BULLETIN 5401

PUMPAGE OF GROUND WATER AND DECLINE OF ARTESIAN PRESSURE IN THE HOUSTON DISTRICT, TEXAS, DURING 1951 AND 1952

By

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Texas Board of Water Engineers

Prepared in cooperation with the Geological Survey,
United States Department of the Interior
and the
City of Houston

January 1954

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ABSTRACT

The withdrawal of ground water in the Houston district, Texas, averaged 284,000,000 gallons a day in 1951 and 308,000,000 gallons a day in 1952, as compared with 254,000,000 gallons a day in 1950. Pumpage by the Houston Water Department increased from 64,400,000 gallons a day in 1950 to 73,700,000 gallons a day in 1952; pumpage in the Pasadena area increased from 65,000,000 gallons a day in 1950 to 75,000,000 gallons a day in 1952; and pumpage in the Katy area increased from 98,000,000 gallons a day in 1950 to 128,000,000 gallons a day in 1952.

The largest decline of artesian pressure were recorded in the Pasadena industrial wells. Declines ranged from 30.7 to 48.7 feet and averaged 39.3 feet. Smaller declines were recorded in the Houston municipal wells, and because of relatively heavy withdrawals from the deeper sands, water levels in the deep wells were proportionately lower. Artesian pressure in the Katy area continued to decline at a slow rate.

INTRODUCTION

LOCATION OF DISTRICT

The Houston district, as used in this report, comprises an area of about 1,800 square miles and includes Harris County west of the San Jacinto River and adjoining parts of Fort Bend, Waller, and Montgomery Counties (fig. 1). The district can be subdivided on the basis of ground-water withdrawals into three main areas (fig. 2) as follows:

(1) The Houston area, consisting of the city of Houston and the closely adjoining territory.

(2) The Pasadena area, including the heavily industrialized zone extending east from Houston along the Houston Ship Channel to the vicinity of Deer Park.

(3) The Katy area, comprising the rice-irrigation area occupying much of western Harris County, northern Fort Bend County, and southeastern Waller County.

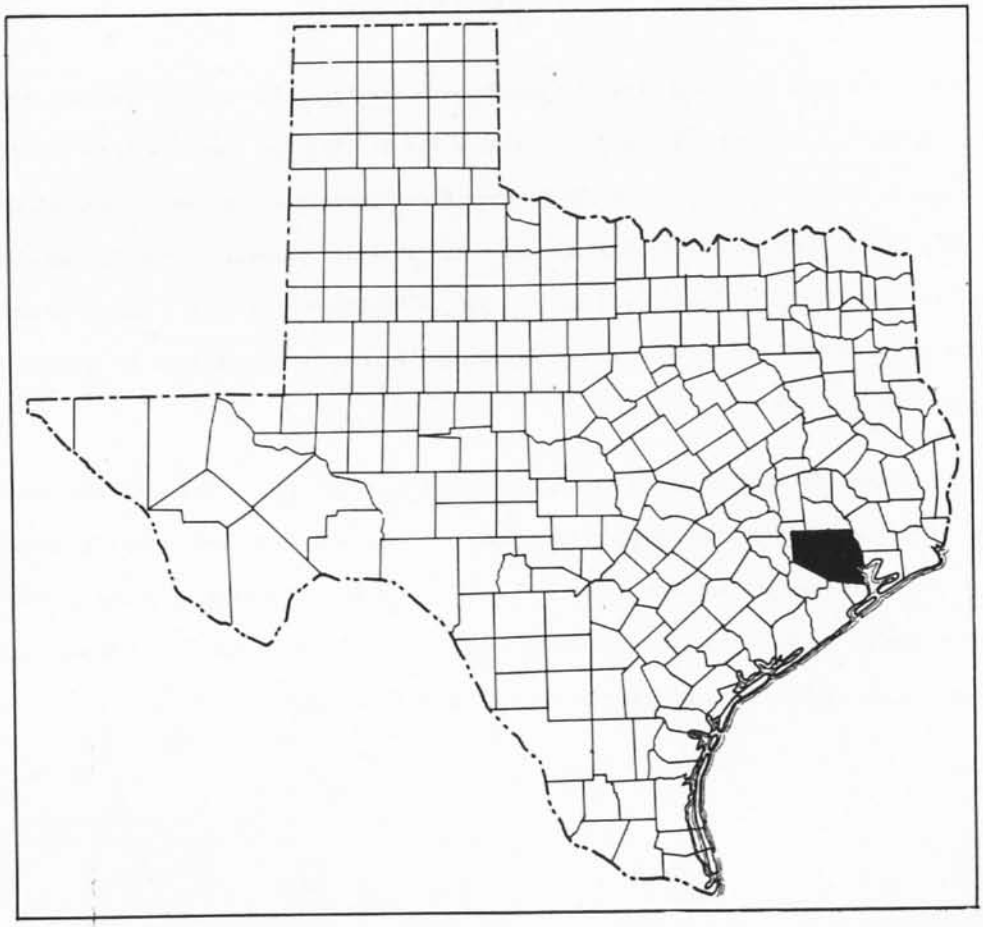

FIGURE 1.-Map of Texas showing location of the Houston district.

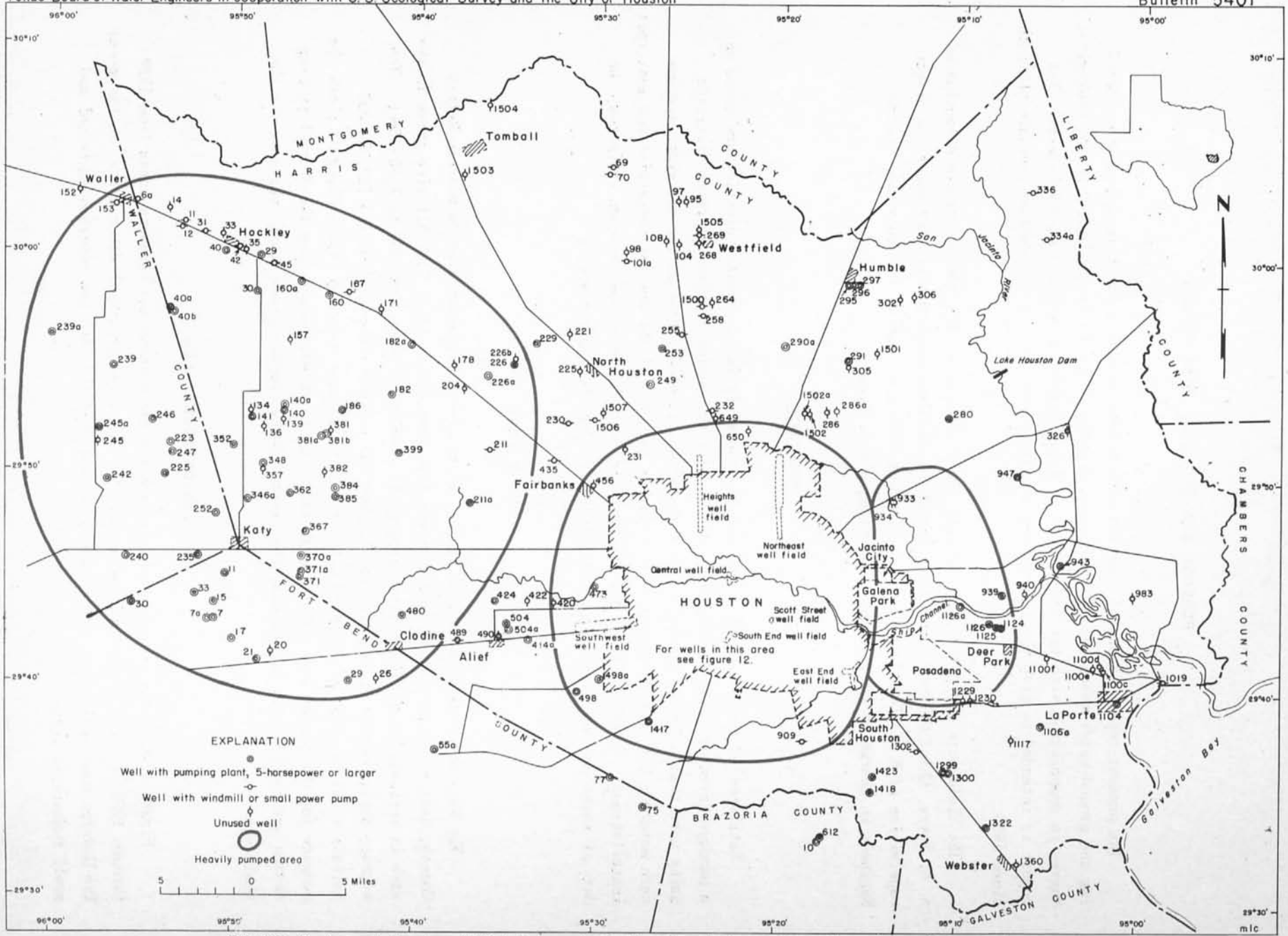

FIGURE 2.-Map of Houston district, Texas, showing location of observation wells and heavily pumped areas.

PURPOSE AND SCOPE OF THIS REPORT

The present report is one of a series of progress reports presenting information regarding the ground-water resources of the Houston district obtained by the United States Geological Survey in cooperation with the Texas Board of Water Engineers and the city of Houston. The report is intended to give the information on pumpage and decline of artesian pressure obtained since 1950.

The field work and preparation of this report were under the administrative direction of A. N. Sayre, Chief of the Ground Water Branch, U. S. Geological Survey, and under the direct supervision of W. L. Broadhurst, former District Geologist, and R. W. Sundstrom, District Engineer in charge of ground-water investigations in Texas.

PUMPAGE

Estimates of the volume of ground-water withdrawals in the Houston district are based on a pumpage inventory made each spring. All industries, municipalities, or water districts using more than 5,000 gallons of water a day were contacted. Most of the municipal systems were metered, but only estimates were available for many of the smaller industrial and municipal installations. Pumpage figures for the Katy area were based on the acreage irrigated, the duty of water per acre, and the total rainfall during the pumping season.

KATY AREA

The Katy area, as used in this report, is the rice-irrigation area in western Harris County, eastern Waller County, and northern Fort Bend County (fig. 2). All rice grown in the area is irrigated with ground water from wells ranging in depth from 200 to 1,600 feet. The average daily pumpage in the area was 117,000,000 gallons a day in 1951 and 128,000,000 gallons a day in 1952, as compared with 98,000,000 gallons a day in 1950. Figure 3 shows the pumpage for the period from 1930 through 1952. Daily withdrawals during the 5-month pumping season are considerably higher than the average daily pumpage given above, which is for the whole year.

HOUSTON-PASADENA AREA

Figure 4 shows the average daily pumpage for the Houston and Pasadena areas from 1930 through 1952, as well as the average pumpage for the three principal water users in the areas: The Houston municipal wells, the Pasadena industrial wells, and the suburban municipal and small industrial wells.

