GROUND-WATER RESOURCES OF THE EL PASO AREA, TEXAS

PROGRESS REPORT NO. 6

By

R. A. Scalapino

With

Section on Quality of Water

By

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PREPARED IN CO-OPERATION BETWEEN THE CITY OF EL PASO, THE TEXAS STATE BOARD OF WATER ENGINEERS, AND THE GEOLOGICAL SURVEY, UNITED STATES DEPARTMENT OF THE INTERIOR

OCTOBER 1949

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INTRODUCTION

Location and extent of area

El Paso, which according to recent estimates has a population of 135,000, is in the extreme western part of Texas on the Rio Grande just below the Franklin Mountains and the Sierra del Paso del Norte in Mexico; it has been known since Spanish times as "The Pass of the North." Ciudad Juarez, which according to the Rand McNally Commercial Atlas of 1940 had a population of 48,676, is across the river from El Paso.

The area and the ground-water reservoirs in it have been described in detail by Sayre and Livingston 1/ and the review of the extent of the area, the ground-water reservoirs, and the early history of development of ground water is summarized largely from their report.

For about 50 miles along the west side of the Franklin and Organ Mountains the Rio Grande flows south-southeast through a broad, flat-bottomed valley known as the Mesilla Valley, locally called the Upper Valley. Near the southern end of the Franklin Mountains, the river turns abruptly southeastward and passes through the El Paso Valley, locally referred to as the Lower Valley. The El Paso Valley, which is about 6 to 8 miles in width and 225 to 350 feet in depth, is carved diagonally across the Hueco bolson. The bolson is a broad, gently tilted plain bounded on the east by the Hueco and Finlay Mountains, on the south by part of the Sierra Madre Oriental of Mexico, on the west by the Franklin Mountains, and on the north by the Tularosa Basin. The bolson surface rises abruptly from the Rio Grande valley floor, giving the appearance of a broad elevated table land, and for this reason it is locally referred to as the Mesa. This report deals primarily with the ground-water reservoir beneath the Hueco bolson and the El Paso or Lower Valley.

Previous reports

An intensive study of the ground-water resources of the El Paso area was begun in 1935 by the Geological Survey, United States Department of the Interior, in cooperation with the City of El Paso and the Texas State Board of Water Engineers. The first report on the results of that investigation was released to the City of El Paso in 1937. A detailed report of the study was released in March 1941; it was later published by the U. S. Geological Survey as Water-Supply Paper 919.

Since August 1936, personnel from the water department of the City of El Paso have made measurements of water levels in wells monthly, collected water samples for chemical analysis from selected wells at regular intervals, and obtained records of the monthly pumpage from city, Army, and industrial wells in the El Paso area, including Juarez, Mexico. The data obtained have

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1/ Sayre, A. N., and Livingston, P.P., Ground-water resources of the El Paso area, Texas: U. S. Geol. Survey Water-Supply Paper 919, 1945.

been given careful study from time to time by several members of the Geological Survey. Eight memoranda and progress reports based on these data have been released since 1937 and the measurements of water levels have been published annually in water supply papers of the U. S. Geological Survey.

Purpose of this report

The present progress report discusses the amount of water pumped, the fluctuations in water levels, and the removal of water from storage during the 13-year period 1936-48. It discusses the salt-water encroachment in certain areas and the resultant effect on the quality of water. The report also discusses the experimental work carried on in cooperation with the City of El Paso to determine the feasibility of artificially recharging the valley or artesian area of the reservoir with surface water from the Rio Grande.

GROUND-WATER RESERVOIRS

The principal water-bearing beds in the El Paso area are the unconsolidated bolson deposits that partially fill the deep structural trough between the Franklin and Hueco Mountains, the younger outwash deposits that form a mantle over the older bolson deposits, and river alluvium that has been deposited in the valley. The unconsolidated deposits consist of alternating beds of clay, sand, and gravel; the individual beds range in thickness from a fraction of an inch to nearly a hundred feet. Although many wells have been drilled in this area and drillers' logs of the material penetrated have been compiled and studied, it is difficult, and in places impossible, to correlate beds from one well to another; therefore, these unconsolidated deposits will be considered as a unit in this report.

Mesa area

Sands can be found in the bolson deposits that yield water of good quality nearly everywhere on the Mesa except in the northeastern part. The yield of wells and the depth to water vary widely from place to place. Near the east side of the Mesa the water level ranges from 300 to 400 feet below the land surface; on the west side near Fort Bliss it is 200 feet; and near the New Mexico-Texas boundary it is about 300 feet. The difference in the depth to water is caused in part by the bolson surface rising toward the east and in part by the water table dipping toward the southeast. In general, the water in the Mesa area does not rise appreciably above the level at which it is encountered-that is, it occurs unconfined or under water-table conditions.

El Paso Valley (artesian) area

Water occurs in the sands and gravels beneath the El Paso Valley at depths ranging from 10 feet to at least 1,276 feet below the land surface; however, not all this water is potable. The water in deep wells in the valley is under artesian pressure and rises in the wells to an elevation comparable to that of the water table in the wells on the Mesa. Water drawn from wells between the depths of about 300 to 800 feet below the surface in the immediate vicinity of El Paso and possibly for a short distance downstream from El Paso generally is of satisfactory quality for public and industrial supplies. In the valley downstream from El Paso most wells are relatively shallow and the water, with the exception of the public supply at Fabens, is in general more or less highly mineralized. A well drilled at Clint to a depth of 1,100 feet is reported to have encountered only briny water.

Shallow water-bearing beds

Shallow water-bearing beds in the Lower Valley contain moderately to highly mineralized water and are apparently more or less completely separated by impervious beds from the deeper aquifer, which contain water of good quality. These shallow water-bearing beds occur at about the same level as or slightly above the upper fresh-water-bearing beds of the Mesa, and under certain conditions this highly mineralized water moves from the shallow beds in the valley into the beds beneath the Mesa. This condition poses a constant threat to the fresh-water-bearing beds in the area.

DEVELOPMENT OF GROUND WATER

History of development and use of ground water

According to Water-Supply Paper 919 (pp. 5-6) the first well to furnish water to the City of El Paso was known as the Watts well, which was dug about 1892 in the El Paso Valley a few hundred feet from the Rio Grande. It yielded a large amount of water but the water was of unsatisfactory quality for human consumption. During the time that water was supplied chiefly from this well, drinking water was shipped to El Paso from Deming, New Mexico. The Watts well supplied the City until 1904. In 1904 the International Water Company bought the water-works and started drilling wells on the Mesa north of Fort Bliss. In 1910 the City acquired the property of the water company and continued to drill wells on the Mesa. The Mesa wells were operated from a central plant by air lift. Owing to the low efficiency and high cost of operating this plant, city officials decided to explore the deep water sands below the Mesa nearer the city. In December 1917, construction was begun on City well 1 (well 50) in the Montana well field (see fig. 4). Pumpage was gradually shifted from the Mesa well field to the Montana well field and wells in the downtown area of El Paso, and in 1926 pumping from the Mesa well field was discontinued. In 1934 an increase in the chloride content of the water from the Montana well field became noticeable and a large part of the pumpage was shifted to the Mesa well field, where new deep wells had been drilled and equipped with deep-well turbine pumps powered with electric motors.

With few exceptions there was a steady increase in total pumpage from deep wells from 1906 to 1943 when the City of El Paso placed in operation its plant for treating surface water. The total average daily pumpage from all deep wells in the El Paso area, including Juarez, Mexico, from 1906 through 1948 is shown graphically in Figure 1,A.

The City of El Paso is the principal user of ground water from deep wells in the El Paso area. Records show that the City used approximately 44 percent of the total amount of water pumped from deep wells during the years 1943 to 1948, inclusive; industries in the area used about 26 percent; the City of Juarez, Mexico, used about 18 percent; and the United States Army at Fort Bliss used about 12 percent.

Figure 1,B shows the total estimated average daily pumpage from all deep wells in the El Paso area from 1936 to 1948, inclusive, and also shows graphically the division of the pumpage between Figure 1,B, the average daily pumpage from deep wells on the Mesa and the pumpase from deep wells in the valley or artesian area for the same period. The graph shows that there was an almost continuous increase in the total demand for ground water from 1936 to 1944. The average total withdrawal from 1936 through 1940 was 16,800,000 gallons a day; from 1941 through 1943, 22,400,000 gallons a day; and from 1944 through 1948, 21,600,000 gallons a day. In 1943 the City of El Paso completed a plant for treating surface water. The plant was placed in operation in November 1943 and thus lessened to some degree the demand on the ground-water reservoir.

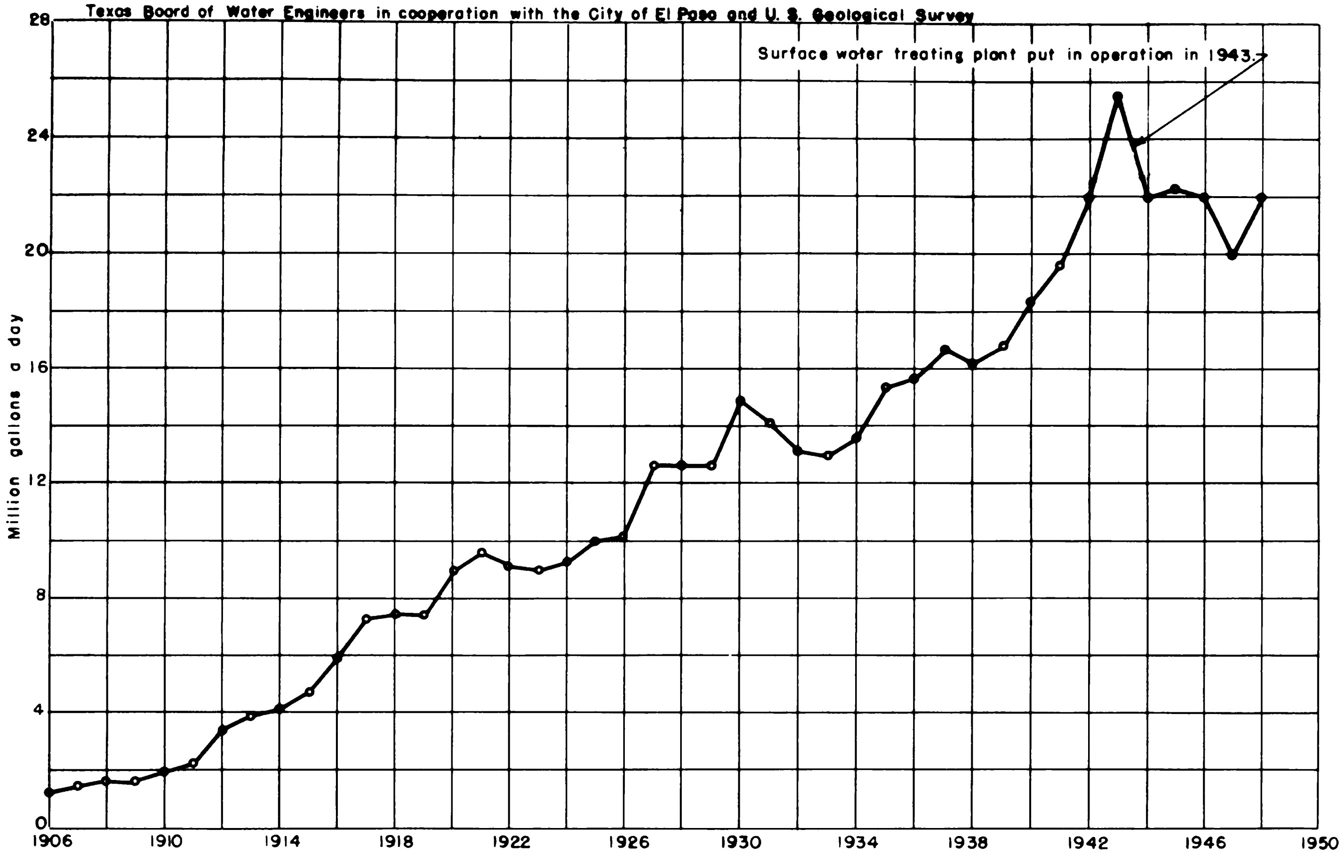

Figure 1,A.-Graph showing average daily pumpage from all deep wells in the El Paso area, Texas, from 1906 to 1948, inclusive.

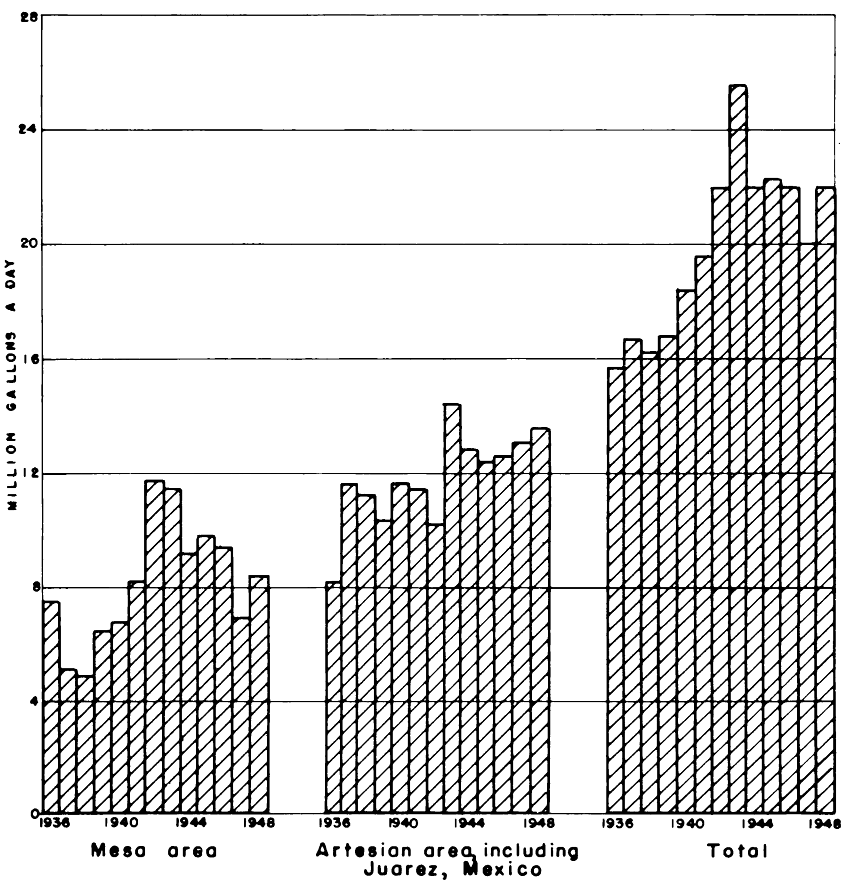

Figure 1, B.- Estimated average daily pumpage from deep wells in the El Paso area from 1936 to 1948, inclusive.

In the Mesa area the average daily pumpage by years from 1936 through 1940 was 6,200,000 gallons a day; from 1941 through 1943, 10,500,000 gallons a day; and from 1944 through 1948, 8,700,000 gallons a day.

In the valley artesian area including Juarez, Mexico, the average daily pumpage by years from 1936 through 1940 was 10,600,000 gallons a day; from 1941 through 1943, 11,900,000 gallons a day; and from 1944 through 1948, 12,900,000 gallons a day. Increasing demands for water by the local industries in the valley artesian area has kept the total pumpage at or near the same rate as in 1942, although the City has lightened the draft on the ground-water reservoir by the use of surface water.

