

TEXAS STATE BOARD OF WATER ENGINEERS

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

PROGRESS REPORT ON THE GROUND-WATER RESOURCES OF THE  
HOUSTON DISTRICT, TEXAS

By

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## Introduction

An investigation of the supply of underground water, or ground water, available for Houston and the region surrounding it has been in progress for several years, as part of a survey of the ground-water resources of Texas by the Texas Board of Water Engineers in cooperation with the Geological Survey of the U. S. Department of the Interior.

The investigation has covered Harris, Galveston and Waller Counties, a large part of Montgomery, Fort Bond and Brazoria Counties, and a small part of Liberty and Grimes Counties. This is the fourth of a series of progress reports, the other three being dated October 17, 1932, December 29, 1933, and March 1, 1937. This report is devoted principally to a discussion of the decline in water levels in wells which has occurred in the Houston-Pasadena area since March 1, 1937.

## Fluctuations in artesian pressure.

## Decline of water levels in wells since March 1, 1937.

Prior to 1937 the artesian pressures in the Houston-Pasadena area had reached a stage of comparative equilibrium, or displayed a very small annual decline. About March 1, 1937 a paper pulp mill was started near Pasadena which required an average supply of well water amounting to about 19,000,000 gallons a day. This represented an increase of almost 40 per cent over the average daily draft by all the wells of the Houston-Pasadena area in 1935 and 1936. Following this sudden heavy increase in pumping a pronounced decline in artesian pressures and lowering of water levels in wells was to be expected not only in the vicinity of Pasadena but even in localities many miles from the new wells. The following is copied from page 24 of the progress report of March 1, 1937, which was submitted to the city authorities early in March, 1937:

When additional pumping at the rate of 20,000,000 gallons a day is started, a deep cone of depression will quickly be developed in the immediate vicinity of the wells, all of which are located within an area of about one square mile. In one area of similar size in this region, the increase in the average daily pumping from about 10,300,000 gallons a day to about 14,200,000 gallons a day caused the average static water level in the area to decline from about 46 feet below sea level in the spring of 1932 to about 68 feet below sea level in the spring of 1936, or a net decline of about 5.6 feet for each million gallons a day increase. In the Pasadena district the fresh water sands are materially thicker than in the area referred to and, if the permeability of the sands is about the same, the rate of decline is likely to be materially less. Nevertheless, with an increase in pumping of 20,000,000 gallons a day at Pasadena, it appears probable that locally the present cone of artesian depression will be deepened to considerably more than 100 feet below sea level. This new cone of depression will expand to adjacent areas. The amount of lowering in

any given direction from the new wells will decrease with the distance from them, but as the area affected expands the rate of decline will decrease and the progress of the regional drawdown can be watched. A pronounced drop in head is to be expected during the spring of 1937 in all wells in the vicinity of Pasadena and probably, also, in the wells of southeastern Houston. Before the end of the summer of 1937 a material decline in artesian head may occur in central and west central Houston eight to ten miles from the new project and necessitate the lowering of pumps in wells in which the water level during pumping is close to the suction limit of the pumps. With proper observation, however, it should be possible to anticipate pronounced regional drawdown at these distances.

The decline in artesian pressures in the area have occurred about as was expected when the report was written. The approximate amount of this decline to May 1938, as recorded in 24 observation wells in the Houston-Galveston area, is given in the table on the next page; the depth of the wells and their distance in an air line from the new development is also shown. The accompanying blueprints show graphically the fluctuations that occurred from 1931 to March, 1937.

The records of a few measurements of depths to water in five of the City wells before and after the increase in pumping near Pasadena are given below.

Central Well F-11

July 15, 1936,	87.0 feet	10 minutes after pump was shut down
Nov. 19, 1937,	72.0 "	30 " " " " " "
Jan. 8, 1938,	72.0 "	10 " " " " " "
Apr. 22, 1938,	77.87 "	1 hour " " " " "

Central Well F-12

Sept. 11, 1935,	55.0 feet	1 day after pump was shut down
July 22, 1936,	79.0 "	5 minutes " " " " "
Jan. 26, 1938,	53.7 "	2 " " " " " "
Jan. 26, 1938,	66.0 "	10 " " " " " "

Heights Well No. 5

Apr. 9, 1938,	58.0 feet	10 minutes after pump was shut down
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Heights Well No. 6

Oct. 7, 1936,	79.2 feet	1 minute after pump was shut down
Apr. 14, 1938,	78.95 "	16 hours " " " " "

South End Well No. 6

July 24, 1936,	97.0 feet	20 minutes after pump was shut down
Apr. 14, 1938,	95.98 "	1 hour " " " " "