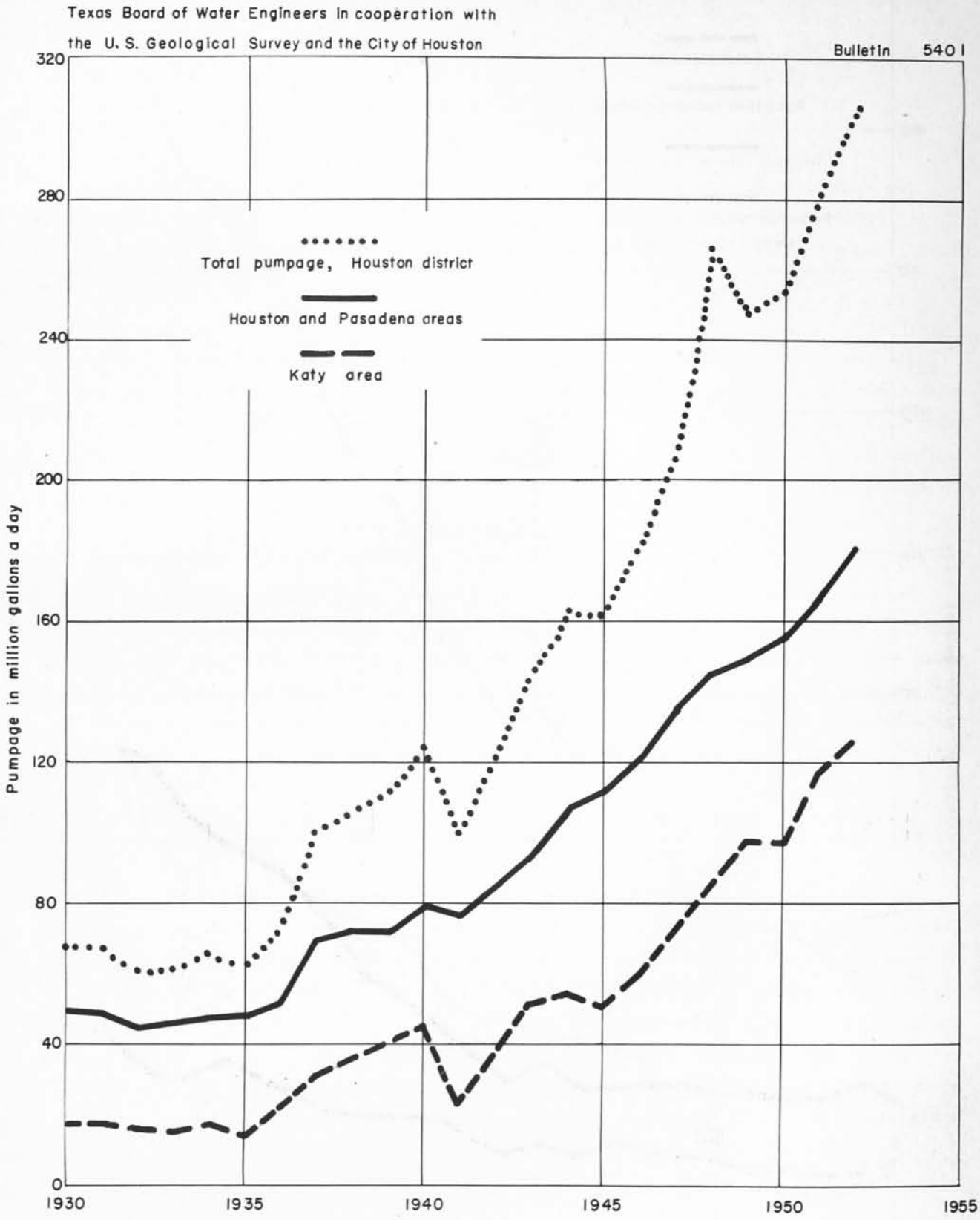

FIGURE 3.- Average daily pumpage in the Houston district, 1930-52

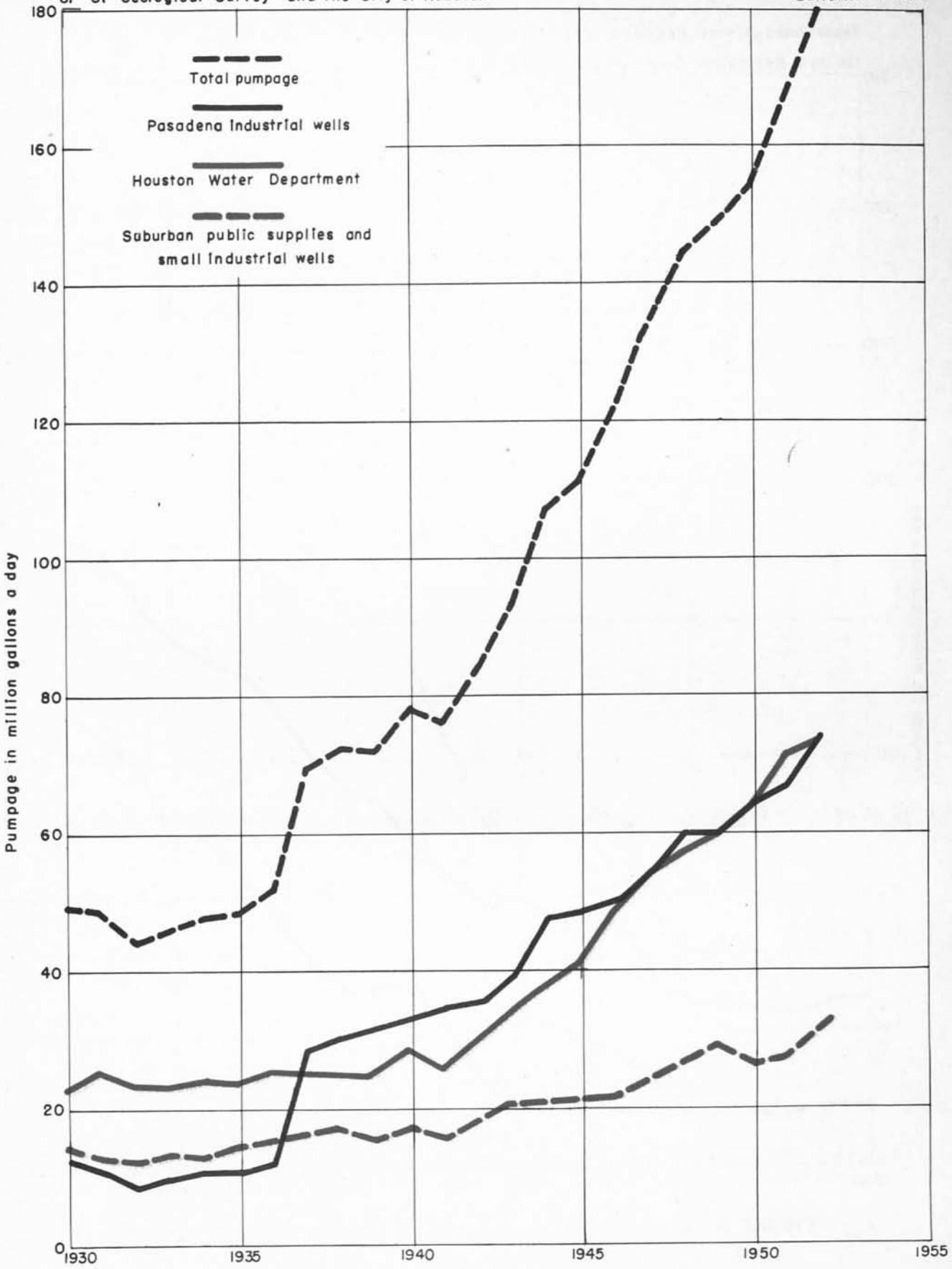

FIGURE 4.- Average daily pumpage in the Houston and Pasadena areas, 1930–52.

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The Houston Water Department pumped an average of 71,800,000 gallons a day in 1951 and 73,700,000 gallons a day in 1952 as compared with 64,400,000 gallons a day in 1950. The large increase over the 1950 pumpage was due partly to the additional water that was made available as a result of the city well-drilling program undertaken during 1950, and partly from the increased demand for water resulting from the 1950 annexation program of the city and the failure of many small industrial wells.

The average daily pumpage from the Pasadena industrial wells was 67,000,000 gallons a day in 1951 and 75,000,000 gallons a day in 1952. Most of the increase over the 1950 figure of 65,000,000 gallons a day resulted from the expansion of the chemical industry. Table 1, which shows the average daily pumpage of ground water in the Houston and Pasadena areas for 1950, 1951, and 1952 by different classes of users, shows that withdrawals by chemical plants increased approximately 80 percent during this period.

Table 1.- Estimated average daily pumpage for public and industrial supplies in the Houston and Pasadena areas during 1950, 1951, and 1952

Pumpage
(million gallons a day)

	1950	1951	1952
Public supplies			
Houston Water Dept.	64.2 1/	71.8	73.7
Suburban	9.5	10.2	12.9
Industrial supplies			
Paper mill	20.0	20.0	22.0
Chemical plants	10.6	14.8	18.2
Oil refineries	22.0	23.2	24.1
Steel mills	9.2	5.7	6.0
Ice plants	2.4	1.8	1.9
Power plants	5.1	7.7	10.1
Tool companies	1.6	1.9	1.9
Railroads and allied plants	3.1	1.7	1.7
Meat packing plants	.6	.8	.6
Laundries	.3	.2	.2
Shipyards	.2	.3	.3
Miscellaneous supplies			
Office buildings, hotels, theatres, country clubs, and other plants that use more than 5,000 gallons a day	6.9	6.8	6.5
Totals	155.7	166.9	180.1

1/ Includes pumpage for districts annexed by city for that part of year operated by city.

Withdrawal of water by power plants, four of which are located in the Houston and Pasadena areas, increased nearly 100 percent during 1951 and 1952. Withdrawals by all other classes of industrial users remained fairly constant.

In 1952 the Houston Water Department operated 49 wells in seven well fields within and adjacent to the city. Figures 5 and 6 show the average daily pumpage from each well field and the hydrograph of a representative well in each field. In addition to these fields, 19 public-supply wells taken over by the city during the 1950 annexation were operated by the city in 1952.

HOUSTON DISTRICT

Withdrawals of ground water in the entire Houston district averaged 284,000,000 gallons a day in 1951 and 308,000,000 gallons a day in 1952, as compared with 254,000,000 gallons a day in 1950. Approximately half the increase in withdrawals took place in the Katy area, the remainder was concentrated in the comparatively small Houston-Pasadena area. Figure 3 shows the average daily pumpage from 1930 to 1952, inclusive, and illustrates the continued upward trend of withdrawals during 1951 and 1952 in all the three areas that compose the district.

DECLINE OF ARTESIAN PRESSURE

Most of the increase in ground-water pumpage took place in areas where withdrawals were already concentrated and correspondingly large declines of artesian pressure occurred between spring water-level measurements in 1951 and 1953.

KATY AREA

Although the general water-level trend in the Katy area is downward, it is at a slow rate compared to declines in the Houston area because the pumpage is seasonal and is spread over a large area. Figure 7 shows hydrographs of two wells in the area (Harris County well 186 and Waller County well 223). Declines of water levels in 48 observation wells in the area between the spring measurements of 1951 and 1953 ranged from 1.3 to 12.4 feet and averaged 6.1 feet. In one well the water level rose 1.1 feet.