Figure 1,B shows that the rate of pumpage from the Mesa area has declined whereas the rate of pumpage from the artesian area has increased. The average pumpage on the Mesa during the period 1944-48 was 1.8 million gallons a day less than it was during the period from 1941 through 1943. In the valley or artesian area the average rate of pumping during the period 1944 through 1948 was 1,000,000 gallons a day greater than that in the period 1941 through 1943.

The following table shows the estimated average pumpage from deep wells in the El Paso area from 1936 to 1948, inclusive, in gallons a day.

Table 1. Estimated average daily pumpage from deep wells in the El Paso area from 1936 to 1948, inclusive, in gallons a day

Year	Artesian area, including Juarez and Montana field	Mesa area	Total
1936	8,200,000	7,500,000	15,700,000
1937	11,600,000	5,100,000	16,700,000
1938	11,300,000	4,900,000	16,200,000
1939	10,300,000	6,500,000	16,800,000
1940	11,600,000	6,800,000	18,400,000
1941	11,400,000	8,200,000	19,600,000
1942	10,200,000	11,800,000	22,000,000
1943	14,100,000	11,500,000	25,600,000
1944	12,800,000	9,200,000	22,000,000
1945	12,400,000	9,900,000	22,300,000
1946	12,600,000	9,400,000	22,000,000
1947	13,100,000	6,900,000	20,000,000
1948	13,600,000	8,400,000	22,000,000

Pumpage from shallow ground water.- The shallow ground water in the valley, as previously mentioned, is too highly mineralized to be used without treatment where water of good quality is required. However, for refrigeration, air conditioning, and other uses it is a convenient source of cool water. No attempt has been made to locate all the shallow wells and only rough estimates have been made of the total volume of water pumped, but it seems likely that the total pumpage is rather large. A large electrical plant, an oil and a copper refinery, several office buildings, and others use shallow ground water, largely untreated. The City of El Paso is now pumping some shallow ground water and treating it in the new Rio Grande treatment plant, to help reduce the draft on the deeper aquifers. It is estimated that the average over-all withdrawal from the shallow wells amounts to more than 3,000,000 gallons a day but probably less than 6,000,000 gallons a day.

FLUCTUATIONS OF WATER LEVELS

Mesa area

Monthly measurements of water levels in selected wells have been made since December 1935. Owing to variations in seasonal pumpage, it has been found that measurements made in January of each year are the most reliable for purposes of showing annual changes of water levels. The contour map (fig. 2) has been prepared to show the change in water levels on the Mesa from January 1936 to January 1949. This map shows that in the 13-year period the water level has fallen a maximum of 16 feet in the Mesa well field and 15 feet in the Fort Bliss well field. It also shows that the compound cone of depression created by these two centers of pumping has spread about 12 miles to the north and perhaps 9 miles or more to the east. Control for the contour lines east of the fields is based on only a few wells; therefore, the position of the contours in the eastern part is largely estimated. The boundary formed by the Franklin Mountains, which halts the migration of the depression to the west, probably causes the cone to spread farther to the north than to the east.

The changes in water levels in seven observation wells located at distances of 1 to 12 miles from the center of pumping are shown graphically in figure 3. In general, the rate of decline has been almost constant since 1936. The approximate locations of these and all other observation wells used in this report are shown on the sketch map, figure 4.

Valley area, including Montana well field

The water levels in the deep artesian wells in the valley respond quickly to changes in the rate of pumping from a well itself or from other wells in the area, and they fluctuate over a rather wide range. This is illustrated by the graphs in figure 5 showing changes in artesian pressures in three observation wells. Although these graphs show variations in water levels of as much as 23 feet during one season, the artesian pressure in none of the wells has shown a sustained downward trend since the first available records.

Table 2 below shows numbers and owners of observations wells shown in table 3 and figure 4.

Table 2. Observation wells in the El Paso area, Texas

Well No.	Owner	Well No.	Owner
8	El Paso Electric Co., well 4	62A	El Paso Water Control and Improvement District No 1, well 2
9	El Paso Electric Co. well	64	U. S. Geological Survey test hole 1
10	El Paso drainage well	65	City of El Paso Municipal Airport well 1
12	City of Juarez, well 1	67	Texas and New Orleans Railway
13	City of Juarez, well 2	67B	Texas and New Orleans Railway
18	City of Juarez, well 3	68	Texas and New Orleans Railway
19	El Paso Milling Company	72	Fort Bliss well 2
21	El Paso City well 10	75	Fort Bliss well 5
25	El Paso Ice and Refrigeration Co.	75B	El Paso City well 15
28	Acme Laundry Co.	75D	El Paso City test well 12
29A	Consumers Ice Co., well 2	76	U. S. Geological Survey test hole 2
30A	El Paso City well 14	77	El Paso City well 11
32A	El Paso City well 17	77B	El Paso City well 15
39	Price Dairy	78C	El Paso City well 4 (test well)
42	El Paso City well 9	78	El Paso City well 11
44	Harry Mitchell Brewing Co.	79	El Paso City well 8
48A	El Paso City well 28	82A	El Paso City well 20
48B	El Paso test well 33	112	El Paso City well 32 (Old Mesa well field)
49	El Paso City well 4	128B	El Paso City well 21
50	El Paso City well 1	128C	El Paso City test well 23
51	El Paso City well 2	130	G. L. Cook
52	El Paso City well 3	136	U. S. Geological Survey test hole 3
52A	El Paso Water Control and Improvement District No. 1, well 1	138	U. S. Army reservation
53	Loretta College	139A	El Paso City test well 29
55	Texas Company Refinery	140	Southern Pacific Lines
59	Nichols Copper Co. (Phelps-Dodge)	143A	El Paso City test well 30
59A	Nichols Copper Co. (Phelps-Dodge)		

The following table gives the altitude of the water levels or artesian pressure in feet above sea level in observation wells in the El Paso area during the period 1944-48.

Table 3. Water levels in the El Paso area, Texas, in feet above sea level

1945

Well	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
8	3,693.27	3,691.62		3,692.63		3,691.82	3,691.82	3,692.12	3,692.22	3,693.81		
9	3,694.73	3,691.62		3,693.61		3,690.17	3,690.42		3,692.58			
10	3,693.87	3,691.80		3,693.00	3,691.67	3,689.99	3,690.37	3,690.12	3,691.81		3,693.25	
12	a/3,634.21				a/3,628.05	a/3,628.32						
18	a/3,659.30				a/3,650.59	a/3,650.96						
19	3,688.47					3,688.05			3,694.44			
21	3,684.41	3,683.44		3,682.81	3,681.88	3,682.03	3,681.89	3,681.86	3,682.95	3,684.67	3,684.45	3,683.37
22A	3,691.74			3,691.68		3,691.52						
28	3,681.89								3,676.71			
29A	3,665.59	3,657.29		3,661.12	3,655.07	3,654.02	3,653.27	3,655.36	3,654.87	3,665.19	3,675.49	3,659.74
30A	3,665.09	a/3,640.77		a/3,644.12	a/3,639.10	a/3,637.59	a/3,637.34	a/3,640.18		3,675.27	3,676.35	
32A	3,666.16	a/3,636.16		a/3,638.12	a/3,633.05	a/3,634.09	a/3,632.28	a/3,634.73		3,675.56	3,675.66	
39	3,666.37							3,658.02				
42	a/3,620.52	a/3,625.37	3,669.73	a/3,623.95	a/3,625.31	a/3,625.94	a/3,623.64	a/3,621.16	a/3,621.35	3,674.04	3,675.90	
42A	3,688.77			3,688.89		3,688.95						
44	3,663.57											
48A	3,671.51	3,669.85	3,674.44	3,672.74	3,664.39	3,662.00	a/3,623.83	3,665.31		3,675.68	3,678.03	3,673.23
48B	3,674.51	3,673.12	3,676.15	3,675.42	3,670.78	3,669.13	3,668.20	3,669.99	3,669.88	3,676.68	3,678.11	3,674.92
49	3,669.86	3,668.35	3,672.51	3,671.36	a/3,600.41	a/3,599.91	a/3,599.16	3,660.93	3,659.75	3,675.57	3,675.57	3,671.67
50	3,674.42	3,673.76	3,676.13	3,675.28	3,657.29	3,657.95	3,657.12	3,666.04	3,665.27	3,675.48	3,677.02	3,673.28
51	3,669.95	3,668.76	3,672.17	3,671.21	3,652.37	3,652.12	3,651.54	3,659.07	3,659.85	3,671.43	3,674.67	3,671.42
52	3,669.69	3,668.55	3,671.51	3,671.06	a/3,629.32	a/3,629.18	a/3,629.51	a/3,633.83		3,671.06	3,674.10	3,670.67
53	3,668.90	3,667.53	3,670.67	3,669.17	3,656.55	3,655.60	3,655.48		3,659.49	3,660.13	3,673.16	
55	3,667.54	3,668.60	3,670.09	3,671.17	3,666.46	3,663.99	3,663.20	3,664.75				
59	3,665.07					3,660.65						
59A	3,669.05					3,665.57						
64	3,676.96	3,677.49	3,677.08	3,677.31	3,676.88	3,676.82	3,676.62	3,676.54	3,676.49	3,675.98	3,676.32	
67B	3,668.05	3,665.27			3,666.52	3,657.35		3,659.13				
72	3,660.47	3,653.48	3,662.44		3,643.49	3,640.56		3,636.91				
75B	3,662.36	3,664.81	3,664.71	3,664.40	3,663.10	3,662.65	3,662.46	3,663.23	3,662.10	3,663.18	3,663.10	3,663.56
75D			3,665.99									
76	3,674.33	3,674.12	3,674.38	3,673.75	3,672.89	3,672.42	3,672.26	3,672.32	3,672.07	3,673.83	3,674.07	3,674.44
77	3,658.85	3,660.56	3,660.45	3,658.40	3,652.62	3,650.49	3,649.63	3,650.11	3,649.83	3,658.29	3,659.76	3,660.22
78C	3,673.96	3,673.76	3,673.89	3,673.91	3,673.60	3,673.49	3,673.30	3,673.15	3,673.00		3,672.90	3,673.09
79	3,658.53	3,661.62		3,661.18								
82A	3,667.79	a/3,605.49	a/3,606.89	a/3,607.38	a/3,603.55	a/3,602.74	a/3,602.74					
112	3,661.21	3,663.25	3,663.52	3,663.26						3,656.15	3,657.62	3,658.33
128C	3,681.49	3,681.37	3,681.40	3,681.33	3,681.18	3,681.04	3,680.90	3,680.79	3,680.68	3,680.59	3,680.48	
128B	a/3,636.07	a/3,634.53	a/3,634.59	a/3,635.83	a/3,634.84	a/3,634.22	a/3,634.44	a/3,634.40	a/3,634.46	a/3,635.42	a/3,635.73	a/3,635.60
130	3,682.12	3,679.99	3,681.96	3,680.57								
136	3,697.41	3,697.42	3,697.57	3,697.61	3,697.31	3,697.29	3,697.23	3,697.20	3,697.17	3,697.17	3,696.98	
139A	3,709.07			3,709.24		3,709.02						
143A	3,723.36			3,723.37		3,723.28						

a/ Pumping.

Table 3. Water levels in the El Paso area, Texas, in feet above sea level -- Continued

1946

Well	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
8								3,688.33				
10	3,693.84	3,682.55			3,691.12	3,691.05	3,689.93				3,690.40	
19	3,688.28						3,688.53					
21	3,683.01				3,682.12	3,682.18	3,682.57	3,682.22	3,682.18	3,682.73	3,682.51	
29A	3,656.34	3,656.61			3,659.32	3,652.68	3,666.69	3,660.38	3,654.83	3,671.60	3,659.89	3,672.74
30A	a/3,636.33	a/3,636.67			3,641.48	3,660.46	3,665.95	3,662.73		3,671.72		3,673.27
32A	a/3,635.64	a/3,633.73			3,661.99		3,667.86	3,663.46		3,671.86		3,672.78
42	a/3,625.07	a/3,623.55						3,660.46		3,670.54		3,673.16
48A	3,669.57	3,668.21			3,667.58		3,664.32	3,661.64	3,663.72	3,669.42	3,671.22	3,675.01
48B	3,673.57	3,672.61			3,672.07	3,668.56	3,671.57	3,668.88	3,669.72	3,673.72	3,674.17	3,675.36
49	3,668.36	3,667.44									3,670.58	
50	3,673.85	3,672.20			3,670.64	3,657.78	3,661.95	3,659.16	3,661.48	3,666.35	3,674.98	3,675.98
51	3,669.06	3,667.67			3,662.39	3,651.97	3,654.94	3,651.87	3,653.65	3,658.02	3,670.42	3,671.85
52	3,668.98										3,669.89	3,670.92
53	3,668.55	3,667.94			3,663.68	3,656.27	3,658.98	3,656.45	3,657.87	3,661.77	3,669.48	3,670.73
55									3,663.05	3,665.51		
64	3,676.70	3,676.68			3,676.44	3,676.28	3,676.25	3,676.23	3,676.01	3,676.01	3,676.23	3,676.06
75B	3,663.24	3,663.55			3,662.48	3,661.62	3,661.51	3,661.40	3,661.75	3,662.02	3,662.73	3,663.15
76	3,674.14	3,674.43			3,672.64	3,671.82	3,671.60	3,671.67	3,672.12	3,672.36	3,673.10	3,673.87
77	3,659.89	3,659.77			3,655.11	3,649.56	3,649.50	3,650.68	3,655.19	3,655.29	3,660.02	3,662.03
78C	3,672.92	3,672.85			3,672.52	3,672.45	3,672.28	3,672.14	3,672.02	3,672.13	3,672.07	3,671.67
112	3,657.04	3,657.46			3,656.31					3,658.57	3,661.99	3,663.03
128B	a/3,635.67	a/3,635.81			a/3,634.52	a/3,633.88	a/3,633.81			a/3,633.92	a/3,633.92	a/3,635.25
128C	3,680.34	3,680.35			3,680.00	3,679.94	3,679.59	3,679.59	3,679.61	3,679.54	3,680.47	3,678.36
136	3,696.90	3,697.25			3,696.96	3,696.81	3,696.76	3,696.72	3,696.65	3,696.61	3,696.79	3,696.68

a/ Pumping.

