TEXAS BOARD OF WATER ENGINEERS

BULLETIN 6017

GROUND-WATER GEOLOGY OF THE HICKORY SANDSTONE MEMBER OF THE RILEY FORMATION, McCULLOCH COUNTY, TEXAS

Prepared in cooperation with the U. S. Geological Survey
and the City of Brady

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By

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United States Geological Survey

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ABSTRACT

McCulloch County in central Texas has an area of 1,066 square miles and had a population of 11,701 in 1950. The economy of the county is dependent chiefly upon farming and ranching, irrigation farming being practiced in the southeastern part. The climate of the county is subhumid, the average annual precipitation being about 24 inches.

The county is underlain by Precambrian rocks consisting of granite, schist, and gneiss. These are overlain in most of the county by Paleozoic and Mesozoic sandstone, limestone, and shale. The principal aquifer in the county is the Hickory sandstone member of the Riley formation of Cambrian age, which has an average thickness in the outcrop area of 360 feet. Throughout the rest of the county the thickness is about 400 feet. The Hickory underlies all the county except for a small area in the southeast corner, where it crops out in a narrow belt surrounding the outcrop of Precambrian rocks. The Hickory sandstone member dips northward and northwestward at about 120 feet per mile.

Water occurs under water-table (unconfined) conditions in much of the outcrop area of the Hickory sandstone member and under artesian (confined) conditions in the rest of the county. Pumping tests indicate a coefficient of transmissibility of about 30,000 gpd (gallons per day) per foot in the outcrop area and about 20,000 gpd per foot at Brady. The coefficient of storage at Brady is about 0.0001.

In 1958 about 3,200 acre-feet of water was pumped from the Hickory in McCulloch County. About 1,600 acre-feet was pumped by the city of Brady and about 1,200 acre-feet was used to irrigate about 1,200 acres in the southeastern part of the county. The rest was used for industrial, domestic, and stock purposes.

Recharge to the Hickory is derived chiefly from precipitation on the outcrop areas in the southeastern part of the county and in neighboring Mason County to the south. The water moves generally northward and northeastward away from the outcrop areas, much of the water ultimately leaving the county as underflow into San Saba County.

About 75,000,000 acre-feet of water is in transient storage in the Hickory in McCulloch County. Most of this water cannot be recovered through wells; however, about 1,000,000 acre-feet would be available to wells if the water levels were lowered 500 feet throughout the county.

The chemical quality of the water in the Hickory sandstone member is good except that the water is hard and, in a few places, the iron content is high. Except for the high iron content, the water meets the standards recommended by the U. S. Public Health Service for drinking water. Most of the water is of excellent quality for irrigation.

INTRODUCTION

Location and Economic Development

McCulloch County is in central Texas; in fact, the county may be said to be "deep in the heart of Texas", as the geographic center of Texas is in the county. Brady, the county seat is about 110 miles northwest of Austin and about 190 miles southwest of Dallas. The county is bounded on the north by Coleman and Brown Counties, on the east by San Saba County, on the south by Mason and Menard Counties, and on the west by Menard and Concho Counties (Figure 1).

McCulloch County has an area of 1,066 square miles. It is served by the Santa Fe Railroad, U. S. Highways 87, 283, 377, and 190; and numerous farm- and ranch-to-market roads and other secondary roads. The population of the county, according to the U. S. Census, was 11,701 in 1950. According to 1957 estimates, the town of Brady had a population of 6,800; other towns include Melvin, population 696; Rochelle, 515; and Mercury, 360.

The economy of McCulloch County is based largely on ranching and farming. The ranches produce cattle, sheep, and angora goats; the principal cultivated crops are cotton, grain sorghum, wheat, corn, oats, peanuts, melons, and sweet potatoes. Irrigation farming is practiced especially in the southeastern part of the county, where 1,200 acres chiefly of cotton, peanuts, melons, and sweet potatoes were irrigated in 1958. The fabrication of aircraft parts and the production of a special type of sand used in the development of oil wells are the main nonagricultural industries of the county.

Purpose and Scope

McCulloch County is a subhumid ranching and farming area. Precipitation, especially during July and August, generally is not sufficient for many field crops; consequently, irrigation with ground water has developed in the southeastern part of the county. Most of the water used for irrigation is obtained from the Hickory sandstone member, the same aquifer that supplies the wells of the city of Brady. Because of the importance of the Hickory as a source of water both for irrigation and for municipal use, the city of Brady, the Texas Board of Water Engineers, and the U. S. Geological Survey entered into a cooperative agreement to conduct an investigation of the ground-water resources of the county with special reference to the Hickory sandstone member. The purpose of the investigation was to obtain information regarding the source, occurrence, utilization, quantity, and chemical quality of ground water in the Hickory in the county.

The investigation was made under the administrative direction of A. N. Sayre and P. E. LaMoreaux, successive chiefs of the Ground Water Branch, U. S. Geological Survey, and under the direct supervision of R. W. Sundstrom, district engineer in charge of ground-water investigations in Texas.

Previous Investigations

The only previous ground-water investigation in McCulloch County was that by Sundstrom and George (1942), in which they briefly described the availability of ground water in the vicinity of Melvin in McCulloch County and Menard in Menard County.

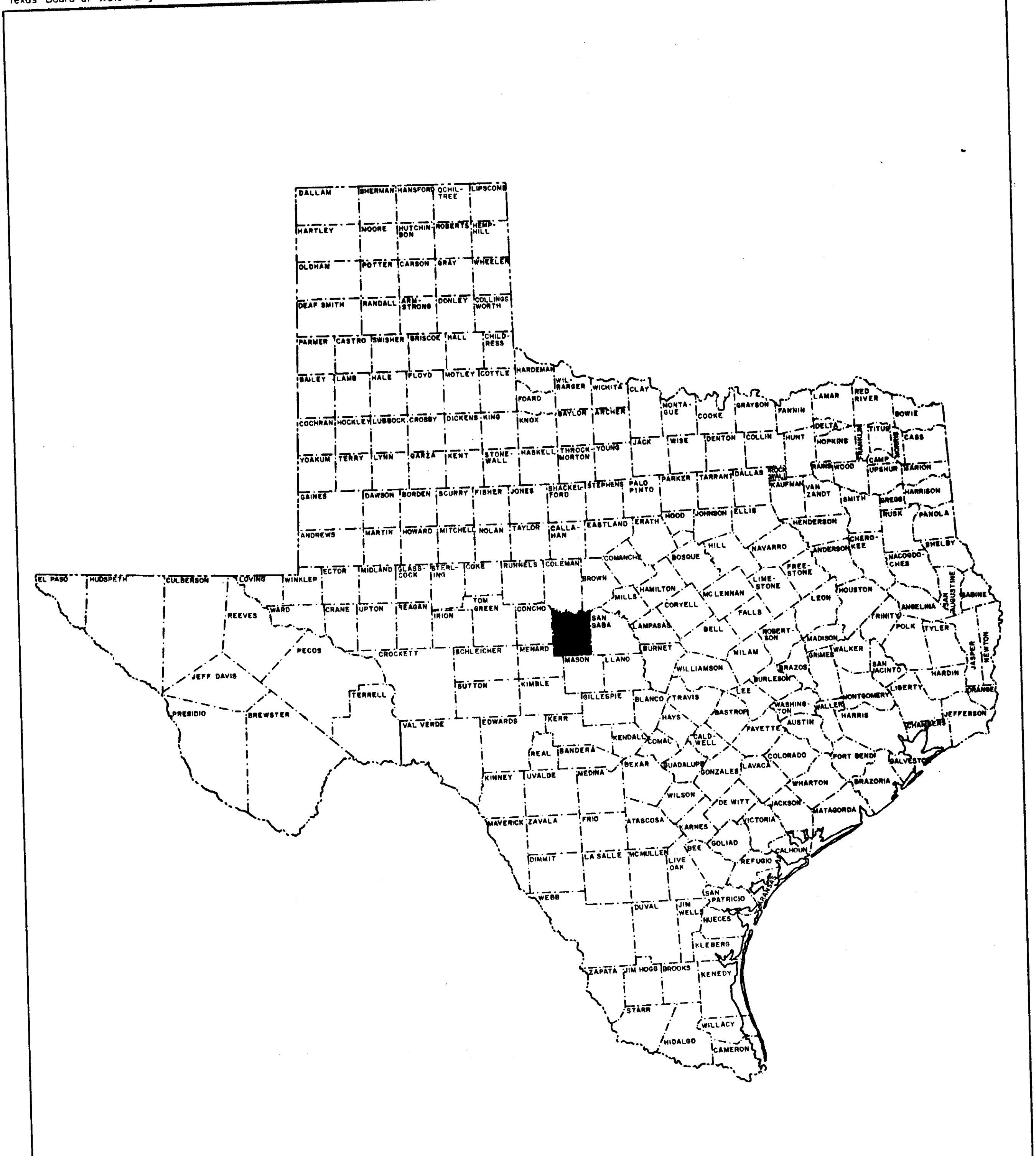

FIGURE 1.— Index map of Texas showing locations of McCulloch County, Texas

Many geologic investigations have been made in McCulloch County; however, most of the early work was in the nature of a reconnaissance. More recent and comprehensive work was done by Bullard and Cuyler (1935), who mapped and described the upper Pennsylvanian and lower Permian rocks along the Colorado River. Plummer (1943) mapped and described the Pennsylvanian and Permian rocks in the county. Cloud and Barnes (1946) described in detail several sections of the Ellenburger group within the county. Bridge, Barnes, and Cloud (1947) redefined and described the stratigraphy of the upper Cambrian rocks in areas adjacent to McCulloch County, and their descriptions and nomenclature have been used in mapping and describing the Cambrian rocks in the county.

Acknowledgments

The writer wishes to thank the landowners of McCulloch County who gave access to their land for geologic and well studies, information about their wells, and the use of the wells for pumping tests. Mr. James Feazelle, superintendent of Public Utilities at Brady and Mr. E.H. Nixon, plant superintendent of the Brady Water Department, gave information and permitted use of the city wells for pumping tests. Mr. Douglas Clary, Mr. M. M. Virdell, and Mr. Fred Wilson, well drillers in the area, gave drillers' logs, samples of drill cuttings from wells, and information about the Hickory sandstone member. Thanks are owed to Mr. J. T. Ogden, manager of the Brady Chamber of Commerce, and to Mr. B.C. Broad of the McCulloch County Electric Cooperative, for cooperation and help. Assistance is gratefully acknowledged to Mr. D. C. Draper of the Texas Board of Water Engineers, who simultaneously made an investigation of the Hickory sandstone member in Mason, San Saba, and Llano Counties,

Methods of Investigation

The fieldwork in McCulloch County was started in October 1957 and continued until December 1958. During that time geologic units were mapped in the southeastern part of the county and the depth to the units was determined in the remainder of the county through a study of well logs. Records of 309 wells (Table 3) were collected and studied, including drillers' logs of 16 wells (Table 4) and electric logs of 31 wells. Monthly depth-to-water measurements were made in 22 observation wells (Table 5). Pumping tests were made on 3 of the city of Brady wells and 6 irrigation wells to determine aquifer coefficients of the Hickory sandstone member. An inventory of pumpage from the Hickory was made; it involved the determination of the duty of water for 17 irrigation wells tapping the Hickory in McCulloch County and adjacent areas in Mason County. Water samples were collected from 35 wells (Table 6) and analyzed chemically in the laboratory of the Geological Survey in Austin. The results of the analyses of 23 samples from 18 wells tapping the Hickory are given in Table 2.

Well-Numbering System

For purposes of numbering the wells, the county was divided into quadrangles: 10 minutes of latitude and longitude on a side (Plate 1). The quadrangles were given letter designations A through S, excluding I, O, and Q, beginning in the northwest corner of the county. The wells are numbered within the quadrangles in a west-to-east, north-to-south succession.

Climate

McCulloch County has a subhumid climate; the summers are hot and the winters are cool.

The long-term mean annual temperature at Brady is 64.4°F. The mean monthly temperature ranges from 45.4°F during January to 81.6°F during July (Figure 3). Maximum temperatures of about 100°F are common in McCulloch County during the summer, and freezes of short duration occur frequently during the winter. The growing season averages 229 days; the average dates of the first and last killing frosts are November 12 and March 28.

The average annual precipitation at Brady for the period of record 1913-58 was 23.95 inches. The wettest year of record was 1919 when the precipitation totaled 41.40 inches; the driest year was 1954 when the precipitation was 8.71 inches (Figure 2). Figure 2 shows that except for 1952, when the precipitation was slightly above average, the recent drought extended from 1950 through 1956. It was during the extremely dry period 1953-54 that large-scale use of water for irrigation was started in McCulloch County. Figure 3, illustrating the monthly distribution of precipitation, shows that the precipitation is greatest during the late spring and least during the winter.

The evaporation station closest to McCulloch County is about 65 miles southeast of Brady at Buchanan Dam. The average annual evaporation from a Weather Bureau class A land pan at the dam is about 82 inches. Figure 3 shows that the most evaporation takes place during the months of high rainfall, thereby nullifying to a certain extent the effects of potential recharge from the rainfall.

Physiography and Drainage

McCulloch County is in parts of three physiographic provinces: the Edwards Plateau, the Osage Plains, and the Llano uplift (Figure 4). The Edwards Plateau, occupying the southwestern part of the county and a narrow east-west-trending belt across the central part, is underlain by nearly flat-lying beds of Cretaceous limestone and sandstone. These form a plateau-like surface in the southwestern part, but erosion has reduced the central part to a line of hills known as the Brady Mountains.

The Osage Plains are underlain by westward- and northwestward-dipping Paleozoic rocks consisting largely of sandstone, shale, and limestone. The rocks are less resistant to erosion than those underlying the Edwards Plateau and Llano uplift, and they form a gently undulating plain which is nearly flat in the northern part of the county.

The Llano uplift in the southeastern part of the county is underlain by lower Paleozoic sandstone, shale, and limestone, dipping north and northwest from a central core of Precambrian granite, schist, and gneiss. The Precambrian rocks and the limestone form hilly areas, whereas the sandstone and shale form areas of low relief. Most of the irrigated area in the county is in the sandy outcrops in the Llano uplift.

The altitude of the land surface in McCulloch County ranges from about 2,100 feet in the southwestern part of the county to less than 1,300 feet in the Colorado River valley in the northeast corner of the county. Thus, the overall relief is more than 800 feet.

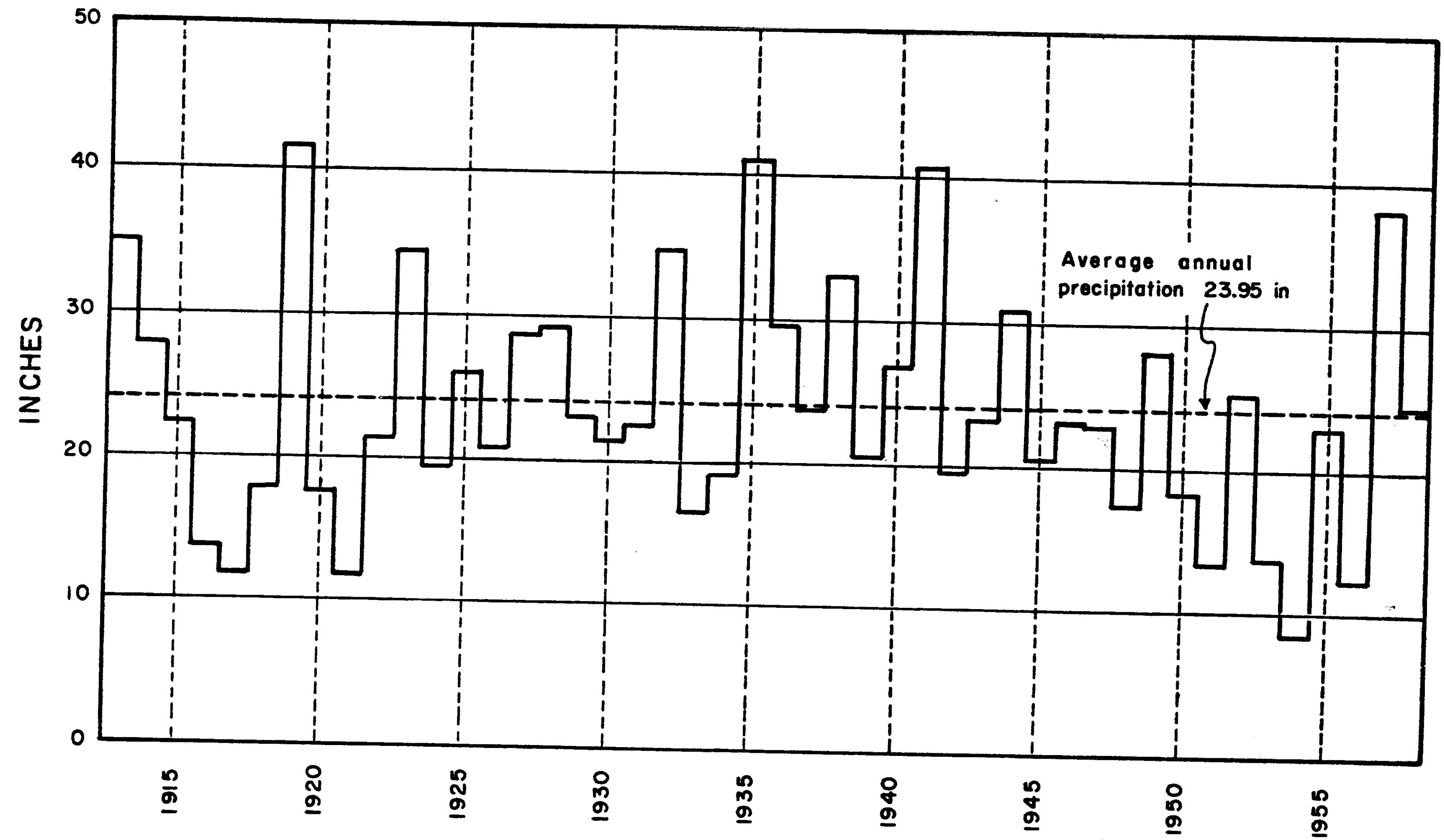

FIGURE 2.—Annual precipitation at Brady, Texas, 1913–58
(From records of U. S. Weather Bureau)

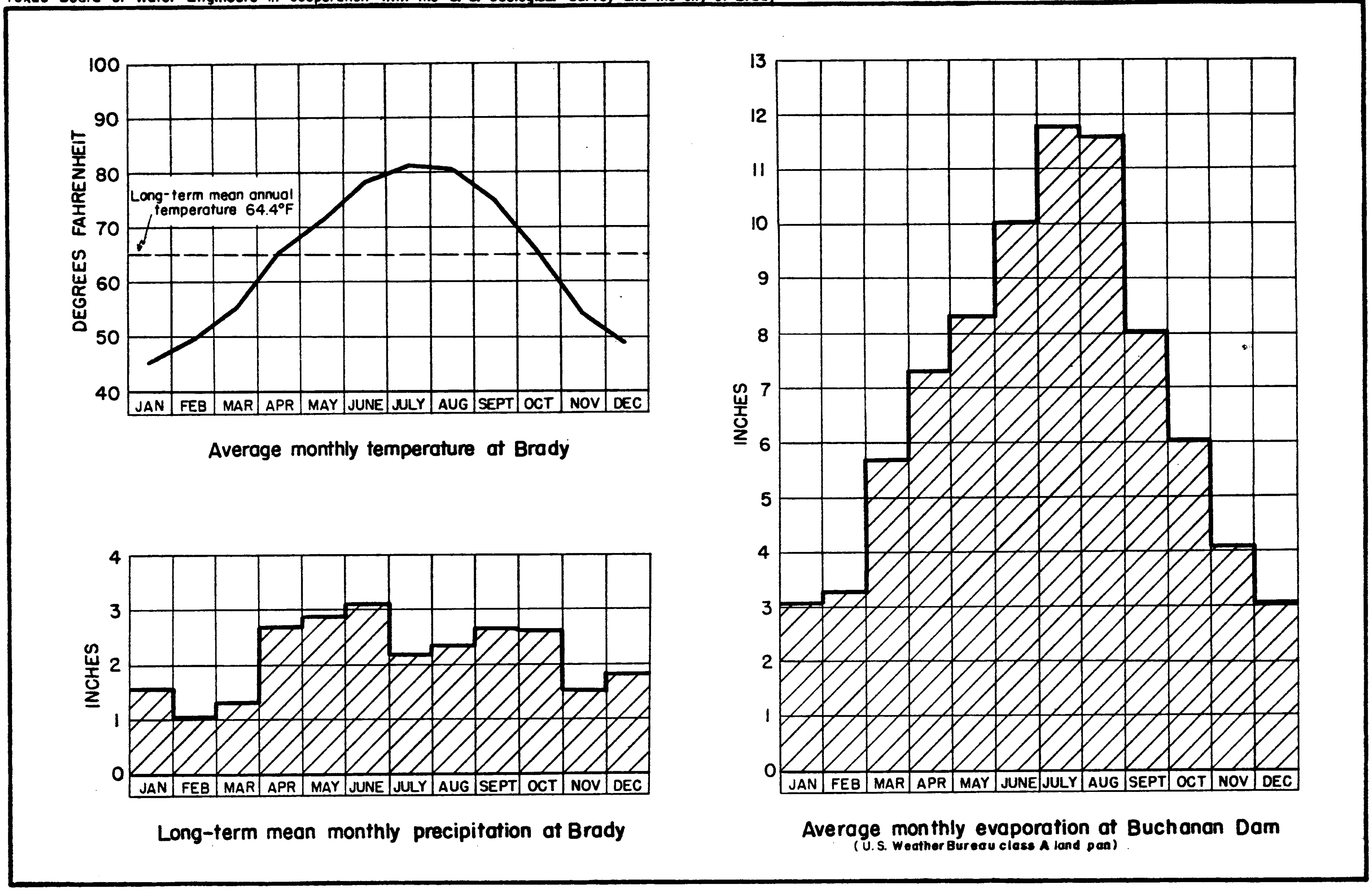

FIGURE 3.- Monthly temperature and precipitation at Brady, McCulloch County, Texas and monthly evaporation at Buchanan Dam

(From records of U.S. Weather Bureau)

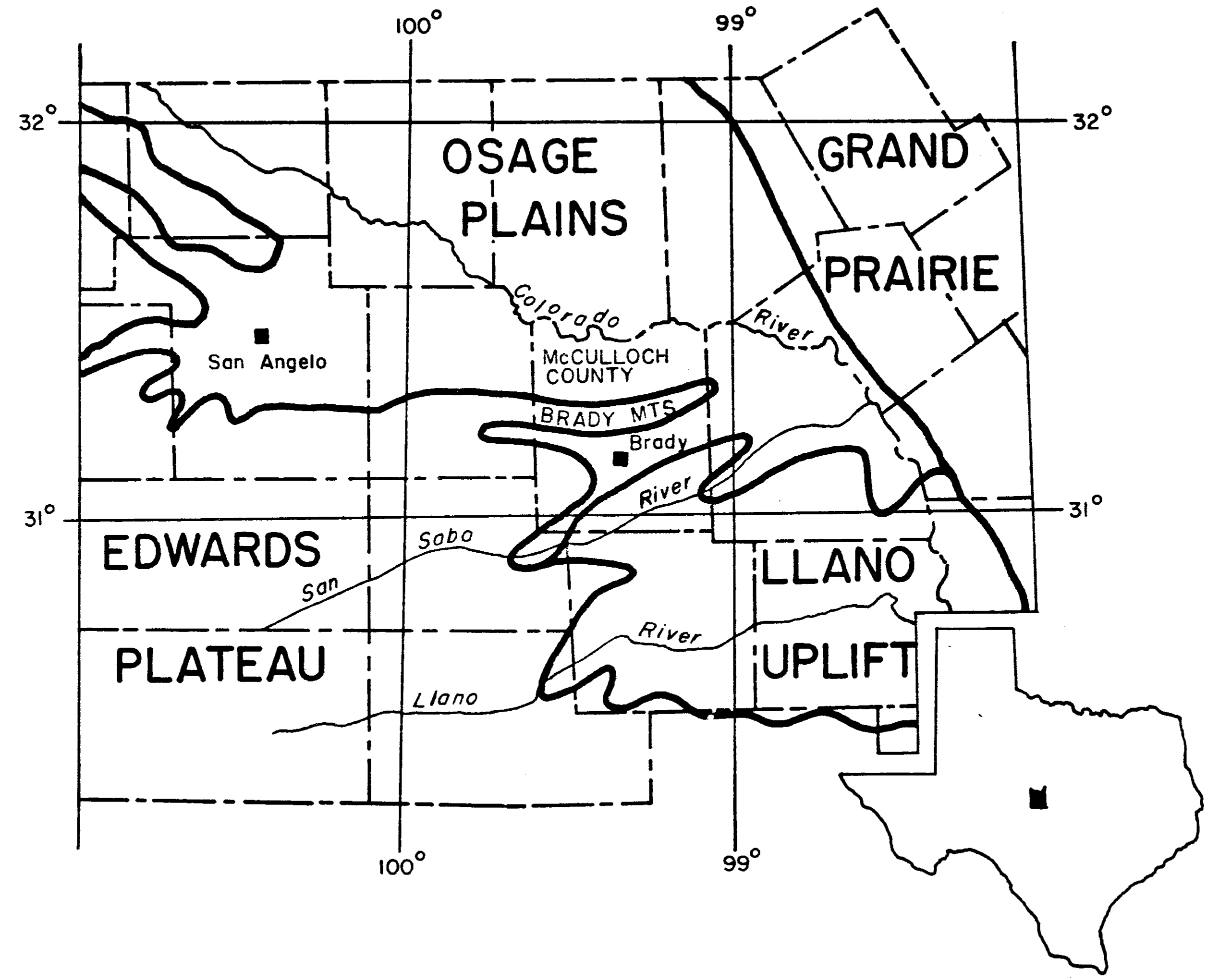

FIGURE 4.- Map of central Texas showing physiographic features

McCulloch County is drained by the Colorado River, which flows in an easterly direction forming the northern boundary of the county. The principal tributaries of the Colorado are Brady Creek, which flows in an easterly direction across the central part of the county, and the San Saba River, which flows in a northeasterly direction across the southern part. The two rivers are perennial except during periods of extreme drought. The other streams are intermittent.