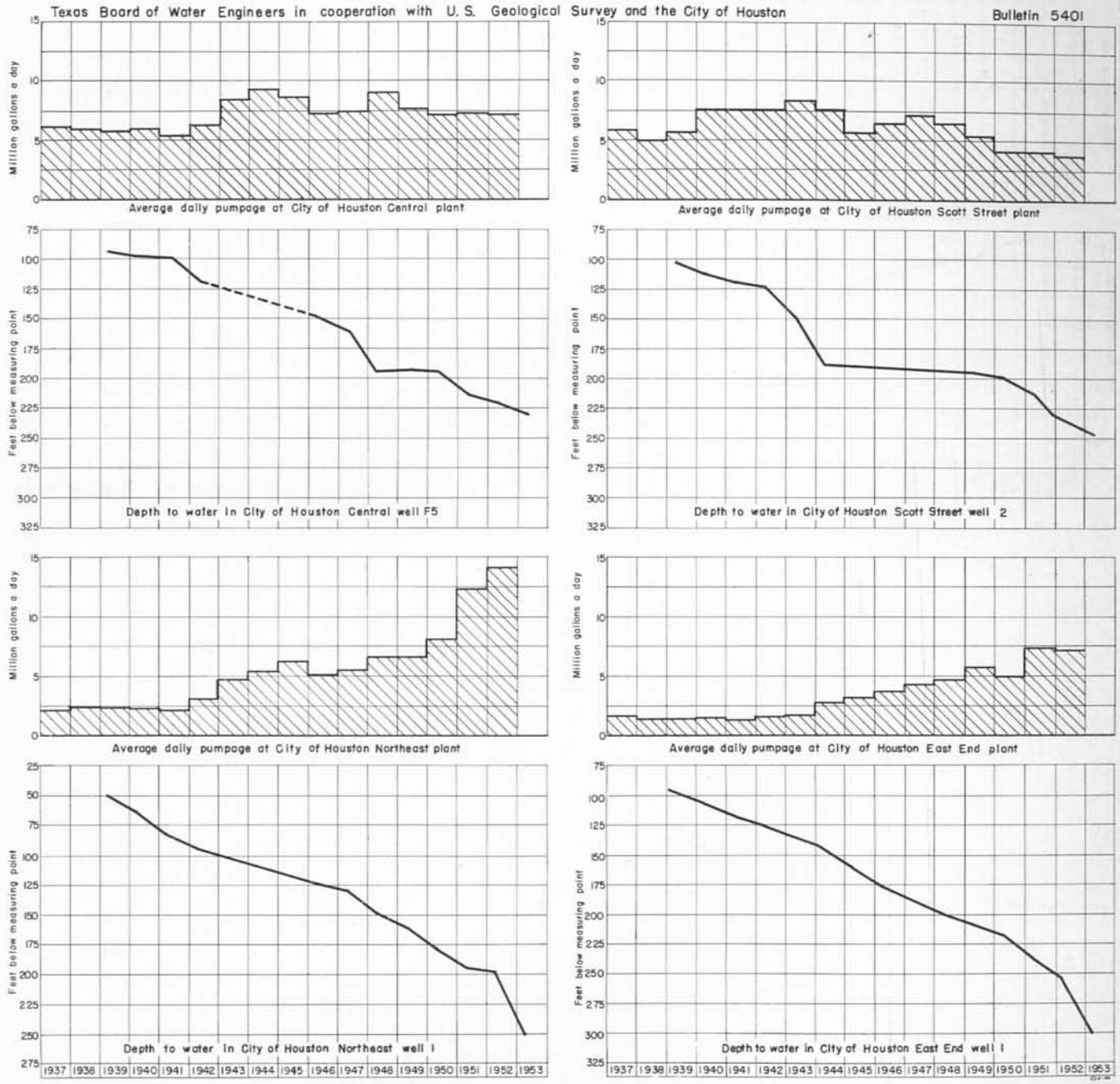

FIGURE 5.—Relation of pumpage to artesian pressure in Houston Central, Scott Street, Northeast, and East End well fields.

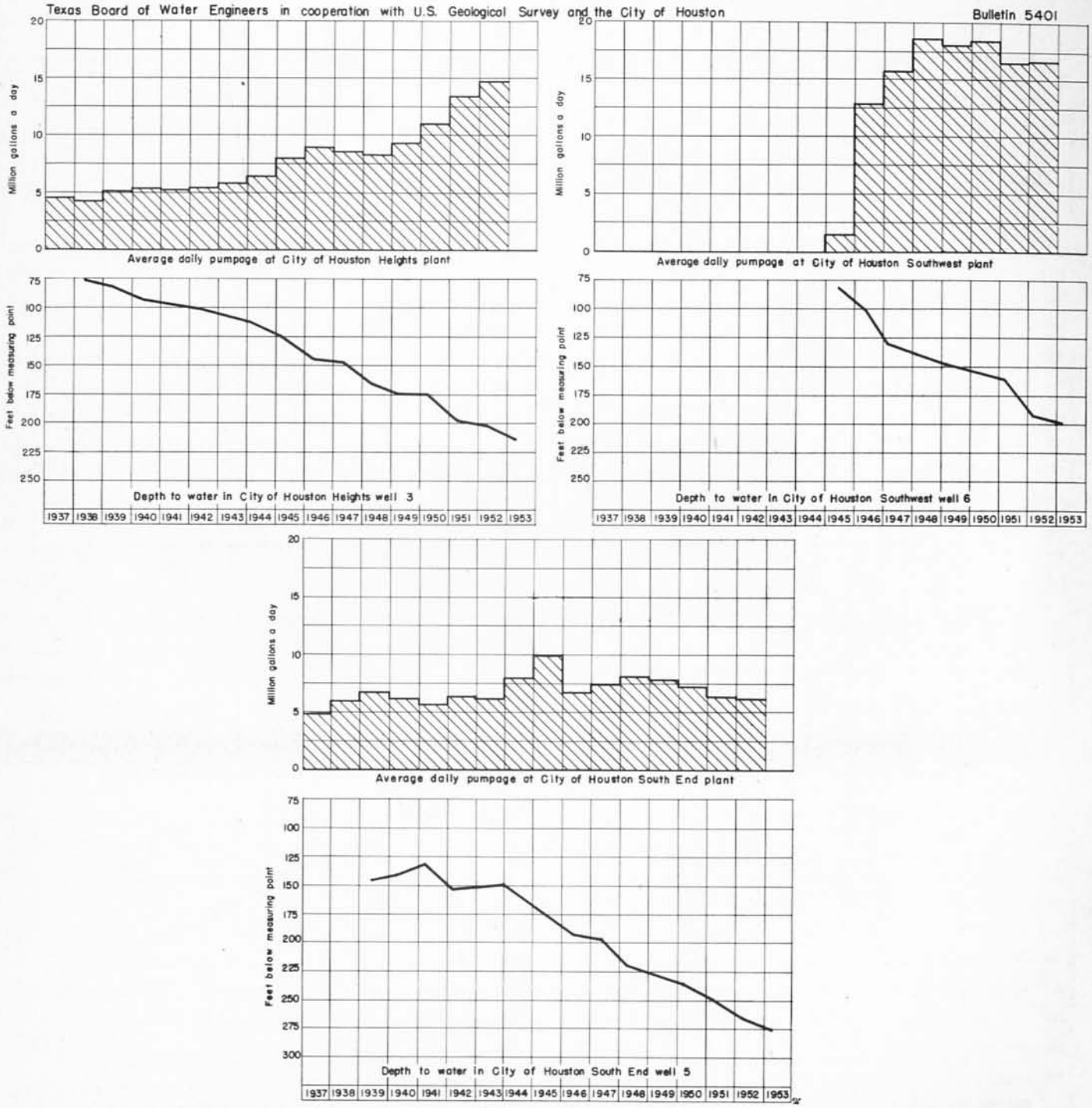

FIGURE 6.— Relation of pumpage to artesian pressure in Houston Heights, Southwest, and South End well fields.

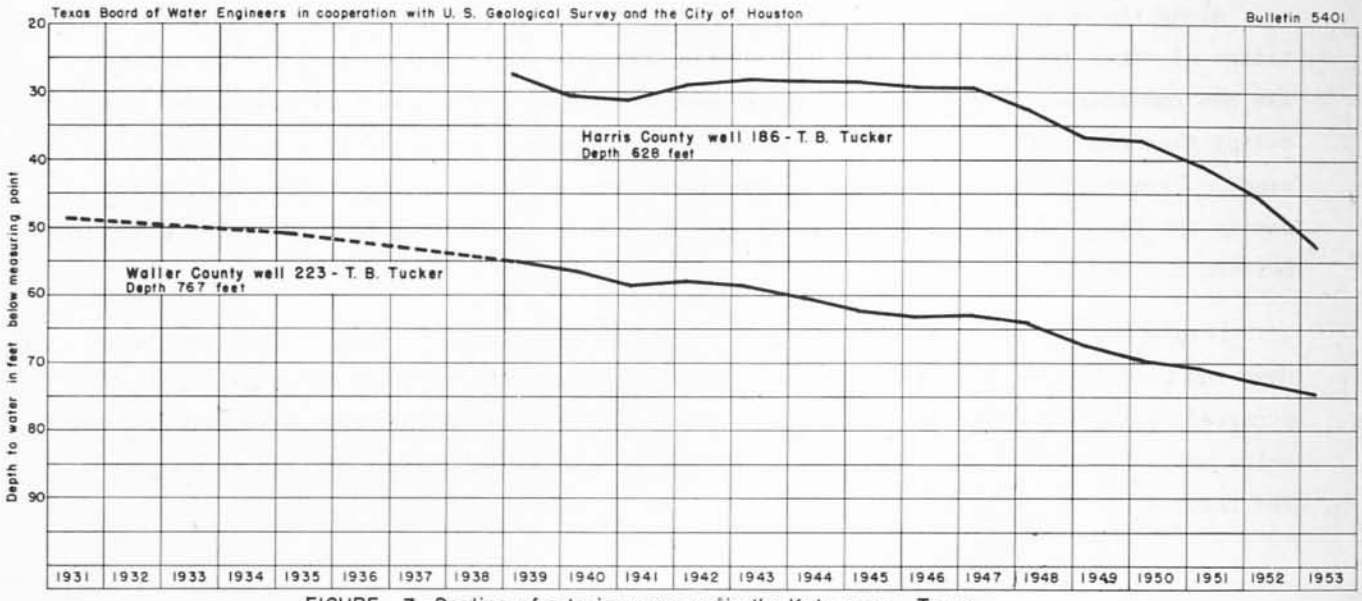

FIGURE 7.- Decline of artesian pressure in the Katy area, Texas.

PASADENA AREA

Most large withdrawals of ground water in the Pasadena area are from sands below 600 feet in depth. Wells screened in these deeper sands showed large water-level declines between the spring of 1951 and the spring of 1953. Nine observation wells in the Pasadena area showed declines ranging from 30.7 to 48.7 feet and averaging 39.3 feet. Figure 8 shows hydrographs of two observation wells (nos. 1170 and 1230) in the area. Figure 9 shows the change in the water level in Harris County well 1170 between spring measurements of each year since 1932.

