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Progress report on the

GROUND-WATER SUPPLY

of the

EL PASO AREA

by

Penn Livingston and J. M. Birdsall

with a foreward by

O. E. Meinzer

Prepared through cooperation between the
Geological Survey, U. S. Department of the Interior;
The Texas State Board of Water Engineers;
and the City of El Paso.

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Foreward

By O. E. Meinzer.

A thorough investigation of the ground-water resources of the El Paso area was begun in 1935 by the Geological Survey, U. S. Department of the Interior, in cooperation with the Texas State Board of Water Engineers and the City of El Paso. The investigation was made under the direction of W. N. White, Engineer in charge of ground-water investigations in Texas. A. N. Sayre and Penn Livingston were assigned to make the investigation. Several progress reports based on this work have been released to the City of El Paso, the first in January, 1937, and the records of water levels have been published annually in Water-Supply Papers. A detailed report on the results of the investigation, by Messrs. Sayre and Livingston, was released to the City in March 1940.

Since the beginning of the investigation a systematic program of obtaining current records of pumpage, water levels, and chemical character of the ground-water has been maintained through the cooperation of El Paso. The present progress report is based on these records to date.

The records for the present report were compiled and studied by J. M. Birdsall, under the direction of Dr. Sayre. Mr. Birdsall prepared the ten maps that accompany the report and he made the computations of unwatering from the lines shown on the maps designated Plates 9 and 10. As Dr. Sayre was called to overseas duty with the Army, Mr. Livingston was called upon to make a final study of the

data, and he prepared the text of this report, with the assistance of Mr. Birdsall.

The records of pumpage, water levels, and chemical character of the ground-water which have been systematically obtained during the last eight years show that the El Paso area has a very large supply of fresh water in subterranean storage, with substantial annual recharge. However, they also show that from year to year there has been a slow but sure depletion of the supply. The City has undoubtedly acted wisely in the steps it has taken in developing a supplementary supply from the Rio Grande. If the present program of obtaining records is continued and the records are given critical study from time to time, the City will be able to proceed in orderly manner to develop the Rio Grande supply as needed, and thus the entire El Paso area may be assured of an adequate water supply for all purposes as far in the future as it is practicable to plan.

PROGRESS REPORT ON THE GROUND-WATER SUPPLY OF THE EL PASO AREA.

Summary of the investigation.

The city of El Paso has for many years obtained a supply of good water from wells. The only other source of water is the Rio Grande, which is now being utilized to some extent. A well field was developed many years ago on the Mesa, northeast of the city (Water Supply Paper 343, pp. 115-117; 228) but for many years a large part of the supply has been obtained from wells in the Rio Grande Valley. The fresh ground-water is derived chiefly by recharge from the mountains. Highly mineralized water, however, underlies the fresh water-bearing beds both on the Mesa and in the Valley. The shallow water-bearing beds within the valley are fed mainly by the Rio Grande and hence the water is highly mineralized in some places. Thus in the Valley the fresh ground-water occurs between overlying and underlying beds of mineralized water.

During 1934 the chloride content of the water from El Paso city well No. 3, in the Montana well field increased rather suddenly. Attempts to locate the source of the contamination were unsuccessful and it was feared that the increase in the chloride content indicated that the beds yielding fresh water being contaminated by salt water. At that time wells in the Montana field supplied a large part of the total city supply, and, therefore, failure of the field would have been serious. This situation emphasized the need for a comprehensive investigation of the ground-water resources of the area, including the determination of the extent and

volume of the subterranean fresh-water reservoir, the source of the fresh-water and its rate of recharge, and the source of the salt-water contamination.