GENERAL GEOLOGY

The rocks cropping out in McCulloch County range from Precambrian in the southeastern part of the county to alluvium of Recent age in the stream valleys. The area1 extent of the outcrops of the different stratigraphic units is shown on the geologic map (Plate l), except that the alluvium is shown only in the southeastern part of the county. A summary of the descriptions of the stratigraphic units is given in Table 1.

McCulloch County lies on the northwest flank of a broad structural dome known as the Llano uplift. During late Paleozoic time a system of large faults developed in the area; the faults strike northeast and dip almost vertically. Some of the faults have a vertical displacement of as much as 1,100 feet. Most of the upward movement as a result of the faulting started near the end of Pennsylvanian time. Post-Paleozoic faulting is not known in the Llano uplift. Erosion between Pennsylvanian and Cretaceous time leveled the uplift, and Cretaceous rocks were deposited on the beveled edges of the Precambrian and Paleozoic rocks. Subsequently the area was very gently domed and truncated by erosion (Cloud and Barnes, 1946, P. 113) so that now the Llano uplift consists of a central core of Precambrian rocks surrounded by Paleozoic rocks which dip away from the uplift in all directions. The only remaining Cretaceous rocks are near the edges of the uplift, where they lie nearly horizontally on the more steeply dipping older rocks. The Llano uplift is not reflected in the topography as a high area; in fact, the Llano River flows through the central part of the uplift.

The Paleozoic rocks in the southern part of McCulloch County dip away from the Llano uplift in a northerly or northwesterly direction, except in a small area in the southeastern part of the county where the dip is to the northeast or east. The dips are generally 120 feet per mile or less, except locally in the southeastern part of the county where faulting has created dips as great as 45 degrees. The stratigraphic and structural relationships of the geologic units in different parts of the county are shown in the geologic sections (Figures 5, 6, and 7).

STRATIGRAPHIC UNITS AND THEIR WATER-BEARING PROPERTIES

Precambrian Era

Rocks of Precambrian age, consisting of highly weathered granite, schist, and gneiss, crop out in southeastern McCulloch County and form a basement complex on which younger rocks have been deposited. The granite is fine- to coarse-grained and contains numerous pegmatite veins. The schist has a high percentage of biotite, which gives it a dark-gray color; and it is often referred to as "gray shale" or "blue mud" by well drillers. The gneiss, which is pinkish and fine-grained, is abundant along the east edge of the outcrop area, where it weathers easily to form a sandy soil similar to that formed by the weathering of the overlying Hickory sandstone member.

Table 1.--Stratigraphic units in McCulloch County, Texas

Era	System	Group	Stratigraphic unit	Thickness (feet)	Character of material	Water-bearing properties
Cenozoic	Quaternary		Alluvium	0-40	Terrace and flood-plain deposits of clay, silt, sand, and gravel	Yields small supplies of water of good chemical quality
Mesozoic	Cretaceous			0-270	Hard, resistant limestone in upper part, grading downward into dark-gray marl. Basal part consists of sand	Yields small supplies of water to domestic and stock wells. Wells may fail during drought periods
Paleozoic	Permian Pennsylvanian Mississippian		Younger Paleozoic rocks	0-2,700	Limestone, shale, and sandstone	Yield small to moderate supplies of water. Some wells may fail during drought periods. At some places in the north-central part of the county the water is reported to be saline and unsuitable for domestic and stock supplies
	Devonian			-	Joint and crack fillings	Not a source of ground water
	Ordovician	Ellenburger		0-600	Gray to yellowish-gray fine to coarse-grained limestone and dolomite	Important source of water for domestic and stock supplies. Wells penetrating porous zones may have moderate yields. Water from wells in northern part of McCulloch County contains more chloride and is softer than the water from the Ellenburger in the southern part
	Cambrian		Wilberns formation: San Saba limestone member	0-280	Chiefly glauconitic limestone	Probably yields small supplies of water
			Wilberns formation: Point Peak shale member	0-160	Well-bedded soft greenish calcareous shale, including beds of dolomite and glauconitic limestone. Reef-like masses of limestone in the upper part	May yield small supplies of water
			Wilberns formation: Morgan Creek limestone member	0-140	Medium to coarse-grained glauconitic limestone	Probably yields small supplies of water
			Wilberns formation: Welge sandstone member	0-50	Brown nonglauconitic sandstone	Yields small supplies of water
			Riley formation: Lion Mountain sandstone member	0-50	Glauconitic sandstone; beds of glauconitic limestone in the upper part and lenses of fossiliferous limestone in the lower part	do
			Riley formation: Cap Mountain limestone member	0-280	Nearly pure granular limestone containing beds of impure dark-brown limestone and calcareous sandstone in the lower part	Not known to yield water to wells
			Riley formation: Hickory sandstone member	0-500	Yellow, brown, and red sandstone. Numerous thin lenses of red or gray clay	Principal aquifer in the county; yields large supplies of water
Precambrian			Precambrian rocks	-	Pink granite, dark-gray schist, and pink gneiss	Yields small supplies of water of good quality

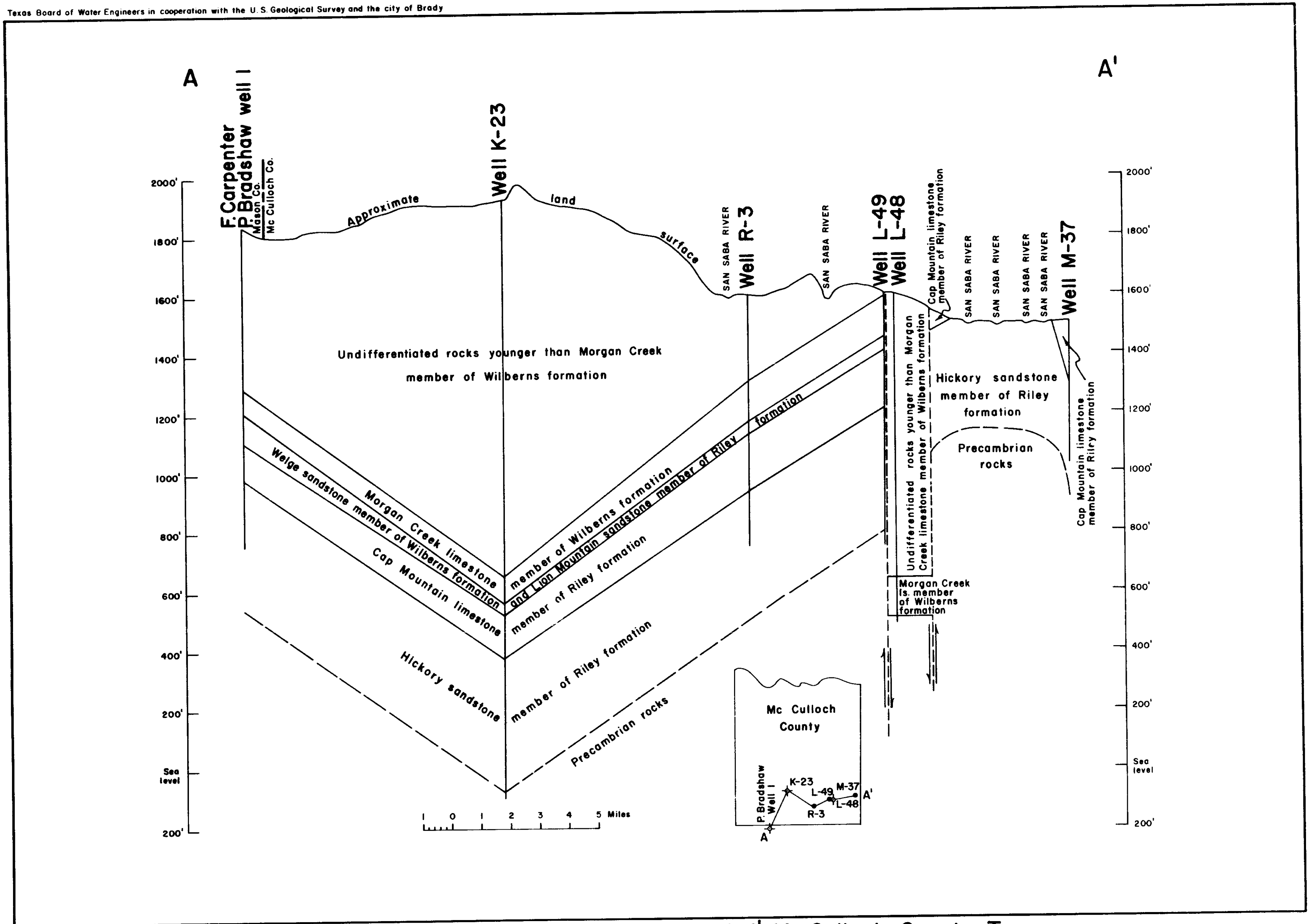

FIGURE 5.- Geologic section along line A-A', Mc Culloch County, Texas

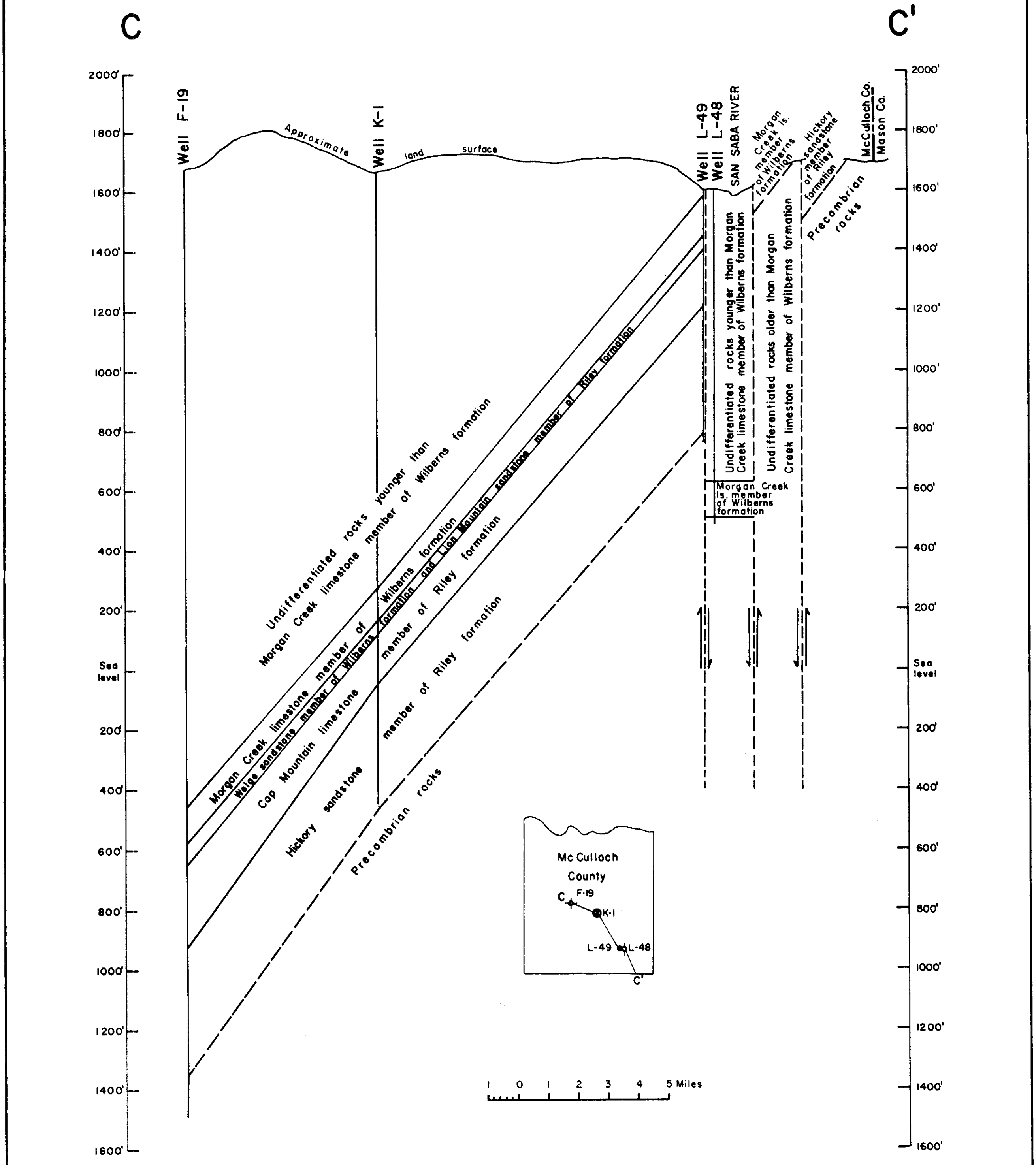

FIGURE 7.—Geologic section along line C-C', McCulloch County, Texas

Although no records were obtained of wells tapping the Precambrian rocks, they are reported to yield small quantities of water of good chemical quality to domestic and stock wells in the outcrop area. The water in the Precambrian rocks occurs in fractures and in the weathered zone in the outcrop area.

Paleozoic Era

CAMBRIAN SYSTEM

Riley Formation

The Riley formation is the oldest formation of Cambrian age in McCulloch County. The Riley has been divided into three members, consisting from bottom to top of the Hickory sandstone member, the Cap Mountain limestone member, and the Lion Mountain sandstone member.

HICKORY SANDSTONE MEMBER

The Hickory sandstone member occupies an outcrop area of about 23½ square miles, forming a modified arc adjacent to the outcrop of the Precambrian rocks in the southeastern part of the county (Plate 1). The Hickory was deposited on an irregular surface of Precambrian rocks; consequently, it varies in thickness from place to place. The average thickness near the outcrop where the full section is present is about 360 feet; however, the maximum observed thickness is about 500 feet in well M-36. Well logs show that the Hickory thickens slightly from the outcrop to an average of about 400 feet downdip to the north and northwest. In general the Hickory dips to the north and northwest at a rate of about 120 feet per mile, an exception being in a small area in the southeastern part of the county where the dip is to the northeast or east. Very steep dips have been observed locally, but these are largely the result of distortion of the beds near faults.

The Hickory sandstone member consists chiefly of yellow, brown, or red sandstone, the upper part being generally dull red or russet. In some places iron-rich layers impart a reddish-black color and a metallic luster to the sandstone. Typically, the Hickory is noncalcareous and nonglauconitic, in contrast to some of the younger Cambrian sandstones. The grain size of the Hickory varies considerably from layer to layer. Reds of sand ranging from very fine-grained to coarse-grained may occur in any part of the Hickory, but in general the beds in the lower part tend to be coarser grained and have a more uniform grain size than the beds in the upper part. The sand grains are fairly well rounded and are cemented with iron oxide or clay. The upper part of the Hickory generally is more firmly cemented with clay and consequently is less permeable than the lower part. The sand beds in the lower part of the Hickory show evidence of having been deposited by wind; however, it is not known whether the deposits are truly eolian or whether they have been reworked by water. The upper part is believed to have been deposited in water.

The Hickory sandstone member contains numerous thin lenses of red and gray clay which generally are only a few inches thick. At some places, particularly about 40 to 60 feet above the base of the Hickory, they are so numerous that they probably seriously retard the vertical movement of ground water.

The Hickory yields large quantities of water to wells in McCulloch County. It is the most important source of ground water in the county in terms of both present development and potential future development. The details of the occurrence of water in the Hickory are discussed in a later section of this report.

CAP MOUNTAIN LIMESTONE MEMBER

The Cap Mountain limestone member of the Riley formation conformably overlies the Hickory sandstone member, the contact being transitional. In the geologic mapping done in connection with this investigation, the boundary was placed at the top of a zone of noncalcareous sandstone and beneath the overlying zone of alternating beds of impure dark-brown limestone and calcareous sandstone. This boundary forms a distinct topographic break on aerial photographs,

The Cap Mountain member consists chiefly of nearly pure granular limestone containing some beds of impure dark-brown limestone and calcareous sandstone, especially in the lower part. The observed thickness of the Cap Mountain ranges from about 120 feet in well E-6 to 280 feet in well F-19. The thickness is 190 feet in well L-49 near the outcrop.

The Cap Mountain limestone member is nearly impermeable except where it has been jointed and faulted, and it is not known to yield water to wells in the county.

LION MOUNTAIN SANDSTONE MEMBER

The Lion Mountain sandstone member, the uppermost member of the Riley formation, conformably overlies the Cap Mountain limestone member. The contact between the two members is generally placed at the base of a bench rising above the relatively flat surface of the Cap Mountain The Lion Mountain consists largely of glauconitic sandstone containing fossiliferous limestone lenses in the lower part and discontinuous beds of glauconitic limestone in the upper part. The observed thickness of the Lion Mountain ranges from 20 to 50 feet in McCulloch County.

The Lion Mountain and the overlying Welge sandstone member of the Wilberns formation were not separated on the geologic map (Plate 1) or in the geologic sections (Figures, 5, 6, and 7). They act as a single ground-water reservoir which is reported to yield small quantities of water to domestic and stock wells in the southeastern part of the county. The water is reported to be hard but otherwise of good chemical quality.

Wilberns Formation

The Wilberns formation consists, from bottom to top, of the Welge sandstone member, Morgan Creek limestone member, Point Peak shale member, and San Saba limestone member.

WELGE SANDSTONE MEMBER

The Welge sandstone member of the Wilberns formation consists of brown poorly cemented mostly nonglauconitic sandstone. It contains abundant quartz grains having recomposed faces that glitter in the sunlight. The Welge ranges from about 20 to 50 feet in thickness. The contact of the Welge with the underlying Lion Mountain is fairly sharp; however, the two units form a single ground-water reservoir and are not separated on the geologic map or sections.

The Welge and Lion Mountain members reportedly yield small quantities of water to domestic and stock wells in the southeastern part of the county.

MORGAN CREEK LIMESTONE MEMBER

The Morgan Creek limestone member of the Wilberns formation conformably overlies the Welge sandstone member It consists chiefly of medium- to coarse-grained glauconitic well-bedded limestone. The lower part of the member is commonly reddish, grading into gray or greenish gray in the upper part. The Morgan Creek ranges in thickness from about 70 to 140 feet; individual beds range from 4 inches to about a foot in thickness, the thickness of individual beds being fairly uniform.

No information is available concerning wells tapping the Morgan Creek member; however, it probably yields small quantities of water to domestic and stock wells in and near the outcrop.

POINT PEAK SHALE MEMBER

The Point Peak shale member of the Wilberns formation consists chiefly of well-bedded soft greenish calcareous shale containing beds of fine-grained dolomite, medium- to fine-grained glauconitic limestone, and conglomerate composed of limestone pebbles. Near the top are beds of oolitic limestone. Scattered to extensive reef-like masses of limestone of algal origin known as bioherms are common in the upper part of the member. The Point Peak shale member averages about 160 feet in thickness. The contact between the Point Peak shale member and the underlying Morgan Creek limestone member is gradational.

It is difficult to distinguish the oolitic limestone and the layers of bioherms in the upper part of the Point Peak from the overlying San Saba limestone member. It is likewise difficult to distinguish the San Saba limestone member from the overlying rocks of the Ellenburger group. Therefore, the Point Peak shale member, the San Saba limestone member, and the rocks of the Ellenburger group were mapped together and are so shown on the geologic map (Plate 1).

No information is available concerning wells tapping the Point Peak shale member; however, the limestone facies may yield small quantities of water to domestic and stock wells.

SAN SABA LIMESTONE MEMBER

The San Saba limestone member of the Wilberns formation conformably overlies the Point Peak shale member. The San Saba consists largely of beds of glauconitic limestone, the lower part at some places consisting of bioherms similar to those in the underlying Point Peak shale member. The San Saba member averages about 280 feet in thickness. The San Saba was not separated from the Point Peak member or the Ellenburger group on the geologic map or sections.

No information is available concerning wells tapping the San Saba; however, the member probably yields small quantities of water to domestic and stock wells in the outcrop area.

ORDOVICIAN SYSTEM

Ellenburger group

The Ellenburger group in McCulloch County consists of the Tanyard and Gorman formations, which have been mapped together with the underlying San Saba limestone and Point Peak shale members of the Wilberns formation.

The Ellenburger consists chiefly of gray to yellowish-gray fine- to coarse-grained limestone and dolomite, parts of which are vugular or porous. Much of the Ellenburger is fossiliferous, and chert is common particularly in the upper part. The observed thickness of the Ellenburger group in McCulloch County ranges from 280 to 600 and averages about 450 feet.

The Ellenburger crops out in a northeastward-trending band averaging about 6 miles in width and crossing the southeastern part of the county (Plate 1). The beds dip to the north and northwest away from the outcrop area at a rate of about 70 feet per mile.

Rocks of the Ellenburger group yield small to moderate supplies of water for domestic and stock use in many places in McCulloch County.

