TEXAS
WATER
DEVELOPMENT
BOARD

Report 109

GROUND-WATER RESOURCES OF BASTROP COUNTY, TEXAS

MARCH 1970

SECOND PRINTING
APRIL 1972

TEXAS WATER DEVELOPMENT BOARD

REPORT 109

GROUND-WATER RESOURCES OF BASTROP COUNTY, TEXAS

By

C. R. Follett
United States Geological Survey

Prepared by the U.S. Geological Survey
in cooperation with the
Texas Water Development Board

March 1970

Second Printing
April 1972

TEXAS WATER DEVELOPMENT BOARD

Published and distributed
by the
Texas Water Development Board
Post Office Box 12386
Austin, Texas 78711

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd.)

TABLES

FIGURES

TABLE OF CONTENTS (Cont'd.)

GROUND-WATER RESOURCES OF BASTROP COUNTY, TEXAS

ABSTRACT

The principal formations in Bastrop County that yield or are capable of yielding moderate or large quantities of water to wells are, in order of decreasing yields, the Wilcox Group, Carrizo Sand, Queen City Sand, and Sparta Sand. The Reklaw, Cook Mountain, and Yegua Formations and the alluvium along the Colorado River are less prolific. The Carrizo and Sparta are almost all sand; the Wilcox and the Queen City are about 40 percent sand and 60 percent sandy clay, clay, or shale. The Carrizo Sand and the underlying Wilcox Group are connected hydrologically and function as a single aquifer.

During the 5-year period from 1962 through 1966, 35 percent of the ground water used was for municipal supply, 35 percent for irrigation, 4 percent for industrial supply, and 26 percent for domestic and livestock supply. The use of ground water is gradually increasing, but the total of 3.7 mgd (million gallons per day) or 4,100 acre-feet per year used in 1966 is small compared to the quantity available.

About 100 million acre-feet of fresh to slightly saline water is in transient storage in the principal aquifers, but only a fraction of this water is economically recoverable by known methods at present costs. About 85 percent of this water is in storage in the Carrizo Sand and Wilcox Group. The Queen City Sand contains about 14 million acre-feet and the Sparta Sand about 1 million acre-feet. The quantity of fresh to slightly saline water perennially available from the Carrizo-Wilcox aquifer is about 23,000 acre-feet per year (21 mgd).

The yields of wells in Bastrop County range from a few gallons a minute to about 1,800 gpm (gallons per minute). Yields of at least 2,000 gpm are possible from properly constructed and screened wells in the Carrizo-Wilcox aquifer. The Queen City Sand probably would yield 300 gpm or more, and the Sparta Sand would yield 200 gpm and possibly as much as 400 gpm to properly constructed wells in areas where sand thickness is large.

The Wilcox Group, Carrizo Sand, Queen City Sand, and Sparta Sand contain large quantities of water that is suitable for public supply, industrial use, and irrigation. The Reklaw Formation, Weches Greensand, Cook Mountain Formation, Yegua Formation, and the alluvium contain water of poorer quality.

The dissolved-solids content of selected water samples ranged from 67 to 4,020 mg/l (milligrams per liter); 49 percent of the samples contained less than 500 mg/l. Excessive iron is one of the county's chief water-quality problems; as 74 percent of the samples contained more than 0.3 mg/l iron. The water sampled was mostly moderately to very hard; about 80 percent of the samples exceeded 60 mg/l hardness.

INTRODUCTION

Purpose and Scope of the Investigation

The purpose of the investigation, which was made by the U.S. Geological Survey in cooperation with the Texas Water Development Board, was to determine the ground-water resources of Bastrop County and to make the results of the study available to the public. This report is based on the records of 600 wells, 7 springs, numerous electrical logs of wells, 90 drillers' logs, 240 chemical analyses of water samples, climatological data, and the results of pumping tests of 11 wells.

During the course of the investigation, an inventory was made of all municipal, industrial, and irrigation wells, and of enough livestock wells, domestic wells, springs, and oil tests to provide basic ground-water data throughout the county (Table 10 and Figure 23). Electrical logs of water wells and oil tests and drillers' logs of water wells (Table 11) were used in conjunction with other data to determine: (1) the thickness of sands containing fresh to slightly saline water; (2) the approximate altitude of the base of the fresh to slightly saline water; and (3) the approximate altitude of the top of the Carrizo Sand and Wilcox Group. An inventory was made of the municipal, industrial, and irrigation pumpage, and water samples were collected to provide representative data on the quality of the available water.

Location and Extent of the Area

Bastrop County is in the west Gulf Coastal Plain of south-central Texas (Figure 1). It is bounded on the northeast by Lee and Williamson Counties, on the northwest by Travis County, on the southwest by Caldwell County, and on the southeast by Fayette County. Bastrop, the county seat, is about 30 miles southeast of Austin on the Colorado River at the junction of State Highways 21, 71, and 95. The county has an area of 885 square miles.

Previous Investigations

Previous investigations relating to the ground-water resources of Bastrop County have resulted in a well-inventory report, a report of water levels in observation wells, and several reports covering large areas that included all or parts of the county. The well-inventory report (Austin, 1954) contains records of 515 wells, drillers' logs of 25 wells, records of water levels in 14 wells, and 133 chemical analyses of water samples. Some of these data are included in this report. Table 1 lists the well numbers used in this report and the corresponding numbers used in the report by Austin (1954). The public water supplies of Bastrop, Elgin, and Smithville were described briefly by Sundstrom, Hastings, and Broadhurst (1948, p. 27-28). Swartz (1957, p. 3-10) tabulated records of water levels in observation wells in Bastrop and Caldwell Counties.

Economic Development

The first permanent settlement by English-speaking settlers in Bastrop County was established in 1829 under the leadership of Stephen F. Austin. By 1850 the U.S. Census Bureau listed a county population of 3,099. The population increased to a recorded maximum of 26,649 in 1920, and has decreased since then to 16,925 in 1960. Populations of the three incorporated towns in Bastrop County in 1960 were

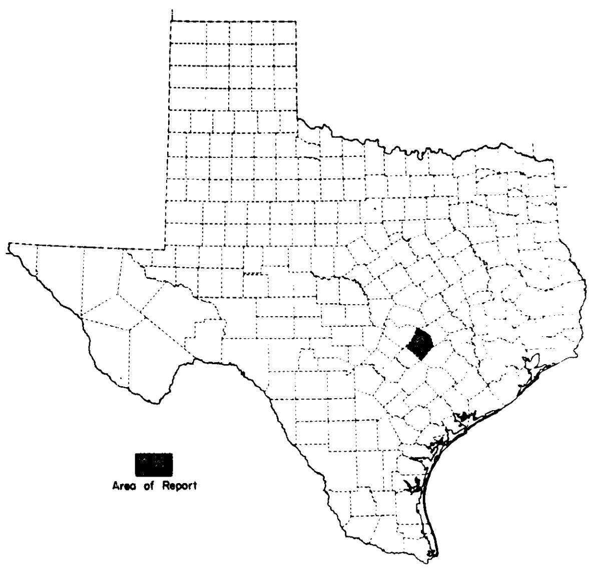


Figure 1.—Location of Bastrop County

Table 1.—Well Numbers Used in This Report and Corresponding Numbers Used by Austin (1954)

NEW NUMBER	OLD NUMBER	NEW NUMBER	OLD NUMBER	NEW NUMBER	OLD NUMBER
AT-58-38-701	B-1	AT-58-52-801	D-33	AT-58-55-401	C-60
AT-58-38-802	B-2	AT-58-52-902	D-2	AT-58-55-402	C-59
AT-58-45-301	B-10	AT-58-53-303	B-39	AT-58-55-501	C-63
AT-58-45-802	B-34	AT-58-53-401	A-1	AT-58-55-602	C-54
AT-58-45-905	B-33	AT-58-53-503	A-15	AT-58-55-604	C-64
AT-58-46-101	B-27	AT-58-53-504	A-12	AT-58-55-605	C-65
AT-58-46-102	B-9	AT-58-53-505	A-11	AT-58-55-701	F-38
AT-58-46-103	B-12	AT-58-53-507	A-13	AT-58-55-705	F-40
AT-58-46-201	B-6	AT-58-53-601	B-58	AT-58-55-706	F-2
AT-58-46-202	B-18	AT-58-53-602	B-59	AT-58-55-801	F-6
AT-58-46-204	B-15	AT-58-53-702	D-4	AT-58-55-901	F-30
AT-58-46-207	B-5	AT-58-53-703	D-8	AT-58-55-903	F-8
AT-58-46-301	B-3	AT-58-53-905	E-1	AT-58-55-904	F-29
AT-58-46-401	B-28	AT-58-53-906	E-2	AT-58-56-101	C-46
AT-58-46-502	B-20	AT-58-53-907	E-3	AT-58-56-103	C-45
AT-58-46-503	B-26	AT-58-53-909	E-4	AT-58-56-108	C-50
AT-58-46-504	B-21	AT-58-54-103	B-40	AT-58-56-401	C-66
AT-58-46-510	B-19	AT-58-54-203	B-42	AT-58-56-501	C-71
AT-58-46-601	B-22	AT-58-54-204	B-41	AT-58-56-502	C-48
AT-58-46-602	B-23	AT-58-54-501	B-49	AT-58-56-504	C-70
AT-58-46-606	B-24	AT-58-54-502	B-48	AT-58-56-701	F-28
AT-58-46-703	B-32	AT-58-54-503	B-47	AT-58-56-702	F-27
AT-58-46-705	B-35	AT-58-54-504	B-46	AT-58-56-704	F-10
AT-58-47-102	C-2	AT-58-54-505	B-45	AT-58-56-705	F-11
AT-58-47-401	C-13	AT-58-54-506	B-50	AT-58-56-802	F-17
AT-58-47-402	C-7	AT-58-54-507	B-51	AT-58-59-601	D-36
AT-58-47-502	C-10	AT-58-54-508	B-44	AT-58-60-101	D-34
AT-58-47-503	C-12	AT-58-54-701	E-5	AT-58-60-103	D-37
AT-58-47-707	C-18	AT-58-54-702	E-6	AT-58-60-104	D-38
AT-58-47-802	C-36	AT-58-54-703	E-7	AT-58-60-301	D-28
AT-58-47-902	C-35	AT-58-54-704	E-25	AT-58-60-302	D-32
AT-58-47-906	C-25	AT-58-54-901	E-11	AT-58-60-307	D-30
AT-58-48-705	C-27	AT-58-55-103	C-38	AT-58-60-308	D-31
AT-58-48-706	C-28	AT-58-55-105	C-39	AT-58-60-602	D-40
AT-58-52-602	A-4	AT-58-55-201	C-37	AT-58-60-605	D-29
AT-58-52-603	A-2	AT-58-55-202	C-40	AT-58-60-701	D-60
AT-58-52-605	A-8	AT-58-55-304	C-44	AT-58-60-702	D-59
AT-58-52-606	A-3	AT-58-55-305	C-32	AT-58-60-708	D-61

Table 1.—Well Numbers Used in This Report and Corresponding Numbers Used by Austin (1954)—Continued

NEW NUMBER	OLD NUMBER	NEW NUMBER	OLD NUMBER	NEW NUMBER	OLD NUMBER
AT-58-60-803	D-58	AT-58-62-504	E-57 7	AT-58-63-908	F-96
AT-58-61-104	D-22	AT-58-62-506	E-41	AT-58-63-909	F-95
AT-58-61-106	D-19	AT-58-62-601	E-44	AT-58-63-910	F-94
AT-58-61-107	D-16	AT-58-62-602	E-45	AT-58-63-913	F-97
AT-58-61-201	D-13	AT-58-62-701	E-61	AT-58-63-914	F-54
AT-58-61-202	D-10	AT-58-62-703	E-65	AT-58-64-101	F-64
AT-58-61-203	D-14	AT-58-62-704	E-67	AT-58-64-201	F-66
AT-58-61-204	D-15	AT-58-62-801	E-54	AT-58-64-202	F-23
AT-58-61-303	E-33	AT-58-62-802	E-55	AT-58-64-203	F-21
AT-58-61-304	E-31	AT-58-62-901	E-46	AT-58-64-204	F-20
AT-58-61-402	D-41	AT-58-62-902	E-47	AT-58-64-205	F-65
AT-58-61-404	D-42	AT-58-62-903	E-52	AT-58-64-401	F-61
AT-58-61-501	D-45	AT-58-63-101	F-43	AT-58-64-402	F-56
AT-58-61-503	E-34	AT-58-63-103	F-36	AT-58-64-403	F-57
AT-58-61-505	D-46	AT-58-63-105	F-37	AT-58-64-404	F-62
AT-58-61-602	E-60	AT-58-63-202	F-33	AT-58-64-405	F-74
AT-58-61-603	E-36	AT-58-63-203	F-35	AT-58-64-501	F-75
AT-58-61-702	D-53	AT-58-63-301	F-31	AT-58-64-502	F-76
AT-58-61-703	D-54	AT-58-63-302	F-32	AT-58-64-503	F-77
AT-58-61-704	D-55	AT-58-63-403	F-109	AT-58-64-504	F-72
AT-58-61-801	D-50	AT-58-63-501	F-47	AT-58-64-505	F-69
AT-58-61-805	D-49	AT-58-63-602	F-52	AT-58-64-506	F-63
AT-58-61-901	E-70	AT-58-63-603	F-58	AT-58-64-507	F-68
AT-58-61-902	E-63	AT-58-63-604	F-55	AT-58-64-701	F-85
AT-58-61-903	E-68	AT-58-63-605	F-59	AT-58-64-702	F-86
AT-58-61-905	E-62	AT-58-63-701	F-107	AT-58-64-703	F-88
AT-58-62-102	E-26	AT-58-63-704	F-108	AT-58-64-708	F-91
AT-58-62-104	E-29	AT-58-63-706	F-110	AT-58-64-709	F-92
AT-58-62-203	E-17	AT-58-63-707	F-111	AT-58-64-807	F-80
AT-58-62-204	E-15	AT-58-63-708	F-112	AT-58-64-808	F-84
AT-58-62-205	E-18	AT-58-63-801	F-48	AT-67-05-101	G-1
AT-58-62-206	E-16	AT-58-63-802	F-105	AT-67-05-102	G-17
AT-58-62-207	E-14	AT-58-63-803	F-106	AT-67-05-104	G-5
AT-58-62-401	E-37	AT-58-63-902	F-101	AT-67-05-201	G-16
AT-58-62-402	E-40	AT-58-63-903	F-102	AT-67-05-203	G-7
AT-58-62-406	E-39	AT-58-63-904	F-100	AT-67-05-204	G-6
AT-58-62-407	E-58	AT-58-63-906	F-50	AT-67-05-205	G-8
AT-58-62-503	E-42	AT-58-63-907	F-93	AT-67-05-206	G-9

Table 1.—Well Numbers Used in This Report and Corresponding Numbers Used by Austin (1954)—Continued

NEW NUMBER	OLD NUMBER	NEW NUMBER	OLD NUMBER	NEW NUMBER	OLD NUMBER
AT-67-05-207	G-10	AT-67-06-901	H-37	AT-67-07-705	J-54
AT-67-05-208	G-13	AT-67-06-902	H-28	AT-67-07-706	J-56
AT-67-05-302	H-1	AT-67-06-903	H-36	AT-67-07-707	J-55
AT-67-05-303	H-20	AT-67-06-904	H-39	AT-67-07-708	J-51
AT-67-05-305	H-18	AT-67-07-102	J-1	AT-67-07-709	J-52
AT-67-05-306	H-21	AT-67-07-201	J-4	AT-67-07-710	J-46
AT-67-05-310	G-12	AT-67-07-202	J-7	AT-67-08-108	J-14
AT-67-05-404	G-22	AT-67-07-205	J-6	AT-67-08-109	J-15
AT-67-05-406	G-20	AT-67-07-301	J-9	AT-67-08-110	J-16
AT-67-05-502	G-24	AT-67-07-303	J-8	AT-67-08-111	J-17
AT-67-05-503	G-25	AT-67-07-305	J-21	AT-67-08-113	J-13
AT-67-05-602	H-23	AT-67-07-306	J-11	AT-67-13-302	H-54
AT-67-05-604	H-22	AT-67-07-309	J-19	AT-67-13-305	H-53
AT-67-06-101	H-4	AT-67-07-310	J-12	AT-67-14-101	H-58
AT-67-06-102	H-16	AT-67-07-311	J-10	AT-67-14-201	H-59
AT-67-06-103	H-17	AT-67-07-401	J-42	AT-67-14-301	H-41
AT-67-06-201	H-5	AT-67-07-403	J-39	AT-67-14-302	H-42
AT-67-06-202	H-13	AT-67-07-405	H-10	AT-67-14-408	H-70
AT-67-06-301	H-8	AT-67-07-501	J-35	AT-67-14-409	H-71
AT-67-06-502	H-32	AT-67-07-503	J-32	AT-67-14-501	H-68
AT-67-06-602	H-35	AT-67-07-504	J-31	AT-67-14-503	H-65
AT-67-06-606	H-11	AT-67-07-601	J-22	AT-67-14-504	H-69
AT-67-06-701	H-51	AT-67-07-701	J-50	AT-67-14-506	H-62
AT-67-06-702	H-49	AT-67-07-702	J-49	AT-67-14-802	H-66
AT-67-06-704	H-48	AT-67-07-703	J-45	AT-67-15-101	J-57
AT-67-06-801	H-43	AT-67-07-704	J-53	AT-67-15-102	J-59

Elgin, 3,511; Bastrop, 3,001; and Smithville, 2,933. Unincorporated communities are Butler, Cedar Creek, McDade, Paige, Red Rock, Rockne, Rosanky, Sayersville, and Upton.

Diversified livestock and crop production is the principal source of income in the county. Other important sources of income are brick and other clay products, dairying, a rendering plant, furniture manufacturing, poultry raising and processing, feed and oil mills, lumber from the "Lost Pines"—a small isolated area of pine trees—cedar, and oil production. About 7,870,000 barrels of oil were produced from 1913 to January 1, 1966. The 1965 production was 94,400 barrels. Some tourist attractions, which are sources of income, are the "Lost Pines", Bastrop and Buescher State Parks, and places of historical interest in Bastrop and Smithville. The mining of lignite added to the economy before natural gas and oil became available.

Topography and Drainage

The land surface of Bastrop County ranges from nearly flat to hilly. Altitudes range from 270 feet about 2 miles southeast of Smithville to 687 feet about 3 miles northeast of McDade. This high area, which is called "Yegua Knobs", extends into Lee County and is similar to the so-called "Iron Mountains" in the southeastern part of Caldwell County. Regionally, the surface of the county rises from southeast to northwest.

Most of the county is drained by the Colorado River and its tributaries; a small part of the county adjacent to Lee County is drained by Yegua Creek, a tributary of the Brazos River. Some of the larger tributary streams of the Colorado, which have small springfed flows even during droughts, are Alum, Cedar, Sandy, and Walnut Creeks. A series of dams upstream on the Colorado help to maintain the flow of the river during periods of drought; they also help to prevent or reduce damaging floods, which were common prior to the construction of the major dams, Buchanan and Mansfield, which were completed in 1937 and 1942, respectively.

Climate

Bastrop County has a dry subhumid climate in which the annual potential evaporation exceeds the annual precipitation. Mild winters and hot summers are common. The average growing season is about 268 days.

The annual precipitation at Smithville averaged 36.73 inches for the period 1917-66 and ranged from 17.94 inches in 1956 to 59.38 inches in 1957 (Figure 2). The 50-year average monthly precipitation for the same period ranged from 2.15 inches in August to 4.18 inches in May and averaged 3.06 inches (Figure 3). Actual monthly precipitation ranged from zero or a trace on six occasions to 23.20 inches in June 1940.

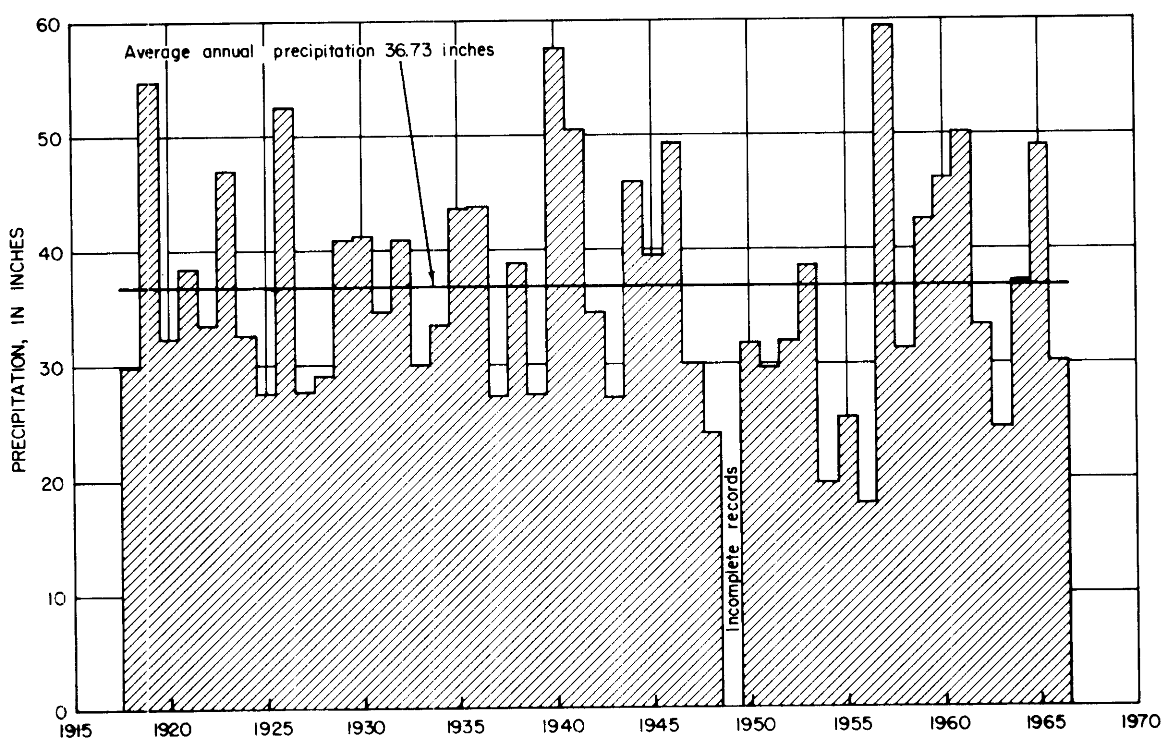


Figure 2.—Annual Precipitation at Smithville, 1917-66

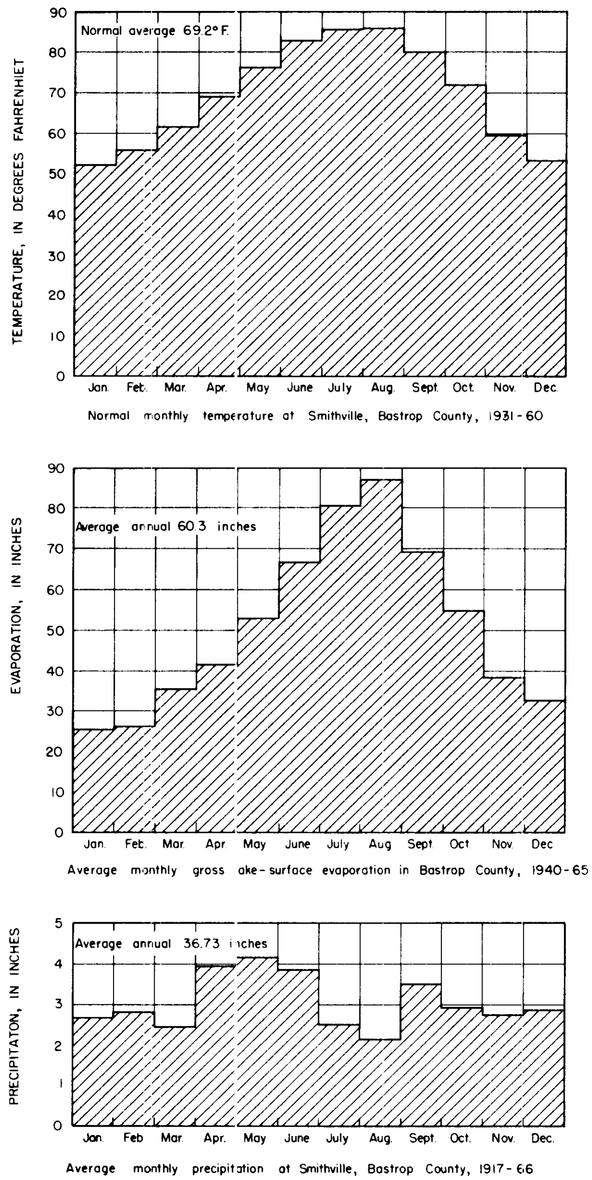


Figure 3.—Average Monthly Precipitation at Smithville, 1917-66; Normal Monthly Temperature at Smithville, 1931-60; and Average Monthly Gross Lake-Surface Evaporation in Bastrop County, 1940-65 (From Kane, 1967, and U.S. Weather Bureau)

The average monthly gross lake-surface evaporation in Bastrop County for the period 1940-65 (Kane, 1967, p. 86 and 97) ranged from 2.5 inches in January to 8.7 inches in August (Figure 3). Average monthly evaporation was 5.0 inches and the average annual was 60.3 inches. Actual monthly evaporation ranged from a minimum of 1.3 inches in February 1948 to a maximum of 11.6 inches in August 1951. Annually, the evaporation ranged from a minimum of 48.0 inches in 1942 to a maximum of 78.0 inches in 1956.

The normal annual temperature (1931-60) at Smithville was about 21°C (69°F), August being the hottest month and January the coldest. As the temperature increases, there is a corresponding increase in gross lake-surface evaporation (Figure 3). Humidity and wind velocity are other factors affecting evaporation.

Well-Numbering System

The well-numbering system used in this report is one adopted by the Texas Water Development Board for use throughout the State. Under this system, each 1-degree quadrangle is given a number consisting of two digits from 01 to 89. These are the first two digits appearing in the well number. Each 1-degree quadrangle is divided into 7½-minute quadrangles which are given 2-digit numbers from 01 to 64. These are the third and fourth digits of the well number. Each 7½-minute quadrangle is subdivided into 2½-minute quadrangles given a single digit number from 1 to 9. This is the fifth digit of the well number. Finally, each well within a 2½-minute quadrangle is given a 2-digit number in the order in which it is inventoried, starting with 01. These are the last two digits of the well number. In addition to the 7-digit well number, a 2-letter prefix is used to identify the county. The prefix for Bastrop County is AT. Thus, well AT-58-55-602 is in Bastrop County (AT), in the 1-degree quadrangle 58 (the numbers of all the wells in Bastrop County begin with either AT-58 or AT-67), in the 7½-minute quadrangle 55, in the 2½-minute quadrangle 6, and was the second well (02) inventoried in the 2½-minute quadrangle (Figure 4).

On the well-location map in this report (Figure 23), the 1-degree quadrangles are numbered in large numerals. The 7½-minute quadrangles are numbered in the northwest corners where possible. The 3-digit number shown with the well symbol contains the number of the 2½-minute quadrangle in which the well is located and the number of the well within that quadrangle.

Acknowledgements

The writer expresses his appreciation for the information and assistance furnished by town officials, farmers, ranchers, personnel of small industries, and personnel of the U.S. Department of Agriculture. Special acknowledgment is made to water-well drillers in the area, particularly Lloyd Ketha and Sterzing Drilling Company.

GEOLOGY AS RELATED TO THE OCCURRENCE OF GROUND WATER

The geologic formations penetrated by water wells in Bastrop County range in age from Quaternary to Cretaceous. These formations, from youngest to oldest are: the alluvium of Quaternary age, which is found along the Colorado River; the Uvalde Gravel of

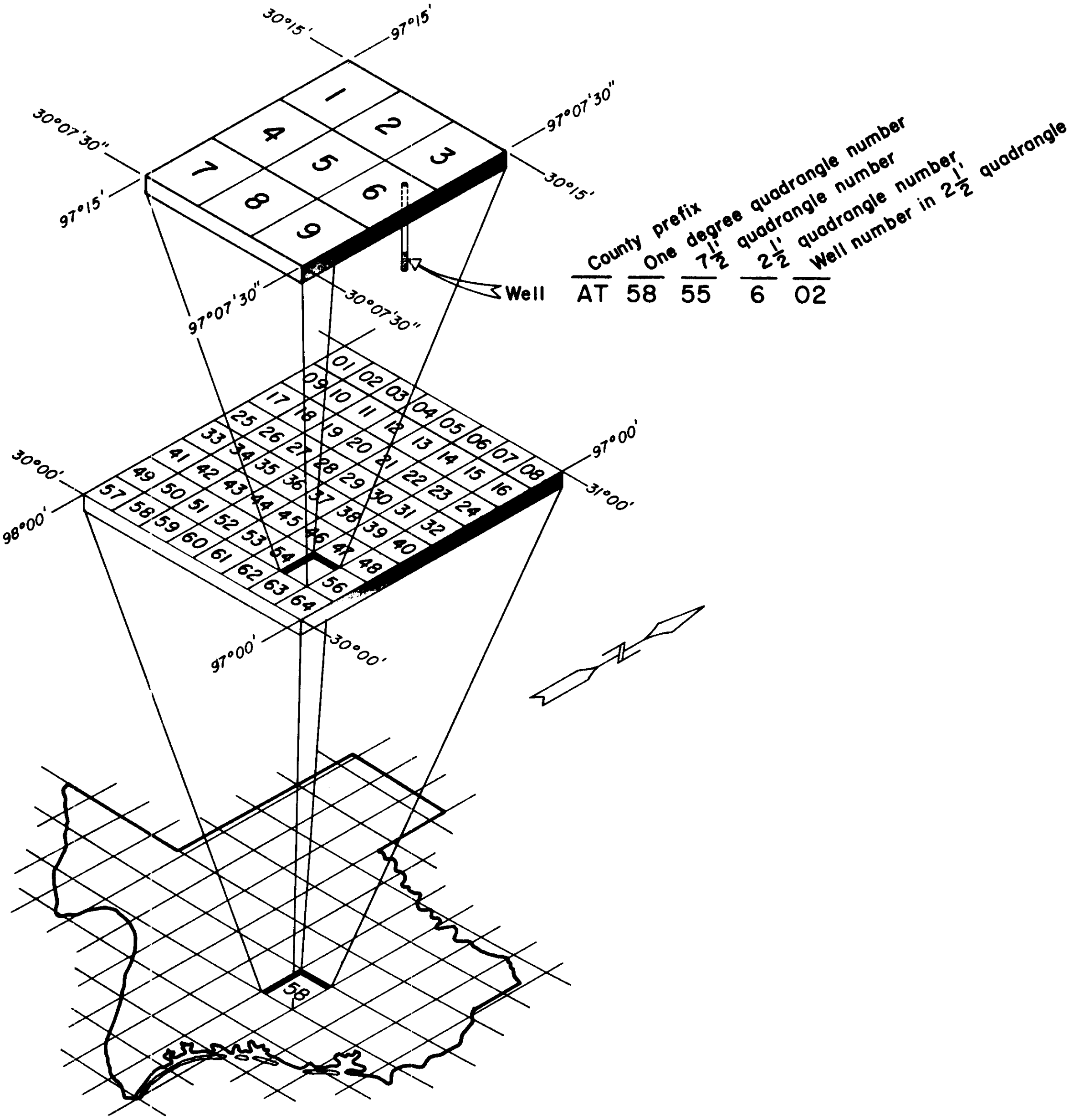


Figure 4

WELL-NUMBERING SYSTEM

Tertiary(?) age; the Yegua Formation, Cook Mountain Formation, Sparta Sand , Weches Greensand, Queen City Sand, Reklaw FormaTion, Carrizo Sand, Wilcox Group, and Midway Group of Tertiary age; and the Navarro Group of Cretaceous age (Table 2). The more important aquifers are the Sparta Sand, Queen City Sand, Carrizo Sand, and Wilcox Group.

The Edwards and associated limestones of Cretaceous age, which occur at a depth of about 2,000 feet along the northwestern county line, would yield water high in sulfate and other minerals in Bastrop County. This aquifer, which occurs at shallower depths to the northwest, contains fresh water in places in Travis County.