Along the ship channel from eastern Pasadena to the Deer Park-LaPorte area, large quantities of water are withdrawn from wells about 500 feet deep. Water levels in these wells are now considerably higher than in the deeper wells and show somewhat less decline, indicating that the sand is either not connected or is remotely connected with the deeper sands. Figure 10 shows hydrographs of two wells, one screened in the shallow sand and one in the deeper sands, and illustrates the difference in artesian head and rate of decline between the two.

During May and June of 1952, several oil refineries along the ship channel were shutdown and used little or no ground water. Figure 11 shows the recovery of water levels that occurred during the shutdown period in two wells at the Shell Refinery at Deer Park and two wells near the Crown Central Refinery at Pasadena, and the subsequent decline as pumping was resumed.

HOUSTON AREA

Figure 12 shows the locations of observation wells and the municipal well fields in the city of Houston. Except in the eastern part of the city most of the large withdrawals are from city wells. In the eastern part, however, the same sands that are heavily pumped in the Pasadena area show similar declines. Nine observation wells in eastern Houston showed water-level declines from the spring of 1951 to the spring of 1953 ranging from 20.1 to 30.1 feet and averaging 25.8 feet. During the same period wells in the city of Houston East End well field, which draw much of their water from deeper sands than those screened in the Pasadena area, showed water-level declines ranging from 24.5 to 33.7 feet and averaging 31.0 feet. Hydrographs for three industrial wells in eastern Houston are shown in figure 13.

FIGURE 8.- Decline of artesian pressure in the Pasadena area, Texas.

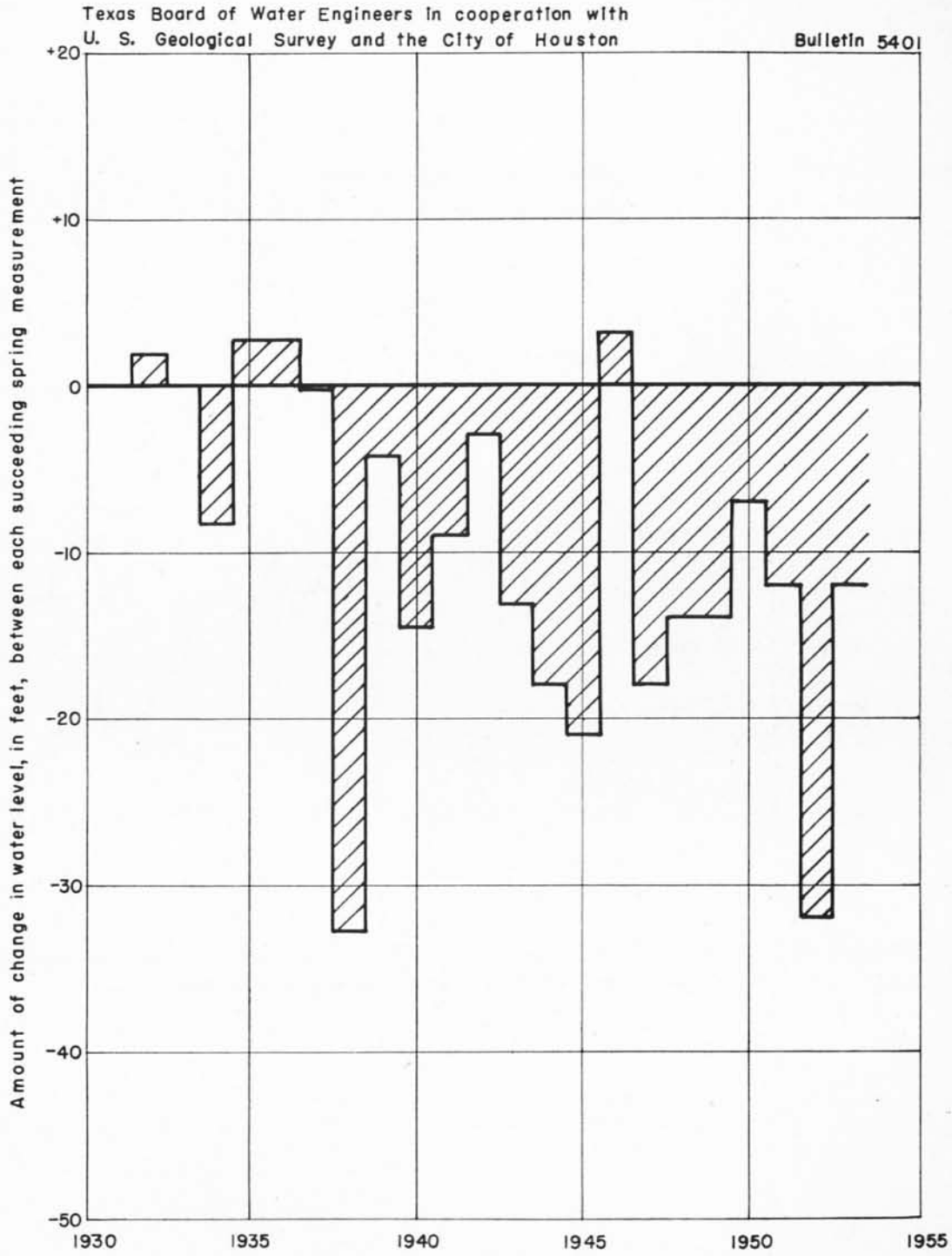

FIGURE 9.– Yearly change in water level in Harris County well 1170.

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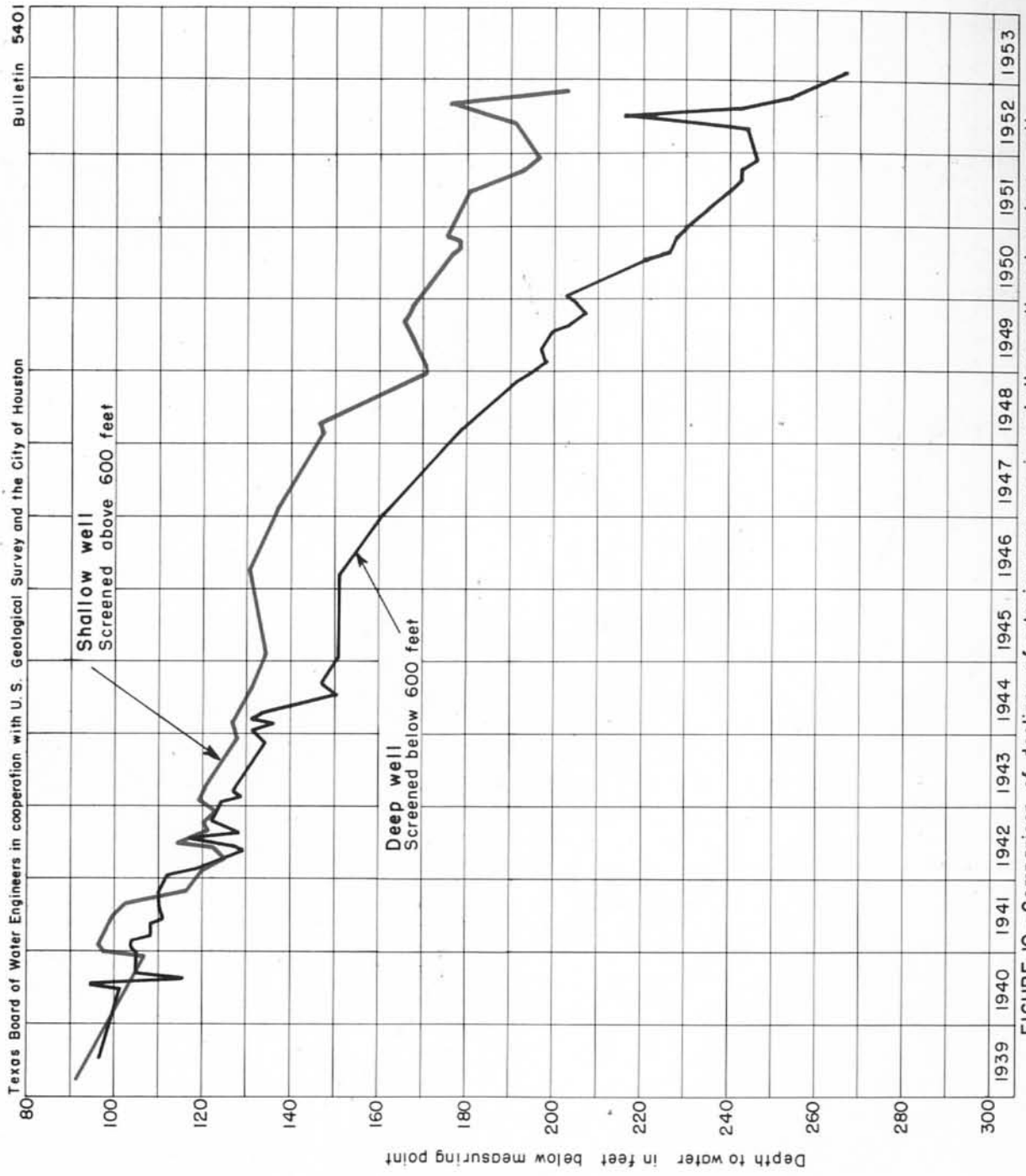

FIGURE 10.- Comparison of declines of artesian pressure in a shallow well and a deep well in the eastern Ship Channel-Pasadena area, Texas.