YOUNGER PAIXOZOIC ROCKS

Rocks of Devonian, Mississippian, Pennsylvanian, and Permian age are present in McCulloch County; however, for purposes of this report they have been mapped as a unit and are referred to as "younger Paleozoic rocks." The unit consists of a maximum of about 2,700 feet of shale, limestone, and sandstone. The Devonian rocks consist of isolated patches of limestone of negligible thickness or as joint and crack fillings in the older rocks. The Mississippian rocks are made up of about 30 feet of dark-colored shale. The Pennsylvanian system is represented by about 2,400 feet of gray to black limestone, gray shale, and sandstone. The Permian rocks present in the county consist of about 300 feet of alternating beds of multicolored shale and gray to purple limestone. The younger Paleozoic rocks yield small to moderate quantities of water to wells in many parts of the county. Some of the water, especially in the northern part of the county, is reported to be saline.

Mesocoic Era

CRETACEOUS SYSTEM

Rocks of Cretaceous age unconformably overlie the Paleozoic rocks and crop out in an eastward-trending band near the center of the northern part of the county and in a large area in the southwestern part (Plate 1). The Cretaceous rocks consist of several geologic formations; however, for purposes of this report they have not been differentiated.

The Cretaceous rocks consist of sand in the lower part overlain by dark gray marl which grades upward into hard, resistant limestone in the upper part. The maximum thickness of the Cretaceous rocks in the county is about 270 feet.

The Cretaceous rocks yield small quantities of water to domestic and stock wells, some of which reportedly fail during dry periods. The water is reported to be hard but otherwise of good chemical quality.

Cenozoic Era

QUATERNARY SYSTEM

Alluvium of Quaternary age is present beneath the flood plains and terraces along many of the streams in McCulloch County. It is shown on the geologic map only in the southeastern part of the county (Plate 1). The alluvium consists of clay, silt, sand, and gravel having a thickness as great as 40 feet. The alluvium reportedly yields small quantities of water of good chemical quality to a few wells in the county.

OCCURRENCE OF GROUND WATER

General Principles

The source of all ground water of good quality is precipitation that falls on the earth's surface. A part of the precipitation runs off directly over the surface. Another part seeps into the soil and is later largely removed by evaporation and transpiration. The remainder, generally not more than a few percent under the conditions existing in McCulloch County, moves downward to the water table thus becoming part of the ground water. Locally, some of the surface runoff may seep into the ground and become part of the ground water.

An aquifer is a water-bearing formation or group of formations capable of yielding water to wells. The aquifer serves both as a conduit through which water moves and a reservoir in which water is in transient storage.

Water in transient storage moves slowly (tens to hundreds of feet per year) from places of recharge to places of discharge. If the water moves beneath a confining bed, which retards its upward movement, it is then said to be under artesian conditions and will rise in wells above the level at which it is first encountered. Ground water may be discharged naturally through seeps and springs in the outcrop of the aquifer itself, by transpiration where the water table is close enough to the surface that it may be reached by the roots of plants, by seepage through semiconfining beds (either upward or downward) into another aquifer having a lower head, or by leakage along faults or joints,

Under natural conditions over a period of years, the amount of water discharged from an aquifer equals the amount of water recharged to it. Whenever the amount of water available for recharge is larger than the amount of water discharged, there is an increase in storage, perhaps to the extent that additional potential recharge is rejected. Whenever large quantities of water are discharged from an aquifer by pumping, the natural hydraulic system is disturbed and water levels are lowered, causing the amount of water naturally discharged to be reduced and/or some of the hitherto rejected recharge to enter the aquifer.

An aquifer has two important hydraulic properties: the ability to transmit water and the ability to store water. These may be expressed as the coefficient of transmissibility, T (the number of gallons per day that will move through a vertical strip of the aquifer 1 foot wide when the hydraulic gradient is unity) and the coefficient of storage, S (the volume of water an aquifer releases from or takes into storage per unit of surface area of the aquifer per unit change in the component of head normal to that surface). The coefficient of storage in nonartesian (water-table) aquifers is approximately equal to the specific yield. The specific yield of a rock is defined as the ratio of the volume of water it will yield by gravity to its own volume.

HYDROLOGIC CHARACTERISTICS

Ground water occurs in the Hickory sandstone member of the Riley formation in the spaces between the sand grains. The sand in the lower part is coarser and contains less cementing material than the sand in the upper part. Consequently, the lower part is more productive and is tapped by most of the larger capacity wells in the county.

The clay lenses in the Hickory, particularly those about 40 to 60 feet above the base, tend to impede the vertical movement of water. Where the clay lenses are present, the water in the lower part of the Hickory is under artesian pressure even in the outcrop area. For example, in the valley of the San Saba River northeast of Voca the artesian pressure in the lower part of the Hickory is sufficient to cause some of the wells to flow. Where the clay layers are not present, the water in the outcrop area occurs under water-table conditions; that is, it is unconfined. North of the outcrop area the Hickory is confined by the overlying formations and the water occurs under artesian conditions.

Pumping tests were made in 9 wells in the county to determine the coefficient of transmissibility and storage of the Hickory. Of the wells, 6 were irrigation wells and 3 were used for public supply at Brady. The tests made on the irrigation wells were short-time recovery tests in which the recovery of water levels was measured in each well after periods of pumping at constant rates. The tests made on the city of Brady wells were interference tests in which well K-2 was pumped and the resulting drawdown of water levels was measured in wells K-1, K-2, and K-3. After shutdown of the pumped well, the recovery of water levels was measured in all three wells. The results of the tests are shown in the following table.

Well No.	Depth (ft.)	Discharge during test (gpm)	Coefficient of transmissibility (gallons per day per foot)	Coefficient of storage	Type of test	Remarks
R-54	125	95	23,000	--	Recovery	Pumped well
S- 2	126	70	31,000	--	do	do
R-58	242	325	36,000	--	do	do
L-42	349	600	30,000	--	do	do
R-28	370	500	21,000	--	do	do
R-23	600	915	38,000	--	do	do
K- 1	2,127	--	20,000	0.00009	Drawdown	Observation well
			20,000	.00009	Recovery	
K- 2	2,114	500	18,000	--	Drawdown	Pumped well
			20,000	--	Recovery	
K- 3	2,112	--	20,000	.0001	Drawdown	Observation well
			19,000	.0001	Recovery	

The tests show that in the vicinity of Brady, the Hickory sandstone member has a coefficient of transmissibility of about 20,000 gpd (gallons per day) per foot and a coefficient of storage of about 0.0001. These coefficients can be used to predict the drawdown caused by pumping. For example, Figure 8 is a graph showing the drawdown to be xpected at different distances from a well pumping 1,000 gpm (gallons per minute) for various periods of time. The aquifer is theoretical in that it is assumed to be infinite in extent, isotropic (transmits water equally well in all directions), and bounded by impermeable beds above and below, and that it does not receive recharge or discharge elsewhere than at the well. The graph can be used to compute drawdowns in the Hickory to the extent that the computed average coefficients represent average conditons in the Hickory and that the Hickory fulfills the theoretical assumptions. For rates of pumping other than 1,000 gpm the fraction or multiple of 1,000 should be multiplied by the drawdown indicated from the graph.

The Hickory member does not conform to the theoretical assumptions in several important respects. The rocks overlying the Hickory are not completely impermeable, and they permit at least a small amount of water to move vertically into or out of the Hickory. Furthermore, the Hickory crops out about 12 miles south of Brady where it receives recharge. The effect on water levels in the Hickory by leakage from the overlying beds and by recharge in the outcrop area would tend to make the drawdowns somewhat less than those given for the theoretical aquifer.

USE OF WATER

The most widespread use of water from the Hickory sandstone member is that for domestic and stock purposes. Although the domestic and stock wells are numerous ,most of them are equipped with windmills or small electric pumps and produce only small quantities of water. The total yield is small compared to other uses in the county-probably not more than 150 acre-feet per year.

The city of Brady originally used surface water from Brady Creek to supply its municipal needs; however, in 1921, after a severe dry spell, the city drilled an exploratory deep water well. This well, K-2, city of Brady No. 1 well, the first municipal well to tap the Hickory in McCulloch County, is 2,114 feet deep and has produced more than 1,000 gpm of water of good chemical quality. The increased use of water by the city of Brady during the period 1930-58,as shown in Figure 9, was supplied by well K-3 drilled in 1930; well L-l, in 1943; and well K-l, in 1955. All produce water from the Hickory. Figure 9 shows that the average daily pumpage at Brady increased from about 250,000 gpd in 1930 to a peak of more than 2,000,OOO gpd in the extremely dry year 1956. Since 1956 the pumpage has declined to about l,400,000 gpd, or an annual total of nearly 1,600 acre-feet in 1958. The seasonal range in daily pumpage at Brady is shown in Figure 10.

The Hickory is the source of all water used for irrigation in McCulloch County, the irrigation being confined to the southeastern part of the county. The first irrigation wells were 2 flowing wells near the San Saba River used, in part, to irrigate small gardens and feed plots. A 3rd well was drilled in 1950 and 4 more, used principally for irrigation, were drilled in 1953. From 1954 to 1957, 17 irrigation wells were drilled, and 1 was drilled in 1958. Twenty-two wells were in use in 1958.

The irrigated acreage in the county is estimated to have been about 300 acres in 1954, 600 in 1955, 950 in 1956, and 1,200 in 1957 and 1958. About 1,300 acres in adjoining parts of Mason and San Saba Counties was irrigated in 1958 by 26 wells tapping the Hickory (D. C. Draper, Texas Board of Water Engineers, oral communication,1958). At present the area irrigated by water from

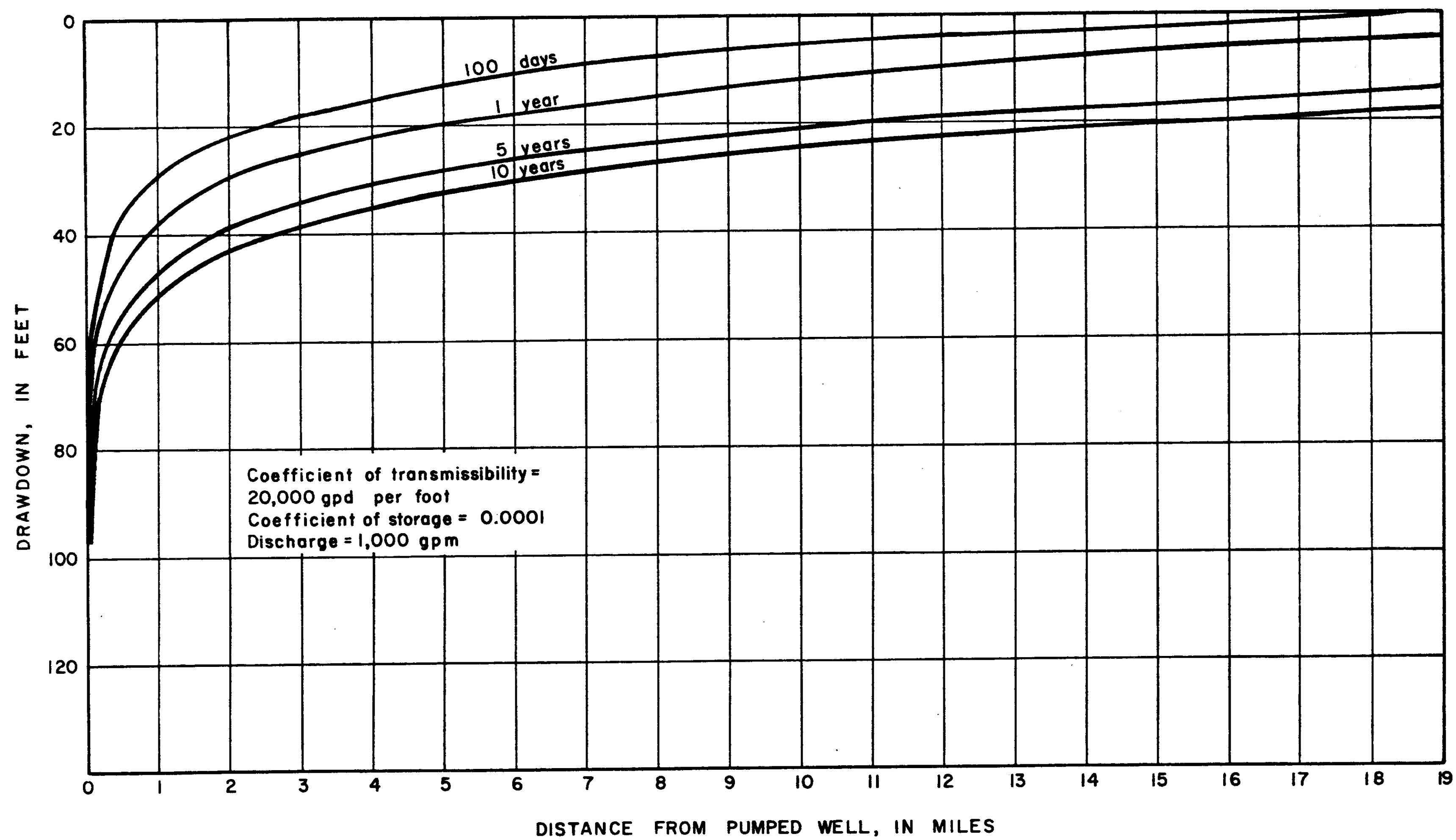

FIGURE 8.— Theoretical drawdown caused by pumping from an infinite aquifer

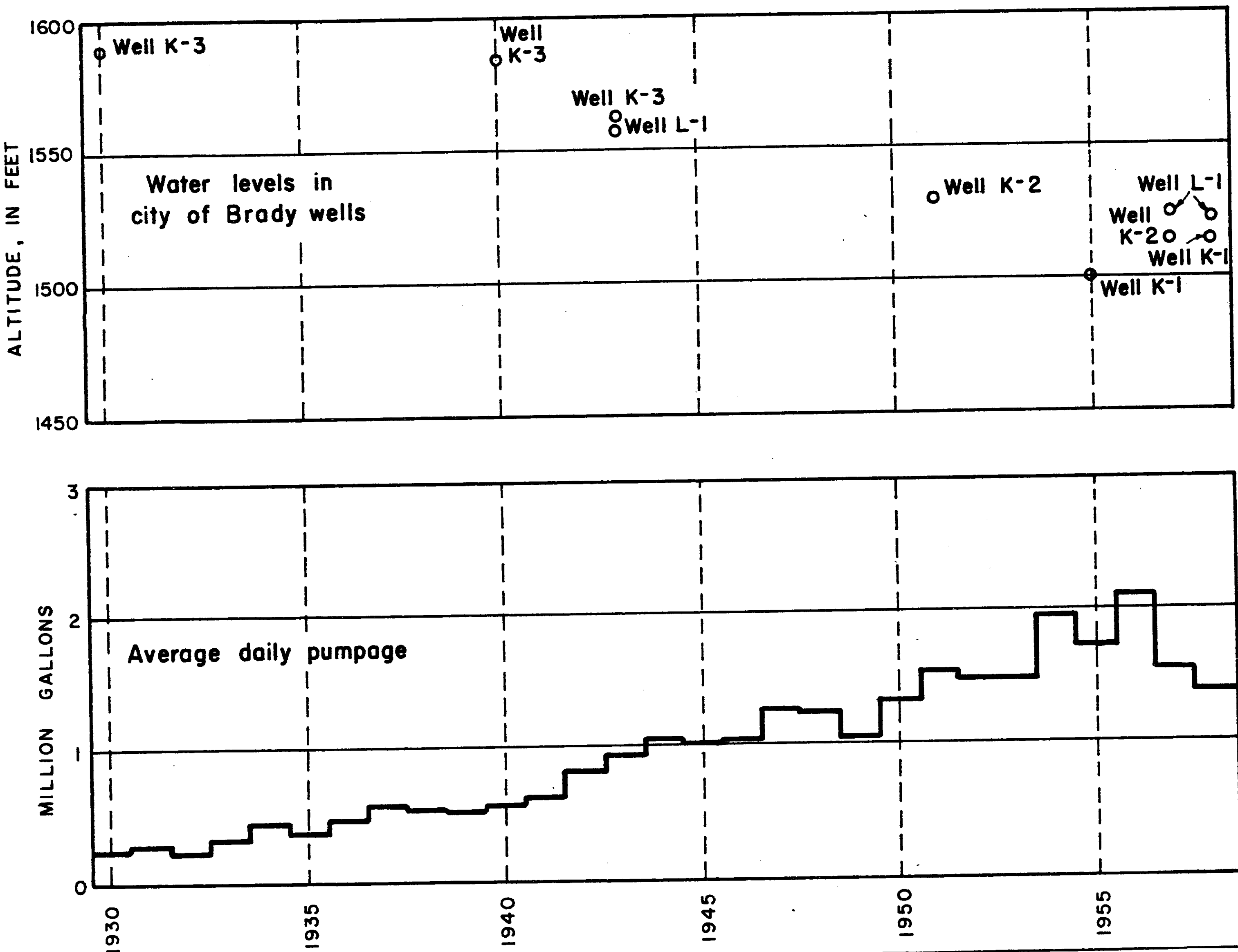

FIGURE 9.- Water levels in city of Brady wells and pumpage by city of Brady, 1930-58

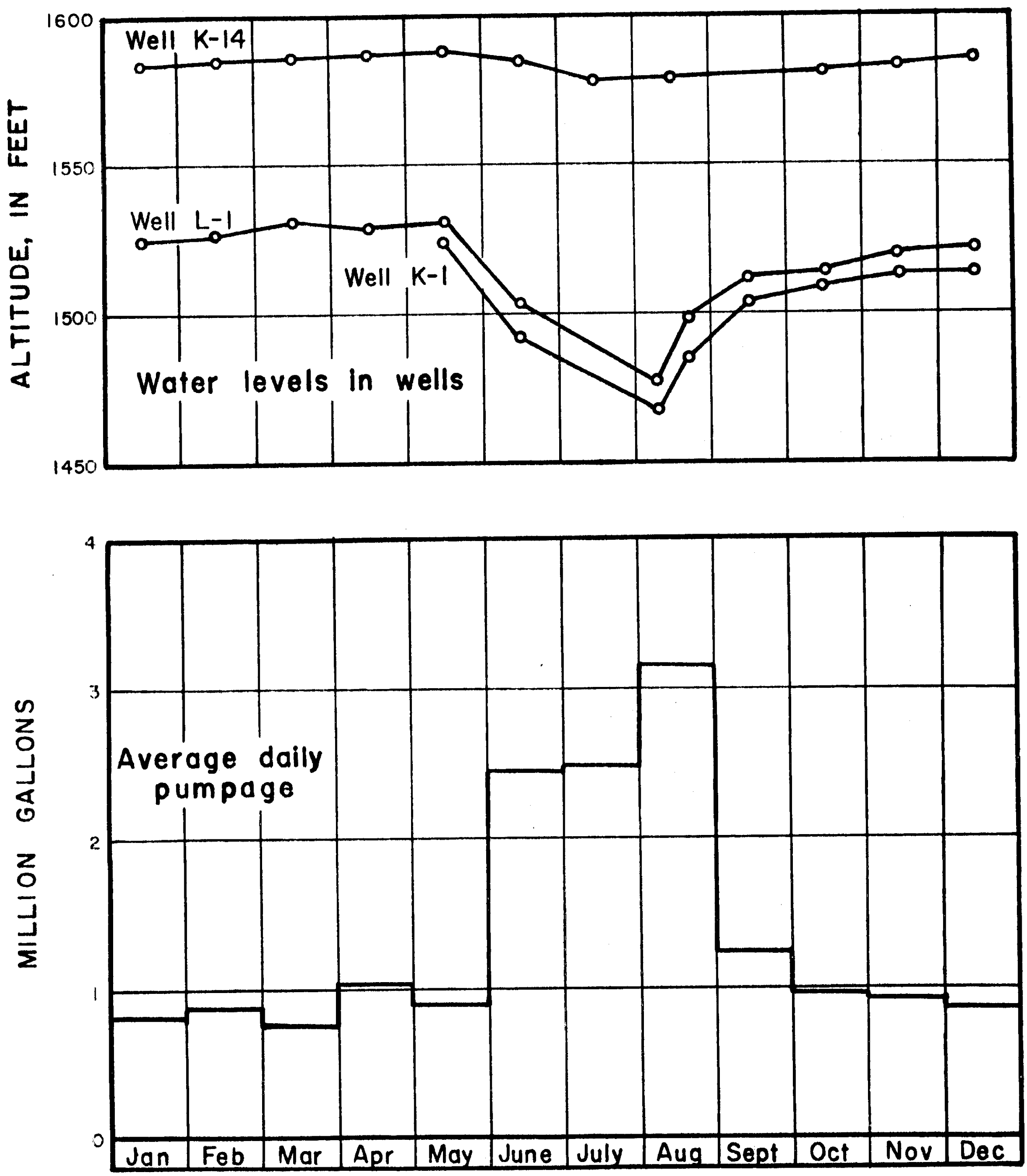

FIGURE 10.—Water levels in wells in Brady and vicinity and pumpage by city of Brady, 1958

the Hickory is confined chiefly to the outcrop area of the Hickory and the immediate vicinity.

Computations made from data collected on 17 wells irrigating crops of various types show that during the 1958 irrigation season an average of about 1.0 acre-foot of water was used for each acre of land under irrigation. This indicates that a total of about 1,200 acre-feet of water was used from the Hickory for irrigation in McCulloch County in 1958, and 1,300 acre-feet was used in the adjoining parts of Mason and San Saba Counties.

The only industrial use of water from the Hickory in McCulloch County in 1958 was that of the San Saba Sand Co., 1½ miles south of Voca. The plant has three wells that produce water from the Hickory for use in processing sand used in the development of oil wells. The plant uses about 360 acre-feet of water annually.

RECHARGE AND DISCHARGE

Recharge to the Hickory sandstone in McCulloch County is derived chiefly from precipitation on the outcrop in the southeastern part of the county and on outcrops in Mason County. A small amount of water probably moves into the Hickory from underlying Precambrian rocks in the outcrop area of the Hickory. The outcrop of the Precambrian rocks is generally topographically higher than the outcrop of the Hickory, and at least a small amount of water undoubtedly moves through cracks in the Precambrian rocks into the Hickory. The Hickory may receive recharge also at some places by the downward movement of water from the overlying rocks, particularly in northwestern Mason County where the San Saba River flows over rocks of Cambrian age.

Water is discharged naturally from the Hickory in McCulloch County by several methods. The principal method is by underflow into adjoining counties, chiefly San Saba County, but probably to some extent into Concho and Menard Counties. Another method of natural discharge is by upward seepage into overlying rocks. In many places the artesian pressure head in the Hickory is greater than that in the overlying rocks, and water is probably moving upward. This condition probably exists in most of the southern part of McCulloch County where the general similarity in quality of the water from the Hickory and from the overlying Cambrian rocks and rocks of the Ellenburger group indicates a hydraulic connection between the rocks. Water is discharged also by evapotranspiration at places in the outcrop area where the water table is near the land surface. In the valley of the San Saba River northeast of Voca in the outcrop area of the Hickory, water is discharged by springs and seeps and by flow into the alluvium along the creek beds. This discharge can be considered to be recharge that has been rejected because the aquifer is full to overflowing, and it could be salvaged in part by lowering the water levels in the outcrop area by pumping.

It is not possible to determine from the existing data the amount of recharge to and natural discharge from the Hickory in the McCulloch area. However, the recharge is perhaps as much as twice the 1958 discharge by wells in the county-that is, perhaps about 7,000 acre-feet per year. Furthermore, the recharge could be increased considerably by lowering the water levels in the outcrop area and salvaging the water presently being discharged by evapotranspiration and seepage to surface.

MOVEMENT OF WATER

Figure 11 shows the altitude of the water surface (piezometric surface) in wells tapping the Hickory sandstone member in McCulloch County in November 1958. The map shows that in general the slope of the piezometric surface, which indicates the direction of movement of water, is toward the north, northeast, and east, away from the outcrop area. West of the fault that passes near Camp San Saba, the water enters McCulloch County from the direction of Hickory outcrop areas in Mason County. North of the outcrop area, the direction of movement assumes a more easterly component, most of the water apparently flowing into San Saba County.