Sand and sandstone of the Pearsall Formation of Cretaceous age are found below 3,000 feet in Bastrop County. Little is known concerning the water-bearing character of this unit in the county. However, in Travis County at Manor, about 8 miles northwest of well AT-58-45-803, a 3,001-foot municipal well in the Pearsall yields slightly saline water containing 746 mg/l (milligrams per liter) sulfate and 264 mg/l chloride, which is used by Manor. Also in Travis County a 3,008-foot well in the Pearsall, about 3 miles northwest of well AT-58-60-101, yields highly mineralized water (sulfate 1,750 mg/l, chloride 988 mg/l) which is unsatisfactory for most purposes. Thus, the Pearsall Formation in Bastrop County probably contains water too highly mineralized for most uses.

Except for the alluvium along the Colorado River, the outcrops of the geologic formations in Bastrop County lie in more or less parallel bands that trend roughly northeastward (Figure 5). Part of the oldest exposed unit, the Navarro Group, crops out along the northwestern county line. Unless disturbed by faulting, the formations dip at rates ranging from about 125 to 200 feet per mile toward the Gulf Coast and generally thicken in that direction, causing the dip of each younger formation to be slightly less steep.

The formations are cut by several faults or fault systems that trend northeastward across the county. Most of the faults parallel the strike of the formations. Formations on the south side of the faults are generally upthrown relative to those on the north side. As a result of a fault extending from near Cedar Creek southwestward across the Caldwell County line, the Midway Group was pushed up and exposed on the south side of the fault, leaving a narrow band of the Wilcox Group on the north side separated from the main body of the Wilcox (Figure 5). Other faults are known to exist, especially in the Paige area. The inferred location of one is shown in Figures 6 and 10. The faults in the county probably do not significantly affect the occurrence of ground water except in a few small areas.

Figures 24, 25, and 26, which are geologic sections constructed from electrical logs of oil tests, show the top, base, and thickness of the various formations or groups of formations and the approximate base of fresh to slightly saline water.

Navarro Group

The Navarro Group is exposed in a belt along the northwestern county line west of the Colorado River (Figure 5). Electrical logs of oil tests indicate the maximum thickness to be about 650 feet. The Navarro, which is composed mostly of clay and silt and some lenses of bluish sandstone, probably does not yield fresh to slightly saline water to wells in Bastrop County. Test holes, which were drilled into the Navarro in search of water, were reported to have found no usable water. Farmers and ranchers- in the area of the Navarro outcrop depend on rainwater stored in cisterns and earth tanks or haul water.

Midway Group

The outcrop of the Midway Group extends across Bastrop County near the northwestern county line. The group, which has a maximum thickness of about 800 feet, consists of clay, silt, glauconific sand, and thin beds of limestone and sandstone. Most of the sand occurs near the top of the Midway. A few dug wells in the Midway yield small quantities-usually a few hundred gallons a day-of slightly to moderately saline water during wet seasons, but many of the wells fail during long dry seasons. Usually the wells are dug to a large diameter to provide a large seepage area and storage space.

Wilcox Group

The Wilcox Group crops out across the north-central part of the county in a belt ranging from about 9 to 15 miles wide and in a narrow belt extending from about the Cedar Creek community southwest into Caldwell County (Figure 5). The base of the Wilcox dips southeastward at 150 to 200 feet per mile; the dip of the base increases from west to east and in the direction of dip. Locally the dip is increased by faults that are upthrown to the southeast. The dip is decreased or reversed by faults that are downthrown to the southeast.

The full thickness of the Wilcox ranges from about 1,400 to 2,600 feet. The maximum thickness occurs in the southeast part of the county along the Fayette-Lee County line. The altitude of the base of the Wilcox ranges from about 500 feet above sea level along the northwestern edge of the outcrop to at least 3,700 feet below sea level in places along the southeastern county line. The altitude of the top of the Wilcox at its contact with the Carrizo Sand ranges from almost 600 feet above sea level where the contact is exposed in the

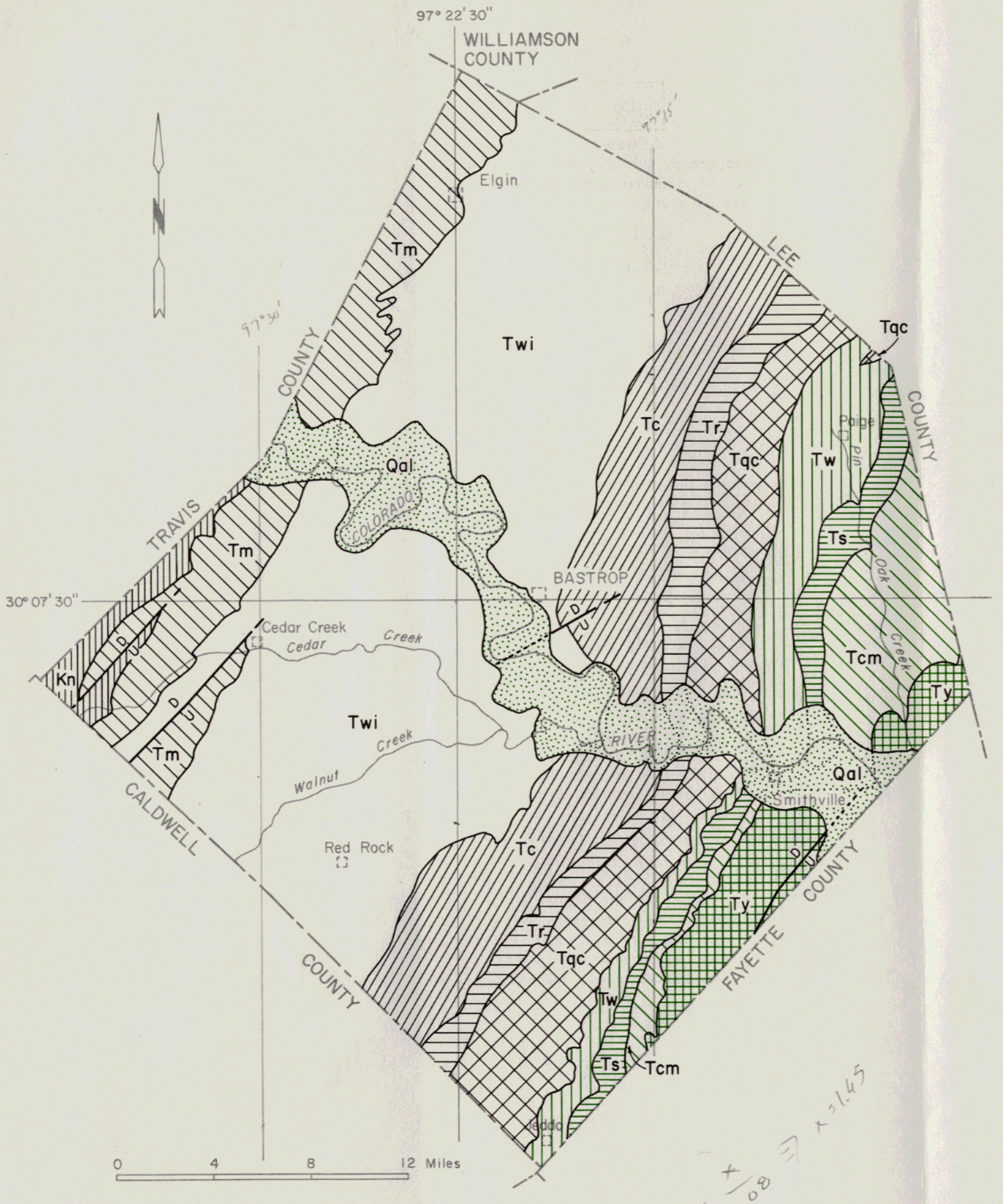


Figure 5

GEOLOGIC MAP

EXPLANATION

QUATERNARY — Holocene

Qal — Alluvium
Sand, gravel, silt, and clay. Yields small to moderate quantities of fresh to slightly saline water

TERTIARY — Eocene

Ty — Yegua Formation
Sand, silt, clay, gypsum, and lignite. Yields small quantities of slightly to moderately saline water

Tcm — Cook Mountain Formation
Clay and small amounts of sand, sandstone, limestone, glauconite, and gypsum. Yields small quantities of fresh to moderately saline water

Ts — Sparta Sand
Fine to medium sand with some clay and silt. Yields small to moderate quantities of fresh to moderately saline water

Tw — Weches Greensand
Glauconitic clay and sand, iron-bearing. Yields small quantities of slightly saline water

Tqc — Queen City Sand
Sand, clay, and some lenses of iron-bearing conglomerate. Yields small to moderate quantities of fresh to slightly saline water

Tr — Reklaw Formation
Clay, silt, glauconitic sand, and thin beds of sandstone. Yields small to moderate quantities of fresh to moderately saline water

Tc — Carrizo Sand
Sand and some thin beds of sandstone and clay. Yields small to large quantities of fresh water

Twi — Wilcox Group
Sand, sandstone, sandy clay, clay, shale, and some thin lenses of limestone and lignite. Yields small to large quantities of fresh to moderately saline water

TERTIARY — Paleocene

Tm — Midway Group
Clay, silt, glauconitic sand, and thin beds of limestone and sandstone. Yields small quantities of slightly to moderately saline water

CRETACEOUS — Gulf

Kn — Navarro Group
Clay, silt, and some lenses of bluish sandstone. Not known to yield fresh to slightly saline water

Contact
Dotted where concealed

D
U
Fault

U, upthrown side; D, downthrown side
Dashed where approximately located; dotted where concealed

Geology adapted from Geologic Map of Texas (Darton and others, 1937)

Table 2.—Geologic Units and Their Water-Bearing Properties

SYSTEM	SERIES	GEOLOGIC UNIT	MAXIMUM THICKNESS (FT)	CHARACTER OF ROCKS	WATER-BEARING PROPERTIES
Quaternary	Holocene	Alluvium	50±	Sand, gravel, silt, and clay.	Yields small to moderate quantities of fresh to slightly saline water to a few wells for domestic and livestock use. Formerly furnished part of Bastrop public supply.
Tertiary(?)	Pliocene(?)	Uvalde Gravel	4±	Predominantly flint cobbles, boulders, and gravel.	Not known to yield water to wells in Bastrop County.
Tertiary	Eocene	Yegua Formation	200±	Medium to fine sand, silt, clay, gypsum, and beds of lignite.	Yields small quantities of slightly to moderately saline water for domestic and livestock use.
		Cook Mountain Formation	370	Clay containing small amounts of sand, sandstone, limestone, glauconite, and gypsum.	Yields small quantities of fresh to moderately saline water for domestic and livestock use.
		Sparta Sand	90	Fine to medium sand with some clay and silt.	Yields small to moderate quantities of fresh to moderately saline water to wells in and near the outcrop area.
		Weches Greensand	100	Iron-bearing glauconitic clay and sand.	Yields small quantities of slightly saline water to a few wells.
		Queen City Sand	535	Massive to thin-bedded fine to medium sand, clay, and some lenses of conglomerate containing iron.	Yields small to moderate quantities of fresh to slightly saline water to wells.
		Reklaw Formation	400	Glauconitic sand and silt in the lower part of formation; clay and thin beds of sandstone in the upper part.	The lower part of the formation yields small to moderate quantities of fresh to slightly saline water to wells for domestic and livestock use, and public supply. The upper part of the formation yields small quantities of slightly to moderately saline water, rarely used. Reklaw is more productive in the Smithville area than elsewhere.
		Carrizo Sand	375	Fine to coarse cross-bedded sand and some thin beds of sandstone and clay.	Yields small to large quantities of fresh water for domestic and livestock use, and some public supply and irrigation. Second most important water-bearing unit in the county.
		Wilcox Group	2,600	Fine to coarse sand and sandstone, sandy clay, clay, and shale, with some lenses of limestone and lignite.	Yields small to large quantities of fresh to moderately saline water to many wells for domestic and livestock use, public supply, and irrigation. Most important water-bearing unit in the county.
	Paleocene	Midway Group	800	Clay, silt, glauconitic sand, and thin beds of limestone and sandstone.	Yields small quantities of slightly to moderately saline water to a few wells, generally dug to provide large seepage area and storage space.
Cretaceous	Gulf	Navarro Group	650	Predominantly clay and silt and some lenses of bluish sandstone.	Mostly non-water bearing. Not known to yield fresh or slightly saline water to wells in Bastrop County.

northeastern part of the county to almost 1,350 feet below sea level near the Fayette County line (Figure 6).

The Wilcox consists chiefly of fine to coarse sand and lesser amounts of clay, sandy clay, sandstone, and silty shale with a few lenses of limestone and lignite. The sand, which constitutes about 40 percent of the Wilcox, is fine to medium and is mostly quartz; however, some organic matter and dark-colored minerals give the sand a "salt and pepper" appearance.

In many places the Wilcox has an upper, middle, and lower sand zone. The middle zone, probably equivalent to the Simsboro Sand Member of the Rockdale Formation of F'lummer (1932) in the Brazos River basin, contains more and generally coarser sand than the other two zones. In Bastrop County east of the Colorado River, the Simsboro Sand Member is recognizable.

Some typical thicknesses of the Simsboro are about 650 feet in well AT-58-63-601 and about 850 feet in wells AT-58-47-901, AT-58-48-704, and AT-58-56-702. West of the Colorado the Simsboro becomes less massive and actually seems to be divided into two or more sand zones. Except for the Simsboro east of the Colorado, individual sand beds in the Wilcox Group are not continuous over long distances, and although some beds are 50 feet or more in thickness, correlation of the beds is difficult even in short distances. The lentlcularity of the sand beds is due mainly to their continental and shallow marine origin as channel, deltaic, and lagoonal deposits.

Figure 7 shows three views of the Wilcox in Bastrop County. The top view (Figure 7A) shows a clay pit, one mile east cf well AT-58-46-301, in about the middle of the Wilcox outcrop. A small fault is indicated by the light-colored material (mostly sand) on the right and the dark-colored material (mostly clay) on the left. The water surface in the 35-foot pit is probably the water table. The middle view (Figure 78) shows the lower Wilcox in a roadcut about 2 miles northeast of well AT-58-53-602. The Wilcox here is a medium sand which is probably near the base of the Simsboro Sand Member. The sand is indurated enough to withstand weathering as this roadcut probably is part of the old road between Bastrop and Austin that was used before the first bridge at Bastrop was built to span the Colorado River. The bottom view (Figure 7C) shows the Wilcox exposed in an east bank of the Colorado River at Powell Bend about 4 miles northwest of Bastrop. At low water, a 40-foot section of indurated medium sand is seen; this section is probably near the top of the Simsboro Sand Member.

Fresh to sightly saline water occurs in the Wilcox at depths ranging from less than 50 feet below land surface at the outcrop to at least 3,820 feet (3,420 feet below sea level) in well AT-67-07-501 near the Fayette County line (Figure 19). Nearly all of the Wilcox contains only fresh to slightly saline water except southeast of the outcrop of the Carrizo Sand where the lower part of the Wilcox contains moderately saline water (Figures 5, 24, 25, and 26). Locally, on the Wilcox outcrop, water in a few shallow wells is moderately saline.

The Wilcox, which is the most important water-bearing unit in the county yields small to large quantities of water to many wells for domestic and livestock use, public supply, industrial use, and irrigation. The Wilcox furnishes all the water used by the cities of Bastrop and Elgin and about half of the total ground water used for irrigation in the county.

Most of the irrigation wells pumping from the Wilcox have yields of less than 500 gpm (gallons per minute), but generally larger yields could be obtained from properly constructed, underreamed, and gravel-packed wells of large diameter that are screened in as many of the sands as practicable.

Carrizo Sand

The Carrizo Sand unconformably overlies the Wilcox Group and crops out in a belt 2 to 4 miles wide extending across the central part of Bastrop County (Figure 5). In general the outcrop is covered by a thick growth of blackjack oak and brush, but the land gradually is being cleared for pasture improvement and grazing. The Carrizo consists chiefly of fine to coarse, loose, cross-bedded sand and some thin beds of sandstone and clay. Generally the sand is white and consists of rounded to subangular coarse quartz grains. In many pits and roadcuts, the Carrizo is sufficiently indurated to form steep faces. Iron staining is indicated by reddish zones in places on the natural outcrop and, after exposure, in pits and roadcuts. The strata are massive and in places slightly cemented with silica.

Figures 8 and 9 are views of outcrops of the Carrizo Sand in two pits in Bastrop County. Figure 8 shows the massiveness and cross-bedding of about 40 feet of the lower part of the Carrizo in a sand pit about 2 1/2 miles east of Bastrop on State Highway 21. The base of the bluff is about 10 feet above the top of the Wilcox Group, which is exposed in a roadcut about 200 feet southeast. A thin layer of high-level terrace gravel rests on the Carrizo; rusty stains indicate the presence of iron. The trees growing on top are part of the "Lost Pines" of Bastrop County. The lower view (Figure 8B) is a close-up of the left half of the upper view (Figure 8A) and is presented to show more detail. Figure 9 shows two views of the Carrizo in a sand and gravel pit about 31/2 miles southeast of Bastrop on State Highway 71. The upper view (Figure 9A) shows an exposure of sand and gravel about 25 feet thick of which the lower two-thirds is indurated, massive, cross-bedded, medium to coarse Carrizo Sand, and the upper third is mostly high-level terrace gravel. The Carrizo on fresh exposure is much lighter in color than the iron-stained surface seen in the

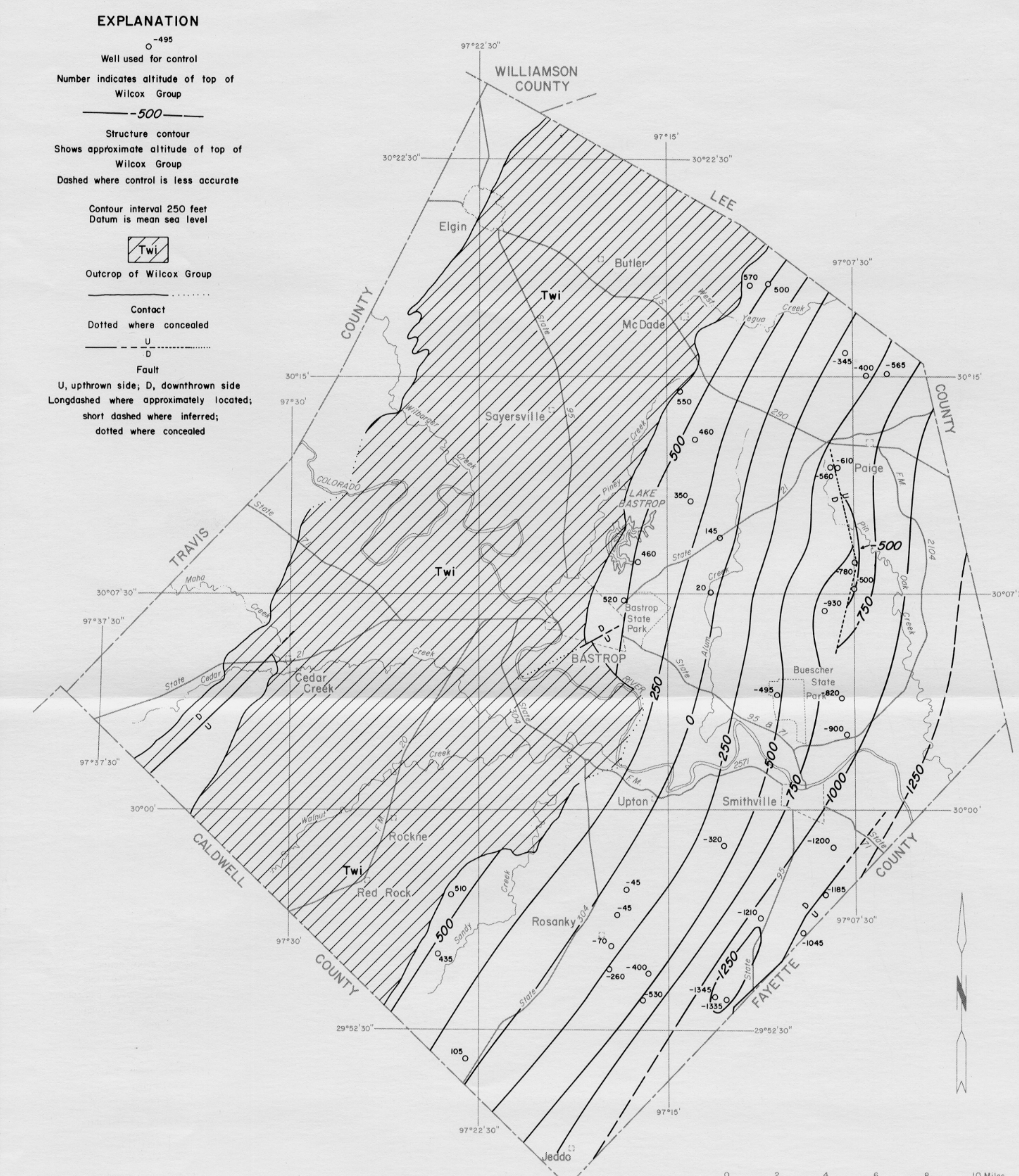
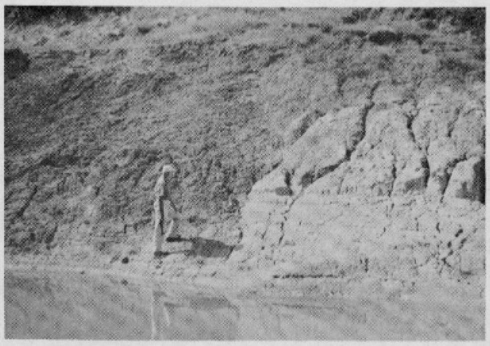


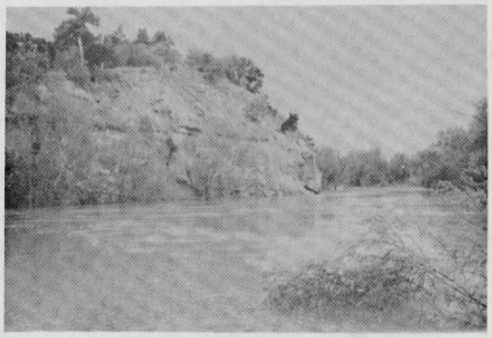
Figure 6

APPROXIMATE ALTITUDE OF THE TOP OF THE WILCOX GROUP



A. Clay pit 1 mile east of well AT-58-46-301

B. Roadcut about 2 miles northeast of well AT-58-53-602



C. Colorado River at Powell Bend, 4 miles northwest of Bastrop

Figure 7

OUTCROPS OF WILCOX GROUP

A. Sand pit 2 1/2 miles east of Bastrop near State Highway 21

B. Sand pit 2 1/2 miles east of Bastrop near State Highway 21. Shows close-up view of left half of bluff in A

Figure 8

OUTCROPS OF CARRIZO SAND

A. Sand and gravel pit 3 1/2 miles southeast of Bastrop by State Highway 71

B. Sand and gravel pit 3 1/2 miles southeast of Bastrop by State Highway 71

Figure 9

OUTCROPS OF CARRIZO SAND

photo. The lower view (Figure 9B) is in the same pit; here the lower part of the Carrizo shows more uniform cross-bedding. The part above the author's head in Figure 9B is high-level terrace gravel having irregular bedding.

The top of the Carrizo Sand dips southeastward at about 140 feet per mile where not affected by faulting. The Carrizo has a maximum thickness of about 375 feet. Altitude of the top of the Carrizo ranges from about 500 feet above sea level near the northern contact of its outcrop with the Reklaw Formation to about 1,200 feet below sea level in the southeastern corner of the county (Figure 10).

The Carrizo, which is the second most important water-bearing unit in the county, yields small to large quantities of fresh water to a few wells in Bastrop County. Most of the wells are used for domestic and livestock purposes; some are used for public supply and irrigation. Generally, the water is low in dissolved solids, but in many places contains an objectionable amount of iron. Three Carrizo wells in the Rosanky area were reported to yield 1,800 gpm each on test when drilled; however, a small part of this water probably came from the underlying Wilcox Group. A new Carrizo well about 31/2 miles southwest of Smithville has a reported yield of 1,300 gpm; a small amount of this water is from the Wilcox. According to Rogers (1967) the downdip extent of fresh to slightly saline water in the Carrizo is 10 to 13 miles southeast of Bastrop County and is at a depth of 2,700 to 3,200 feet below sea level.

There are several reasons why the Carrizo Sand has undergone little development in the county. In many places the Carrizo outcrop area and the area southeastward from it, is sparsely inhabited so there has been very little need for the development of water supplies. Another factor limiting development of the Carrizo is the availability of suitable water in the overlying Queen City Sand and younger aquifers, which because of their shallower depth, are more economical sources of water.

Reklaw Formation

The Reklaw Formation conformably overlies the Carrizo Sand and crops out across the county in a l- to 2-mile-wide belt adjacent to the southeast edge of the Carrizo outcrop (Figure 5). The lower part of the formation, which is equivalent to the Newby Glauconitic Sand Member of Stenzel (1938, p. 65-7 1), consists principally of glauconitic sand and silt about 100 feet thick. The sand is finer grained than the underlying Carrizo and is buff colored instead of white. In some places, the Newby is probably in hydraulic continuity with the Carrizo. The upper part of the Reklaw, equivalent to the Marquez Shale Member of Stenzel (1938, p. 71.78), consists chiefly of clay and a few thin beds of sandstone. The Reklaw, which has a maximum thickness of about 400 feet, dips southeastward at about 130 to 140 feet per mile and increases in thickness in the direction of the dip.

In some places in the county, the basal sand of the Reklaw yields small to moderate quantities of fresh to slightly saline water to a few wells for domestic and livestock use and public supply. The upper part of the Reklaw yields small quantities of slightly to moderately saline water and is therefore rarely tapped by wells.

In many places, the Reklaw yields only small quantities of moderately saline water, but the Smithville area is an exception. The city of Smithville obtains part of its municipal supply of fresh water from wells which draw partly from the Reklaw. This supply of fresh water, which occurs in relatively thick sand, is probably a local occurrence as electrical logs of wells a few miles to the southwest or northeast indicate less available sand and more mineralized water. Yields of 200 to 300 gpm of fresh to slightly saline water are possible from the Reklaw in the Smithville area.

Queen City Sand

The Queen City Sand conformably overlies the Reklaw Formation and crops out in a northeastward-trending belt about 1 1/2 to 4 miles wide across Bastrop County (Figure 5). It is composed of massive to thin-bedded, light-gray, fine to medium sand, clay, and some lenses of iron-bearing conglomerate. On the outcrop, the Queen City generally weathers to various shades of red, tan, and brown; however, in some places the sand is light colored or almost white. The Queen City dips southeastward at about 120 feet per mile and has a maximum thickness of about 535 feet. The formation is about 40 percent sand.

Figure 11 shows two views of the Queen City Sand in a roadcut 4 miles northwest of Smithville on State Highway 71. The upper view (Figure 11A) shows about 15 feet of the lower part of the formation covered with a layer of high-level terrace material. The lower view (Figure 11 B) is a close-up of that part of the upper view where the author is standing. The massive cross-bedded sand has some thin layers of clay or silt. Correlation of individual beds is difficult or impossible even in short distances, but sand or clay zones usually can be correlated.

The Queen City yields small to moderate quantities of fresh to slightly saline water to wells in and near its outcrop, and area devoted principally to ranching. Yields of 300 gpm, or possibly more, may be expected from properly constructed wells. According to Rogers (1967), the southeastern extent of fresh to slightly saline water in the Queen City is from 10 to 14 miles southeast of Bastrop County and is at a depth of 1,300 to 2,400 feet below sea level.

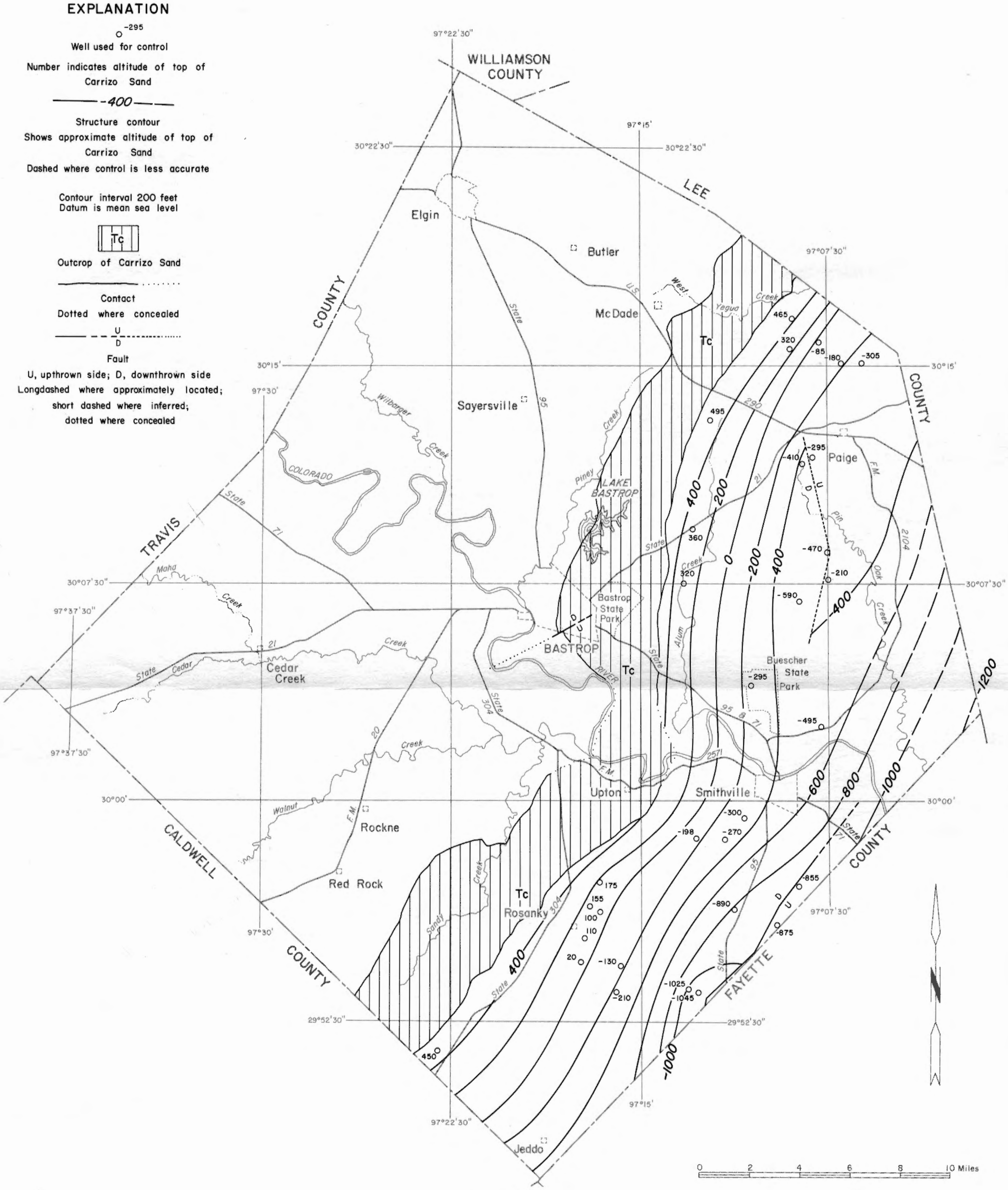
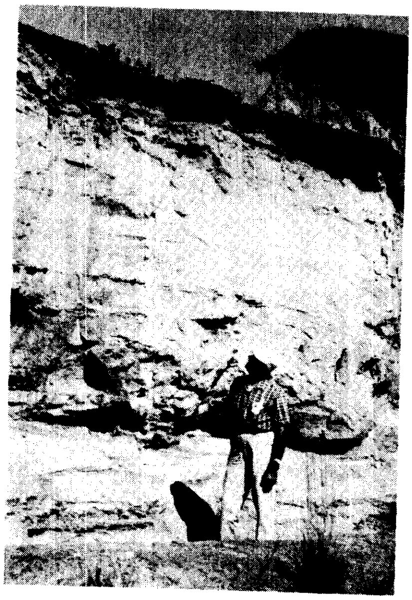


Figure 10

APPROXIMATE ALTITUDE OF THE TOP OF CARRIZO SAND

Base map from U.S. Geological Survey topographic quadrangles

A. Roadcut 4 miles northwest of Smithville by State Highway 71



B. Roadcut 4 miles northwest of Smithville by State Highway 71.
Shows close-up view of lower part of cut in A

Figure 11

OUTCROPS OF QUEEN CITY SAND

Weches Greensand

The Weches Greensand crops out in a band 1 to 3 miles wide extending northeastward across the southeastern part of Bastrop County where it conformably overlies the Queen City Sand (Figure 5). The Weches is composed of about 100 feet of brown, iron-bearing glauconitic clay and sand.

