448	18.0	June 23, 1962	C,W	S	Rock-lined dug well.
* 401	T. B. Miller	C. P. Powers	1900	30	24	18	Tr	1,593	19.8	June 7, 1962	J,E, 1/2	D,S	Do.
* 402	C. C. Jackson	-- Brumbalo	1926	79	5	79	Tr,G	1,613	27.0	Feb. 11, 1937	N	N	
* 403	A. A. Hardee	--	--	92	20	--	Tr,G	--	55.7	do	N	N	
* 404	C. C. Jackson	Marvin Sides	1956	95	6	95	Tr,G	1,613	35.3	June 15, 1962	J,E, 3/4	D,S	
405	Oliver Wesley	Bud Griffin & Frank Marion	1954	200	7	60	CC	1,587	--	--	C,W	N	
* 406	C. A. Brown	--	1890	75	6	60	G	1,552	45	--	C,W	D,S	
407	do	--	1908	35	6	30	Tr,G	1,594	25.6	June 15, 1962	N	N	
408	do	L. A. Sides	1935	120	6	120	CC	1,594	90.1	do	N	N	
* 409	A. A. Hardee	John Ed Conner	1961	80	6	80	G	1,577	8.4	do	N	N	
410	do	J. A. Caraway	1925	125	6	125	G	1,560	64.4	do	N	N	
411	do	--	1961	Surface	--	--	G	1,504	Flows	do	N	S	

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
31-27-412	W. H. Boney	--	1920	--	6	--	Tr,G	1,607	37.4	Oct. 4, 1962	N	N	
413	do	John Lester	1938	30	42	14	Tr	1,602	32.6	do	N	N	
* 414	S. L. Williamson	-- Norton	1948	86	6	86	G	1,609	62.8	July 2, 1962	J,E, 1/2	D,S	
* 415	G. E. Hall	Ector Water Co.	1962	215	10	14	G	1,594	--	--	J,E, 3/4	S, Ind	Used for waterflood supply.
* 416	do	do	1925	215	10	14	G	1,601	--	--	S,E, 3/4	S, Ind	Do.
* 417	do	do	1962	75	10	10	G	1,567	--	--	S,E, 3/4	Ind	Do.
* 418	do	do	1960	215	10	14	G	1,602	--	--	S,E, 3/4	Ind	Do.
* 419	do	do	1960	215	10	14	G	1,594	--	--	S,E, 3/4	Ind	Do.
* 420	do	do	1960	215	10	14	G	1,593	--	--	S,E, 3/4	Ind	Do.
* 421	do	do	1960	215	7	215	G	1,588	--	--	S,E, 3/4	Ind	Do.
* 422	A. A. Hardee	John Ed Conner	1962	145	6	130	G	1,581	50.0	Sept. 17, 1962	S,E, 1	D,S	
* 423	G. E. Hall	Ector Water Co.	1960	215	10	14	CC	1,578	51.2	July 11, 1962	S,E, 3/4	--	Used for waterflood supply.
* 424	do	do	1960	215	10	14	CC	1,568	--	--	S,E, 3/4	--	Do.
* 501	C. T. Botts	Frank Sides	1924	131	7	100	CC	1,572	39.7	April 23, 1962	N	N	
* 502	Unknown	Frank Dupree	1903	69	3-1/2	--	Tr,HC	--	30.0	Feb. 24, 1937	N	N	Unable to locate. Assumed abandoned.
* 503	do	Humble Oil Co.	1920	100	18	--	CC	--	20.0	do	N	N	Do.
* 504	C. L. Bargsley	--	1910	100	6	100	CC	1,490	--	--	J,E, 3/4	S	
* 505	Frank Bargsley	Frank Bargsley	1948	54	6	54	CC	1,529	--	--	C,W	S	
* 506	C. C. Veale	--	1880	75	6	9	CC	1,501	--	--	C,E, 3/4	D,S	
* 507	N. L. Moore	--	--	80	--	--	CC	1,491	65	--	J,E, 1/2	D	
* 508	C. N. Dempsey	-- Brumbalo	1928	80	6	80	CC	1,562	--	--	J,E, 1	D,S	

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of Water	Remarks
31-27-509	C. N. Dempsey	--	1937	100	6	3	CC	1,490	--	--	C,W	N	
* 510	J. W. Veale	Madison Bargsley	1930	168	5	60	CC	1,571	--	--	C,G, 1-1/4	D,S	
* 511	Wesley Dempsey	--	1936	120	6	--	CC	1,532	--	--	J,E, 1	D,S	
* 512	A. H. Boney	--	1900	58	6	58	HC	1,537	38	--	C,W	S	
* 513	do	--	1918	68	6	68	HC	1,534	38	--	J,E, 1	D	
* 514	H. L. Caraway	--	1910	180	--	--	CC	1,484	--	--	C,H	N	
* 515	Don Bradford	-- Norton	1949	95	6	95	CC	1,570	--	--	C,E, 1/2	D,S	
516	do	--	1945	175	12-1/2	100?	CC	1,569	100.8	Sept. 24, 1962	C,G, 2-1/2	N	
517	do	Madison Bargsley	1945	115	6	155	CC	1,571	71.4	June 5, 1962	N	N	
* 701	J. L. Ready	--	1909	41	6	--	Tr	1,601	29.4	Feb. 11, 1937	N	N	
* 702	C. C. Goforth	-- Collins	--	19	36	19	Tr	1,580	12.1	Oct. 4, 1962	N	N	Rock-lined dug well.
* 703	W. H. Boney	-- Ford	1933	182	6	--	CC	1,570	34.7 44.4	June 8, 1962 Aug. 4, 1962	J,E, 1/2	D,S	
* 704	H. C. Wilkinson	--	1918	153	5	40	CC	1,572	--	--	C,W	N	
705	do	--	1953	100	--	--	CC	1,562	--	--	C,W	N	
* 706	do	G. E. Register	1961	168	6	168	CC	1,571	23	--	J,E, 3/4	D,S	
* 707	C. N. Adams	-- Norton	1940	60	6	60	G	1,594	40	--	J,E	D,S	
* 708	J. L. Ready	--	--	200	--	--	CC	1,591	28.1	June 7, 1962	S,E, 1-1/2	S	
709	C. E. Boney	M. C. Boney	1933	14	17	9	Tr	1,578	11.5	June 6, 1962	N	N	Rock-lined dug well.
* 710	do	do	1936	24	--	--	Tr	1,595	23.2	do	J,E, 1/4	D,S	Do.
* 711	J. A. Ridling	Marvin Sides	1956	98	5	98	CC	1,609	43	--	J,E	D,S	
* 712	C. C. Goforth	C. C. Goforth	1923	21	36	21	Tr	1,581	5.5	June 6, 1962	B,H	D,S	Rock-lined dug well.
* 713	do	G. E. Register	1945	57	6	57		1,576	10.3	do	B,H	D,S	
* 714	Hames Estate	do	1959	81	6	72	CC	1,588	24.6	Oct. 5, 1962	C,W	S	

See footnote at end of table.

Table 3.--Records of wells and springs, Stephens County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water level: Below land-surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*31-27-715	Mrs. Miley E. Williams	--	1900	40	42	40	Tr	1,588	27.8	April 26, 1962	B,H	D,S	
* 716	J. D. Eakin	--	1960	88	5	88	CC	1,600	34.4	June 7, 1962	N	N	
* 717	do	--	1850	30	36	30	Tr	1,584	21.4	do	C,W	D,S	Rock-lined dug well.
718	J. L. Ready	--	--	60	8	60	Tr,G, HC	1,601	--	--	N	N	
* 719	do	--	--	60	8	60	Tr,G, HC	1,603	31.3	June 7, 1962	J,E, 1	D,S	
* 720	Mrs. Ora Holder	-- Hefflin	1940	65	6	65	Tr,G, HC	1,591	--	--	C,W	D,S	
* 721	do	do	--	65	6	65	Tr,G, HC	1,589	31.0	June 7, 1962	C,W	S	
* 801	Bullock School	--	--	22	36	19	CC	1,554	12.5	June 4, 1962	Cf,E, 1/2	D	
* 802	B. R. Hatton	G. E. Register	1956	118	5	--	PS	1,541	83	--	C,E,?	D	
803	do	--	1962	245	10	240	PS	1,538	120	--	C,G, 7-1/2	S	Old oil test. Hatton #1 plugged back to 245 ft.
804	Paul Smith	--	1918	285	--	--	PS,W, WM	1,545	--	--	N	N	
* 805	Mrs. W. W. Hatton	G. E. Register	1962	400	5-1/2	400	WM	1,559	246.7	April 25, 1962	S,E, 1-1/2	D	
806	do	W. W. Hatton	1930	12	54	12	CC	1,552	5.8	Sept. 19, 1962	N	N	Rock-lined dug well.
* 807	Rudy Wells	--	1860	--	--	--	HC	1,584	24.8	June 5, 1962	B,H	S	Do.
* 808	N. L. Sudderth	John Gray & Marvin Sides	1954	375	6	360	WM	1,543	--	--	C,E, 1	D,S	
809	J. A. Ridling	--	--	50	7	--	Tr	1,600	38	--	N	N	Old oil test plugged back to 50 ft.
* 28-101	Mrs. William Graham Estate	--	1902	23	30	23	All	--	11.8	Feb. 17, 1937	N	N	Unable to locate. Assumed abandoned.
102	do	--	1890	107	5	--	PS	--	81.8	do	N	N	Do.
* 103	Mrs. C. Lambert	Roy Johnson	1947	365	5	350	WM	1,511	--	--	C,E, 1	D,S	
104	Robert Jackson	--	1910	100	5	60	CC	1,477	--	--	C,W	N	
105	Mrs. L. C. Link	--	--	Surface	--	--	R	1,513	Flows	Sept. 26, 1962	N	N	Wet weather spring.

* See Table 4 for chemical analysis of the water.

Table 4.--Chemical analyses of water from wells and springs, Stephens County

(Analyses given are in parts per million except specific conductance, pH, percent sodium, and SAR)