Several irregularities on the piezometric surface reflect the effects of pumping or natural discharge in the southeastern part of the county. The 1,500-foot contour swings up the San Saba River valley northeast of Voca, probably reflecting the discharge of flowing wells in the area and/or natural discharge by seeps and springs in the valley. The southward bend of the 1,550- and 1,600-foot contours south and southwest of Voca probably represents the effects of pumping in those areas. The cone of depression caused by the pumping at Brady could not be defined from the existing data and is not shown on the map.

WATER IN STORAGE

Large quantities of water are in transient storage in the Hickory sandstone member in McCulloch County; however, most of the water cannot be recovered through wells because of forces of capillarity which would retain a large part of the water in the sand against the force of gravity and because of the great depth at which much of the water occurs. If it is assumed that the average thickness of the Hickory throughout the county is 400 feet and that the porosity of the sandstone is 0.3, it can be shown that about 75 million acre-feet of water is in transient storage in the county. This figure in itself has little practical significance, for the reasons stated above. For a more practical consideration, assuming a specific yield of 0.1 for that part of the Hickory occurring above 500 feet and assuming a storage coefficient of 0.0001 in the remainder of the county, about 1 million acre-feet of water would be available to wells from storage if the water levels were lowered 500 feet.

FLUCTUATION OF WATER LEVEL

Water levels in aquifers such as the Hickory sandstone member fluctuate almost continuously from artificial and natural causes. In general, the major factors that control the changes of water levels are the rates of recharge to and discharge from the aquifer. Minor factors include variations in atmospheric pressure, tidal fluctuations, earthquakes, and other disturbances. The fluctuations are usually gradual, but it is not uncommon for water levels to rise or fall several inches or feet in a few minutes.

Fluctuations due to natural processes generally occur in cycles: daily, annual, or larger. Daily fluctuations are caused chiefly by tidal and barometric effects and by changes in the rate of evapotranspiration. Annual fluctuations are generally the result of changes in the rate of precipitation and evapotranspiration throughout the year, and consequently in the amount of water available for recharge. Such fluctuations are shown in the hydrographs of wells M-36 and S-7 in Figure 12. These wells are in the outcrop of the Hickory and are remote from heavily pumped areas. Consequently, the fluctuations probably present the natural effects of recharge and evapotranspiration. The water levels are high in the spring when the precipitation is greatest and low in the summer when the effects of evapotranspiration are large and precipitation is low.

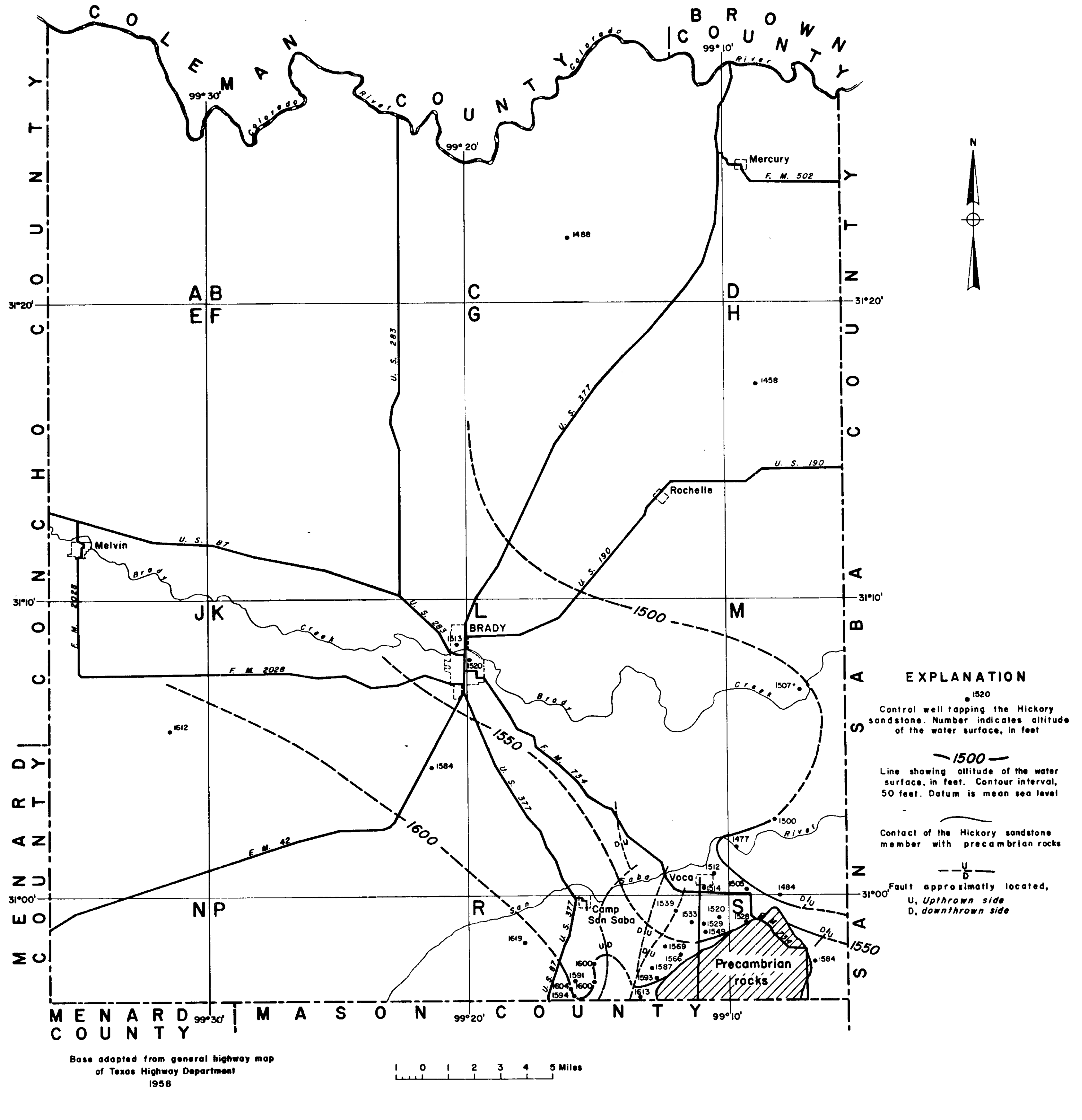

FIGURE 11.—Altitude of the water surface in wells tapping the Hickory sandstone member, McCulloch County, Texas, November 1958

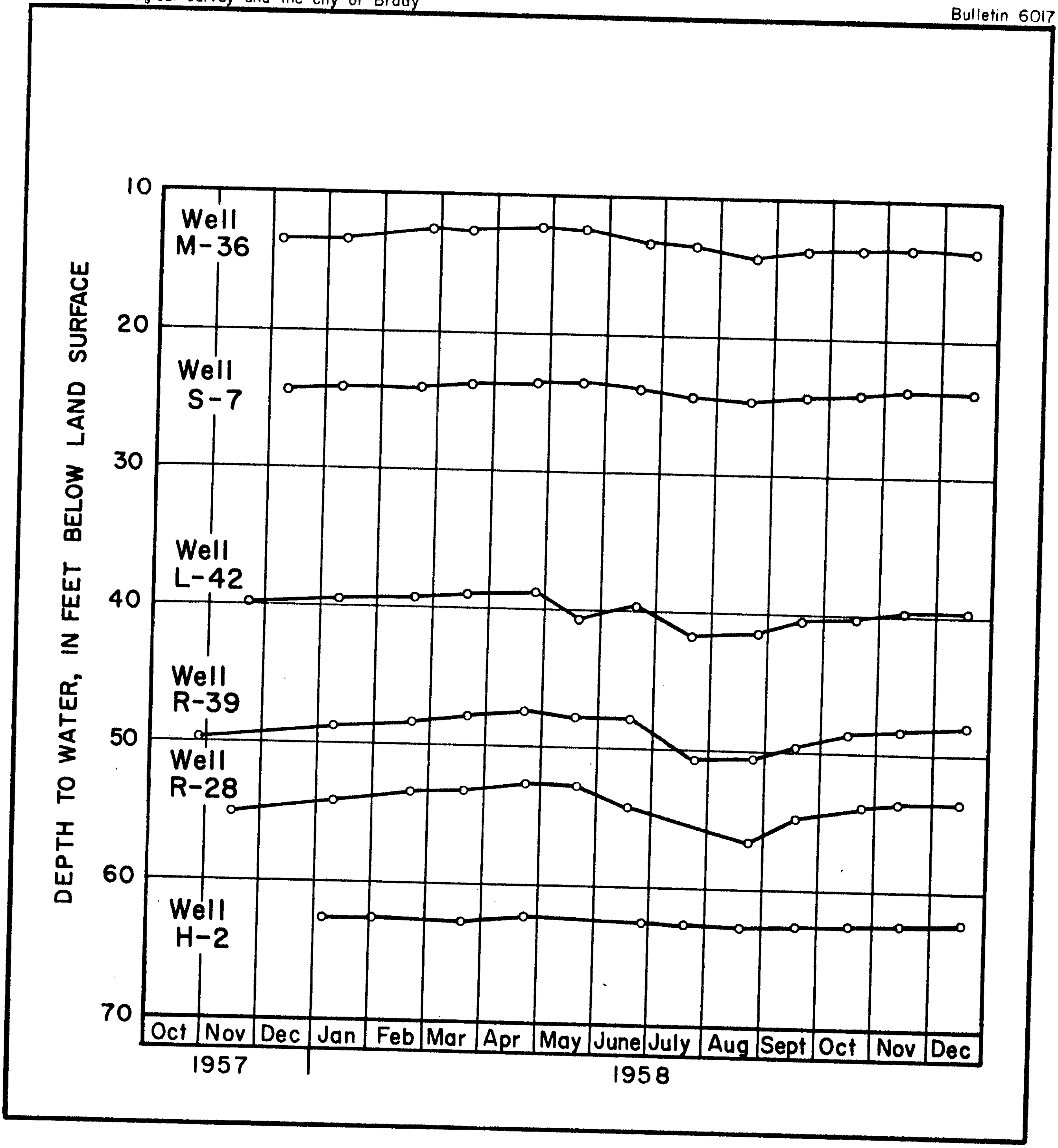

FIGURE 12.—Hydrographs of selected wells tapping the Hickory sandstone member, McCulloch County, Texas

Fluctuations of considerable magnitude are caused by pumping and are especially conspicuous in the artesian part of the aquifer. Withdrawals of ground water cause cones of depression to form in the piezometric surface, the cones being centered at centers of pumping. The depth of the cone of depression decreases with distance from the points of discharge. Figure 10 shows the average daily pumpage by months for the year 1958 at the city of Brady, together with hydrographs of two of the city wells (L-l and K-l), and well K-14 about 4 miles south of Brady. The figure clearly shows that, as a result of the increase in pumpage during June, July, and August, the water levels in wells L-l and K-l were lowered considerably, whereas the level in well K-14, which is remote from the area of pumping, was lowered by only a small amount. The decline in water levels due to pumping in the artesian part of the reservoir is merely a decline in the pressure in the reservoir and does not represent a dewatering of the aquifer. It is notable that the water levels in all three wells recovered significantly during the fall months when the pumping was decreased, and by the end of the year, the water levels had recovered nearly to the levels of the previous January. Figure 9 shows the average daily pumpage at Brady, by years, for the period 1930-58 and the resultant decline in water levels in the city wells during that period.

Figure 12 shows hydrographs of selected wells tapping the Hickory sandstone member in McCulloch County. Well H-2 is more than 16 miles from the irrigated area and is about 15 miles from Brady. In 1958 the water level in the well was lower in the summer than in the spring and fall, probably representing the effect of pumping at Brady. It is notable that the range of fluctuation was less than 1 foot. The hydrographs of wells L-42, R-39, and R-28 show the effects of the pumping for irrigation in the outcrop area, the water levels being lowest in July and August.

Figure 13 is a map showing the change in water levels from October-November 1957 to November 1958 in wells in the outcrop area of the Hickory. In most of the area, the water levels were either higher in 1958 than in 1957 or had changed very little. A maximum rise of more than 2 feet was recorded in two relatively small areas. Water levels were lower in an area east, southeast, and south of Voca, the largest decline being more than 3 feet in an area in which there are several irrigation wells. The map indicates that in the outcrop area as a whole the recharge during the period 1957 to 1958 was probably greater than the discharge.

QUALITY OF WATER

All ground water contains dissolved minerals, the amount and kind of minerals largely determining the suitability of the water for different uses. The U. S. Public Health Service (1946, p. 371-384) has established standards for drinking water used on common carriers engaged in interstate commerce. The standards have been widely used in evaluating the suitability of water for drinking, although in many places water containing mineral content far in excess of that recommended in the standards has been used with no apparent ill effects. The Maximum concentrations of some mineral substances recommended in the standards are as follows;:

Iron (Fe) and manganese (Mn) together should not exceed 0.3 ppm (part per million).
Magnesium (Mg) should not exceed 125 ppm.
Chloride (Cl) should not exceed 250 ppm.
Sulfate (SO_4) should not exceed 250 ppm.
Fluoride (F) must not exceed l-5 ppm.
Dissolved solids should not exceed 500 ppm; however, 1,000 ppm may be permitted if water of better quality is not available.

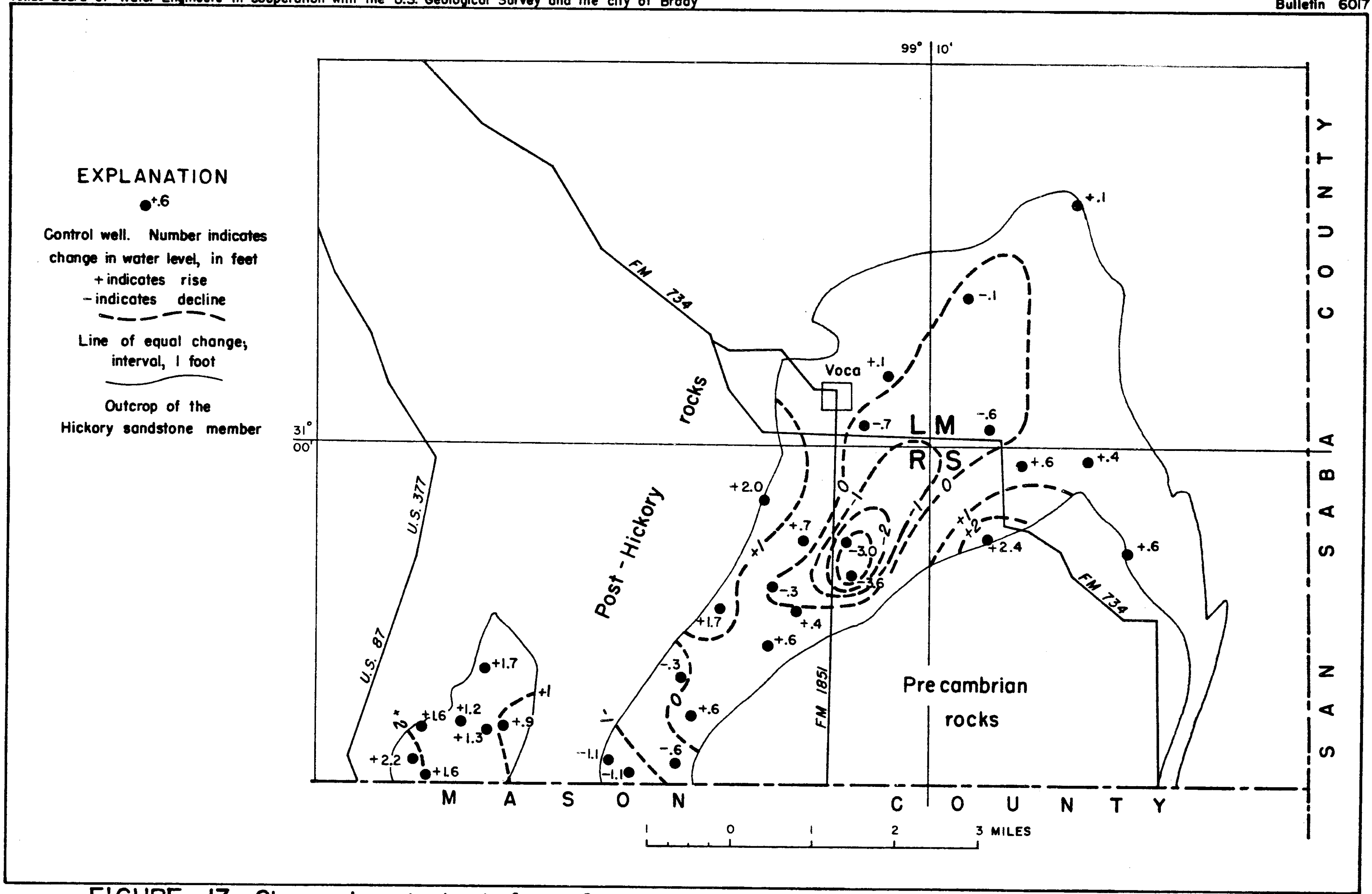

FIGURE 13.- Change in water levels from October-November 1957 to November 1958 in wells in the outcrop of the Hickory sandstone member, McCulloch County, Texas

These standards were set primarily as a protection against digestive disturbances and because they represent limits beyond which the taste of the water may become objectionable. Water containing magnesium and sulfate much in excess of the standards may have a laxative effect. Water high in fluoride content causes mottling of the teeth if used continuously by children (Dean, Dixon, and Cohen, 1935, p. 424-442); however, fluoride concentrations of about 1.0 ppm appear to reduce the incidence of tooth decay (Dean, Arnold, and Elvove, 1942, p. 1155-1179). Water having a chloride content much in excess of the standards has a salty taste. High concentrations of iron may cause staining of plumbing fixtures and an undesirable taste. Water containing more than 44 ppm of nitrate should be regarded as unsafe for infant feeding because it may cause methemoglobinemia, or "blue baby" disease (Maxcy, 1950, p. 271). A high nitrate content may be an indication of pollution from organic matter, and water containing excessive nitrate should be tested for bacterial content.

Calcium and magnesium are the principal constituents in water that give it the property called hardness. Hard water causes excessive soap consumption and creates incrustations in boilers, pipes, and hot water heaters. The hardness equivalent to the bicarbonate and carbonate content is called carbonate hardness; the remainder is called noncarbonate hardness. The figures given for the hardness of a water may be evaluated by comparing them with the commonly accepted standards of hardness for public and industrial supplies given in the following table:

Hardness range (ppm)	Classification
60 or less	Soft
61 - 120	Moderately hard
121 - 200	Hard
More than 200	Very hard

The presence of moderate amounts of silica in water is not harmful for most purposes; however, for some industrial uses it may be undesirable. Silica in boiler-feed water is objectionable because it forms a hard schale, the scale-forming process increasing with the pressure in the boiler. The following table shows the maximum allowable concentrations of silica for water used in boilers (Moore, 1940, p. 263):

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

In appraising the quality of water for irrigation, both the concentration and the composition of dissolved constituents should be considered. The chemical characteristics that appear to be most important in evaluating the quality of water for irrigation in most areas, including McCulloch County, are (1) relative proportion of sodium to other cations (an index of the sodium hazard), (2) total concentration of soluble salts (an index of the salinity hazard), and (3) concentration of boron. A system of classification commonly used for judging the quality of a water for irrigation was proposed in 1954 by the U. S. Salinity Laboratory Staff (1954, p. 69-82). The classification is based primarily 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).

The relative importance of the dissolved constituents is dependent upon the degree to which they accumulate in the soil. Kelley (1951, p. 95-99) cited areas having an average annual precipitation of about 18 inches in which salts did not accumulate in the irrigated soil. Wilcox (1955, p. 15) stated that the system of classification of irrigation waters proposed by the Salinity Laboratory Staff "..is not directly applicable to supplemental waters used in areas of relatively high rainfall." Thus, in McCulloch County where the average annual precipitation is about 24 inches, the system of classification is probably not fully applicable. Wilcox (1955, p. 16) indicated that water generally may be used safely for supplemental irrigation if its conductivity is less than 2,250 micromhos per centimeter at 25°C and its SAR is less than 14. Each individual situation should be appraised when consideration is being given to irrigating with water of which the specific conductance and SAR exceed these limits or where soil or drainage conditions are unfavorable or when the crop to be grown is especially sensitive to the hazards of sodium and salinity.

An excessive concentration of boron will make water unsuitable for irrigation. Wilcox (1955, p. 11) has indicated that a boron concentration of as much as 1.0 ppm is permissible for irrigating sensitive crops; a concentration of as much as 3.0 ppm is permissible for tolerant crops.

During the investigation in McCulloch County, 40 chemical analyses of water from 35 wells were studied. Of these, 23 are analyses of water from 18 wells tapping the Hickory sandstone member and are shown in Table 2. The rest of the analyses are available for inspection in the office of the Geological Survey in Austin, Texas.

Water from the Hickory sandstone member meets, in most respects, the standards for drinking water as recommended by the U. S. Public Health Service. The analyses indicate that, except for water from well K-14, the sulfate content is well within the concentration recommended in the standards. However, the water from this well is not typical of water from the Hickory, as water from overlying younger Paleozoic rocks is believed to be leaking into the well. The magnesium content in all samples was less than 125 ppm. The chloride content was less than 250 ppm. In none of the wells did the fluoride content exceed the limit in the Public Health Service standards. The dissolved-solids content of water from the Hickory was less than 500 ppm in all wells except in well K-14, which, as stated above, is probably not representative of the Hickory, and well C-8, the northernmost well sampled in the Hickory. The nitrate content in all the samples from the Hickory was less than 44 ppm; however, wells R-54, R-62, and S-2 all have concentrations that suggest possible contamination from organic sources.

Most of the water from the Hickory is very hard. Of the 18 wells sampled only 6 yielded water having a hardness of less than 200 ppm. The silica content in 17 samples averaged about 18 ppm. Of 6 samples of water from the city of Brady wells, the iron content ranged from 0.12 to 0.32 ppm and averaged 0.24 ppm. The analysis for well L-49 showed an iron content of 1.8 ppm; however, the high content may be due to the presence of pipe scale or other foreign matter in the water.

Table 2.--Analyses of water from selected wells tapping the Hickory sandstone member in McCulloch County, Texas

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

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Sodium-adsorption ratio (SAR)	Specific conductance (micromhos at 25°C)	pH
C-8	M. D. Rice	2,580	Nov. 25, 1958	14	-	12	6.5	263	329	54	215	-	0.5	-	738	56	91	15	1,300	8.2
J-4	G. R. White	2,008	Nov. 22, 1958	14	-	49	41	52	362	62	31	-	.0	-	427	291	28	1.3	736	7.3
K-2	City of Brady well 1	2,114	June 5, 1943	5.2	0.20	52	45	22 13	364	51	18	0.6	.0	-	397	315	12	.5	-	7.5
K-2	do	2,114	Jan. 17, 1946	12	.32	59	46	12 8.4	366	41	20	.8	.0	-	389	336	7	.3	661	7.8
K-2	do	2,114	June 20, 1958	15	-	54	40	36	367	49	16	.8	.2	-	382	299	21	.9	671	7.3
*K-3	City of Brady well 3	2,112	Feb. 1941	17	.29	53	44	40	390	47	21	-	-	-	402	313	-	-	-	7.9
*K-3	do	2,112	Feb. 1943	14	.12	54	46	26	363	51	21	.6	-	-	376	324	-	-	-	7.5
K-3	do	2,112	June 6, 1943	9.0	.22	53	37	50	376	47	24	.6	.0	-	399	284	28	1.3	-	8.0
K-14	W. H. Winters	1,500	Nov. 25, 1958	9.8	-	75	37	230	312	320	175	-	4.0	-	1,000	339	60	5.4	1,620	7.5
L-1	City of Brady well 3	2,082	Nov. 1943	12	.32	52	43	26	366	41	13	1.4	.0	-	376	307	16	.7	-	8.0
L-1	do	2,082	Feb. 5, 1959	14	-	53	39	20 6.4	354	40	12	.9	.0	-	360	292	13	.5	637	7.6
L-49	Tommy Brook	850	June 22, 1943	13	1.8	61	40	16	360	36	11	.6	1.5	-	368	316	10	.4	-	8.2
M-13	C. T. White	900	Mar. 31, 1958	10	-	35	17	100	235	88	60	1.0	4.3	-	440	158	58	3.5	761	8.0
M-45	Evans Adkins	400	Apr. 1, 1958	15	-	55	45	33 7.6	375	50	29	1.0	.0	-	429	322	18	.8	720	7.7
M-55	Ed Spiller	165	Nov. 25, 1958	24	-	44	6.8	36	131	18	59	0.8	4.8	-	270	138	36	1.3	451	6.6

* Analyzed by Texas State Health Department.