Only a few wells tap the formation because the water is slightly saline and high in iron. Water from some of the Weches wells is called "alum water" by the local people. A yield of only a few gallons per minute could be expected from wells tapping the Weches.

Sparta Sand

The Sparta Sand overlies the Weches Greensand and according to Darton and others (1937), crops out in a narrow belt 1 to 2 miles wide extending across Bastrop County from near the south corner to the Lee County line southeast of Paige (Figure 5). However, the writer was unable to find the Sparta exposed in roadcuts or fields southeast of Paige. This apparent absence of Sparta is probably due to faulting. Most of the Sparta Sand consists of fine to medium, stratified, loose to lightly cemented sand beds that are cross-bedded and separated by thin layers of clay and silt. The Sparta, which has a maximum thickness observed in electric logs of 90 feet, dips southeastward at about 100 feet per mile.

Figure 12 shows three views of the Sparta Sand in Bastrop County. Figure 12A is a view of the Sparta in a roadcut 2 miles south of Paige on Farm-to-Market Road 2104. About 15 feet of sand with some thin layers of clay and silt are exposed in the cut. The center and bottom pictures were taken in a sand pit about 3/4 mile southeast of Jeddo, a community near the southern extremity of the county. About 25 feet of basal Sparta is seen in the center view (Figure 12B) as a massive section of medium sand.

Because the water table stands at 36.9 feet below land surface in well AT-67-14-502, about 100 feet from the pit, the ponded water seen in Figure 12B is not the water table but is runoff from rains. The bottom view (Figure 12C) is a close-up showing some of the bedding characteristics of the Sparta. On the surface the Sparta weathers to a deep loose white sand, which resembles the Carrizo.

The Sparta yields small to moderate quantities of fresh to moderately saline water to wells in and near the outcrop area. Well AT-58-56-803, an irrigation well, pumps about 90 gpm from the Sparta Sand. Higher yields, maybe as much as 400 gpm, could be obtained from properly constructed wells in the Sparta near the southern extremity of the county. According to Rogers (1967), fresh to slightly saline water is obtainable from the Sparta as much as 12 to 15 miles southeast of the Bastrop County line, where the water extends to a depth of 2,000 to 2,400 feet below sea level.

Cook Mountain Formation

The Cook Mountain Formation overlies the Sparta Sand and crops out across the southeastern part of Bastrop County. West of the Colorado River, the Cook Mountain outcrop is a narrow belt about a mile wide indicating a thinner section or much steeper dip than east of the river where the outcrop has a width of as much as 6 miles (Figure 5).

The Cook Mountain, a marine deposit, consists mainly of clay and a few thin lenses of sand, sandstone, limestone, glauconite, and gypsum. Maximum thickness of the formation observed in logs was 370 feet.

In Bastrop County, the Cook Mountain yields small quantities of fresh to moderately saline water to a few domestic and livestock wells on the outcrop; usually wells are drilled to the underlying Sparta Sand to obtain more and better quality water. Only small quantities of water may be expected from wells tapping the Cook Mountain.

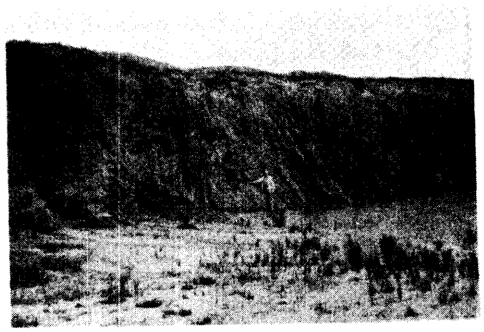
Yegua Formation

The Yegua Formation, which overlies the Cook Mountain Formation, crops out in a northeast-trending belt 4 to 9 miles wide across Bastrop, Fayette, and Lee Counties. Most of the outcrop, however, is in the two latter counties. As a result of faulting along the Bastrop-Fayette County line west of the Colorado River, there is a repetition of part of the Cook Mountain and Yegua Formations.

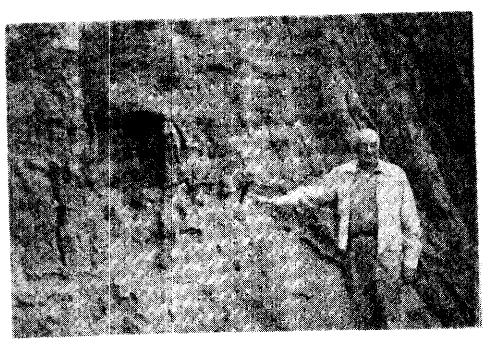
The Yegua, a continental deposit, consists of layers of medium to fine sand, silt, sandy and carbonaceous or gypsiferous clay, and lignite, which cannot be traced or correlated for any great distance. The Yegua, which contains more sand, carbonaceous matter, gypsum, and fossilized wood than the Cook Mountain, has a thickness of about 200 feet for the part in Bastrop County. Only the lower part of the Yegua, however, crops out in the county.

Only a few domestic and livestock wells in Bastrop County draw slightly to moderately saline water from the Yegua. Because only a part of the formation is present in Bastrop County, probably only small yields could be expected from wells tapping the aquifer. In Fayette County, according to Rogers (1967, fig. 15), the water in the Yegua remains fresh to slightly saline to a depth of about 800 feet.

A. Roadcut 2 miles south of Paige by Farm-to-Market Road 2104



B. Sand pit by county road near well AT-67-14-502



C. Sand pit by county road near well AT-67 -14-502. Shows close-up view of lower part of pit wall in B

Figure 12

OUTCROPS OF SPARTA SAND

Uvalde Gravel

The Uvalde Gravel ranges in thickness from a few inches to about 4 feet and caps some of the higher divides in Bastrop County, particularly those northeast of the Cedar Creek community and some of the higher ridges between Smithville and Paige. These outcrops of Uvalde Gravel are not shown on the geologic map. The Uvalde consists mostly of cobbles, boulders, and gravel, the gravel being chiefly flint and to a lesser extent, limestone.

The formation is not known to yield water to wells in Bastrop County, but in some places it aids in recharging the underlying formations by retarding surface-water runoff. The principal use of the Uvalde Gravel is road ballast.

Alluvium

The alluvium, as defined in this report, is restricted to the deposits along the Colorado River (Figure 5). The alluvium occurs as river-bottom land along the Colorado River and underlies the floodplains. In some places the alluvium is mostly on one side of the river; in other places on both sides. Generally, the floodplain deposits are not connected for great distances on either side of the river and are not always connected beneath the river bed. The maximum thickness is about 50 feet.

During early settlement times in Texas, river-bottom plantations used water from numerous wells dug in the alluvium. Most of these wells are now abandoned and filled, but a few, such as AT-58-62-403, are still in use.

The alluvium, as observed in the gravel pits and river banks, consists principally of sand with some small gravel having a few cobbles and disconnected layers or lenses of clay and silt. The sand seems to be more coarse with increased depth of occurrence, and in some places, such as at spring AT-58-62-507, the water emerges at the contact of about 15 feet of gravel with a clay bed in the underlying Wilcox Group. Several springs above the level of the water in the Colorado River were observed flowing from the alluvium along the river banks. Examples of these springs are AT-58-62-104, 507, and AT-58-63-908. In many places along the Colorado, bedrock was observed above the water level in the river. This indicates, at least at these places, that water in the alluvium is effluent to the stream. In some places during high river stages, the river temporarily would be influent to the alluvium; but the water as bank storage would flow out again as soon as the river stage returned to normal.

Alluvium along the Colorado yields small to moderate quantities of fresh to slightly saline water to a few domestic and livestock wells. Until about 1965, the city of Bastrop obtained most or all of its municipal water supply from shallow wells in the alluvium near the Colorado River. Although several irrigation wells between Austin and the Bastrop County line pump water from the alluvium, no irrigation wells presently obtain, or are reported to have previously obtained, water from the alluvium in Bastrop County.

GROUND-WATER HYDROLOGY

Occurrence of Ground Water

The general principles of the occurrence and movement of ground water in all types of rocks have been described in detail by many writers including Meinzer (1923, p. 2-142), Meinzer and others (1942, p. 385-478), and Tolman (1937).

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

In sandy outcrop areas, ground water is unconfined and is under water-table conditions. Downdip from the outcrop, where the aquifer is overlain by less permeable material, the water becomes confined and is under artesian conditions.

Water under artesian conditions, if not disturbed by heavy pumping, will rise in wells to an elevation equal to its elevation in the recharge area minus the loss in pressure due to friction. Where the elevation of the land surface at a well is considerably below the general level of the area of the outcrop, the pressure may be sufficient to cause the water to rise above the land surface. A few wells in Bastrop County flow, such as well AT-67-05-1 10 on the bank of Walnut Creek northwest of Red Rock, well AT-58-55-503 southwest of Paige, and several wells in the Colorado River bottoms downstream from Bastrop. Of the wells along the Colorado, well AT-58-63-701, 4 miles northwest of Smithville, probably has the largest flow of all flowing wells in the county (360 gpm).

Ground water in the county moves slowly (tens to hundreds of feet per year) under the influence of gravity from areas of recharge to areas of discharge. Figure 13 is a diagrammatic sketch showing the movement of water in the sands and clays and the relationship of fresh to

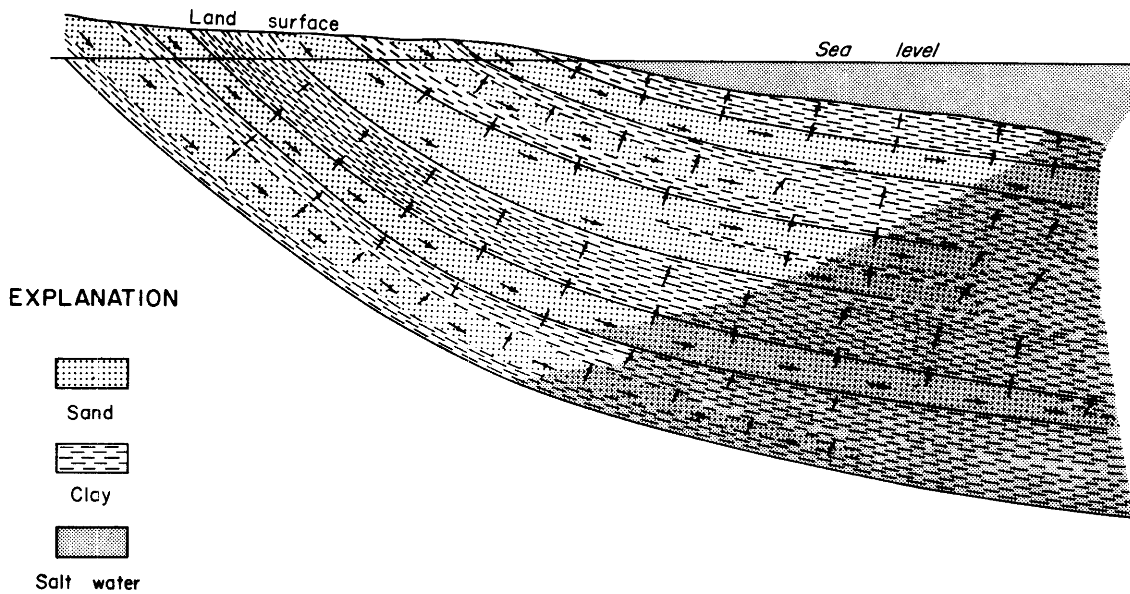


Figure 13.—Movement of Water and Theoretical Relationship of Fresh Water to Salt Water in the Gulf Coast Region

more mineralized water. The darker shading to the right indicates more mineralized water downdip. This fresh water-salt water relationship in Bastrop County is illustrated in Figures 24, 25, and 26 which show that the water in the lower part of the Wilcox becomes mineralized downdip.

Ground water in the county is discharged naturally through seeps and springs in the outcrop area of the aquifers, by transpiration where the water table is close enough to the surface to be reached by the roots of plants or trees, and by seepage through semiconfining beds, or along faults, into another aquifer having a lower pressure. Ground water is also discharged artificially through wells.

Ground-Water Development

The inventory of 600 wells, 7 springs, and numerous oil tests (Table 10) includes only a part of the total number of wells in the county; however, records of all the municipal, industrial, and irrigation wells were obtained. Locations of the wells inventoried are shown in Figure 23.

Records of the use of ground water for all purposes for the years 1962-66 are shown in Table 3. During this 5-year period, 35 percent of the water was used for municipal supply, 35 percent for irrigation, 4 percent for industrial supply, and 26 percent for domestic and livestock supply. The use of ground water is gradually increasing but the total of 3.7 mgd (million gallons per day) or 4,100 acre-feet per year used in 1966 is small compared to the quantity available.

According to Sundstrom, Hastings, and Broadhurst (1948, p. 27-29) the withdrawal of ground water for the municipal supply of Bastrop, Elgin, and Smithville was about 0.55 mgd (620 acre-feet per year) in 1942. Between 1955 and 1966 their pumpage ranged from 0.87 mgd (970 acre-feet per year) in 1955 to 1.2 mgd (1,400 acre-feet per year) in 1961. From 1942 to 1960 the combined pumpage (Table 4) of the three cities increased 35 percent from 0.55 mgd (620 acre-feet per year) to 0.74 mgd (830 acre-feet per year) even though the population of the three cities decreased 5 percent between 1940 and 1960.

The town of Paige (population 220 in 1960) installed a municipal supply system in late 1965. In 1966 the town's pumpage was 1,156,000 gallons or slightly more than 3,000 gpd (gallons per day).

About 5 percent of the people in the county depend on cisterns, streams, or earthen reservoirs for water used for domestic and livestock purposes. Most of these people live on or near the outcrop areas of the Navarro and Midway Groups (Figure 5) which yield little or no water to wells.

Ground water has never been used extensively for irrigation in Bastrop County. In general, the precipitation is well distributed throughout the year and is adequate for growing crops and pasture grass, but when precipitation is below normal during the growing season, ground water is used for supplemental irrigation. Records indicate that prior to 1958 only five irrigation wells were in existence in the county, and probably not all were used during any one year; no more than 100 acres were irrigated in any year, and generally the acreage was much less. According to Gillett and Janca (1965), 45 acre-feet of water was used to irrigate 40 acres of improved pasture grass and 25 acres of peanuts in 1958. Data collected during this study indicate that the pumpage increased from 200 acre-feet (0.18 mgd) to

Table 3.—Use of Ground Water, 1962-66

(Figures are approximate because some of the pumpage is estimated. Municipal supply figures are shown to the nearest 0.01 mgd and to the nearest acre-foot. Industrial, irrigation, domestic, and livestock figures are shown to two significant figures. Totals are rounded to two significant figures.)

YEAR	MUNICIPAL SUPPLY		INDUSTRIAL		IRRIGATION		DOMESTIC AND LIVESTOCK		TOTALS	
	MGD	AC-FT/YR	MGD	AC-FT/YR	MGD	AC-FT/YR	MGD	AC-FT/YR	MGD	AC-FT/YR
1962	0.95	1,061	0.13	150	0.18	200	0.77	860	2.1	2,300
1963	1.14	1,283	.13	150	.34	380	.77	860	2.4	2,700
1964	1.09	1,218	.13	150	1.3	1,500	.77	860	3.3	3,700
1965	1.02	1,149	.13	150	1.7	1,900	.77	860	3.7	4,100
1966	1.06	1,189	.13	150	1.7	1,900	.77	860	3.7	4,100

Table 4.—Municipal Pumpage of Ground Water, 1942, 1955-66

(Figures are approximate because some of the pumpage was estimated. Figures are shown to nearest 0.01 mgd and to nearest acre-foot. Totals are rounded to two significant figures.)

YEAR	BASTROP		ELGIN		McDADE		PAIGE		SMITHVILLE		TOTALS	
	MGD	AC-FT/YR	MGD	AC-FT/YR	MGD	AC-FT/YR	MGD	AC-FT/YR	MGD	AC-FT/YR	MGD	AC-FT/YR
1942	0.20	224	0.25	280	--	--	--	--	0.10	112	0.55	620
1955	.36	409	.19	218	0.00	2	--	--	.30	338	.87	970
1956	.54	604	.19	215	.00	8	--	--	.40	448	1.2	1,300
1957	.40	452	.19	218	.00	8	--	--	.30	336	.90	1,000
1958	.40	453	.20	224	.00	8	--	--	.50	560	1.1	1,200
1959	.37	411	.18	199	.00	9	--	--	.53	591	1.1	1,200
1960	.26	294	.22	250	.00	10	--	--	.25	278	.74	830
1961	.36	405	.24	271	.00	8	--	--	.60	678	1.2	1,400
1962	.36	398	.27	303	.01	11	--	--	.31	349	.98	1,100
1963	.47	531	.30	333	.01	14	--	--	.36	405	1.2	1,300
1964	.50	561	.27	302	.01	14	--	--	.30	341	1.1	1,200
1965	.39	433	.27	299	.01	12	--	--	.36	405	.98	1,100
1966	.42	471	.28	318	.01	12	0.00	4	.34	384	1.1	1,200

irrigate 170 acres in 1962 to 1,900 acre-feet (1.7 mgd) to irrigate 930 acres in 1966 (Table 5). The major irrigated crop is improved grass for pasture and hay; minor crops are peanuts and vegetables.

Most of the ground water used for irrigation was pumped from the Carrizo Sand and Wilcox Group; one small-capacity irrigation well pumps from the Sparta Sand. The use of ground water for supplemental irrigation of improved pasture grass, and possibly some other feed crops, probably will increase as the irrigation of improved pasture grass seems to be profitable in the production of beef cattle. Most of the future development of ground water for irrigation will be in the northeast-trending middle part of the county where a substantial quantity of water is available in the Carrizo Sand and the Wilcox Group.

During the 1962-66 period, about 0.13 mgd (150 acre-feet per year) of ground water was used for industrial purposes in Bastrop County by brick and rendering plants and a pipeline station. Ground water for industrial use is available for development from the Sparta, Queen City, and Carrizo Sands and from the Wilcox Group.

Aquifer Tests

Aquifer tests were made in 9 wells tapping the Wilcox Group and 1 well each in the Carrizo and Queen City Sands to determine the ability of the sands to transmit and store water. The other aquifers were not tested because of a lack of suitable wells. Test data were analyzed by the Theis nonequilibrium method (Theis, 1935) and the Theis recovery method (Wenzel, 1942, p. 95). The results of the tests are shown in Table 6.

Smithville city well AT-58-63-901, which draws from the Queen City Sand, was tested when the well was completed in 1954. The transmissivity obtained in the test was 4,300 gpd per foot. In Lee County, Thompson (1966, p. 37) reported a transmissivity of 7,000 gpd per foot from a test at Giddings of a city well that tapped the Queen City Sand; he estimated the storage coefficient for the artesian part of the Queen City in Lee County to be 0.0002.

The transmissivity of the Carrizo Sand, which was determined by testing well AT-58-63-701, was 23,000 gpd per foot. Available information indicates that this well probably was screened in only part of the Carrizo Sand. On the basis of drawdowns and yields of three Carrizo wells in the vicinity of Rosanky, the transmissivity of a complete Carrizo Sand section in the county is estimated to average 50,000 gpd per foot or slightly more. According to Shafer (1965), the transmissivity of the Carrizo Sand in Gonzales County ranged from 39,000 to 65,000 gpd per foot and averaged about 50,000 gpd per foot with the storage coefficient in one of the wells tested being 0.0002. This compares favorably with the average transmissivity of about 60,000 gpd per foot and storage coefficient of 0.00022 determined in four Carrizo wells in Atascosa and Wilson Counties (Anders, 1957, table 3).

Aquifer tests were made in nine wells tapping the Wilcox Group in Bastrop County. The transmissivities, ranging from 1,100 to 29,000 gpd per foot, should be considered representative of the intervals of sand screened in the wells and not of the entire formation because each well tested was on the Wilcox outcrop where only a part of the formation was present and only a part of the available sand was screened. Storage coefficients determined from the tests ranged from 0.0003 to 0.0006. The average transmissivity of a complete Wilcox section in the county is estimated to be about 100,000 gpd per foot. Transmissivities east of the Colorado River, where the Simsboro Sand Member of the Rockdale Formation of Plummer (1932) is fairly thick, probably would be greater than those west of the Colorado.

Table 5.—Acres Irrigated, Quantity of Ground Water Pumped, and Number of Irrigation Wells, 1962-66

YEAR	APPROXIMATE ACRES IRRIGATED	GROUND WATER USED* MGD	GROUND WATER USED* ACRE-FEET	NUMBER OF WELLS AVAILABLE FOR USE
1962	170	0.18	200	10
1963	260	.34	380	10
1964	770	1.3	1,500	17
1965	950	1.7	1,900	17
1966	930	1.7	1,900	17

* Figures are rounded to two significant figures because they are calculated from the well owner's estimate of the number of hours the well was used, pumping rate, and acres irrigated.

TABLE 6.--SUMMARY OF AQUIFER TESTS

WELL	AQUIFER*	DATE TESTED	INTERVALS SCREENED (FEET BELOW LAND SURFACE)	PUMPING RATE (GPM)	TRANSMISSIVITY (GPM/FT)	STORAGE COEFFICIENT	SPECIFIC CAPACITY (GPM/FT)	TIME (HOURS)	REMARKS
AT-58-46-501 City of Elgin well 6	Twi	Apr. 11, 1956 do	66-120 (underreamed and gravel-packed)	412 412	3,900 4,100	--	6.9	2 --	Drawdown in pumped well. Recovery in pumped well.
AT-58-47-602 Elgin-Butler Brick Co. well 2	Twi	1952	340-397 (underreamed and gravel-packed)	60	1,100	--	--	--	Recovery in pumped well.
AT-58-47-701 City of McDade	Twi	Sept. 14-15, 1955	500-600	205	3,200	--	1.5	8	Do.
AT-58-54-501 Camp Swift well 1	Twi	July 31, 1942	264-293,316-337, 431-453, 463-495,520-564 (underreamed and gravel-packed)	625	26,000	--	17.8	--	Recovery in pumped well, probably affected by nearby fault.
AT-58-54-503 Camp Swift well 3	Twi	June 12, 1942	273-350, 395-423, 440, 549 (underreamed and gravel-packed)	--	28,000	0.0005	12.4	--	Drawdown interference from pumping well AT-58-54-502 at 630 gpm.
AT-58-54-504 Camp Swift well 4	Twi	do	250-342, 389-530 (underreamed and gravel-packed)	--	26,000	.0004	17.2	24	Drawdown interference from pumping well AT-58-54-505 at 605 gpm.
AT-58-54-505 Camp Swift well 5	Twi	do	260-339, 449-549 (underreamed and gravel-packed)	--	29,000	.0003	20.2	24	Drawdown interference from pumping well AT-58-54-502 at 630 gpm.
AT-58-54-508 Camp Swift test well 2T	Twi	July 27, 1942	347-550	--	22,000	.0006	20.0	24	Recovery when well AT-58-54-505 shut down.
AT-58-54-512 Camp Swift test well 1T	Twi	Nov. 8-9, 1941	Depth 574 ft, part is slotted	--	22,000	--	--	--	Drawdown interference from pumping well AT-58-54-508 at 600 gpm.
AT-58-63-701 Leonard Nut Co.	Tc	Oct. 18, 1960	Depth 391 ft, lower part is slotted	390	23,000	--	66	3/4	Recovery in flowed well.
AT-58-63-901 City of Smithville well 4	Tqc	Oct. 6, 1954	170-190, 276-296, 349-370, 410-440 (underreamed and gravel-packed)	459	4,300	--	2.7	9	Drawdown in pumped well.

* Twi-Wilcox Group, Tc-Carrizo Sand, Tqc-Queen City Sand.

On the basis of a study of logs of wells and of the results of the aquifer tests in Bastrop and adjoining counties, a complete composite section of the Carrizo-Wilcox aquifer probably has a transmissivity of 150,000 gpd per foot. Where the thickness of both units reaches a maximum in the east-central part of the county, the transmissivity is probably more than 200,000 gpd per foot. The writer knows of no well in Bastrop or in adjacent Caldwell, Fayette, or Lee Counties that is screened in the entire Carrizo-Wilcox section.

According to Thompson (1966, p. 41), at Dime Box in Lee County, the 75 feet of saturated sand in the Sparta Sand had a transmissivity of about 14,000 gpd per foot and a storage coefficient of 0.0004. This transmissivity compares favorably with the average of several transmissivities obtained during pumping tests conducted by the author and others at Bryan in Brazos County, about 50 miles northeast of Bastrop County.

Because the Sparta has a maximum thickness of about 90 feet and is mostly sand in Bastrop County, the transmissivity of 14,000 gpd per foot obtained in the Lee County test for a similar thickness may be considered representative of the Sparta in Bastrop County.

The transmissivities and storage coefficients determined from aquifer tests may be used to predict the drawdown of water levels caused by pumping a well or by a general increase in pumping in an area. Figure 14 shows the theoretical relation between drawdown of water levels and different transmissivities. The calculations of drawdown were based on a well or group of wells pumping 500 gpm continuously for 1 year from an extensive aquifer having a storage coefficient of 0.0005 and transmissivities as shown on the different curves. As a result of pumping 500 gpm continuously for 1 year, the aquifer having an assumed transmissivity of 10,000 gpd per foot, the water level would decline about 44 feet at a distance of 1,000 feet from the pumped well; it would decline about 25 feet at 5,000 feet and about 10 feet at 20,000 feet. Because drawdown is directly proportional to the pumping rate, the drawdown for rates other than 500 gpm can be determined by multiplying the drawdown values shown in Figure 14 by the proper multiple or fraction of 500.

Figure 15 shows the relation between time and drawdown of water levels caused by a well pumping 100 gpm from an infinite aquifer having a storage coefficient of 0.0005 and a transmissivity of 10,000 gpd per foot. Most of the drawdown takes place in the first few days of pumping, but the water level will continue to decline indefinitely until a source of recharge or point of discharge is intercepted to offset the pumpage and reestablish equilibrium in the aquifer. Because the drawdown is directly proportional to the pumping rate, the drawdown for rates other than 100 gpm can be determined by multiplying the drawdown values shown in Figure 15 by the proper multiple or fraction of 100.

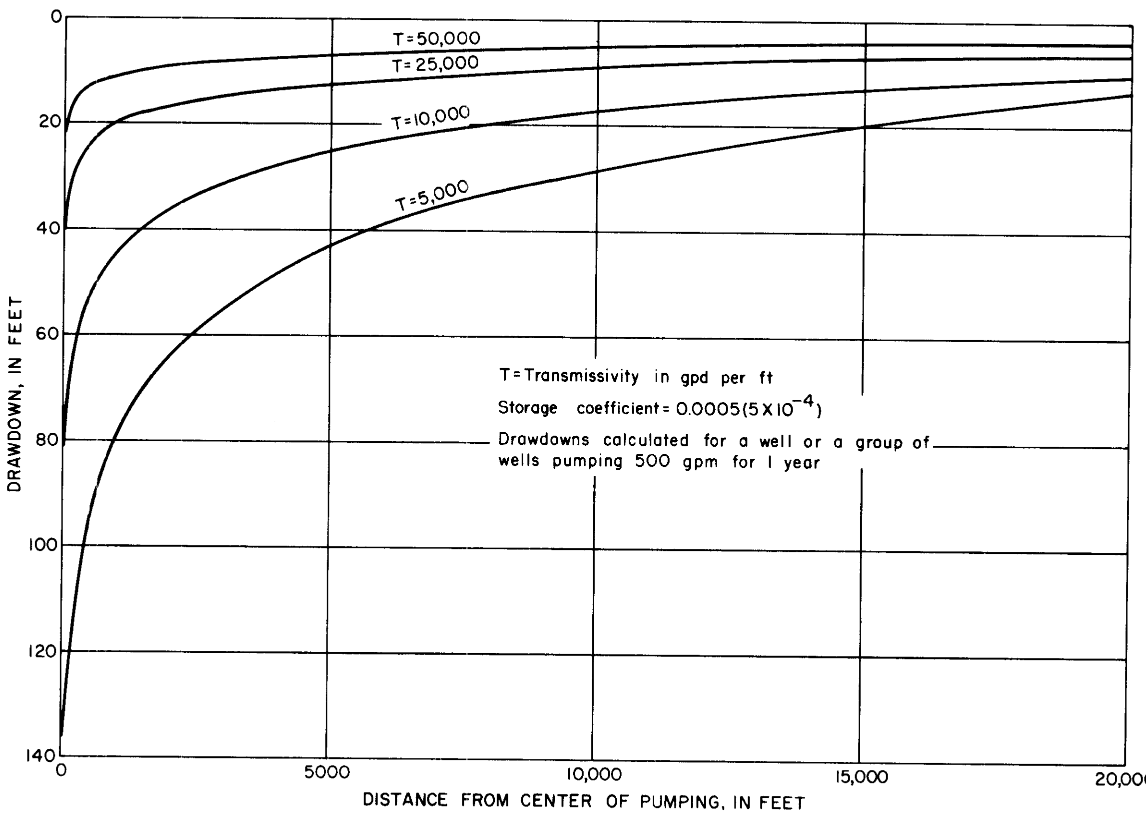


Figure 14.—Relation of Drawdown to Transmissivity and Distance

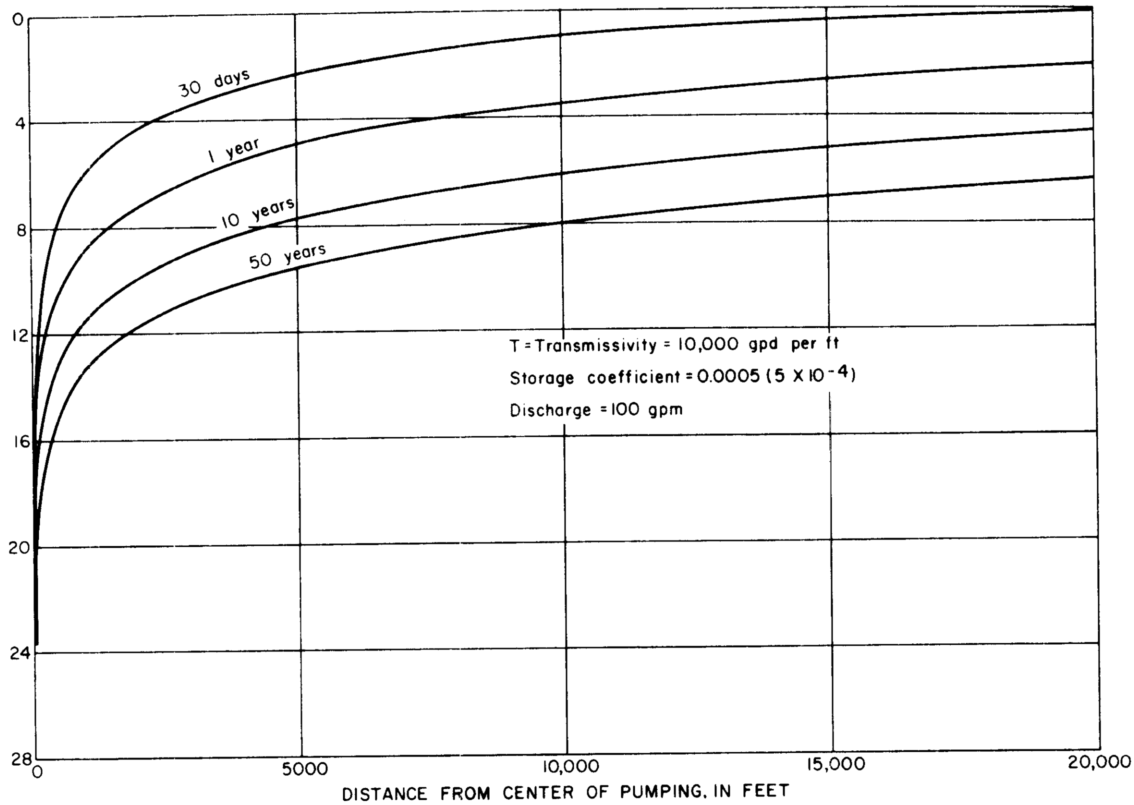


Figure 15.—Relation of Drawdown to Time and Distance

Note that Figures 14 and 15 show that the drawdown caused by a pumping well is greatest near the pumping well and that the drawdown decreases as the distance from the pumping well increases. This relationship is the practical reason for properly spacing wells to reduce their mutual interference and thus reduce the pumping cost.