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium* (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C.)	pH	SAR
30-08-601[b]	Southwestern Gas Products Co.	170	3-19-62	26	--	111	13	29	370	25	40	0.3	9.7	436	330	16	735	6.9	0.7
602[b]	do	70	do	27	--	110	14	40	406	20	37	.4	14	462	332	21	775	6.8	1.0
801[c]	D. G. Stover	36	2- 9-37	--	--	--	--	--	439	814	560	--	--	2,389	--	--	--	--	--
802[b]	Lester Clark	47	3-13-62	15	--	197	41	141	480	246	220	.1	8.7	1,100	660	32	1,750	6.9	2.4
803[b]	do	47	5-31-62	18	--	205	56	181	408	474	202	.4	28	1,370	742	35	2,010	7.0	2.9
805[b]	A. W. Tipton	48	do	11	--	167	39	130	340	246	182	.4	44	1,020	577	33	1,580	7.0	2.4
24-801[c]	P. B. Loving	35	2-16-37	--	--	302	114	706	415	808	1,120	--	--	3,254	1,226	--	--	--	--
31-01-401[b]	Weldon Powers	133	4-26-62	9.3	--	345	121	1,830	108	0	3,720	--	--	6,080	1,360	75	10,700	7.3	22.0
501[b]	W. D. Boyd	36	3-20-62	16	--	126	26	63	286	42	178	.2	37	629	422	25	1,130	7.0	1.3
02-601[a]	Mrs. J. T. McDonald	60	7-17-62	15	--	260	68	620	386	274	1,204	.3	34	2,631	930	--	4,650	7.8	--
801[a]	B. H. Trammell	24	7-21-62	12	--	329	81	294	285	687	430	.4	164	2,156	1,152	--	3,150	8.5	--
03-501[b]	Mrs. Elon Rickles	144	4- 6-62	13	--	108	67	529	516	189	760	.5	2.2	1,920	545	68	3,270	7.5	9.8
601[c]	Ed Ford	127	3-17-37	--	--	28	32	287	281	226	255	--	--	966	200	--	--	--	--
[a]		150	8-22-62	20	--	63	22	184	406	131	124	.4	< .4	744	246	--	1,165	7.5	--
602[c]	do	148	3-17-37	--	--	--	--	--	348	179	142	--	--	761	--	--	--	--	--
603[c]	H. J. Wesley	166	do	--	--	--	--	--	250	58	174	--	--	559	--	--	--	--	--
604[b]	S. E. Copeland	160	4- 5-62	13	--	120	35	146	442	202	132	.8	.0	866	444	42	1,370	6.8	3.0
605[b]	Ed Ford	160	do	8.2	--	185	50	379	474	453	430	.4	29	1,770	667	55	2,720	7.3	6.4
606[a]	do	160	8-22-62	18	--	78	34	281	420	245	240	.5	3.8	1,107	344	--	1,740	7.6	--
609[b]	Lee Burgess	132	4- 6-62	16	--	52	26	312	426	226	232	.7	.8	1,070	236	74	1,740	7.3	8.8
610[a]	Ben Burgess	160	8-24-62	17	--	86	42	203	370	173	232	.4	< .4	935	387	--	1,540	7.7	--
614[b]	Ed Ford	140	4- 5-62	13	--	298	81	516	340	496	920	.4	129	2,620	1,080	51	4,080	7.2	6.8
615[b]	H. J. Wesley	150	do	7.6	--	44	19	729	384	215	870	1.0	6.2	2,080	188	89	3,600	7.4	23.0
802[b]	Edmond Corbett	126	6-26-62	13	--	46	24	480	420	170	525	1.1	.2	1,460	214	83	2,490	7.4	14
803[b]	do	126	do	14	8.6	76	27	133	416	58	132	1.0	.0	646	300	49	1,100	7.2	3.3
804[b]	J. B. Collins	105	6-28-62	18	3.9	68	35	166	404	36	216	.8	.0	739	314	54	1,390	7.4	4.1
901[b]	H. F. Cook	22	4- 7-62	17	--	92	9.0	4.6	304	13	11	.4	.2	297	266	24	500	6.9	.1

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Stephens County--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium* (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C.)	pH	SAR
31-04-401a/	W. A. Gragg	165	8-22-62	22	--	126	39	235	462	262	220	0.3	< .4	1,132	379	--	1,770	7.4	--
403a/	Mrs. Emili C. Jones	140	8-21-62	7	--	32	8	52	68	16	112	.2	< .4	260	114	--	512	7.0	--
701b/	Lloyd Potts	170	4- 7-62	11	--	56	19	1,250	470	201	1,650	1.9	1.5	3,420	218	93	5,740	7.4	37
09-201b/	Mrs. Ada Ball	43	3-31-62	15	--	232	3232	175	406	66	480	.3	16	1,220	710	35	2,190	6.8	2.9
10-201a/	B. H. Trammell	24	7-21-62	18	--	234	57	221	325	393	418	.4	17	1,518	820	--	2,500	8.1	--
202a/	Jack Black	20	do	18	--	457	81	357	287	634	950	.3	< .4	2,368	1,474	--	4,150	8.1	--
203a/	do	28	do	24	--	377	195	714	583	1,162	1,230	.4	3.1	3,992	1,740	--	6,020	7.9	--
204a/	do	20	do	17	--	457	85	420	290	706	944	.1	< .4	2,772	1,490	--	4,350	7.9	--
701c/ b/	Travis Robbins	96 98	2-12-37 3-31-62	-- 17	-- --	31 22	19 19	230 239	488 468	77 73	128 131	-- 1.9	-- 2.8	725 736	157 133	-- 80	-- 1,220	-- 7.8	-- 9.0
702b/	Mrs. J. E. Townsend	120	do	18	--	32	22	175	450	39	97	1.3	2.0	607	170	69	1,030	7.4	5.8
704b/	David Cahill	150	do	12	--	13	7.9	288	608	46	96	2.4	2.8	767	65	91	1,270	7.7	16
706b/	Thurman Latham	109	4- 2-62	14	--	12	9.2	231	492	37	86	2.3	1.2	635	68	88	1,070	7.6	12
11-601b/ c/	E. E. Mitchell	127 127	6-28-62 3-18-37	10 --	-- --	29 --	15 --	885 --	480 439	120 124	1,090 990	-- --	2.5 --	2,390 2,084	134 --	93 --	4,170 --	7.6 --	33 --
701c/	D. W. Deaver	56	do	--	--	--	--	--	281	39	84	--	--	417	--	--	--	--	--
801c/	C. M. Caldwell	72	do	--	--	138	33	--	122	< 10	246	--	--	476	480	--	--	--	--
803b/	G. D. Devenport	18	6-25-62	17	--	265	64	609	416	728	780	--	61	2,730	924	59	4,090	7.2	8.7
12-101b/	S. G. Copeland	150	6-28-62	8.3	--	9.5	3.6	598	500	58	608	2.8	3.5	1,540	38	97	2,720	7.4	42
102b/	do	137	do	9.8	--	13	5.4	427	520	91	325	1.3	1.5	1,130	54	94	1,940	7.6	25
17-201a/	Gilbert Ridings	190(?)	7-20-62	11	--	32	17	308	329	160	235	.4	< .4	939	150	--	1,650	8.5	--
301c/	D. C. Edwards Estate	138	3-17-37	--	--	74	26	1,040	512	81	1,450	--	--	2,923	291	--	--	--	--
302b/	B. F. Dickson	95(?)	6-16-62	8.2	4.6	48	17	1,740	322	35	2,600	--	--	4,610	190	95	8,000	7.2	55
501a/	Mrs. Myrtle E. Conner	120	7-20-62	11	--	37	19	1,225	454	375	1,430	.6	< .4	3,333	168	--	5,700	8.6	--
18-101b/	J. D. Collins	135	4- 4-62	19	--	54	38	116	548	21	49	.7	1.5	568	291	46	953	7.3	3.0
102b/	T. D. Fambrough	120	6-19-62	18	--	44	18	134	366	41	92	1.2	.2	528	184	61	887	7.1	4.3
103b/	do	80	do	1.5	9.8	28	20	149	146	116	166	.6	0	553	152	68	983	7.2	5.3
104b/	Jack Fambro	80	6-21-62	20	--	77	26	151	420	104	121	.5	3.8	710	299	52	1,170	7.1	3.8
105b/	Ellis Hope	153	6-19-62	19	--	275	38	264	420	19	745	.4	1.2	1,570	842	41	2,870	6.6	4.0

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Stephens County--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium* (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C.)	pH	SAR
31-18-106[b]	Ellis Hope	100	6-19-62	19	--	292	37	244	566	96	510	0.3	162	1,640	880	38	2,690	6.4	3.6
107[b]	C. D. Griggs	128	6-18-62	15	13	348	26	131	544	22	560	.2	.0	1,370	976	23	2,450	6.9	1.8
[a]		128	9-21-62	19	--	816	123	754	466	211	1,990	.1	845	4,988	2,542	--	7,090	7.3	--
108[c]	C. A. Fore	75	2-10-37	--	--	16	31	142	329	50	110	--	--	511	169	--	--	--	--
[a]		75	7-17-62	21	--	49	26	145	407	31	110	.5	< .4	582	228	--	1,057	7.9	--
201[b]	John Vick	100	6-19-62	19	--	180	29	317	472	202	460	.4	12	1,450	568	55	2,420	6.9	5.8
203[b]	George Masters	150	6-18-62	20	--	129	33	137	520	16	219	.4	4.5	815	458	39	1,430	7.1	2.8
204[b]	do	70	do	8.2	29	107	23	167	444	13	245	.7	.0	782	362	50	1,420	7.0	3.8
501[c]	L. Williams	200	2-10-37	--	--	85	29	1,336	476	751	1,470	--	--	3,905	333	--	--	--	--
601[c]	S. T. Swenson	90	2-19-37	--	--	2	1	459	647	245	160	--	--	1,185	11	--	--	--	--
[b]		90	6-20-62	9.2	--	7.5	2.8	413	600	218	145	1.8	1.0	1,090	30	97	1,760	7.7	33
602[b]	J. D. Cox	200	6-15-62	8.6	--	27	10	1,360	512	269	1,680	--	.5	3,610	108	96	6,110	7.2	57
603[a]	Floyd Vick	120	7-18-62	12	--	6	3	620	700	284	280	.8	< .4	1,572	150	--	1,650	8.6	--
605[c]	S. T. Swenson	Dug 34	2-19-37	--	--	21	11	125	146	104	100	--	--	433	97	--	--	--	--
606[b]	L. C. Burke	185	6-16-62	7.4	--	63	23	2,240	390	4.0	3,400	--	--	5,930	252	95	10,100	7.2	61
607[b]	do	210	do	8.3	--	64	22	2,210	402	.0	3,350	--	--	5,850	250	95	9,910	7.1	61
701[a]	Mrs. M. M. Carey	100	10- 9-62	7.5	--	30	14	1,379	315	5	2,000	1.5	2.2	3,592	132	--	4,610	7.4	--
702[a]	Alex Fambro	150	7-13-62	16	--	26	12	216	315	66	173	.6	< .4	683	118	--	1,165	8.6	--
802[c]	T. C. Fambro	60	2- 5-37	--	--	52	26	150	342	116	114	--	--	626	235	--	--	--	--
805[a]	Alex Fambro	100	7-13-62	11	--	16	6	616	393	350	470	2	4.0	1,692	68	--	2,750	8.7	--
806[a]	do	140	do	11	--	5	2	385	373	24	356	.6	< .4	986	20	--	1,760	8.6	--
807[b]	Jess Fambro	150	6-22-62	10	--	10	3.8	500	436	356	280	1.4	1.0	1,380	40	96	2,240	7.5	34
901[c]	C. McCauley	14	2-10-37	--	--	--	--	--	232	< 10	14	--	--	212	--	--	--	--	--
902[b]	G. E. Langford	130	6-15-62	8.6	--	85	43	1,110	372	1,870	380	--	4.8	3,680	389	86	4,990	7.2	24
903[b]	I. C. Peeks	190	6-14-62	6.6	.12	30	11	903	346	302	1,050	--	3.6	2,480	120	94	4,200	7.4	36
904[b]	Hal Langford	150	6-15-62	15	--	69	18	25	280	16	38	.6	.0	320	246	18	567	7.1	.7
906[b]	E. D. Morgan	150	6-18-62	10	--	44	14	1,300	386	338	1,650	--	2.5	3,550	168	94	5,970	7.2	44
908[a]	G. E. Langford	148	9-15-62	16	--	568	248	499	627	1,727	760	.1	< .4	4,127	2,438	--	4,950	6.9	--
910[c]	Floyd Vick	110	2-10-37	--	--	--	--	--	464	220	160	--	--	942	--	--	--	--	--