Table 3. Water levels in the El Paso area, Texas, in feet above sea level - Continued

1947

Well	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
8	3,688.99					3,687.31						
9	3,691.82											
10	3,691.26	3,692.50	3,690.90	3,689.83		3,687.20			2,687.94			3,683.45
18	3,653.07											
19	3,690.08											
21	3,682.71		3,682.68	3,682.60		3,682.36		3,682.22	3,682.42			
29A	3,658.60	3,657.13		3,667.74		3,666.32						
30A	a/3,641.95	a/3,640.86	3,670.49			3,664.51		3,670.13	3,671.69			3,676.22
32A	a/3,636.95	a/3,636.43		a/3,642.44				3,670.60	3,672.22			3,675.60
42	a/3,626.32	a/3,625.97	3,671.28	3,670.66				3,669.36	3,670.85			3,676.58
48A	3,671.41	3,669.49	3,674.62			3,667.32	3,664.38	3,668.75	3,671.69			3,667.76
48B	3,674.11	3,672.42	3,675.38	3,675.19		3,671.38	3,670.58	3,673.21	3,673.73			3,677.63
49	3,671.01	3,668.16	3,672.46									3,674.59
50	3,675.38	3,673.93	3,676.28			3,669.58	3,666.29	3,665.48	3,667.66			3,677.88
51	3,670.52	3,668.63	3,672.18									
52	3,670.78	3,668.39										
53	3,670.35	3,667.85	3,671.27			3,663.50		3,660.83	3,665.38			3,674.28
55	3,669.59					3,660.82						
59	3,664.52											
64	3,677.20	3,677.18	3,676.93	3,676.86		3,675.88	3,675.72	3,675.65	3,676.38			3,676.28
67B	3,667.87											
72	3,657.37											
75B	3,663.60	3,663.18	3,663.95	3,662.95		3,662.55	3,660.15	3,660.62	3,660.63			3,664.43
76	3,674.14	3,674.03	3,673.82	3,673.93		3,672.26	3,671.88	3,671.78	3,671.45			3,674.49
77	3,662.04	3,661.28	3,662.18	3,658.72		3,658.00	3,655.25	3,655.17	3,654.81			3,664.84
78C	3,671.67	3,671.79	3,671.56			3,671.48	3,671.33	3,671.44	3,671.28			3,670.36
112	3,663.03	3,662.74	3,663.56			3,657.53						3,664.44
128B	a/3,635.25	a/3,633.89				a/3,632.34						3,632.34
128C	3,678.36	3,679.22	3,679.07	3,679.10		3,678.88	3,678.70	3,678.66	3,678.51			3,679.11
136	3,696.68	3,696.61	3,696.46	3,696.52		3,696.45	3,696.24	3,696.25	3,696.11			3,696.28
139A	3,708.51					3,708.39						
143A	3,722.91					3,723.26						

a/ Pumping.

Table 3. Water levels in the El Paso area, Texas, in feet above sea level - Continued

1948

Well	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
8	3,686.51											
10	3,687.42					3,686.95		3,686.64				
21	3,682.97					3,683.45		3,683.78				
29A						[illegible]		3,669.24		3,674.49		3,676.67
30A	3,673.28					3,667.89				3,674.74		3,677.31
32A	3,672.50					3,670.36		3,669.34		3,674.69		3,676.72
39											3,674.94	
42	3,667.02									3,675.01		3,677.86
48A	3,674.82		3,677.80							3,676.10		3,677.09
48B	3,675.71		3,677.50			3,668.78	3,670.25	3,671.54	3,673.92	3,676.43	3,677.02	3,678.38
49	3,672.00		3,674.44								3,673.03	3,683.95
50	3,676.88		3,680.79	a/3,607.57		3,665.12	3,664.46	3,666.43	3,671.64	3,676.35	3,677.29	3,677.60
52			3,674.99							3,671.59		3,672.98
53	3,671.77		3,673.81			3,658.45		3,659.48	3,664.26	3,671.00		3,675.65
55	3,668.92		3,668.85			3,660.20						
64	3,675.61					3,675.78	3,675.58	3,675.66	3,675.29	3,675.46	3,676.51	3,675.55
72	3,659.27											3,657.28
75B	3,663.07		3,663.32		3,660.17	3,659.36	3,658.97	3,658.97	3,656.18	3,660.60	3,662.36	3,664.13
75D												3,665.37
76	3,673.84					3,671.80	3,671.17	3,671.13	3,670.92	3,672.36	3,673.05	3,674.10
77	3,660.72					3,653.60		3,653.11				3,664.88
78C	3,670.74					3,670.99		3,670.59		3,670.54		3,670.20
82A												3,670.20
112	3,657.21											3,661.27
128B	a/3,633.23		3,676.64									3,676.93
128C	3,678.75		3,679.24			3,678.40		3,678.03	3,678.03	3,677.93		3,678.48
130												3,678.85
136	3,696.24					3,696.03	3,695.93	3,695.98	3,695.75	3,695.67	3,695.58	3,695.86
139A	3,709.02					3,708.34						
143A	3,723.69					3,723.01						

a/ Pumping.

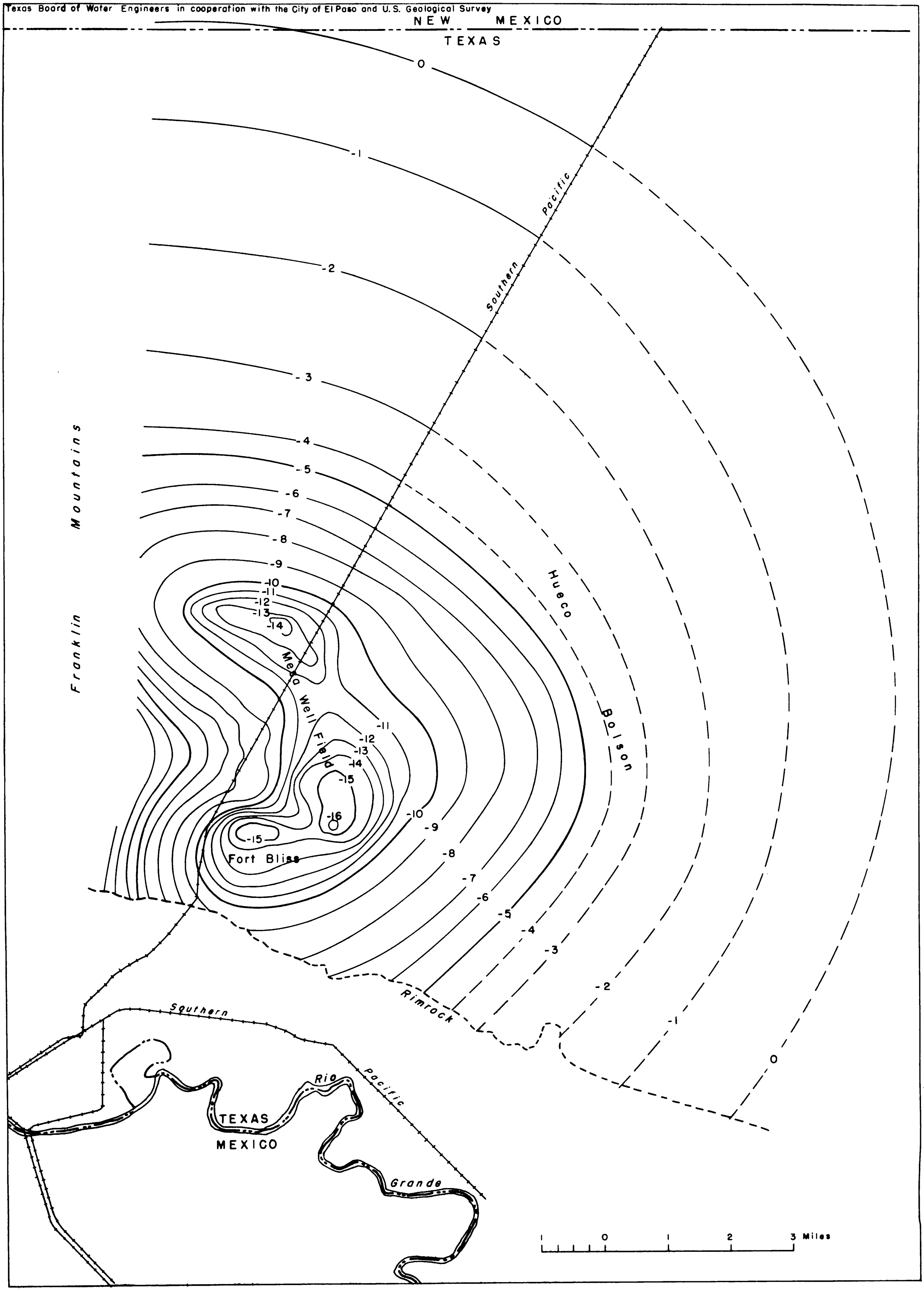

Figure 2.-Map of the El Paso area showing decline (-) of the water table on the Mesa northeast of El Paso from January 1936 to January 1949.

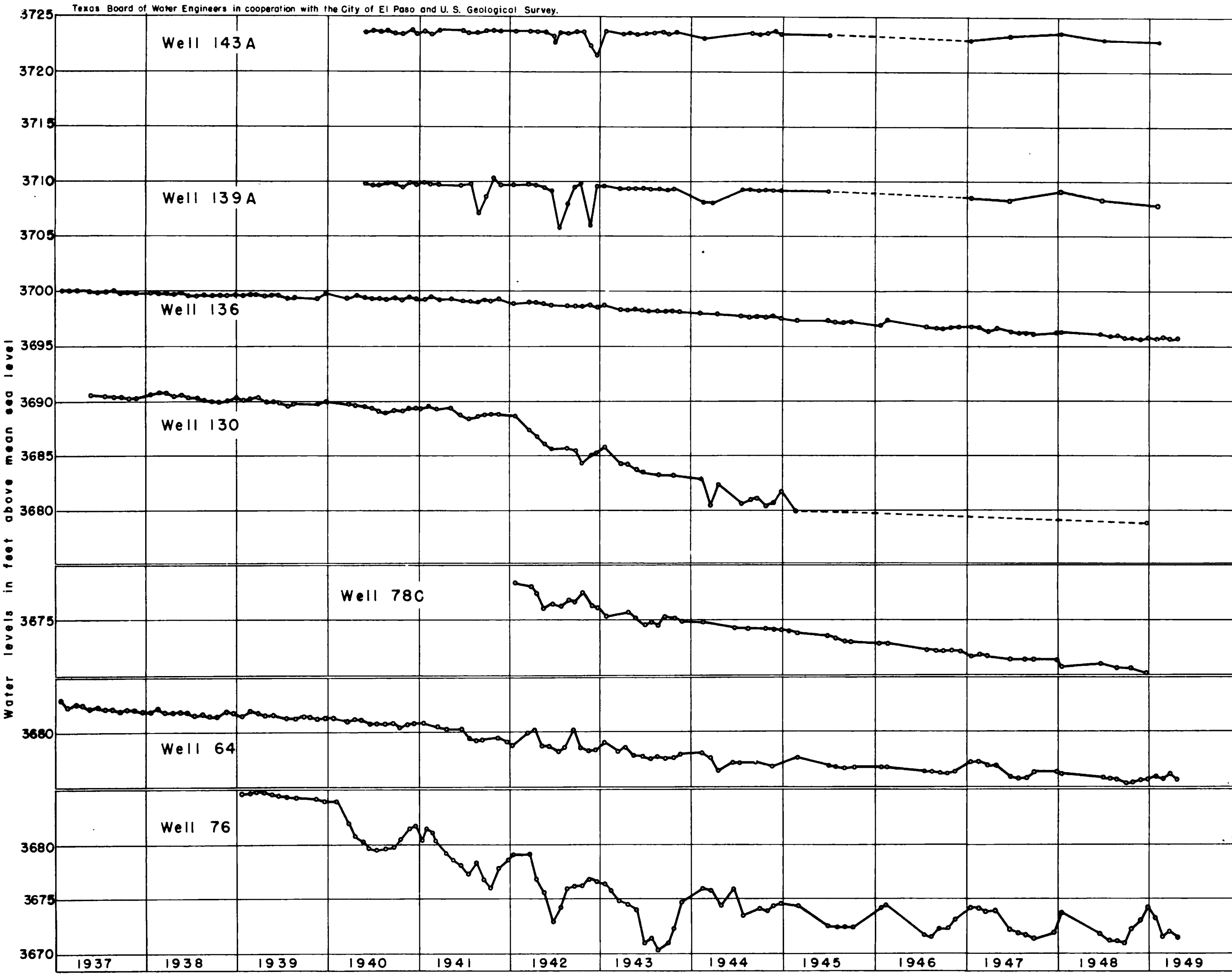

Figure 3.- Water levels in observation wells in the Mesa area, El Paso, Texas.

(For locations of wells, see fig. 4)

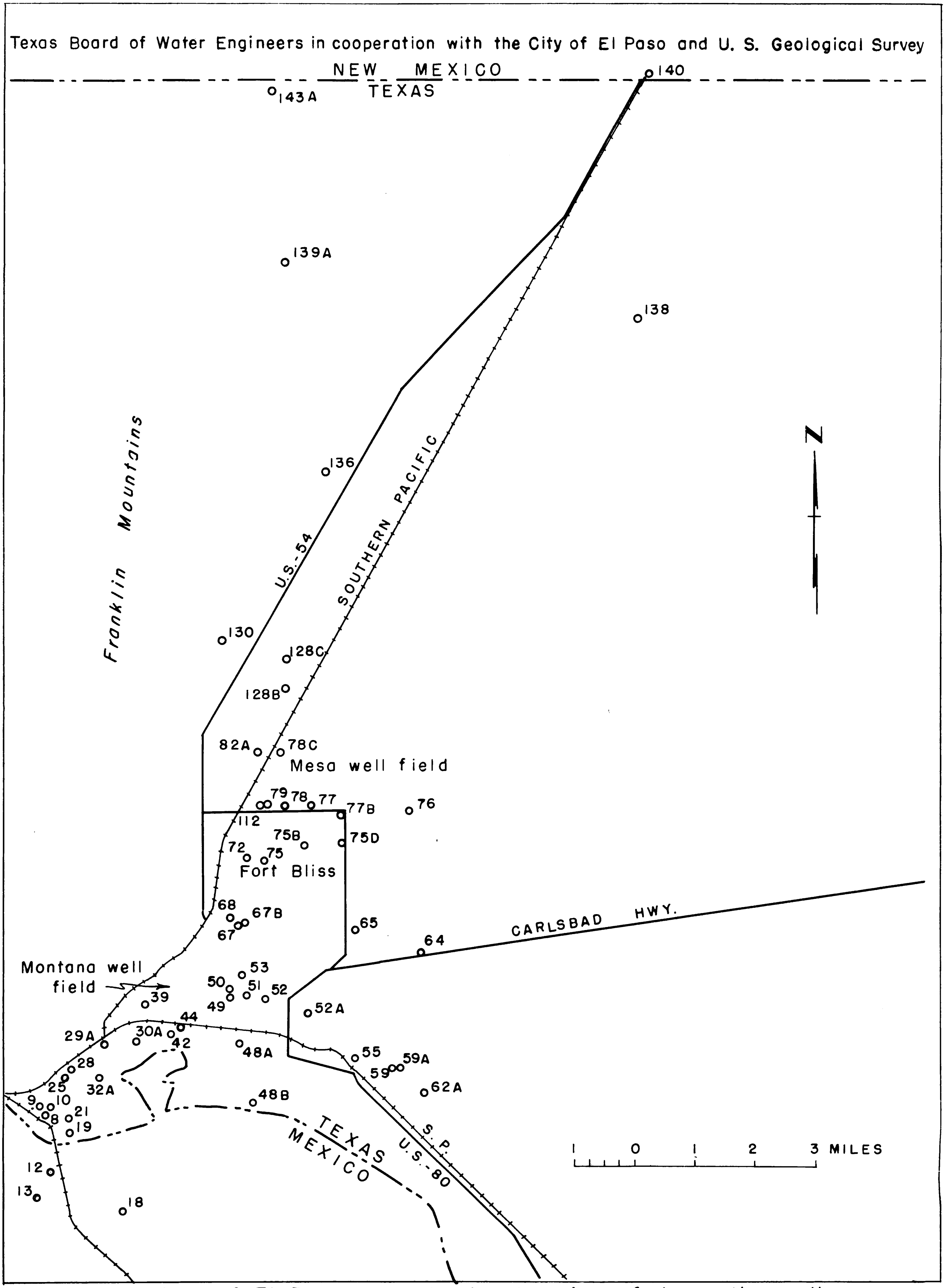

Figure 4.-Map of El Paso area showing locations of observation wells used in this report.