The specific capacity of a well is directly related to the transmissivity of the aquifer. Table 6 shows that the specific capacities of nine wells ranged from 1.5 to 66 gpm per foot of drawdown. Specific capacities of wells tapping the same formation may differ widely because of the amount of sand screened, the difference in well construction, the degree of well development, and pumping time. The specific capacities shown in Table 6 were determined from pumping tests at the end of ¾ to 24 hours.

Changes in Water Levels

Water levels in wells were measured during previous studies in the county in 1946 and 1951-52 and as a part of this study in 1964-66. Water-level measurements were made periodically in selected observation wells during the period 1937-41 and since 1950 as part of the statewide observation well program of the U.S. Geological Survey and the Texas Water Development Board. Although some of these water-level records have been published previously, all are included in this report in Tables 10 and 12.

The water-level fluctuations in wells in the county indicate mostly natural rising or declining trends due to differences in the time of year in which the water levels were measured and differences in rainfall. Pumping for public supply, industrial use, and irrigation has not caused any noticeable change in water levels except during the 1942-46 period when the Camp Swift public-supply wells about 5 miles north of Bastrop were pumped heavily. During this period, water levels declined in a radius of a few miles of the pumping, but the levels recovered after pumping ceased. Except for Camp Swift, there has been only slight withdrawal of water for public supply, industrial use, and irrigation; and this withdrawal was widely distributed over the county. This pumping was so small and widespread in comparison to the available water supply that a regional water-level decline would have been too small to be easily detected.

The changes of the water levels in some of the Wilcox wells that reflect relatively heavy rainfall, deficiencies in rainfall, or pumping are shown in Figure 16. This figure shows graphically the record of precipitation at Smithville from 1950 through 1966 and the water-level fluctuation in three wells. The effect of the cumulative deficiency in rainfall from 1950 through

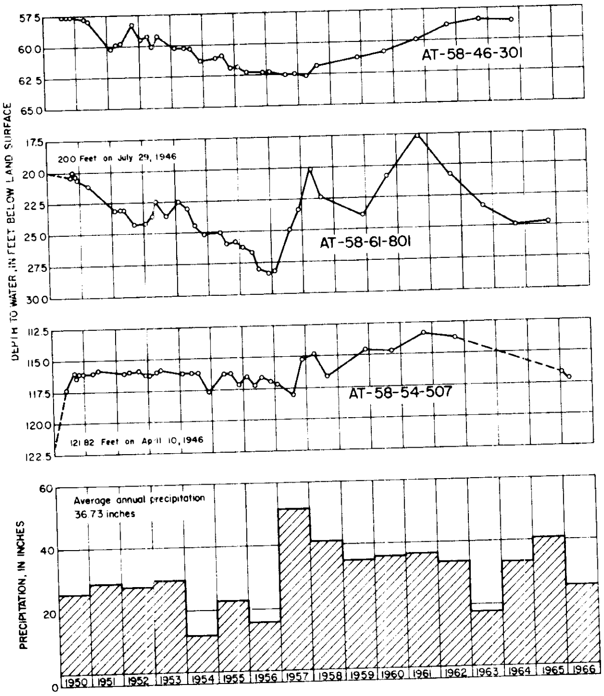


Figure 16.—Changes in Water Levels in Wells Tapping the Wilcox Group and Annual Precipitation at Smithville, 1950-66

1956, which is shown by shallow dug wells AT-58-46-301 and AT-58-61-801, was net declines of about 5 and 8 feet, respectively. The effect of the period of relatively heavy rainfall from 1957 through 1965 was a net rise of about 4 feet. Well AT-58-54-507, a deep well screened in sands between 299 and 667 feet, shows a recovery of about 6 feet between 1946 and 1950 when Camp Swift was abandoned and the pumpage reduced.

An expanded observation-well program is recommended for the future so that any trend in the water-level fluctuations can be established prior to any large-scale development. Selected wells drawing from the Carrizo Sand and Wilcox Group are most important for observation; wells drawing from the Queen City Sand and Sparta Sand are of secondary importance.

Well Construction and Yield

During pioneer days, water used for domestic purposes was obtained mostly from dug wells or shallow hand-bored wells; only a few fortunate people had springs or streams available. The dug, hand-bored, and early drilled wells usually penetrated only a few feet of the saturated zone and yielded small quantities of water. Most of the wells completed since 1930 have been drilled wells.

Figure 17 illustrates the construction of the two most common types of present-day wells, the straight-walled well and the underreamed and gravel-packed well. The straight-walled type of construction is commonly used for domestic, livestock, and small irrigation, industrial, and public-supply wells when a relatively small yield is adequate or the cost is a major factor. The underreamed and gravel-packed type of construction is generally used where a larger yield is desired. Instead of underreaming, many irrigation wells are drilled to a large diameter and gravel packed from the land surface to the bottom of the hole.

The Bastrop municipal wells (drilled for and used by Camp Swift during World War II) that tap the Wilcox Group and the Smithville municipal wells that tap the Reklaw Formation, Queen City Sand, and the Carrizo Sand are underreamed, screened, and gravel packed opposite the water-bearing sands. The gravel pack in these wells increases the effective diameter of the wells and allows more water to enter at a reduced velocity. This reduces the drawdown and aids in preventing or retarding the entrance of sand into the wells.

Most of the irrigation wells in the county are straight-walled wells (not underreamed or gravel packed), cased with torch-slotted casing opposite the water sands, or uncased opposite the sands if the hole will stay open. Little effort is made to relate the width of the slots to the diameter of the sand grains. If the slots are too large, considerable quantities of sand will enter the well, resulting in excessive wear of the pumps. On the other hand, slots that are too small or insufficient in number may cause excessive "entrance losses", thereby increasing the drawdown and decreasing the specific capacity of the wells.

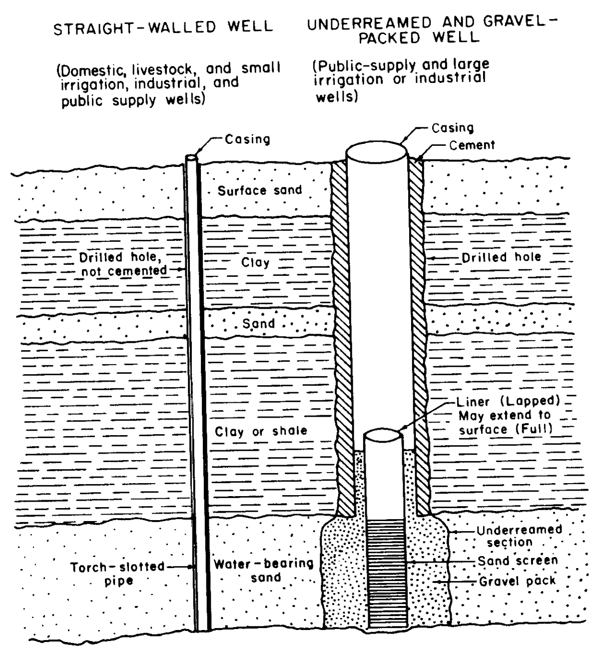


Figure 17.—Typical Construction of Domestic, Livestock Public Supply, Industrial, and Irrigation Wells

The domestic and livestock wells generally are of small capacity and are equipped with windmills, pump jacks, jet pumps, or submersible pumps. The older domestic and livestock wells usually were cased with galvanized pipe nearly to the bottom of the well, and no screen or slotted casing was used; these wells are called "open-end" wells. The more recently drilled wells generally are cased to the bottom and have the lowermost 20 to 40 feet of casing torch slotted. These wells generally are pumped at less than 5 gpm, but they are still vulnerable to "sanding up", and some must be cleaned periodically.

AVAILABILITY OF GROUND WATER

The geologic formations containing significant quantities of fresh to slightly saline water in Bastrop County are the Sparta Sand, Queen City Sand, Carrizo Sand, and Wilcox Group. In this report, the Carrizo Sand and the Wilcox Group are considered as a unit because they are hydrologically connected. The Carrizo-Wilcox aquifer is the principal aquifer as it contains and can furnish more than 90 percent of the ground-water potential of the county. Other less significant, though still locally important, geologic formations that can supply mostly small quantities of fresh to slightly saline water are the alluvium, Yegua Formation, Cook Mountain Formation, Weches Greensand, and Reklaw Formation.

Figure 18 shows the estimated potential yield of wells tapping the Carrizo Sand and Wilcox Group in various areas in Bastrop County. The estimates of yields are based primarily on the thickness of sand, the estimated composite transmissivity of the water-bearing section, and on the specific capacities and yields of wells in Bastrop and adjoining counties. Furthermore, the estimates are based on the assumption that the wells would be properly constructed for maximum yield and screened in all sands containing fresh to slightly saline water. The estimated potential yields of wells tapping the Carrizo Sand and Wilcox Group increase from zero near the northwest margin of the Wilcox outcrop to at least 2,000 gpm fron the combined Carrizo and Wilcox in the northeast-trending band across the east-central part of the county. The estimated yield decreases to 700 to 1,000 gpm in a small area in the east corner of the county because water in part of the sand in the Wilcox becomes moderately saline.

The 0 to 500 gpm area is entirely on the Wilcox outcrop. Sand thicknesses and yields vary considerably in short distances.

The base of fresh to slightly saline water in the Carrizo Sand and Wilcox Group ranges from about 500 feet above sea level in places along the northwestern extent of the Wilcox outcrop to about 3,400 feet below sea level 5 miles southwest of Smithville (Figure 19). The configuration of this base of fresh to slightly saline water roughly conforms to the configuration of the base of the Wilcox Group in the area northwest of the outcrop of the Reklaw Formation, as nearly all of the Wilcox in this area contains only fresh to slightly saline water. Southeast of the outcrop of the Carrizo Sand, the basal sand in the Wilcox contains moderately saline water.

The approximate thickness of sand in the Carrizo Sand and Wilcox Group ranges from zero where the saturated sand is first encountered near the northwestern extent of the Wilcox outcrop to more than 1,400 feet in a small area a few miles east of Bastrop and immediately southeast of the Carrizo outcrop (Figure 20). A large area of sand in the subsurface from 1,200 to 1,400 feet thick in the Carrizo Sand and Wilcox Group is between Bastrop and Smithville and extends from Lee County to near the Caldwell County line. Usually these areas of thick accumulations of sand are most favorable for developing large water supplies.

The quantity of water perennially available from the Carrizo-Wilcox aquifer, which is the most favorable aquifer for future large-scale developments of ground water, depends chiefly on the rate of recharge. To estimate the rate of recharge, it is assumed that the ground water passes through a vertical section of the aquifer 35 miles long, roughly along the line of contact of the Carrizo Sand and Reklaw Formation (Figure 5). In this vertical section, the composite transmissivity of the sand is estimated from sand thickness and hydraulic conductivity to be about 150,000 gpd per foot; the average hydraulic gradient is about 4 feet per mile. On this basis, the quantity of water that moves across this vertical section is about 21 mgd or about 23,000 acre-feet per year; this quantity is the present transmission capacity of the aquifer and represents a part of the total rate of recharge. In addition, an unknown quantity of recharge is rejected to streams as spring flow and seepage on the outcrop, and some is consumed by evapotranspiration. Therefore, the 21 mgd of recharge that is effectively replenishing the aquifer represents a conservative quantity of water that is available for development on a perennial basis without depleting the aquifer.

Converted to annual precipitation, the 21 mgd (23,000 acre-feet per year) is equivalent to about 1 1/2 inches of water effectively recharging the approximately 280 square miles of the sandy part of the Wilcox Group and Carrizo Sand that crops out in the county. The 1 1/2 inches of recharge, which is 4 percent of the average annual precipitation at Smithville, compares favorably with the 2.2 inches of recharge (7 percent of the average annual precipitation) to the Carrizo Sand and Wilcox Group in adjacent Caldwell County (Follett, 1966, p. 49).

In addition to the 23,000 acre-feet per year (the present recharge and transmission rate) that is available on a perennial basis, about 85,000,000 acre-feet of water is in transient storage in the Carrizo-Wilcox aquifer. Most of this water in storage is not available to wells because of economic factors and because a large part of the water cannot be drained from the sand. However, a part of this vast quantity of water in storage is available for more intensive development in excess of the perennial yield.

In order to determine how much is readily available for intensive development, the following assumptions are necessary to calculate the amount of water that would be obtained if wells were installed so that the Carrizo-Wilcox aquifer could be dewatered to a depth of 400 feet:

1. The average depth to water at present is 50 feet; therefore 350 feet of the upper 400 feet is saturated.

2. The water is under water-table conditions to 400 feet.

3. No water is released from the clays in the Wilcox or from the sands below 400 feet.

4. Half of the saturated 350 feet (or 175 feet) is sand.

5. Thirty percent of the sand is void and only half of the water therein is recoverable by wells.

6. There are no large-scale ground-water developments of the Carrizo-Wilcox aquifer in adjoining counties to the east, south, or west.

7. Recharge, which probably would continue at an accelerated rate, is excluded from the calculations.

The results of the calculations indicate that about 7 million acre-feet of water could be pumped from storage. This quantity would supply, for example, 100 mgd (about 112,000 acre-feet per year) for more than 60 years. Thereafter, the pumping rate would need to be reduced to stabilize the declining water levels.

About 1 million acre-feet of water is in transient storage in the Sparta Sand, but only a small part of this quantity is available to wells. The water is fresh to slightly saline throughout the Sparta's subsurface extent in the county. Yields of 200 gpm, and possibly as much as 400 gpm in some places, could be obtained from wells tapping the Sparta except in places on its outcrop where the Sparta is relatively thin.

Based on a transmissivity of 14,000 gpd per foot, a hydraulic gradient of 5 feet per mile, and a 28-mile length of aquifer across which the water moves, the transmission capacity of the Sparta is about 2 mgd or about 2,200 acre-feet per year. Assuming no major development of the Sparta in Lee or Fayette Counties, this quantity of water could be pumped perennially from the Sparta in Bastrop County without excessive decline of water levels.

About 14 million acre-feet of water is in transient storage in the Queen City Sand in Bastrop County. Except in a few places, the water is fresh to slightly saline throughout its subsurface extent in the county. Probably 300 gpm or more could be pumped from properly constructed wells tapping the Queen City, except in places on the outcrop where the aquifer is relatively thin.

The transmission capacity of the Queen City Sand in Bastrop County is about 2 mgd or about 2,200 acre-feet per year. This is based on an average transmissivity of 10,000 gpd per foot, an average hydraulic gradient of 5 feet per mile, and a 36-mile length of aquifer across which the water moves. The 10,000 gpd per foot transmissivity is derived from an estimated average saturated sand thickness of 200 feet in the county and a hydraulic conductivity of 50 gpd per square foot from the Smithville aquifer test. This hydraulic conductivity compares favorably with the 43 gpd per square foot obtained at Giddings in Lee County by Thompson (1966, p. 37), who also assigned an average transmissivity of 10,000 gpd per foot to the Queen City in Lee County. Assuming no major development of the Queen City in the adjoining counties, it is estimated that the present transmission capacity of about 2 mgd or about 2,200 acre-feet per year could be pumped perennially from the Queen City Sand in Bastrop County without excessive decline of water levels.

QUALITY OF GROUND WATER

Quality Standards and Suitability for Use

The suitability of a water supply largely depends on its chemical quality and the contemplated use of the water. Wells in and near the outcrop of nearly all of the aquifers in Bastrop County generally yield water that is of good chemical quality and suitable for most uses. However, in moving downdip through the aquifers, the water dissolves the soluble rock material and increases its mineral content. Consequently, those parts of the aquifers at considerable depth generally yield water that is more mineralized than the water from these same aquifers at shallow depths. Table 7 indicates the source and significance of dissolved mineral constituents and properties of water.

The chemical analyses of water samples from 171 wells and 1 spring in Bastrop County are given in Table 13. Except where otherwise noted, these analyses were made by the U.S. Geological Survey in Austin, Texas.

The depth of a well is an important influence on many chemical constituents and properties of ground water, especially iron, hardness, dissolved solids, and pH. Analyses in Table 13 represent water from 22 wells less than 40 feet in depth, 37 wells from 40 to 100 feet in depth, 70 wells from 101 to 500 feet in depth, 39 wells from 501 to 1,000 feet in depth, and 2 wells more than 1,000 feet in depth. The depth range was from 16 to 1,220 feet.

Much of the ground water in Bastrop County conforms to the chemical standards established by the U.S. Public Health Service (1962, p. 7-8) for drinking water used on common carriers engaged in interstate commerce. According to the standards, chemical constituents should not be present in a water supply in excess of the stated concentrations whenever more suitable supplies are, or can be made, available at reasonable cost. Some of the chemical constituents used in evaluating public water supplies are fluoride, iron, sulfate, chloride, nitrate, and dissolved solids. Table 8 shows a comparison of the quality of ground water in Bastrop County with the standards recommended by the U.S. Public Health Service and other authorities.

Excessive iron in water is one of Bastrop County's chief water-quality problems. An excessive concentration of iron (greater than 0.3 mg/l) contributes a metallic taste to water, and if iron occurs in excess of 0.5 or 0.6 mg/l, yellow or reddish stains appear on plumbing fixtures and washed clothing looks dingy. Of the iron determinations made, the minimum was 0.00 mg/l in well AT-58-47-705 (depth 632 feet) tapping the Wilcox Group, and the maximum was 210 mg/l in well AT-67-14-408 (depth 159 feet) tapping the Queen City Sand. Of the 104 iron determinations tabulated in Table 8, 77 exceeded 0.3 mg/l.

The high iron concentrations can be reduced by aeration or other methods. Removal or reduction of iron by cities or industries having iron problems is fairly common and relatively simple. But generally, in rural areas, where water is pumped from the well directly into an automatic pressure system, no convenient method of iron removal or reduction, other than the installation of commercial systems, is available.

Large concentrations of sulfate in combination with other ions impart a bitter taste to water, commonly referred to as an alum taste. Sulfate in excess of 250 mg/l acts as a laxative in some people. The minimum concentration of sulfate in the samples analyzed was 1 mg/l in well AT-58-63-803 (depth 230 feet) tapping the Reklaw Formation, and the maximum was 1,740 mg/l in well AT-58-56-504 (depth 200 feet) tapping the Cook Mountain Formation. Of 160 sulfate determinations tabulated in Table 8, only 31 (19 percent) contained more than 250 mg/l sulfate. The high sulfate water, which occurred in samples from all of the aquifers, affects only local areas and is not a significant problem in Bastrop County.

Water having a chloride content exceeding 250 mg/l may have a salty taste, but if the concentration is not too excessive, individuals may become conditioned to the waters in a short time. Of the samples analyzed for chloride, the minimum concentration was 6.1 mg/l in well AT-58-55-203 (depth 173 feet) tapping the Carrizo Sand, and the maximum was 2,150 mg/l in well AT-58-64-504 (depth 79 feet) tapping the Yegua Formation. Of the 162 chloride determinations tabulated in Table 8, only 20 (12 percent) contained over 250 mg/l chloride. The high chloride concentrations, which occurred in samples from all of the aquifers except the Carrizo Sand, Reklaw Formation, and alluvium, are not a serious problem in Bastrop County.

Figure 21 shows the depth of wells tapping various aquifers in Bastrop County and iron and chloride content of water from the wells. The iron-depth relationship established for Lee County by Thompson (1966, p. 58-63) -that the iron concentration is greater in water from wells about 80 to 375 feet in depth than it is in wells less than 80 feet or more than 375 feet-does not seem to be as clearly defined in Bastrop County. The iron concentration as tabulated in Table 8 was more than 0.3 mg/l in 74 percent of the samples from wells 80 to 375 feet in depth but was also more than 0.3 mg/l in 76 percent of the wells less than 80 and more than 375 feet in depth. The first noticeable decrease in the iron concentration occurs below 600 feet where only 57 percent of the iron determinations was more than 0.3 mg/l.

Most of the wells shown in Figure 21 tap sand beds well above the base of fresh to slightly saline water, and in these parts of the aquifers, shallow wells may have higher chloride concentrations than nearby deeper wells. However, the chloride concentration rises sharply near the base of the fresh to slightly saline water.

The upper limit of fluoride for an area varies with the annual average of maximum daily air temperatures. On the basis of the 38-year annual average of maximum daily air temperature of 27°C (81.3°F) at Smithville, fluoride in water should not average more than 0.8 mg/l in Bastrop County. Table 13 shows that fluoride exceeded the 0.8 mg/l limit in only 5 (2 from same well) of the 104 samples analyzed for fluoride. The maximum fluoride content was 2.0 mg/l in a well tapping the Reklaw Formation and Queen City Sand, 11 samples contained no fluoride. Of the 81 fluoride determinations tabulated in table 8, only 2 contained more than 0.8 mg/l fluoride.

Concentrations of nitrate in excess of 45 mg/l (the upper limit recommended by the U.S. Public Health Service) in water used for infant feeding have been related to the incidence of infant cyanosis (methemoglobinemia or "blue baby" disease)-a reduction of the oxygen content in the blood constituting a form of asphyxia (Maxcy, 1950, p. 271). Nitrate in concentrations of more than several milligrams per liter may

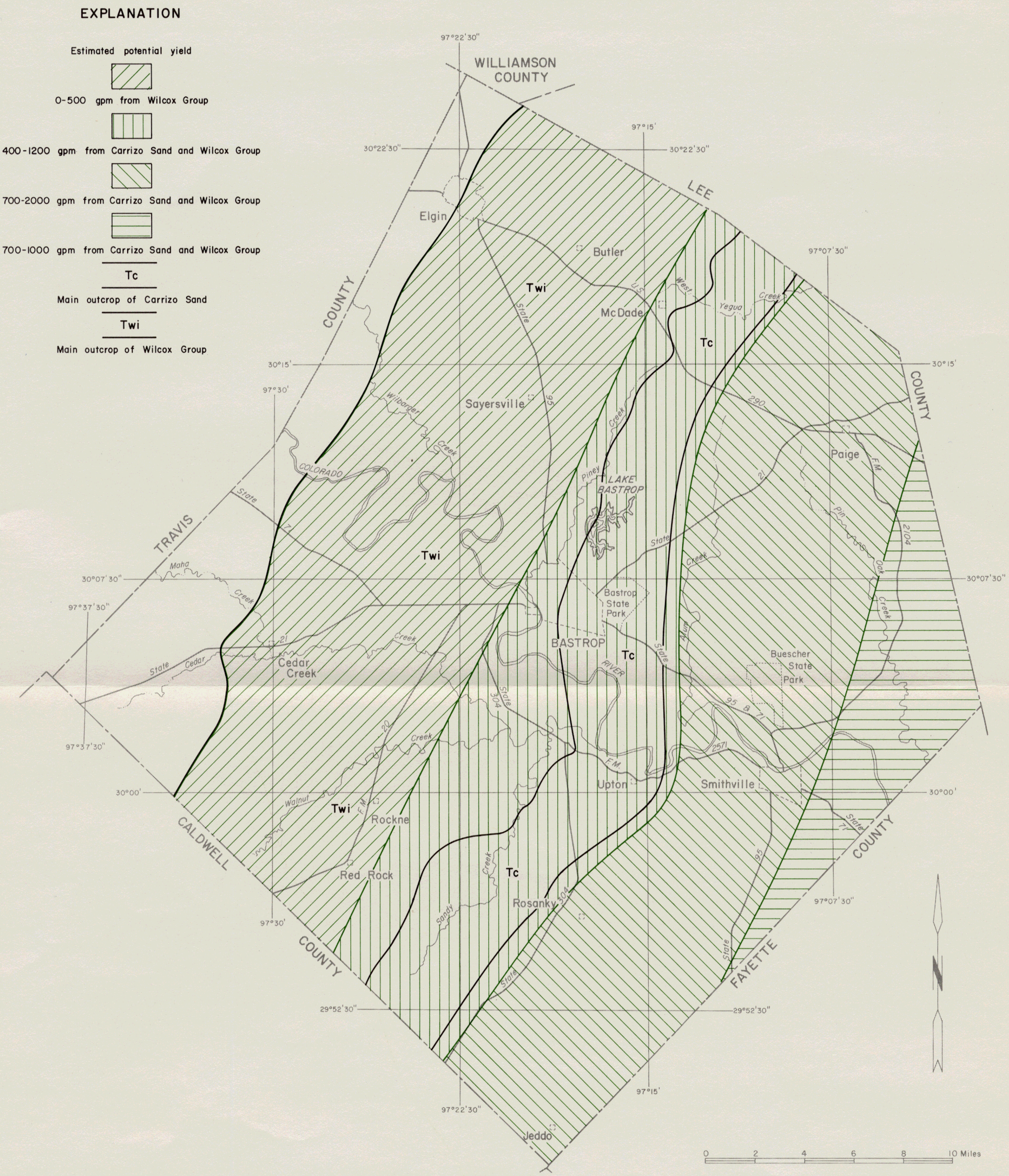


Figure 18

ESTIMATED POTENTIAL YIELD OF WELLS TAPPING THE CARRIZO SAND AND WILCOX GROUP

Base map from U.S. Geological Survey topographic quadrangles

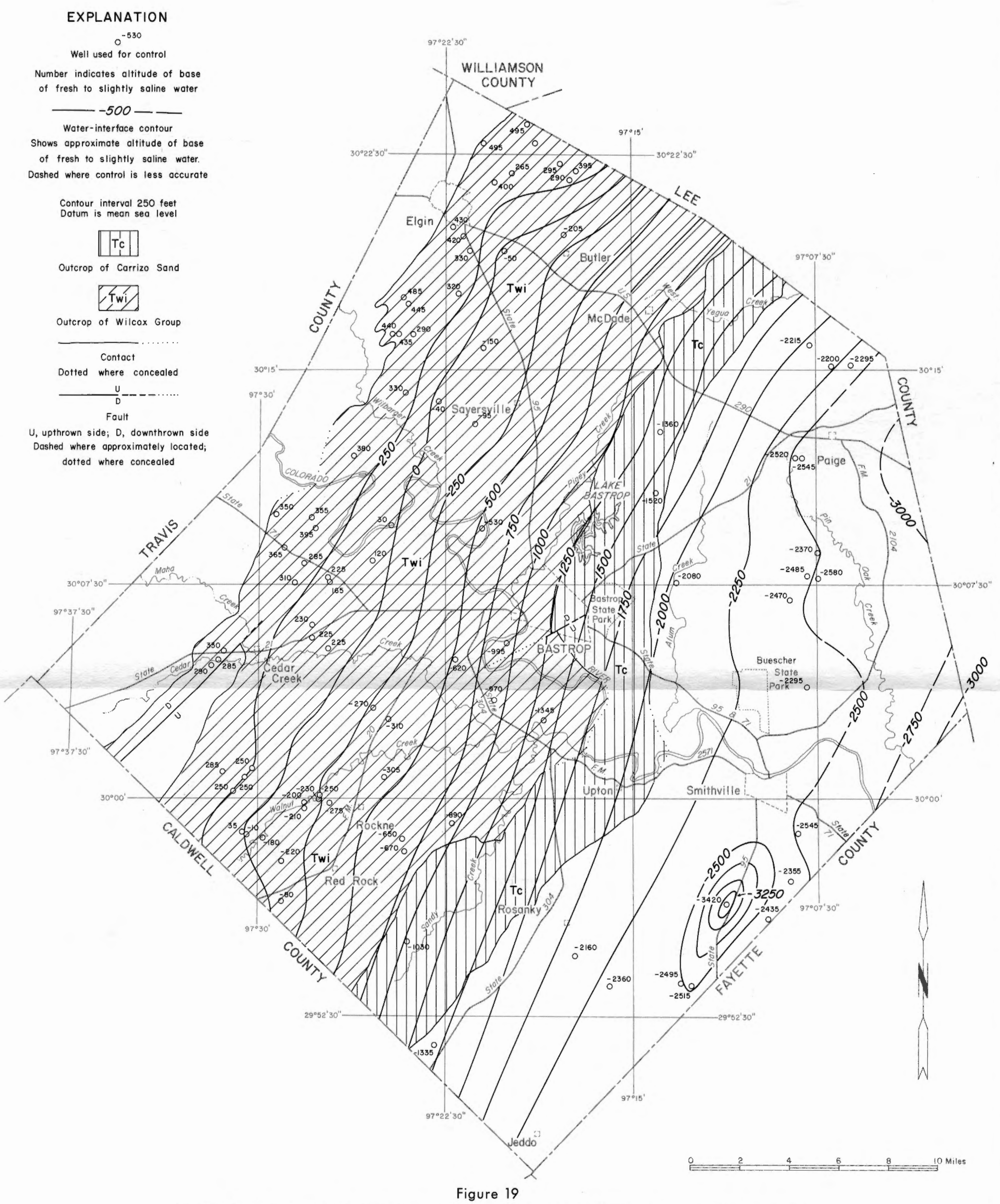


Figure 19

APPROXIMATE ALTITUDE OF THE BASE OF FRESH TO SLIGHTLY SALINE WATER IN THE CARRIZO SAND AND WILCOX GROUP

Base map from U.S. Geological Survey topographic quadrangles

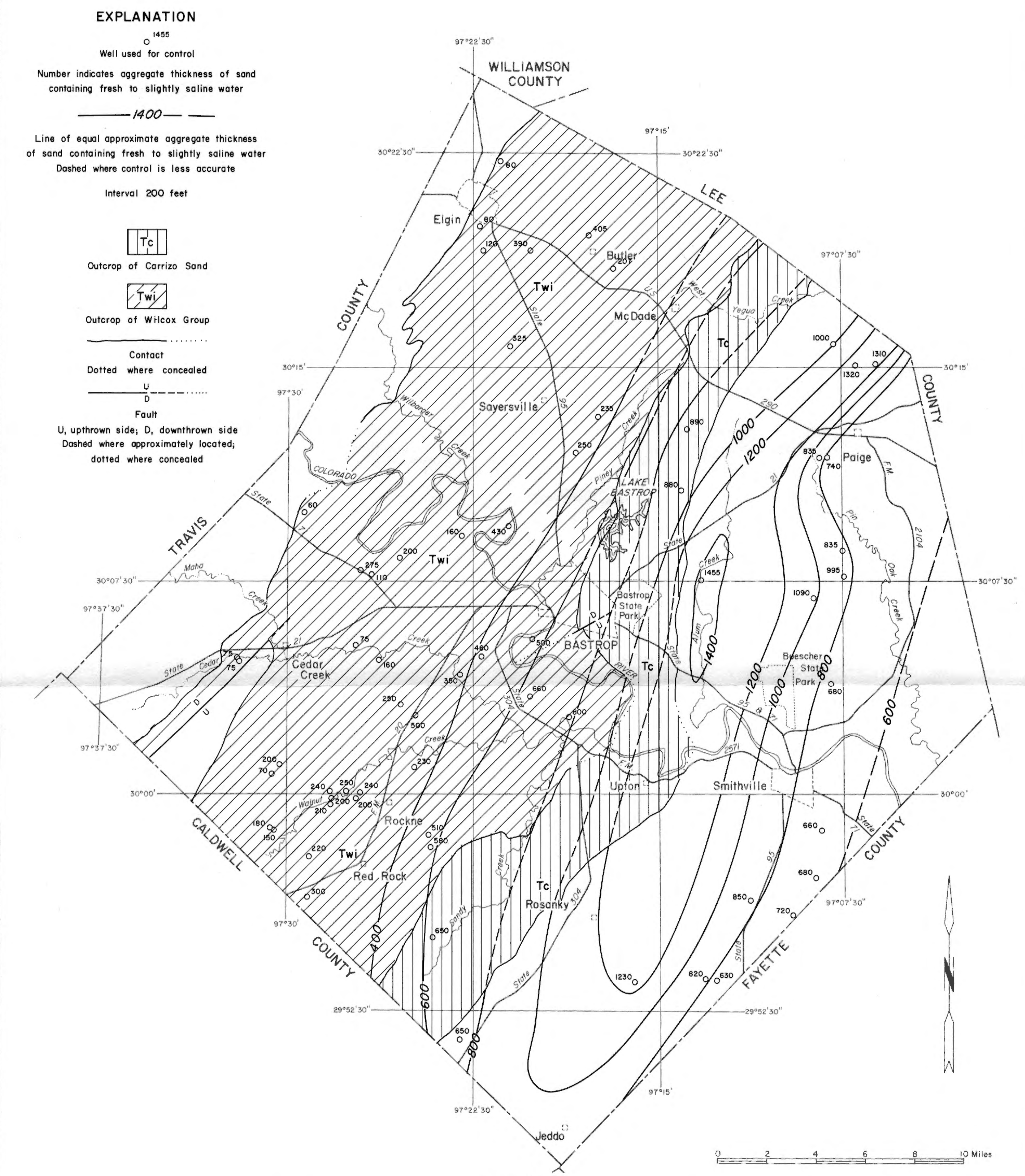


Figure 20

APPROXIMATE THICKNESS OF SAND CONTAINING FRESH TO SLIGHTLY SALINE WATER IN THE CARRIZO SAND AND WILCOX GROUP

Base map from U.S. Geological Survey topographic quadrangles

Table 7.--Source and Significance of Dissolved-Mineral Constituents and Properties of Water

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

indicate previous contamination by sewage or other organic matter (Lohr and Love, 1954, p. 10). The nitrate of 145 determinations tabulated in Table 8 ranged from 0.0 mg/l in 56 samples to 995 mg/l in well AT-58-55-605 (depth 38 feet) tapping the Weches Greensand. In only eight wells did the nitrate exceed 45 mg/l. These were dug wells 27 to 56 feet in depth. Because the high nitrate concentrations were all in dug wells, the pollution probably was from nitrogenous material washing or falling into the wells. In some places, properly curbed wells would undoubtedly reduce the nitrate content of the water.