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Stephens County--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium* (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C.)	pH	SAR
31-19-301c/	R. M. Rogers	89	2-15-37	--	--	3	2	343	628	54	136	--	--	847	17	--	--	--	--
302b/	Otis Hodges	33	6-12-62	15	--	174	30	66	494	78	148	0.3	5.9	760	558	20	1,320	6.6	1.2
303c/	R. M. Rogers	135	2-17-37	--	--	29	11	1,250	976	< 10	1,440	--	--	3,210	117	--	--	--	--
304b/	D. L. Nelms	200	6-12-62	11	--	41	9.1	243	526	76	108	1.5	2.6	751	140	79	1,280	7.2	8.9
305b/	R. J. Carey	166	do	10	1.2	26	13	602	408	38	740	2.4	2.8	1,640	118	92	2,900	7.2	24
306a/	Garland Coody	175	8- 6-62	11	--	22	16	1,093	775	116	1,291	5.0	< .4	2,935	121	--	4,800	8.1	--
307b/	R. M. Rogers	65	6-12-62	13	--	164	4.9	37	500	28	36	.3	22	551	429	16	905	6.6	.8
308b/	Garland Coody	150	6-13-62	9.0	1.5	20	11	1,130	784	49	1,320	--	.2	2,930	95	96	4,990	7.4	50
309c/ b/	J. R. Coody	82 100	2-17-37 6-13-62	-- 12	-- --	17 17	11 8.8	164 158	378 356	54 49	54 53	-- .9	-- 3.5	486 477	87 78	-- 81	-- 792	-- 7.1	-- 7.8
310c/ b/	J. M. Luttrell	24 24	2-15-37 6-12-62	-- 9.1	-- 8.4	-- 166	-- 15	-- 159	110 316	27 32	615 374	-- .3	-- --	1,089 910	-- 476	-- 42	-- 1,650	-- 6.8	-- 3.2
311b/	J. M. Rogers	20	do	18	--	305	33	553	418	20	1,230	--	.5	2,370	896	57	4,180	6.8	8.0
401c/	R. A. Sorgee Estate	340	2-19-37	--	--	18	9	1,023	616	350	1,020	--	--	2,723	80	--	--	--	--
402c/	Garland Coody	84	do	--	--	--	--	--	439	123	275	--	--	964	--	--	--	--	--
502a/	R. J. Carey	134	9- 4-62	15	--	199	113	604	373	363	1,121	.3	< .4	2,599	960	--	4,100	7.4	--
503b/	Mrs. Albert Smith	30	6-13-62	16	--	122	21	59	444	54	67	.4	4.2	562	391	25	928	7.1	1.3
504a/	Elmer Hudspeth	65	8-28-62	10	--	98	61	435	531	385	415	.3	< .4	1,665	497	--	2,540	7.7	--
602a/	Mrs. L. C. Link	141	7-10-62	11	--	8	5	539	512	243	349	7.5	< .4	1,426	39	--	2,360	8.5	--
603b/	Garland Coody	120	6-13-62	20	25	174	39	103	420	119	246	.9	1.2	910	594	27	1,540	6.6	1.8
604b/	J. R. Coody	100	6-26-62	12	.74	99	13	29	344	47	23	.3	.2	392	300	18	673	6.9	.7
803b/	D. B. Raney	1,000	4-19-62	9.3	--	11	7.2	754	806	290	520	--	.2	1,990	57	97	3,260	7.8	43
901b/	D. M. Stanford	199	do	11	--	11	6.8	770	768	353	520	--	.2	2,050	56	97	3,310	7.7	45
902b/	D. B. Raney	200	do	12	--	180	5.4	82	454	62	150	.2	.2	715	471	27	1,230	7.1	1.6
904b/	Mrs. L. C. Link	75	7-10-62	17	--	33	19	108	320	89	13	.6	.4	431	163	--	704	7.0	--
905b/	W. H. Birdwell	629	11- 2-62	3.5	--	140	67	4,552	71	13	7,376	1.5	< .4	12,188	624	--	10,430	7.4	--
20-101c/	H. C. Thompson	98	2-17-37	--	--	74	41	61	427	33	50	--	--	469	356	--	--	--	--
102b/	do	140	6-13-62	15	--	86	9.1	29	332	18	14	.3	4.8	339	252	20	550	7.2	.8
103c/	do	Dug 35	2-17-37	--	--	--	--	--	183	85	385	--	--	872	--	--	--	--	--

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Stephens County--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium* (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C.)	pH	SAR
31-20-103b/	H. C. Thompson	Dug 35	6-13-62	15	--	368	22	65	286	116	225	0.3	590	1,540	1,010	12	2,250	7.0	0.9
105b/	Lee Mitchell	368	do	9	--	32	17	1,500	592	158	1,960	--	.5	3,970	150	96	6,720	7.2	53
106b/	do	140	do	14	--	46	16	176	396	79	108	1.5	1.2	637	181	68	1,040	7.2	5.7
401a/	Mrs. L. C. Link	91	7-10-62	19	--	63	17	32	307	21	15	.2	1.8	324	228	--	557	8.4	--
402a/	do	61	do	15	--	105	5	6	315	14	6	.2	4.0	315	283	--	565	8.4	--
403a/	do	Spring	do	15	--	83	7	8	266	10	11	.2	4.0	269	235	--	428	7.9	--
404a/	do	339	do	10	--	11	13	787	561	349	632	5	< .4	2,107	82	--	3,430	8.6	--
405a/	do	298	do	10	--	7	2	550	556	99	411	3	< .4	1,380	28	--	2,290	8.7	--
406a/	do	72	do	17	--	65	16	41	306	31	16	.2	< .4	349	230	--	600	8.5	--
701c/	Lone Star Gas Co.	365	2-18-37	--	--	2	6	319	573	58	136	--	--	803	29	--	--	--	--
703a/	Mrs. L. C. Link	273	7-10-62	11	--	14	5	930	681	167	942	5	< .4	2,440	55	--	3,950	8.6	--
705a/	do	330	do	10	--	6	2	649	637	56	556	7.5	1.8	1,627	25	--	2,780	8.6	--
706b/	Joe Jackson	90	6- 2-62	5	--	3.8	2.1	293	584	102	41	1.4	.2	742	18	97	1,200	8.3	30
709a/	D. D. Vaughn	120	9-20-62	9	--	3	2	317	609	138	34	1.7	2.9	813	16	--	1,280	8.5	--
801a/	T & P Coal & Oil Co.	225	7-10-62	10	--	3	--	261	490	54	57	.7	< .4	648	8	--	1,065	8.6	--
803a/	E. W. Hohhertz	22	do	11	--	116	8	57	246	23	146	.2	4.0	486	322	--	904	8.1	--
25-201b/	Mrs. O. R. Wallis	12	6-16-62	30	--	114	45	74	380	188	85	.8	1.2	725	470	25	1,160	6.9	1.5
202a/	G. B. Greiner	75	6- 2-62	22	--	86	40	89	390	114	85	1.5	13.5	643	320	--	1,152	8.0	--
301c/	Noble Robertson	6	2- 8-37	--	--	--	--	--	220	31	24	--	--	261	--	--	--	--	--
501a/	Jesse Garrett	158	7-11-62	9	--	26	7	303	358	118	205	.4	20	880	95	--	1,460	8.6	--
602a/	A. R. Knight	330	7-13-62	5	--	35	5	123	178	14	149	.6	1.3	420	110	--	780	7.3	--
903b/ c/	S. H. Boles	140 72	6-29-62 1-28-37	12 --	-- --	3 3	1 4	357 374	476 549	47 20	244 260	1.1 --	1.0 --	900 931	12 22	99 --	1,560 --	7.9 --	45 --
904b/	Lester Thorpe	200	6-29-62	9.1	--	2.5	.7	294	468	69	134	1.1	1.2	742	9	99	1,260	8.0	43
905b/	Mrs. M. H. Thorpe Estate	206	do	11	--	3.2	1.1	306	456	86	150	1.1	1.2	784	12	98	1,330	7.9	38
906b/	G. W. Thorpe	205	do	11	--	3.0	1.0	289	376	127	140	.8	1.2	758	12	98	1,280	7.8	36
907b/	do	175	do	11	--	3.5	.9	273	380	111	124	.9	1.0	712	12	98	1,210	7.7	34
26-101c/	Alex Fambro	131	3- 9-37	--	--	21	12	310	427	97	230	--	--	880	103	--	--	--	--

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Stephens County--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Cal-cium (Ca)	Magne-sium (Mg)	Sodium* (Na)	Bicar-bonate (HCO_3)	Sul-fate (SO_4)	Chlo-ride (Cl)	Fluo-ride (F)	Ni-trate (NO_3)	Dis-solved solids	Total hard-ness as $CaCO_3$	Per-cent so-dium	Specific conduct-ance (micromhos at 25°C.)	pH	SAR
31-26-101a/	Alex Fambro	131	7-13-62	13	--	12	9	380	381	99	329	0.8	0.4	1,043	75	--	1,800	8.5	--
102c/	Joseph E. Rumsey	135	2- 8-37	--	--	18	10	845	512	77	1,010	--	--	2,212	86	--	--	--	--
103c/	Paul Wagley	192	do	--	--	16	6	854	549	15	1,030	--	--	2,191	61	--	--	--	--
a/		192	10-27-62	10	--	1	9	777	528	3	925	1.5	< .4	1,986	42	--	2,910	8.0	--
109b/	E. C. Head	135	6-21-62	9.5	--	22	9.4	847	508	48	1,040	--	.5	2,230	94	95	3,840	7.3	38
110b/	Joseph E. Rumsey	200	do	11	--	11	4.8	551	532	27	550	1.9	.8	1,420	47	96	2,470	7.5	35
111a/	A. R. Knight	65	7-13-62	22	--	247	90	297	378	630	470	.4	< .4	1,942	990	--	2,920	7.9	--
201c/	O. R. Gilbert	185	3- 9-37	--	--	206	72	--	85	226	340	--	--	886	809	--	--	--	--
b/		185	6-22-62	23	--	102	26	79	358	146	61	.4	--	613	362	32	980	7.2	1.8
202c/	Mrs. Willie Sykes	120	2- 6-37	--	--	--	--	--	281	100	70	--	--	481	--	--	--	--	--
203b/	J. W. Jackson	160	6-25-62	21	--	236	22	54	406	396	35	1.0	--	965	680	15	1,390	7.0	.9
204a/	Alex Fambro	100	7-13-62	13	--	68	25	96	344	78	67	.2	1.3	525	273	--	872	8.4	--
205a/	do	100	do	16	--	65	29	96	315	96	66	.4	1.3	534	278	--	880	8.5	--
206c/	O. R. Gilbert	180	3- 9-37	--	--	--	--	--	336	144	78	--	--	601	--	--	--	--	--
207c/	Wayland School (County or State)	180	do	--	--	54	24	79	165	175	64	--	--	477	235	--	--	--	--
208c/	T. C. Fambro	165	do	--	--	84	23	82	354	85	74	--	--	522	304	--	--	--	--
209b/	G. M. Lauderdale	135	6-22-62	24	--	116	29	62	360	158	59	.4	--	625	409	25	985	7.1	1.3
210b/	do	120	do	23	--	138	29	68	364	210	66	.3	--	713	464	24	1,090	7.0	1.4
214a/	Alex Fambro	152	7-13-62	18	--	64	29	123	305	74	133	.4	4.0	602	280	--	1,050	8.4	--
215b/	D. M. Duncan	94	6-22-62	24	--	98	29	46	418	59	41	.8	.8	505	364	22	836	6.8	1.0
216c/	E. C. Head	180	3- 9-37	--	--	56	23	140	366	128	74	--	--	601	234	--	--	--	--
b/		180	6-21-62	21	--	80	22	75	334	81	66	.5	.2	510	290	36	845	7.1	1.9
219b/	T. G. Gilbert	115	6-22-62	20	22	243	30	55	454	380	57	.2	.0	1,010	730	14	1,430	6.9	.9
221b/	O. R. Gilbert	156	7- 7-62	22	--	110	28	85	364	177	64	.4	.0	665	390	32	1,050	7.0	1.9
222b/	J. W. Jackson	160	6-25-62	.8	--	26	13	85	60	62	134	.2	.0	351	118	61	671	6.9	3.4
301b/	D. E. Turner	150	6-14-62	10	--	21	9.4	452	378	428	222	1.0	3.8	1,330	91	92	2,130	7.2	21
302b/	do	125	do	10	--	27	13	465	364	470	242	.9	.8	1,410	121	89	2,250	7.0	18
303b/	B. G. Langford	150	do	12	--	16	7.2	429	402	388	190	.3	.0	1,240	70	93	1,930	7.5	22
304a/	C. B. Greenlee	134	7-13-62	17	--	206	43	127	449	443	79	.2	< .4	1,136	680	--	1,630	8.3	--