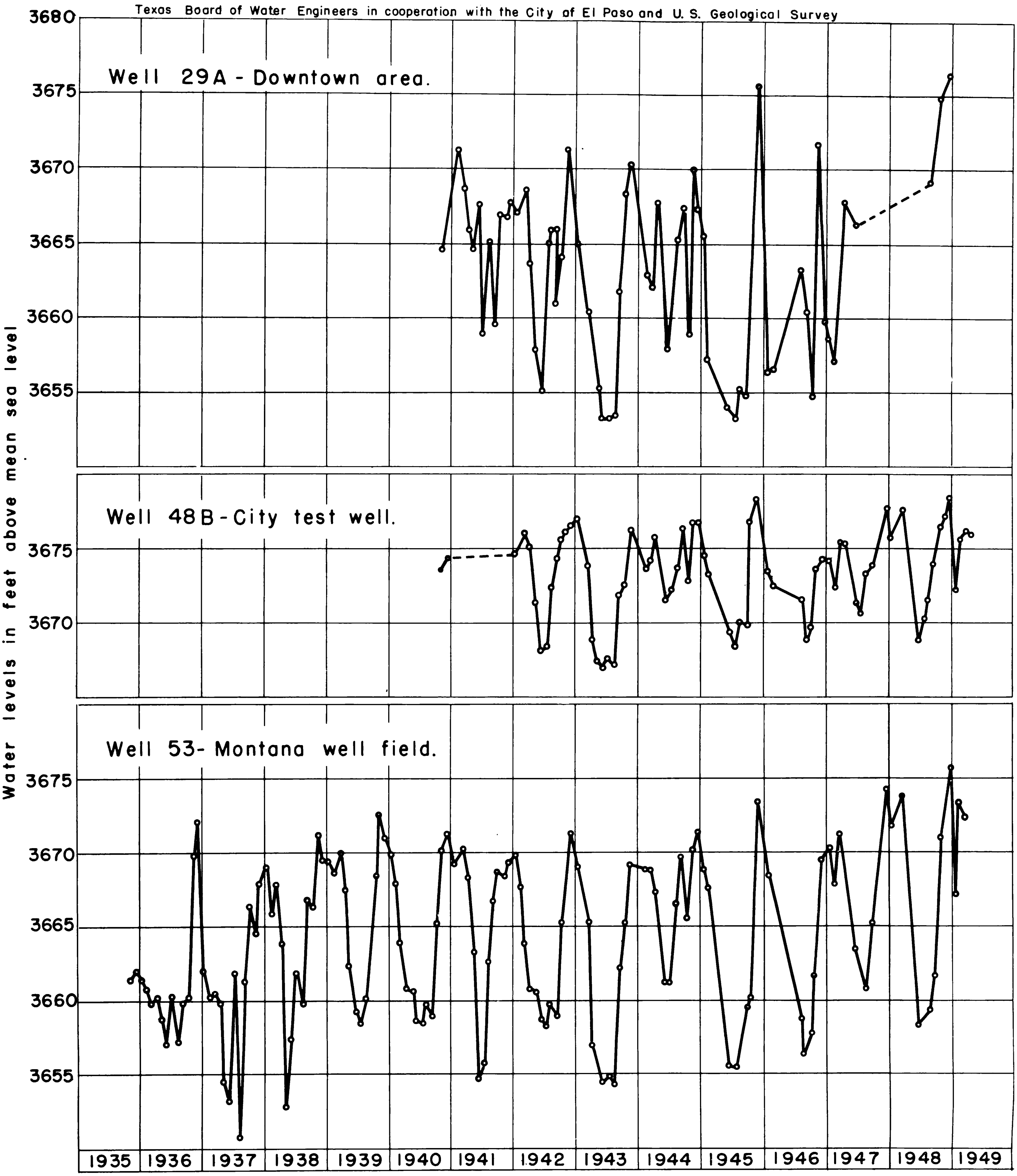

Figure 5.- Water levels in observation wells in the artesian area, El Paso, Texas.
(For locations of wells, see fig. 4)

REMOVAL OF WATER FROM STORAGE ON THE MESA

In the progress reports of 1944 and 1945, water-table conditions were assumed to exist throughout the Mesa north of the rimrock, and computations based on the records of water-level measurements showed the volume of material unwatered on the Mesa to be 206,000 acre-feet from 1936 to 1943 and 100,000 acre-feet during the 2-year period 1943-44. Using the same method, it is estimated that the volume of material unwatered during the years from 1945 to 1949 was 118,000 acre-feet and during the entire 13-year period 1936 to 1949 was 424,000 acre-feet.

In previous reports the figure of 17½ percent has been used as the specific yield, and it has been computed that the amount of water removed from storage was about 4,600,000 gallons a day from 1936 to 1943, and about 8,000,000 gallons a day during 1943 and 1944. Using the same figure, it has been computed that 4,600,000 gallons a day was removed from storage from 1945 to 1949; and about 5,100,000 gallons a day for the entire period from 1936 to 1949.

The pumpage of ground water in the El Paso area for the 13-year period from 1936 to 1949 averaged about 20,100,000 gallons a day. Of this amount it is computed that about 5,100,000 gallons a day was removed from storage on the Mesa. Therefore, the difference between these figures indicates that an average of about 15,000,000 gallons a day was obtained from recharge or lateral movement of water toward the well fields from beyond the Mesa; study of the available data indicates that most of this water came from recharge on the Mesa.

ARTIFICIAL RECHARGE

Experimental studies

The availability of excess surface water from the Rio Grande during the winter, when the demand on the output of the treatment plant is low, suggested to Mr. E. J. Umbenhauer, Superintendent of the El Paso Department of Water and Sewage, the possibility of storing some of this water in the artesian area for removal at a later date. The practice would have the added advantage of increasing the head in the fresh-water sands and helping to prevent, to some extent, the encroachment of salt water into these sands. In 1947 the U. S. Geological Survey was requested to make an investigation to determine the feasibility of this plan, and considerable field work and study have been done by R. W. Sundstrom and the writer.

In February 1948 the Geological Survey, in cooperation with the City of El Paso and the Texas State Board of Water Engineers, began field work to obtain the data necessary for computing the effects of recharge and comparing these computations with the observed effects. Water was injected into well 49 (City well 4) at the rate of 1,060 gallons a minute for 15 days, and the effect on the water level in well 50 (City well 1) was recorded by an automatic water-stage recorder.

In connection with the recharge investigation, a pumping test was made in the Montana well field to determine the effect of pumping on the artesian pressure. In this test, well 49 (City well 4) were pumped continuously at the rate of 1,360 gallons a minute for 48 hours and the resulting drawdowns were observed in well 50 (City well 1), 1,000 feet from well 49; well 53 (Loretta College), 3,200 feet from well 49; well 52 (City well 3), 3,450 feet from well 49;

and well 48 (City well 18), 4,000 feet from well 49. From the results of this test, the coefficients of transmissibility and storage for the water-bearing materials were computed mathematically by means of the Theis nonequilibrium formula. The coefficient of transmissibility may be expressed as the number of gallons of water that will move in 1 day through a vertical strip of the aquifer 1 foot wide and having the height of the aquifer, when the hydraulic gradient is unity. The coefficient of storage, under artesian conditions, may be expressed as the volume of water, measured in cubic feet, released from storage in each column of the aquifer having a base 1 foot square and a height equal to the thickness of the aquifer, when the artesian head is lowered 1 foot.

The coefficients of storage and transmissibility obtained from this test are listed in the table below.

Table 4. Coefficients of transmissibility and storage obtained in pumping test on well 49 (City well 4)

Well No.	Coefficient of transmissibility	Coefficient of storage
49	Pumped well	
50	124,400	0.00271
53	139,600	.00117
52	82,400	.00063
48a	129,100	.00138

Using the data above, the theoretical rise in the artesian pressure in well 50 (City well 1) resulting from the artificial recharge at 1,060 gallons a minute was computed and found to follow very closely the observed rise in pressure recorded by the automatic water-stage recorder. Water was again injected into well 49 (City well 4) at a constant rate of 550 gallons a minute for 3 days and then increased to 700 gallons a minute for 9 days. The rise in water levels was recorded on automatic water-stage recorders in wells 50 and 53 and measured with a steel tape at frequent intervals in wells 52 and 48a. By using the coefficients of transmissibility and storage obtained from the pumping tests, by means of the Theis nonequilibrium formula, the theoretical rise in artesian pressures was computed. The observed and computed theoretical rises in pressure caused by artificial recharge agree closely. (See fig. 6).

Theoretical effect of recharge

Owing to the close correlation between the computed and observed rises in pressure, calculation of the theoretical effect of recharging the Montana well field at a higher rate than that used during the experiment seems justified. For the purpose of computation, four wells spaced at intervals of 1,500 feet were assumed to be located in the Montana well field, each well to be recharged at the rate of 1,000 gallons a minute for 90 days. The pressure cone developed by this hypothetical recharge field has been computed, using averages of the coefficients of transmissibility and storage obtained in the pumping test and taking into consideration the boundary formed by the Franklin Mountains on the west. The results of this study are shown in figure 7. The contour showing a rise of 10 feet reaches a distance of about 4 miles south and east from the center of recharge, and it was computed that a rise in artesian pressure of 1 foot would occur at a distance of about 11 miles south and east from the center of recharge.

The boundary between artesian and ground-water conditions has not been definitely established, but for purposes of computation it was assumed to be near the rimrock of the Mesa. The rise in water levels in wells on the Mesa where water-table conditions prevail would not be nearly so great

Texas Board of Water Engineers in cooperation with the City of El Paso and U. S. Geological Survey

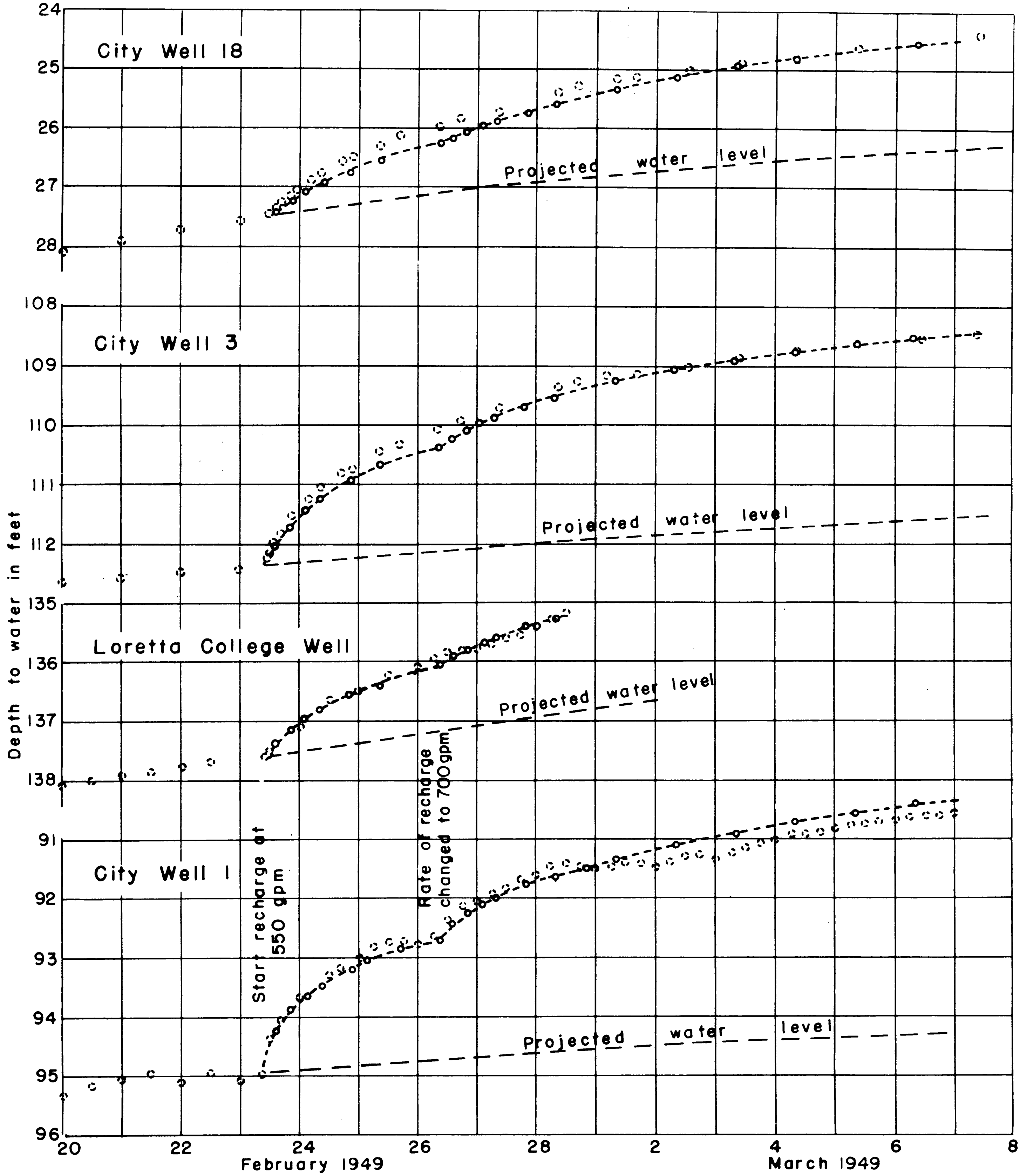

Figure 6.- Graph showing rise in water levels in observation wells due to recharge of City well 4, and theoretical rise as computed by the Theis non-equilibrium formula.