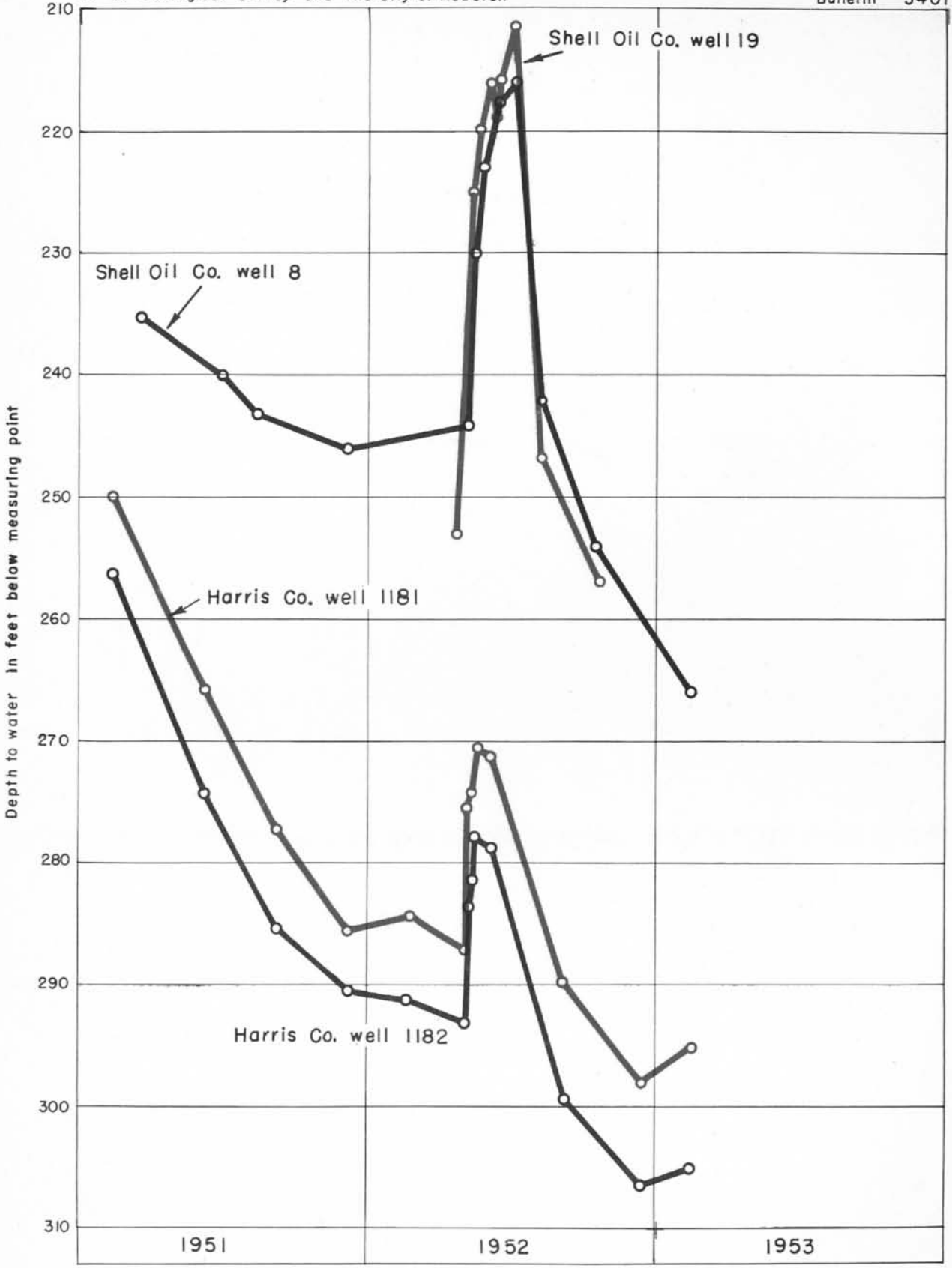

FIGURE 11.- Recovery of water levels during shutdown of wells at Shell Oil Co., Sinclair Oil and Refining Co., and Crown-Central Petroleum Co. refineries, summer 1952

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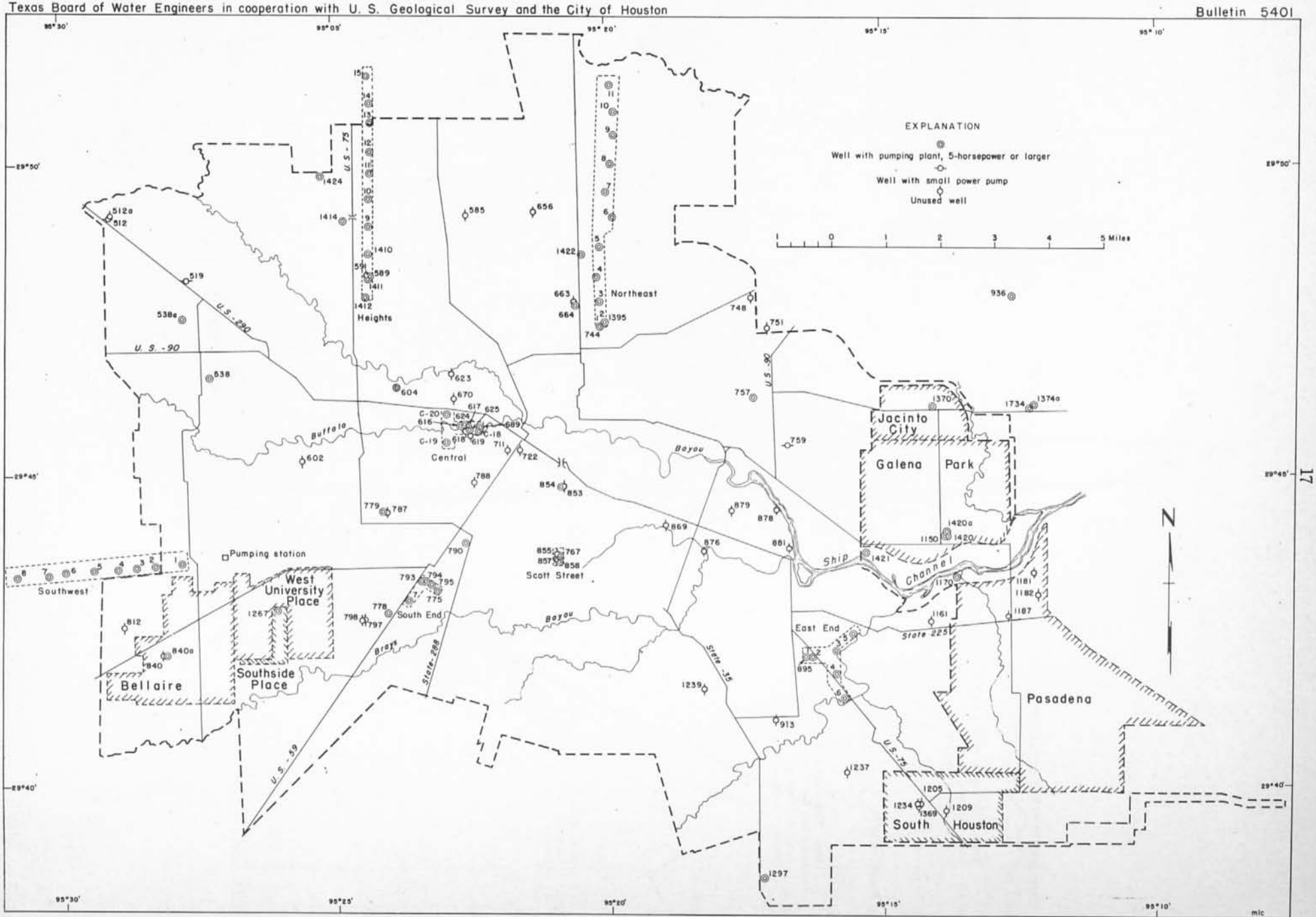

FIGURE 12.- Observation wells and municipal well fields, Houston, Tex.

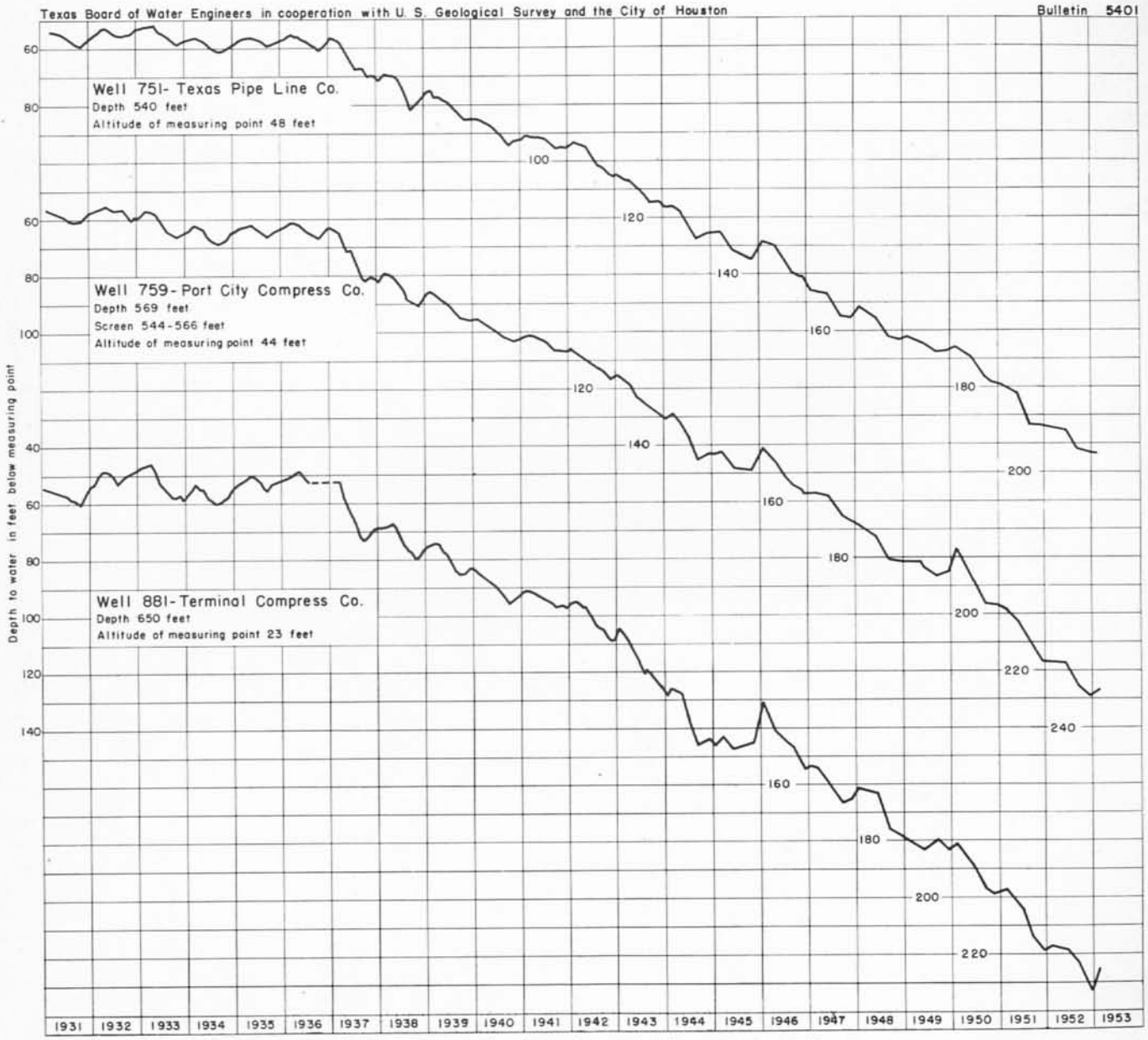

FIGURE 13.- Decline of artesian pressure in eastern Houston, Tex.

Throughout the remainder of the city, the heaviest withdrawals are mostly from deeper sands through city wells. Declines are greater in the deep wells than in the shallow wells.

Figures 5 and 6 show water-level declines in representative wells in the city well fields. Hydrographs showing water-level declines in certain other wells screened in the shallower sands are shown in figure 14 for northern Houston, and in figure 15 for central and western Houston.

Table 2 gives the net decline in water levels in the Houston municipal well fields between 1952 and 1953. Some of the figures are not comparable because the shutdown times before measurements were different. However, the figures, as well as measurements in other wells, do show that wells screened only in the deeper sands generally have larger water-level declines than wells screened in the shallower sands, and that wells screened in both shallow and deep sands show water-level declines falling between the two.