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Stephens County--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Cal-cium (Ca)	Magne-sium (Mg)	Sodium* (Na)	Bicar-bonate (HCO_3)	Sul-fate (SO_4)	Chlo-ride (Cl)	Fluo-ride (F)	Ni-trate (NO_3)	Dis-solved solids	Total hard-ness as $CaCO_3$	Per-cent so-dium	Specific conduct-ance (micromhos at 25°C.)	pH	SAR
31-26-401c/	A. F. Billman	158	2- 8-37	--	--	9	2	530	671	70	400	--	--	1,341	32	--	--	--	--
402c/	J. C. Rominger	149	2- 6-37	--	--	11	4	765	531	< 10	900	--	--	1,941	42	--	--	--	--
a/		Over 200	7-19-62	11	--	11	3	780	478	6	939	1.0	<0.4	2,000	45	--	3,500	8.6	--
403a/	Paul Wagley	198	6- 2-62	12	--	7	5	500	517	20	465	1.5	< .4	1,266	40	--	2,280	8.1	--
404d/	C. F. Hogan	210	8-21-58	--	--	74	34	2,215	461	147	3,275	--	--	6,206	--	93	--	8.3	--
b/		210	6-21-62	9.8	--	74	22	2,160	448	22	3,250	--	--	5,760	276	94	9,280	7.2	57
405a/	K. D. Pilgrim	200	6-11-62	15	--	9	4	445	515	23	395	1.3	< .4	1,145	37	--	2,150	7.7	--
407a/	Alex Fambro	160	7-13-62	9	--	5	2	523	559	36	442	2	< .4	1,316	22	--	2,270	8.6	--
501c/	J. K. Pruitt Estate	77	2- 6-37	--	--	44	10	493	561	70	490	--	--	1,383	151	--	--	--	--
502c/	R. F. Ledbetter	125	2-11-37	--	--	--	--	--	220	392	102	--	--	895	--	--	--	--	--
a/		125	6-11-62	28	--	178	56	118	365	453	95	.1	< .4	1,108	675	--	1,600	7.1	--
503c/	J. C. Thompson	70	2-11-37	--	--	--	--	--	201	220	43	--	--	544	--	--	--	--	--
504c/	T. W. Mills	106	do	--	--	--	--	--	104	282	310	--	--	971	--	--	--	--	--
506a/	do	110	6- 9-62	21	--	112	27	64	320	107	81	.2	30	600	390	--	1,035	7.2	--
509b/	Irven A. Gray	90	5-29-62	23	--	202	20	38	468	222	38	.3	.0	773	586	12	1,150	6.7	.7
510b/	do	160	do	20	--	200	20	43	410	258	50	.4	.2	794	582	14	1,170	7.0	.8
511b/	Alfred Cole	70	6-22-62	7	138	1,220	159	1,730	2	167	5,160	--	--	8,440	3,700	50	13,800	4.7	12
512a/	J. D. Ridling	138	6- 9-62	22	--	33	19	94	303	13	66	.6	< .4	397	160	--	735	7.1	--
601a/	P. C. Langford	110	do	24	--	136	34	77	366	253	42	.4	< .4	746	480	--	1,200	7.4	--
602a/	R. L. Tuton	121	do	18	--	168	29	106	405	340	76	.3	< .4	936	504	--	1,450	7.1	--
604a/	G. E. Hall	100	7-11-62	15	--	128	26	25	244	238	38	.4	1.8	592	428	--	1,030	7.7	--
702b/	J. R. Perry	180	6-29-62	9.4	--	9	3.1	479	482	72	425	2.1	2.5	1,240	36	97	2,180	7.6	35
703b/	W. T. Hinson	199	do	14	--	40	13	327	532	41	270	1.5	1.2	970	154	82	1,680	7.1	11
705b/	Gunsight Cemetary	215	do	9.6	--	8	1.4	408	506	39	322	1.7	.0	1,040	26	97	1,830	7.4	35
706b/	J. H. Boles	205	do	11	--	11	4.3	723	548	38	800	--	.5	1,860	45	97	3,290	7.5	47
804c/	M. A. Frost	173	2-11-37	--	--	--	--	--	6	69	525	--	--	924	--	--	--	--	--
901a/	A. C. Thompson	120	6- 8-62	18	--	140	27	71	425	82	105	.2	10.9	663	460	--	1,195	7.1	--
902a/	R. A. Barker Estate	30	6- 9-62	38	--	132	43	291	727	218	208	2.4	5.4	1,296	596	--	2,000	7.5	--
903a/	Mrs. M. E. Frasier Estate	150	do	20	--	274	47	75	449	450	110	.1	< .4	1,197	880	--	1,800	7.2	--

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Stephens County--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium* (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C.)	pH	SAR
31-26-904[a]	R. B. Wymer	50	6- 9-62	22	--	196	66	250	500	247	400	0.7	27	1,455	760	--	2,440	7.2	--
906[b]	Mrs. Ola Frasier	192	5-30-62	15	--	82	21	52	372	49	33	.4	.2	436	291	28	733	6.9	1.3
27-101[c]	Willis Knight	12	2-12-37	--	--	--	--	--	134	62	92	--	--	342	--	--	--	--	--
102[c]	Mrs. Kit Gardenheim	11	2-10-37	--	--	--	--	--	268	376	920	--	--	2,190	--	--	--	--	--
103[b]	H. M. Munnerlyn	100	6-15-62	14	--	190	59	96	552	205	145	.3	66	1,050	717	22	1,740	6.8	1.6
105[b]	A. W. Howton	140	6-14-62	9	--	13	8.1	710	752	166	580	--	1.2	1,860	66	96	3,080	7.5	38
106[b]	G. R. Langford	150	do	9.7	--	49	22	1,240	318	748	1,320	--	6.5	3,550	213	93	5,650	7.2	37
201[c]	J. B. Jones	65	2-17-37	--	--	--	--	--	256	38	146	--	--	492	--	--	--	--	--
[a]		65	9- 8-62	17	--	501	56	215	354	148	430	.2	1,151	2,692	290	--	3,520	7.1	--
202[c]	M. A. Truesdell	19	2-17-37	--	--	194	15	190	275	108	440	--	--	1,082	544	--	--	--	--
203[c]	J. C. Bradford	19	2-12-37	--	--	--	--	--	311	46	146	--	--	548	--	--	--	--	--
[a]		19	9-10-62	20	--	112	5	94	390	61	86	.1	< .4	570	303	--	905	7.4	--
204[c]	Charlie Bobo	100	2-12-37	--	--	7	11	206	512	46	30	--	--	552	62	--	--	--	--
205[b]	W. L. Carey	140	6-14-62	10	--	3.5	2.0	172	402	29	20	1.2	.0	436	16	96	690	7.8	19
206[b]	D. M. Stanford	100	4-19-62	14	--	11	7.2	121	332	22	16	1.0	1.5	357	57	82	587	7.8	7
207[b]	C. L. Bargsley	100	5-24-62	10	--	9	11	237	482	45	97	1.7	.2	648	68	88	1,080	7.9	12
209[b]	M. A. Truesdell	18	do	18	--	130	5	90	346	55	122	.2	33	623	345	36	1,040	7.2	2.1
210[b]	do	115	7-19-62	9.6	--	120	9.5	66	308	31	138	.3	1.2	527	338	30	956	6.7	1.6
212[b]	Frank Bargsley	100	5-24-62	10	--	6	4.5	200	450	38	40	1.2	.8	522	34	93	844	8.0	15
214[a]	K. E. McDonald	110	9- 8-62	10	--	3	1	194	441	37	25	1.7	< .4	489	13	--	776	8.3	--
215[a]	do	20	do	18	--	127	11	46	3 2	55	74	.1	< .4	514	363	--	822	7.3	--
216[a]	do	105	6- 4-62	11	--	5	6	172	388	30	33	1.3	< .4	449	35	--	785	8.0	--
217[b]	New Hope Baptist Church	110	5-24-62	10	--	77	4.2	182	428	31	32	1.2	.8	478	35	92	781	7.8	13
218[b]	Robert Jackson	100	6- 2-62	16	--	15	8.3	115	336	23	14	.7	.0	357	72	78	586	7.6	5.9
219[b]	J. B. Jones	130	5-25-62	14	--	7.8	4.2	150	350	37	25	.7	1.2	412	37	90	672	7.8	11
221[a]	J. C. Bradford	101	8-29-62	9	--	11	9	180	479	17	24	2.0	< .4	488	66	--	715	7.9	--
222[b]	Mrs. Artie Sherrill	125	5-24-62	10	--	--	2.7	207	458	36	42	1.5	.8	531	26	95	864	7.8	18
226[a]	S. A. Davis	125	8-22-62	16	--	18	11	103	322	21	17	.6	< .4	345	88	--	560	7.6	--

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Stephens County--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium* (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C.)	pH	SAR
31-27-227[a]	S. A. Davis	100	8-22-62	12	--	6	2	162	389	28	21	1.0	<0.4	424	23	--	677	8.1	--
232[a]	do	100	do	18	--	83	11	166	376	130	96	.4	8	697	253	--	1,079	7.5	--
233[a]	do	20	do	21	--	45	5	29	172	27	16	.1	< .4	228	130	--	366	6.9	--
234[b]	Mrs. Ellen Justice	Unknown	6-23-62	9.2	--	5	2.3	167	400	28	18	1.1	.2	428	22	94	696	7.7	15
301[b]	do	Unknown	do	8.1	--	70	6.5	57	294	22	40	.3	4.4	353	201	38	618	7.0	1.7
302[b]	do	450	do	9.3	--	23	8.7	1,040	868	558	750	--	2.8	2,820	94	96	4,390	7.7	47
303[b]	D. M. Stanford	500	4-19-62	9.1	--	1,220	79	1,620	281	101	4,650	--	--	7,820	3,370	51	13,000	6.7	12
[a]		500	9- 4-62	9	--	192	16	480	381	111	613	1.0	< .4	1,609	545	--	3,040	7.7	--
304[a]	do	21	8-29-62	15	--	111	6	25	342	23	35	.1	< .4	383	304	--	638	7.4	--
305[b]	R. C. Stuard	203	5-25-62	4.9	--	6	2.3	233	392	81	84	2.7	.5	607	24	95	1,010	8.1	21
306[b]	do	125	do	20	--	124	21	102	412	82	107	.6	52	712	396	36	1,160	7.0	2.2
307[b]	Joe Jackson	50	5-29-62	18	--	105	26	45	208	71	156	.3	1.8	525	369	21	940	7.2	1.0
308[b]	Mrs. Ellen Justice	90	6-23-62	10	--	3	1.7	181	416	34	20	1.4	.0	456	14	96	741	7.8	21
309[b]	do	28	do	12	--	132	3.3	15	360	24	38	.2	2.6	404	343	9	699	7.0	.4
401[a]	T. B. Miller	30	6- 7-62	27	--	96	19	145	483	105	77	1.0	27	735	320	--	1,250	8.0	--
402[c]	C. C. Jackson	79	2-11-37	--	--	97	29	75	372	77	100	--	--	561	363	--	--	--	--
403[c]	A. A. Hardee	92	do	--	--	--	--	--	104	254	192	--	--	745	--	--	--	--	--
404[b]	C. C. Jackson	95	6-15-62	20	--	145	29	69	392	89	117	.3	64	726	482	24	1,110	6.5	1.4
406[b]	C. A. Brown	75	do	17	--	212	26	69	360	166	188	.3	65	920	636	19	1,500	6.5	1.2
409[b]	A. A. Hardee	80	do	14	--	245	53	106	388	222	360	.4	2.8	1,190	830	22	2,220	6.6	1.6
414[b]	S. L. Williamson	86	7- 2-62	19	--	800	124	247	300	208	1,820	--	16	3,380	2,510	18	5,900	6.6	2.1
415[a]	G. E. Hall	215	7-11-62	17	--	174	32	145	442	169	235	.1	7	997	566	--	1,750	7.5	--
416[a]	do	215	do	17	--	203	41	85	386	164	253	.3	4.4	957	675	--	1,750	7.5	--
417[a]	do	75	do	17	--	211	39	55	325	308	165	.1	< .4	965	688	--	1,600	8.4	--
418[a]	do	215	do	15	--	206	46	40	386	257	148	.1	< .4	902	705	--	1,550	7.6	--
419[a]	do	215	do	17	--	329	63	140	390	214	600	.1	< .4	1,555	1,080	--	2,800	7.3	--
420[a]	do	215	do	17	--	349	62	170	476	260	565	.1	2.9	1,660	1,114	--	2,900	7.5	--
421[a]	do	215	do	15	--	84	25	220	454	122	228	.1	4.4	922	324	--	1,750	7.6	--
422[a]	A. A. Hardee	145	9-18-62	16	--	353	73	119	485	507	364	.1	< .4	1,671	1,180	--	2,420	7.1	--