A general classification of water based on dissolved-solids content in mg/l is as follows (Winslow and Kister, 1956, p. 5):

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

The upper limit of dissolved solids, as recommended by the U.S. Public Health Service, is 500 mg/l. The dissolved-solids content of 203 water samples collected in Bastrop County ranged from a minimum of 67 mg/l in well AT-58-55-203 (depth 173 feet) tapping the Carrizo Sand to a maximum of 4,020 mg/l in well AT-67-07-505 (depth 289 feet) tapping the Cook Mountain Formation. Of the 144 determinations tabulated in Table 8 (not more than one per well), the dissolved-solids content was less than 500 mg/l in 71 samples (49 percent), between 500 and 1,000 mg/l in 48 samples (34 percent), and more than 1,000 mg/l in 25 samples (17 percent).

In Bastrop County, selective testing while drilling wells would greatly increase the chance of finding water containing less than 500 mg/l dissolved solids from the Wilcox Group, Carrizo Sand, Queen City Sand, and Sparta Sand. The Midway Group, Reklaw Formation, Weches Greensand, Cook Mountain Formation, and Yegua Formation are less likely to yield water having less than 500 mg/l dissolved solids.

Calcium and magnesium are the principal constituents that cause hardness of water. Water having a hardness of 60 mg/l or less is classed as soft; 61 to 120 mg/l, moderately hard; 121 to 180 mg/l, hard; and more than 180 mg/l, very hard. Excessive hardness causes increased consumption of soap and induces the formation of scale in tea kettles, hot water heaters, boilers, and pipes.

In Bastrop County, in general, the water from shallow wells is very hard, but softer water can be obtained from relatively deep wells. The hardness, as determined in 229 samples, ranged from 4 mg/l in well AT-58-46-402 (depth 80 feet) tapping the Wilcox Group, to 2,450 mg/l in well AT-67-07-505 (depth 289 feet) tapping the Cook Mountain Formation. Of the 164 determinations tabulated in Table 8 (not more than one per well), the hardness was over 60 mg/l in 133 samples.

All of the water samples from the alluvium, Yegua Formation, Cook Mountain Formation, and Weches Greensand were very hard (more than 180 mg/l). Water samples from the Reklaw Formation, Queen City Sand, Carrizo Sand, and Wilcox Group ranged from soft to very hard. Water samples from wells 400 feet deep or more usually were softer than water from shallower wells.

The quality of water for industry does not necessarily depend on its acceptability for human consumption, but varies according to the individual requirements of each process. Ground water used for industry may be classified into three principal categories—boiler, cooling, and processing. Of these, the quantity used for cooling far exceeds the others. Cooling water is usually selected not only for its temperature and source of supply, but also for its chemical quality. Any water-quality characteristic that may adversely affect heat exchange surfaces is undesirable. For example, calcium, magnesium, aluminum, iron, and silica may cause scale which reduces heat exchange. Corrosiveness also is an objectionable feature. Acids, oxygen, carbon dioxide, calcium and magnesium chloride, and sodium chloride make water corrosive.

Boiler water for the production of steam must meet rigid chemical-quality requirements because the problems of corrosion and encrustation are intensified when water is heated. Treatment of boiler water generally is needed, and therefore its suitability for treatment must be considered, because in modern closed systems the boiler water is reused many times. The calcium and magnesium content affects the industrial value of water by contributing to the formation of scale. Silica in boiler water is undesirable because it also forms a hard scale, the scale-forming tendency increasing with pressure in the boiler. The following table shows maximum suggested concentrations of silica for water used in boilers (Moore, 1940, p. 263).

CONCENTRATION OF SILICA (MG/L)	BOILER PRESSURE (POUNDS PER SQUARE INCH)
40	Less than 150
20	150 to 250
5	251 to 400
1	More than 400

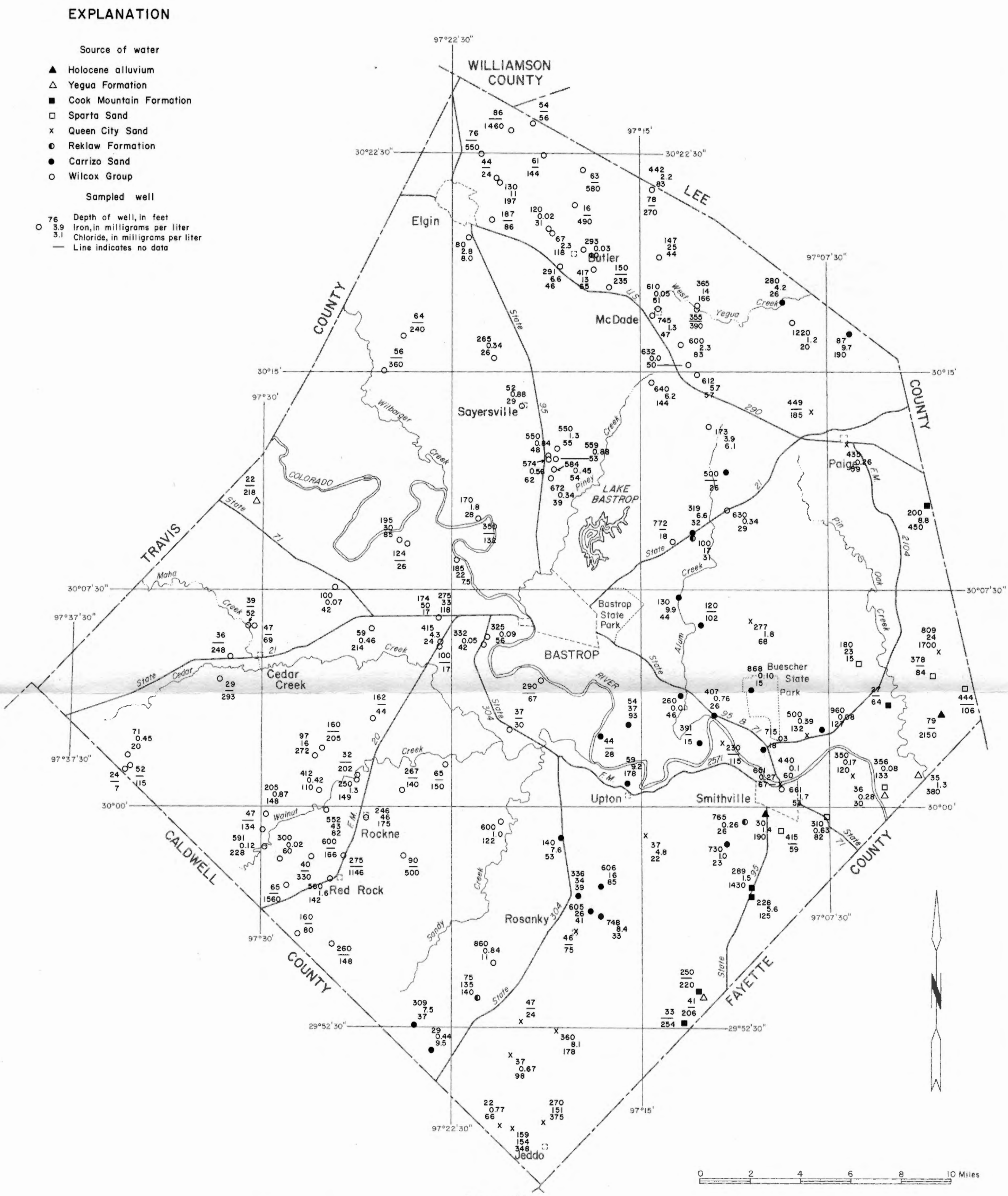


Figure 21

DEPTHS OF WELLS TAPPING VARIOUS AQUIFERS AND IRON AND CHLORIDE CONTENT OF WATER FROM WELLS

Base map from U.S. Geological Survey topographic quadrangles

Table 8.--Comparison of Quality of Ground Water in Bastrop County With Standards Recommended by U.S. Public Health Service (1962, p. 7-8) and Others.

	CRITERIA FOR PUBLIC AND DOMESTIC SUPPLY																		CRITERIA FOR IRRIGATION SUPPLY									
	SILICA (SiO_2)		IRON (Fe)		SULFATE (SO_4)		CHLORIDE (Cl)		FLUORIDE (F)		NITRATE (NO_3)		DISSOLVED SOLIDS				HARDNESS AS $CaCO_3$		SPECIFIC CONDUCTANCE (MICROMHOS at 25°C)				SODIUM-ADSORPTION RATIO		RESIDUAL SODIUM CARBONATE		BORON (B)	
UPPER LIMITS[a]	20 MG/L		0.3 MG/L		250 MG/L		250 MG/L		0.8 MG/L		45 MG/L		500 MG/L				60 MG/L		2250				14 ME/L		2.5 ME/L		1.0 mg/l	
	NUMBER OF DETERMINATIONS																											
	Total	Over 20 mg/l	Total	Over 0.3 mg/l	Total	Over 250 mg/l	Total	Over 250 mg/l	Total	Over 0.8 mg/l	Total	Over 45 mg/l	Total	Less than 500 mg/l	500 to 1000 mg/l	Over 1000 mg/l	Total	Over 60 mg/l	Total	Over 2250	Total	Over 2250	Total	Over 14 me/l	Total	Over 2.5 me/l	Total	Over 1.0 mg/l
Midway Group	3	2	1	1	5	2	5	3	1	0	4	1	4	0	1	3	5	5	4	1	0	0	1	0	1	0	0	0
Wilcox Group	69	53	54	40	87	14	89	10	46	2	85	3	77	38	28	11	93	79	76	4	72	5	35	7	33	10	13	0
Carrizo Sand	21	16	19	17	21	0	21	0	12	0	20	1	19	18	1	0	22	11	22	0	29	1	10	0	9	1	3	0
Reklaw Formation	3	1	3	2	4	1	4	0	1	0	3	0	4	1	3	0	4	2	4	0	2	0	1	0	2	0	1	0
Queen City Sand	16	6	13	8	18	7	18	3	12	0	15	0	18	5	8	5	18	14	17	3	17	0.	7	1	7	0	1	0
Weches Greensand	2	2	2	2	2	1	2	0	2	0	2	1	2	0	1	1	1	1	1	1	2	0	0	0	0	0	0	0
Sparta Sand	6	1	3	2	6	1	6	0	2	0	6	0	6	3	3	0	6	6	6	0	10	0	4	0	3	0	1	0
Cook Mountain Formation	5	2	4	4	7	2	7	3	0	0	5	2	5	0	3	2	7	7	5	2	4	1	3	0	3	0	0	0
Yegua Formation	1	1	0	0	2	1	2	1	0	0	1	0	1	0	0	1	2	2	1	1	1	0	0	0	0	0	0	0
Alluvium	4	3	5	1	8	2	8	0	5	0	4	0	8	6	0	2	6	6	7	0	20	0	0	0	0	0	0	0
Totals	130	87	104	77	160	31	162	20	81	2	145	8	144	71	48	25	164	133	143	12	157	7	61	8	58	11	19	0

[a] See section entitled "Quality of Ground Water" in this report.

The upper limit for silica in boiler-feed water is 20 mg/l if boiler pressures are as much as 250 psi (pounds per square inch). Of the 130 determinations tabulated in Table 8, the minimum concentration of silica was 0.4 mg/l in well AT-58-56-801 (depth 572 feet) tapping the Queen City Sand, and the maximum was 117 mg/l in well AT-58-47-402 (depth 147 feet) tapping the Wilcox. In almost 67 percent of the samples, silica exceeded 20 mg/l. Except for the Sparta Sand and the Queen City Sand, silica exceeded 20 mg/l in about half or more than half of the samples.

The suitability of water for irrigation depends on the chemical quality of the water and other factors such as soil texture and composition, the subsoil texture, type of crop, irrigation practices, and climate. Many classifications of irrigation water express its suitability in terms of one or more variables; and offer criteria for evaluating the relative overall suitability of irrigation water rather than placing rigid limits on the concentrations of certain chemical constituents The more important variables in the evaluation of water for irrigation are the proportion of sodium to total ions, an index of the sodium hazard; total concentration of soluble salts, an index of the salinity hazard; amount of boron; and RSC (residual sodium carbonate).

A high percentage of sodium in water tends to break down soil structure by deflocculating the colloidal particles. Consequently, the soil may become plastic, the movement of water and air through the soil can be restricted, drainage problems may develop, and cultivation may be difficult.

A system of‘ classification commonly used for judging the suitability of the quality of water for irrigation was proposed by the U.S. Salinity Laboratory Staff (1954, p. 69-82). It is based primarily on the salinity hazard as measured by the electrical conductivity of the watelr and on the sodium hazard as measured by the SAR (sodium-adsorption ratio). Wilcox (1955, p. 15) stated that this system of classification "...is not directly applicable to supplemental waters used in areas of relatively high rainfall." Because the annual precipitation in Bastrop County averages about 37 inches, most irrigation is supplemental; the classification is therefore not directly applicable but is useful as a guide. Generally, water may be used safely for supplemental irrigation, according to Wilcox (1955, p. 16), if its conductivity is less than 2,250 micromhos per centimeter at 25°C and its SAR is less than 14.

The system of classification (Figure 22) shows that of 26 samples (11 from irrigation wells, 11 from domestic and livestock. wells, and 4 from public supply wells), 21 samples had SAR of less than 14 and conductivities of less than 2,250. Of the other five samples, of which only one exceeded both the SAR of 14 and conductivity of 2,250, two were from wells used for irrigation-well AT-67-05-1 10 for occasional supplemental irrigation of Bermuda grass for grazing, and well AT-67-05-201 for supplemental irrigation of an orchard and vegetables. No ill effects were observed as the result of using this water since 1951 for limited irrigation. Thus, in Bastrop County, where irrigation is used chiefly to supplement the relatively high rainfall, much of the ground water would be suitable for supplemental irrigation on the generally sandy soil.

Most of the water samples with a SAR of more than 14 or a specific conductivity of more than 2,250 either came from shallow wells or deeper wells in formations not likely to yield enough water for irrigation. Where the water quality is questionable, such factors as soil type, both surface and subsurface drainage, and method of application should be considered.

An excessive concentration of boron renders water unsuitable for irrigation. Scofield (1936, p. 286) indicated that boron concentrations of as much as 1 mg/l are permissible for irrigating most boron-sensitive crops, and concentrations as much as 3 mg/l are permissible for the more boron-tolerant crops. Table 8 shows that in 19 samples none exceeded 1.0 mg/l. The boron content ranged from 0.00 to 0.72 mg/l (only three samples exceeded 0.4 mg/l). Boron probably will not be a problem in Bastrop County.

Another factor used in assessing the suitability of water for irrigation is the RSC. Excessive RSC will cause the water to be alkaline, and the organic content of the soil on which it is used may become a grayish-black. The soil thus affected is referred to as "black alkali". Wilcox (1955, p.11) states that laboratory and field studies have resulted in the conclusion that water containing more than 2.5 me/l (milliequivalents per liter) RSC is not suitable for irrigation; water containing from 1.25 to 2.5 me/l is marginal, and water containing less than 1.25 me/l probably is safe. However, it is believed that good irrigation practices and proper use of soil additives might make it possible to use successfully the marginal water for irrigation. Furthermore, the degree of leaching will modify the limit to some extent (Wilcox, Blair, and Bower, 1954, p. 265). The generally sandy soils in Bastrop County, coupled with relatively high rainfall, should offer a relatively high degree of leaching.

The RSC as determined in 58 samples in Bastrop County ranged from 0.00 to 10.0 me/l in 37 samples. RSC ranged from 0.01 to 1.25 me/l in seven samples, from 1.26 to 2.50 me/l in three samples, and from 2.51 to 10.1 me/l in 11 samples. Table 8 shows the highest incidence of RSC to be in the Wilcox Group.

Because irrigation in Bastrop County is practiced only during periods of deficient rainfall, and because much of the ground water from the principal aquifers meets various irrigation standards, use of this water is considered safe for agriculture. Coastal Bermuda grass is the principal crop irrigated and is relatively tolerant to sodium and salinity hazards. Furthermore, most of the irrigated land is sandy to very sandy and generally has good drainage. The sprinkler system of application of irrigation water was used by all irrigators in the county, and this method may permit the use of poorer quality water because smaller applications are possible. The Carrizo Sand and Wilcox Group supply most of the ground water used for irrigation.

Ground water of good chemical quality is available in many of the aquifers in Bastrop County. Large supplies of ground water suitable for public supply, irrigation, and many industrial needs are obtainable from the Wilcox Group, Carrizo Sand, Queen City Sand, and Sparta Sand. Water-bearing formations having poorer quality water are the Reklaw Formation, Weches Greensand, Cook Mountain Formation, Yegua Formation, and alluvium.

Disposal of Oil-Field Brine

Relatively little oil-field brine has been produced in conjunction with oil in Bastrop County. In 1961, 69,492 barrels of brine was produced with about 125,000 barrels of oil. Table 9 shows the reported quantity of salt water produced in connection with the production of oil in Bastrop County in 1961. Between 1961 and 1966, six additional producing oil fields were discovered. Figure 23 shows the location of the producing oil fields.

The Railroad Commission of Texas requires that the brine be disposed of in such a manner that it will not contaminate potable surface or ground water. The open-pit method of brine disposal is one of the most hazardous of the methods available to the oil industry. Brine in open pits is allowed to evaporate but is free to soak into the ground and contaminate the ground water, and some may overflow into the natural drainage. Even if the brine evaporated, the salt would remain in the pit as a source of contamination unless the pit had a relatively impervious lining (and very few do).

Two significant conditions occur in an aquifer upon contamination. First, the brine that is being added to the ground at one point may not affect the quality of water in wells nearby for many years because of the slow movement of the ground water; consequently, no complaints may be registered and no one may be aware of the damage done. Second, when the contamination is finally discovered, or when the quality of the water supply is degraded, the damage cannot be immediately rectified merely by stopping the contamination at its

Table 9.—Oil-Field Brine Production and Disposal, 1961

(From Texas Water Commission and Texas Water Pollution Control Board, 1963)

OIL FIELD	BRINE PRODUCTION (BARRELS)	BRINE DISPOSAL			
		OPEN SURFACE PIT		UNKNOWN	
		BARRELS	PERCENT	BARRELS	PERCENT
Bateman	4,480	3,385	75.6	1,095	24.4
Cedar Creek	7,025	7,025	100	0	0
Hilbig	20,700	20,700	100	0	0
Hilbig, south	0	0	0	0	0
Jim Smith	750	750	100	0	0
Lentz	21,900	21,900	100	0	0
Marsha	800	800	100	0	0
Peg (Austin Chalk)	1,277	1,277	100	0	0
Peg (Buda Lime)	2,000	2,000	100	0	0
Pierson (1,500 Serpentine)	0	0	0	0	0
Riddle	1,460	1,460	100	0	0
Yoast	9,100	9,100	100	0	0
Totals*	69,492	68,397	98.4	1,095	1.6

* 99.5 percent is within Colorado River watershed;
0.5 percent is within Guadalupe River watershed.

source, becuase purification by leaching and dilution will require a longer time than the period of contamination. A no-pit order by the Railroad Commission went into effect throughout Texas on January 1, 1969. This was a big step forward, but it will not mean that pollution of ground water by oil-field brine has ended. Other methods of brine disposal are potentially hazardous. The injection method of disposal is effective, except that generally the brine is gathered and stored in pits and then pumped into the injection wells. Some of the brine may seep into the fresh-water aquifer if the pit is dug into permeable material and is unlined. Also, leaks from injection wells are hard to detect before they have damaged the ground-water supply.

No evidence of contamination of ground water by salt water was found although contamination could be occurring locally. There is little present danger of widespread contamination by oil-field brine in Bastrop County because only a relatively small quantity of brine is produced annually. Yet, brine even in small quantities when improperly disposed is a potential source of contamination of ground water.

CONCLUSIONS

Although the population of the county is decreasing, the use of ground water is gradually increasing. However, the quantity used in 1966 (4,100 acre-feet) is small compared with the quantity of fresh and slightly saline ground water available (at least 23,000 acre-feet per year). About 100 million acre-feet is in transient storage in the principal aquifers. Of this, 85 percent is in the Carrizo-Wilcox aquifer. Excessive iron and hardness are the main ground-water quality problems.

Although the ground-water resources of Bastrop County are for the most part underdeveloped, a program of hydrologic data collection should be established to refine the estimates of availability which have been made. This program should include an expansion of the program of observation of water levels to cover the area adequately; it should also include a program of annual inventory of ground-water pumpage. A continuing inventory should be made of new large wells as they are drilled. Wells should be selected for resampling purposes in order to keep abreast of changes in quality of water as a result of development and possible oil-field brine pollution.

DEFINITIONS OF TERMS

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

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

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

Fresh water.—Water containing less than 1,000 mg/l (milligrams per liter) dissolved solids (Winslow and Kister, 1956, p. 5).

Hydraulic conductivity.—The rate of flow of water in gallons per day through a cross sectional area of 1 square foot under a unit hydraulic gradient. Also called coefficient of permeability.

Moderately saline water.—Water containing 3,000 to 10,000 mg/l dissolved solids (Winslow and Kister, 1956, p. 5).

Potentiometric surface.—The imaginary surface to which water will rise in artesian wells or the surface formed by the water table in the outcrop areas. The terms "water table" and "potentiometric surface" are synonymous in the outcrop area, but potentiometric surface alone is applicable in artesian areas.

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

Slightly saline water.—Water containing 1,000 to 3,000 mg/l dissolved solids (Winslow and Kister, 1956, p. 5).

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

Specific conductance (conductivity).—A measure of the ability of a solution to conduct electricity, expressed in micromhos per centimeter at 25°C. It is approximately proportional to the content of dissolved solids.

Storage coefficient.—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.

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

Transmissivity.—The number of gallons of water that will move in one day through a vertical strip of the aquifer one foot wide and having the height of the aquifer when the hydraulic gradient is unity. It is the product of the hydraulic conductivity and the saturated thickness of the aquifer. Also called coefficient of transmissibility.

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

Water table.—The upper surface of a saturated zone except where that surface is formed by impermeable material.

Yield.—The following ratings apply for general discussion of yields of wells in Bastrop County.

DESCRIPTION	YIELD (GALLONS PER MINUTE)
Small	Less than 50
Moderate	50 to 500
Large	More than 500

REFERENCES CITED

Adams, J. B., Jr., 1957, The petrology and origin of the Simsboro Sand, Bastrop County, Texas: Univ. Texas (unpublished Master's thesis), 75 p.

Anders, R. B., 1957, Ground-water geology of Wilson County, Texas: Texas Board Water Engineers Bull. 5710, 62 p., 9 figs., 3 pls.

Austin, G. M., 1954, Records of wells in Bastrop County, Texas: Texas Board Water Engineers Bull. 5413, 43 p., 1 pl.

Darton, N. H., and others, 1937, Geologic map of Texas: U.S. Geol. Survey map.

Follett, C. R., 1966, Ground-water resources of Caldwell County, Texas: Texas Water Devel. Board Rept. 12, 138 p., 18 figs., 3 pls.

Gillett, P. T., and Janca, I. G., 1965, Inventory of Texas irrigation, 1958 and 1964: Texas Water Comm. Bull. 6515, 317 p., 6 pls.

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

Kane, J. W., 1967, Monthly reservoir evaporation rates for Texas, 1940 through 1965: Texas Water Devel. Board Rept. 64, 111 p., 7 pls.

Lohr, E. W., and Love, S. K., 1954, The industrial utility of public water supplies in the United States, 1952, pt. 2: U.S. Geol. Survey Water-Supply Paper 1300, 462 p.

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

Maxcy, K. F., 1950, Report on the relation of nitrate concentrations in well waters to the occurrence of methemoglobinemia in infants: Natl. Research Council Bull. Sanitary Eng. and Environment, app. D, p. 265-271.

Meinzer, O. E., 1923, The occurrence of ground water in the United States, with a discussion of principles: U.S. Geol. Survey Water-Supply Paper 489, 321 p., 110 figs., 31 pls.

Meinzer, O. E., [editor], 1942, Hydrology, v. 9 *of* Physics of the earth: New York, McGraw-Hill Book Co., Inc., p. 385-477.

Moore, E. W., 1940, Progress report of the committee on quality tolerances of water for industrial uses: New England Water Works Assoc. Jour., v. 54, p. 263.

Plummer, F. B., 1932, Cenozoic systems in Texas, *in* The geology of Texas, v. 1, Stratigraphy: Univ. Texas Bull. 3232 [1933], p. 519-818.

Rogers, L. T., 1967, Availability and quality of ground water in Fayette County, Texas: Texas Water Devel. Board Rept. 56, 117 p., 17 figs.

Scofield, C. S., 1936, The salinity of irrigation water: Smithsonian Inst. Ann. Rept. 1934-35, p. 275-287.

Shafer, G. H., 1965, Ground-water resources of Gonzales County, Texas: Texas Water Devel. Board Rept. 4, 89 p., 12 figs., 4 pls.

Stenzel, H. B., 1938, The geology of Leon County, Texas: Univ. Texas Bull. 3818, 295 p.

Sundstrom, R. W., Hastings, W. W., and Broadhurst, W. L., 1948, Public water supplies in eastern Texas: U.S. Geol. Survey Water-Supply Paper 1047, 285 p., 1 fig.

Swartz, B. W., 1957, Records of water levels in Bastrop and Caldwell Counties, Texas, 1937 through December 1956: Texas Board Water Engineers Bull. 5702, 22 p., 4 figs.

Texas Water Commission and Texas Water Pollution Control Board, 1963, A statistical analysis of data on oil field brine production and disposal in Texas for the year 1961 from an inventory conducted by the Texas Railroad Commission: Texas Railroad Comm. Dist. 1, v. 1, 158 p.

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

Thompson, G. L., 1966, Ground-water resources of Lee County, Texas: Texas Water Devel. Board Rept. 20, 131 p., 22 figs., 3 pls.

Tolman, C. F., 1937, Ground water: New York, McGraw-Hill Book Co., Inc., 593 p.

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

U.S. Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkali soils: U.S. Dept. Agriculture Handb. 60, 160 p.

Wenzel, L. K., 1942, Methods for determining permeability of water-bearing materials, with special reference to discharging-well methods, *with a section on* Direct laboratory methods and a bibliography on permeability and laminar flow, by V. C. Fishel: U.S. Geol. Survey Water-Supply Paper 887, 192 p., 17 figs., 6 pls.

Wilcox, L. V., 1955, Classification and use of irrigation waters: U.S. Dept. Agriculture Cir. 969, 19 p., 4 figs.

Wilcox, L. V., Blair, G. Y., and Bower, C. A., 1954, Effect of bicarbonate on suitability of water for irrigation: Soil Science, v. 77, no. 4, p. 259-266.

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

Winslow, A. G., and others, 1957, Salt water and its relation to fresh ground water in Harris County, Texas: U.S. Geol. Survey Water-Supply Paper 1360-F, p. 375-407.

Table 11.—Drillers' Logs of Wells

Well AT-58-45-903

Owner: Alex Glasscock.
Driller: Sterzing Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Clay, red, top	4	4
Clay, yellow	18	22
Shale, gray, sandy	32	54
Shale, brown, hard	36	90
No Record	75	165
Clay, green, sandy	42	207
Caprock, hard	2	209
Clay, green, sandy	11	220

Well AT-58-46-105

Owner: A. J. Caldwell.
Driller: ——

	THICKNESS (FEET)	DEPTH (FEET)
Clay, red	20	20
Sand, white	40	60
Shale, blue	30	90
Sand, gray	7	97
Shale, blue	3	100
Sand, gray and white	9	109
Shale, blue	21	130

Well AT-58-46-203

Owner: A. Y. McWilliams.
Driller: Sterzing Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Topsoil	2	2
Clay, red	3	5
Sand, white	2	7
Clay, red, sandy	27	34
Caprock	1	35
Lignite	7	42
Shale, gray	43	85
Shale, green	20	105
Shale, green, sandy	59	164
Caprock, hard	1	165
Sand, gray, water	35	200

Well AT-58-46-205

Owner: H. O. Jenkins
Driller: Sterzing Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Surface	2	2
Clay, yellow	13	15
Sand, gray, and lignite	102	117
Caprock, hard	3	120
Shale, blue and gray, sandy	65	185
Caprock, hard	1	186
Sand, blue gray, water	61	247

Well AT-58-46-208

Owner: Ervin S. Stuard.
Driller: Sterzing Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Surface	1	1
Clay, red	11	12
Clay, yellow, sandy	68	80
Shale, blue	7	87
Lignite	3	90
Shale, hard	41	131
Lignite	3	134
Shale, hard	11	145
Caprock, hard	1	146
Sand, gray, water	124	270

Well AT-58-46-409

Owner: Mrs. Pauline Morzec.
Driller: Sterzing Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Surface	4	4
Rock, sandy, hard	1	5
Shale, sandy, yellow	20	25
Shale, gray	50	75
Sand, gray, water	10	85
Shale, brown, and lignite	1	86
Sand, gray, water	94	180

Well AT-58-46-501

Owner: City of Elgin, well 6.
Driller: Layne-Texas Co.

	THICKNESS (FEET)	DEPTH (FEET)
Surface sand	5	5
Sand, yellow, and fine gravel	37	42
Shale, blue	22	64

Well AT-58-46-501—Continued

	THICKNESS (FEET)	DEPTH (FEET)
Sand and shale, broken	16	80
Sand, white and black	33	113
Shale, sandy, lignite, broken	7	120
Shale and lignite	15	135
Lignite, hard	2	137
Shale, and streaks of lignite	34	171
Lignite, hard	2	173
Shale and streaks of lignite	27	200

Well AT-58-46-504

Owner: Elgin Standard Brick Mfg., Co.
Driller: Layne-Texas Co.