Table 2.--Analyses of water from selected wells tapping the Hickory sandstone member in McCulloch County--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Sodium-adsorption ratio (SAR)	Specific conductance (micromhos at 25°C)	pH
R-3	C. E. Myrick	842	June 20, 1958	14	-	61	40	9.3 3.8	361	24	16	.8	.0	0.08	347	316	6	.2	615	7.2
R-9	Tommy Brook	430	June 22, 1943	-	-	64	40	0.9	350	18	14	-	1.0	-	325	324	1	.0	-	-
R-23	H. Schmidt	800	July 22, 1958	15	-	88	16	14 1.9	322	23	21	.3	2.5	.15	344	286	10	.4	596	7.1
R-28	Arthur Hurley	370	July 17, 1958	18	-	86	9.9	16 1.9	290	11	27	.4	7.0	.15	322	255	12	.4	554	7.1
R-46	A. T. Owens	137	Nov. 25, 1958	16	-	94	16	11	340	9.8	25	-	2.0	-	344	300	8	.3	604	7.1
R-54	J. W. Behrens	125	July 10, 1958	28	-	51	9.4	34 3.3	160	27	46	1.0	27	.15	317	166	30	1.1	512	6.6
R-62	C. B. Clevenger	120	do	32	-	32	6.1	27 2.4	102	15	38	.9	15	.10	220	105	35	1.1	359	6.5
S-2	J. F. Dean	118	July 22, 1958	23	-	26	5.9	31 2.1	101	16	27	.7	21	.10	206	89	42	1.4	333	6.4

Most of the water from the Hickory sandstone member in McCulloch County is suitable for irrigation, as shown on Figure 14, on which are plotted the values of conductivity and sodium-adsorption-ratio (SAR) for samples taken from wells tapping the Hickory. The figure shows that all the wells sampled in the outcrop area yield water that has a low sodium hazard and a medium salinity hazard. The sample from well K-14 had a high salinity hazard and a medium sodium hazard; however, this well is probably affected by leakage from overlying younger Paleozoic rocks. The most undesirable well for irrigation is well C-8, the water from which had both high salinity and sodium hazards; however, even this well could probably be used safely for supplemental irrigation. Water of similar or poorer quality is used elsewhere in Texas for irrigation on a full-time basis. Of 6 determinations for boron, all were within the permissible limits suggested by Wilcox (1955, p. 11).

Ground Water in Other Aquifers

During the investigation of the Hickory sandstone member, records were obtained of many wells tapping rocks of Cambrian age younger than the Hickory. Some of these wells may tap the Hickory also, and others may yield water from rocks of the overlying Ellenburger group. Data are not available to evaluate quantitatively the hydrologic properties of the younger Cambrain rocks; however, they generally are not a source of water for wells yielding more than a few tens of gallons per minute. Most of the wells tapping the younger Cambrian rocks are used for domestic and stock purposes; however, one well (E-5) is used for municipal supply at Melvin. The Melvin well possibly taps the Ellenburger group as well as the Cambrian rocks. According to the chemical analyses of water from 5 wells, the water from the younger Cambrian rocks is hard but otherwise of good chemical quality.

Rocks of the Ellenburger group are an important source of water for domestic and stock supplies in McCulloch County. The importance of the Ellenburger lies in the fact that it underlies practically the whole county and in most of the southern and central parts it can be reached by fairly shallow wells. The water occurs in an interconnected system of cracks forming porous zones in the limestone and dolomite. Wells penetrating the porous zones may have moderate yields; however, if the zones are not extensive the wells may not produce enough water for domestic and stock use. Chemical analyses of water from 10 wells believed to tap the Ellenburger indicate that in the southern part of the county the water is hard, but otherwise of good chemical quality. In the northern part of the county, the water is more highly mineralized, the most objectionable constituent being chloride. Analyses of water from 6 wells tapping the Ellenburger in the B and C quadrangles show that the chloride content ranged from 295 to 400 ppm.

The younger Paleozoic rocks yield small supplies of water to domestic and stock wells, especially in the northern part of the county and to public supply wells at Mercury and Rochelle. The rocks should not be considered as a major source of supply, being of importance only locally. Many of the wells reportedly go dry during droughts. The chemical quality of the water varies widely. The analysis of water from well D-3, which supplies the city of Mercury, shows the water to be of good chemical quality and acceptable for most purposes. The water from well G-4 had a rather high sulfate content (226 ppm), but was otherwise of good chemical quality. The two analyses should not be considered typical, as in many areas the water is report to be highly mineralized and not suitable for domestic or stock use.

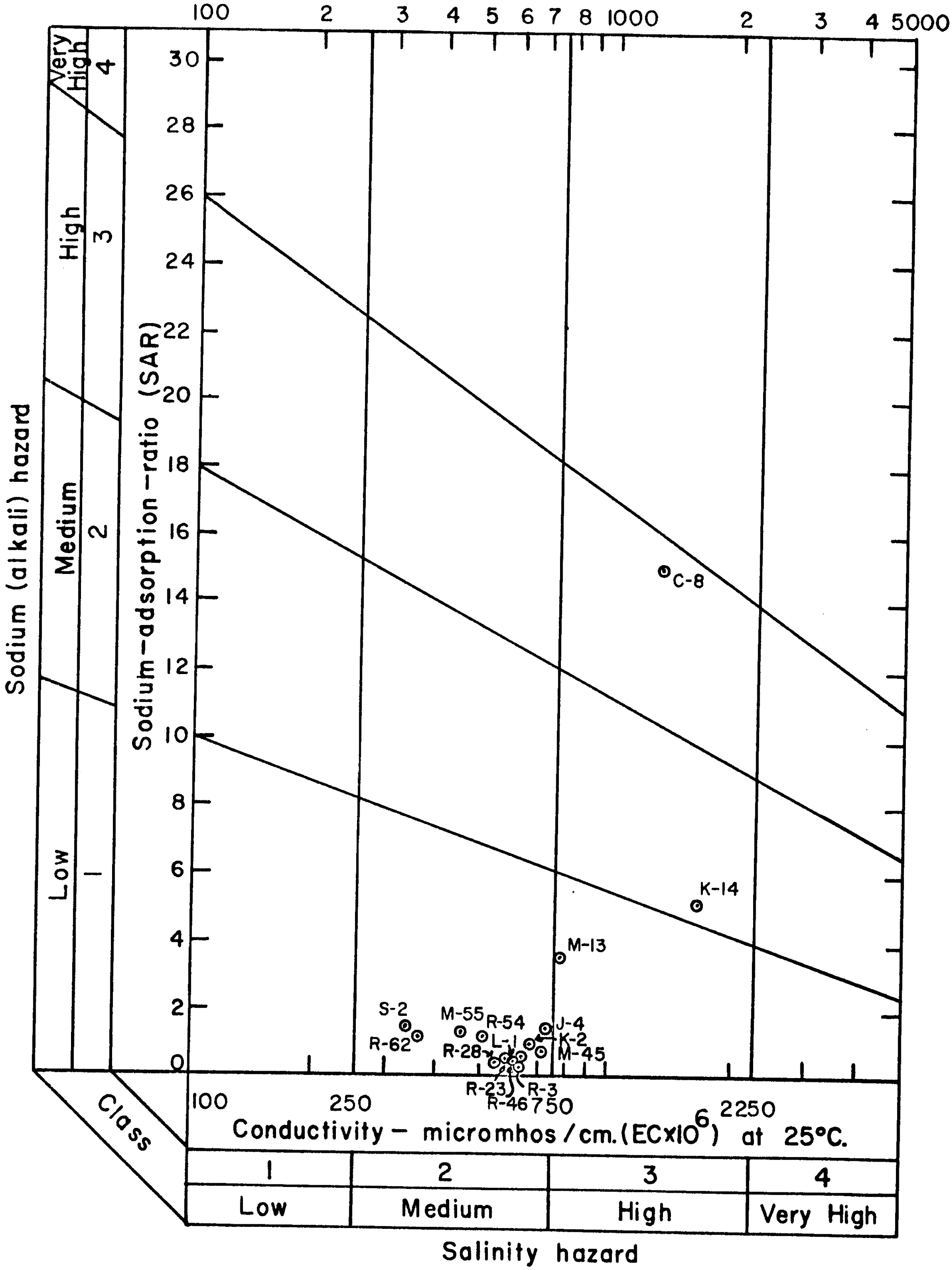

FIGURE 14.—Diagram for the classification of irrigation waters

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

CONCLUSIONS

The Hickory sandstone member of the Riley formation of Cambrian age is the principal aquifer in McCulloch County. The Hickory lies on a basement of Pre-cambrian rocks consisting of granite, schist, and gneiss, and is overlain in most of the county by younger Paleozoic rocks. The Hickory underlies practically all of McCulloch County except the extreme southeastern part, where it crops out around the margins of the outcrop of the Precambrian rocks. From the area of outcrop the Hickory dips to the north and northwest at a rate of about 120 feet per mile. The Hickory sandstone has an average thickness of about 400 feet and consists chiefly of sandstone and minor amounts of shale.

The principal source of recharge to the Hickory is precipitation on the outcrop area in McCulloch and Mason Counties. Recharge probably occurs also by seepage from streams that flow across the outcrop, and to a smaller extent by upward seepage from cracks in the underlying Precambrian rocks near the outcrop. Downward seepage from overlying rocks may occur where the artesian head in the Hickory is diminished by pumping. The direction of movement of water in the Hickory is generally to the north and northeast from the direction of outcrop areas in McCulloch County and in Mason County to the south.

Water is discharged naturally from the Hickory in McCulloch County by underflow into adjoining Menard and San Saba Counties, by upward seepage into overlying formations, and by evapotranspiration and flow through seeps and springs in the outcrop area, particularly in the valley of the San Saba River northeast of Voca. The water discharged through seeps and springs in the area northeast of Voca may be considered as rejected recharge to the Hickory. In other words, in this area the formation is completely full of water.

Water is discharged artificially from the Hickory through wells. The city of Brady is the largest single user of water from the Hickory in McCulloch County, the total use for the city during 1958 having been about 1,600 acre-feet. Another large use of the water in McCulloch County is that for irrigation, particularly in the area of the outcrop of the Hickory in the southeastern part of the county, where in 1958 about 1,200 acre-feet of water was used for irrigation. Water is used for domestic and stock purposes throughout the county; however, the total used for these purposes is small. About 360 acre-feet per year is used at an industrial installation.

The chemical quality of the water from the Hickory in most places in McCulloch County is good, except that most of the water is hard. Practically all the water meets the drinking-water standards of the U. S. Public Health Service and most of the water is likewise suitable for irrigation.

Large supplies of water are available from storage in the Hickory in McCulloch County. It can be computed that about a million acre-feet of water available from storage above a depth of 500 feet in the county. Although the data are too meager for definite conclusions, it appears that the rate of recharge to the Hickory in the McCulloch County area is at least as great and probably twice as great as the 1958 pumpage. For these reasons it is believed that the Hickory could support a much larger ground-water development without depleting the aquifer.

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Table 3.--Records of wells and springs in McCulloch County, Texas

All wells are drilled unless otherwise noted in remarks.
Water level : Reported water levels given in feet; measured water levels given in feet and tenths.
Method of lift and type of power : A, air-lift; B, bucket; C, cylinder; Cf, centrifugal; E, electric; G, gasoline, butane, or Diesel; H, hand; J, jet; N, none; T, turbine; W, windmill. Number indicates horsepower.
Use of water : D, domestic; Ind, industrial; Irr, irrigation, N, none; P, public supply; S, stock.

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
A-1	George Garrett	--	--	60	48	Younger Paleozoic rocks	43.8	Oct. 17, 1958	C,W	D,S	Dug. Water reported hard. Old well.
A-2	Ed L. Spiller	--	1900	62	6	do	--	--	C,W	D,S	Water reported hard.
A-3	S. P. Tomlinson	--	1956	70	7	do	--	--	C,E	D,S	Water reported at 52 ft, the occurrence of water of good quality is spotty in this area, most of the farmers use water from tanks.
A-4	Joe Awalt	Wiley Walker	1928?	64	36	do	45.7	Oct. 21, 1958	C,W	D	Dug.
B-1	J. S. Hays	--	--	38	--	do	--	--	C,W	S	Dug. Water reported hard and high in iron content. Old well.
B-2	do	--	1946	80	8	do	72	1958	C,E	D,S	Water reported hard.
B-3	George Reed	--	--	28	--	do	13	1958	J,E	D,S	Dug. Old well.
B-4	Tommy Caylor	--	1947	130	--	do	56.2	Oct. 21, 1958	C,W	D,S	
*B-5	Mrs. Ollie M. Lohn	Yoder & Taylor	1949	2,450	7	Ellenburger group	(+)	--	Flows	S	Oil test. Flow reported 25 gpm. Reported altitude of land surface 1,670 ft.
B-6	Mrs. Mary M. Pierce	--	1893	52	--	Younger Paleozoic rocks	--	--	J,E	D	Dug.
B-7	L. B. Turner	--	--	60	--	do	--	--	N	N	Dug. Old well.
*C-1	W. N. White	--	--	1,600	--	Ellenburger group	(+)	--	Flows	S	Flow reported 60 gpm.
*C-2	do	--	--	1,480	--	do	(+)	--	Flows	S	Flow reported 10 gpm.
*C-3	do	--	--	1,600	--	do	(+)	--	Flows	S	Flow reported 4½ gpm.
*C-4	do	--	--	1,600	--	do	--	--	C,W	S	

See footnotes at end of table.

Table 3.--Records of wells and springs in McCulloch County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
C-5	D. S. Pumphrey	Willie Beekly	1921	506	--	Younger Paleozoic rocks	--	--	C,W	D,S	
*C-6	do	Virgil Brock	1947	2,115	6	Ellenburger group	--	--	C,W,E	S	1/
*C-7	W. N. White	--	--	1,380	--	do	--	--	C,W	S	
*C-8	M. D. Rice	Jessie Briggs	1946	2,580	8	Hickory sandstone member	116.4 117.3	Jan. 16, 1958 Dec. 9, 1958	C,E	D,S	Oil test. Altitude of land surface 1,605 ft. 2/
C-9	Harry Curtis	Bomjack Oil Co.	1936	1,281	--	Ellenburger group	--	--	C,W	S	Oil test. 1/
C-10	do	W. B. Osborn	1956	3,030	--	--	--	--	N	N	Oil test. Altitude of land surface 1,550 ft. 3/
C-11	do	--	1929	1,776	8	Ellenburger group	40	1958	C,W	S	1/
D-1	Sam McCollum	--	1952	300	--	Younger Paleozoic rocks	--	--	J,E	D,S	
D-2	do	Frank Carpenter	1953	2,557	10	Hickory sandstone member	--	--	N	N	Oil test.
*D-3	City of Mercury	--	1910	436	8	Younger Paleozoic rocks	--	--	C,W,E	P	
D-4	O. G. Scoggins	--	--	70	--	do	--	--	J,E	S	
D-5	do	--	--	120	--	do	--	--	C,W	S	
E-1	H. E. Crumley	--	--	20	--	do	--	--	N	N	Dug. Reported to go dry during droughts.
E-2	Roy Moore	M. M. Virdell	1955	90	--	do	--	--	C,W	S	Reported weak supply.
E-3	J. F. Green	do	1950	185	--	Cretaceous rocks	--	--	J,E	D,S	do.
E-4	do	--	1907	73	--	do	--	--	C,W	S	do.
*E-5	City of Melvin	--	1946	2,800	7	Cambrian rocks, and Ellenburger group(?)	190	Jan. 1957	T,E, 20	P	Drilled to 2,957 ft, plugged back to 2,800 ft. Casing perforated from 2,260 to 2,500 ft. Altitude of land surface, 1856 ft. 1/

* See footnotes at end of table.

Table 3.--Records of wells and springs in McCulloch County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level		Method of lift	Use of water	Remarks
							Below land surface datum (ft.)	Date of measurement			
E-6	O. E. Hedge	McDaniel & Beecherl	1949	3,103	--	--	--	--	N	N	Oil test. Altitude of land surface 1,905 ft. 3/
F-1	W. W. Ludwick	--	1925	100	5	Younger Paleozoic rocks	--	--	J,E	D,S	
F-2	C. A. Latimer	Davies & Williams	1952	50	--	do	--	--	C,W	D,S	
F-3	L. Lohn	--	1915	100	6	do	--	--	C,W	S	
F-4	do	--	1921	100?	6	do	--	--	C,W	S	
F-5	do	M. M. Virdel	1948	76	7	do	--	--	J,E	D,S	Water reported very hard.
F-6	C. P. Lohn	Curtis McShan	1933	190	6	do	--	--	C,E	D,S	
F-7	do	--	--	200	6	do	--	--	C,W	S	Reported weak supply. Old well.
F-8	George Reed	M. M. Virdell	1950	210	--	do	--	--	C,E	D	Discharge reported 2 gpm.
F-9	W. H. Bloomer	--	--	14	--	do	--	--	N	N	Dug. Old well.
F-10	J. Rockett Hall	--	1900	60	--	Cretaceous rocks	--	--	C,W	D,S	
F-11	W. D. Hall	--	1918	400	--	Younger Paleozoic rocks	--	--	C,W	S	
F-12	D. H. Dutton	M. M. Virdell	1951	250	4	do	--	--	C,E	S	Reported weak supply of highly mineralized water.
F-13	Ira Murrah	--	--	150	--	Cretaceous rocks (?)	112.3	Sept.26, 1958	C,W	D,S	Old well.
F-14	Gardner Broad	M. L. Leddy	1920	150	--	do	--	--	C,W	D,S	
F-15	B. C. Broad	Heinze & Spanel	1958	2,150	--	--	--	--	N	N	Oil test. Altitude of land surface 1,911 ft. 3/
F-16	C. A. Latimer	--	1880	16	--	Younger Paleozoic rocks	--	--	C,W, J,E	D,S	Dug. Reported strong supply.
F-17	H. Paul Hanson	M. M. Virdell	1950	65	6	do	--	--	C,W	D,S	
F-18	Harry E. Hanson	--	1908	67	--	Cretaceous rocks	--	--	C,W	D,S	Dug.

* See footnotes at end of table.

Table 3.--Records of wells and springs in McCulloch County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
F-19	Eric Swinson	C. E. Smith	1951	3,160	--	--	--	--	N	N	Oil test. Altitude of land surface 1,675 ft. 3/
F-20	V. M. Joyce	--	--	30	36	Cretaceous rocks	18.7	Oct. 13, 1958	C,W	D,S	Dug. Old well.
G-1	B. E. Gressett	--	--	70	6	do	--	--	C,W	D,S	Old well.
G-2	O. G. Scoggins	--	--	90	--	do	--	--	J,E	D,S	
G-3	do	--	--	60	--	do	--	--	C,W	S	
*G-4	J. R. Boyd & M. A. Gainer	--	1926	300	8	Younger Paleozoic rocks	--	--	C,E	P	Supplies water for city of Rochelle.
G-5	M. N. Williamson	--	--	48	--	do	26.6	May 21, 1958	C,W	N	Old well.
G-6	do	M. M. Virdell	1926	375	4	Ellenburger group	202.6	do	C,W	D,S	Originally drilled to 265 ft, deepened to 375 ft in 1932.
G-7	do	--	1922	311	6	do	165.9	do	N	N	
G-8	do	Fred Wilson	1952	300	--	do	--	--	C,W	S	
G-9	do	do	1951	341	--	do	63.8	May 21, 1958	C,W	S	
G-10	A. L. Neal	Ernest Wigginton	1948	300	8	do	40.2	May 7, 1958	C,W	S	
H-1	O. G. Scoggins	--	--	100	--	Younger Paleozoic rocks	--	--	C,W	S	
H-2	do	Homer Head	1948	3,000	7	Hickory sandstone member	62.7 62.3	Jan. 6, 1958 Dec. 19, 1958	T,E, 7½	N	Altitude of land surface 1,520 ft. 2/
H-3	C. T. White	--	--	800	--	Ellenburger group	--	--	C,W	S	
H-4	do	--	--	661	--	do	--	--	C,W	S	
H-5	do	--	--	573	--	do	--	--	C,W	S	
H-6	do	--	--	568	--	do	--	--	C,W	S	
H-7	do	--	--	602	--	do	--	--	C,W	S	
H-8	A. L. Neal	Ernest Wigginton	1947	450?	8	do	122.7	May 7, 1958	C,W,E	D,S	

* See footnotes at end of table.

Table 3.--Records of wells and springs in McCulloch County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
H-9	A. L. Neal	V. M. Bleeken	1952	450?	8	Ellenburger group	74.0	May 7, 1958	C,W	D,S	
H-10	do	M. M. Virdell	1955	300	6	do	46.0	do	C,W	S	
H-11	C. T. White	--	--	550	--	do	--	--	C,W	S	
J-1	G. R. White	--	--	1,738	--	Cambrian rocks	297.6 296.7	Feb. 5, 1958 Dec. 19, 1958	C,W	S	Altitude of land surface 1,907 ft. 2/
J-2	do	--	--	160	--	Younger Paleozoic rocks	--	--	C,W	S	
J-3	do	--	--	200	--	do	143.6	Feb. 5, 1958	C,W	D,S	
*J-4	do	--	--	2,008	--	Hickory sandstone member	335.8 335	Feb. 5, 1958 Dec. 1958	T,E	S	Altitude of land surface 1,947 ft. 2/
J-5	do	--	--	230	--	Younger Paleozoic rocks	--	--	C,W	S	
J-6	do	--	--	140?	--	Cretaceous rocks	--	--	C,W	S	
J-7	do	--	--	1,450	--	Ellenburger group (?)	--	--	C,W	S	
J-8	do	--	--	130	--	Cretaceous rocks (?)	--	--	C,W	S	
J-9	do	--	--	130	--	do	--	--	C,W	S	
J-10	Mrs. K. W. Haby	M. M. Virdell	1940	600	8	Younger Paleozoic rocks	--	--	C,W	S	
K-1	City of Brady well 4	Kent & Preston	1955	2,127	16	Hickory sandstone member	170 154.7	June 30, 1955 Dec. 20, 1958	T,E, 100	P	Pump set at 350 ft. Casing cemented Discharge 750 gpm. 1/ 2/ 3/
*K-2	City of Brady well 1	Higdon & Newman	1921	2,114	15	do	144 158	June 1951 Oct. 1957	T,E, 60	P	Discharge 585 gpm. 1/
*K-3	City of Brady well 2	Layne-Texas Co.	1930	2,112	15	do	86 90 113	June 1930 1940 June 1943	T,E, 100	P	Pump set at 300 ft. Altitude of land surface 1,674 ft. Discharge 730 gpm. 1/
K-4	W. H. Winters	Fred Wilson	1952	200	--	Younger Paleozoic rocks	--	--	C,W	S	

* See footnotes at end of table.