An investigation was begun in July 1935 by the Geological Survey, U. S. Department of the Interior, in cooperation with the Texas Board of Water Engineers and the City of El Paso, and the field work was actively carried on until August 1936. During the course of the investigation the geology of the area was studied with particular reference to the occurrence and source of the ground-water. All the available well data were collected and studied and the depth to water in many wells was measured. Numerous shallow test holes were bored in the valley to determine the slope of the shallow water table and the chemical character of the water. Deep test wells were drilled to obtain samples of the water-bearing material for the determination of permeability and specific yield. A large number of water analyses was made. Resistivity measurements were made at nearly 200 stations to obtain information regarding the thickness and distribution of the water-bearing material.

Since August 1936 measurements of the water levels in wells have been made monthly, water samples have been taken for chemical analysis from certain wells semi-annually, and records have been obtained of the monthly pumpage from city, Army, industrial, and institutional wells in the El Paso area, including Juarez. An extensive test drilling program was carried on by the city during 1939-40 to obtain additional information regarding the material underlying the Mesa.

The following reports based on this investigation have been released in printed, mimeographed, or typewritten form.

Pumpage

For the past 40 years there has been, with few exceptions, an increase, from year to year, in the total pumpage from wells. From 1900 to about 1919 practically all the water furnished to the city water works came from the Mesa well field. From 1919 until about 1934 most of the water was supplied by wells in the Montana well field and from other wells drilled in the Valley within the city. In 1934 an increase in the salt content of the water from the Montana well field became noticeable and a large part of the pumpage was again shifted from that field to the Mesa field. During recent years several more production wells have been drilled, extending the Mesa field several miles northward. Meanwhile there has been a great increase in pumpage for industrial plants, chiefly in the Valley, and for Fort Bliss, on the Mesa.

During 1943 the City of El Paso completed a plant to treat water taken from the Rio Grande. However, this plant supplies only a small part of the water required and therefore the city still depends largely upon the wells for its water supply. The following is quoted from a letter by E. J. Umbenhauer, Superintendent of the Department of Water and Sewerage of El Paso, dated April 24, 1944 "The new river water treatment plant was placed in operation in November 1943 and was operated until the first of this year. It was out of service in January and February because there was no water in the canal, due to repair work on the canal banks. The plant was again started in March and has been operated to date. The pumpage has been kept around three million gallons per day when the plant

is in operation because of the present limit of 3,980 acre feet allowed per fiscal year ending September 30, 1944. Last week, however, the pumpage was increased to six million gallons per day because the water left in the allotment was sufficient to pump at that rate through the summer peak."

The following table shows the estimated pumpage from all deep wells in the El Paso area from 1906 to 1943. These estimates do not include the pumpage from the shallow wells in the Valley.

ESTIMATED AVERAGE DAILY PUMPAGE FROM ALL DEEP WELLS IN THE EL PASO AREA, INCLUDING JUAREZ, FROM 1906 TO 1943, IN MILLION GALLONS PER DAY

Year	M.G.D.	Year	M.G.D.	Year	M.G.D.	Year	M.G.D.
1906	1.2	1916	5.9	1926	10.2	1936	15.7
1907	1.4	1917	7.3	1927	12.6	1937	16.7
1908	1.6	1918	7.4	1928	12.6	1938	16.2
1909	1.6	1919	7.4	1929	12.6	1939	16.8
1910	1.9	1920	9.0	1930	14.9	1940	18.4
1911	2.2	1921	9.6	1931	14.1	1941	19.6
1912	3.4	1922	9.2	1932	13.1	1942	22.0
1913	3.9	1923	9.0	1933	13.0	1943	25.6
1914	4.1	1924	9.3	1934	13.6		
1915	4.7	1925	10.0	1935	15.4		

The following tables show the estimated pumpage from the Montana field and from the Mesa from 1936 to 1943.

ESTIMATED AVERAGE DAILY PUMPAGE FROM WELLS IN THE MONTANA WELL FIELD FROM 1936 to 1943, IN MILLION GALLONS PER DAY.