	THICKNESS (FEET)	DEPTH (FEET)
Sand	2	2
Clay	21	23
Sand, blue	50	73
Clay	38	111
Rock	2	113
Shale and clay	50	163
Shale	47	210
Shale, sandy	73	283
Sand, good	80	363
Shale	5	368

Well AT-58-46-505

Owner: Elgin Standard Brick Mfg., Co.
Driller: Layne-Texas Co.

	THICKNESS (FEET)	DEPTH (FEET)
Topsoil	2	2
Clay	28	30
Sand, fine, gray	38	68
Clay	99	167
Clay and sandy clay	88	255
Clay, sandy	18	273
Shale with sand streaks	14	287
Sand with shale streaks	25	312
Sand, fine, gray	50	362
Shale	8	370

Well AT-58-46-508

Owner: J. K. Prewitt.
Driller: J. K. Prewitt.

	THICKNESS (FEET)	DEPTH (FEET)
Clay, mixed	20	20
Lignite	3	23
Clay	21	44
Lignite	2	46
Clay, dark gray	19	65
Clay, white, sandy	12	77
Sand, fine, water	50	127
Sand, hard	1	128
Shale, sandy	8	136
Sand, water	25	161
Rock	1	162
Sand streaks	45	207
Sand, water	84	291

Well AT-58-46-509

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

	THICKNESS (FEET)	DEPTH (FEET)
Topsoil	8	8
Sand, loose	24	32
Sand, hard	28	60
Sand, loose	7	67

Well AT-58-46-601

Owner: Elgin-Butler Brick Co.
Driller: A. Bartrug.

	THICKNESS (FEET)	DEPTH (FEET)
Shale, hard	45	45
Sand, water	11	56
Shale, light	2	58
Shale, blue	77	135
Shale, brown	69	204
Coal	5	209
Shale	47	256
Sand, water	28	284
Shale, light brown	9	293

Well AT-58-46-602

Owner: Elgin-Butler Brick Co.
Driller: Layne-Texas Co.

	THICKNESS (FEET)	DEPTH (FEET)
Soil	3	3
Clay and caliche	44	47
Sand, gray, fine	6	53
Shale with lignite streaks	109	162
Shale	128	290
Rock	1	291
Shale	46	337
Rock	6	343
Shale	6	349
Sand, gray, fine and shale streaks	41	390
Shale	14	404

Well AT-58-46-604

Owner: Harold Smith.
Driller: Sterzing Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Topsoil	7	7
Clay, gray	19	26
Clay, blue and white	9	35
Clay and lignite, brown	11	46
Shale, gray and blue	19	65
Lignite	3	68
Shale, gray	22	90
Sand, gray, water	30	120
Caprock, hard	3	123
Shale, hard, gray	17	140
Sand, gray, water	150	290
Shale, hard, blue	45	335
Shale, hard, sandy	20	355
Shale, gray, sandy	5	360
Caprock, hard	1	361
Shale, hard, sandy	29	390
Sand, gray, water	27	417

Well AT-58-46-605

Owner: Chester Jessen.
Driller: Sterzing Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Clay, yellow	2	2
Shale, gray, sandy	38	40
Lignite and sandy shale	4	44
Shale, gray	41	85
Sand, gray	55	140
Sand, blue, water	72	212

Well AT-58-46-702

Owner: H. M. Heine.
Driller: Sterzing Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Topsoil	1	1
Shale, red, and sandrock	21	22
Shale, sandy	53	75
Sand, brown, and lignite	30	105
Shale, green	30	135
Sand, gray, water	5	140
Caprock, hard	1	141
Sand, water	104	245

Well AT-58-46-706

Owner: Henry E. Stobbelbein.
Driller: Sterzing Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Topsoil	4	4
Sand, red	4	8
Clay, white, sandy	82	90
Lignite	2	92
Shale, sandy, green	35	127
Caprock, hard	14	141
Sand, water	1	142
Caprock, hard	4	146
Sand, gray, water	6	152
Shale, sandy, brown	85	237
Caprock, hard	2	239
Shale, sandy, brown	6	245

Well AT-58-46-707

Owner: W. E. Tinsley.
Driller: Sterzing Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Sand, loose	1	1
Sand and red clay	4	5
Clay, yellow	19	24
Shale, gray	52	76
Caprock, hard	1	77
Shale, gray	48	125
Caprock, hard	1	126
Sand, gray and shale	14	140
Sand and shale	20	160
Caprock, hard and lignite	70	230
Sand, gray, water	20	250
Shale, light-blue	15	265
No record	101	366

Well AT-58-47-701

Owner: Bastrop Water Control & Improvement District.
Driller: Texas Water Wells, Inc.

	THICKNESS (FEET)	DEPTH (FEET)
Clay, sandy	7	7
Sand and rock	88	95
Shale and lignite	16	111
Sand	32	143
Shale	93	236
Sand	38	274
Shale	14	288
Sand	15	303
Shale with streaks of sand	53	356
Sand with streaks of lignite	40	396
Shale with streaks of sand and lignite	96	492
Sand with streaks of shale	79	571
Shale with streaks of sand	25	596
Shale with streaks of sand and lignite	92	688
Lignite	57	745
Rock	1	746

Well AT-58-47-903

Owner: Murphy Webb.
Driller: Pomykal Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Clay	10	10
Sand	30	40
Shale	10	50
Sand	25	75
Shale	10	85
Sand and lignite	23	108
Sand	67	175
Shale, sandy	40	215
Sand	65	280

Well AT-58-47-905

Owner: Murphy Webb.
Driller: Pomykal Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Sand	5	5
Sand and shale	35	40
Shale, blue	18	58
Sand	32	90
Shale	40	130
Sand	28	158
Shale	12	170
Sand	85	255
Shale	5	260
No record	20	280
Sand	35	315
Shale	30	345
Shale, sandy	35	380
No record	85	465
Shale	155	620
Shale, sandy	110	730
No record	15	745
Shale, sandy	90	835
Shale	75	910
Shale, sandy	230	1,140
Sand	20	1,160
No record	10	1,170
Sand	30	1,200
No record	20	1,220

	THICKNESS (FEET)	DEPTH (FEET)
Well AT-58-47-907		
Owner: Fred C. Meyers. Driller: Pomykal Drilling Co.		
Sand	35	35
Shale, black	15	50
Sand and shale	25	75
Shale	65	140
Sand	15	155
Shale	40	195
No record	15	210
Shale	5	215
No record	35	250
Sand	16	266
Well AT-58-53-502		
Owner: Glen Harwell. Driller: Roy A. Farrar.		
Sand, loam	2	2
Clay, red	8	10
Sand, river, coarse	39	49
Sandrock, hard, red	8	57
Sand, ashy gray and black, water	29	86
Well AT-58-53-506		
Owner: Colon E. McDonald. Driller: Glass Drilling Co.		
Surface	28	28
Gravel, water	11	39
Shale, blue, sandy, water	41	80
Rock, hard, yellow	1	81
Well AT-58-53-706		
Owner: J. R. Jones. Driller: Sterzing Drilling Co.		
Topsoil	4	4
Clay, gray	12	16
Shale, blue	69	85
Gravel and hard caprock	40	125
Shale, brown, gray sanc	118	243
Well AT-58-53-707		
Owner: Ed Williams. Driller: Lloyd Ketha.		
Clay, yellow, and sandy clay	53	53
Shale, gray	34	87
Clay, gray and buff, sandy	48	135
Clay, gray, sandy	25	160
Shale with thin ledges of sandy shale	40	200
Well AT-58-53-708		
Owner: M. L. Wise. Driller: Sterzing Drilling Co.		
Soil, sandy	10	10
Quicksand	15	25
Clay, yellow	67	92
Caprock, hard	2	94
Sand, water	126	220
Well AT-58-53-803		
Owner: L. W. Scheel. Driller: Lockhart Welding Service.		
Sand	5	5
Gravel	7	12
Sand	22	34
Clay, blue	26	60
Coal	4	64
Sand and clay	16	80
Shale	18	98
Rock	2	100
Shale	60	160
Rock and coal	8	168
Shale	48	216
Sand	44	260

	THICKNESS (FEET)	DEPTH (FEET)
Well AT-58-52-808		
Owner: James Walters. Driller: Sterzing Drilling Co.		
Surface	1	1
Gravel, postoak	3	4
Clay, red	3	7
Shale, sandy, white	98	105
Sand, gray, water	47	152
No record	5	157
Sand, blue-gray	10	167
Well AT-58-53-901		
Owner: Ted Deison. Driller: Roy A. Farrar.		
Sand, loam	4	4
Clay, red	6	10
Sand and gravel	5	15
Quicksand, white	40	55
Sand, dark gray, ashy	55	110
Well AT-58-53-912		
Owner: James L. Broadhurst. Driller: Lloyd Ketha.		
Surface material	4	4
Clay	11	15
Sand and gravel	75	90
Sand	90	180
Lignite	18	198
Shale	6	204
Lignite	6	210
Rock	8	218
Rock, sand, and shale	22	240
Sand	64	304
Rock, sand, and shale	56	360
Well AT-58-54-201		
Owner: Texas Rendering Co., Inc. Driller: S. W. Glass.		
Surface	5	5
Clay, hard, yellow	4	9
Shale, gray	8	17
Lignite	2	19
Shale	6	25
Sand, gray	8	33
Shale	24	57
Packsand	8	65
Sand, water	1	66
Shale, yellow	8	74
Shale, blue	12	86
Shale, sandy	16	102
Shale, gray	32	134
Shale, rusty	71	205
Rock and sand	2	207
Shale, gray	13	220
Lignite	19	239
Shale, gray, sandy	11	250
Shale, blue, hard	30	280
Lignite	18	298
Shale, dark	6	304
Sand, white, hard	4	308
Sand, red, water	5	313
Sand, gray, water	51	364
Well AT-58-54-202		
Owner: Texas Rendering Co., Inc. Driller: Sterzing Drilling Co.		
Topsoil	2	2
Clay, yellow and red	19	21
Lignite	4	25
Shale, brown	40	65
Shale, blue	20	85
Caprock, hard	1	86
Shale, brown	172	258
Caprock, hard	3	261
Shale, brown, sandy	89	350
Shale, hard	9	359
Shale, brown, sandy	5	364
Caprock, hard	1	365
Shale, brown, sandy	35	400

	THICKNESS (FEET)	DEPTH (FEET)
Well AT-58-54-301		
Owner: Texas Rendering Co., Inc. Driller: Stokes Drilling Co.		
Topsoil, red	10	10
Shale	63	73
Boulders	5	78
Shale	12	90
Lignite	60	150
Shale	75	225
Shale, sandy	10	235
Shale	148	383
Boulders	6	389
Sand	61	450
Shale	30	480
Sand	60	540
Boulders	5	545
Sand	20	565
Boulders	7	572
Sand	40	612
Boulders	8	620
Sand, coarse, good	23	643
Shale	15	658
Well AT-58-54-501		
Owner: City of Bastrop. Driller: Layne-Texas Co.		
Clay, fill	4	4
Shale	32	36
Sand	7	43
Rock	1	44
Shale and lignite	37	81
Shale, sandy and lignite	10	91
Lignite and shale	16	107
Sand, fine	10	117
Rock	1	118
Shale and sandy shale	21	139
Shale	31	170
Sand	27	197
Lignite	7	204
Shale	15	219
Sand, fine	30	249
Shale	24	273
Sand	31	304
Rock	3	307
Lignite and shale	12	319
Sand	29	348
Shale	16	364
Rock	3	367
Shale	7	374
Rock	1	375
Shale	17	392
Rock	2	394
Shale	23	417
Rock	3	420
Shale	14	434
Sand, gray	8	442
Shale, hard, gray	5	447
Sand, cut good	17	464
Rock	1	465
Shale and lignite, hard	9	474
Shale, sandy	32	506
Shale, and sandy shale	9	515
Shale, sandy	13	528
Sand, good	48	576
Shale	8	584
Well AT-58-54-502		
Owner: City of Bastrop. Driller: Layne-Texas Co.		
Surface, soil	2	2
Shale	133	135
Lignite	5	140
Shale	33	173
Lignite	4	177
Shale	17	194
Rock	1	195
Shale	14	209
Rock	2	211

Table 11.—Drillers' Logs of Wells—Continued

	THICKNESS (FEET)	DEPTH (FEET)
Well AT-58-54-502—Continued		
Shale	17	228
Lignite	19	247
Shale, sandy	29	276
Shale and hard layers	3	279
Sand, good	37	316
Rock	2	318
Sand, gray	29	347
Rock	1	348
Sand, fine	31	379
Shale, sandy	57	436
Shale	12	448
Rock, hard	3	451
Sand, good	74	525
Shale	6	531
Well AT-58-54-503		
Owner: City of Bastrop. Driller: Layne-Texas Co.		
Soil	2	2
Clay	6	8
Sand	10	18
Lignite	2	20
Rock	59	79
Shale and lignite	56	135
Shale, sandy	21	156
Lignite	6	162
Shale	22	184
Rock	2	186
Sand, fine	20	206
Lignite and shale	35	241
Sand	78	319
Shale and lignite	18	337
Rock, hard	2	339
Shale, sandy	29	368
Sand, fine	34	402
Shale	2	404
Rock	2	406
Shale	2	408
Rock, hard	2	410
Sand	102	512
Shale	2	514
Sand and layers of lignite	23	537
Sand	16	553
Shale	6	559
Well AT-58-54-504		
Owner: City of Bastrop. Driller: Layne-Texas Co.		
Clay, sandy and sand	23	23
Shale, lignite and sandy shale	54	77
Rock	1	78
Shale and lignite	39	117
Sand, fine, hard packed	18	135
Lignite	12	147
Shale and lignite	36	183
Sandrock	19	202
Shale and lignite	34	236
Sand, gray	105	341
Rock	8	349
Shale	30	379
Rock	4	383
Sand, coarse	147	530
Shale, hard	5	535
Well AT-58-54-505		
Owner: City of Bastrop. Driller: Layne-Texas Co.		
Clay, sandy	8	8
Sand, yellow	19	27
Shale and lignite	47	74
Rock	2	76
Shale, sandy and lignite	41	117
Rock	2	119
Shale, hard, sandy and lignite	39	158
Rock	2	160
Sand	18	178
Shale and lignite	29	207
Sandrock	12	219

	THICKNESS (FEET)	DEPTH (FEET)
Well AT-58-54-505—Continued		
Shale, sandy and lignite	20	239
Sand	38	277
Rock	2	279
Sand	50	329
Rock	2	331
Shale, sandy, and lignite	27	358
Rock, hard	4	362
Sand and breaks of shale	45	407
Shale	17	424
Sand, coarse	121	545
Shale and lignite	3	548
Rock	2	550

Well AT-58-54-506

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

	THICKNESS (FEET)	DEPTH (FEET)
Surface, soil	3	3
Shale	30	33
Sand	7	40
Shale, sandy, and lignite	124	164
Sand	12	176
Shale, sandy and lignite	44	220
Sand, fine, and shale layers	39	259
Shale and lignite	10	269
Rock	2	271
Sand, gray	10	281
Shale	2	283
No record	1	284
Sand, thin hard layers	62	346
Shale	3	349
Sand	16	365
Shale	2	367
Sand	30	397
Shale, sandy	12	409
Rock	1	410
Shale, sandy hard layers	6	416
Sand, good	94	510
Sand, broken	17	527
Sand, good	26	553
No record	1	554
Sand	26	580
Shale	10	590

Well AT-58-54-507

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

	THICKNESS (FEET)	DEPTH (FEET)
Soil, sandy	2	2
Clay, brown	10	12
Sand, fine, clay, and lignite	18	30
Rock, hard	1	31
Sand, fine, lignite and shale	26	57
Sand, hard, shale, lignite, and layers of rock	48	105
Shale, hard	35	140
Rock, hard	3	143
Shale, hard	23	166
Sand, hard, fine	15	181
Shale, hard	22	203
Sand, hard (cut clean)	69	272
Sand, hard, few thin shale layers	22	294
Sand, hard (cut clean)	36	330
Sand and shale, thin layers of rock	6	336
Rock	2	338
Sand, hard, and shale	13	351
Rock, hard	3	354
Sand, hard	14	368
Rock, hard	4	372
Sand, hard	23	395
Shale	9	404
Shale, layers of rock	4	408
Shale	3	411
Sand (cut fair)	14	425
Sand, hard layers of rock	5	430
Sand and shale, broken	20	450
Rock, hard	7	457
Sand, hard layers	10	467
Sand (cut clean)	45	512

	THICKNESS (FEET)	DEPTH (FEET)
Well AT-58-54-507—Continued		
Sand, thin shale streaks, hard layers (fair)	14	526
Sand (cut clean)	35	561
Sand, thin shale streaks, hard layers (fair)	26	587
Sand (cut good)	48	635
Sand and shale, broken layers of rock	15	650
Sand (cut good)	18	668
Rock	4	672

Well AT-58-54-508

Owner: U. S. Government (Camp Swift).
Driller: J. R. Johnson.

	THICKNESS (FEET)	DEPTH (FEET)
Topsoil, sandy	6	6
Clay, sandy, yellow	26	32
Sandrock, brown	11	43
Clay, sandy, brown	50	93
Lignite	7	100
Shale, sandy, brown	17	117
Shale, sandy	18	135
Shale, sandy, gray	67	202
Lignite	17	219
Shale, blue	12	231
Sandrock, hard	12	243
Shale, sandy, gray	27	270
Shale, sticky, blue	28	298
Sandrock	4	302
Shale, sandy	16	318
Sandrock, hard, with shale streaks	31	349
Shale, sandy	6	355
Sand	25	380
Sand with shale streaks	16	396
Packsand, hard, water	65	461
Sandstone, hard	4	465
Sand, water	44	509
Packsand, hard	41	550

Well AT-58-54-510

Owner: H. L. Linenberger.
Driller: Glass Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Surface material	25	25
Shale	7	32
Sand	43	75
Packsand, hard	25	100
Sand	40	140
Shale, blue	27	167

Well AT-58-54-512

Owner: U. S. Government (Camp Swift).
Driller: J. R. Johnson.

	THICKNESS (FEET)	DEPTH (FEET)
Topsoil	4	4
Clay, sandy	16	20
Clay, greenish-gray	20	40
Clay, gray	20	60
Clay, lignitic	10	70
Clay, dark-gray	28	98
Lignite	2	100
Clay, lignitic	10	110
Clay, dark-colored	70	180
Clay, sandy, dark-colored	4	184
Sandrock	2	186
Clay, sandy, dark-colored	34	220
Lignite	10	230
Clay, lignitic	10	240
Clay, sandy, dark-colored	62	302
Sand, fine, and clay	48	350
Sand, fine	3	353
Clay, dark-gray	6	359
Sand, white, fine	10	369
Sandrock, hard	16	385
Clay, sandy, dark-colored	5	390
Clay, sandy	10	400
Sand	50	450
Clay, sandy	20	470
Sand and clay	1	471
Sandrock	24	495
Sand with thin shale beds	79	574

	THICKNESS (FEET)	DEPTH (FEET)
Well AT-58-54-706		
Owner: C. D. McCall. Driller: Lloyd Ketha.		
Surface material	6	6
Clay	36	42
Gravel	9	51
Sand	2	53
Gravel	32	85
Sand	53	138
Shale, sandy	47	185
Sand	5	190
Shale, hard	30	210
Clay	2	212
Shale	19	231
Sand	3	234
Shale	3	237
Sand	1	238
Shale	6	244
Sandrock	2	246
Shale	3	249
Sand	60	309
Shale	14	323
Sand	3	326
Sandrock	4	330
Shale	16	346
Rock	52	398
Sand	42	440
Well AT-58-54-903		
Owner: Lower Colorado River Authority. Driller: M. E. Hiddon.		
Surface	3	3
Clay	9	12
Clay and packsand	4	16
Sandrock	2	18
Sand with clay	22	40
Shale, brown	25	65
Shale, brown with sand streaks	15	80
Shale and sand	15	95
Shale, sandy with lignite	6	101
Sandrock	1	102
Shale, sandy, broken	14	116
Sand	16	132
Rock	1	133
Shale	8	141
Rock, hard	1	142
Shale, blue	18	160
Shale, brown	20	180
Shale, sandy, brown with hard streaks	64	244
Shale, streaky, brown	21	265
Rock	1	266
Shale, brown with hard streaks	29	295
Shale, streaky, brown	20	315
Sand, hard	5	320
Shale, brown	47	367
Rock, hard	3	370
Shale, sandy, brown	25	395
Rock, hard	3	398
No record	3	401
Rock, hard	2	403
Shale, sandy, blue	26	429
Shale, sticky	61	490
Sand	20	510
Shale, sandy	18	528
Sand	6	534
Shale	2	536
Sand	4	540
Shale with sticky streaks and lignite	30	570
Shale, sandy, broken	16	586
Sand	76	662
Well AT-58-55-202		
Owner: J. D. Brown. Driller: Roy A. Farrar.		
Soil	6	6
Clay, yellow	83	89
Clay, brown	18	107
Quicksand, red	43	150

	THICKNESS (FEET)	DEPTH (FEET)
Well AT-58-55-204		
Owner: Vernon Hurst. Driller: Pomykal Drilling Co.		
Clay	20	20
Sand	85	105
Shale	5	110
No record	25	135
Sand	55	190
Shale, black	60	250
Sand	39	289
Well AT-58-55-205		
Owner: Vernon Hurst. Driller: Pomykal Drilling Co.		
Sand	20	20
Shale	45	65
Sand	125	190
Well AT-58-55-702		
Owner: Earl Scott. Driller: Lloyd Ketha.		
Surface sand	3	3
Clay, sandy, gray and red	11	14
Sand and sandy clay, red and yellow	14	28
Sand, red to purple	4	32
Shale, blue	36	68
Sand	4	72
Shale with traces of igneous clay	9	81
Sand with traces of lignite	17	98
Shale	2	100
Well AT-58-55-704		
Owner: Joe R. Brown. Driller: Leroy Richter.		
Clay, sandy	140	140
Shale, blue	50	190
Shale, hard	59	249
Rock	1	250
Shale	38	288
Rock	1	289
Shale	145	434
Rock	2	436
Sand	71	507

	THICKNESS (FEET)	DEPTH (FEET)
Well AT-58-55-904		
Owner: Paul Artmann. Driller: American Water Co.		
Surface	15	15
Shale	25	40
Shale, sandy	25	65
Shale	100	165
Sand	41	206
Well AT-58-56-703		
Owner: E. J. Lottman. Driller: Sterzing Drilling Co.		
Surface	1	1
Clay, mixed	39	40
Caprock, hard	1	41
Shale and lignite, brown	99	140
Caprock, hard	1	141
Sand, water, gray	76	217
Sand, water, gray	31	248
Shale, green	7	255
Sand, water, green	80	335
Shale, gray	12	347
Well AT-58-56-706		
Owner: Paul Artmann. Driller: American Water Co.		
Sand and rock	70	70
Shale, sandy	40	110
Shale, sandy, and rock	290	400
Shale	60	460
Shale, sandy, and rock	105	565
Shale, blue	85	650
Sand and rock	75	725
Well AT-58-60-304		
Owner: W. A. Maley. Driller: Lockhart Welding Service		
Topsoil	4	4
Gravel	14	18
Clay, yellow	22	40
Rock	1	41
Shale with sand layers	19	60

	THICKNESS (FEET)	DEPTH (FEET)
Well AT-58-60-304—Continued		
Rock	2	62
Shale with sand layers	28	90
Shale	30	120

Well AT-58-60-601

Owner: W. A. Maley.
Driller: Lockhart Welding Service.

	THICKNESS (FEET)	DEPTH (FEET)
Clay, red	6	6
Clay, brown	34	40
Clay with sand layers	20	60
Rock	3	63
Shale with sand layers	27	90
Rock	2	92
Shale and fine sand	13	105
Rock	2	107
Shale	15	122
Rock	3	125
Shale and fine sand	15	140
Rock	2	142
Shale	8	150

Well AT-58-60-908

Owner: Robert Townsend.
Driller: Sterzing Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Gravel	3	3
Clay, yellow	19	22
Shale, white and sand	13	35
Shale, sandy, white	25	60
Shale, sandy, blue	2	62
Shale, sandy, white	18	80
Sand, blue	22	102
Sand, bluish	38	140

Well AT-58-61-103

Owner: William Lytle.
Driller: Sterzing Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Gravel	3	3
Clay, yellow	42	45
Caprock, hard	1	46
Sand, brown	9	55
Caprock, hard	1	56
Shale, sandy	14	70
Sand, blue, water	30	100

Well AT-58-61-302

Owner: R. A. Redondo.
Driller: Roy A. Farrar.

	THICKNESS (FEET)	DEPTH (FEET)
Gravel and sand	4	4
Clay, yellow	26	30
Clay, red and mixed sand	23	53
Clay, black	10	63
Clay, blue	22	85
Shale, green and sand	18	103
Sand, gray, fine	32	135

Well AT-58-61-306

Owner: James A. Berry
Driller: Sterzing Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Gravel	5	5
Clay, red	7	12
Sand	78	90
Sand, gray, water	58	148
Shale, hard, blue	42	190
Caprock, hard	2	192
Sand, gray, water	53	145
Lignite	5	250

Well AT-58-62-109

Owner: Texas Tropical Fish Hatchery.
Driller: Lloyd Ketha.

	THICKNESS (FEET)	DEPTH (FEET)
Surface and sandy clay	22	22
Sand, river, and gravel	19	41
Shale, sandy	27	68
Lignite	6	74
Shale, sandy shale with ledges of rock	45	119
Lignite	5	124
Shale, sandy with thin ledges of rock	81	205
Sand and rock	75	280

Table 11.—Drillers' Logs of Wells—Continued

	THICKNESS (FEET)	DEPTH (FEET)
Well AT-58-62-206		
Owner: City of Bastrop. Driller: Big State Water Well Drilling Co.		
Surface material	10	10
Clay	10	20
Gravel	32	52
Well AT-58-62-803		
Owner: Tom Guinane. Driller: Lloyd Ketha.		
Clay, sandy	19	19
Clay, sandy, and gravel	35	54
Sand with ledges of shale	55	109
Rock, hard gray sandstone	5	114
Sand	24	138
Well AT-58-63-204		
Owner: J. H. Ricke.. Driller: Leroy Richter.		
Clay	55	55
Sand	5	60
Shale	23	83
Sand	32	115
Well AT-58-63-405		
Owner: J. D. Claiborne. Driller: A. L. Gibson & Son.		
Topsoil	20	20
Sand and gravel	20	40
Shale	100	140
Sand	40	180
Well AT-58-63-606		
Owner: Texas Parks and Wildlife Dept. Driller: Sterzing Drilling Co.		
Topsoil	5	5
Gravel	25	30
Clay, sandy	60	90
Sand and sandy clay	120	210
Sandstone and sandy clay	20	230
Sand	40	270
Clay	10	280
Sand	30	310
Clay and sandstone	40	350
Sand	20	370
Sandstone and sandy clay	30	400
Sand	50	450
Clay, sandy, with sandstone streaks	180	630
Sand	10	640
Clay, sandy	40	680
Sand	45	725
Clay	20	745
Sand, fine	10	755
Sand, coarse	145	900
Sand with clay streaks	30	930
Well AT-58-63-901		
Owner: City of Smithville. Driller: Layne-Texas Co.		
Surface sand, clay and gravel	33	33
Shale, brown, layers of sand and boulders	64	97
Rock	2	99
Sand and shale	6	105
Shale and lime shells	11	116
Shale, sandy, hard, and layers of limerock	44	160
Sand and shale	30	190
Shale and sandy layers	54	244
Shale, brown	29	273
Sand	26	299
Shale, brown	51	350
Sand, brown	13	363
Limerock	2	365
Sand, brown	5	370
Shale, brown	38	408
Sand, dark-brown	20	428
Shale	2	430
Sand, dark-gray	1	440
Shale	2	442
Sand, dark-brown	2	444
Shale	28	472
Rock	1	473

	THICKNESS (FEET)	DEPTH (FEET)
Well AT-58-63-901—Continued		
Shale, gray	101	574
Sand	6	580
Rock	1	581
Sand, shaly	29	610
Shale, gray	13	623
Sand and shale	25	648
Shale and shells	28	676
Well AT-58-63-902		
Owner: City of Smithville. Driller: Layne-Texas Co.		
Soil	24	24
Gravel (river alluvium)	12	36
Shale, sandy	244	280
Sand	40	320
Shale, sandy	270	590
Sand, hard	35	625
Shale, sandy	77	702
Deepened in 1964.		
Shale and aandy shale	58	760
Shale, sandy, and sand	60	820
Sand and sandy shale	38	858
Shale, sandy, and sand breaks	45	903
Well AT-67-05-104, partial log		
Owner: O. B. Lentz. Driller: Beckman, Inc.		
Clay	25	25
Sand, water	6	31
Clay	15	46
Sand, water	15	61
Lignite	1	62
Sand, water	83	145
Shale	161	306
Shale and sandy shale	194	500
Rock	6	506
Sand, water	12	518
Shale, sandy	118	636
Shale, soft	151	787
Shale	125	912
Total depth		100
Well AT-67-05-112		
Owner: Jack R. Simmons. Driller: J. T. Hall.		
Clay	6	6
No record	6	12
Sand and shale	26	38
Sand, red	21	59
Rock	2	61
Sand, blue	26	87
Rock	1	88
Sand and shale	8	96
Rock	1	97
Sand and shale	48	145
Sand, water	10	155
Shale	12	167
Sand, water, streaks of shale	33	200
Shale	5	205
Well AT-67-05-208		
Owner: Rudolph Goertz. Driller: --		
Clay, yellow	60	60
Soapstone	70	130
Sand	29	159
Sandstone	1	160
Coal	4	164
Ash material	18	182
Sand, water	1	183
Well AT-67-05-210		
Owner: Bernard Seidel. Driller: Lloyd Ketha.		
Surface material	4	4
Clay	16	20
Shale	15	35
Rock	5	40
Shale	35	75
Sand	5	80

Well AT-65-05-210—Continued

	THICKNESS (FEET)	DEPTH (FEET)
Shale	118	198
Shale, sandy	22	220
Rock	2	222
Shale, sandy	158	380
Rock	2	382
Shale	48	430
Rock	1	431
Shale	69	500
Sand	70	570
Rock	3	573
Shale, sandy	10	583
Rock	2	585
Shale	35	620
Rock	2	622
Shale and sand stringers	78	700

Well AT-67-05-408

Owner: M. I. Harris.
Driller: Sterzing Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Clay, red	12	12
Shale, gray, sandy	33	45
Caprock, hard	1	46
Shale, sandy	6	52
Shale, blue	22	74
Sand, blue, water	46	120

Well AT-67-05-901

Owner: H. I. Walker.
Driller: Leroy Richter.

	THICKNESS (FEET)	DEPTH (FEET)
Clay, light	12	12
Iron ore and rock	6	18
Clay, red	52	70
Rock	5	75
Sand, fine	175	250
Sand, coarse, red	30	280
Sand, blue	29	309

Well AT-67-06-104

Owner: Deed L. West.
Driller: Lloyd Ketha.

	THICKNESS (FEET)	DEPTH (FEET)
Surface, clay and sandy ledges	38	38
Shale, rock ledges and sandy shale	530	568
Sand, gray-blue with ledges of shale	32	600

Well AT-67-06-203

Owner: Vernon L. Frampton.
Driller: Adcock Pipe & Supply Co.

	THICKNESS (FEET)	DEPTH (FEET)
Surface soil	3	3
Clay, yellow	25	28
Clay, sandy with gravel	4	32
Clay, yellow	25	57
Clay, red with sand streaks	49	106
Shale, gray	53	159
Sand, water	44	203
Sand, water, with lignite streaks	40	243
Shale, sandy	40	283
Sand, fine, water	20	303
Sand, coarse, water	45	348
Shale, blue, sandy	44	392

Well AT-67-06-501

Owner: Victor D. Michna.
Driller: Lockhart Welding Service.

	THICKNESS (FEET)	DEPTH (FEET)
Sand	2	2
Clay	53	55
Sand	35	90
Shale	8	98
Rock	3	101
Shale	34	135
Sand and rock	25	160

Well AT-67-06-604

Owner: Paul McCloskey.
Driller: Leroy Richter.

	THICKNESS (FEET)	DEPTH (FEET)
Clay	75	75
Sand, fine	10	85
Shale	13	98
Sand	38	136

Well AT-67-06-605

Owner: I. D. Easley.
Driller: Lockhart Welding Service.