The following information relates to a few privately owned industrial wells that are not included in the list of observation wells in the table. According to report of Mr. G. L. Hoss, Resident Engineer for the Sinclair Refining Company, well 6 at the refinery near Pasadena showed a decline in level of about 25 feet between February 1937 and February 1938. According to records obtained through L. H. Kendall, Chief Engineer, the water levels

Decline of water levels in Houston wells  
January and February 1937 to March 1, 1938

Well	Depth (feet)	Distance from Pasadena paper pulp mill (miles)	Decline Jan. - Mar. to Oct. 1937 (feet)	Rise from Oct. 1937 to Mar. 1938	Net decline Jan. - Mar. 1937 to Mar. 1, 1938	Decline or rise May 1937 to May 1938
1170	836	5/8 NW	43	8	35	--
1176	800 $\frac{1}{2}$	1 $\frac{3}{4}$ NNW	44	9	35	$\frac{1}{2}$ 4.9
890	1,284	3 $\frac{1}{2}$	29	6	23	--
881	650 $\frac{1}{2}$	4 WNW	20	5	15	- 7.4
886	540	4 W	9	4	5	--
878	905	4 $\frac{1}{2}$ NW	25?	?	?	-10.2
759	396	4 $\frac{1}{2}$ NW	19	2	17	- 9.3
876	?	5 $\frac{1}{2}$ WNW	--	--	6 $\frac{1}{2}$	- 3.6
757	676	6 NW	14	1.5	13	- 9.4
868	697	6 $\frac{1}{4}$ WNW	6	5	1 $\frac{2}{3}$	$\frac{1}{2}$ 1.0
751	540	6 $\frac{1}{2}$ NW	14	1	13	- 7.4
738	417	7 $\frac{1}{2}$ NW	3	0	3	- 2.5
853	650	8 $\frac{1}{4}$ WNW	11	7	4	- 2.6
680	1,350 $\frac{1}{2}$	9 NW	18	4	14	$\frac{1}{2}$ 2.0
662	834	9 $\frac{1}{2}$ NW	14	0.5	14	- 8.7
790	606	9 $\frac{1}{2}$ W	3	4	$\frac{1}{2}$ 1	- 7.7
619	900	10 NW	8	5	3	- 5.1
656	665	10 $\frac{1}{2}$ NW	--	--	11	--
606	575	11 NW	8	3	5	- 6.5
604	--	11 $\frac{1}{2}$ NW	7	6	1	- 0.1
590	--	13	--	--	--	--
602	1,038	13 W	10	--	--	--
804	650 $\frac{1}{2}$	14 W	7	1 $\frac{1}{2}$	--	--
809	1,100 $\frac{1}{2}$	15 W	7	1	6	--
898	900		7		6	-9.0

$\frac{1}{2}$  June 1937 to March 1, 1938

$\frac{2}{3}$  Net decline in nearby well 1,200 to 1,300 feet deep reported about 30 feet in two years ending in fall of 1937. This doubtless is partly due to large increase in local pumpage.

in wells at the Shell refinery four or five miles east of Pasadena had a net decline from March, 1937 to March, 1938, ranging in different wells from 11 to 18 feet. A well 1,200 to 1,300 feet deep, at the Hughes Tool Company about six miles northwest of Pasadena, according to Mr. Goddard, Superintending Engineer, has had a decline in head of about 30 feet during the past two years. This well is within a few hundred feet of observation well No. 868, which is 697 feet deep and had a net decline of only about five feet during the last two years. The deeper well is one of two heavily pumped, closely spaced wells that supplied an average of about 1,500,000 gallons a day in 1936 and 1937, or about 1,000,000 gallons a day more than was pumped from them in 1935.

Most of the wells which were used in the regular observation program and which are listed in the table range from about 600 to about 900 feet in depth. Two of them, Nos. 680 and 890, are about 1,300 feet deep and two, Nos. 602 and 809, are about 1,100 feet deep. This observation-well set-up is obviously not wholly satisfactory for recording fluctuations in artesian pressures in all the water-bearing horizons. In this area the shallow sands from about 200 to about 400 feet are fairly well shut off from the sands at 600 to 1,100 feet and the latter in turn are shut off from the sands at 1,300 to 1,700 feet. The isolation apparently is not complete, but is sufficient to cause a lag varying from weeks to years in the transmission of declines in artesian pressure from one horizon to another. This has been known for several years and urgent recommendations have been made that additional wells, which now are tightly closed and inaccessible, should be opened up for measurement -- especially wells that tap the deeper sands. This, however, has not yet been done.

The attached map shows the location of the regular observation wells, the depth of the wells, all city pumping stations, and the pumping stations of the Champion Paper and Fiber Company.