Figure 16 shows in detail the effect of pumping on artesian pressure. The hydrograph of the city of Houston well F-10 in the city's Central well field for 1952 shows the daily high water level as taken from water-level recorder charts. The correlation between pumpage and water levels is evident. During the first four months of the year the pumpage remained fairly constant except that all the wells were shutdown on Sundays. The water levels during the period showed only a small net change, although the effect of the weekly shutdown of the field is apparent. The increased pumpage during the hot, dry months of May through October caused a net decline of water levels of about 30 feet; however, the weekly fluctuation of water levels because of cutback of pumping on Sundays is still evident. During November and December there was a decrease in the pumpage and a corresponding rise in water level.

In the area north of Houston, small to moderate water-level declines occurred between the spring measurements in 1951 and in 1953. Declines recorded in 11 observation wells ranged from 7.4 to 20.7 feet and averaged 13.3 feet.

HOUSTON DISTRICT

Figures 17, 18, and 19 are maps showing the altitude of water levels in wells penetrating the most heavily pumped sands in all three areas of the Houston district. Figures 17 and 18 are based on measurements made in the springs of 1941 and 1951, respectively, and are included for comparison with figure 19 which is based on measurements made in the spring of 1953. Figures 20 and 21 are profiles across the Houston district from west to east and from north to south, respectively, and show the altitude of the potentiometric surface in the springs of 1931, 1941, 1951, and 1953.

The results of the investigation to date show that the artesian pressures in the different sands and different parts of the district could be brought into better balance if the pumpage were redistributed.

FIGURE 14.- Decline of artesian pressure in northern Houston, Tex.

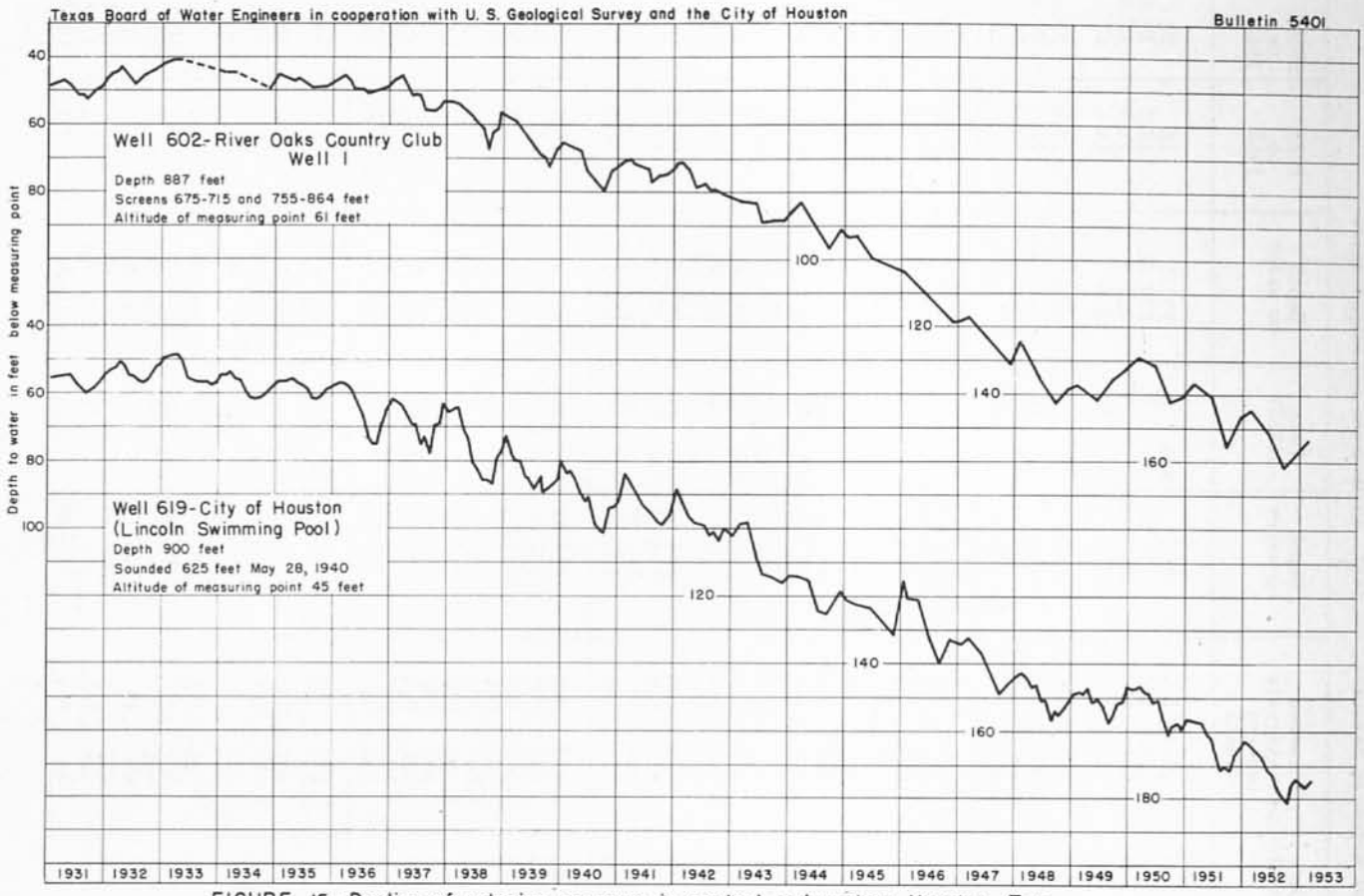

FIGURE 15.-Decline of artesian pressure in central and western Houston, Tex.

Table 2.- Net declines of artesian pressure, in feet, in Houston municipal wells

Plant	Office no.	City well no.	Date (1952)	Screened at intervals between (feet)	Depth to water	Date (1953)	Depth to water	1952 to 1953	1951 to 1953	1946 to 1953	1939 to 1953
Central	617	F- 1	Mar. 10	893-1,499	215	Mar. 3	231	16	24	-	135.5
	616	F- 5	5	894-1,438	221.85	3	233.38	11.5	19.5	86.2	137.8
	618	F-10	5	889-1,320	200.9	3	212.8	11.9	17.0	74.6	126.2
	625	F-12	5	1,154-2,025	210	12	224	14	22	94.0	140.5
		D-17	5	708- 978	295.67	3	219.71	14.0	23.0	-	132.6
		C-18	5	884-1,989	210.90	12	224.52	13.6	27.4	94.2	-
		C-19	7	1,160-1,960	237.38	3	245.39	8.0	21.1	-	-
		C-20	5	1,015-1,940	223.57	12	239.61	16.0	22.0	-	-
East End	895	1	3	1,026-1,646	254.29	27	270.71	16.4	33.7	94.0	172.3
		3	10	1,190-2,350	254.18	9	269.74	15.5	33.3	-	-
		4	3	1,001-2,510	248.84	9	261.22	12.4	32.3	-	-
		5	7	1,469-2,560	232.01	Feb. 27	243.76	11.8	24.5	-	-
Heights	589	5	Feb. 29	410-1,856	161.90	26	177.8	15.9	22.5	-	115.8
	1410	6	29	581-1,226	193.70	Mar. 13	216.3	22.6	32.8	76.4	137.8
	1412	7	29	561-1,454	190.67	2	215.50	24.8	29.2	71.5	126.2
	1411	8	29	556-1,240	194.72	Feb. 26	228.68	34.0	38.8	78.9	145.9
		9	29	610-1,710	188.29	Mar. 2	197.24	8.9	15.1	-	-
		10	Mar. 14	600-1,860	198.50	2	202.68	4.2	26.0	-	-
		11	14	700-1,760	200	13	217.19	17.2	43.9	-	-
		12	10	900-1,750	204.63	13	229.99	25.4	31.4	-	-
		13	10	890-1,800	194.56	Feb. 26	192.36	+2.2	+6.8	-	-
		14	Feb. 29	950-1,790	190.20	26	192.07	1.9	+2.9	-	-
		15	28	700-1,680	145.79	26	184.66	38.9	50.1	-	-
Northeast	744	1	29	1,013-1,872	214.58	26	231.83	17.2	37.1	108.9	181.9
	1395	2	Mar. 5	451-1,279	198	26	208	10	19	75.9	125.9
		3	Feb. 29	1,143-1,990	217.95	27	228.82	10.9	33.7	100.9	-
		4	Mar. 5	1,030-2,060	211.27	26	228.98	17.7	36.3	-	-
		5	Feb. 29	1,060-1,960	206.08	Mar. 4	221.98	15.9	32.1	-	-
		6	Mar. 5	1,017-1,819	212.39	26	220.94	8.6	24.6	-	-
		7	Feb. 29	1,001-1,880	213.48	26	225.7	12.2	33.9	-	-
		9	29	1,020-1,920	206.31	Feb. 27	235.6	29.3	48.4	-	-
		10	Mar. 5	700-1,830	195.69	Mar. 2	214.32	18.6	42.9	-	-
		11	Feb. 29	710-1,960	180.73	2	199.76	19.0	39.1	-	-
Scott Street	855	2	Mar. 3	1,323-1,521	229.09	Mar. 3	245.31	16.2	34.0	91.5	150.5
South End	795	2	3	489-1,337	156.7	10	175.7	19.0	10.6	66.4	93.6
	793	5	7	1,275-1,595	239.19	10	249.64	10.5	36.6	81.8	135.4
		7	7	1,425-1,932	244.42	10	256.32	11.9	40.4	103.1	-
Southwest		1	4	726-1,498	193	10	194.89	1.9	7.9	-	96.9 a/
		2	6	675-1,473	185.66	10	190.41	4.8	10.0	-	-
		3	4	686-1,396	196.01	9	194.51	+1.5	10.0	-	103.6 a/
		4	6	692-1,490	184.93	9	194.20	9.3	12.5	75.9	101.8 a/
		5	4	652-1,379	181.90	4	192.70	10.8	16.4	-	23.4 b/
		6	4	548-1,360	178.35	4	179.75	1.4	13.7	-	40.5 c/
		8	6	559-1,445	143.50	3	148.91	5.4	10.0	-	42.3 d/