○ Observed water level ○--○ Computed water level

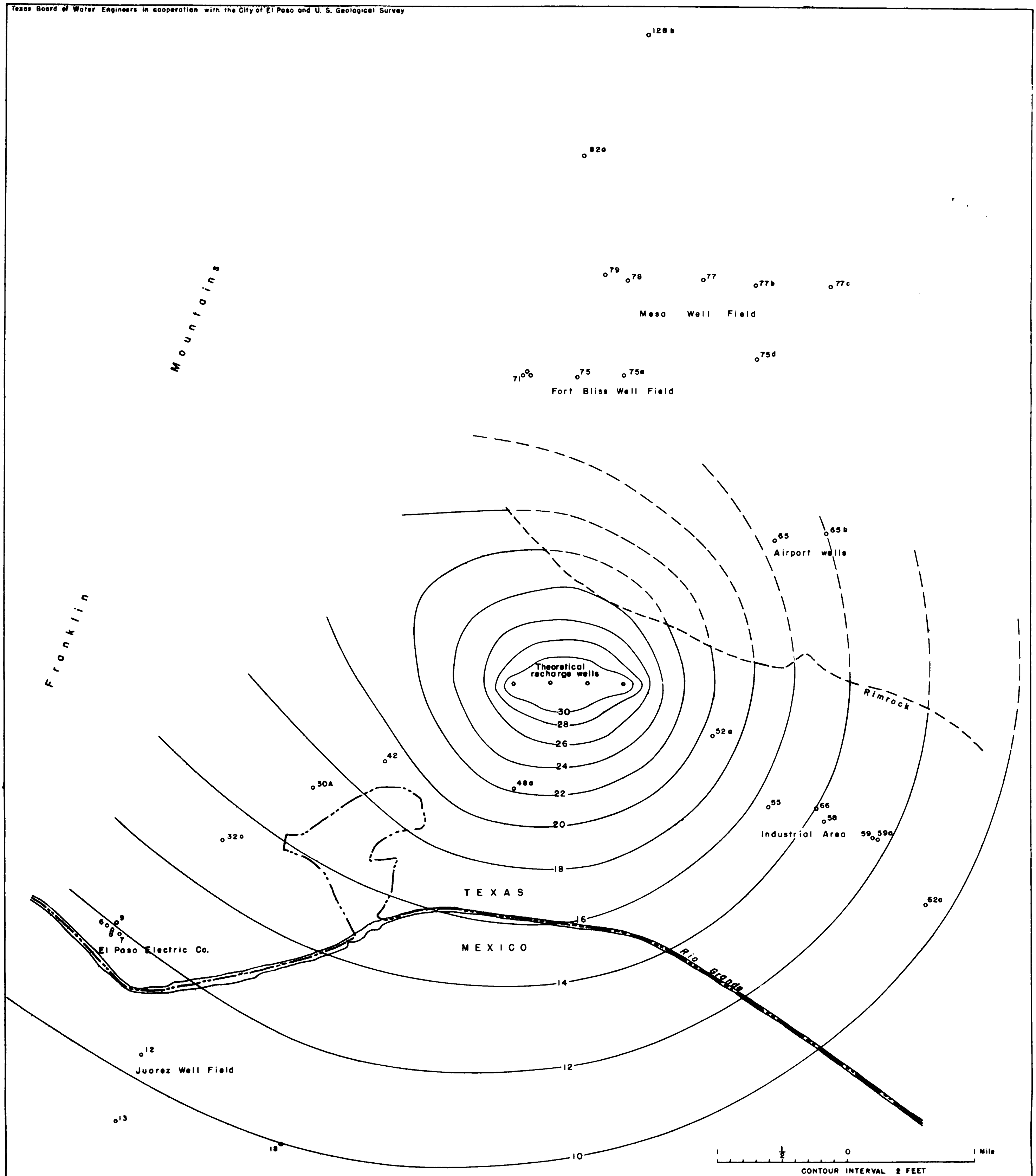

Figure 7.-Map of the El Paso area showing the theoretical rise of artesian pressure in feet after recharging the Montana well field 90 days at a rate of 5.76 million gallons a day.

nor would the cone spread so far, owing to the fact that the water-bearing beds have a specific yield of about 17½ percent (0.175) as compared to an average storage coefficient of 0.0015 in the artesian area. The exact boundary between the two areas has not been established; therefore, the spread of the pressure cone has been computed only for the area assumed to be under artesian pressure.

It is apparent from study of the data that recharge at the rate of 4,000 gallons a minute for 90 days would raise the artesian pressure in most of the deep wells in the artesian area from 10 to 35 feet. (See fig. 7). It must be remembered that the rise is largely a result of the transmission of pressure and does not represent the position of water introduced by recharge. The position of the recharge water has not been computed, but at the end of 90 days the recharge water would not have moved more than a few hundred feet from the recharge wells, and most of the water could be recovered if pumping in the immediate vicinity of the recharge wells were started immediately after injection stops. Pumping from industrial wells near the Montana well field would lower the artesian pressure built up by recharge, but it would not withdraw any appreciable quantity of the water used in recharge.

A discussion in a following section of this report points out that salt-water encroachment into the fresh-water beds is taking place in some parts of the artesian area. Where such encroachment is taking place, the increase in artesian pressure due to artificial recharge would be beneficial in retarding or halting the advance of salt water into the aquifer. Further benefits of artificial recharge in the Montana well field area could be expected in the Mesa area, where the rate of movement of ground water from the Mesa toward the artesian area would be retarded owing to the increase of pressure in the artesian area. Also, the yield of the wells in the valley area, where many of the city and industrial wells are located, would increase at comparable pumping levels and the cost per gallon of pumping from the wells would decrease.

SALT-WATER ENCROACHMENT

In the artesian area, where wells penetrate beds containing highly mineralized water before reaching fresh-water beds, there is always danger of the mineralized water moving into the fresh water, either through holes in the well casings or by penetration through or around the barrier separating the two aquifers. Since 1935 the mineral content in the water from some of the wells in the El Paso area has increased steadily. As examples, the increase in chloride in 10 wells is shown graphically in figures 8, 9, and 10.

Although the total increase in mineral content has not become alarming at any of the City wells, there is a definite upward trend that should be given careful consideration in future development of the ground-water supply of the area. Further lowering of water levels or the artesian pressure probably would accelerate the rate of encroachment.

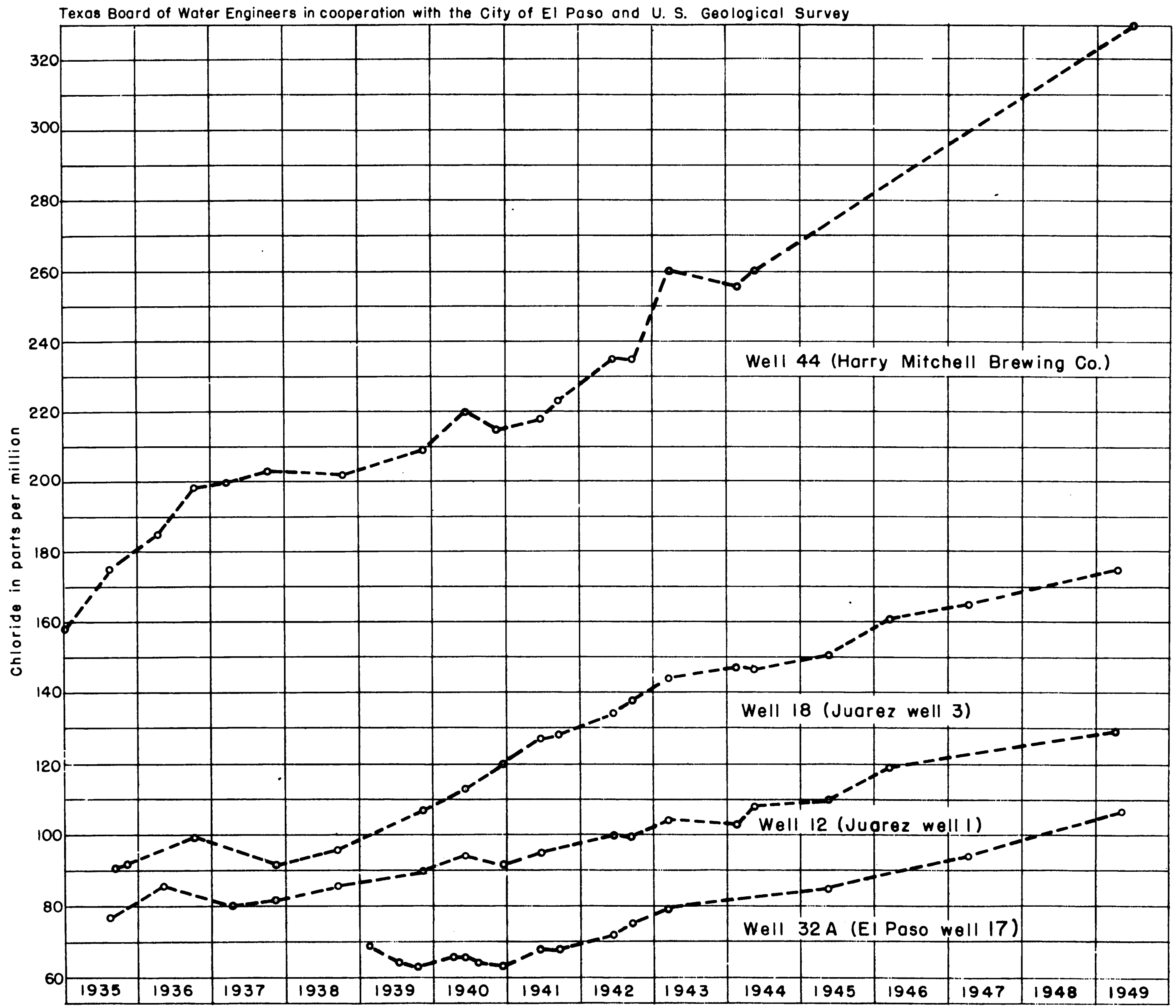

Figure 8.- Graph showing increase in chloride content in the water from wells in the artesian area of El Paso, Texas and Juarez, Mexico.

mlc-1949

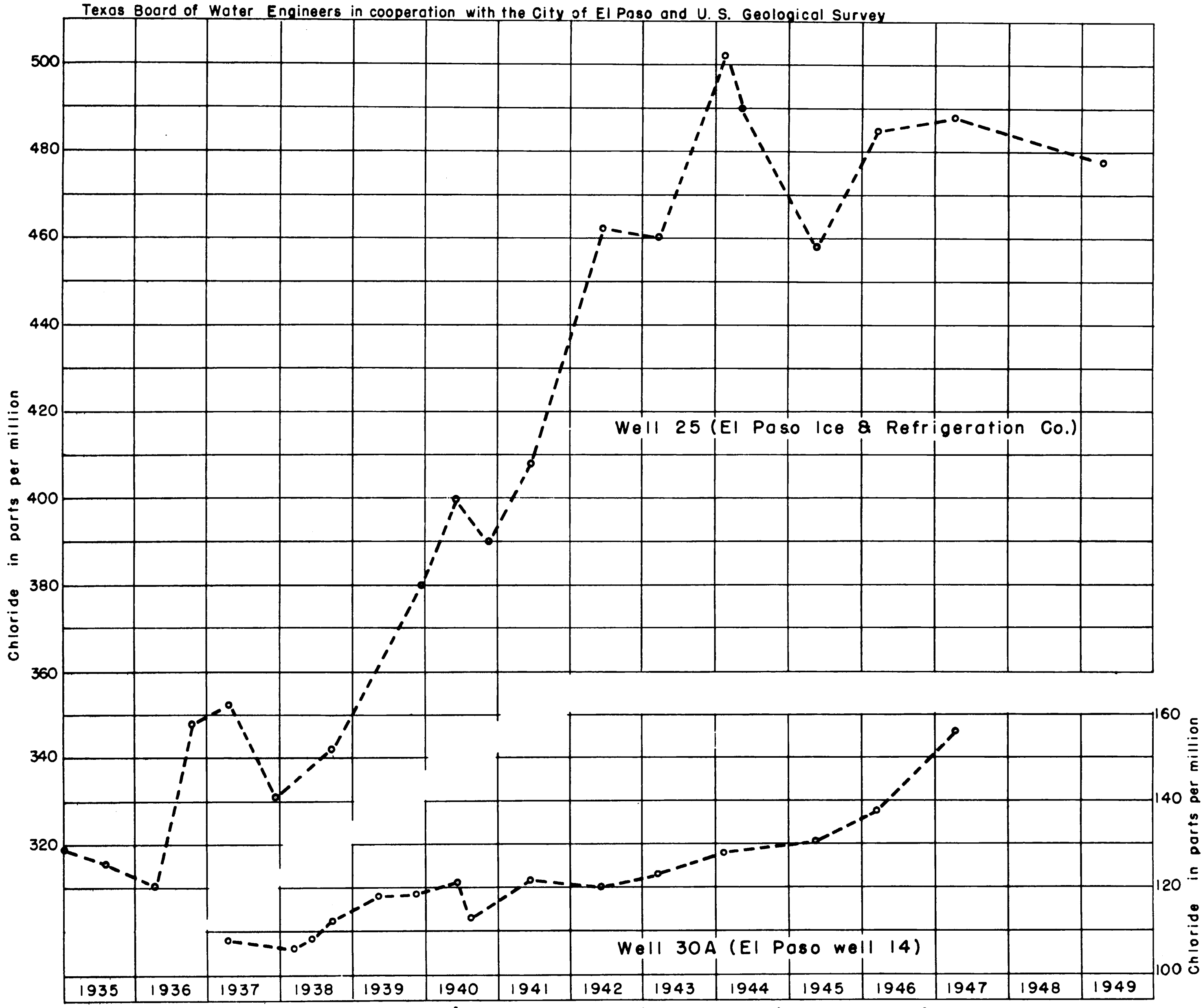

Figure 9.-Graph showing increase in chloride content in the water from wells in the artesian area of El Paso, Texas.

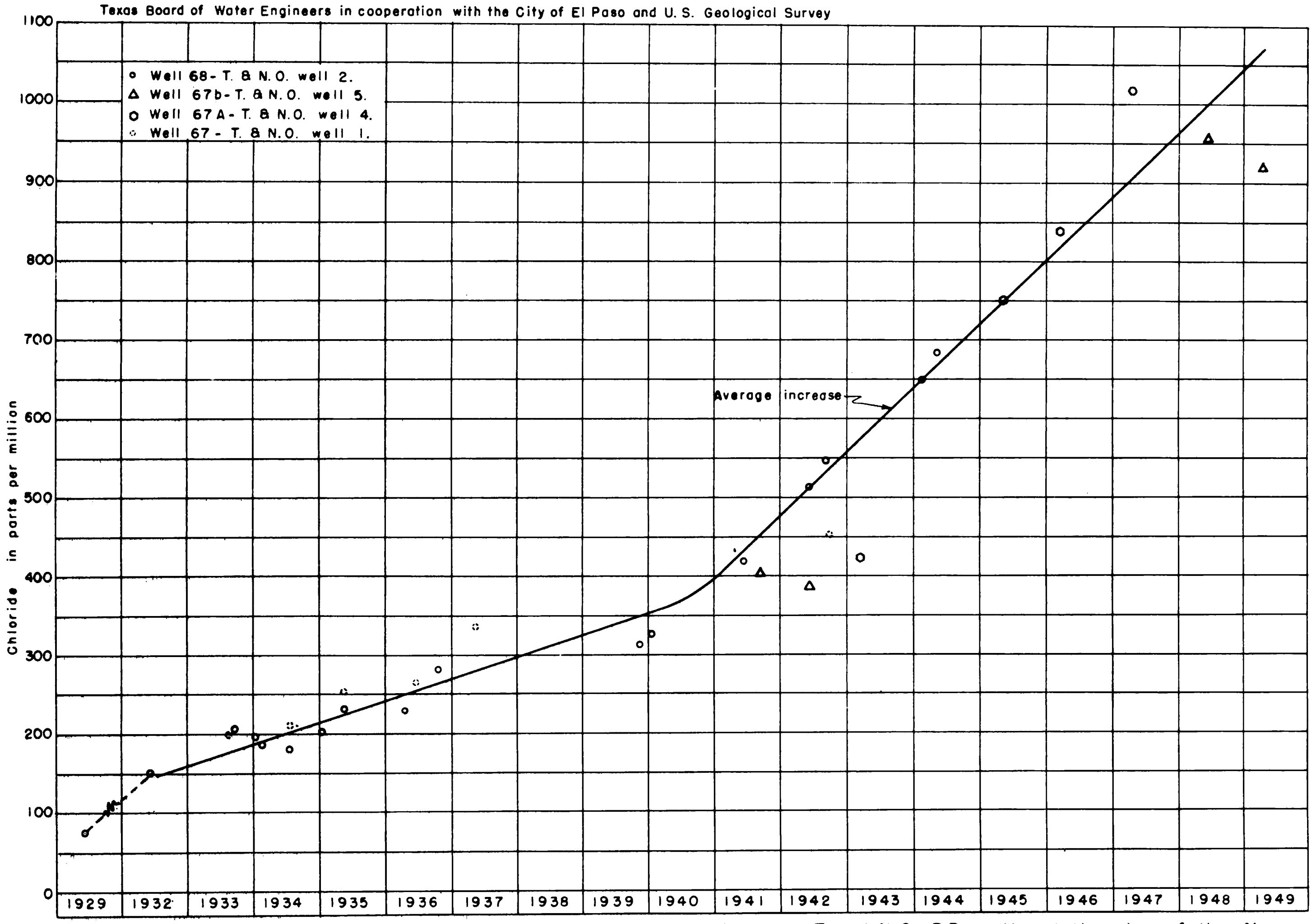

Figure 10.- Graph showing increase in chloride content in the water from the T. and N. O. R.R. wells at the edge of the Mesa, El Paso, Texas.

mlc-1949

The following table shows the chloride in parts per million in water from eight observation wells in the artesian area at the time of the first analysis and last analysis and the percentage increase in chloride of the last analysis over the first

Table 5. Chloride in water from eight observation wells in the El Paso area, Texas

Well	Owner	FIRST ANALYSIS		LAST ANALYSIS		Percentage increase
		Date	Chloride (ppm)	Date	Chloride (ppm)	
12	Juarez well 1	8-22-35	77	4-22-49	129	68
18	Juarez well 3	9-23-35	91	4-22-49	175	92
25	El Paso Ice and Refrigeration Co.	8-23-35	316	4-22-49	478	52
30A	El Paso well 14	4-20-37	108	4-26-47	178	65
32A	El Paso well 17	2- 4-39	69	4-22-49	107	55
44	Mitchell Brewery	1- 5-35	158	5- 8-44	260	65
67 and 67B 1/	T. & N. O. well at edge of the Mesa	10-25-31	38	4-21-49	920	2,400

1/ Companion wells.