A study of all the records given above leads to the conclusion that the decline in head, although serious, still has not reached major proportions at any considerable distance from the paper pulp mill. It is noted that the greatest decline seems to be toward the northwest, almost directly up the dip. The decline in downtown Houston between March 1937 and March 1938 ranged from three feet in well 619 to 14 feet in well 680. The records of water levels in the city wells at the Central, Heights, and South End stations are difficult to interpret because of the varying lengths of time the pumps were shut down before the measurements were taken. Apparently, wells Central F-11, Heights No. 6 and South End No. 6 have suffered loss in artesian head since 1936, but the decline has not been very large. Several of the regular observation wells showed a substantial rise during the winter and the water levels in three of them were higher in May 1938 than they were in May 1937. However, the records indicate clearly that the new pumping at Pasadena has caused a substantial lowering. A further decline in water levels is to be expected in the coming year and should be carefully watched.

Pumpage: present and proposed

The estimated daily pumpage in the Houston area and adjacent regions in 1937 is given below:

Estimated average daily pumpage in 1937  
in Houston district and adjacent region  
(Houston-Pasadena-Texas City-Galveston-Katy areas)

	Million gallons	
Houston Water Department	25.2	(City records)
Champion Paper and Fiber Co. (starting March 1)	19.0	
Miscellaneous Pumpage Houston- Pasadena and area along ship- channel Pasadena to La Porte	26.0	
Total	70.2	
Baytown	13.5	(Humble Oil & Refining Co. records)
Texas City, Alta Loma and Galveston City supply	15.0	
Miscellaneous pumpage Houston to Galveston	5.0	
Katy Rice area	16.0	
Grand Total	119.7	

As indicated by the table, the total pumpage in the Houston-Pasadena-Ship Channel area is estimated as about 70,000,000 gallons a day and the grand total for the region as about 120,000,000 gallons a day. With the exception of the draft by the wells of the paper pulp mill, the pumping in the Houston-Pasadena-Ship Channel area in 1937 probably was not much greater than that in 1930, the increase perhaps being of the order of 2,000,000 to 4,000,000 gallons a day. Since 1930 many new industries have been established in the area and Houston has had a substantial increase in population. However, most industries use a comparatively small amount of water and the increase in population apparently has not been followed by a comparable increase in the public demands for water.

Under normal conditions of growth in population and industry the available supply of ground water within comparatively easy reach of Houston should supply the needs of the Houston-Pasadena-Ship Channel district for many years. However, it appears that plans are to be made immediately looking toward a supply for the area averaging around 170,000,000 gallons a day or almost two and one-half times the present pumpage. This quantity, plus the amount now pumped in the Baytown, Galveston, Texas City, and Katy areas would make a grand total of 220,000,000 gallons a day.

#### Conclusions

So far as is known, withdrawals of ground water in quantities approximating 200,000,000 gallons a day have not been attempted anywhere in the world under conditions of ground-water occurrence comparable to those which exist in the Houston region. About 150,000,000 gallons a day is pumped from wells for the public supply of the City of Berlin in Germany and an approximately equal amount is pumped from wells on Long Island by the City of New York and by other communities and industrial establishments. However, both