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Stephens County--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Cal-cium (Ca)	Magne-sium (Mg)	Sodium* (Na)	Bicar-bonate (HCO_3)	Sul-fate (SO_4)	Chlo-ride (Cl)	Fluo-ride (F)	Ni-trate (NO_3)	Dis-solved solids	Total hard-ness as $CaCO_3$	Per-cent so-dium	Specific conduct-ance (micromhos at 25°C.)	pH	SAR
31-27-423[a]	G. E. Hall	215	7-11-62	15	--	138	38	88	329	65	243	0.1	3.8	753	508	--	1,500	7.9	--
424[a]	do	215	do	10	--	6	4	567	583	210	295	5.0	<.4	1,430	29	--	2,300	9.3	--
501[c]	C. T. Botts	131	2-12-37	--	--	163	19	77	482	85	122	--	--	703	487	--	--	--	--
502[c]	Unknown	69	2-24-37	--	--	29	13	402	561	81	325	--	--	1,126	128	--	--	--	--
503[c]	do	100	do	--	--	540	96	1,618	342	15	3,520	--	--	5,957	1,744	--	--	--	--
504[b]	C. L. Bargsley	100	4-19-62	16	--	45	20	63	324	26	26	.9	1.2	357	195	41	602	7.2	2.0
505[b]	Frank Bargsley	54	5-24-62	15	--	78	25	22	364	16	20	.7	.0	356	298	14	608	7.4	.6
506[a]	C. C. Veale	75	6-24-62	12	--	6	5	195	425	36	33	2.4	<.4	499	38	--	840	7.7	--
507[a]	N. L. Moore	80	6- 8-62	12	--	8	6	255	527	55	53	3.8	<.4	656	45	--	1,050	7.9	--
508[a]	C. N. Dempsey	80	6- 4-62	22	--	130	38	52	478	49	96	.3	3.8	626	480	--	1,060	8.0	--
510[a]	J. W. Veale	168	6- 5-62	12	--	59	40	186	490	100	118	1.2	4.1	761	310	--	1,300	7.4	--
511[a]	Wesley Dempsey	120	do	11	--	10	16	440	559	132	306	4.8	<.4	1,195	90	--	2,200	8.3	--
512[a]	A. H. Boney	58	6- 4-62	12	--	84	18	232	427	109	206	.8	<.4	871	285	--	1,460	8.2	--
513[c]	do	50	2-12-37	--	--	--	6	418	476	116	300	--	--	1,074	25	--	--	--	--
[a]		68	6- 4-62	11	--	13	4	372	525	111	231	4.2	<.4	1,005	50	--	1,875	8.3	--
514[a]	H. L. Caraway	180	10- 3-62	8	--	20	15	331	493	75	240	3.2	<.4	935	109	--	1,570	8.1	--
515[a]	Don Bradford	95	6- 5-62	14	--	37	12	307	488	124	174	3.8	31	943	140	--	1,675	8.2	--
701[c]	J. L. Ready	41	2-11-37	--	--	119	13	52	464	38	32	--	--	482	353	--	--	--	--
702[c]	C. C. Goforth	19	do	--	--	--	--	--	256	<10	8	--	--	223	--	--	--	--	--
[a]		19	10- 4-62	31.5	--	149	30	12	630	16	8	.5	<.4	557	497	--	886	7.2	--
703[c]	W. H. Boney	182	3- 2-37	--	--	13	8	670	665	252	505	--	--	1,775	65	--	--	--	--
[a]		182	10- 4-62	5.5	--	4	3	607	538	180	485	3.3	1.6	1,569	22	--	2,260	8.6	--
704[c]	H. C. Wilkinson	153	2-11-37	--	--	20	9	616	665	230	455	--	--	1,657	85	--	--	--	--
[a]		153	6- 8-62	18	--	13	10	630	670	249	435	4.0	1.7	1,691	74	--	2,900	7.8	--
706[a]	do	168	do	12	--	50	35	605	649	240	515	4.0	<.4	1,780	270	--	3,100	7.8	--
707[a]	C. N. Adams	60	do	24	--	200	34	74	459	70	245	.1	5.5	879	640	--	1,600	7.1	--
708[a]	J. L. Ready	200	10- 5-62	20	--	272	31	228	487	217	438	.2	70.5	1,517	805	--	2,000	7.5	--
710[a]	C. E. Boney	24	6- 6-62	21	--	364	105	240	359	197	775	.4	310	2,189	1,340	--	3,680	7.3	--
711[a]	J. A. Ridling	98	do	20	--	174	33	152	390	100	350	.1	<.4	1,022	570	--	1,840	7.7	--

See footnotes at end of table.

Table 4.--Chemical analyses of water from wells and springs, Stephens County--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium* (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C.)	pH	SAR
31-27-712a/	C. C. Goforth	21	6- 6-62	38	--	70	25	8	334	7	20	1.6	<0.4	334	278	--	545	7.6	--
713a/	do	57	do	22	--	480	141	206	371	275	905	.2	314	2,526	1,780	--	4,150	7.4	--
714a/	Hames Estate	81	do	16	--	104	35	204	647	110	161	.4	< .4	948	405	--	1,500	7.6	--
715a/	Mrs. Miley E. Williams	40	do	25	--	224	40	222	632	172	355	.7	16.4	1,366	725	--	2,240	7.6	--
716a/	J. D. Eakin	88	6- 7-62	21	--	118	18	110	576	63	42	.1	< .4	655	370	--	1,023	8.0	--
717a/	do	30	do	28	--	118	18	225	515	107	214	1.5	< .4	947	370	--	1,640	7.8	--
719a/	J. L. Ready	60	do	25	--	102	10	79	437	45	44	.1	14	534	295	--	945	7.6	--
720a/	Mrs. Ora Holder	65	do	22	--	480	44	355	481	250	1,075	.1	14	2,477	1,380	--	4,460	7.3	--
721a/	do	65	do	25	--	316	33	280	410	131	735	.1	13	1,735	925	--	3,200	7.4	--
801c/ a/	Bullock School	19 22	2-12-37 6- 4-62	-- 63	-- --	-- 61	-- 19	-- 37	366 249	69 42	96 33	-- 1.1	-- < .4	548 378	-- 230	-- --	-- 595	-- 7.1	-- --
802a/	B. R. Hatton	118	6- 5-62	11	--	15	3	940	730	45	975	4.0	< .4	2,353	50	--	4,000	7.8	--
805a/	Mrs. W. W. Hatton	400	6- 4-62	9	--	52	41	1,995	473	2	2,980	1.6	< .4	5,314	300	--	8,970	8.2	--
807a/	Rudy Wells	Dug unknown	6- 5-62	15	--	288	62	114	183	173	280	.3	687	1,709	975	--	2,570	7.7	--
808a/	N. L. Sudderth	375	9-19-62	7	--	38	26	1,320	477	12	1,890	2.0	< .4	3,530	201	--	5,750	7.9	--
28-101c/	Mrs. Wm. Graham	23	2-17-37	--	--	--	--	--	146	139	21	--	--	350	--	--	--	--	--
103b/	Mrs. C. Lambert	365	5-29-62	11	--	8.0	3.5	897	820	336	680	--	3.0	2,340	34	98	3,900	7.7	67

a/ Analysis by Texas State Department of Health Laboratories
b/ Analysis by U. S. Geological Survey, Quality of Water Branch
c/ Analysis by The University of Texas
d/ BJ Service Inc.
* Includes both Sodium and Potassium (Na + K) for analyses performed by the U. S. Geological Survey, which are indicated by footnote b/.

Table 5.--Reported brine production and disposal in 1961, Stephens County

Area no. shown on Plate 3	Field		Disposal in pits (bbl)	Disposal in injection wells (bbl)	Total brine production (bbl)
1	Lenoir		3,650	0	
	County Regular		0	12,775	
		Total	3,650	12,775	16,425
2	Woodson-Allison/Caddo/		0	16,790	
		Total	0	16,790	16,790
3	Bowar/Caddo/		6,080	0	
	Bowar/Mississippi/		9,065	0	
	Bowar, NE/Mississippi/		0	820	
	Bowar, SE/Mississippi/		100	0	
	Powers/Marble Falls/		0	0	
		Total	15,305	820	16,125
4	Harding Bros./Caddo, Lower/		900	0	
	Harding Bros./Caddo, Upper/		300	0	
	Harding Bros./Mississippi/		10,000	0	
	Harding Bros., NE/Caddo, Lower/		0	0	
	Harding Bros., NE/Mississippi/		1,825	0	
	Tipton, North/Caddo/		1,480	0	
	Tipton, North/Caddo, Lower/		66,430	0	
	Tipton, North/Strawn/		0	0	
		Total	80,935	0	80,935
5	Eloise Kay/Marble Falls/		0	0	
	Eloise Kay/Mississippi/		0	0	
	Eloise Kay/Strawn/		0	10,000	
	Stribling		750	0	
		Total	750	10,000	10,750
6	Richard Kyle/Hope Sand/		2,920	0	
		Total	2,920	0	2,920
7	Crystal Falls		0	40,873	
	Crystal Falls/Mississippi/		3,650	5,475	
	Crystal Falls/4100 Conglomerate/		0	0	
	Hannah/Mississippi/		0	0	
	Ross Sloan		0	17,080	
	County Regular		1,825	0	
		Total	5,475	63,428	68,903

Table 5.--Reported brine production and disposal in 1961, Stephens County--Continued

Area no. shown on Plate 3	Field	Disposal in pits (bbl)	Disposal in injection wells (bbl)	Total brine production (bbl)
8	County Regular	0	73,800	
	Total	0	73,800	73,800
9	Alfred Donnell/Mississippi/	0	5,475	
	Atkins	0	10,220	
	Bill-Ray/Atoka/	365	0	
	Britton/Mississippi/	0	18,000	
	Britton, North/Mississippi/	2,920	0	
	Brownville	0	0	
	Brownville, North/Mississippi/	0	219,000	
	Brownville, West/Caddo, Middle/	2,500	0	
	Con-Rich/Conglomerate/	1,200	0	
	Delong/Zone A/	0	1,825	
	Delong/Zone B/	0	34,451	
	Delong/Zone C/	45	0	
	Donnell	0	0	
	Double-D/Ellenburger/	0	158,410	
	Echols	5,235	0	
	Eliasville, East/Mississippi/	12,775	0	
	Eliasville/Mississippi/	18,411	0	
	Hill	0	153,300	
	Hill, North/Mississippi/	0	6,440	
	Jim Kern, East/Conglomerate/	0	0	
	Jim Kern, East/Mississippi/	0	0	
	Pratt/Mississippi Lime/	0	27,375	
	Rickels	700	0	
	Rickels/Conglomerate/	0	17,480	
	Rickels/Mississippi/	0	14,000	
	Rickels/2nd Conglomerate/	0	5,000	
	Rounsaville/2650 Strawn/	0	2,520	
	Ryan/Bend Conglomerate/	300	0	
	Ryan/Chappel Lime/	12,000	0	
	Ryan, East/Mississippi/	0	0	
	Ryan, South/Bend Conglomerate/	300	0	
	Tullos	2,775	0	
	Walker Davis	2,407	0	
	Walker-Davis/3960 Conglomerate/	0	0	
	Welwood-Hill/Mississippi/	0	51,500	
	Welwood-Morrison/Mississippi/	0	54,750	
	Welwood-TXL/Mississippi/	0	0	
	William & Jack	4,380	0	
	County Regular	118,666	1,114,593	
	Total	184,979	1,904,194	2,089,173
10	Minnie-Roy/Mississippi/	850	0	
	Total	850	0	850