QUALITY OF WATER

By Burdge Irelan

Analyses of water from 24 supply wells, arranged chronologically, are given in the tables on pages 13-21 . Most of the analyses were made in the laboratory of the City of El Paso or in the Geological Survey laboratories in Washington or Austin. A few of the analyses were made in commercial or industrial laboratories. Information as to the source of a small number of analyses is missing. When known, the sources of the analyses are given.

As has been previously pointed out in Water-Supply Paper 919, few generalizations can be made regarding the quality of the ground water in the El Paso area. The tables indicate that most of the wells yield water that varies somewhat in chemical composition. These variations are probably due to changes in pumping and mutual interference of the wells. Wells that produce water from more than one zone may show some changes in composition due to changes in the proportions of the water produced from the different zones.

In order to determine whether significant changes are occurring in the character of water being produced from any area or from a particular well, it is helpful to know the limitations and precision of the analyses themselves. The collected analyses come from a number of sources and in many cases the methods of analysis used are not known. Where changes shown in the tables are small, they may be due to differences in analytical procedures and techniques. Changes of only a few parts per million or a few percent in any constituent should not be regarded as important unless supported by changes in other constituents.

Not all the constituents tabulated can be assumed to have been determined with equal precision. The determinations of chloride are probably the most nearly correct, followed by the bicarbonate and sulfate determinations, whereas the dissolved-solids and hardness determinations are the least accurate.

The tabulated dissolved solids may be either the residue left on evaporation or the sum of the constituents found by analysis, bicarbonate being recalculated as carbonate. The sum may or may not include the silica, as the silica determination has been omitted by many analysts. The residue on evaporation may also include some water of crystalization. A variation of 10 percent in the dissolved solids reported should not, therefore, be regarded as significant.

Formerly many of the hardness determinations were made by the soap method. Where calcium and magnesium are reported, the hardness is customarily calculated. The soap-method and calculated values for hardness do not ordinarily agree exactly. The soap value is the least reproducible and is increasingly unreliable for hardness values above 100.

In some of the analyses sodium was determined and separate calculated values are given for potassium. Usually, however, sodium was calculated by difference from the reacting values of the other constituents, and the value includes potassium. As the error in calculating sodium is the sum of the errors of the individual determinations, small changes in the sodium tabulations are not significant.

The bicarbonate value is usually precise unless accompanied by changes in calcium that may indicate precipitation of calcium carbonate. Most of the sulfate values are good, but some sulfate determinations may have been made by turbidity methods and may be as much as 25 percent in error. Where sulfate exceeds 100 parts per million, turbidity methods are seldom used and the higher values for sulfate are dependable.

Chloride is easily determined and the amounts reported are usually reliable. Consequently changes in chloride in the table indicate accurately changes in the water quality. Nitrate is usually low and is mainly useful in accurately calculating the sum of dissolved solids and the sodium. Nitrate above 10 parts per million is more apt to be in error than lower amounts.

Wells 12 and 18 in Juarez and well 25 in El Paso show a gradual increase in the dissolved solids without significant changes in the proportions of the various constituents. These changes may indicate contamination of the main water-bearing beds. Other wells in the downtown area show smaller changes of the same nature. The effect of the recent artificial recharge of well 49 (City well 4) with treated surface water is plainly shown by the increased sulfate and decreased chloride in the analysis for April 22, 1949.

The tabulated analyses clearly show that changes are occurring in the chemical characteristics of water from wells in the El Paso area. A continued program of chemical analyses is necessary to observe future changes and to determine the remedial measures that may be needed to protect the available water supplies.

SUMMARY

Pumpage from the bolson deposits, the principal fresh-water-bearing aquifers of the El Paso area, increased from 1,200,000 gallons a day in 1906 to 15,700,000 gallons a day in 1936, and to a peak of 25,600,000 gallons a day in 1943. In 1944 the City of El Paso placed its Rio Grande treatment plant in operation. Since that time the city has been using treated surface water from the Rio Grande and treated ground water from shallow wells in the downtown area of El Paso to reduce the total pumpage of ground water from deep wells to an average of 21,700,000 gallons a day during the period from 1944 to 1948, inclusive. During recent years less water has been pumped from wells on the Mesa, and thus the center of pumping from all wells in the El Paso area in 1948 was farther south, toward the valley of the Rio Grande, than it was prior to 1944.

Each year since 1936 the withdrawal of ground water from storage on the Mesa, has exceeded the amount of water contributed from recharge. As a result, the water levels in wells on the Mesa have declined persistently since 1936. From the amount of decline in water levels on the Mesa, it has been computed that about 425,000 acre-feet of material has been unwatered, which indicates that on the average about 5,000,000 gallons of water a day has been removed from storage on the Mesa from 1936 to 1949. Subtracting the amount of water removed from storage from the total pumpage indicates that an average of about 15,000,000 gallons a day was obtained from recharge on the Mesa or from other sources. A study of the data at hand indicates that most of this water came from recharge on the Mesa.

It has been pointed out in this and previous reports that there is danger of salt-water encroachment into the fresh-water aquifer, both in the artesian area in the valley and in parts of the Mesa. Graphs of the chloride content of the water from 10 wells are shown in the report. These graphs clearly indicate that, during the period of observation since 1935, the mineral content of the water from these wells has increased steadily. The continuation of the steady rise in mineral content of the water poses a threat to the future usefulness of at least a part of the ground-water reservoir that is now yielding good potable water.

The results of experimental tests in artificial recharge indicate that it may be practicable to inject surface water into the ground-water reservoir for the purpose of storing water for later use. Such recharge would also be advantageous in maintaining the water table and artesian pressure at higher levels, which in turn would halt or retard the rate of ingress of salt water into the fresh-water sands.

Careful observation and study should be continued in the El Paso area. More observation wells for both water-level observation and the collection of water samples for chemical analyses are needed northeast and east of the Mesa well field.

Table 6. Analyses of water from wells in the El Paso area, Texas
(Results are in parts per million)

Well	Owner	Depth of well (ft.)	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$	Source of analysis a/
12	Juarez, Mexico (City well 1)	499	Jan. 5, 1935	-	-	-	-	-	-	211	120	118	-	-	237	1
			Aug. 22, 1935	-	-	-	-	-	-	174	-	77	-	-	243	1
			May 4, 1936	444	-	-	78	14	64	195	106	86	-	-	252	5
			Apr. 12, 1937	526	26	0.03	86	14	69	189	140	80	-	0.2	272	1
			Nov. 1, 1937	-	-	-	87	16	-	192	140	82	-	-	283	1
			Sept.26, 1938	538	23	-	88	16	73	196	155	86	-	.0	286	-
			Nov. 15, 1939	552	-	-	92	15	71	192	154	90	-	.0	292	1
			June 12, 1940	550	-	-	93	16	80	204	166	94	-	.0	298	1
			Dec. 4, 1940	532	-	-	95	16	72	204	156	92	-	.0	303	1
			June 17, 1941	532	-	-	95	15	74	198	155	95	0.3	.1	298	1
			June 3, 1942	548	-	-	95	16	78	200	161	100	-	.0	303	1
			Sept.15, 1942	547	-	-	98	15	76	200	160	99	-	.5	306	1
			Mar. 26, 1943	566	-	-	102	16	77	206	165	104	-	1.0	320	1
			Feb. 11, 1944	566	-	-	104	16	74	201	170	103	-	.2	326	1
			May 9, 1944	580	-	-	103	18	77	202	172	108	-	2.5	331	1
			May 22, 1945	671	-	-	110	19	72	204	179	110	-	.4	352	1
			Mar. 27, 1946	660	-	-	114	19	77	210	183	119	-	.2	362	1
			Apr. 22, 1949	720	25	-	122	22	81	206	212	129	-	.0	395	1
18	Juarez, Mexico (City well 3)	660	Sept.23, 1935	562	-	-	108	17	71	257	148	91	-	.2	340	1
			Dec. 22, 1935	626	12	-	112	9.2	82	259	148	92	-	-	318	1
			Oct. 28, 1936	528	-	-	84	15	86	208	142	99	-	.0	272	1
			Nov. 2, 1937	-	-	-	110	18	73	254	140	92	-	-	349	1
			Sept.26, 1938	620	-	-	112	19	73	256	165	96	-	.25	358	1
			Nov. 15, 1939	660	-	-	124	20	69	262	170	107	-	.0	392	1
			June 12, 1940	647	-	-	129	21	73	272	177	113	-	-	409	1
			Dec. 4, 1940	677	-	-	134	23	76	284	184	120	-	.0	429	1
			June 17, 1941	770	25	-	140	23	75	279	191	127	.0	.25	444	1
			Sept.18, 1941	713	-	-	136	25	84	296	194	128	-	.0	442	1
			June 3, 1942	728	-	-	142	24	84	288	202	134	-	.0	453	1
			Sept.15, 1942	741	-	-	146	24	84	286	208	138	-	-	463	1
			Mar. 26, 1943	775	-	-	153	24	89	295	218	144	-	1.5	480	1
			Feb. 11, 1944	794	-	-	166	25	80	297	230	147	-	.2	518	1
			May 9, 1944	792	-	-	152	27	91	296	227	147	-	2.0	490	1
			May 22, 1945	955	-	-	170	29	74	304	233	151	-	.0	544	1
			Mar. 27, 1946	828	-	-	171	29	78	286	243	161	-	.0	546	1
			Apr. 26, 1947	-	-	-	-	-	-	306	-	165	-	-	-	1
			Apr. 22, 1949	984	26	-	167	33	107	307	276	175	-	.0	552	1

Table 6. Analyses of water from wells in the El Paso area, Texas -- Continued

Well	Owner	Depth of well (ft.)	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$	Source of analysis a/
25	El Paso, Texas (El Paso Ice & Refrigeration Co. well 4)	509	Jan. 7, 1935	-	-	-	-	-	-	173	112	319	-	-	234	1
			Aug. 23, 1935	-	-	-	-	-	-	164	-	316	-	-	165	1
			Apr. 22, 1936	796	-	-	49	16	230	170	107	310	-	0.0	188	1
			Oct. 28, 1936	842	-	-	56	17	240	170	97	348	-	.0	210	1
			Apr. 19, 1937	904	31	0.06	57	17	247	169	105	352	-	.10	212	1
			Nov. 2, 1937	-	-	-	56	17	-	174	104	331	-	.0	210	1
			Sept. 28, 1938	898	31	-	56	17	244	176	109	342	-	.0	210	1
			Nov. 14, 1939	904	-	-	-	-	222	170	110	380	-	.0	308	1
			June 11, 1940	951	-	-	68	21	262	172	115	400	-	.0	256	1
			Nov. 29, 1940	937	-	-	66	21	259	178	113	390	-	.0	251	1
			June 17, 1941	937	-	-	55	22	268	144	113	408	.0	.0	228	1
			Sept. 19, 1941	935	-	-	64	21	260	168	112	395	-	.0	246	1
			June 2, 1942	1,059	-	-	80	24	286	170	123	462	-	.0	298	1
			Sept. 15, 1942	1,053	-	-	77	24	286	165	126	458	-	1.0	290	1
			Mar. 26, 1943	1,066	-	-	82	24	286	177	127	460	-	.0	303	1
			Feb. 12, 1944	1,140	-	-	94	27	295	166	136	502	-	1.5	346	1
			May 8, 1944	1,110	-	-	85	30	289	161	136	490	-	.0	336	1
			May 23, 1945	1,060	-	-	89	27	270	164	134	458	-	.2	333	1
			Mar. 25, 1946	1,130	-	-	97	29	285	183	140	485	-	1.0	361	1
			Apr. 28, 1947	-	-	-	-	-	-	176	-	488	-	-	-	1
			Apr. 22, 1949	1,150	34	-	92	32	280	170	151	478	-	.2	361	1
30A	El Paso, Texas (City well 14)	703	Apr. 20, 1937	450	26	0.12	23	8.6	126	172	69	108	-	.0	93	1
			Mar. 11, 1938	465	26	6.4	27	17	108	179	69	106	-	-	137	2
			June 24, 1938	446	18	5.8	34	8.0	115	176	69	108	-	-	118	2
			Sept. 24, 1938	423	29	.02	22	7.5	129	171	63	112	-	.15	86	1
			May 1, 1939	471	17	-	32	4.6	148	168	112	118	-	-	99	2
			Nov. 16, 1939	425	-	-	-	-	138	172	66	118	-	.0	76	1
			June 10, 1940	435	-	-	-	-	138	176	68	121	-	.0	86	1
			Aug. 28, 1940	473	31	-	17	6.2	141	170	73	113	-	-	68	2
			June 16, 1941	443	-	-	24	8.1	135	161	68	122	0.3	.25	94	1
			Sept. 18, 1941	467	-	-	24	9.7	141	170	73	136	-	.0	100	1
			Sept. 18, 1941	399	38	-	28	10	143	178	77	140	-	.25	111	2
			Mar. 13, 1942	504	35	-	25	9.0	150	175	61	140	-	-	100	2
			June 2, 1942	438	-	-	22	8.5	134	172	69	120	-	.0	90	1
			June 2, 1942	475	42	-	28	12	153	182	95	145	-	-	120	2
			Sept. 15, 1942	454	-	-	23	7.7	141	193	67	118	-	-	89	1
			Mar. 23, 1943	445	-	-	26	8.1	133	173	69	123	-	.5	98	1
			Feb. 11, 1944	450	-	-	26	8.0	135	170	69	128	-	.2	98	1
			May 22, 1945	490	-	-	27	8.6	135	170	70	131	-	.0	103	1
			Mar. 25, 1946	519	-	-	25	8.7	152	192	71	139	-	.0	98	1
			Apr. 26, 1947	-	-	-	-	-	-	178	-	156	-	-	74	1