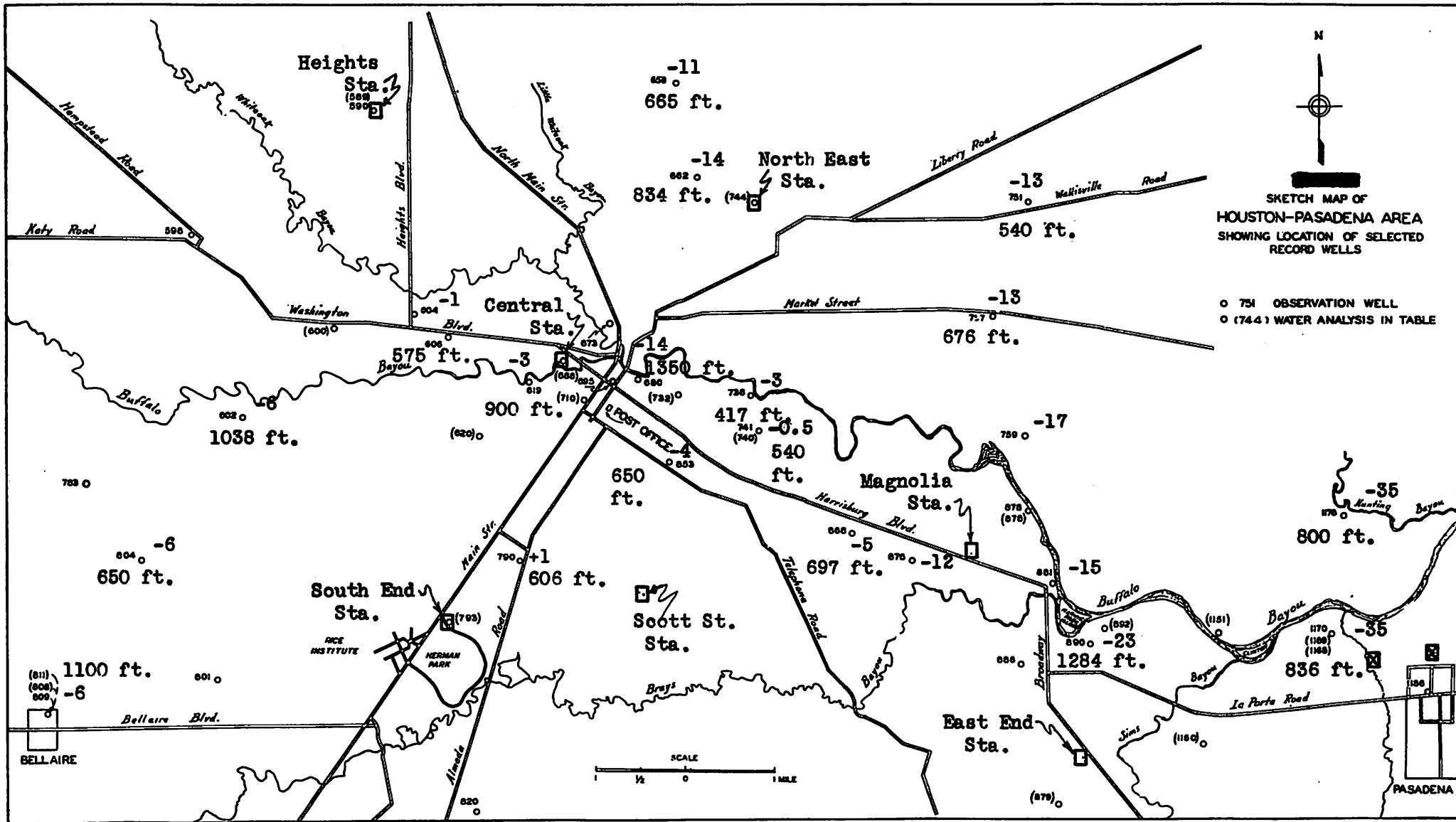
in the Berlin area and on Long Island the water is obtained from gravels and sand in glacial deposits which are subject to heavy replenishments by local rainfall. The water-bearing sands of the Houston region are buried beneath impermeable clays and probably are replenished only at their outcrops, located mostly in areas many miles from the well fields. In the case of the deeper wells at Houston the areas of intake may be 50 miles or more distant. Under these conditions the available supply is largely, if not entirely, determined by the capacity of the sands to transmit water from the outcrops to the wells. The carrying capacity of the sands varies directly with the hydraulic gradient and this is increased when depressions in artesian pressure are created by heavy pumping. However, in this region possibilities of such increase are limited by the fact that if the well fields are pumped too hard and the artesian pressures lowered too far below sea level, salt water will be drawn into the fresh water-bearing sands from areas down dip in the direction of the Gulf.

Under these circumstances it is probable that the ground-water reservoirs would not sustain the additional draft unless, indeed, wells are put down far out along the strike of the water-bearing sands, and ground water piped relatively great distances to the Houston area (see mimeographed report of March 1, 1937, pps. 28 to 30). If additional supplies are developed from surface sources, it seems almost certain that the ground-water resources of the Houston-Pasadena area will still need to be fully utilized.

#### Recommendations

The need of closely watching the ground-water situation at Houston is as great now as it ever was -- perhaps greater. A program commensurate with the importance of the problem would include the following:

Inventories of industrial pumpage in the Houston-Pasadena-Ship Channel area would be continued and made more accurate than it has heretofore been possible to make them with the limited funds available. More observation wells would be added to the present list -- especially deep wells -- and observations would be made monthly throughout the territory as well as within the Houston-Pasadena area itself. Some of the observation wells would be equipped with automatic water stage recorders. Samples of water would be frequently collected and analyzed from selected deep wells throughout Harris County. The ground-water studies would be extended to adjacent areas in Liberty, Fort Bend and Brazoria Counties, which thus far have not been fully covered.



-14 = Net decline of water levels in wells in feet, from January-March 1937 to March 1938.  
 650 ft. = Depth of well.      □ City pumping stations.      ▣ Paper mill pumping stations.