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
K-5	W. H. Winters	Fred Wilson	1952	325	--	Younger Paleozoic rocks	--	--	C,W	S	
K-6	Miller Bros.	--	1928	240	--	do	--	--	C,W	D,S	Water reported hard.
K-7	W. J. White	--	1920	380	--	do	127.2	Jan. 29, 1958	C,W	D,S	
K-8	do	--	1900	170	--	do	--	--	C,W	S	
K-9	W. H. Winters	Fred Wilson	1952	500	--	do	--	--	C,W	S	
K-10	do	do	1952	248	--	do	50.9	Jan. 30, 1958	C,W	S	
K-11	do	do	1952	860	6	Ellenburger group	213.1	do	C,W	S	1/
K-12	do	do	--	270	--	Younger Paleozoic rocks	--	--	C,W	S	
K-13	do	J. E. Brock	1929	1,900	6	Hickory sandstone member	--	--	C,W	S	
*K-14	do	do	1939	1,500	--	do	264.1 262.8	Jan. 15, 1958 Dec. 19, 1958	C,W	S	Reported water may leak into the well from above the Hickory sandstone. Altitude of land surface 1,848 ft. 2/
K-15	Tol Roberts	V. M. Bleeker	1950	1,711	6	do	333.5	Nov. 27, 1957	C,W	D,S	1/
K-16	Duke Mann	J. M. Virdell	1926	384	6	Younger Paleozoic rocks	--	--	C,W	S	
K-17	H. J. Davies	Fred Wilson	1956	601	--	Ellenburger group	140	1956	C,W	D,S	
K-18	D. S. Appleton	Clarence Virdell	1930	473	--	do	80	1930	C,W	S	
K-19	do	--	1950	521	--	do	81.3	June 19, 1958	C,W	D,S	
*K-20	T. Gray	--	1951	625	--	do	108.7	June 2, 1958	C,W	D,S	Temp. 70°F.
*K-21	do	--	1930	150	--	do	--	--	C,W	S	Temp. 71°F.
*K-22	H. J. Davies	Virgil Brock	1948	1,113	--	Cambrian rocks	65 50.7	1948 June 19, 1958	C,W	S	Altitude of land surface 1,786 ft. Temp. 72°F.
K-23	-- Harkrider	Tucker Drilling Co.	1955	2,030	--	--	--	--	N	N	Oil test. Altitude of land surface 1,926 ft. 3/

* See footnotes at end of table.

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
K-24	Aubrey Cavin	--	--	80	--	Cretaceous rocks	--	--	C,W	D,S	Old well.
*L-1	City of Brady well 3	Layne-Texas Co.	1943	2,082	12	Hickory sandstone member	117 152.2	Nov. 1943 Dec. 20, 1958	T,E, 150	P	Altitude of land surface 1,673 ft. 1/ 2/
L-2	P. R. Rutherford	--	1948	1,000	--	Ellenburger group (?)	176.5	May 5, 1958	C,W	S	
L-3	Paul Engdahl	Davies & Williams	1955	263	--	Ellenburger group	100 78.6	1955 May 5, 1958	C,E	D,S	
L-4	P. R. Rutherford	-- Woolsey	1945	525	--	do	117.9	May 5, 1958	C,W	S	
L-5	do	M. M. Virdell	1944	630	--	do	--	--	C,W	S	
L-6	do	-- Ford	1919	640	--	do	--	--	C,W	S	
L-7	do	Robert Virdell	1946	315	--	do	75.7	May 5, 1958	C,W,E	D,S	
L-8	do	Fred Wilson	1956	1,038	--	Cambrian rocks(?)	84.8	do	C,W	S	
L-9	Charley Bryson	Clarence Virdell	1947	600	--	Ellenburger group	--	--	C,W	S	
L-10	Mrs. H. H. Session	--	1925	700?	--	do	--	--	C,W	S	
L-11	do	--	--	713	--	do	141.9	May 6, 1958	C,W	S	Old well.
L-12	do	--	1943	800?	--	Cambrian rocks(?)	--	--	J,E	D,S	
L-13	Ainsley Thomas	Davies & Williams	1951	397	6	Ellenburger group	100 90.9	Dec. 1951 May 6, 1958	C,W	N	
L-14	do	do	1950	576	6	do	80	1950	J,E	D,S	
L-15	Charles Bryson	Clarence Virdell	1927	438	--	do	--	--	C,W	D,S	
L-16	Tommy Brook	H. H. Virdell	1952	533	--	Ellenburger group (?)	110.6	May 14, 1958	C,W	S	
L-17	do	--	--	350?	--	Ellenburger group	41.0	do	C,W	S	Old well.
L-18	do	H. H. Virdell	1952	452	--	do	147.4	do	C,W	S	
L-19	do	--	1942	350	--	do	62.2	do	C,W	D,S	

* See footnotes at end of table.

Table 3.--Records of wells and springs in McCulloch County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
L-20	Tommy Brook	H. H. Virdell	1951	523	--	Cambrian rocks	170	1958	C,W	S	Reported 22 ft of white sand at bottom
L-21	Mrs. Bevans Oles	--	--	--	--	Ellenburger group (?)	18.0	Dec. 5, 1957	C,W	S	Old well.
L-22	Tommy Brook	--	1930	350	--	Cambrian rocks(?)	7.9	May 8, 1958	C,W	S	
L-23	do	--	1930	350	--	do	--	--	C,W	S	
L-24	do	--	1930	350	--	Ellenburger group	.4	May 4, 1958	C,W	S	
L-25	do	--	1930	350	--	do	30.9	May 8, 1958	C,W	D,S	
L-26	do	--	1930	350	--	do	99.9	do	C,W	S	
L-27	Mrs. H. H. Session	--	1923	375	--	do	49.2	May 6, 1958	C,W	S	
L-28	do	--	1925	365	--	do	32.8	May 6, 1958	C,W	D,S	
L-29	I. O. K. Kothman	--	1943	1,630	6	Hickory sandstone member	--	--	T,E	D,S	
L-30	Mrs. J. T. Mann	J. M. Virdell	--	1,426	--	Cambrian rocks	174.8	Nov. 27, 1957	C,E	D,S	
*L-31	T. Gray	--	1948	1,003	--	do	95.3	May 29, 1958	C,W	S	Altitude of land surface 1,780 ft.
L-32	M. J. Bean	--	1913	1,100	--	do	118.8	May 27, 1958	C,W	S	
L-33	Tommy Brook	--	--	490	--	Ellenburger group	124.0	May 15, 1958	C,W	S	
L-34	do	--	--	350	--	do	64.7	do	C,W	S	
L-35	Fred Appleton	M. M. Virdell	1956	275	--	do	20	1956	C,W	S	
L-36	Tommy Brook	--	1945	430	--	do	92.5	May 15, 1958	C,W	S	
L-37	George A. Spiller	J. E. Davies	--	502	--	do	1.1	Dec. 4, 1957	C,W	S	Old well.
L-38	Mrs. Bevans Oles	--	--	30	--	Cambrian rocks	.0	Dec. 5, 1957	C,W	S	Dug. Reported to never go dry. Old well.
L-39	do	M. M. Virdell	1951	800	6	do	116.6	do	C,W	S	
L-40	do	--	--	--	--	do	48.9	do	J,E	D,S	Old well.
L-41	C. B. Hillyard	J. E. Davies	--	196	6	do	--	--	C,W	D,S	Old well.

* See footnotes at end of table.

Table 3.--Records of wells and springs in McCulloch County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
L-42	Herman Attaway	Milton Vater	1957	349	10	Hickory sandstone member	39.9 39.8	Nov. 20, 1957 Dec. 19, 1958	T,G	Irr	Altitude of land surface, 1,552 ft. Discharge 600 gpm. 2/
L-43	--	--	--	--	--	do	75.0 75.7	Nov. 18, 1957 Nov. 5, 1958	C,W	S	Altitude of land surface 1,590 ft.
L-44	Liberty Baptist Church	Douglas Clary	1958	150	8	do	--	--	N	N	
L-45	George A. Spiller	J. E. Davies	--	125	6	Ellenburger group	28.4	Dec. 4, 1957	C,W	D,S	Old well.
L-46	H. H. Behrens	do	--	90	--	do	8.4	do	C,W	D,S	do.
L-47	do	do	--	39	--	do	8.5	do	C,H	D,S	
L-48	Tommy Brook	Douglas Clary	1954	1,245	--	Cambrian rocks	30 9.1 10.4	1954 May 16, 1958 Nov. 18, 1958	N	N	Altitude of land surface 1,600 ft. 1/ 3/
*L-49	do	--	1927	850	--	Hickory sandstone member	(+)	--	Flows	S	Flow reported 50 gpm. Altitude of land surface 1,600 ft. 3/
L-50	do	H. C. Harris	1947	344	5	Cambrian rocks	--	--	C,W	S	1/
L-51	--	--	--	500	6	Hickory sandstone member	1.0	May 27, 1958	N	N	Old well.
L-52	Tommy Brook	--	--	415	--	do	(+)	--	Flows	S	do.
L-53	do	--	--	425	--	Cambrian rocks	--	--	J,E,1	S	Old well.
L-54	R. P. Appleton	-- Dyer	1936	150	--	do	78.2	May 28, 1958	C,W,E	D,S	
L-55	M. J. Bean	--	1937	372	--	Cambrian rocks(?)	12.2	do	C,W	S	
L-56	Mrs. Lillian Rivenbergh	Fred Wilson	1948	100	--	Ellenburger group (?)	16.3	do	C,W	S	
L-57	E. T. Williams	do	1947	318	--	Cambrian rocks(?)	--	--	C,W	S	
L-58	do	Clarence Virdell	1930	302	--	Ellenburger group (?)	18.0	May 28, 1958	C,W	S	
L-59	T. Gray	--	--	20	--	Cretaceous rocks (?)	--	--	C,W	S	Old well.

* See footnotes at end of table.

Table 3.--Records of wells and springs in McCulloch County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level		Method of lift	Use of water	Remarks
							Below land surface datum (ft.)	Date of measurement			
L-60	Fred Appleton	--	1940	360	--	Ellenburger group	--	--	C,W	S	
M-1	A. L. Neal	M. M. Virdell	1951	240	8	do	20.5	May 7, 1958	C,W	S	
M-2	C. T. White	--	--	602	--	do	53.7	Jan. 28, 1958	C,W	S	
M-3	do	--	1947	386	--	do	40.4	do	C,W	S	
M-4	do	--	--	661	--	Cambrian rocks	--	--	C,W	S	
M-5	do	--	1942	612	--	do	123.4	Jan. 28, 1958	C,W	S	
M-6	P. R. Rutherford	-- Bleeker	1950	930	--	do	--	--	C,W	S	
M-7	do	do	1950	800?	--	do	177.5	May 5, 1958	C,W	S	
*M-8	C. T. White	--	--	700	--	do	103.5	Jan. 22, 1958	C,W	S	
*M-9	do	--	1944	592	6	do	61.0	do	C,W	S	
*M-10	do	--	1945	362	--	Ellenburger group (?)	31.0	do	C,W	S	
M-11	do	--	--	712	--	Cambrian rocks	71.1 69.8	Jan. 22, 1958 Mar. 31, 1958	C,W	S	
M-12	do	--	--	835	--	do	192.5 191.5	Jan. 22, 1958 Mar. 31, 1958	C,W	S	
*M-13	do	--	--	900	--	Hickory sandstone member	(+)	--	Flows, J,E	D,S	Altitude of land surface 1,507 ft. Temp. 71°F.
M-14	do	--	1952	715	--	Cambrian rocks	64.6	Jan. 24, 1958	C,W	S	
M-15	do	--	--	490	--	do	159.4	do	C,W	S	
M-16	do	--	--	430	--	do	--	--	C,W	S	
M-17	do	--	1951	470	--	do	--	--	C,W	S	
M-18	do	--	1940	752	--	do	68.3	Jan. 27, 1958	C,W	S	
M-19	do	--	1951	403	--	do	124.8	do	C,W	S	
M-20	do	--	1948	420	--	do	91.7	do	C,W	S	

* See footnotes at end of table.

Table 3.--Records of wells and springs in McCulloch County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
M-21	C. T. White	--	--	565	--	Cambrian rocks	163.8	Jan. 27, 1958	C,W	S	
M-22	do	--	--	945	--	Hickory sandstone (?) member	--	--	C,W	S	
M-23	do	--	--	348	--	Cambrian rocks	--	--	C,W	S	
M-24	-- Locklear	--	--	300?	--	do	94.4	Oct. 31, 1957	C,W	S	
M-25	do	--	--	90	--	do	70.4	do	C,W	S	
M-26	Ed Spiller	--	1957	480	--	Hickory sandstone member	--	--	C,W	D,S	
M-27	D. R. Jordan	Joe Davies	1955	305	6	do	30	1955	N	N	
M-28	do	Joe Allen	1954	210	6	Hickory sandstone (?) member	35 78.4	1954 Dec. 4, 1957	C,W	D,S	
M-29	C. L. Jordan	Fred Wilson	1950	166	6	Hickory sandstone member	23 50.6	1950 Dec. 4, 1957	C,W	D,S	1/
M-30	Catherine Jordan Hillyard	Joe Davies	1955	186	6	do	14 15.0	1955 Dec. 4, 1957	C,W	S	
M-31	D. R. Jordan	Fred Wilson	1950	450	6	do	20	1950	C,W	S	
M-32	C. L. Jordan	C. E. Davies	1900	--	6	do	12 15.6	1956 Dec. 4, 1957	N	N	
M-33	do	do	1900	296	6	do	12 11.2	1956 Dec. 4, 1957	N	N	
M-34	W. L. Willis	Fred Wilson	--	--	--	do	12.6	Dec. 4, 1957	C,W	S	
M-35	Leonard Willis	J. J. Davies	--	100	--	do	--	--	J,E, 3/4	D,S	Old well.
M-36	do	H. H. Virdell	1954	503	8	do	25 13.6	1954 Dec. 16, 1958	C,W	S	Altitude of land surface 1,513 ft. 2/
M-37	J. E. Edmiston	Joe Allen	1955	480	9	do	(+)	--	Flows	S	Flow reported 15 gpm. Altitude of land surface 1,500 ft. 3/
M-38	do	--	1936	180	--	do	3.1	Dec. 5, 1957	J,E	D,S	

* See footnotes at end of table.

Table 3.--Records of wells and springs in McCulloch County--Continued

Well	Owner	Driller	Date com- plet- ed	Depth of well (ft.)	Diam- eter of well (in.)	Water-bearing unit	Water level		Method of lift	Use of water	Remarks
							Below land surface datum (ft.)	Date of measurement			
M-39	J. E. Edmiston	Clarence Virdell	1936	160	--	Ellenburger group	67.4	Dec. 5, 1957	C,W	S	
M-40	Marvin Burns	do	1935	700	--	Cambrian rocks(?)	126.2	Nov. 20, 1957	C,W	S	Originally drilled to 700 ft, but filled to 400 ft. Several cavernous openings encountered when drilled.
M-41	do	H. H. Virdell	1954	650	8	Cambrian rocks	(+)	--	Flows, C,W	S	
M-42	do	Clarence Virdell	1935	560	6	do	7.7	Nov. 20, 1957	C,W	S	
M-43	J. E. Edmiston	H. H. Virdell	1953	750	6	do	88.5	do	C,W	S	
M-44	do	do	1927	190	6	Hickory sandstone member	(+)	--	Flows	S	
*M-45	Evans Adkins	--	--	400?	8	do	(+)	--	Flows	D,S, Irr	Flow reported 60 gpm. Old well.
M-46	John Cotton	H. H. Virdell	1956	150	--	do	18.3	Dec. 5, 1957	C,W	S	
M-47	C. L. Jordan	Joe Allan	1954	180	6	do	48 45.8 45.2	1954 Dec. 4, 1957 Nov. 5, 1958	C,W	D,S	Altitude of land surface 1,522 ft.
M-48	Katherine Jordan Hillyard	--	--	--	6	do	37.9 38.0 37.9	Dec. 4, 1957 Nov. 5, 1958 Dec. 16, 1958	C,W	S	Old well.
M-49	Mrs. Cal Willis	--	--	125	6	do	(+)	--	Flows	D,S	Flow reported 5 gpm.
M-50	L. R. Elliott	Jim Spiller	--	126	6	do	(+)	--	Flows	D,S Irr	Flow reported 30 to 40 gpm. Old well.
M-51	Marvin Burns	--	--	173	3	do	(+)	--	Flows	S	Flow reported 30 to 40 gpm. Old well. Temp. 69°F.
M-52	do	J. E. Davies	--	175	6	Cambrian rocks	59.4 48.4	Nov. 20, 1957 Nov. 5, 1958	C,W	S	Altitude of land surface 1,588 ft. Old well.
M-53	do	-- Woosley	1946	233	10	Ellenburger group (?)	68.5	Nov. 5, 1958	C,W	S	
M-54	do	H. H. Virdell	1952	920	8	Cambrian rocks	32.7	do	C,W	S	

* See footnotes at end of table.

Table 3.--Records of wells and springs in McCulloch County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*M-55	Ed Spiller	H. H. Virdell	1947	165	6	Hickory sandstone member	52.0 52.3	Nov. 26, 1957 Dec. 19, 1958	C,W	D,S	Altitude of land surface 1,558 ft. 2/
N-1	Mrs. K. W. Haby	--	--	500	8	Ellenburger group (?)	--	--	C,W	S	Originally drilled to 1,996 ft, plugged back to 500 ft.
N-2	do	--	1929	420	8	do	--	--	C,W	S	
P-1	do	Fred Wilson	1938	650	8	do	--	--	C,W	S	
P-2	do	Bob Lee	1928	580	8	do	--	--	C,W,E	D,S	
P-3	T. Gray	--	--	250	--	do	10.0	June 2, 1958	C,W	S	Old well.
P-4	do	--	1937	250	--	do	--	--	C,W	S	
P-5	do	Fred Wilson	1957	310	--	do	78.2	June 2, 1958	C,W	D,S	
P-6	do	--	1930	45	--	do	--	--	C,W	S	
R-1	Lillian Rivenbergh	--	--	--	--	Cambrian rocks(?)	9.6	May 28, 1958	C,W	S	
R-2	M. J. Bean	-- Doyle	1953	570	--	Cambrian rocks	17.8	do	C,W	D,S	Altitude of land surface 1,595 ft.
*R-3	C. E. Myrick	Davies & Williams	1956	842	10	Hickory sandstone member	(+)	--	Flows	S, Irr	Flow reported 60 gpm. Altitude of land surface 1,600 ft. 3/
R-4	Henry Turner	--	1954	301	--	Cambrian rocks	--	--	C,W	S	
R-5	do	--	--	300?	--	do	--	--	C,W	D,S	Old well.
R-6	E. T. Williams	J. E. Davies	--	518	--	Hickory sandstone member	6.1	May 27, 1958	C,W	D,S	Altitude of land surface 1,581 ft. Old well.
R-7	Fred Otte	--	1938	806	--	do	12.4	May 16, 1958	C,W	D,S	
R-8	Tommy Brook	--	1950	400	--	do	(+)	--	Flows	D,S	
*R-9	do	--	1950	430	--	do	(+)	--	Flows	S, Irr	
R-10	Fred Otte	-- Virdell	1951	201	--	Cambrian rocks	25 42.2	1951 May 16, 1958	C,W	D,S	
R-11	do	do	1948	610	--	Hickory sandstone member	26.6	May 16, 1958	C,W	S	

* See footnotes at end of table.

Table 3.--Records of wells and springs in McCulloch County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
R-12	--	--	--	--	--	Cambrian rocks	67.0	May 21, 1958	C,W	S	
R-13	Edith Cohen	Joe Davies	1956	300	12	Hickory sandstone member	44.9 43.2	Nov. 18, 1957 Dec. 15, 1958	N	N	Altitude of land surface 1,643 ft. 2/
R-14	E. H. Elliott	--	1927	227	--	Cambrian rocks	--	--	C,W,E	D,S	
R-15	Edith Cohen	Joe Davies	1956	350	8	do	--	--	C,W	S	
R-16	C. E. Myrick	Check Doyle	--	390	6	do	--	--	C,W	D,S	
R-17	do	Davies & Williams	1955	754	8	Hickory sandstone member	25.2 30.3	Nov. 13, 1957 Nov. 6, 1959	T,E, 5	Irr	Reported irrigated 10 acres in 1957. Altitude of land surface 1,649 ft. Temp. 69°F.
R-18	F. G. Kidd	-- Martin	1912	585	--	Cambrian rocks	--	--	C,W	D,S	
R-19	Mrs. M. E. Teague	--	1951	150	--	Cambrian rocks(?)	22.4	June 28, 1958	C,W	S	
R-20	M. E. Kidd	Douglas Clary	1930	390	--	Cambrian rocks	10.1	June 16, 1958	C,W	S	
R-21	do	-- Martin	1912	374	--	do	--	--	C,W	S	
R-22	H. Schmidt	H. C. Harris	1940	385	--	do	--	--	C,W	S	
*R-23	do	Milton Vater	1954	600	10	Hickory sandstone member	121.8	June 24, 1958	T,G	Irr	Pump set at 230 ft. Reported irrigates 90 acres. Altitude of land surface 1,724 ft. Discharge estimated 800 gpm.
R-24	M. E. Kidd	H. C. Harris	1940	393	--	Cambrian rocks	144.0	June 27, 1958	C,W	S	
R-25	H. L. Wood	--	--	240	--	do	125.3	June 28, 1958	C,W	S	Old well.
R-26	Edith Cohen	Fred Wilson	1955	350	8	Hickory sandstone member	89.2 87.6	Nov. 8, 1957 Nov. 3, 1958	C,W	S	Altitude of land surface 1,679 ft.
R-27	do	do	1955	275	12	do	63.5 61.2	Nov. 8, 1957 Dec. 15, 1958	C,W	S	Altitude of land surface 1,665 ft. 2/
*R-28	Arthur Hurley	Milton Vater	1954	370	10	do	55.0 53.3	Nov. 13, 1957 Dec. 15, 1958	T,G	Irr	Altitude of land surface 1,647 ft. Discharge 500 gpm. 1/ 2/
R-29	Edith Cohen	Fred Wilson	--	250	8	do	63.7 62.5	Nov. 8, 1957 Nov. 3, 1958	C,W	S	2/

* See footnotes at end of table.