Year	M.G.D.	Year	M.G.D.
1936	3.2	1940	2.3
1937	3.4	1941	1.3
1938	2.7	1942	0.8
1939	1.9	1943	1.2

ESTIMATED AVERAGE DAILY PUMPAGE FROM WELLS ON THE MESA NORTHEAST OF EL PASO FROM 1936 TO 1943, IN MILLION GALLONS PER DAY.

Year	M.G.D.	Year	M.G.D.
1936	7.5	1940	6.8
1937	5.1	1941	8.2
1938	4.9	1942	11.8
1939	6.5	1943	11.5

In 1943 the total pumpage from all deep wells in the El Paso area for which records were obtained amounted to 9,332,882,000 gallons, or a daily average of 25,569,500 gallons. The greatest pumpage in 1943 occured in August, when the daily average was 32,813,000 gallons, and the smallest pumpage occurred in December, when the daily average was only 16,490,000 gallons. These totals are based on records of pumpage from the El Paso City wells, the city wells of Juarez, the wells at Fort Bliss, and the wells at the establishments listed in the following table.

PRIVATE PLANTS THAT FURNISHED RECORDS OF PUMPAGE OF WATER FROM WELLS IN 1943

Acme Laundry
Elite Laundry
El Paso Electric Co. Wells 1 & 2 & 3
El Paso Foundry
El Paso Ice Company
El Paso Laundry
Fabens
Midwest Dairy
McElroy
Mitchell Brewing Co.
Peyton Packing Company
Phelps-Dodge Wells 1 & 2
Sambrano Water Works
S. P. Railway
Standard Oil Company
Texas Company
T. & N. O. Railroad Wells 2 & 5
T. & P. Railroad
Western Gas Company
Ysleta C. C.

The average daily pumpage for the El Paso public supply and for all other listed supplies is given in the following table for each month in 1943

AVERAGE DAILY PUMPAGE FROM DEEP WELLS IN THE EL PASO AREA DURING EACH MONTH IN 1943, IN GALLONS

	El Paso Public Supply	Other supplies (including Juarez public supply)	Total
January	8,230,000	10,589,000	18,819,000
February	10,722,000	13,385,000	24,107,000
March	11,354,000	12,215,000	23,569,000
April	14,445,000	12,638,000	27,083,000
May	16,109,000	14,530,000	30,639,000
June	18,079,000	13,858,000	31,937,000
July	16,117,000	03,473,000	29,590,000
August	18,243,000	14,570,000	32,813,000
September	14,083,000	13,634,000	27.717,000
October	10,488,000	12,550,000	23,038,000
November	8,694,000	12,030,000	10,724,000
December	6,135,000	10,355,000	16,490,000

Water levels in wells.

Monthly measurements of the water levels in selected wells have been made since December 1935. Owing to variations in the seasonal pumpage it was found that measurements made during January of each year were the most reliable for purposes of showing annual change of the water levels. Maps have been prepared, therefore, for January of each year from 1936 to 1943 showing by contours the altitude at which water stood in the wells. (See Plates 7 to 8). Maps have also been prepared showing the decline or rise of the water levels from 1936 to 1939 and from 1936 to 1943 (See Plates 9 and 10).

The 1936-1939 map (Plate 9) shows that in this three-year period the water level rose about 4 feet near the center of pumpage in the Mesa well field of the city, fell about 4 feet in the Fort Bliss well field, rose about 8 feet in the Montana well field and fell about 10 feet near the center of pumpage in the downtown area. These fluctuations were due chiefly to increase in pumpage in some areas and decrease in others.

The pumpage from the Mesa well field of the city was about 2,500,000 gallons a day less in 1937 and 1938 than in 1936, but the pumpage from wells at Fort Bliss remained about the same. The pumpage from the Montana well field was about 700,000 gallons a day less in 1938 than during previous two years, and this decrease was reflected in a rise in the water levels. The decline in the water levels in the downtown area from 1936 to 1939 was caused by an increase in the pumpage in that area.