Table 5.--Reported brine production and disposal in 1961, Stephens County--Continued

Area no. shown on Plate 3	Field		Disposal in pits (bbl)	Disposal in injection wells (bbl)	Total brine production (bbl)
11	Whittenburg/Strawn/		5,475	12,775	
		Total	5,475	12,775	18,250
12	Ivan/Mississippi Lime/		1,769	0	
	County Regular		2,920	0	
		Total	4,689	0	4,689
13	Stroud/Deep/		160	0	
	County Regular		1,730	0	
		Total	1,890	0	1,890
14	Iles/Conglomerate/		28,050	0	
	Iles/Conglomerate, Upper/		0	0	
		Total	28,050	0	28,050
15	Pharris/Conglomerate/		365	0	
		Total	365	0	365
16	O'Neal/Caddo/		3,600	12,600	
		Total	3,600	12,600	16,200
17	Akin		3,926	0	
	Bellvick/2750 Strawn/		375	0	
	Breckenridge		0	0	
	Connally-Thorton		0	0	
	Ivan/Marble Falls/		0	0	
	Moon		91	0	
	Parks Pierce		1,500	0	
	Singleton/Caddo/		547	89,425	
	County Regular		442,737	650,526	
		Total	449,176	739,951	1,189,127
18	Gourley, East/3900 Conglomerate/		0	0	
	Gourley/Strawn Sand/		5,320	0	
	Harris/Marble Falls/		0	127,750	
	Jackson/Lassiter Strawn/		12	0	
	Jackson/Strawn/		192	93,075	
	Rollins/2700 Sand/		30	0	
	Stanford/Strawn, Lower/		0	0	
	Sunshine/Strawn/		21	0	
	County Regular		20,057	292,467	
		Total	25,632	513,292	539,529*

See footnote at end of table.

Table 5.--Reported brine production and disposal in 1961, Stephens County--Continued

Area no. shown on Plate 3	Field		Disposal in pits (bbl)	Disposal in injection wells (bbl)	Total brine production (bbl)
19	Ibex, East		1,460	0	
	Ibex, East/Ellenburger/		500	0	
	Ibex, East		730	0	
	Loving		2,787	0	
		Total	5,477	0	5,477
20	Big Sandy/Marble Falls/		0	0	
	Chaney		0	109,500	
	Eolian/Ellenburger/		3,560	0	
	Northeast Area		0	434,265	
	Chaney		0	70,000	
	Northeast Area		0	0	
	County Regular		3,650	45,625	
		Total	7,300	659,390	666,690
21	County Regular		0	3,600	
		Total	0	3,600	3,600
22	Fincher/Caddo/		0	3,650	
	Necessity		4,320	0	
	County Regular		2,190	0	
		Total	6,510	3,650	10,160
23	Bloomquist/Lake Sand/		24	0	
	Lee Ray		0	1,884	
	Manning-O'Connor		9,125	179,230	
	County Regular		1,778	270,300	
		Total	10,927	451,414	462,341
24	Aunt Em/Ellenburger/		0	30,660	
	Mueller-O-/Ellenburger/		0	350,400	
	Norvell/Conglomerate/		300	0	
	Norvell, Southeast		3,650	0	
	County Regular		1,800	0	
		Total	5,750	381,060	386,810
25	Fletcher/Lake Sand/		2,036	0	
	Hancock/Strawn/		15,630	0	
	County Regular		61,188	0	
		Total	78,854	0	78,854

Table 5.--Reported brine production and disposal in 1961, Stephens County--Continued

Area no. shown on Plate 3	Field	Disposal in pits (bbl)	Disposal in injection wells (bbl)	Total brine production (bbl)
26	County Regular	7,220	0	
		Total 7,220	0	7,220
27	Wiles/3450 Conglomerate/	0	0	
	County Regular	390	0	
		Total 390	0	390
1 to 27	County Regular total	666,151	2,449,686	3,116,442*
1 to 27	All fields total	936,169	4,859,539	5,796,313*

* Includes 605 barrels disposed of by methods other than pits and injection wells in County Regular field in Area 18.

Table 6.--Chemical analyses of oil-field brines, Stephens County

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

Compiled by Rowland Laxson, et al., 1960, Resistivities and chemical analyses of formation waters from the West Central Texas area: West Central Texas Section of the Society of Petroleum Engineers of A.I.M.E.; and BJ Service Inc., 1960, The chemical analyses of brines from some fields in North & West Texas.

Formation	Field	Average depth of well (ft.)	Area no. shown on Plate 3	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Specific gravity	pH
Pennsylvanian											
Moran Sand	Manning-O'Connor	2,065	23	5,250	1,080	22,800	158	20	47,600	1.064	6.0
Strawn	South Breckenridge	1,858	17	9,020	1,280	30,941	63	81	67,300	1.085	6.5
Do.	Connally-Thorton	1,975	17	10,215	1,958	26,380	47	65	70,800	1.101	6.2
Do.	Hohertz	1,640	18	7,340	1,086	29,810	93	11	65,600	1.082	6.1
Do.	Jackson	1,760	18	5,315	1,302	27,205	240	6	54,900	1.075	6.5
Do.	Wayland	2,700	22	8,970	1,227	36,500	152	5	75,800	1.098	5.6
Caddo	Breckenridge	3,075-3,125	17	12,530	2,930	41,400	45	62	94,500	1.122	6.2
Do.	South Breckenridge	3,360	17	11,970	4,321	44,503	132	19	102,300	1.128	6.4
Do.	do	3,400	17	10,300	3,800	43,900	77	55	97,100	1.123	6.3
Do.	Northwest Breckenridge	3,207	17	10,280	3,770	43,276	106	12	95,800	1.124	6.6
Do.	Lee Ray Ext.	3,358	23	10,480	3,630	44,200	98	53	97,200	1.126	6.8
Do.	County Regular	3,200	--	14,580	3,365	48,830	68	51	110,900	1.140	6.0
Do.	do	3,200	--	12,380	2,590	40,450	26	20	91,800	1.117	6.2
Do.	Manning-O'Connor	3,300	23	9,700	4,240	41,100	124	20	93,000	1.123	6.7
Do.	O'Neal	--	16	12,090	4,135	42,530	26	20	91,800	1.127	6.3
Do.	Bowar	--	3	8,970	4,250	42,000	59	8	93,000	1.123	6.5
Do.	do	--	3	8,610	4,620	41,400	54	7	92,500	1.124	6.7
Bond Sand	Bankline-Owens	3,675	23	12,020	1,223	40,550	130	417	87,100	1.113	6.5
Conglomerate	Breckenridge	3,777	17	13,680	2,120	45,000	170	127	99,700	1.132	6.8
Do.	South Breckenridge	3,972	17	10,530	2,370	41,000	105	158	88,500	1.116	6.6
Marble Falls	East Breckenridge	--	17	14,900	2,180	55,500	100	270	118,000	1.142	6.1
Do.	N. E. Breckenridge	4,000	17	10,845	2,852	57,034	62	1,222	14,500	1.146	6.2
Do.	Breckenridge Regular	4,056	--	14,200	1,896	52,100	108	168	110,800	1.135	6.1
Do.	Necessity	3,740	22	15,300	2,110	47,656	72	190	106,650	1.129	5.9
Do.	Tiffin	3,794	25	8,650	1,913	38,250	109	261	79,600	1.103	6.4
Do.	Iles	4,000	14	11,900	1,290	45,472	207	142	94,700	1.124	6.4
Do.	Wildcat	3,800	18	15,260	1,693	56,400	87	154	117,588	1.135	--
Do.	O'Neal	3,983	16	17,125	2,605	55,780	103	134	123,700	1.158	5.4
Do.	Green	--	8	15,890	2,297	56,620	141	156	122,200	1.158	6.8
Duffer	Wildcat	3,800	--	8,650	1,913	38,250	109	261	79,600	--	--
Mississippian											
Mississippian	Walker-Davis	4,180-4,192	9	13,980	1,222	31,500	447	837	76,150	1.098	6.7
Do.	Bowar	--	3	11,070	2,020	33,700	80	421	77,200	1.100	6.5
Do.	Woodson-Allison	--	2	3,340	605	27,000	430	1,300	48,000	1.061	6.9
Do.	Wildcat	--	--	3,180	395	31,450	140	1,925	53,800	1.062	6.9
Ordovician											
Ellenburger	Breckenridge	4,205	17	2,566	561	25,279	217	1,156	44,171	1.055	6.6
Do.	Compton	4,300	24	3,150	633	27,000	293	867	48,200	1.061	7.6
Do.	Manning-O'Connor	4,224	23	2,231	564	26,198	261	720	45,300	1.056	7.4
Do.	Wildcat	4,352	18	1,605	530	20,910	256	763	35,900	1.048	6.8
Do.	Walker-Davis	4,400	9	8,480	641	23,450	962	896	51,700	1.070	7.2

APPENDIX

SUPPLEMENTARY DISCUSSIONS OF QUALITY OF WATER, GEOLOGY, AND HYDROLOGY

SUPPLEMENTARY DISCUSSIONS OF QUALITY OF WATER, GEOLOGY, AND HYDROLOGY

Geology of North-Central Texas

Regional Structure

The counties included by the Texas Water Commission in the study of ground-water resources in north-central Texas are in the Grand Prairie and Osage Plains geographic provinces of Texas. The Grand Prairie region is defined as a belt of counties west of the Balcones fault zone and north of the Llano uplift, and has been described as a modified northeastward continuation of the Edwards Plateau. At the surface in the Grand Prairie region are Cretaceous rocks of the Comanche Series dipping gently to the east and southeast. Some faulting is exhibited in the Cretaceous formations near the Balcones zone, but in general no major structural features are reflected by these beds other than the regional eastward dip. To the west of the Grand Prairie region is the Osage Plains province extending from the Edwards Plateau and Llano uplift northward to the Red River. Surface formations in the Osage Plains of north-central Texas are of Pennsylvanian and Permian age except where these rocks are overlain locally by remnants of Cretaceous sediments or Recent alluvial deposits. Pennsylvanian and Permian beds of the region form a westward dipping homocline with an average dip of 50 feet per mile. Formations significant to the occurrence of ground water under study in the Osage Plains have not been affected by major structural deformation. The principal, large, buried structural features, illustrated in Figure A1, include the Bend flexure, the Red River uplift, eastern Midland shelf, and the Concho arch and developing Concho foreland.

Depositional History

The geologic environment in which the rock units underlying north-central Texas were laid down and the stratigraphic relationship of these units one to another determine the character of the water-bearing formations, which are the sources of ground water. Structural movement and crustal settling and shifting, which followed the deposition of the rocks in the area, influenced the mode of occurrence of ground water. An understanding of these complex historical events is important to a comprehension of how ground water occurs and how it can best be developed.

The sequence of geologic events significant to the occurrence of ground water in north-central Texas began in Pennsylvanian times, and continued through the deposition of Permian rocks throughout most of the area, Cretaceous sediments over a large part of the area, and Pleistocene to Recent alluvial sediments found at the surface in local areas and along most of the streambeds.

The Pennsylvanian and Permian seas that deposited sediments in the north-central Texas area were shallow--probably less than 100 feet deep. This is

Figure A I

Major Structural Features in North-Central Texas

Texas Water Commission in cooperation with the Texas Water Pollution Control Board

evidenced by the large amounts of sandstone, the repetition and extent of coal deposits, and the presence of frequent local unconformities. Present also are conglomerates, mud cracks, ripple marks, cross-bedding, and fossils that are found in a shallow-water environment. Thus, ground water occurs in this area in formations of sediments deposited very nearly horizontally in shallow seas that were alternately advancing and retreating. Such a depositional environment resulted in a complex system of lateral and vertical changes in the character of the materials deposited. Few widespread continuous mantles of sediments such as those that characterize the Gulf Coast region of Texas are found. However, in contrast to the local, discontinuous, highly variable, shallow-water, clastic deposits characteristic of these periods, certain limestone units are relatively widespread. These limestones were deposited in extensive shallow seas advancing from the north and east, and are traceable as continuous units throughout much of the area under study. Thus, these limestone beds, while only locally significant as water-bearing units, are extremely important as horizon markers in identifying the age and character of the intervening sediments.