Table 3.--Records of wells and springs in McCulloch County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
R-30	Edith Cohen	Joe Davies	1945	257	8	Hickory sandstone member	53.9 52.0 52.7 52.6	Nov. 8, 1957 May 16, 1958 June 18, 1958 Nov. 3, 1958	C,W	D	Altitude of land surface 1,653 ft.
R-31	do	Fred Wilson	1955	151	8	do	35.2 34.3	Nov. 8, 1957 Nov. 3, 1958	C,W	S	
R-32	Fred Dobbs	do	1953	210	6	Cambrian rocks	85.7 86.8	Nov. 13, 1957 Dec. 15, 1958	C,W	S	Altitude of land surface 1,682 ft. 2/
R-33	do	--	--	138	6	Hickory sandstone member	108.7 109.8	Nov. 13, 1957 Nov. 3, 1958	C,W	S	
R-34	do	-- Kenzie	1943	100	6	do	67.6 68.7	Nov. 13, 1957 Nov. 3, 1958	C,W	S	Altitude of land surface 1,682 ft.
R-35	--	--	--	--	--	do	55.9 56.5	Nov. 19, 1957 Nov. 3, 1958	C,W	D,S	
R-36	G. F. Clevenger	Douglas Clary	1956	69	14	do	33.6 33.0	Oct. 29, 1957 Dec. 19, 1958	N	N	Altitude of land surface 1,626 ft. 2/
R-37	Tom Baze	Paul Benavides	1956	143	10	do	45.8 45.9	Oct. 29, 1957 Dec. 19, 1958	N	N	Altitude of land surface 1,633 ft. 2/
R-38	W. E. Hardin	Douglas Clary	1956	123	14	do	42	1958	T,G	Irr	Discharge reported 200 gpm.
R-39	Mrs. V. Passmore	Milton Vater	1955	190	9	do	49.8 47.6	Oct. 29, 1957 Dec. 19, 1958	T,G	Irr	Altitude of land surface 1,617 ft. 2/
R-40	Tommy Brook	--	1930	450	--	Cambrian rocks	90.5	May 22, 1958	C,W	S	
R-41	do	Harris & Mier	1936	1,090	--	--	--	--	N	N	Oil test. Abandoned.
R-42	Tom Keyzar	Fred Wilson	--	200	--	Cambrian rocks	97.4	Nov. 15, 1957	C,W	S	1/
R-43	J. E. Herrington	--	--	--	--	do	15.0	Nov. 19, 1957	C,W, T,E	S	Dug.
R-44	E. O. Henderson	Milton Vater	1956	350	--	Hickory sandstone member	40	1957	T,G	Irr	Discharge measured 300 gpm. Reported to irrigate about 40 acres.
R-45	Mrs. G. B. Owens	Fred Wilson	1956	361	10	do	30 48.1	1956 June 12, 1958	T,G	Irr	Discharge reported 450 gpm. Pump set at 176 ft. Altitude of land surface 1,586 ft.

* See footnotes at end of table.

Table 3.--Records of wells and springs in McCulloch County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
*R-46	A. T. Owens	Fred Wilson	1942	137	6	Hickory sandstone member	95.4 93.1	Nov. 15, 1957 Dec. 19, 1958	C,W	D,S	Altitude of land surface 1,632 ft. 2/
R-47	G. F. Clevenger	Alvie Stewart	1955	300	10	do	79.4	Oct. 29, 1957	T,G	Irr	Discharge reported 400 gpm. Irrigated 77 acres in 1957. Altitude of land surface 1,602 ft.
R-48	San Saba Sand Co.	Fred Wilson	1957	119	10	do	39 34.6	1957 Nov. 21, 1958	T,E, 15	Ind	Discharge measured 230 gpm. Altitude of land surface 1,555 ft.
R-49	do	Douglas Clary	1958	105	15	do	46.8 35.6	June 25, 1958 Nov. 21, 1958	T,E, 15	Ind	Altitude of land surface 1,558 ft. 1/
R-50	do	Fred Wilson	1957	124	12	do	30 39.9	1957 Nov. 21, 1958	T,E, 15	Ind	Altitude of land surface 1,551 ft.
R-51	J. W. Behrens	Douglas Clary	1958	121	12	do	37.1	May 23, 1958	J,E	D	
R-52	do	Milton Vater	1958	100	10	do	24.1	Nov. 6, 1958	N	N	
R-53	do	J. W. Behrens	1953	95	8	do	11.8 16.1 15.4	Oct. 28, 1957 June 10, 1958 Nov. 2, 1958	T,E, 5	Irr	Discharge reported 150 gpm. Altitude of land surface 1,564 ft.
*R-54	do	M. M. Virdell	1955	125	12	do	29.7	Oct. 28, 1957	T,E, 5	Irr	Discharge reported 150 gpm.
R-55	do	J. W. Behrens	1955	107	8	do	30.4 33.3	Oct. 28, 1957 Dec. 19, 1958	T,E, 5	Irr	Drawdown reported 45.3 ft after 10 minutes pumping. Altitude of land surface 1,562 ft. 1/
R-56	Gary McLerrain	M. M. Virdell	1957	240	10	do	73.4 72.7	Oct. 28, 1957 Nov. 3, 1958	T,G	Irr	Discharge reported 320 gpm. Pump set at 128 ft. Altitude of land surface 1,606 ft.
R-57	J. R. Kiser	Fred Wilson	1957	175	10	do	--	--	N	N	
R-58	W. J. Meredith	A. C. Stewart	1955	242	12	do	103.3 103.6	Nov. 15, 1957 Nov. 3, 1958	T,G	Irr	Discharge reported 325 gpm. Reported to irrigate about 75 acres. Altitude of land surface 1,619 ft.
R-59	do	Douglas Clary	1958	180	12	do	68 69.1	Apr. 1958 Nov. 5, 1958	T,G	Irr	Discharge reported 285 gpm.
R-60	J. R. Kiser	do	1956	100	15	do	--	--	T,G	Irr	

* See footnotes at end of table.

Table 3.--Records of wells and springs in McCulloch County--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Diameter of well (in.)	Water-bearing unit	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks
R-61	J. R. Kiser	Douglas Clary	1956	100	14	Hickory sandstone member	37.9 37.5	Oct. 28, 1957 Nov. 6, 1958	T,G	Irr	Discharge reported 143 gpm. Irrigated 60 acres in 1957.
*R-62	C. B. Clevenger	do	1956	120	12	do	52.5 51.9	Oct. 29, 1957 Nov. 3, 1958	T,G	Irr	Altitude of land surface 1,618 ft.
S-1	Ed Spiller	--	--	100	--	do	64.5	Dec. 4, 1957	C,W	S	Old well.
*S-2	J. F. Dean	A. C. Stewart	1954	126	10	do	55	Oct. 1957	T,E, 5	Irr	Discharge 70 gpm.
S-3	do	do	1954	118	12	do	43	Oct. 1957	T,E, 7½	Irr	Irrigated 100 acres in 1957.
S-4	-- Holloway	--	--	--	--	do	25.5 23.2	Nov. 20, 1957 Dec. 19, 1958	N	N	Altitude of land surface 1,551 ft. 2/
S-5	-- Thompson	--	--	--	8	do	14.2	Oct. 31, 1957	C,W	S	Altitude of land surface 1,513 ft.
S-6	Ed Spiller	--	--	60	--	do	43.4 42.8	Oct. 3, 1957 Nov. 4, 1958	C,W	N	Old well.
S-7	W. B. Thompson	--	--	--	--	do	24.3 23.7	Dec. 4, 1957 Dec. 19, 1958	C,W	N	Altitude of land surface 1,508 ft. 2/
S-8	do	--	--	--	--	do	19.1	Jan. 8, 1958	N	N	
S-9	do	--	--	--	--	do	17.1	do	N	N	
S-10	J. D. Millsap	--	--	--	--	do	--	--	C,W	S	
S-11	Marvin Burns	J. E. Davies	1914	150	6	Cambrian rocks	--	--	C,W	S	
S-12	J. D. Millsap	--	--	--	--	Hickory sandstone member	102.4	Nov. 26, 1957	C,W	S	
S-13	Louis Brockman	--	--	43	--	do	16.3 15.7	Oct. 30, 1957 Nov. 4, 1958	C,W	N	
S-14	do	--	--	46	--	do	--	--	C,W	D,S	Old well.
S-15	--	--	--	--	--	Hickory sandstone (?) member	46.0	Nov. 18, 1957	C,W	N	
S-16	Bud Baxter	-- Virdell	1954	177	8	Hickory sandstone member	65.6 52.2	Oct. 30, 1957 Dec. 19, 1958	T,G	Irr	Discharge reported 200 gpm. Irrigated about 40 acres in 1957. Altitude of land surface 1,637 ft. 2/

1/ See table 4 for drillers' logs of wells in McCulloch County, Texas. 2/ See table 5 for water levels in wells in McCulloch County, Texas 3/ For electric logs and radio activity logs see files of Texas Board of Water Engineers. * See table 6 for chemical analyses of water from wells and springs in McCulloch County, Texas

Table 4.--Drillers' logs of wells in McCulloch County, Texas

Well C-6

Owner: D. S. Pumphrey. Driller: Virgil Brock.

	Thickness (feet)	Depth (feet)
Limestone, medium crystalline, gray to light brown	30	30
Limestone, medium crystalline, gray to light brown, and shale	10	40
Shale, gray	20	60
Limestone, medium crystalline, white, buff	20	80
Limestone, medium crystalline, buff and light gray	10	90
Limestone, medium crystalline, fossiliferous, gray	25	115
Shale, red and gray	30	145
Shale, gray and green	10	155
Sandstone, fine, green, and limestone	10	165
Sandstone, fine, green, and red and green shale	10	175
Limestone, crystalline, buff	10	185
Limestone, medium crystalline, light buff	10	195
Shale, brown and gray	14	209
Limestone, crystalline, fine, buff	5	214
Limestone, crystalline, fine, light gray	14	228
Shale, fossiliferous, dark gray	10	238
Shale, black, and coarse, crystalline, fossiliferous, brown limestone	10	248
Limestone, crystalline, fine, white	12	260
Limestone, crystalline, fine and buff fusulinid	15	275
Shale, gray	35	310
Shale, red	20	330
Shale, sandy, red and gray	12	342
Sandstone, medium, white	18	360
Shale, gray	60	420
Sandstone, fine, green and coarse brown	10	430
Sandstone, fine, green, and gray shale	10	440
Shale, gray	10	450
Shale, red and brown	25	475
Shale, gray	10	485
Shale, sandy, gray	15	500
Sandstone, medium, black and white	22	522
Shale, red and green	13	535

(Continued on next page)

	Thickness (feet)	Depth (feet)
Well C-6--continued		
Shale, red, green, and brown	5	540
Shale, sandy	15	555
Lime, sandy	10	565
Shale, gray	5	570
Shale, sandy, gray	20	590
Sandstone, very fine, light green, and medium crystalline, fossiliferous, glauconitic, black limestone	10	600
Limestone, crystalline, fine, fossiliferous, black	5	605
Limestone, crystalline, medium, fossiliferous, black	15	620
Limestone, crystalline, medium, fusulinid, light brown	10	630
Limestone, crystalline, medium, fusulinid, light brown, some fluorescent	10	640
Limestone, crystalline, medium, black	40	680
Limestone, crystalline, medium, light brown	10	690
Limestone, crystalline, medium, black	22	712
Shale and pyrite, black	28	740
Shale, black	152	892
Shale, black, and very fossiliferous, glauconitic, fusulinid, dark gray limestone	8	900
Shale, black, and fossiliferous, glauconitic, dark gray limestone	15	915
Limestone, fossiliferous, glauconitic, dark gray, and black shale	7	922
Limestone, crystalline, coarse, fossiliferous, fusulinid, dark gray	3	925
Limestone, crystalline, coarse, fossiliferous, fusulinid, dark gray and black shale	10	935
Limestone, crystalline, medium, fossiliferous, buff	10	945
Limestone, crystalline, coarse, fossiliferous, fusulinid, gray and light brown	10	955
Limestone, crystalline, coarse, fossiliferous, fusulinid, light brown	5	960
Limestone, crystalline, coarse, fossiliferous, fusulinid, light brown, and black shale	5	965
Limestone, crystalline, coarse, black	15	980
Limestone, crystalline, coarse, black and light brown	5	985

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	Thickness (feet)	Depth (feet)
Well C-6--continued		
Limestone, crystalline, coarse, fossiliferous, black and light brown, and calcareous, light gray shale	10	995
Limestone, dark gray, and sandy, dark brown shale	5	1,000
Limestone, crystalline, coarse, fossiliferous, dark gray	6	1,006
Shale, sandy, black	8	1,014
Limestone, crystalline, fine, light brown	11	1,025
Limestone, crystalline, fine, light brown, and fossiliferous brachiopods and bryozoa	13	1,038
Limestone, crystalline, fine, light brown	32	1,070
Limestone, crystalline, coarse, fossiliferous, brown and dark gray	5	1,075
Shale, sandy, dark brown	17	1,092
Shale, sandy, dark brown and gray	25	1,117
Limestone, shaly, fossiliferous, brown	8	1,125
Shale, sandy, brown and gray	19	1,144
Shale, sandy, brown	20	1,164
Sandstone, glauconitic, fine, and sandy, brown shale	3	1,167
Limestone, crystalline, coarse, white	30	1,197
Limestone, crystalline, fine, white	9	1,206
Limestone, crystalline, medium, white	6	1,212
Limestone, crystalline, fine, white, and milky chert	28	1,240
Dolomite, crystalline, fine, light gray	20	1,260
Limestone, crystalline, coarse, white	6	1,266
Limestone, crystalline, fine, white, and milky chert	14	1,280
Limestone, crystalline, fine, white	55	1,335
Limestone, crystalline, fine, white and milky chert	15	1,350
Limestone, crystalline, fine, white and light brown chert	45	1,395
Limestone, crystalline, medium, white and light gray	10	1,405
Limestone, crystalline, medium, buff	5	1,410
Limestone, crystalline, fine, white	35	1,445
Limestone, crystalline, coarse, light brown	60	1,505

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

Well C-9

Owner: Harry Curtis. Driller: Bomjack Oil Co.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Caliche and lime--------	22	22	Shale, red and blue------	135	1,010
Lime and shale----------	78	100	Lime and shale, black----	112	1,122
Shale and lime----------	135	235	Shale, black------------	68	1,190
Shale, red and blue-----	428	663	Lime, white-------------	14	1,204
Sand-------------------	15	678	Shale, black and gray----	26	1,230
Sand and shale----------	105	783	Lime--------------------	51	1,281
Lime and shale, blue----	92	875			

Well C-11

Owner: Harry Curtis. Driller: --

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Lime-------------------	35	35	Lime--------------------	28	270
Shale, white-----------	5	40	Red bed-----------------	30	300
Red bed----------------	10	50	Lime, white-------------	30	330
Shale, blue------------	10	60	Shale, blue-------------	45	375
Lime, white------------	32	92	Red bed-----------------	25	400
Shale, black-----------	28	120	Sand--------------------	24	424
Red bed----------------	15	135	Shale, blue-------------	86	510
Lime-------------------	35	170	Shale, white------------	30	540
Red bed----------------	15	185	Sand (salt water)--------	15	555
Shale, sandy-----------	27	212	Shale, blue-------------	70	625
Sand-------------------	3	215	Red bed-----------------	10	635
Red bed----------------	15	230	Lime, hard--------------	7	642
Shale, blue------------	12	242	Shale, blue-------------	52	694

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Well C-11--continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Lime (brackish water)---	61	755	Lime (water)-------------	10	1,180
Shale, black------------	10	765	Lime---------------------	65	1,245
Lime--------------------	40	805	Lime (water)-------------	10	1,255
Shale, black------------	117	922	Lime---------------------	95	1,350
Lime--------------------	33	955	Lime (water)-------------	20	1,370
Shale, black------------	25	980	Lime---------------------	140	1,510
Lime--------------------	45	1,025	Sand, red----------------	10	1,520
Lime, black-------------	3	1,028	Lime---------------------	15	1,535
Lime--------------------	68	1,096	Sand, white--------------	10	1,545
Shale, brown------------	74	1,170	Lime and sandy lime------	231	1,776

Well E-5

Owner: City of Melvin. Driller: --

No record---------------	200	200	Shale, green-------------	70	780
Sand--------------------	70	270	Lime and shale, red------	70	850
Sand, lime, and shale---	40	310	Lime---------------------	140	990
Shale, blue-------------	30	340	Lime and shale, sandy----	90	1,080
Shale, red--------------	10	350	Shale--------------------	20	1,100
Shale, green------------	20	370	Lime---------------------	30	1,130
Lime--------------------	10	380	Sand---------------------	30	1,160
Sand and shale----------	50	430	Lime and shale, sandy----	40	1,200
Shale, sandy, red and green-----------------	80	510	Lime---------------------	260	1,460
Shale, green------------	140	650	Shale, sandy-------------	80	1,540
Lime--------------------	60	710	Lime---------------------	30	1,570

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Well E-5--continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Shale	55	1,625	Sand, fine to very coarse quartz	100	2,700
Shale and sand	35	1,660	Sand, very coarse quartz pebbles, and glauconite	100	2,800
Lime and shale	110	1,770	Sand and fine to medium quartz	80	2,880
Lime, dolomite white and light tan	450	2,220	Sand, and red and gray, fine to medium quartz	10	2,890
Lime, dolomite, sand and medium and coarse quartz	40	2,260	Sand and light brown, fine to medium quartz	20	2,910
Sand, fine to coarse quartz and dolomite	270	2,530	Sand, very coarse quartz, trace of dolomite and glauconite	47	2,957
Sand, fine to medium quartz, and glauconite	70	2,600			

Well K-1

Owner: City of Brady well 4. Driller: Kent & Preston.

Lime	15	15	Lime, gray	32	277
Shale, red	20	35	Shale, black	28	305
Lime, sandy	20	55	Lime	10	315
Shale, blue	18	73	Shale	3	318
Lime, sandy	22	95	Lime	97	415
Shale, blue	5	100	Lime, hard	83	498
Lime	12	112	Lime, sandy	4	502
Shale	36	148	Lime	43	545
Lime	17	165	Lime, hard	15	560
Shale, dark	65	230	Lime, soft	10	570
Lime, brown	3	233	Lime, hard	5	575
Shale, gray	12	245	Lime, soft	18	593

(Continued on next page)

Well K-1--continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Lime, hard	19	612	Shale, green, sandy	21	1,543
Lime	178	790	Sand with shale streaks	40	1,583
Lime, sandy	10	800	Sand, brown	52	1,635
Lime, hard	10	810	Sand, hard	5	1,640
Lime	40	850	Sand, red	10	1,650
Lime and iron	18	868	Sand, hard	5	1,655
Lime	302	1,170	Shale, sandy	40	1,695
Shale and shells	25	1,195	Sand, gray	17	1,712
Lime	57	1,252	Sand, red, hard	78	1,790
Lime, sandy, increase in water	6	1,258	Sand, gray	10	1,800
Lime, white	37	1,295	Shale, sandy	49	1,849
Shale	11	1,306	Sand, hard	8	1,857
Lime	14	1,320	Sand and shale streaks	2	1,859
Shale	7	1,327	Sand, coarse	44	1,903
Shale and shells	12	1,339	Sand, soft	12	1,915
Shale	39	1,378	Sand, hard	12	1,927
Lime	7	1,385	Sand, soft	10	1,937
Shale, sandy	19	1,404	Sand, hard	5	1,942
Lime, broken	31	1,435	Sand, soft (more water)	16	1,958
Lime, hard	5	1,440	Sand, coarse	47	2,005
Lime, broken	5	1,445	Shale, blue	5	2,010
Shale, sandy	32	1,477	Sand, white and coarse	116	2,126
Shale, red, sandy	45	1,522	Granite	1	2,127

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

Well K-2

Owner: City of Brady well 1. Driller: Higdon & Newman.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	22	22	Sand, gray	7	847
Gravel	3	25	Lime, white	30	877
Gumbo, red	10	35	Lime, brown	30	907
Lime, white	15	50	Shale, green	1	908
Shale, blue	22	72	Lime, gray	222	1,130
Lime, gray	23	95	Shale, green	3	1,133
Shale, blue	67	162	Lime, broken	5	1,138
Rock, red	12	174	Shale, brown	2	1,140
Shale, blue	13	187	Shale, blue	5	1,145
Lime, hard, white	231	418	Lime, gray	120	1,265
Soapstone, hard	2	420	Lime, broken, sand, and shale	202	1,467
Lime, white	15	435	Sand (water, tested 35 gpm)	36	1,503
Soapstone	15	450	Shale, blue	3	1,506
Lime, white	110	560	Lime and sand, broken	174	1,680
Sand (water)	25	585	Sand, red (water)	127	1,807
Lime, white	35	620	Shale, blue	3	1,810
Sand (water)	18	638	Sand, very fine to coarse, gray (water)	302	2,112
Lime, white	22	660	Shale, blue	2	2,114
Sand (water)	10	670			
Lime, white	140	810			
Lime, brown	30	840			

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

Well K-3

Owner: City of Brady well 2. Driller: Layne Texas Co.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Clay	20	20	Shale	20	1,365
Sand and gravel	12	32	Lime	15	1,380
Shale, blue	18	50	Sand	12	1,392
Shale, sandy	25	75	Lime	78	1,470
Sand	10	85	Sand	23	1,493
Shale, sandy, gray	20	105	Shale	17	1,510
Lime, white	11	116	Sand, hard	25	1,535
Shale, blue	74	190	Sand, hard, and shale	25	1,560
Shale, blue, red	15	205	Sand, coarse	35	1,595
Lime, gray	6	211	Shale	10	1,605
Shale, gray	24	235	Shale, sandy	27	1,632
Lime	211	446	Lime, white	31	1,663
Sand	7	453	Sand	17	1,680
Lime	89	542	Sand, red	16	1,696
Shale, gray	13	555	Sand	29	1,725
Lime	40	595	Sand and red rock	25	1,750
Shale, gray	5	600	Shale	20	1,770
Lime	530	1,130	Sand	65	1,835
Shale, blue	5	1,135	Sand and shale	14	1,849
Lime	128	1,263	Sand	55	1,904
Shale	17	1,280	Sand, hard (water)	24	1,928
Lime	10	1,290	Sand, brown	175	2,103
Shale and sand	50	1,340	Shale, blue	9	2,112
Rock, red	5	1,345			

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

Well K-11

Owner: W. H. Winters. Driller: Fred Wilson.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil and caliche--------	4	4	Shale, blue--------------	15	258
Lime, yellow------------	26	30	Lime, hard, gray---------	17	275
Clay, sandy, yellow-----	3	33	Shale, blue--------------	5	280
Shale, blue-------------	2	35	Shale, red---------------	3	283
Shale, gray-------------	30	65	Lime, gray---------------	4	287
Lime, yellow------------	8	73	Shale, red---------------	4	291
Shale, gray and yellow--	3	76	Lime, gray---------------	10	301
Lime, yellow------------	10	86	Lime, gritty, blue-------	6	307
Limestone, blue---------	7	93	Shale, blue--------------	9	316
Limestone, gray---------	16	109	Lime, blue---------------	4	320
Shale, gray-------------	4	113	Shale, gray--------------	2	322
Lime, gray--------------	3	116	Lime, brown--------------	5	327
Shale and gray gravel---	2	118	Shale, gray--------------	2	329
Lime, gray--------------	22	140	Lime, hard, gray---------	20	349
Shale, gray-------------	34	174	Sandrock, gray-----------	3	352
Sandrock, gray----------	10	184	Lime, brown--------------	4	356
Shale, gray-------------	2	186	Shale, gray--------------	7	363
Sandrock, gray----------	12	198	Lime, brown--------------	16	379
Shale, sandy, gray------	9	207	Shale, blue--------------	10	389
Shale, blue-------------	8	215	Shale, red---------------	2	391
Lime, blue--------------	2	217	Lime, gray-blue----------	6	397
Shale, blue-------------	25	242	Shale, red---------------	21	418
Rock--------------------	1	243	Shale, blue--------------	8	426

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

Well K-11--continued

Lime, blue-gray----------	5	431	Lime, blue-gray----------	31	463
Soft break---------------	1	432	Limestone----------------	397	860

Well K-15

Owner: Tol Roberts. Driller: V. M. Bleeker.

No record----------------	705	705	Shale, green-------------	10	1,470
Lime---------------------	630	1,335	Shale, brown-------------	15	1,485
Shale, brown-------------	15	1,350	Lime---------------------	30	1,515
Shale--------------------	25	1,375	Sand---------------------	80	1,595
Shale, sandy-------------	15	1,390	Sand and lime------------	7	1,602
Lime---------------------	70	1,460	Lime, sandy--------------	109	1,711

Well L-1

Owner: City of Brady well 3. Driller: Layne Texas Co.