Plate 10 shows that from 1936 to 1943 the water levels fell about 20 feet in the Mesa well field of the city and also in the vicinity of the pumped wells at Fort Bliss, rose about 10 feet in the Montana well field, and fell as much as 15 feet in the downtown area. The total pumpage from the wells on the Mesa increased from about 7,500,000 gallons a day in 1936 to about 11,800,000 gallons a day in 1942, and consequently there was a pronounced decline in the water level. The pumpage from the Montana well field decreased from an average of about 3,200,000 gallons a day in 1936 to only about 800,000 gallons a day in 1942, and consequently the water levels rose. Part of the load was shifted from the Montana field to the downtown area,

and with the addition of the normal increase in the demand for water, the pumpage, in the downtown area increased by about 4 million gallons a day from 1936 to 1943. The increase in pumpage resulted in a considerable lowering of the water level.

The records of the water levels in the El Paso area have been published currently in the following U. S. Geological Survey Water Supply Papers:

WATER SUPPLY PAPERS THAT CONTAIN RECORDS OF WATER LEVELS IN WELLS IN THE EL PASO AREA

Year	Water Supply Paper	Number of wells reported.
1934	817	3
1935	817	37
1936	817	37
1937	840	35
1938	845	47
1939	886	42
1940	909	50
1941	939	48
1942	947 (in press)	48
1943	989 (in preparation)	48

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(1) Tables showing water level measurements (first in 1943; first in 1944; and in June of 1944)

(2) and the rise or decline (between the first measurements in 1943 and the first in 1944; between the first measurement in 1944 and those in June 1944; and between the first measurements in 1943 and those of June 1944

(3) the average rise or decline of the three columns of measurements in (2)

Quality of Water

Water samples have been obtained from a large number of wells in the El Paso area, and analyses of these samples have been made generally either by the U. S. Geological Survey or the city of El Paso. These samples have been obtained from pumped wells, usually twice a year--one sample near the end of the season of slack pumping in the spring and one during the season of heavy pumping. A tabulation of the available water analyses to date accompanies this report.

In areas where wells penetrate beds containing highly mineralized water before reaching the fresh water beds there is always danger that holes may corrode in the casing and allow the salty water to flow into the well. If a well that has a hole in the casing is allowed to stand idle the salty water flows into the well during that time. When the well is pumped following a rest the water during the first few minutes may be highly mineralized. Information regarding a defective well may be obtained by testing the mineral content of water samples caught at frequent intervals immediately after the pump has been started. For purposes of detecting a rise in the mineral content in the fresh water-bearing beds it is necessary that the samples be collected after the initial rise in the salt water content has passed. For this reason all the water samples for which analyses are shown in the table were obtained after the wells had been pumped continuously for several hours.

A few interesting facts are shown by this table of analyses. With a few exceptions the quality of the water obtained from wells on the Mesa has not changed much from 1935 to 1944. The increase of the salt content of the water from wells at the edge of the Mesa owned by the T. & N. O. Railway is undoubtedly due to highly mineralized water that enters the wells at or near the water table. This highly mineralized water is moving from the vici ity of the Rio Grande northward toward the Mesa and at the present time has contaminated the upper water-bearing beds to such an extent that the water from the wells at the edge of the Mesa.is no longer fit to use for boilers without treatment. Probably wells at the edge of the Mesa would still yield water of good quality if the upper water-bearing beds that contain the high mineralized water were cased off. It is interesting to note that the analyses of water from well 77 B (City well 15 at Wilson and Airport Roads in the Mesa field) show a decrease in the total solids from about 600 parts per million in 1938 to about 440 parts in 1944.

Well 25, owned by the El Paso Ice and Refrigeration Company, yielded water that increased gradually in total solids from about 800 p. p. m. in 1936 to more than 1,100 parts in 1944. A gradual increase such as this is more likely to indicate contamination of the main water-bearing beds than contamination through a hole in the casing. Wells 50, 51, 52 and 49 (City wells 1, 2, 3, and 4 in the Montana well field), show only a moderate increase in mineral content since 1935. The pumpage from the Montana well field has been reduced greatly during recent years and this probably has been the main reason why the mineral content has not increased more.