Table 6. Analyses of water from wells in the El Paso area, Texas -- Continued

Well	Owner	Depth of well (ft.)	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$	Source of analysis a/
32A	El Paso, Texas (City well 17)	750	Feb. 4, 1939	426	17	4.3	34	14	74	88	62	69	-	-	143	2
			July 11, 1939	377	15	.15	18	6	133	172	124	64	-	-	71	2
			Oct. 28, 1939	382	20	-	31	9.1	102	174	92	63	-	-	115	2
			Apr. 16, 1940	364	25	2.4	30	9.1	92	172	77	66	-	-	113	2
			June 10, 1940	323	-	-	37	11	71	178	50	66	-	.0	138	1
			Aug. 28, 1940	394	22	-	35	11	89	177	87	64	-	-	133	2
			Dec. 5, 1940	397	31	-	35	11	86	179	81	63	-	.0	133	1
			June 16, 1941	397	26	-	36	11	89	178	81	68	.6	.0	135	1
			Sept. 18, 1941	407	45	-	37	9.0	106	190	86	80	-	.0	129	2
			Sept. 18, 1941	374	-	-	35	12	89	183	80	68	-	.0	137	1
			Feb. 6, 1942	410	36	-	43	12	97	193	86	86	-	-	166	2
			June 2, 1942	386	-	-	36	11	94	188	80	72	-	-	135	1
			June 2, 1942	413	51	-	42	14	93	187	94	80	-	-	163	2
			Sept. 15, 1942	387	-	-	36	11	94	182	81	75	-	.0	135	1
			Mar. 24, 1943	401	-	-	40	12	93	186	85	79	-	.0	150	1
			May 22, 1945	457	-	-	43	12	94	184	87	85	-	-	157	1
			Apr. 26, 1947	-	-	-	-	-	-	188	-	94	-	-	148	1
			Apr. 22, 1949	552	-	-	67	20	88	197	123	107	-	-	249	1
42	El Paso, Texas (City well 9)	802	Sept. 1, 1933	538	16	-	25	5.2	161	191	66	147	-	-	84	4
			Mar. 30, 1935	528	14	-	31	7.4	147	208	61	138	-	-	109	-
			Aug. 19, 1935	-	-	-	-	-	-	172	-	138	-	-	72	1
			Sept. 16, 1935	490	-	-	21	8.0	156	183	76	139	-	.0	85	1
			Mar. 17, 1937	611	31	-	30	10	184	174	78	202	-	.05	116	1
			June 13, 1938	507	25	1.8	22	6.0	167	188	84	132	-	-	132	2
			Sept. 24, 1938	516	35	-	20	8.1	156	186	83	130	-	.0	83	1
			May 1, 1939	531	23	1.6	30	4.0	167	183	117	130	-	-	112	2
			June 10, 1940	501	-	-	22	8.0	158	188	90	130	-	.0	88	1
			Aug. 29, 1940	515	28	-	23	8.2	148	183	85	124	-	-	92	2
			Nov. 28, 1940	484	-	-	20	7.7	155	188	80	129	-	.0	82	1
			June 16, 1941	489	-	-	23	6.9	156	176	74	136	0.9	.0	86	1
			Sept. 18, 1941	518	40	-	26	9.0	158	195	80	142	-	.0	102	2
			Feb. 6, 1942	515	40	-	25	10	162	197	85	145	-	-	104	2
			June 2 1942	471	-	-	20	7.4	152	184	66	135	-	.0	80	1
			June 2, 1942	521	44	-	25	12	172	193	105	156	-	-	112	2
			Mar. 23, 1943	491	-	-	25	7.7	153	186	76	137	-	.5	94	1
			Feb. 11, 1944	486	-	-	22	7.0	155	185	75	136	-	.2	84	1
			May 8, 1944	486	-	-	20	6.7	158	188	76	132	-	1.0	78	1
			May 22, 1945	526	-	-	23	7.3	153	181	76	136	-	.0	88	1
			Mar. 25, 1946	544	-	-	22	7.0	168	205	77	142	-	.0	84	1
			Apr. 22, 1949	524	32	-	19	7.1	76	181	77	139	-	.0	76	1

Table 6. Analyses of water from wells in the El Paso area, Texas -- Continued

Well	Owner	Depth of well (ft.)	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$	Source of analysis a/
44	El Paso, Texas (Mitchell Brewery well)	353	Jan. 5, 1935	-	-	-	-	-	-	176	68	158	-	-	189	1
			Aug. 27, 1935	-	-	-	-	-	-	150	-	175	-	-	165	1
			Apr. 22, 1936	533	-	-	47	18	129	168	71	185	-	0.0	191	1
			Oct. 28, 1936	562	-	-	50	19	136	180	70	198	-	.0	203	1
			Mar. 19, 1937	592	29	0.06	49	19	138	167	73	200	-	.05	200	1
			Oct. 29, 1937	-	-	-	48	20	-	170	64	203	-	.25	202	1
			Oct. 3, 1938	605	27	-	48	19	142	170	79	202	-	.0	198	-
			Nov. 18, 1939	618	-	-	50	19	140	166	73	209	-	.0	203	1
			June 11, 1940	606	-	-	49	20	152	172	80	220	-	.0	204	1
			Nov. 28, 1940	595	-	-	52	19	146	174	77	215	-	.0	208	1
			June 16, 1941	591	-	-	53	19	144	170	73	218	0.5	.25	210	1
			Sept. 18, 1941	600	-	-	50	20	149	170	74	223	-	.0	207	1
			June 2, 1942	628	-	-	52	19	159	172	78	235	-	.0	208	1
			Sept. 15, 1942	625	-	-	54	20	154	172	76	235	-	1.0	217	1
			Mar. 27, 1943	666	-	-	59	21	163	170	79	260	-	.5	233	1
			Feb. 11, 1944	657	-	-	60	22	157	170	78	256	-	.2	240	1
			May 8, 1944	665	-	-	60	24	157	168	80	260	-	1.0	248	1
			July 27, 1949	880	28	-	65	31	186	167	88	330	-	0	290	1
48A	El Paso, Texas (City well 18)	--	Feb. 26, 1940	738	14	-	55	21	161	185	78	263	-	-	224	2
			Apr. 13, 1940	595	28	-	43	13	157	179	72	198	-	-	162	2
			Aug. 20, 1940	595	30	-	41	15	145	173	68	189	-	-	163	2
			June 16, 1941	601	32	-	43	15	149	170	62	203	.4	.35	169	1
			Apr. 22, 1942	636	32	-	54	21	150	191	85	223	-	-	221	2
			June 2, 1942	568	-	-	40	15	156	180	68	200	-	.2	162	1
			Apr. 22, 1949	675	29	-	55	21	146	159	89	225	-	.2	224	1
49	El Paso, Texas (City well 4)	882	Jan. 1, 1935	-	-	-	-	-	-	153	60	256	-	-	204	1
			Sept. 11, 1935	616	-	-	45	15	170	164	54	250	-	1.1	174	1
			Apr. 22, 1936	-	-	-	-	-	-	160	-	249	-	-	210	1
			Oct. 28, 1936	593	-	-	42	14	166	166	53	235	-	-	162	1
			June 13, 1938	698	31	4.1	50	17	178	165	63	270	-	-	195	2
			Nov. 4, 1938	669	31	.2	51	16	177	158	56	274	--	-	193	1
			Apr. 15, 1939	730	24	.3	64	17	167	161	80	268	-	-	249	2
			Dec. 21, 1939	715	26	.3	51	15	195	162	75	260	-	-	190	2
			Apr. 16, 1940	733	31	1.2	52	16	173	160	57	272	-	-	198	2
			June 10, 1940	685	-	-	52	17	185	162	70	280	-	1.0	200	1
			Aug. 29, 1940	715	27	-	49	16	172	161	56	264	-	1	190	1
			June 16, 1941	662	-	-	52	17	178	162	56	278	0.7	.8	200	1
			May 20, 1942	846	46	-	64	22	198	160	76	350	-	-	251	1
			June 2, 1942	689	-	-	52	17	187	157	60	295	-	.5	200	1
			May 22, 1945	836	-	-	56	16	217	145	63	350	-	.5	206	1
			Apr. 22, 1949	813	31	-	42	19	213	136	144	282	-	3.2	183	1

Table 6. Analyses of water from wells in the El Paso area, Texas -- Continued

Well	Owner	Depth of well (ft.)	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$	Source of analysis a/
52	El Paso, Texas (City well 3)	862	June 29, 1936	499	-	-	43	18	120	184	72	152	-	3.0	181	1
			Oct. 28, 1936	635	-	-	50	17	168	162	66	253	-	1.2	195	1
			May 6, 1937	-	-	-	49	19	128	174	66	188	-	3.3	200	1
			June 25, 1937	672	33	0.12	48	16	176	158	65	252	-	1.7	186	1
			Oct. 29, 1937	-	-	-	50	18	-	162	66	246	-	1.4	199	1
			Mar. 11, 1938	720	33	.13	80	20	130	162	73	252	-	-	282	2
			June 13, 1938	684	24	.11	51	15	165	161	71	242	-	-	189	2
			Sept.23, 1938	691	32	-	52	18	174	162	71	258	-	1.2	194	1
			May 1, 1939	723	25	.7	54	12	196	159	113	258	-	-	186	2
			Feb. 29, 1940	702	28	-	63	24	137	170	72	257	-	-	257	2
			June 10, 1940	656	-	-	54	19	168	168	72	258	-	1.8	213	1
			Aug. 29, 1940	705	31	-	50	16	160	160	79	232	-	-	192	2
			June 16, 1941	634	-	-	53	17	164	163	65	252	.9	1.5	202	1
			June 2, 1942	681	-	-	57	21	172	162	70	280	-	1.2	229	1
			June 2, 1942	749	36	-	64	24	182	167	96	295	-	-	259	2
			May 22, 1945	780	-	-	60	20	175	158	71	289	-	2.2	232	1
			Mar. 25, 1946	702	-	-	55	19	180	169	67	282	-	1.5	216	1
			June 7, 1948	689	36	-	42	17	172	170	82	228	-	1.8	175	1
			Apr. 22, 1949	743	36	-	56	21	172	161	76	274	-	2.2	226	1
55	El Paso, Texas (Texas Co. well)	694	Jan. 5, 1935	-	-	-	-	-	-	154	80	206	-	-	144	1
			Aug. 28, 1935	-	-	-	-	-	-	140	-	212	-	-	118	1
			Apr. 22, 1936	581	-	-	33	11	172	148	81	210	-	.75	128	1
			Nov. 15, 1939	586	-	-	-	-	178	151	79	218	-	.70	126	1
			Nov. 29, 1940	596	-	-	35	11	176	160	83	210	-	2.0	133	1
			Sept.18, 1941	557	-	-	38	14	155	178	71	189	-	2.5	152	1
			June 3, 1942	587	-	-	34	10	176	158	77	212	-	.5	126	1
			Sept.16, 1942	-	-	-	-	-	-	172	75	208	-	.5	-	1
			Feb. 15, 1944	596	-	-	36	11	176	156	76	219	-	.8	135	1
			May 9, 1944	606	-	-	37	11	178	163	79	217	-	3.5	138	1
			May 22, 1945	642	-	-	42	12	165	154	77	217	-	.5	154	1
			Mar. 25, 1946	640	-	-	36	11	181	169	76	220	-	.4	135	1
			Apr. 26, 1947	-	-	-	-	-	-	158	-	225	-	-	-	1
			June 8, 1948	673	40	-	36	12	182	164	77	227	-	.8	140	1
			Apr. 22, 1949	643	34	-	35	11	180	152	77	225	-	3.2	132	1
65A	El Paso, Texas (Airport well)	530	Jan. 7, 1935	-	-	-	-	-	-	214	80	74	-	-	117	1
			Mar. 13, 1936	460	-	-	25	9.9	135	228	100	68	-	8.2	103	1
			Oct. 28, 1936	468	-	-	24	9.4	138	236	101	66	-	8.0	99	1
			May 3, 1937	-	-	-	24	8.7	141	236	106	65	-	7.5	96	1
			Oct. 29, 1937	-	-	-	24	9.2	-	238	112	66	-	7.4	98	1
			Sept.28, 1938	534	62	-	24	11	138	224	109	70	-	5.0	105	1
			Nov. 16, 1939	455	-	-	-	-	143	230	105	67	-	6.7	87	1
			Apr. 8, 1940	525	50	-	24	9.0	140	232	99	76	-	-	97	2
			June 12, 1940	511	-	-	26	10	152	240	120	78	-	6.8	106	1
			Nov. 28, 1940	470	-	-	24	8.8	141	240	105	64	-	9.0	96	1
			June 16, 1941	531	57	-	25	9.3	137	233	99	68	1.0	6.8	100	-
			Sept.18, 1941	540	56	-	22	12	144	244	124	78	-	-	130	2
			Sept.18, 1941	459	-	-	23	10	137	228	100	71	-	6.0	98	1
			Sept.16, 1942	440	-	-	24	8.7	130	216	97	69	-	4.5	96	1
			June 3, 1942	458	-	-	24	9.9	135	230	98	70	-	7.5	100	1
			June 3, 1942	530	58	-	29	13	144	233	125	76	-	-	126	2
			Mar. 25, 1943	452	-	-	26	9.9	131	234	99	64	-	6.3	106	1
			Mar. 27, 1946	530	-	-	25	9.1	139	232	100	73	-	5.5	100	1
			Apr. 21, 1949	536	56	-	23	9.1	140	228	102	71	-	7.2	95	1

Table 6. Analyses of water from wells in the El Paso area, Texas -- Continued

Well	Owner	Depth of well (ft.)	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$	Source of analysis a/
67	El Paso, Texas (T & N O well 8)	869	Oct. 25, 1921	309	24	-	32	11	66	225	27	38	-	-	125	-
			June 12, 1929	434	-	-	55	24	62	223	37	102	-	8.9	236	3
			Aug. 22, 1933	578	32	-	90	40	54	201	49	200	-	8.7	389	3
			Jan. 12, 1934	576	41	-	83	40	58	204	38	202	-	8.9	372	3
			Feb. 19, 1934	589	35	-	88	29	76	186	53	204	-	8.9	339	3
			July 25, 1934	585	22	-	87	43	60	202	50	212	-	8.7	394	3
			May 27, 1935	666	35	-	96	48	68	198	53	255	-	8.7	437	3
			June 4, 1936	702	36	-	102	49	75	217	53	268	-	11	456	3
			May 6, 1937	-	-	-	107	47	90	228	56	288	-	5.5	460	1
			June 17, 1941	875	-	-	136	67	91	178	68	420	0.3	4.0	615	1
			Sept. 16, 1942	911	-	-	143	63	105	178	55	452	-	5.0	616	1
67A	El Paso, Texas (T & N O well 4)	860	Mar. 26, 1943	890	-	-	144	71	83	196	64	425	-	6.3	651	1
			May 23, 1945	1,400	-	-	240	124	95	180	95	755	-	5.4	1,110	1
			Mar. 26, 1946	1,520	-	-	260	139	95	167	99	840	-	4.0	1,220	1
			Apr. 28, 1947	-	-	-	-	-	-	174	-	1,020	-	-	1,350	1
67B	El Paso, Texas (T & N O well 5)	860	Sept. 18, 1941	805	-	-	136	57	80	150	51	402	-	5.2	574	1
			June 2, 1942	799	-	-	125	53	96	166	50	388	-	5.6	530	1
			June 9, 1948	1,750	35	-	293	130	148	154	102	958	-	4.3	1,270	1
			Apr. 21, 1949	1,700	33	-	280	123	154	160	103	920	-	5.9	1,200	1
68	El Paso, Texas (T & N O well 2)	864	1922 (?)	330	36	-	34	14	43	174	32	42	-	-	142	2
			June 12, 1929	384	-	-	55	19	52	211	40	76	-	5.8	215	3
			July 11, 1932	479	26	-	65	26	71	192	43	153	-	6.2	272	3
			Aug. 22, 1933	566	24	-	76	41	66	182	47	209	-	8.7	358	3
			Jan. 12, 1934	606	35	-	82	33	56	180	25	198	-	8.9	340	3
			Feb. 19, 1934	522	19	-	84	31	57	172	46	188	-	8.9	337	3
			July 25, 1934	514	21	-	75	31	63	178	44	180	-	8.7	315	3
			Jan. 5, 1935	-	-	-	-	-	-	199	48	202	-	-	218	1
			May 27, 1935	612	33	-	88	36	75	182	44	232	-	8.7	368	1
			Apr. 23, 1936	580	-	-	88	39	73	194	48	230	-	6.3	380	1
			Oct. 28, 1936	651	-	-	100	49	72	188	48	282	-	7.3	451	1
			Nov. 16, 1939	737	-	-	108	55	71	182	55	312	-	3.2	496	1
			June 11, 1940	764	-	-	124	64	66	200	72	335	-	4.4	572	1
			Nov. 29, 1940	743	-	-	112	55	86	200	58	328	-	5.6	506	1
			June 2, 1942	1,042	-	-	161	86	100	197	76	515	-	7.5	756	1
			Sept. 15, 1942	1,086	-	-	167	91	103	192	77	548	-	5.0	791	1
			Feb. 17, 1944	1,240	-	-	208	109	90	181	85	650	-	12	967	1
			May 9, 1944	1,270	-	-	196	111	111	148	91	685	-	5.5	946	1