Soil---------------------	2	2	Lime and red rock--------	15	160
Gravel-------------------	3	5	Lime and shale-----------	10	170
Gravel and clay----------	15	20	Shale, gray--------------	25	195
Gravel-------------------	15	35	Shale, brown-------------	10	205
Gravel, lime, and shale-	15	50	Lime and shells----------	11	216
Lime---------------------	10	60	Lime---------------------	324	540
Lime, white--------------	25	85	Sand (water)-------------	5	545
Shale, sandy-------------	10	95	Lime---------------------	5	550
Shale--------------------	25	120	Sand---------------------	5	555
Shale, blue--------------	13	133	Lime---------------------	348	903
Shale and lime (some water)----------------	12	145	Lime, dark gray----------	17	920

(Continued on next page)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well L-1--continued					
Lime, hard	29	949	Shale	6	1,346
Lime and shale streaks	34	983	Lime and shells	14	1,360
Lime	17	1,000	Lime	16	1,376
Shale	10	1,010	Lime and shale	30	1,406
Lime	40	1,050	Lime and shells	4	1,410
Lime and shale	37	1,087	Rock, red	4	1,414
Lime, broken	8	1,095	Sand, fine (water)	21	1,435
Shale, green	6	1,101	Shale, sandy, green	5	1,440
Lime	8	1,109	Shale	5	1,445
Shale, dark	9	1,118	Shale, green	5	1,450
Lime	7	1,125	Rock, red	5	1,455
Lime and broken shale	13	1,138	Sand, fine, brown	23	1,478
Lime and shells	12	1,150	Shale, sandy	22	1,500
Lime, gray	40	1,190	Sand, fine	20	1,520
Lime	34	1,224	Rock, red	3	1,523
Lime and shale	11	1,235	Sand, fine, hard	42	1,565
Lime	5	1,240	Shale, sandy	45	1,610
Shale	3	1,243	Sand, fine, red	75	1,685
Lime	7	1,250	Shale, sandy	20	1,705
Lime and shale	25	1,275	Sand, fine	20	1,725
Lime and sandy shells	25	1,300	Shale, blue	5	1,730
Lime and sand	10	1,310	Sand, fine, brown	60	1,790
Lime, sandy	22	1,332	Shale, sandy	5	1,795
Lime	8	1,340	Sand, coarse, white	245	2,040

(Continued on next page)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well L-1--continued					
Shale-------------------	10	2,050	Schist, green------------	5	2,065
Shale, sandy, dark------	10	2,060	Granite------------------	17	2,082

Well L-48

Owner: Tommy Brook. Driller: Douglas Clary.

Lime, decomposed, and caliche---------------	25	25	Lime, pink---------------	15	450
Lime, pink--------------	40	65	Lime, brown, very hard---	20	470
Lime, white-------------	5	70	Lime, white, hard--------	20	490
Lime, pink--------------	50	120	Lime, gray-white---------	10	500
Lime, yellow------------	40	160	Lime, blue---------------	55	555
Lime, white-------------	10	170	Flint, yellow------------	5	560
Lime, pink--------------	10	180	Lime, blue---------------	40	600
Lime, white-------------	20	200	Lime, yellow-------------	20	620
Lime, yellow------------	10	210	Lime, blue---------------	50	670
Lime, white-------------	5	215	Lime, green and yellow---	5	675
Shale, red--------------	2	217	Lime, blue---------------	25	700
Lime, pink--------------	3	220	Chalk, little lime-------	20	720
Lime, white-------------	20	240	Lime, blue---------------	25	745
Lime, pink--------------	10	250	Lime, gray, hard---------	5	750
Lime, white-------------	10	260	Lime, white, very fine---	50	800
Lime, pink--------------	5	265	Lime, white (water)------	5	805
Lime, white-------------	50	315	Sand, white (water)------	15	820
Lime, purple (water)----	10	325	Lime, sandy, white, hard, with iron pyrite-------	24	844
Lime, white-------------	110	435	Lime, blue---------------	2	846

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Well L-48--continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Lime, brown-------------	4	850	Sand, blue----------------	4	1,064
Lime, sandy-------------	10	860	Lime, brown---------------	13	1,077
Lime, blue-gray---------	40	900	Sand, white---------------	23	1,100
Lime, blue (water)------	15	915	Rock, red-----------------	10	1,110
Lime, sandy-------------	5	920	Sand, blue----------------	3	1,113
Lime, sandy, blue-------	45	965	Sand, brown---------------	12	1,125
Lime, sandy, blue-brown-	35	1,000	Sand, blue, very hard, and little lime---------	25	1,150
Glauconite--------------	5	1,005	Sandrock, brown-----------	15	1,165
Lime, gray, hard--------	5	1,010	Sand, brown---------------	35	1,200
Lime, gray--------------	8	1,018	Shale, blue, hard---------	30	1,230
Sand, coarse, brown-----	27	1,045	Sand, brown---------------	15	1,245
Sandrock, brown---------	15	1,060			

Well L-50

Owner: Tommy Brook. Driller: H. C. Harris.

Topsoil-----------------	5	5	Sandstone, white----------	3	301
Limestone, gray---------	125	130	Sandstone, red------------	5	306
Limestone, white--------	10	140	Shale, dark green---------	1	307
Limestone, blue---------	153	293	Sandstone, brown and red--	37	344
Sandstone, brown--------	5	298			

Well M-29

Owner: C. L. Jordan. Driller: Fred Wilson.

Sand, soil, and gravel--	16	16	Sandrock, brown-----------	15	135
Sandrock, brown---------	34	50	Sandrock, brown with breaks of water-bearing sand---	31	166
Sandrock, blood red-----	70	120			

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

Well R-28

Owner: Arthur Hurley. Driller: Milton Vater.

Dirt, red----------------	20	20	Clay and limestone--------	10	170
Sand (water)------------	80	100	Clay, red, and sand------	10	180
Sand and red clay--------	12	112	Sandstone, shaly, red----	20	200
Sand (water)------------	22	134	Sand (water)-------------	120	320
Sand and little clay----	26	160	Granite, red-------------	50	370

Well R-42

Owner: Tom Keyzar. Driller: Fred Wilson.

Sand, brown and yellow--	18	18	Lime, brownish-gray------	20	160
Sandrock, brown---------	30	48	Lime, shelly, brown------	25	185
Sandrock, yellow--------	17	65	Lime, shelly, gray-------	15	200
Lime, sandy, gray-------	75	140			

Well R-49

Owner: San Saba Sand Co. Driller: Douglas Clary.

Sand, red with streaks of clay---------------	20	20	Shale, blue, and sand containing feldspar----	5	105
Sand (water)------------	80	100			

Table 5.--Water levels in wells in McCulloch County, Texas

Date	Water level	Date	Water level	Date	Water level

Well C-8

Owner: M. D. Rice

Date	Water level	Date	Water level	Date	Water level
Jan. 16, 1958	116.45	June 19, 1958	116.15	Nov. 14, 1958	116.81
Mar. 3	115.64	Sept. 4	122.27	Dec. 19	117.34
19	116.55	18	116.60		
May 20	115.52	Oct. 16	116.14		

Well H-2

Owner: O. G. Scoggins

Date	Water level	Date	Water level	Date	Water level
Jan. 6, 1958	62.75	June 23, 1958	62.48	Oct. 16, 1958	62.55
Feb. 3	62.54	July 17	62.85	Nov. 14	62.25
Mar. 19	62.63	Aug. 19	62.68	Dec. 19	62.28
Apr. 23	62.12	Sept. 18	62.65		

Well J-1

Owner: G. R. White

Date	Water level	Date	Water level	Date	Water level
Feb. 5, 1958	297.65	May 20, 1958	296.85	Oct. 15, 1958	297.12
Mar. 3	297.62	July 18	296.90	Nov. 14	296.69
19	297.74	Aug. 15	297.02	Dec. 19	296.70
Apr. 22	297.12	Sept. 18	297.26		

Well J-4

Owner: G. R. White

Date	Water level	Date	Water level	Date	Water level
Feb. 5, 1958	335.80	May 20, 1958	335.13	Sept. 18, 1958	335.24
Mar. 3	335.82	June 18	335.20	Oct. 15	335.57
19	335.75	July 18	335.45	Nov. 14	334.77
Apr. 22	334.90	Aug. 20	335.33	Dec. 19	335.03

Table 5.--Water levels in wells in McCulloch County--Continued

Date	Water level	Date	Water level	Date	Water level
		Well K-1			
Owner: City of Brady well 4					
June 30, 1955	170	Aug. 20, 1958	201.90	Oct. 15, 1958	158.58
May 19, 1958	144.42	27	182.81	Nov. 13	154.98
June 19	176.05	Sept.17	163.65	Dec. 20	154.68
		Well K-14			
Owner: W. H. Winters					
Jan. 15, 1958	264.12	May 19, 1958	260.47	Oct. 15, 1958	266.60
Feb. 20	262.70	June 19	262.58	Nov. 14	264.47
Mar. 17	261.50	July 18	269.70	Dec. 19	262.81
Apr. 23	261.19	Aug. 20	268.92		
		Well L-1			
Owner: City of Brady well 3					
Nov. 1943	117	Apr. 22, 1958	144.80	Sept.18, 1958	161.80
Dec. 17, 1957	150.55	May 19	142.92	Oct. 20	159.77
Jan. 16, 1958	148.90	June 19	171.70	Nov. 14	153.58
Feb. 20	146.40	Aug. 20	197.85	Dec. 20	152.18
Mar. 18	142.67	27	176.58		
		Well L-42			
Owner: Herman Attaway					
Nov. 20, 1957	39.88	Mar. 17, 1958	39.00	June 18, 1958	39.61
Jan. 9, 1958	39.40	Apr. 23	38.82	July 17	41.74
Feb. 20	39.37	May 19	40.50	Aug. 25	41.16

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Date	Water level	Date	Water level	Date	Water level
		Well L-42--continued			
Sept.17, 1958	40.41	Nov. 13, 1958	39.80	Dec. 19, 1958	39.80
Oct. 15	40.05				

Well M-36

Owner: Leonard Willis

1954	25	Apr. 23, 1958	12.37	Sept.17, 1958	13.82
Dec. 5, 1957	13.59	May 19	12.65	Oct. 15	13.58
Jan. 9, 1958	13.40	June 18	13.07	Nov. 13	13.45
Feb. 26	12.61	July 17	13.65	Dec. 16	13.65
Mar. 17	12.80	Aug. 19	14.18		

Well M-55

Owner: Ed Spiller

Nov. 26, 1957	51.99	May 19, 1958	52.13	Oct. 15, 1958	52.75
Jan. 8, 1958	52.25	June 19	52.42	Nov. 13	52.58
Feb. 20	52.34	July 17	53.04	Dec. 19	52.29
Mar. 17	52.08	Aug. 18	53.18		
Apr. 23	51.80	Sept.17	53.06		

Well R-13

Owner: Edith Cohen

Nov. 8, 1957	44.93	May 19, 1958	43.10	Oct. 15, 1958	43.36
Jan. 8, 1958	44.23	June 18	43.29	Nov. 13	43.23
Feb. 20	43.87	July 17	44.00	Dec. 15	43.20
Mar. 17	43.40	Aug. 18	44.61		
Apr. 22	43.10	Sept.17	43.77		

Well R-27

Owner: Edith Cohen

Date	Water level	Date	Water level	Date	Water level
Nov. 8, 1957	63.46	May 19, 1958	61.08	Sept.17, 1958	61.99
Jan. 8, 1958	62.34	June 18	62.66	Oct. 15	61.48
Mar. 17	61.40	July 17	66.23	Nov. 13	61.23
Apr. 22	61.28	Aug. 18	66.20	Dec. 15	61.17

Well R-28

Owner: Arthur Hurley

Date	Water level	Date	Water level	Date	Water level
Nov. 13, 1957	55	Apr. 22, 1958	52.78	Sept.17, 1958	54.70
Jan. 8, 1958	54.20	May 19	52.89	Oct. 15	53.87
Feb. 20	53.66	June 18	54.10	Nov. 13	53.41
Mar. 17	53.02	Aug. 25	56.22	Dec. 15	53.30

Well R-32

Owner: Fred Dobbs

Date	Water level	Date	Water level	Date	Water level
Nov. 13, 1957	85.69	May 19, 1958	85.94	Oct. 15, 1958	86.43
Jan. 8, 1958	86.07	June 18	85.95	Nov. 17	86.32
Feb. 20	86.30	July 17	86.18	Dec. 15	86.77
Mar. 17	85.66	Aug. 18	86.26		
Apr. 22	85.55	Sept.17	86.42		

Well R-36

Owner: G. F. Clevenger

Date	Water level	Date	Water level	Date	Water level
Oct. 29, 1957	33.60	Feb. 20, 1958	33.98	Apr. 22, 1958	33.30
Jan. 8, 1958	33.95	Mar. 17	33.73	May 19	33.60

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Date	Water level	Date	Water level	Date	Water level
Well R-36--continued					
June 18, 1958	33.48	Sept.17, 1958	33.47	Nov. 13, 1958	33.02
July 17	33.43	Oct. 15	33.32	Dec. 19	33.05
Aug. 18	33.32				

Well R-37

Owner: Tom Baze

Oct. 29, 1957	45.76	May 19, 1958	45.95	Sept.17, 1958	46.39
Jan. 8, 1958	46.00	June 18	45.88	Oct. 15	46.22
Mar. 17	45.87	July 22	45.92	Nov. 13	46.10
Apr. 22	45.56	Aug. 18	46.16	Dec. 19	45.90

Well R-39

Owner: Mrs. B. Passmore

Oct. 29, 1957	49.77	May 19, 1958	47.71	Oct. 15, 1958	48.60
Jan. 8, 1958	48.62	June 18	47.72	Nov. 13	48.06
Feb. 20	48.28	July 23	50.41	Dec. 19	47.63
Mar. 17	47.96	Aug. 25	50.42		
Apr. 22	47.40	Sept.17	49.40		

Well R-46

Owner: A. T. Owens

Nov. 15, 1957	95.37	May 19, 1958	91.75	Sept.17, 1958	94.30
Jan. 15, 1958	94.90	June 19	92.39	Oct. 15	93.71
Mar. 17	92.11	July 22	99.95	Nov. 13	93.33
Apr. 23	91.79	Aug. 25	96.05	Dec. 19	93.08

Date	Water level	Date	Water level	Date	Water level

Well R-55

Owner: J. W. Behrens

Date	Water level	Date	Water level	Date	Water level
Nov. 28, 1957	30.39	Apr. 22, 1958	32.78	Sept.17, 1958	34.40
Jan. 8, 1958	33.70	May 19	33.25	Oct. 15	33.75
Feb. 20	34.88	June 18	33.70	Nov. 13	33.35
Mar. 17	33.37	Aug. 25	34.90	Dec. 19	33.31

Well S-4

Owner: -- Holloway

Date	Water level	Date	Water level	Date	Water level
Nov. 20, 1957	25.50	May 19, 1958	22.34	Oct. 15, 1958	23.01
Jan. 8, 1958	26.00	June 18	21.99	Nov. 13	23.08
Feb. 20	24.44	July 17	22.35	Dec. 19	23.25
Mar. 17	23.50	Aug. 18	22.60		
Apr. 22	22.58	Sept.17	22.81		

Well S-7

Owner: W. B. Thompson

Date	Water level	Date	Water level	Date	Water level
Dec. 4, 1957	24.29	May 19, 1958	23.69	Oct. 15, 1958	24.05
Jan. 8, 1958	24.11	June 18	23.95	Nov. 13	23.90
Feb. 20	24.02	July 17	24.35	Dec. 19	23.75
Mar. 17	23.84	Aug. 18	24.76		
Apr. 23	23.70	Sept.17	24.10		

Well S-16

Owner: Bud Baxter

Date	Water level	Date	Water level	Date	Water level
Oct. 30, 1957	65.59	Feb. 20, 1958	53.73	Apr. 23, 1958	54.20
Jan. 8, 1958	54.58	Mar. 17	53.06	May 19	51.80

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Table 5.--Water levels in wells in McCulloch County--Continued

Date	Water level	Date	Water level	Date	Water level
		Well S-16--continued			
June 18, 1958	51.76	Sept.17, 1958	55.37	Nov. 13	52.86
July 17	53.39	Oct. 15	53.85	Dec. 19	52.02
Aug. 25	58.53				

Table 6.--Analyses of water from wells and springs in McCulloch County, Texas

(Results are in parts per million, except specific conductance, pH, and percent sodium.)

Water-bearing unit: H, Hickory sandstone member; C, Cambrian rocks younger than Hickory sandstone member; E, Ellenburger group; P, younger Paleozoic rocks

Well	Owner	Depth of well (ft.)	Water-bearing unit	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Sodium adsorption ratio (SAR)	Specific conductance (micromhos at 25°C)	pH
B-5	Mrs. Ollie M. Lohn	2,450	E	Oct. 28, 1956	-	-	-	-	229	305	-	295	-	-	-	145	77	8.3	1,480	8.2
C-1	W. N. White	1,600	E	July 26, 1951	15	-	28	17	278	346	64	280	-	0.2	871	140	10	10	1,600	8.2
C-2	do	1,480	E	do	15	-	30	13	372	394	48	400	-	.0	1,070	128	86	14	1,930	8.2
C-3	do	1,600	E	Aug. 14, 1951	15	0.18	24	12	333	407	15	342	-	.0	1,010	110	89	14	1,760	7.5
C-4	do	1,600	E	July 26, 1951	15	-	17	8.7	388	415	14	400	-	3.0	1,050	78	91	19	1,960	8.4
C-6	D. S. Pumphrey	2,115	E	do	15	-	14	7.1	384	409	19	385	-	.5	1,030	64	93	21	1,930	8.2
C-7	W. N. White	1,380	E	do	17	-	11	9.8	400	459	50	360	-	.0	1,070	68	93	21	1,950	8.6
C-8	M. D. Rice	2,580	H	Nov. 25, 1958	14	-	12	6.5	263	329	54	215	-	.5	738	56	91	15	1,300	8.2
D-3	City of Mercury	436	P	Jan. 17, 1946	7	.53	8.4	10	310 18	570	1.6	204	0.6	.2	848	62	89	17	1,490	7.9
*E-5	City of Melvin	2,800	C	Mar. 1952	11	.68	63	24	71	323	53	64	.6	-	426	256	-	1.9	-	7.7
G-4	J. R. Boyd & M. A. Gainer	300	P	Jan. 18, 1946	5.5	.64	28	17	201 15	318	226	68	1.2	1.2	720	140	73	7.4	1,160	8.2
J-4	G. R. White	2,008	H	Nov. 22, 1958	14	-	49	41	52	362	62	31	-	.0	427	291	28	1.3	736	7.3
K-2	City of Brady well 1	2,114	H	June 5, 1943	5.2	.20	52	45	22 13	364	51	18	.6	.0	397	315	12	.5	-	7.5
K-2	do	2,114	H	Jan. 17, 1946	12	.32	59	46	12 8.4	366	41	20	.8	.0	389	336	7	.3	661	7.8
K-2	do	2,114	H	June 20, 1958	15	-	54	40	36	367	49	16	0.8	0.2	382	299	21	0.9	671	7.3
*K-3	City of Brady well 3	2,112	H	Feb. 1941	17	0.29	53	44	40	390	47	21	-	-	402	313	-	-	-	7.9

*Analyzed by Texas State Health Department.

Table 6.--Analyses of water from wells and springs in McCulloch County--Continued

Well	Owner	Depth of well (ft.)	Water-bearing unit	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Sodium adsorption ratio (SAR)	Specific conductance (micromhos at 25°C)	pH
*K-3	City of Brady well 3	2,112	H	Feb. 1943	14	.12	54	46	26	363	51	21	.6	-	376	324	-	-	-	7.5
K-3	do	2,112	H	June 6, 1943	9.0	.22	53	37	50	376	47	24	.6	.0	399	284	28	1.3	-	8.0
K-14	W. H. Winters	1,500	H	Nov. 25, 1958	9.8	-	75	37	230	312	320	175	-	4.0	1,000	339	60	5.4	1,620	7.5
K-20	T. Gray	625	E	June 19, 1958	16	-	100	42	27	424	43	47	.5	26	556	422	12	.6	899	7.1
K-21	do	150	E	do	15	-	126	33	6.8 1.0	488	15	16	.4	30	509	450	3	.1	828	7.5
K-22	H. J. Davies	1,113	C	do	17	-	83	38	37	372	46	61	.8	2.5	465	364	18	.8	816	7.3
L-1	City of Brady well 3	2,082	H	Nov. 1943	12	.32	52	43	26	366	41	13	1.4	.0	376	307	16	.7	-	8.0
L-1	do	2,082	H	Feb. 5, 1959	14	-	53	39	20 6.4	354	40	12	.9	.0	360	292	13	.5	637	7.6
L-31	T. Gray	1,003	C	June 20, 1958	17	-	62	40	20	355	25	30	.8	1.5	366	319	12	.5	655	7.2
L-49	Tommy Brook	850	H	June 22, 1943	13	1.8	61	40	16	360	36	11	.6	1.5	368	316	10	.4	-	8.2
M-8	C. T. White	700	C	Mar. 31, 1958	14	-	168	28	33	513	58	69	.2	33	705	534	12	.6	1,120	7.5
M-9	do	592	C	do	10	-	30	13	104	206	93	59	.6	4.4	430	128	64	4.0	726	8.0
M-10	do	363	E	do	14	-	132	52	11	375	20	82	.2	153	648	544	4	.2	1,120	8.0
M-13	do	900	H	do	10	-	35	17	100	235	88	60	1.0	4.3	440	158	58	3.5	761	8.0
M-45	Evans Adkins	400	H	Apr. 1, 1958	15	-	55	45	33 7.6	375	50	29	1.0	0.0	429	322	18	0.8	720	7.7
M-55	Ed Spiller	165	H	Nov. 25, 1958	24	-	44	6.8	36	131	18	59	.8	4.8	270	138	36	1.3	451	6.6

*Analyzed by Texas State Health Department.

Table 6.--Analyses of water from wells and springs in McCulloch County--Continued

Well	Owner	Depth of well (ft.)	Water-bearing unit	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)		Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Sodium adsorption ratio (SAR)	Specific conductance (micromhos at 25°C)	pH
*R-3	C. E. Myrick	842	H	June 20, 1958	14	-	61	40	9.3	3.8	361	24	16	.8	.0	347	316	6	.2	615	7.2
R-9	Tommy Brook	430	H	June 22, 1943	-	-	64	40	0.9		350	18	14	-	1.0	325	324	1	.0	-	-
*R-23	H. Schmidt	800	H	July 22, 1958	15	-	88	16	14	1.9	322	23	21	.3	2.5	344	286	10	.4	596	7.1
*R-28	Arthur Hurley	370	H	July 17, 1958	18	-	86	9.9	16	1.9	290	11	27	.4	7.0	322	255	12	.4	554	7.1
R-46	A. T. Owens	137	H	Nov. 25, 1958	16	-	94	16	11		340	9.8	25	-	2.0	344	300	8	.3	604	7.1
*R-54	J. W. Behrens	125	H	July 10, 1958	28	-	51	9.4	34	3.3	160	27	46	1.0	27	317	166	30	1.1	512	6.6
*R-62	C. B. Clevenger	120	H	do	32	-	32	6.1	27	2.4	102	15	38	.9	15	220	105	35	1.1	359	6.5
*S-2	J. F. Dean	118	H	July 22, 1958	23	-	26	5.9	31	2.1	101	16	27	.7	21	206	89	42	1.4	333	6.4

* Boron (B) Well R-3, 0.08; well R-23, 0.15; well R-28, 0.15; well R-54, 0.15; well R-62, 0.10; well S-2, 0.10.