	THICKNESS (FEET)	DEPTH (FEET)
Sand	2	2
Clay, red	15	17
Clay, gray	13	30
Clay, blue	105	135
Sand and clay	45	180
Sand, blue	30	210
Shale, gray	50	260
Sand, white	76	336

Well AT-67-06-802

Owner: Berry Sandlin.
Driller: Lockhart Welding Service.

	THICKNESS (FEET)	DEPTH (FEET)
Sand	2	2
Clay	38	40
Sand	14	54
Shale	66	120
Sand, and black shale	60	180
Shale	15	195
Rock	3	198
Shale	62	260
Rock	2	262
Sand, fine	58	320
Sand with rock	80	400
Sand	19	419

Well AT-67-06-803

Owner: Roy F. Seitz.
Driller: Lockhart Welding Service.

	THICKNESS (FEET)	DEPTH (FEET)
Sand	2	2
Clay	28	30
Sand	15	45
Shale	48	93
Sand	2	95
Shale	145	240
Sand and shale	40	280
Sand, shale, and rock	80	360
Rock	2	362
Sand	98	460

Well AT-67-07-402

Owner: P. H. Lastovice.
Driller: John Maresh Drilling Co.

	THICKNESS (FEET)	DEPTH (FEET)
Clay, brown	10	10
Clay, white	20	30
Clay, gray	5	35
Rock	1	36
Clay, gray	184	220
Rock	2	222
Sand	78	300

Well AT-67-07-505

Owner: George Zapalac.
Driller: Leroy Richter.

	THICKNESS (FEET)	DEPTH (FEET)
Clay	90	90
Rock	1	91
Sand	40	130
Shale	10	140
Rock	1	141
Shale	57	198
Rock	1	199
Shale	41	240
Rock	2	242
Shale, sandy	22	264
Rock	1	265
Sand	24	289

Well AT-67-13-307

Owner: E. W. Schonaisk.
Driller: Davenport Irrigation Equipment Co.

	THICKNESS (FEET)	DEPTH (FEET)
Sand and gravel	5	5
Shale, sandy	15	20
Shale	35	55
Shale, sandy	40	95
Sand	70	165
No record	15	180

Table 11.—Drillers' Logs of Wells—Continued

	THICKNESS (FEET)	DEPTH (FEET)
Well AT-67-13-308		
Owner: E. M. Lamza. Driller: Lockhart Welding Service.		
Sand	2	2
Clay, red	10	12
Clay, and sand	28	40
Clay, blue	100	140
Rock	5	145
Shale	115	260
Rock	2	262
Shale	28	290
Rock	1	291
Sand, shale, and rock	69	360
Well AT-67-13-309		
Owner: J. J. Rable. Driller: Lockhart Welding Service.		
Clay, red and yellow	40	40
Clay, blue	50	90
Sand, brown	15	105
Shale, blue	85	190
Sand with lignite	40	230
Sand, blue	40	270
Well AT-67-14-202		
Owner: L. Pena & Sons. Driller: Lockhart Welding Service.		
Sand	3	3
Clay, red and yellow	37	40
Sand and clay	20	60
Shale	230	290
Rock	2	292
Sand	68	360

	THICKNESS (FEET)	DEPTH (FEET)
Well AT-67-14-302, partial log		
Owner: W. L. Trlica. Driller: R. C. Shellman.		
Clay, soft, yellow	50	50
Sand, loose, gray, pepper specked with hard streaks	67	117
Clay, yellow	18	135
Sand, gray	7	142
Shale, soft and hard streaks	26	168
Sand, brown, fine	39	207
Shale, brown, soft, gummy	16	223
Total depth		248
Well AT-67-14-505		
Owner: F. A. Brosch. Driller: John Maresh.		
Clay, brown	36	36
Clay, white	14	50
Sandrock	40	90
Clay, dark-gray	42	132
Rock, hard	8	140
Clay, dark-gray	30	170
Sand	20	190
Clay, dark-gray	30	220
Sand	50	270

Table 12.—Water Levels in Wells

Well AT-58-45-802

Owner: Louis Lawhon.

DATE	WATER LEVEL
Aug. 4, 1950	35.21
Sept. 14	35.25
Oct. 11	35.08
Nov. 9	35.19
Dec. 14	35.19
Apr. 21, 1951	35.24
June 5	34.28
Feb. 21, 1952	35.02
Apr. 15	35.70
May 9	35.55
Sept. 18	34.72
Jan. 21, 1953	36.34
Apr. 9	37.58
May 20	37.27
Sept. 16	37.03
Feb. 16, 1954	37.06
May 17	37.06
Aug. 5	38.23
Dec. 2	40.26
May 18, 1955	37.94
Aug. 19	38.83
Nov. 4	39.66
Feb. 9, 1956	38.39
May 7	39.16
Aug. 21	41.62
Nov. 27	41.90
Feb. 15, 1957	39.36
Aug. 7	41.66
Nov. 15	38.98
Apr. 7, 1958	41.74
Aug. 26	38.97
Nov. 25, 1959	36.93
Sept. 1, 1960	37.68
Sept. 18, 1961	35.20
Sept. 19, 1962	34.37
Sept. 10, 1963	36.40
Oct. 6, 1964	36.20

Well AT-58-46-102

Owner: D. W. Dalley.

DATE	WATER LEVEL
Aug. 2, 1950	69.04
Sept. 14	69.76
Oct. 11	69.63
Nov. 9	70.85
Dec. 14	64.93
Apr. 27, 1951	70.72
June 5	59.82
Feb. 21, 1952	71.28
Apr. 15	67.88
May 9	71.50
Sept. 18	68.73
Jan. 21, 1953	67.12
Apr. 9	67.93
May 20	68.47
Sept. 15	71.18
Feb. 16, 1954	69.79
May 17	66.90
Aug. 5	69.16
Dec. 2	69.95
May 18, 1955	68.11
Aug. 19	70.23
Nov. 4	69.35
Feb. 9, 1956	59.49
May 7	68.54
Aug. 21	69.75
Nov. 27	68.64
Feb. 15, 1957	68.29
Aug. 7	63.88
Nov. 15	66.32
Apr. 7, 1958	67.58
Aug. 26	71.61
Nov. 25, 1959	67.64
Sept. 1, 1960	69.98
Sept. 18, 1961	61.15
Sept. 19, 1962	63.03
Sept. 10, 1963	63.97
Oct. 11, 1965	60.57

Well AT-58-46-301

Owner: T. B. Carter.

DATE	WATER LEVEL
Aug. 3, 1950	57.58
Sept. 14	57.58
Oct. 11	57.53
Nov. 9	57.58
Apr. 27, 1951	57.89
June 5	57.96
Feb. 21, 1952	60.25
Apr. 15	59.90
May 9	59.79
Sept. 18	58.40
Jan. 21, 1953	59.53
Apr. 9	59.21
May 20	60.11
Sept. 15	59.31
Feb. 16, 1954	60.32
May 17	60.29
Aug. 5	60.28
Dec. 2	61.41
May 18, 1955	61.05
Aug. 19	60.89
Nov. 4	61.96
Feb. 9, 1956	61.89
May 7	62.24
Nov. 27	62.38
Feb. 15, 1957	62.31
Aug. 7	62.63
Nov. 15	62.49
Apr. 7, 1958	62.66
Aug. 26	61.85
Nov. 25, 1959	61.19
Sept. 1, 1960	60.93
Sept. 18, 1961	60.03
Sept. 19, 1962	58.90
Sept. 10, 1963	58.38
Oct. 6, 1964	58.55

Table 12.—Water Levels in Wells—Continued

Well AT-58-46-503

Owner: H. W. Walker.

DATE	WATER LEVEL
Aug. 3, 1950	44.90
Sept. 14	43.60
Oct. 11	43.43
Nov. 9	43.67
Dec. 14	42.81
Apr. 27, 1951	43.06
June 5	43.38
Feb. 21, 1952	44.31
Apr. 15	45.38
May 9	44.12
Sept. 18	44.47
Apr. 9, 1953	44.91
May 20	45.24
Sept. 15	46.00
Feb. 16, 1954	45.98
May 17	46.45
Aug. 5	46.29
Dec. 2	46.89
May 18, 1955	46.58
Aug. 19	47.70
Nov. 4	47.71
Feb. 9, 1956	47.80
May 7	48.06
Aug. 21	48.26
Nov. 27, 1956	48.59
Feb. 15, 1957	48.71
Aug. 7	50.83
Nov. 15	48.54
Apr. 7, 1958	47.07
Aug. 26	47.11
Nov. 25, 1959	46.04
Sept. 1, 1960	46.35
Sept. 19, 1962	40.79
Sept. 10, 1963	39.02
Oct. 6, 1964	42.76
Oct. 11, 1965	41.32

Well AT-58-52-902

Owner: Texas Highway Department.

DATE	WATER LEVEL
Jan. 6, 1938	11.78
Apr. 22	7.86
Oct. 17	10.43
Feb. 1, 1939	10.40
May 1	11.21
July 14	12.83
Dec. 5	14.08
Apr. 1, 1940	14.32
July 9	14.85
Nov. 21	14.90
June 2, 1941	6.99
Sept. 14, 1950	13.74
Oct. 11	14.17
Nov. 9	14.00
Dec. 14	13.96
Apr. 27, 1951	13.43
Feb. 21, 1952	17.54
Apr. 15	17.02
May 9	16.80
Sept. 18	19.44
Nov. 7	20.44
Jan. 21, 1953	16.03
Apr. 12	14.93
May 20	13.24
Sept. 16	15.82
Feb. 16, 1954	13.96
May 17	15.86
Aug. 5	18.32
Dec. 2	19.95
May 18	17.73
Aug. 19, 1955	23.63
Nov. 4	20.21
Feb. 9, 1956	19.42
May 7	19.96
Aug. 21	22.20
Nov. 27	23.02
Feb. 13, 1957	22.91
Aug. 7	17.10
Nov. 15	11.38
Apr. 7, 1958	7.31
Aug. 26	15.33
Nov. 24, 1959	15.65
Sept. 27, 1960	14.64

Measurements discontinued.

Well AT-58-54-501

Owner: City of Bastrop, well 1.

DATE	WATER LEVEL
May --, 1942	133
Dec. 27, 1945	146.3
Apr. 10, 1946	138.26
Sept. 14, 1950	132.11
Oct. 11	132.44
Nov. 9	132.33
June 5, 1951	132.01
Apr. 9, 1953	132.84
9-1-66	140.00
Sept. 18, 1961	129.93

Well AT-58-54-502

Owner: City of Bastrop, well 2.

DATE	WATER LEVEL
Apr. --, 1942	111
12-27-45	123.7
Apr. 10, 1946	118.81
June 15, 1950	109.72
Sept. 14	109.20
Oct. 11	110.26
Nov. 19	106.72
Dec. 14	109.05
June 5, 1951	108.93

Well AT-58-54-507

Owner: City of Bastrop, well 7.

DATE	WATER LEVEL
Apr. 30, 1943	140
Apr. 10, 1946	121.82
June 15, 1950	117.35
Sept. 14	116.01

DATE	WATER LEVEL
Well AT-58-54-507—Continued	
Oct. 11, 1950	116.29
Nov. 9	116.11
Dec. 14	116.05
Apr. 27, 1951	116.02
June 5	115.88
Apr. 15, 1952	116.07
May 9	115.97
Sept. 18	115.90
Dec. 5	116.34
Jan. 21, 1953	116.35
Apr. 9	116.03
May 20	115.88
Feb. 16, 1954	116.17
May 17	116.17
Aug. 5	116.20
Dec. 2	117.70
May 18, 1955	116.20
Aug. 19	116.21
Nov. 4	117.18
Feb. 9, 1956	116.48
May 7	117.33
Aug. 21	116.60
Nov. 27	116.92
Feb. 13, 1957	117.06
Aug. 7	118.12
Nov. 15	115.17
Apr. 7, 1958	114.93
Aug. 26	116.64
Nov. 25, 1959	114.66
Sept. 1, 1960	114.82
Sept. 18, 1961	113.42
Sept. 19, 1962	113.80
Jan. 11, 1966	116.67
Apr. 27	117.29

DATE	WATER LEVEL
Well AT-58-54-901	
Owner: G. W. Vaughn.	
Jan. 7, 1938	123.18
Apr. 22	122.76
Oct. 17	122.69
Feb. 1, 1939	122.25
May 1	119.92
July 14	127.40
Sept. 14, 1950	120.51
Oct. 11	118.93
Dec. 14	118.57
Apr. 27, 1951	123.23
Well AT-58-55-105	
Owner: John A. Dube	
Sept. 28, 1960	115.47
Sept. 18, 1964	125.36
Oct. 6	124.64
Oct. 11, 1965	114.28
Mar. 30, 1966	108.03
Apr. 28	108.04
Oct. 3	107.85
Well AT-58-55-501	
Owner: Wesley McPhaul.	
Jan. 7, 1938	7.48
Apr. 22	4.30
Oct. 17	7.27
Feb. 1, 1939	6.89
May 1	7.50
July 14	8.20
Dec. 5	8.80
Apr. 1, 1940	8.68
July 9	6.29
Nov. 21	8.35
June 2, 1941	3.36
Feb. 9, 1953	9.06
Sept. 27, 1965	6.73

DATE	WATER LEVEL
Well AT-58-55-602	
Owner: Max Schlinder.	
Jan. 8, 1938	62.78
Apr. 22	62.82
Oct. 17	57.35
Feb. 1, 1939	54.34
May 1	59.96
July 14	59.23
Dec. 5	61.39
Apr. 1, 1940	61.91
July 9	62.46
Nov. 21	62.48
June 2, 1941	62.75
Well AT-58-56-502	
Owner: Paul Saegert.	
Jan. 8, 1938	121.74
May 2	118.76
Oct. 17	119.36
Feb. 1, 1939	118.99
May 1	119.60
July 14	119.80
Dec. 5	119.77
Apr. 1, 1940	119.62
July 9	119.71
Nov. 21	119.73
June 2, 1941	117.70
Feb. 11, 1953	108.39
Well AT-58-60-301	
Owner: A. Reyes.	
July 18, 1946	21.34
Sept. 14, 1950	18.99
Oct 11	18.97
Nov. 9	18.78
Dec. 14	18.83
Apr. 27, 1951	19.11
Feb. 21, 1952	22.89
Apr. 15	23.03

Well AT-58-60-301—Continued

DATE	WATER LEVEL
May 9, 1952	22.92
Sept. 18	23.06
Nov. 13	19.28
Jan. 21, 1953	18.72
Apr. 12	18.44
May 20	18.33
Sept. 16, 1953	18.92
Feb. 16, 1954	18.60
May 17	19.70
Aug. 5	22.12
Dec. 2	22.92
May 18, 1955	20.99
Aug. 19	19.74
Nov. 4	18.49
Feb. 9, 1956	18.71
May 7	18.99
Aug. 21	26.01
Nov. 27	23.07
Feb.	15, 1957
Aug. 7	20.44
Nov. 15, 1957	18.78
Apr. 7, 1958	18.69
Aug. 26	20.56
Nov. 24, 1959	19.29
Sept. 1, 1960	19.14
Sept. 18, 1961	19.23
Sept. 19, 1962	17.75
Sept. 10, 1963	18.38
Oct. 6, 1964	17.04
Oct. 11, 1965	16.60

Well AT-58-60-702

Owner: R. N. Mallcoat.

DATE	WATER LEVEL
July 19, 1946	39.08
Sept. 13, 1950	40.2
Oct. 11	40.1
Nov. 9	40.2
Nov. 7, 1952	42.8
Oct. 9, 1964	41.4

Well AT-58-61-201

Owner: Ben Clayton.

DATE	WATER LEVEL
Jan. 7, 1938	4.17
Apr. 22	2.54
Oct. 17	13.14
Feb. 1, 1939	7.44
Apr. 1	7.25
July 14	11.61
Dec. 5	16.53
Apr. 1, 1940	7.88
July 9	3.21
Nov. 21	5.96
June 2, 1941	3.64
Sept. 14, 1950	6.09
Oct. 11	6.12
Nov. 9	5.63
Dec. 14	6.10
Apr. 27, 1951	6.52
Feb. 21, 1952	6.86
Apr. 15	5.44
May 9	6.61
Sept. 18	5.38
Jan. 21, 1953	4.24
Apr. 12	5.03
May 20	2.58
Sept. 16	6.23
Feb. 16, 1954	5.50
May 17	8.51
Dec. 2	8.17
May 18, 1955	6.68
Aug. 19	8.41
Nov. 4	7.29
Feb. 9, 1956	5.83
May 7	7.35
Aug. 21	17.38
Nov. 27	15.52
Feb. 13, 1957	19.10
Aug. 7	7.36
Nov. 15	2.67
Apr. 7, 1958	4.07
Aug. 26	8.79
Nov. 24, 1959	4.08
Sept. 1, 1960	4.25
Sept. 18, 1961	2.71
Sept. 19, 1962	4.80
Sept. 10, 1963	12.99
Oct. 6, 1964	3.30
Oct. 11, 1965	2.61

Well AT-58-61-801

Owner: Cass Callahan.

DATE	WATER LEVEL
July 29, 1946	20.00
Sept. 14, 1950	20.32
Oct. 11	19.98
Nov. 9	20.30
Dec. 14	20.60
Apr. 27, 1951	21.09
Feb. 21, 1952	23.10
Apr. 15	23.15
May 9	23.12
Sept. 18	24.33
Jan. 21, 1953	24.22
Apr. 12	23.59
May 20	22.39
Sept. 16	23.62
Feb. 16, 1954	22.53
May 17	23.04
Aug. 5	24.49
Dec. 2	25.15
May 18, 1955	25.03
Aug. 19	26.03
Nov. 4	25.89
Feb. 9, 1956	26.25
May 7	26.66
Aug. 21	27.99
Nov. 27	28.30
Feb. 13, 1957	28.12
Aug. 7	25.04

DATE	WATER LEVEL
Well AT-58-61-801--Continued	
Nov. 15, 1957	23.37
Apr. 7, 1958	19.99
Aug. 26	22.42
Nov. 24, 1959	23.89
Sept. 1, 1960	20.90
Sept. 18, 1961	17.37
Sept. 19, 1962	20.80
Sept. 10, 1963	23.40
Oct. 6, 1964	24.88
Oct. 16	24.76
Oct. 11, 1965	22.87
Well AT-58-62-102	
Owner: J. K. Young.	
Jan. 7, 1938	26.82
Apr. 22	45.22
Oct. 17	27.14
Feb. 1, 1939	25.91
May 1	28.34
July 14	30.56
Dec. 5	30.09
Apr. 1, 1940	28.66
July 9	28.86
Nov. 21	29.93
June 2, 1941	23.30
Well AT-58-62-203	
Owner: Texas Public Utility Co.	
Jan. 7, 1938	22.12
Apr. 22	23.60
Oct. 17	22.70
Feb. 1, 1939	22.67
May 1	22.83
July 14	23.01
Dec. 5	23.30
Apr. 1, 1940	23.33
July 9	23.03
Nov. 21	23.34
Well AT-67-05-101	
Owner: Ralph Cox.	
July 25, 1946	29.4
Sept. 14, 1950	35.3
Oct. 11, 1950	30.22
Dec. 14	33.39
Apr. 27, 1951	36.06
Feb. 21, 1952	34.01
Apr. 15	33.32
May 9	37.50
Sept. 18	35.08
Jan. 21, 1953	32.68
May 20	30.09
Sept. 16	30.85
Feb. 16, 1954	29.48
May 17	35.96
May 7, 1956	35.62
Nov. 27	33.85
Feb. 13, 1957	31.91
Apr. 7, 1958	27.97
Aug. 26	43.17
Nov. 24, 1959	31.94
Sept. 1, 1960	40.64
Oct. 13, 1964	25.52

Table 13.--Chemical Analyses of Water From Wells and Springs

(Analyses given are in milligrams per liter, except percent sodium, sodium-adsorption ratio, residual sodium carbonate, specific conductance, and pH.)

Water-bearing units: Tm, Midway Group; Twi, Wilcox Group; Tc, Carrizo Sand; Tr, Reklaw Formation; Tqc, Queen City Sand; Tw, Weches Greensand; Ts, Sparta Sand; Tcm, Cook Mountain Formation; Ty, Yegua Formation; Qal, Quaternary alluvium.

WELL	DEPTH OF WELL (FT)	DATE OF COLLECTION	WATER-BEARING UNIT	SILICA (SiO_2)	IRON (Fe)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	BICARBONATE (HCO_3) a/	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	BORON (B)	DISSOLVED SOLIDS	HARDNESS AS $CaCO_3$	PERCENT SODIUM	SODIUM ADSORPTION RATIO (SAR)	RESIDUAL SODIUM CARBONATE (RSC)	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C)	pH
AT-58-38-701	86	Feb. 6, 1946	Tm,Twi	--	--	394	146	*384	--	248	150	1,460	--	1.2	--	2,660	1,580	35	--	--	--	--
802	54	Aug. 2, 1950	Twi	34	--	18	6.8	* 68	--	139	15	56	--	15	--	290	73	67	--	--	462	7.9
45-301	18	do	Tm	--	--	--	--	--	--	282	280	14	--	--	--	--	436	--	--	--	1,040	7.3
802	56	Aug. 4, 1950	Tm	38	--	136	36	*200	--	1/ 302	84	360	--	100	--	1,100	488	47	--	--	1,850	8.3
905	64	do	Twi	--	--	--	--	--	--	1/ 271	120	240	--	--	--	--	336	--	--	--	1,400	8.4
46-101	187	Aug. 3, 1950	Twi	32	--	70	15	* 51	--	248	22	86	--	.0	--	418	236	32	--	--	691	8.2
102	76	Aug. 2, 1950	Twi	12	--	165	68	*258	--	334	191	550	--	3.5	--	1,410	691	45	--	--	2,470	7.4
103	44	do	Twi	71	--	5.6	3.8	* 57	--	115	14	24	--	14	--	246	30	81	--	--	316	6.8
105	130	July 29, 1957	Twi	39	11	43	13	*169	--	201	73	197	--	.0	--	655	161	70	5.8	--	1,140	7.2
204	16	Aug. 3, 1950	Twi	42	--	93	48	*194	--	100	66	490	--	11	--	1,150	430	50	--	--	1,840	7.7
207	61	do	Twi	32	--	94	17	* 72	--	266	22	144	--	21	--	568	304	34	--	--	952	7.2
301	63	do	Twi	28	--	139	50	*198	--	132	46	580	--	11	--	1,120	552	44	--	--	2,140	7.2
302	--	Feb. 10, 1955	Twi	42	--	43	11	45	6.4	40	42	132	0.1	.0	0.04	342	152	38	--	--	611	6.5
402	80	Aug. 16, 1966	Twi	--	2.8	--	--	--	--	1/423	33	8.0	--	--	--	--	4	--	--	6.4	778	8.8
501	120	June 28, 1960	Twi	29	.1	26	7.6	41	6.2	41	28	91	.3	1.8	.08	251	96	46	1.8	--	442	6.5
503	57	Aug. 3, 1950	Twi	--	--	--	--	--	--	82	180	256	--	--	--	--	272	--	--	--	1,440	7.6
508	291	Aug. 10, 1966	Twi	30	6.6	36	3.5	20	3.7	84	15	46	.1	.2	.02	196	104	29	.9	.00	335	6.3
509	67	Sept. 20, 1941	Twi	28	.07	32	8.9	* 40		25	30	107	--	1.5	--	306	116	--	--	--	--	--
509	67	Feb. 10, 1943	Twi	30	2.3	27	9.1	50	5.8	26	30	118	.4	1.0	--	331	105	--	--	--	--	7.4
510	120	Aug. --, 1943	Twi	29	.02	11	2.4	* 21	--	34	9.6	31	.0	.5	--	128	37	--	--	--	192	6.4
2/ 510	120	Aug. 11, 1951	Twi	12	--	27	6.7	* 31	--	39	22	76	--	.05	--	231	96	--	--	--	--	--
601	293	Aug. 3, 1950	Twi	29	--	34	16	* 84	--	248	41	62	--	1.8	--	390	151	55	--	--	677	8.3
601	293	Mar. 15, 1952	Twi	23	.03	21	8.6	* 66	--	180	25	40	--	.5	--	276	88	62	--	--	462	8.3
604	417	Sept. 18, 1964	Twi	36	13	39	9.4	* 37	--	90	48	65	.3	.0	.05	279	136	37	1.4	.00	461	6.9
606	150	Feb. 2, 1946	Twi	--	--	436	144	*165	--	--	1,640	235	--	1.2	--	2,620	1,680	18	--	--	--	--
707	265	Aug. 15, 1966	Twi	20	.34	52	13	42	3.0	226	59	26	.2	.2	--	326	183	33	1.3	.04	548	7.5

See footnotes at end of table.

Table 13.--Chemical Analyses of Water From Wells and Springs--Continued

WELL	DEPTH OF WELL (FT)	DATE OF COLLECTION	WATER-BEARING UNIT	SILICA (SiO_2)	IRON (Fe)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	BICARBONATE (HCO_3) a/	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	BORON (B)	DISSOLVED SOLIDS	HARDNESS AS $CaCO_3$	PERCENT SODIUM	SODIUM ADSORPTION RATIO (SAR)	RESIDUAL SODIUM CARBONATE (RSC)	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C)	pH
AT-58-47-102	78	Feb. 27, 1956	Twi	--	--	--		--	--	49	120	270	--	0.6	--	660	338	--	--	--	1,090	7.0
109	442	June 19, 1965	Twi	31	--	130	18	* 42	--	312	111	84	0.4	.2	--	570	398	19	0.9	0.00	951	7.2
109	442	Aug. 10, 1966	Twi	29	2.2	130	16	37	3.2	300	105	83	.2	.2	--	552	390	17	.8	.00	914	6.7
402	147	Feb. 26, 1953	Twi	117	25	18	9.2	* 33	--	8	83	44	--	.0	--	332	83	47	--	--	366	5.7
701	610	June 27, 1960	Twi	32	.05	82	19	49	4.5	223	134	51	.7	.2	0.17	483	282	27	1.3	.00	762	7.3
2/ 702	355	Mar. 14, 1955	Twi	--	--	236	77	*232	--	250	631	390	--	--	--	1,816	908	--	--	--	--	--
3/ 703	365	Aug. 9, 1963	Twi	--	--	208	56	*110	--	201	451	309	--	--	--	1,254	--	24	1.8	--	2,022	7.4
3/ 703	365	Oct. 24, 1963	Twi	--	--	168	50	*127	--	177	538	227	--	--	--	1,091	--	30	2.3	--	1,759	--
3/ 703	365	Sept. 11, 1964	Twi	49	14	150	39	* 99	--	184	350	166	.3	.0	.08	943	534	29	1.9	.00	1,420	6.2
704	600	Apr. 26, 1964	Twi	1.3	1.1	90	28	57	5.1	114	256	80	.2	.0	.06	574	340	26	1.3	.00	911	7.2
704	600	Sept. 11, 1964	Twi	37	2.3	122	33	* 70	--	242	264	83	.5	.0	.08	729	440	26	1.4	.00	1,040	6.9
705	632	June 27, 1964	Twi	46	.00	64	15	27	4.8	166	77	50	.3	.2	.05	366	221	20	.8	.00	568	7.3
706	347	Mar. 30, 1966	Twi	46	13	300	61	53	6.0	364	612	119	.0	.0	--	1,380	1,000	10	.7	.00	1,880	6.7
707	745	Feb. 4, 1953	Twi	30	1.3	63	19	* 53	--	231	90	47	.3	.0	--	442	235	33	--	--	667	7.3
903	280	Sept. 28, 1965	Tc	32	4.2	15	5.5	* 18	--	18	45	26	.3	.0	.02	151	60	39	1.0	.00	233	5.5
905	1,220	do	Twi	27	1.2	24	5.6	* 70	--	216	27	20	.3	.2	--	280	83	65	3.3	1.88	449	7.4
48-705	87	Feb. 13, 1953	Tcm	48	9.7	150	34	* 62	--	208	200	190	.5	1.0	--	934	514	21	1.2	.00	1,260	6.7
52-605	22	Jan. 30, 1947	Qal?	--	--	172	41	*149	--	377	281	218	--	16	--	1,060	598	35	--	--	1,720	--
605	22	July --, 1947	Qal?	--	--	--	--	--	--	416	262	192	--	21	--	--	480	--	--	--	1,670	--
902	26	Dec. 24, 1948	Tm	19	--	228	127	*892	--	840	1,530	530	--	3.2	--	3,740	1,090	64	--	--	5,320	--
53-707	200	Aug. 3, 1966	Tm	49	76	133	22	69	3.4	316	78	172	.4	.0	--	682	422	26	1.5	.00	1,160	6.8
809	100	July 9, 1966	Twi	36	.07	24	3.7	23	1.5	78	6.0	42	.4	.2	--	175	75	39	1.2	.00	277	6.6
905	195	Mar. 23, 1953	Twi	34	30	95	19	* 66	--	294	92	85	--	.5	--	582	315	31	--	--	915	7.4
908	124	Nov. 17, 1955	Qal, Twi	--	--	--	--	--	--	230	--	26	--	--	--	--	234	--	--	--	599	8.0
54-203	52	Feb. 20, 1953	Twi	20	.88	28	6.8	* 28	--	46	23	29	.0	70	--	255	98	38	--	--	370	6.9
501	584	July 31, 1942	Twi	--	.45	89	12	* 34	--	238	72	54	--	.0	--	453	272	--	--	--	--	--

See footnotes at end of table.

Table 13.--Chemical Analyses of Water From Wells and Springs--Continued

WELL	DEPTH OF WELL (FT)	DATE OF COLLECTION	WATER-BEARING UNIT	SILICA (SiO_2)	IRON (Fe)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	BICARBONATE (HCO_3) [a]	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	BORON (B)	DISSOLVED SOLIDS	HARDNESS AS $CaCO_3$	PERCENT SODIUM	SODIUM ADSORPTION RATIO (SAR)	RESIDUAL SODIUM CARBONATE (RSC)	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C)	pH
AT-58-54-501	584	July 30, 1943	Twi	--	0.83	89	12	* 33	--	238	71	53	--	0.0	--	445	272	21	--	--	--	7.2
501	584	Aug. 6, 1946	Twi	36	.05	78	12	* 49	--	244	74	52	0.4	.0	--	450	244	--	1.4	0.00	646	7.3
[4] 502	297-357	Feb. 16, 1942	Twi	28	--	70	17	* 39	--	251	68	36	.3	.2	--	381	244	26	--	--	--	--
[4] 502	439-51	Feb. 20, 1942	Twi	32	--	84	14	* 30	--	234	71	47	.2	.2	--	413	267	--	--	--	--	--
502	531	Apr. 1, 1942	Twi	39	1.0	90	13	* 36	--	240	84	51	.4	.0	--	453	278	--	--	--	--	7.7
502	531	June 12, 1942	Twi	41	.31	91	14	* 35	--	247	80	53	.1	.0	--	444	284	21	--	--	670	7.5
502	531	July 27, 1942	Twi	--	.44	92	14	* 35	--	246	82	54	--	.0	--	462	287	--	--	--	--	--
502	531	July 30, 1943	Twi	--	.66	92	13	* 34	--	244	79	54	--	.0	--	462	283	21	--	--	--	7.4
502	531	Aug. 6, 1946	Twi	--	.15	78	11	* 47	--	236	68	54	.4	.0	--	446	240	--	--	--	650	7.4
[4] 503	238-340	Feb. 20, 1942	Twi	30	--	80	16	* 30	--	252	73	34	.2	.2	--	411	266	20	--	--	--	--
[4] 503	238-524	do	Twi	24	--	84	13	* 18	--	198	85	36	--	.2	--	413	263	--	--	--	--	--
[4] 503	468-524	Feb. --, 1942	Twi	35	--	95	13	* 30	--	228	87	55	.2	.2	--	445	290	--	--	--	--	--
503	559	Apr. 23, 1942	Twi	40	.58	102	14	* 57	--	228	148	67	.2	.0	--	546	312	28	--	--	791	7.7
503	559	July 27, 1942	Twi	--	.88	93	15	* 32	--	242	86	53	--	.0	--	463	294	--	--	--	--	--
503	559	July 30, 1943	Twi	--	1.2	98	12	* 32	--	238	86	56	--	.0	--	488	294	19	--	--	--	7.3
503	559	Aug. 6, 1946	Twi	--	.20	77	12	* 48	--	244	75	48	.4	.0	--	436	242	--	--	--	659	7.3
504	535	Apr. 30, 1942	Twi	43	1.5	97	12	* 31	--	224	96	54	--	.0	--	480	292	19	--	--	--	--
504	535	Aug. 1, 1942	Twi	--	1.2	94	14	* 34	--	236	89	57	--	.0	--	477	292	20	--	--	--	--
504	535	July 30, 1943	Twi	--	1.2	95	12	* 37	--	243	86	55	--	.2	--	473	286	22	--	--	--	7.4
504	535	Aug. 6, 1946	Twi	--	.10	66	12	* 61	--	243	74	49	.4	.0	--	437	214	--	--	--	658	7.3
505	550	May 16, 1942	Twi	37	.24	88	13	* 32	--	228	78	53	.2	.0	--	470	273	20	--	--	--	--
505	550	July 27, 1942	Twi	--	1.3	95	12	* 34	--	234	87	55	--	.0	--	469	286	20	--	--	--	--
505	550	July 30, 1943	Twi	--	1.8	97	12	* 36	--	245	90	53	--	.0	--	483	292	21	--	--	--	7.5
505	550	Aug. 6, 1946	Twi	--	.05	68	12	* 68	--	243	85	55	.4	.0	--	471	219	--	2.0	.00	737	7.2
506	590	July 30, 1943	Twi	--	.96	93	11	* 34	--	248	75	50	--	.0	--	471	277	21	--	--	--	7.3
506	590	Aug. 6, 1946	Twi	--	.10	68	12	* 60	--	253	72	47	.4	.0	--	448	219	--	--	--	652	7.3

See footnotes at end of table.