Pennsylvanian Deposition

The upper Pennsylvanian rocks of north-central Texas include the Strawn, Canyon, and Cisco Groups, each of which has been subdivided into several formations and members. In the Colorado River Basin the Strawn Group is composed principally of alternating beds of sandstone and shale, probably representing near-shore deposits with the source area for the sediments being a land mass to the east and northeast, which is now concealed under younger strata. Beds of the Strawn Group overlap to the west so that the total thickness of the group is probably not greater than 1,200 feet at any one point. Cretaceous rocks overlying these older beds in the area of the Bend flexure prevent tracing individual units of the Strawn on the surface from the Colorado River Basin into the Brazos River Basin. In general, the Strawn of the Colorado River Basin contains coarser sediments than in the Brazos River Basin, although beneath the Cretaceous sediments to the north in Wise County the Strawn again assumes a near-shore facies marked by coal beds and lenses of sand and sandy shale.

The Canyon Group in north-central Texas is characterized by thick limestone beds alternating with shale, and contains relatively little sandstone. The source of the sediments in the Canyon was again from the east, and was lower than during Strawn deposition as shown by the decrease of terriginous clastic material, which marked much of the Strawn deposition. Sandstone lenses occurring in the Canyon Group, of extreme importance to the occurrence of ground water in local areas, probably were deposited in channels formed during periods of nonmarine occurrence. In Jack and Wise Counties the character of Canyon sediments--conglomerates, irregular sands, and several coal beds--indicates an approach to the shoreline. Also in the southern region of the Colorado River Basin some conglomerates are found in the basal Canyon. The surface expression of the Canyon Group in the Brazos River Basin is separated by Cretaceous rocks from Canyon beds in the Colorado River Basin, and no definitive stratigraphic correlation of individual formations has been traced from one basin into the other.

There was no widespread erosion of Canyon deposits except perhaps in the western Llano area. Tectonic activity to the north included the gradual uplift of the Red River arch, possible folding in the Wichita system, and other disturbances in the mid-continent area. Canyon sedimentation was also affected by the continued development of the eastern Midland shelf and the subdued, but still prominent, Concho arch and the Bronte axis.

Sedimentation continued into Cisco time, as evidenced by the lack of a marked unconformity between the Canyon and Cisco strata. Local disconformities and channeling are apparent in both the outcrop areas of these beds and in the subsurface, indicating that the shelf environment of late Canyon time became more and more deltaic locally during Cisco time. The Cisco Group in the north-central Texas region is comprised chiefly of shale, sandstone, conglomerate, and limestone, with local coal beds. Eastward the sand and conglomerate deposits increase in thickness while to the west the conglomerate and the coal disappear. In the northern part of the area the limestone disappears from the Cisco Group as deposition occurred in a nonmarine or partially marine facies.

Deposition in the late Pennsylvanian was affected by uplift in the Llano area as the initial westward tilting of the Concho foreland began toward the Midland basin. This westward tilting was to continue throughout Permian time. The Bend flexure, previously called the Bend arch, which extends from the Llano area to the Red River uplift, came into existence during late Pennsylvanian and early Permian times as a result of the differential subsidence of the Midland basin and the eastern Midland shelf, and the consequent westward tilting of the Concho foreland.

Permian Deposition

No major unconformity marks the contact between Pennsylvanian and Permian rocks, indicating relatively continuous deposition from the Cisco of the upper Pennsylvanian into the Wichita of the lower Permian. Local disconformities and channeling are apparent both in the surface and the subsurface, however, with the shoreline of the Permian sea having oscillated back and forth while it continued its slow migration toward the west as the tilting of the Concho foreland into the Midland basin progressed. The extensive Permian sea was shallow over north-central Texas, resulting in deposition of sediments under widely varying conditions.

Rocks of the Wichita Group have been mapped at the surface from the Red River to the Llano uplift. In the Colorado River Basin the Wichita Group, representing the oldest Permian deposition, is characterized by a marine shale and limestone facies, while northward the marine beds decrease in importance and red beds become more prominent. Near the Red River, deposition of the Wichita Group was in a marginal marine environment marked chiefly by a red-bed facies of shale and sandstone. Deposition was apparently continuous in the Wichita, and no pronounced unconformities have been found in the Group.

Mesozoic (Cretaceous) Deposition

The close of Wichita deposition marked the end of Paleozoic time in north-central Texas, and great changes in the position of the land masses in Texas were to characterize the beginning of the Mesozoic in the State. The early Mesozoic was a period of continental elevation, and no Triassic deposition is known to have occurred in the area included in this study. This period of non-deposition continued through the Jurassic, and the first marine deposition that occurred in north-central Texas after the close of the Permian was in early Cretaceous times. As a result of the massive change in land-surface elevation in the first half of the Mesozoic, however, drainage in the Texas area had been reversed by the time Cretaceous deposition began. Instead of northwesterly drainage into inland Paleozoic seas, drainage from the earliest Cretaceous period onward was toward the southeast in the direction of what is now the Gulf of Mexico. Thus the regional dip of Cretaceous rocks overlying the Pennsylvanian and Permian sediments of north-central Texas is toward the southeast.

West of an irregular, northeast-trending line through Brown, Eastland, Jack, Wise, and Montague Counties, the only Cretaceous rocks remaining after extensive periods of erosion are remnants and outliers that, although not extensive, are locally significant as sources of ground water and as recharge areas for underlying older rocks. East of this irregular line Cretaceous beds are found at the surface in a continuous band eastward to the outcrop of Eocene sediments.

All of the known Cretaceous deposition in the area of study belongs to the Comanche Series. The Comanche has been divided into the Trinity, Fredericksburg, and Washita Groups, and both the Trinity and the Fredericksburg are found in this area. Generally, all of the Comanche sediments belong to a near-shore or shallow-water environment.

Quality of Ground Water

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

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

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

Included among the factors determining the suitability of ground water as a supply are the limitations imposed by the contemplated use of the water. Criteria have been developed to cover most categories of water quality, including bacterial content, physical characteristics, and chemical constituents. Water-quality problems associated with the first two categories can usually be alleviated economically, but the removal of undesirable chemical constituents can be difficult and expensive. For many purposes the dissolved solids content constitutes a major limitation on the use of water. One general classification of water based on dissolved-solids content (Winslow and Kister, 1956, p. 5) is as follows:

Description	Dissolved-solids content (ppm)
Fresh	Less than 1,000
Slightly saline	1,000 to 3,000
Moderately saline	3,000 to 10,000
Very saline	10,000 to 35,000
Brine	More than 35,000

The United States Public Health Service has established standards of drinking water to be used on common carriers engaged in interstate commerce. The standards are designed primarily to protect the traveling public, and are often used to evaluate public water supplies. According to these standards, chemical constituents should not be present in the water supply in excess of the listed concentration shown in the following table, except where other more suitable supplies are not available. Some of the standards adopted by the U. S. Public Health Service (1962, p. 2152-2155) are as follows:

Substance	Concentration (ppm)
Chloride (Cl)	250
Fluoride (F)	(*)
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate (NO_3)	45
Sulfate (SO_4)	250
Total dissolved solids	500

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

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

Water having concentration of chemical constituents in excess of the recommended limits may be objectionable for many reasons. Water containing an excess of 45 ppm of nitrate has been related (Maxcy, 1950, p. 271) to the incidence of infant cyanosis (methemoglobinemia or "blue baby" disease). The high concentrations of nitrate may be an indication of pollution from organic matter, commonly sewage. Iron and manganese in excessive concentrations cause reddish-brown or dark gray precipitates, which stain clothing and plumbing fixtures. Sulfate in water in excess of 250 ppm may produce a laxative effect, and water containing chloride exceeding 250 ppm may have a salty taste. Fluoride is concentrations of about 1 ppm may reduce the incidence of tooth decay, but excessive concentration may cause teeth to become mottled (Dean, Arnold, and Elvove, 1942, p. 1155-1159).

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

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

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

Although cooling water is usually selected on the basis of its temperature and source of supply, its chemical quality is also significant. Any characteristic that may adversely affect the heat-exchange surfaces is undesirable.

Substances such as magnesium, calcium, iron, and silica may cause the formation of scale. Another objectionable feature that may be found in cooling water is corrosiveness caused by calcium and magnesium chloride, sodium chloride in the presence of magnesium, acids, and the gases oxygen and carbon dioxide.

The production of steam requires high quality-of-water standards. Under the extreme temperature and pressure conditions the problems of corrosion and incrustation are intensified. Under these conditions the presence of silica becomes undesirable as it forms a hard scale or incrustation.

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

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

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

Both the concentration and the composition of the dissolved constituents should be considered in appraising quality of water for irrigation. The chemical characteristics that appear to be most important in evaluating the quality of water for irrigation are: (1) relative proportion of sodium to the other cations, (2) total concentration of soluble salt, (3) amount of residual sodium carbonate, and (4) concentration of boron.

The U. S. Salinity Laboratory staff (1954, p. 69-82) proposed a system of classification commonly used for checking the quality of water for irrigation. The classification is based on the salinity hazard as measured by the electrical conductivity of the water and the sodium hazard as measured by the sodium adsorption ratio (SAR). Figure A2 illustrates this classification system.

The importance of the dissolved constituents of water to be used for irrigation depends upon the degree to which the constituents accumulate in the soil. Kelley (1951, p. 95-99) cited areas having an average annual precipitation of