a/ 1945-53
b/ 1949-53
c/ 1948-53
d/ 1947-53

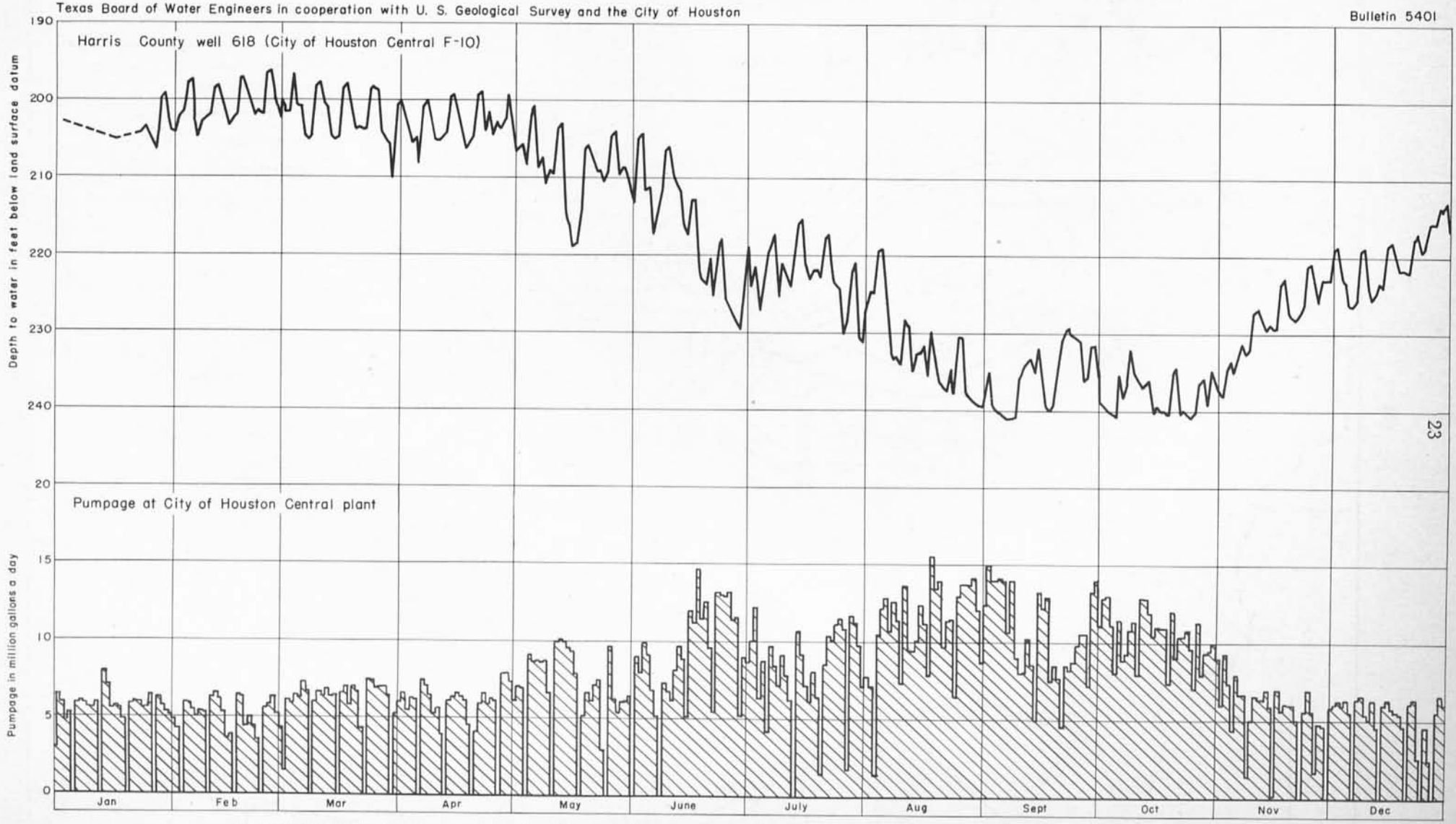

FIGURE 16.- Effect of pumping in City of Houston Central well field on water level in Central well F-10, 1952.

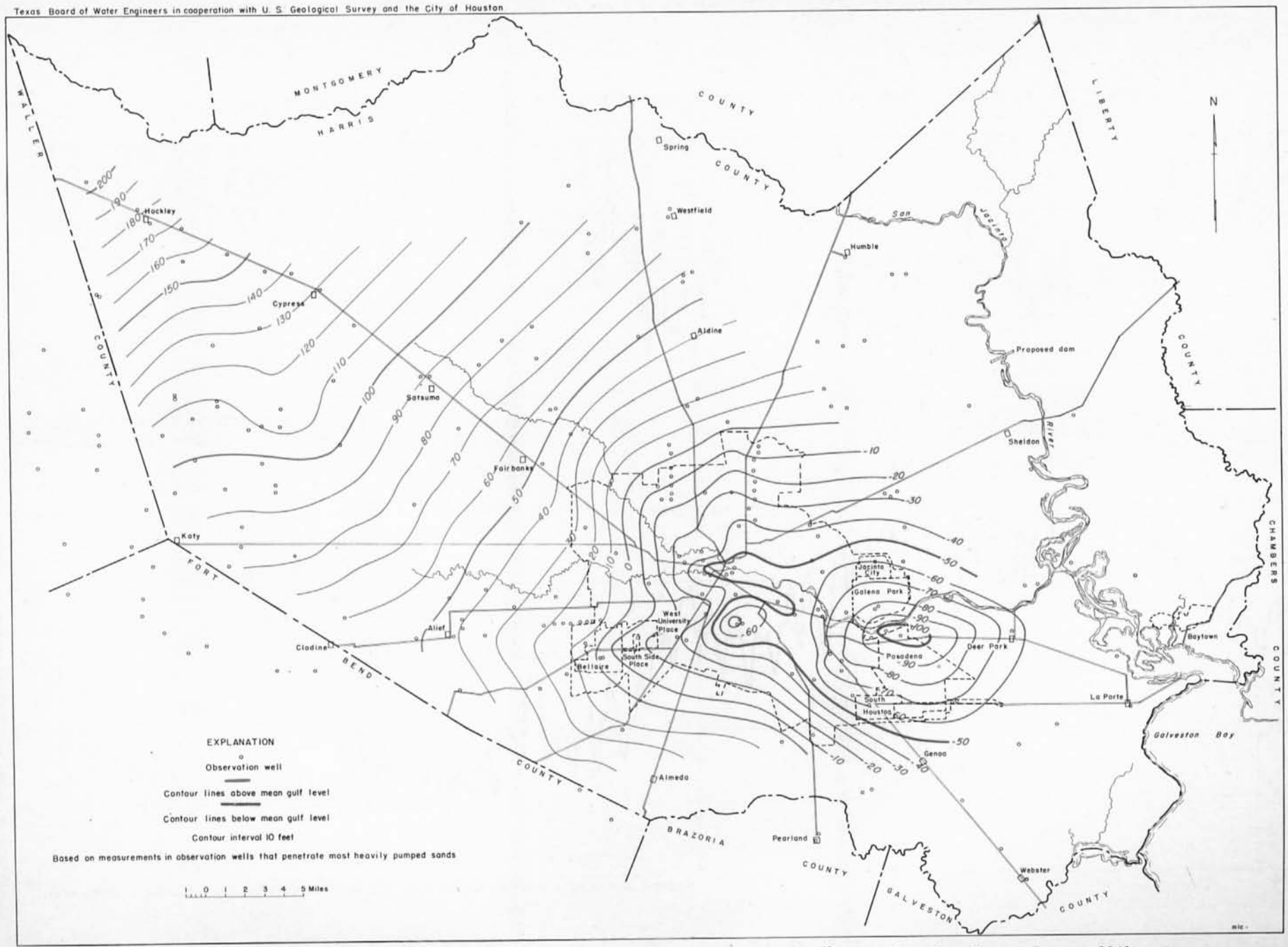

FIGURE 17.-Approximate altitude of water levels, in feet, in wells in the Houston district, Texas, January 1941.

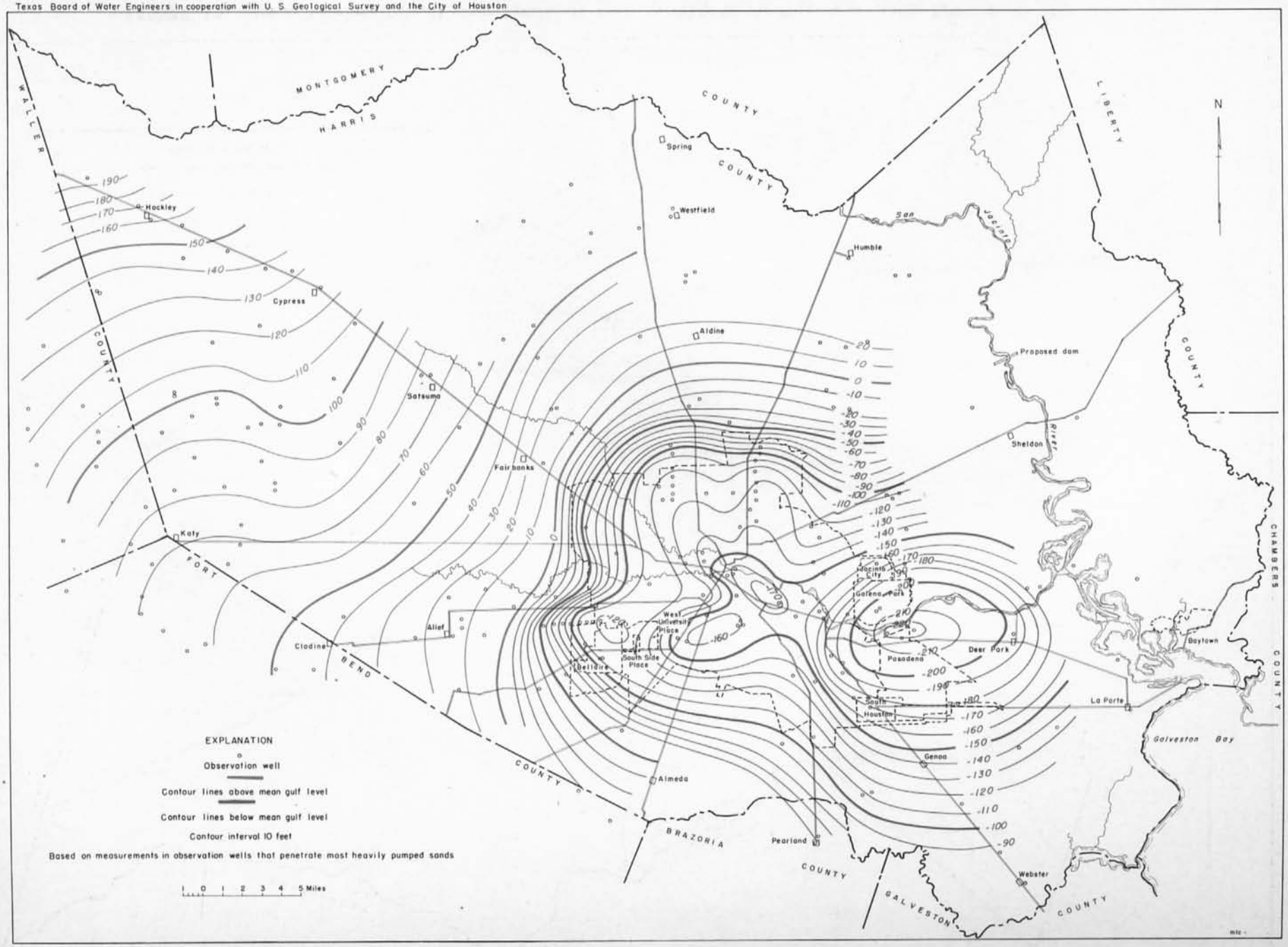

FIGURE 18.- Approximate altitude of water levels, in feet, in wells in the Houston district, Texas, March 1951.