Table 13.--Chemical Analyses of Water From Wells and Springs--Continued

WELL	DEPTH OF WELL (FT)	DATE OF COLLECTION	WATER-BEARING UNIT	SILICA (SiO_2)	IRON (Fe)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	BICARBONATE (HCO_3) a/	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	BORON (B)	DISSOLVED SOLIDS	HARDNESS AS $CaCO_3$	PERCENT SODIUM	SODIUM ADSORPTION RATIO (SAR)	RESIDUAL SODIUM CARBONATE (RSC)	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C)	pH
AT-58-54-507	672	July 30, 1943	Twi	30	0.34	89	12	* 31	--	254	71	39	1.0	0.2	--	418	272	20	0.8	0.00	--	7.6
4/ 508	290	Sept. 30, 1941	Twi	--	--	--	--	--	--	45	--	810	--	--	--	3,800	--	--	--	--	--	--
4/ 508	315	do	Twi	--	--	--	--	--	--	97	--	790	--	--	--	--	--	--	--	--	--	--
4/ 508	331	do	Twi	--	--	--	--	--	--	100	--	775	--	--	--	--	--	--	--	--	--	--
4/ 508	346	do	Twi	--	--	--	--	--	--	174	--	525	--	--	--	--	--	--	--	--	--	--
4/ 508	425	Oct. 2, 1941	Twi	--	--	--	--	--	--	319	300	212	--	--	--	1,097	--	--	--	--	--	--
4/ 508	445	do	Twi	--	--	--	--	--	--	329	290	218	--	--	--	1,141	--	--	--	--	--	--
4/ 508	464	do	Twi	--	--	--	--	*147	--	320	300	212	--	--	--	1,151	555	--	--	--	--	--
4/ 508	475	Oct. 3, 1941	Twi	--	--	--	--	--	--	--	300	215	--	--	--	--	552	--	--	--	--	--
4/ 508	500	do	Twi	--	--	--	--	--	--	--	300	212	--	--	--	--	558	--	--	--	--	--
4/ 508	525	do	Twi	--	--	--	--	--	--	--	280	212	--	--	--	--	552	--	--	--	--	--
4/ 508	547	Oct. 4, 1941	Twi	--	--	--	--	*144	--	316	280	218	--	--	--	1,004	546	--	--	--	--	--
508	550	Nov. 9, 1941	Twi	--	1.6	69	12	* 26	--	189	58	45	--	.2	--	379	223	21	--	--	--	7.2
508	550	Nov. 12, 1941	Twi	--	--	--	--	--	--	--	206	45	--	--	--	--	--	--	--	--	--	--
508	550	Nov. 14, 1941	Twi	36	1.5	75	9.8	* 32	--	207	59	46	.0	.2	--	379	228	--	--	--	--	--
508	550	Aug. 1, 1942	Twi	--	.84	74	11	* 32	--	216	61	48	--	.0	--	388	230	24	--	--	--	--
4/ 512	325	Sept. 18, 1941	Twi	--	--	189	65	*180	--	220	527	285	--	--	--	1,358	740	35	--	--	--	--
4/ 512	355	do	Twi	--	--	158	42	*152	--	284	368	198	--	--	--	1,157	556	--	--	--	--	--
4/ 512	357-377	do	Twi	22	.05	102	26	* 79	--	274	173	91	.1	.2	--	658	362	--	--	--	--	7.3
4/ 512	400	do	Twi	--	.06	167	42	*139	--	314	347	194	--	.2	--	1,118	590	34	--	--	--	7.7
4/ 512	430	Sept. 20, 1941	Twi	--	.05	174	45	*155	--	268	407	225	--	.0	--	1,138	623	--	--	--	--	7.4
4/ 512	477-460	Sept. 23, 1941	Twi	--	.05	128	20	* 80	--	244	203	118	--	.2	--	669	403	--	--	--	--	7.7
4/ 512	250-488	do	Twi	--	.01	91	13	* 49	--	207	109	73	.3	.0	--	437	281	28	--	--	--	7.8
4/ 512	507	Sept. 24, 1941	Twi	--	.05	91	12	* 47	--	232	94	66	--	.25	--	424	270	--	--	--	--	7.6
4/ 512	450-538	Sept. 24, 1941	Twi	--	.05	91	12	* 48	--	223	98	70	--	.25	--	429	278	--	--	--	--	7.6
4/ 512	552	do	Twi	--	.05	86	17	* 44	--	238	93	63	--	.25	--	420	286	--	--	--	--	--

See footnotes at end of table.

Table 13.--Chemical Analyses of Water From Wells and Springs--Continued

WELL	DEPTH OF WELL (FT)	DATE OF COLLECTION	WATER-BEARING UNIT	SILICA (SiO_2)	IRON (Fe)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	BICARBONATE (HCO_3) [a]	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	BORON (B)	DISSOLVED SOLIDS	HARDNESS AS $CaCO_3$	PERCENT SODIUM	SODIUM ADSORPTION RATIO (SAR)	RESIDUAL SODIUM CARBONATE (RSC)	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C)	pH
AT-58-54-512	574	do	Twi	36	0.56	86	15	* 45	--	243	84	62	--	0.25	--	474	276	--	--	--	--	--
702	185	Mar. 23, 1953	Twi	28	22	82	8.1	* 20	--	294	30	7.5	--	.2	--	394	16	--	--	--	556	7.8
705	170	June 14, 1967	Twi	29	1.8	46	5.0	26	3.6	168	15	28	0.3	.2	--	236	135	29	1.0	0.05	384	7.0
706	440	July 7, 1967	Twi	13	--	10	3.7	213	2.6	386	13	132	.4	.0	--	578	40	91	15	5.53	1,000	8.2
55-103	618	Feb. 4, 1953	Twi	48	5.7	69	23	* 31	--	158	122	57	--	.0	0.14	477	266	20	--	--	654	6.8
105	640	Sept. 12, 1964	Twi	44	6.2	154	50	* 69	--	270	302	144	.4	.0	.12	897	590	20	1.2	.00	1,340	6.5
203	173	Sept. 27, 1965	Tc	15	3.9	8.5	1.4	* 10	--	43	4.4	6.1	.1	.2	--	67	27	45	.8	.17	97	6.4
304	449	Feb. 13, 1953	Tqc	10	--	232	94	*189	--	270	858	185	.0	1.5	--	1,700	966	30	--	--	2,310	7.8
502	500	June 24, 1953	Tc	24	24	--	--	--	--	57	--	26	--	--	--	--	64	--	--	--	239	7.0
504	630	June 14, 1967	Twi	39	.34	58	12	27	8.2	201	51	29	.2	.2	--	324	194	22	.8	.00	511	6.9
605	38	Jan. 29, 1953	Tw	36	--	318	92	*324	--	226	186	492	.6	995	--	2,550	1,170	38	--	--	3,610	7.5
702	100	July 30, 1965	Tr	--	17	--	--	--	--	0	80	31	--	--	--	--	44	--	--	.00	311	[5] 4.4
703	319	Aug. 11, 1965	Tc	30	6.6	13	4.3	* 34	--	47	37	32	.2	.5	--	180	50	59	2.1	.00	281	5.8
706	772	Jan. 22, 1953	Twi	22	--	25	8.1	* 73	--	224	44	18	--	.2	--	300	96	62	--	--	487	8.1
[3] 56-105	468	Jan. 12, 1966	Tqc	--	.1	100	28	* 56	--	257	221	40	.2	--	--	700	368	--	--	--	1,070	7.9
108	46	Feb. 11, 1953	Tw	26	1.7	154	28	86	2.2	385	215	92	.7	25	--	893	499	27	--	--	1,260	7.6
[2] 109	435	May 27, 1964	Tqc	--	.26	82	29	62	9	244	200	59	.2	--	--	690	327	--	--	--	1,045	7.6
503	541	Mar. 29, 1966	Tqc	16	.27	66	31	120	8.0	248	196	115	.0	.2	--	674	292	46	3.0	.00	1,130	7.5
504	200	Feb. 2, 1953	Tcm	11	8.8	322	292	*348	--	376	1,740	450	--	9.3	--	3,360	2,000	27	3.4	.00	4,130	7.3
801	572	Mar. 25, 1966	Tqc	.4	.33	53	22	78	6.7	322	72	46	.2	.5	--	437	222	42	2.3	.83	767	7.3
60-301	36	Aug. 1, 1947	Twi	--	--	--	--	--	--	360	394	248	--	32	--	--	600	--	--	--	2,150	--
307	47	July 18, 1946	Twi	--	--	--	--	--	--	[1] 310	100	69	--	41	--	--	300	--	--	--	--	--
308	39	do	Twi	--	--	--	--	--	--	[1] 388	20	52	--	12	--	--	240	--	--	--	--	--
602	29	July 18, 1945	Twi	--	--	--	--	--	--	346	50	293	--	.0	--	--	420	--	--	--	--	--
701	21	Aug. 6, 1946	Twi	--	--	--	--	--	--	149	35	48	--	7.8	--	--	128	--	--	--	--	--
701	21	Oct. 9, 1964	Twi	34	.45	18	3.9	* 31	--	106	10	20	.3	2.2	--	171	61	52	1.7	.52	262	6.6

See footnotes at end of table.

Table 13.--Chemical Analyses of Water From Wells and Springs--Continued

WELL	DEPTH OF WELL (FT)	DATE OF COLLECTION	WATER-BEARING UNIT	SILICA (SiO_2)	IRON (Fe)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	BICARBONATE (HCO_3) a/	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	BORON (B)	DISSOLVED SOLIDS	HARDNESS AS $CaCO_3$	PERCENT SODIUM	SODIUM ADSORPTION RATIO (SAR)	RESIDUAL SODIUM CARBONATE (RSC)	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C)	pH
AT-58-60-702	52	July 19, 1945	Twi	--	--	--	--	--	--	1/480	28	115	--	1.2	--	--	210	--	--	--	--	--
708	24	July 24, 1945	Twi	--	--	--	--	--	--	1/102	10	7	--	4.8	--	--	128	--	--	--	--	--
61-107	803	Mar. 28, 1952	Twi	17	--	11	4.5	*138	--	290	10	68	--	1.5	--	393	46	87	--	--	690	7.8
203	59	Mar. 2, 1952	Twi	46	--	148	22	* 65	--	262	80	214	0.0	.5	--	705	460	23	--	--	1,230	6.9
304	100	Mar. 2, 1953	Twi	44	--	72	6.1	* 34	--	131	124	17	.0	21	--	407	204	26	--	--	576	6.9
305	415	Oct. 3, 1954	Twi	30	--	88	7.6	* 29	--	148	121	47	.1	.0	--	422	250	20	--	--	628	7.8
305	415	Feb. 5, 1956	Twi	--	4.3	--	--	--	--	124	--	24	--	--	--	--	336	--	--	--	737	6.9
307	174	Mar. 15, 1959	Twi	38	50	124	15	20	5.9	124	337	17	.9	.0	--	632	371	10	0.5	--	862	6.7
307	275	Mar. 4, 1960	Twi	36	33	106	14	* 41	--	137	260	18	1.0	.0	--	545	322	22	1.0	--	756	6.3
505	162	July 29, 1946	Twi	--	--	--	--	--	--	31	700	44	--	.0	--	--	645	--	--	--	--	--
702	97	July 8, 1952	Twi	55	16	382	83	*129	--	276	928	272	--	.5	--	1,990	1,290	18	--	--	2,590	7.4
703	412?	Mar. 30, 1953	Twi	15	.42	18	9.5	*223	--	363	110	110	.4	.0	--	672	84	85	--	--	1,120	8.0
705	160	May --, 1958	Twi	40	--	162	35	*113	--	306	243	205	.6	.0	--	949	548	31	2.1	--	1,500	8.0
801	32	July 25, 1946	Twi	--	--	--	--	--	--	1/ 408	120	202	--	52	--	--	490	--	--	--	--	--
802	250	Feb. 27, 1957	Twi	15	1.3	38	22	*193	--	291	150	149	--	.0	--	710	186	69	6.2	--	1,200	7.7
901	267	July 26, 1946	Twi	--	--	--	--	--	--	498	55	140	--	.0	--	--	510	--	--	--	--	--
902	65	Apr. 1, 1953	Twi	22	--	95	50	*141	--	551	81	150	.2	.2	--	832	442	41	--	--	1,410	7.3
62-104	Spring	Aug. 23, 1949	Qal	24	--	94	8.6	* 18	--	298	29	23	.0	3.8	--	348	270	28	--	--	568	8.2
107	332	Aug. 2, 1966	Twi	14	.05	2.4	1.9	258	1.5	568	51	42	.4	.2	--	650	14	97	30	9.03	1,080	8.0
110	325	do	Twi	14	.09	2.6	1.8	288	1.6	632	48	56	.7	.0	--	724	14	98	33	10.1	1,200	8.1
204	52	June 25, 1942	Qal	14	.02	75	16	* 47	--	271	38	34	.2	--	--	359	203	33	--	--	--	7.3
2/ 205	54	Apr. 24, 1958	Qal	--	.04	91	21	* 20	--	329	51	33	.2	5.8	--	378	--	--	--	--	630	7.4
2/ 206	52	Jan. 2, 1957	Qal	--	.02	67	13	* 25	--	248	24	40	.3	--	--	329	224	--	--	--	549	7.4
2/ 207	58	Feb. 28, 1957	Qal	--	.10	66	15	* 26	--	240	29	41	.3	--	--	343	--	--	--	--	572	7.3
407	37	Mar. 6, 1953	Twi	34	--	27	4.4	* 19	--	40	27	30	.0	28	--	220	85	32	--	--	311	6.8
506	290	do	Twi	14	--	5.1	2.3	*254	--	386	156	67	--	1.5	--	690	22	96	--	--	1,140	8.0

See footnotes at end of table.

Table 13.--Chemical Analyses of Water From Wells and Springs--Continued

WELL	DEPTH OF WELL (FT)	DATE OF COLLECTION	WATER-BEARING UNIT	SILICA (SiO_2)	IRON (Fe)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	BICARBONATE (HCO_3) a/	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	BORON (B)	DISSOLVED SOLIDS	HARDNESS AS $CaCO_3$	PERCENT SODIUM	SODIUM ADSORPTION RATIO (SAR)	RESIDUAL SODIUM CARBONATE (RSC)	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C)	pH
AT-58-62-602	54	Jan. 26, 1953	Tc	45	0.37	30	15	* 46	--	0	74	93	--	55	--	490	136	39	--	--	662	4.3
901	44	Jan. 27, 1953	Qal,Tc	28	--	100	25	* 21	--	320	89	28	--	--	--	476	352	11	--	--	747	7.0
903	59	Jan. 23, 1953	Tc	54	9.2	43	17	*151	--	--	241	178	0.2	5.6	--	705	178	65	--	--	1,110	4.4
63-103	120	Jan. 27, 1953	Tc	1.6	--	38	17	* 65	--	87	88	102	--	.0	--	378	165	46	--	--	645	6.9
105	130	Jan. 22, 1953	Tc	71	9.9	11	7.7	* 32	--	9	57	44	--	.0	--	232	59	54	--	--	289	5.5
202	277	Jan. 27, 1953	Tqc	26	1.8	98	30	* 50	--	265	155	68	.2	1.8	--	630	368	23	--	--	886	7.3
402	260	Feb. 25, 1956	Tc	--	--	--	--	--	--	126	141	49	--	--	--	--	251	--	--	--	638	--
402	260	Nov. 23, 1964	Tc	48	.01	79	11	* 32	--	128	136	46	.1	.0	0.00	415	242	22	0.9	0.00	633	7.4
501	407	Dec. 12, 1952	Tc	16	.76	3.2	1.5	*184	--	1/ 454	3.6	26	--	.0	--	458	14	97	--	--	752	8.8
603	960	Mar. 23, 1966	Tqc	13	.08	33	9.8	253	6.8	185	340	127	.2	.8	--	875	123	81	9.9	.57	1,410	7.5
606	868	June 14, 1967	Tc	16	.10	2.2	0.2	117	.9	282	9.6	15	.3	.2	--	300	6	97	21	4.49	481	7.6
701	391	Oct. 18, 1960	Tc	14	--	2.0	.0	106	.9	255	10	15	--	.0	--	273	5	97	21	--	456	7.8
801	715	Dec. 10, 1952	Tc	15	.03	1.2	.8	119	1.2	1/ 288	4.7	18	.2	.0	.13	306	6	97	--	--	500	8.5
803	230	Nov. 11, 1952	Tr	12	--	5.6	3.8	269	4.2	1/ 552	1.0	115	--	.0	.42	682	30	94	--	--	1,190	8.6
4/ 901	170-440	Oct. 7, 1954	Tqc	10	.1	58	19	* 85	--	232	127	60	--	--	--	614	223	--	--	--	--	7.7
4/ 902	581-661	May 15, 1952	Tr,Tc	56	1.7	13	7.0	*264	--	1/ 665	15	53	.9	.4	--	725	62	90	--	--	--	8.3
4/ 902	581-661	Feb. 7, 1964	Tr,Tc	--	.13	13	6.0	*251	--	630	12	51	.2	--	--	960	58	--	--	--	--	8.0
4/ 902	579-885	July 9, 1964	Tr,Tc	--	--	3	--	* 71	--	1/ 167	11	9	.2	--	--	257	9	--	--	--	326	8.6
903	651	Sept. 30, 1941	Tqc,Tr?	--	--	--	--	*111	--	278	150	79	--	--	--	--	255	--	--	--	--	--
903	651	Feb. 10, 1943	Tr?Tqc?	14	.14	45	18	139	7.8	1/ 274	156	78	.3	.0	--	596	186	61	--	--	--	8.3
2/ 903	651	May 15, 1952	Tr?Tqc?	19	.74	54	19	*122	--	226	176	78	.1	.4	--	563	213	56	--	--	--	--
904	651	Sept. 30, 1941	Tr?Tqc?	--	--	--	--	*247	--	706	6.0	51	--	--	--	--	120	--	--	--	--	--
904	651	Feb. 10, 1943	Tr?Tqc?	13	.06	11	5.5	266	8.8	1/ 683	1.2	52	2.0	.0	--	708	50	90	--	--	--	8.4
2/ 904	651	May 15, 1952	Tr?Tqc?	19	.27	27	12	*146	--	1/ 280	105	67	.4	.4	--	517	117	73	--	--	--	8.3
914	500	Dec. 16, 1952	Tqc	13	.39	6.5	2.6	*303	--	384	177	132	--	.0	--	810	26	96	--	--	1,340	8.2
64-201	809	Dec. 31, 1952	Tqc	10	24	220	99	*1,060	--	82	762	1,700	--	.5	--	3,890	956	71	--	--	6,380	7.1

See footnotes at end of table.

Table 13.--Chemical Analyses of Water From Wells and Springs--Continued

WELL	DEPTH OF WELL (FT)	DATE OF COLLECTION	WATER-BEARING UNIT	SILICA (SiO_2)	IRON (Fe)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	BICARBONATE (HCO_3) a/	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	BORON (B)	DISSOLVED SOLIDS	HARDNESS AS $CaCO_3$	PERCENT SODIUM	SODIUM ADSORPTION RATIO (SAR)	RESIDUAL SODIUM CARBONATE (RSC)	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C)	pH
AT-58-64-201	809	Mar. 23, 1966	Tqc	2.0	--	188	39	1,000	18	44	198	1,860	--	0.5	--	3,330	630	77	17	0.00	6,070	6.7
404	180	Jan. 2, 1953	Ts	48	23	14	6.4	* 20	--	53	39	15	--	.0	--	175	61	42	--	--	238	6.5
405	27	Dec. 29, 1952	Tcm	12	--	90	12	* 49	--	50	73	64	--	215	--	569	274	28	--	--	812	7.5
504	79	Feb. 19, 1952	Ty	90	--	638	189	*512	--	102	351	2,150	--	--	--	3,980	2,370	32	--	--	6,830	6.4
507	378	Dec. 31, 1952	Ts	14	--	24	9.1	*173	--	230	158	84	--	1.8	--	588	98	79	--	--	966	7.9
602	444	Aug. 19, 1964	Ts	13	--	16	6.1	*174	--	220	106	106	0.2	4.0	0.38	534	65	85	9.4	2.31	843	7.2
702	356	Sept. 29, 1965	Ts	13	.08	36	16	*224	--	198	280	133	.2	.2	--	799	156	76	7.8	.13	1,290	7.4
703	36	Dec. 18, 1965	Qal,Ty	22	.28	87	8.7	* 29	--	290	20	30	--	19	--	373	253	20	--	--	597	7.6
706	350	Jan. 5, 1966	Tqc	14	.17	70	23	*192	--	188	348	120	--	.0	--	859	268	61	5.1	.00	1,330	7.2
808	35	Dec. 19, 1952	Qal,Ty	18	1.3	224	79	*299	--	173	283	380	--	695	--	2,060	884	42	--	--	2,920	7.2
67-05-101	47	May 25, 1946	Twi	--	--	--	--	--	--	449	280	134	--	.0	--	--	232	--	--	--	--	--
102	40	Aug. 22, 1946	Twi	--	--	--	--	--	--	182	30	330	--	118	--	--	375	--	--	--	--	--
109	300	July 29, 1966	Twi	11	.02	4.6	3.2	288	2.0	578	92	60	.5	.0	--	740	25	96	25	8.78	1,220	8.0
110	591	do	Twi	13	.12	13	8.0	364	3.3	440	179	228	.3	.2	--	1,020	67	92	19	5.71	1,750	7.9
112	205	Dec. 29, 1965	Twi	38	.87	155	30	*116	--	312	285	148	.2	.0	--	925	510	33	2.2	.00	1,420	7.0
b/ 201	275	Feb. 22, 1951	Twi	--	--	--	--	--	--	531	110	146	--	--	--	1,000	300	--	--	--	1,410	7.9
201	600	May 17, 1951	Twi	24	--	18	16	*334	--	521	184	166	--	.0	.44	1,010	111	87	14	6.32	1,660	8.0
203	552	Dec. 11, 1952	Twi	14	43	14	23	*212	--	304	281	82	--	.2	--	804	197	70	--	--	1,250	7.7
206	246	Dec. 16, 1952	Twi	21	46	56	70	* 93	--	426	33	175	--	.2	--	657	428	32	--	--	1,210	7.5
207	260	Jan. 2, 1948	Twi	16	--	24	24	*322	--	520	202	158	--	.0	.4	999	158	82	--	--	1,630	--
207	260	Jan. 24, 1951	Twi	13	--	24	20	*334	--	524	197	150	--	1.2	--	1,070	142	84	--	--	1,630	7.9
210	564	June 14, 1967	Twi	16	1.6	10	5.7	352	3.3	546	153	142	.3	.2	--	950	48	94	22	7.98	1,530	7.6
304	90	Aug. 9, 1956	Twi	--	--	--	--	--	--	517	350	500	--	--	--	1,740	960	--	--	--	2,900	7.3
404	160	Apr. 1, 1953	Twi	11	--	46	38	* 76	--	348	36	80	--	.0	--	458	271	38	--	--	787	7.4
405	65	Apr. 10, 1954	Twi	--	10	--	--	--	--	45	--	1,560	--	--	--	--	1,620	--	--	--	5,580	6.1
502	260	Apr. 1, 1953	Twi	18	--	50	30	*247	--	545	125	148	--	.2	--	901	248	68	--	--	1,480	7.4

See footnotes at end of table.

Table 13.--Chemical Analyses of Water From Wells and Springs--Continued

WELL	DEPTH OF WELL (FT)	DATE OF COLLECTION	WATER-BEARING UNIT	SILICA (SiO_2)	IRON (Fe)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	BICARBONATE (HCO_3) [a]	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	BORON (B)	DISSOLVED SOLIDS	HARDNESS AS $CaCO_3$	PERCENT SODIUM	SODIUM ADSORPTION RATIO (SAR)	RESIDUAL SODIUM CARBONATE (RSC)	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C)	pH
AT-67-05-901	309	July 29, 1966	Tc	32	7.5	9.2	3.5	26	4.9	26	34	37	0.3	0.2	--	161	38	56	1.8	0.00	256	6.0
06-104	600	do	Twi	8.8	1.0	6.0	2.7	293	2.6	416	137	122	.4	.0	--	778	26	95	2.5	6.29	1,300	8.0
201	140	Jan. 23, 1953	Tc	74	7.6	5.3	3.4	* 39	--	4	32	53	--	.0	--	227	27	66	--	--	259	5.2
502	46	Dec. 21, 1952	Tqc	43	--	13	6.5	* 53	--	29	27	75	.2	21	--	279	59	66	--	--	408	6.5
605	336	Oct. 21, 1964	Tc	46	34	21	6.5	* 57	--	45	104	39	.3	1.5	--	305	79	61	2.8	.00	432	6.0
607	605	Aug. 28, 1959	Tc	--	26	--	--	23	12	0	119	41	--	--	--	--	78	--	1.1	--	409	4.5
608	748	Aug. 26, 1966	Tc	47	8.4	18	9.7	22	11	0	110	33	.1	.2	--	251	85	28	1.0	.00	460	[6] 3.3
609	606	Aug. 8, 1966	Tc	41	16	63	25	31	10	19	218	85	.2	2.1	--	499	260	20	.8	.00	764	5.7
702	75	Dec. 10, 1952	Tr	58	135	101	55	* 76	--	--	466	140	--	.2	--	936	518	24	--	--	1,330	[7] 3.2
703	860	Oct. 22, 1964	Twi	12	.84	4.5	1.0	*162	--	417	8.0	11	.5	1.2	--	406	15	96	18	6.53	655	8.0
801	47	Dec. 2, 1952	Tqc	47	--	7.0	1.6	* 53	--	72	30	24	--	24	--	218	24	83	--	--	312	7.1
07-101	966	May 14, 1968	Tc,Twi	36	--	38	8.0	22	6.9	83	61	37	.1	.0	.04	250	128	26	.8	.00	402	6.9
102	37	Jan. 22, 1953	Tqc	96	4.8	15	9.1	* 78	--	0	203	22	.2	5.0	--	442	75	69	--	--	565	[8] 4.3
201	730	Dec. 4, 1952	Tc	13	1.0	34	9.8	* 38	--	172	32	23	--	.8	--	239	125	40	--	--	407	7.9
201	730	Aug. 16, 1960	Tc	52	15	--	--	--	--	144	--	96	--	--	--	--	249	--	--	--	835	5.8
204	765	Dec. 29, 1965	Tr	14	.26	22	6.1	* 81	--	214	42	26	.2	.0	--	296	80	69	3.9	1.91	504	7.7
205	30	Dec. 4, 1952	Qal	29	1.4	204	54	*107	--	355	386	190	--	3.2	--	1,150	731	24	--	--	1,750	7.6
310	310	Dec. 13, 1952	Ta	18	.63	53	22	* 94	--	228	117	82	--	.8	--	499	221	48	2.7	.00	833	7.9
311	415	Dec. 4, 1952	Ts	19	--	65	21	* 66	--	226	118	59	--	.8	--	478	248	37	--	--	778	7.7
503	228	Jan. 26, 1953	Tcm	34	5.6	79	29	*101	--	293	114	125	--	.2	--	644	316	41	--	--	1,030	7.8
505	289	Aug. 3, 1966	Tcm	15	1.5	630	214	438	16	113	1,220	1,430	--	1.5	--	4,020	2,450	28	3.8	.00	5,850	6.9
706	33	July 15, 1946	Tcm	--	--	--	--	--	--	[1] 330	130	254	--	89	--	--	555	--	--	--	--	--
708	250	do	Tcm	--	--	--	--	--	--	364	210	220	--	--	--	--	300	--	--	--	--	--
709	41	do	Ty	--	--	--	--	--	--	48	95	206	--	1.2	--	--	180	--	--	--	--	--
13-305	29	Dec. 3, 1952	Tc	31	.44	4.8	4.1	* 16	--	4	33	9.5	--	16	--	131	29	55	--	--	152	6.2
308	360	Oct. 21, 1964	Tc	39	56	37	9.1	* 75	--	32	181	55	.1	1.8	--	427	100	56	2.9	.00	613	5.7

See footnotes at end of table.

Table 13.--Chemical Analyses of Water From Wells and Springs--Continued

WELL	DEPTH OF WELL (FT)	DATE OF COLLECTION	WATER-BEARING UNIT	SILICA (SiO_2)	IRON (Fe)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	BICARBONATE (HCO_3) [1]	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	BORON (B)	DISSOLVED SOLIDS	HARDNESS AS $CaCO_3$	PERCENT SODIUM	SODIUM ADSORPTION RATIO (SAR)	RESIDUAL SODIUM CARBONATE (RSC)	SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C)	pH
AT-67-14-101	37	Dec. 9, 1952	Tqc	75	0.67	9.2	4.8	*123	--	13	131	98	--	31	--	551	42	86	--	--	719	6.3
202	360	Dec. 28, 1956	Tqc	19	8.1	180	49	* 98	--	272	374	178	0.2	.2	--	1,030	650	2.5	1.7	0.00	1,600	7.0
408	159	Dec. 1, 1952	Tqc	90	154	56	37	*508	--	0	982	348	--	.0	--	2,020	408	73	--	--	2,530	9/ 2.7
408	159	Jan. 29, 1953	Tqc	106	210	61	27	164	21	0	1,080	370	.5	5.0	0.72	2,050	402	22	--	--	2,480	3.7
409	22	Dec. 9, 1952	Tqc	42	.77	18	6.3	* 44	--	62	21	66	.0	.0	--	241	71	57	--	--	362	6.5
505	270	Nov. 16, 1964	Tqc	12	151	110	55	112	17	56	452	375	.1	.8	--	1,280	500	25	2.1	.00	1,990	5.6

* Sodium and potassium calculated as sodium (Na).
1/ Includes any carbonate present.
2/ Analyzed by Texas State Department of Health.
3/ Analyzed by Texas A&M University.
4/ Test sample taken when test well was at depth or interval indicated.
5/ Sample contains 0.6 mg/l total acidity as H^{+1}.
6/ Sample contains 0.5 mg/l total acidity as H^{+1}.
7/ Sample contains 0.8 mg/l total acidity as H^{+1}.
8/ Sample contains 2.0 mg/l total acidity as H^{+1}.
9/ Sample contains 2.4 mg/l total acidity as H^{+1}.
10/ Sample contains 0.2 mg/l total acidity as H^{+1}.