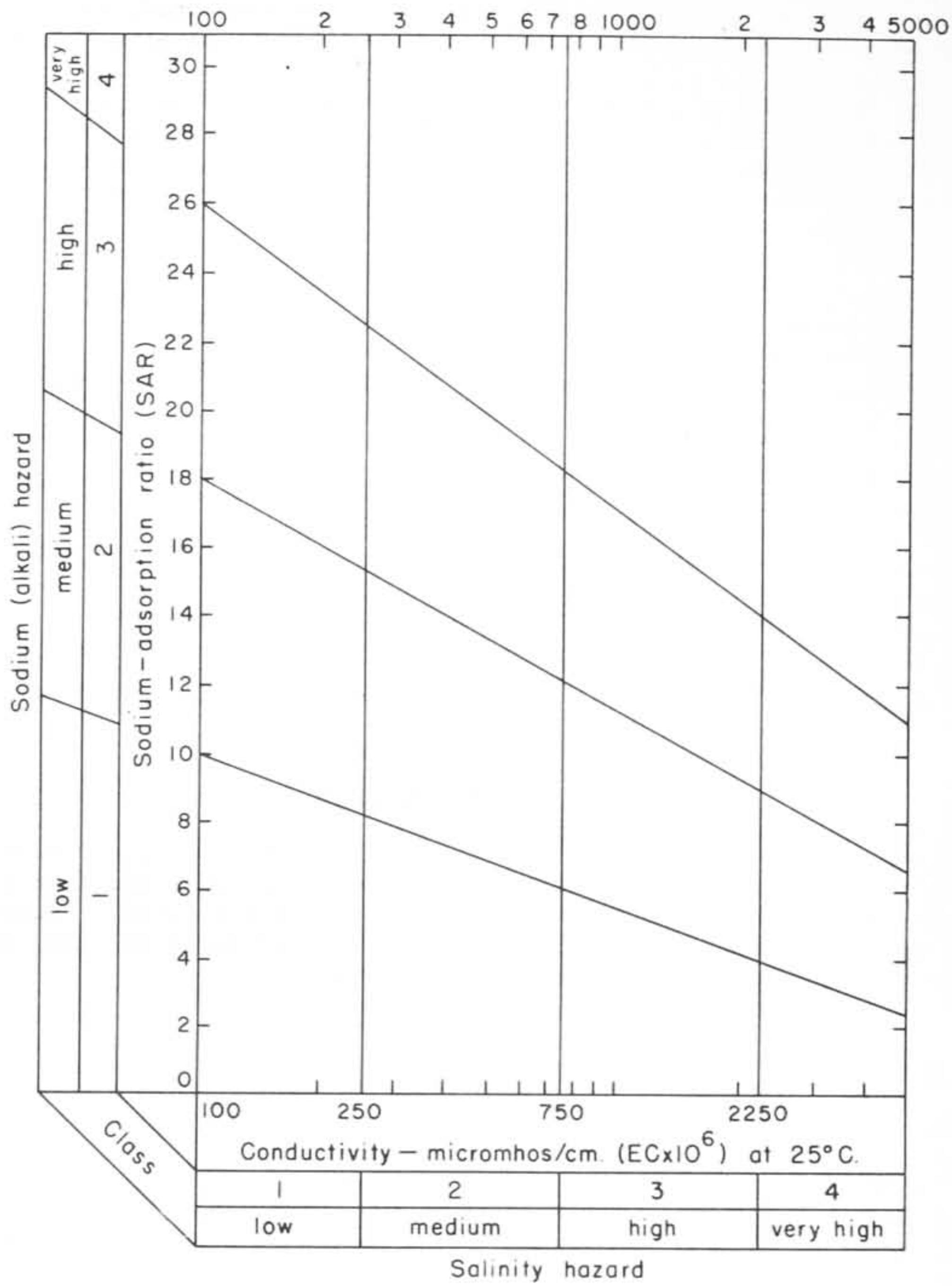

Figure A2

Diagram for the Classification of Irrigation Waters

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

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about 18 inches in which the salts did not accumulate in the irrigated soil. It has been suggested (Wilcox, 1955, p. 15) that the system of the classification of irrigation water proposed by the salinity laboratory staff is not directly applicable to the supplemental waters used in areas of relatively high rainfall.

Boron in excess will also make water unsuitable for irrigation. Scofield (1936, p. 286) has indicated that a boron concentration of as much as 1 ppm is permissible for irrigating sensitive crops, and as much as 3 ppm is permissible for tolerant crops. His suggested permissible limits of boron for irrigation waters are shown in the following table:

Classes of water		Sensitive crops (ppm)	Semitolerant crops (ppm)	Tolerant crops (ppm)
Rating	Grade			
1	Excellent	0.33	0.67	1.00
2	Good	0.33 to .67	0.67 to 1.33	1.00 to 2.00
3	Permissible	.67 to 1.00	1.33 to 2.00	2.00 to 3.00
4	Doubtful	1.00 to 1.25	2.00 to 2.50	3.00 to 3.75
5	Unsuitable	1.25	2.50	3.75

Ground-Water Hydrology

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

Hydrologic Cycle

The water available for use by man--whether as rain, streamflow, water from wells, or spring discharge--is captured in transit, and after its use and reuse is returned to the hydrologic cycle from which it came. This cycle is illustrated in Figure A3. Graphically, Figure A3 shows the continuing movement of water from the oceans through evaporation to precipitation and its return either directly or ultimately to the ocean.

Ground-Water Occurrence and Movement

The geologic history of sedimentary deposition and erosion are primary factors controlling the occurrence and movement of ground water in the north-central Texas area. The rocks found in the shallow subsurface range from sporadic, uncemented, clastic beds to the more widespread, continuous, cemented or compacted shales, sandstones, and limestones. In uncemented rocks such as sand, gravel, and clay, water occurs in the spaces between individual particles,

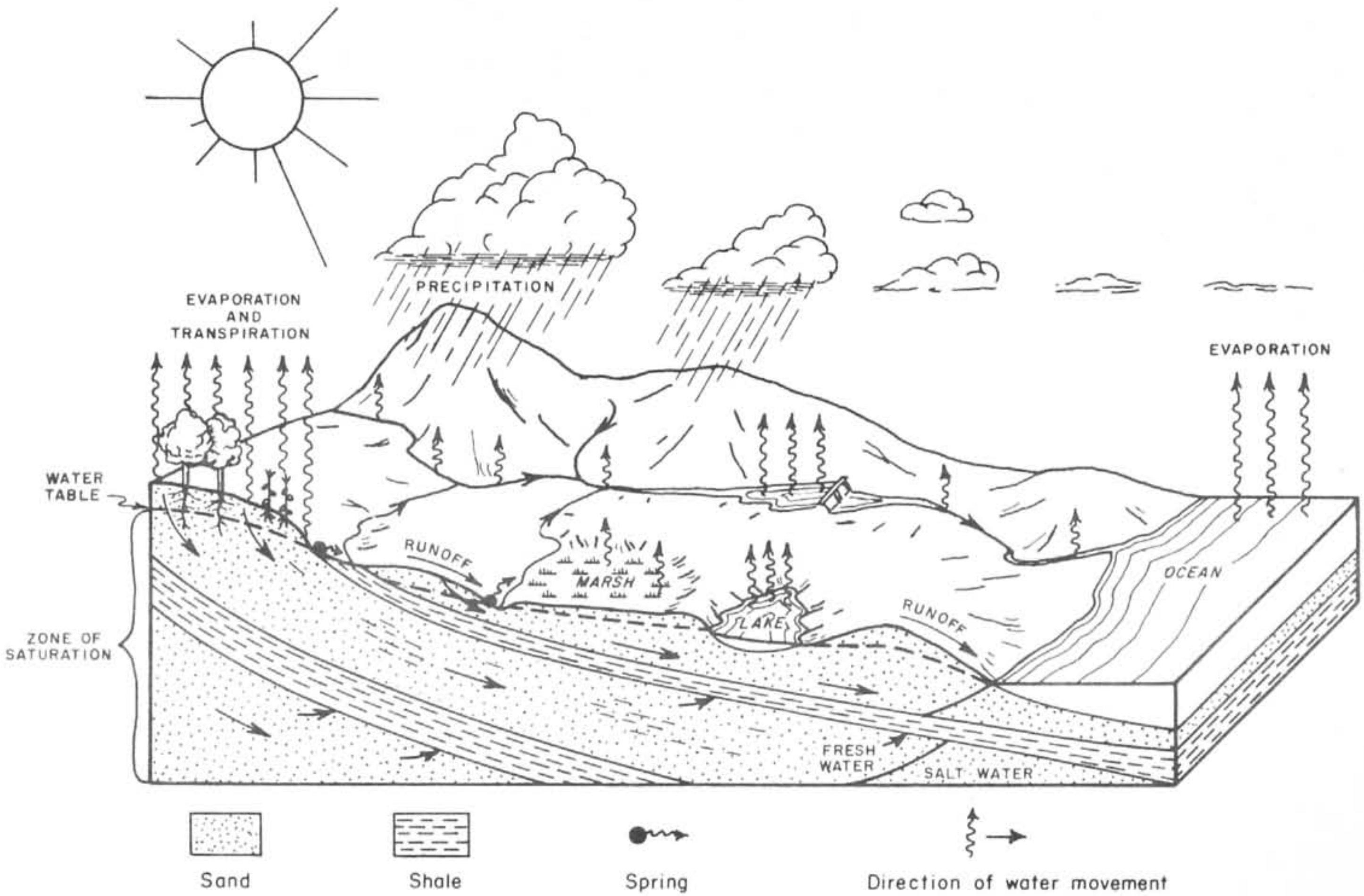

Figure A3

Hydrologic Cycle

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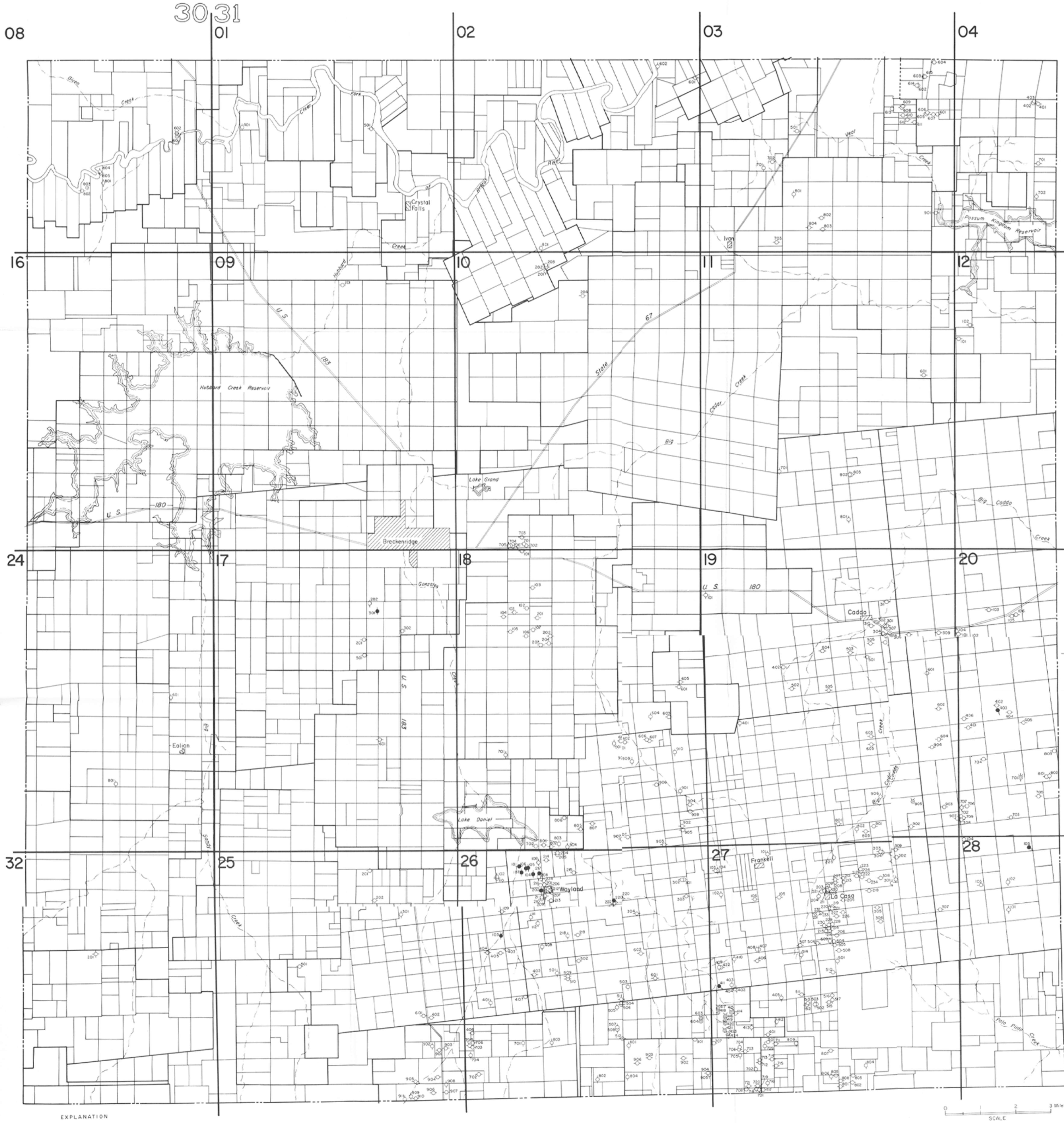
whereas in well cemented or compacted sedimentary rocks it occurs chiefly in cracks and fissures produced by earth movement or contraction, and in openings formed by solution where the rocks are soluble. If these openings are isolated, the movement of ground water is hindered. However, most openings are interconnected so as to permit ground water to move through them. The essential factor is that ground water of usable quality is continually moving from the point at which it entered the ground-water body, called the recharge area, to points of discharge, generally at lower elevations, either in stream drainage or through wells.

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

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



EXPLANATION

In Use / Abandoned

Domestic and Stock Wells

Industrial Wells

Irrigation Wells

Flowing Wells

Spring

Plate I

Map Showing Locations of Wells and Springs, Stephens County

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