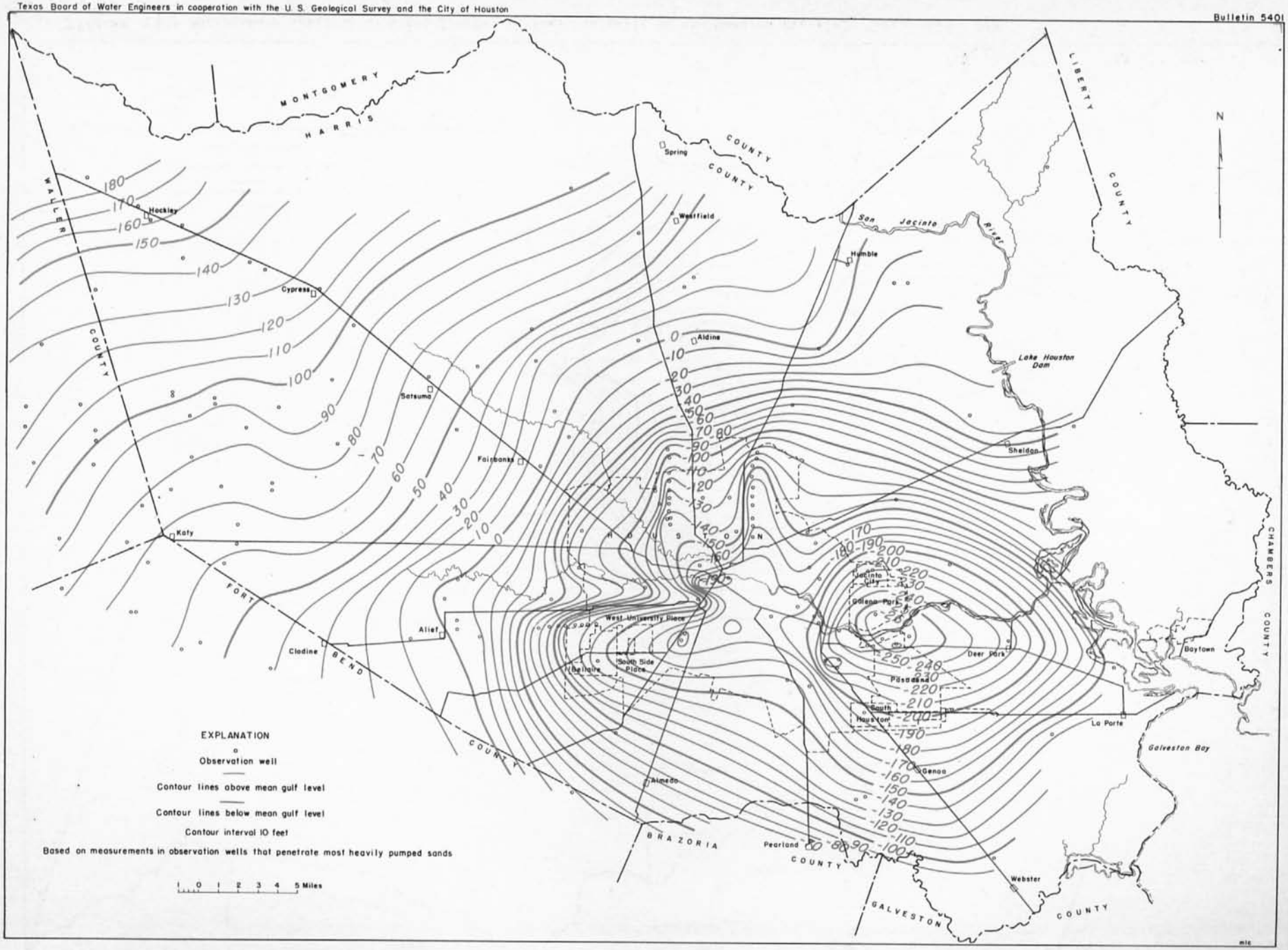

FIGURE 19.- Approximate altitude of water levels, in feet, in wells in the Houston district, Texas, March 1953.

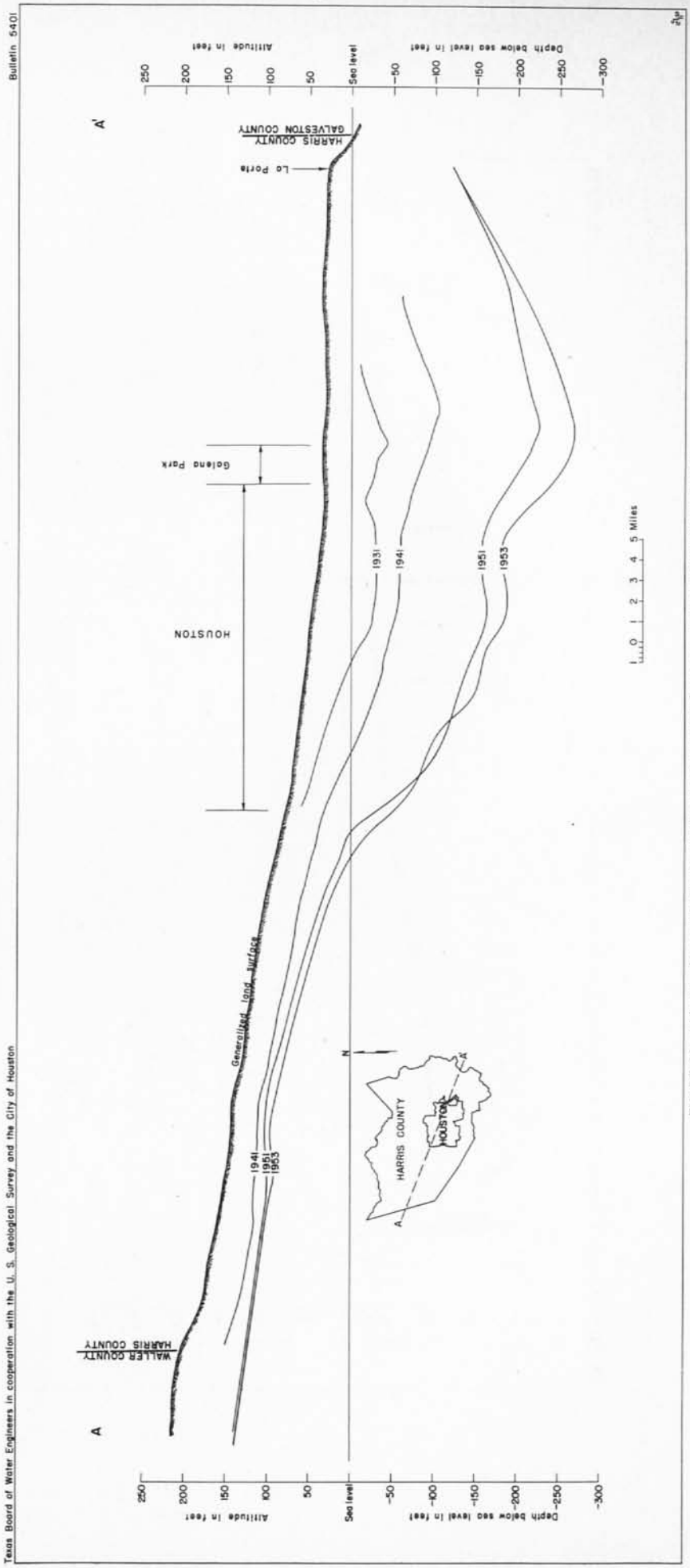

FIGURE 20.- Altitude of potentiometric surface along line A-A', springs of 1931, 1941, 1951, and 1953.

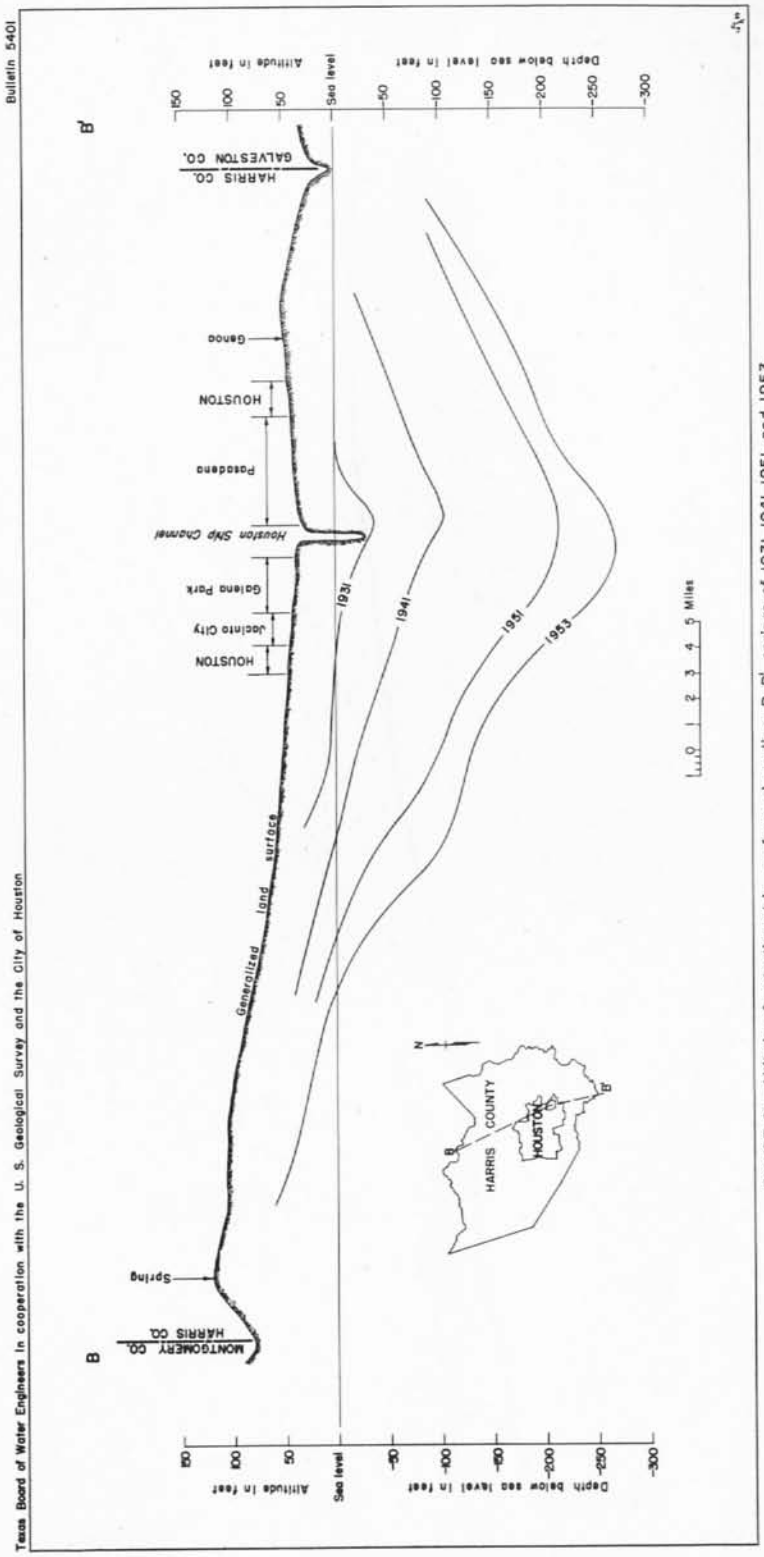

FIGURE 21.- Altitude of potentiometric surface along line B-B', springs of 1931, 1941, 1951, and 1953.