Table 6. Analyses of water from wells in the El Paso area, Texas -- Continued

Well	Owner	Depth of well (ft.)	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$	Source of analysis a/
75	El Paso, Texas (Fort Bliss well 5)	770	Jan. 12, 1934	261	23	-	32	10	44	173	15	40	-	-	121	3
			Jan. 5, 1935	-	-	-	-	-	-	183	40	38	-	-	147	1
			Apr. 23, 1936	271	-	-	32	13	53	178	39	41	-	5.0	133	1
			Oct. 28, 1936	266	-	-	34	13	49	178	36	39	-	7.0	138	1
			Apr. 17, 1937	297	32	0.03	33	12	56	178	36	40	-	7.5	132	1
			Sept.29, 1938	308	31	-	33	14	57	186	45	43	-	5.3	140	1
			Nov. 16, 1939	276	-	-	-	-	55	-	38	42	-	4.7	129	1
			June 10, 1940	276	-	-	35	13	52	184	35	45	-	5.2	141	1
			June 17, 1941	287	-	-	37	13	54	184	40	46	0.8	5.2	148	1
			Sept.19, 1941	281	-	-	30	13	60	186	34	46	-	6.8	128	1
			Sept.19, 1941	330	48	-	37	14	68	200	55	54	-	-	149	2
			June 3, 1942	282	-	-	35	13	54	188	39	42	-	6.6	141	1
			Sept.16, 1942	280	-	-	35	13	53	182	42	43	-	4.5	141	1
			Feb. 17, 1944	296	-	-	41	13	54	203	37	45	-	5.5	156	1
			May 9, 1944	297	-	-	36	13	59	195	42	45	-	6.0	144	1
			May 23, 1945	346	-	-	40	14	50	185	40	48	-	6.1	158	1
			Mar. 26, 1946	391	-	-	40	15	57	201	36	57	-	3.5	162	1
			Aug. 13, 1946	325	31	.0	39	14	57	190	41	52	.6	6.5	155	1
			Apr. 28, 1947	-	-	-	-	-	-	188	-	46	-	-	118	1
			June 8, 1948	336	34	-	34	15	55	188	39	48	-	6.0	146	1
			Apr. 26, 1949	326	-	-	38	14	55	183	41	50	-	7.5	152	1
			Apr. 21, 1949	326	32	-	34	13	59	182	41	49	-	6.6	138	1
75D	El Paso, Texas (City well 19)	--	Feb. 6, 1942	486	50	-	27	9	139	211	97	94	-	-	105	2
			Mar. 13, 1942	486	54	-	20	14	125	212	94	94	-	-	133	2
			May 20, 1942	498	49	-	29	13	135	214	115	88	-	-	126	2
			Mar. 25, 1943	446	-	-	34	12	117	205	90	86	-	6.0	134	1
			May 8, 1944	455	-	-	28	10	130	208	93	86	-	5.5	111	1
			May 22, 1945	494	-	-	27	9.8	127	203	92	84	-	4.5	108	1
			Mar. 25, 1946	538	-	-	26	9.8	137	224	92	85	-	4.7	106	1
			June 7, 1948	492	40	-	24	9.5	133	206	90	87	-	4.9	99	1
			Apr. 22, 1949	502	40	-	24	9.8	134	199	103	83	-	5.6	100	1

Table 6. Analyses of water from wells in the El Paso area, Texas -- Continued

Well	Owner	Depth of well (ft.)	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$	Source of analysis a/
77B	El Paso, Texas (City well 15)	--	May 23, 1938	607	16	12	39	12	163	178	109	171	-	-	147	2
			Nov. 16, 1939	569	-	-	32	12	154	172	89	162	-	2.5	129	1
			Apr. 8, 1940	530	25	-	31	10	173	177	109	167	-	-	119	2
			June 10, 1940	543	-	-	34	12	155	180	91	162	-	-	134	1
			Aug. 29, 1940	578	32	-	30	10	182	178	93	155	-	-	116	2
			June 16, 1941	580	34	-	32	11	154	177	85	157	1.1	2.5	125	1
			Feb. 6, 1942	488	47	-	32	11	136	214	95	104	-	-	124	2
			June 3, 1942	426	-	-	25	10	124	202	73	90	-	4.5	104	1
			May 30, 1942	484	43	-	29	12	136	208	107	95	-	-	122	2
			Sept.16, 1942	450	-	-	26	10	130	202	92	89	-	3.0	106	1
			Mar. 25, 1943	446	-	-	28	10	126	202	91	87	-	4.0	111	1
			Feb. 15, 1944	450	-	-	27	9.8	129	198	93	90	-	3.8	108	1
			May 28, 1944	440	-	-	26	10	127	202	85	89	-	4.0	106	1
			May 22, 1945	512	-	-	28	10	127	198	92	89	-	4.1	111	1
			Mar. 25, 1946	530	-	-	27	10	138	220	92	92	-	3.8	108	1
			Apr. 26, 1947	-	-	-	-	-	-	198	-	86	-	-	-	1
			June 7, 1948	498	39	-	25	12	132	208	92	92	-	3.8	112	1
			Apr. 22, 1949	482	36	-	24	10	129	197	91	86	-	4.4	101	1
78	El Paso, Texas (City well 11)	736	Sept.11, 1935	430	-	-	56	21	73	193	84	96	-	4.5	226	1
			Apr. 22, 1936	-	-	-	-	-	-	193	-	88	-	-	264	1
			June 25, 1937	477	36	.13	56	20	78	195	83	94	-	6.7	222	1
			June 3, 1938	460	25	16	52	19	78	200	86	88	-	-	203	2
			June 11, 1940	498	39	0.04	56	21	78	204	92	92	-	5.2	226	1
			June 16, 1941	447	-	-	56	20	81	204	91	91	0.9	6.8	222	1
			Sept.19, 1941	453	-	-	55	21	82	208	97	88	-	7.5	224	1
			Apr. 28, 1947	-	-	-	-	-	-	204	-	92	-	-	-	1
			Apr. 21, 1949	481	36	-	54	21	75	196	86	91	-	8.3	222	1
79	El Paso, Texas (City well 8)	--	Jan. 5, 1935	-	-	-	-	-	-	190	60	52	-	-	196	1
			Sept.16, 1935	311	-	-	44	16	49	184	59	46	-	6.7	176	1
			Apr. 22, 1936	-	-	-	-	-	-	182	-	42	-	-	206	1
			Oct. 28, 1936	298	-	-	44	16	44	182	54	42	-	8.8	176	1
			Apr. 25, 1937	-	-	-	45	17	50	184	64	47	-	9.4	182	1
			Oct. 29, 1937	-	-	-	43	16	-	188	46	41	-	8.3	173	1
			Mar. 11, 1938	347	26	8.0	61	21	-	189	62	43	-	-	239	2
			July 9, 1938	325	27	6.0	65	18	-	188	57	46	-	-	236	2
			Sept.23, 1938	353	36	-	44	16	52	192	60	45	-	7.8	176	1
			May 1, 1939	399	19	-	60	16	44	190	83	50	-	-	216	2
			May 8, 1940	371	32	1.5	45	15	35	192	65	64	-	-	177	2
			June 10, 1940	324	-	-	46	16	52	194	59	46	-	9.4	181	1
			Aug. 29, 1940	382	37	-	41	15	55	189	61	45	-	-	163	2
			Nov. 28, 1940	325	-	-	46	16	52	196	62	45	-	7.0	181	1
			June 16, 1941	315	-	-	44	16	51	190	56	46	.7	7.8	176	1
			Sept.19, 1941	315	-	-	43	16	52	193	56	44	-	9.0	174	1
			Sept.19, 1941	358	43	-	54	20	41	208	59	50	-	-	215	2
			June 3, 1942	318	-	-	44	16	52	194	55	46	-	9.2	176	1
			June 3, 1942	368	51	-	54	19	48	198	80	51	-	-	213	2
			Sept.16, 1942	344	-	-	49	18	53	201	68	52	-	4.5	196	1
			Mar. 25, 1943	338	-	-	51	18	49	202	65	49	-	7.0	202	1
			May 22, 1945	423	-	-	51	19	52	200	69	51	-	13	206	1
			June 7, 1948	402	42	-	46	17	58	200	60	54	-	9.6	185	1
			Apr. 21, 1949	386	42	-	48	18	55	198	64	48	-	11	186	1

Table 6. Analyses of water from wells in the El Paso area, Texas -- Continued

Well	Owner	Depth of well (ft.)	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$	Source of analysis a/
82A	El Paso, Texas (City well 20)	--	Feb. 8, 1942	273	38	-	35	15	75	202	43	37	-	-	147	2
			Mar. 11, 1942	276	32	0.01	36	13	40	184	36	25	0.8	6.8	143	1
			June 3, 1942	272	38	-	39	14	38	186	46	26	-	-	155	2
			Sept. 17, 1942	244	-	-	35	12	41	181	37	25	-	5.0	137	1
			Mar. 25, 1943	239	-	-	38	12	36	180	32	26	-	6.0	144	1
			Feb. 15, 1944	243	-	-	36	12	39	177	34	25	-	10	139	1
			May 8, 1944	228	-	-	34	13	34	166	35	24	-	6.0	138	1
			May 22, 1945	278	-	-	36	12	38	177	35	25	-	7.2	139	1
			Mar. 25, 1946	30[illegible]	-	-	34	13	42	188	28	29	-	6.5	138	1
			Apr. 28, 1947	-	-	-	-	-	-	184	-	28	-	-	-	1
			June 7, 1948	290	32	-	34	14	44	180	39	32	-	6.7	142	1
			Apr. 21, 1949	288	29	-	34	13	43	178	37	30	-	7.2	138	1
128	El Paso Natural Gas Co. (Mesa)	--	Jan. 7, 1935	-	-	-	-	-	-	201	120	208	-	-	220	1
			Sept. 23, 1935	563	-	-	45	20	137	200	106	152	-	4.5	194	1
			Apr. 32, 1936	-	-	-	-	-	-	199	-	144	-	-	222	1
			Oct. 28, 1936	502	-	2.6	32	17	129	110	112	158	-	.0	150	1
			Apr. 22, 1937	-	-		42	20	150	196	128	152	-	7.1	187	1
			Oct. 29, 1937	-	-	-	46	21	-	190	110	140	-	6.7	201	1
			Sept. 26, 1938	587	30	-	44	20	135	202	113	142	-	3.0	192	1
			Nov. 14, 1939	546	-	-	-	-	[illegible]	199	109	138	-	5.0	180	1
			June 11, 1940	586	-	-	43	20	146	204	124	146	-	7.0	190	1
			Nov. 28, 1940	559	-	-	43	19	139	214	112	135	-	5.3	185	1
			June 17, 1941	554	-	-	43	18	139	203	110	137	1.7	5.3	182	1
			Sept. 19, 1941	552	-	-	43	18	136	184	116	142	-	6.0	182	1
			June 3, 1942	564	-	-	42	18	143	205	112	142	-	6.4	179	1
			Sept. 16, 1942	566	-	-	41	17	146	204	115	142	-	4.5	172	1
			Mar. 25, 1943	576	-	-	46	19	141	204	117	146	-	6.3	193	1
			Feb. 15, 1944	580	-	-	44	18	146	201	118	148	-	7.5	184	1
			May 8, 1944	580	-	-	41	19	148	157	123	148	-	3.5	180	1
			Mar. 25, 1946	645	-	-	43	19	150	216	12[illegible]	146	-	.8	186	1
			Apr. 26, 1947	-	-	-	-	-	-	206	-	143	-	-	-	1
			June 9, 1948	649	44	-	41	18	154	208	127	144	-	6.9	176	1
			Apr. 21, 1949	639	43	-	40	18	146	194	125	140	-	6.8	174	1

Table 6. Analyses of water from wells in the El Paso area, Texas -- Continued

Well	Owner	Depth of well (ft.)	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+ K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$	Source of analysis a/
128B	El Paso, Texas (City well 21)	--	Feb. 8, 1942	354	42	-	37	12	80	222	60	50	-	-	142	2
			June 3, 1942	337	50	-	42	15	64	211	60	49	-	-	167	2
			Sept.17, 1942	298	-	-	39	13	56	204	46	38	-	5.0	151	1
			Mar. 25, 1943	299	-	-	42	13	53	203	46	39	-	5.8	158	1
			Feb. 15, 1944	301	-	-	43	14	51	201	47	39	-	8.4	165	1
			May 8, 1944	308	-	-	40	13	59	206	47	42	-	5.5	154	1
			May 22, 1945	360	-	-	43	14	55	201	55	42	-	5.1	165	1
			Mar. 25, 1946	386	-	-	42	14	54	210	36	47	-	3.8	162	1
			Apr. 28, 1947	-	-	-	-	-	-	204	-	48	-	-	-	1
			June 7, 1948	377	39	-	42	15	63	210	52	52	-	5.4	166	1
			Apr. 21, 1949	372	37	-	43	14	60	198	55	50	-	6.0	160	1

a/ Source of analyses.

(1) U. S. Geological Survey.

(2) City of El Paso.

(3) Southern Pacific Laboratories.

(4) El Paso Testing Laboratories.

(5) Bureau of Industrial Chemistry, The University of Texas.

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2. Estimating safe yield as illustrated by El Paso, Texas, ground-water investigation, by A. N. Sayre: Econ. Geology, vol. 35, no. 7, pp. 697-708, November 1938.
3. Ground-water resources of the El Paso area, Texas, by A. N. Sayre and Penn Livingston: U. S. Geol. Survey Water-Supply Paper 919, 1945.
4. Ground-water supply of El Paso area, Texas, by A. N. Sayre, released to the City of El Paso in August 1940.
5. Progress report on the ground-water supply of the El Paso area, Texas, by Penn Livingston and J. M. Birdsall, released to the City of El Paso in August 1944.
6. Ground-water resources of the El Paso area, Texas, Progress Report, by R. W. Sundstrom, released to the City of El Paso in May 1945.

Following are listed the water supply papers of the Geological Survey that contain records of water levels in wells in the El Paso area, Texas:

Water-Supply Paper	Year
817	1934
817	1935
817	1936
840	1937
845	1938
886	1939
909	1940
939	1941
947	1942
989	1943
1019	1944
1026	1945