Wells 1 and 3 owned by the City of Juarez have yielded water that has been increasing steadily in mineral content since 1935 but the total increase has not been alarming.

Quantity of Water

The ground water in the El Paso area occurs in the unconsolidated sediments underlying the Rio Grande Valley and the Mesa. The deposits consist of alternating layers of clay and sand or gravel that range in thickness from very thin beds to about a hundred feet and in lateral extent probably from only a few feet to several miles. Several of the beds encountered in the Montana well field seem to be traceable for about half a mile, that is, entirely across the field. Not only do the individual beds thicken and thin and pinch out from place to place, but the whole section may change within a short distance and the percentage of sand and gravel may vary within wide limits.

It would appear from the above description of the sediments that the water found in the beds would everywhere be under water-table conditions and that the recharge to the beds would be by direct penetration from the land surface. However, in the Rio Grande Valley there is a water table which is essentially independent of the drawdown of the water levels in the deep wells. In the Valley the shallow water is highly mineralized as compared to the water in the deeper beds. During the investigation in 1935-36 holes were bored to the shallow water near some of the large city wells. The water levels in the shallow wells were observed carefully when the pumps in the deep wells were started or stopped, and in all cases it showed that the shallow

water levels remained unaffected by the pumpage from the deep wells. In the vicinity of the Mesa well field of the City the first water encountered is of good quality and wells drilled in that area draw water from all water-bearing beds that are penetrated.

Data are not available to show the exact dividing line between the artesian conditions in the valley and the water-table conditions underlying the Mesa, but for purposes of estimating the volume of unwatered material a line was drawn approximately between the Valley and the Mesa. Assuming water-table conditions throughout the Mesa, it was computed that during the three-year period from January 1936 to January 1939 about 23,000 acre-feet of material was unwatered. On the basis of available data it is believed that the specific yield of the unwatered material underlying the Mesa is between 15 and 20 percent, and accordingly a specific yield of 17 ½ percent was adopted by Dr. Sayre for use in the unwatering computations. If the specific yield is taken to be 17½ percent, a total of about 1,340 million gallons of water was removed from storage during the three year period--an average of about 1.2 million gallons a day. In contrast, during the three year period the pumpage from the Mesa was about 6,395 million gallons, or about 5.8 million gallons a day, and the total pumpage in the El Paso area was about 17,743 million gallons or a out 16.2 million gallons a day.

Likewise it was computed that during the seven-year period from January 1936 to January 1943 about 206,000 acre-feet of material was watered and about 11,765 million gallons of water was removed from storage -- an average of about 4.6 million gallons a day. In contrast, during the seven-year period the pumpage from the Mesa was a-

bout 16,556 million gallons, or about 7.3 million gallons a day, and the total pumping in the El Paso area was about 45,797 million gallons or about 17.9 gallons a day.

ESTIMATED PUMPAGE AND COMPUTED REMOVAL FROM STORAGE OF GROUND WATER IN THE EL PASO AREA, IN AVERAGES OF MILLION GALLONS A DAY.

	January 1936 to January 1939	January 1936 to January 1943
Total pumpage in El Paso area	16.2	17.9
Pumpage from the Mesa	5.8	7.3
Removal from storage (Mesa)	1.2	4.6

It is believed that the pumped water which was not obtained from the computed unwatering, was derived largely by recharge from mountain runoff. However, in part it may have been derived in less obvious ways from storage-by unwatering on the Mexican side of the Rio Grande Valley; by replacement of fresh ground-water with overlying mineralized water in the Valley, which in turn was replaced by water from the Rio Grande; and possibly by rise of underlying salt water, which might in turn have been replaced by inward percolation from more distant sources.