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GROUND WATER IN HIGH PLAINS IN TEXAS

Progress report No. 6

By

W. L. Broadhurst

Prepared in cooperation with the Geological Survey,
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CONTENTS

TABLES

ILLUSTRATIONS

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INTRODUCTION

The source of the ground water in the High Plains in Texas and the amount of the available perennial supply have been subjects of speculation and controversy for the layman since the region was first settled. However, at times since about 1900 the geology and water resources in the region have been studied, and the earlier works were published in reports by Johnson 1/ and Gould 2/ 3/. In 1909, O. E. Meinzer 4/, chief of the Ground Water Division in the U. S. Geological Survey, made a brief study of ground water in the High Plains in the Portales Valley, New Mexico, near the Texas border. In 1914 a study of the geology and hydrology in the Llano Estacado, or Southern High Plains, was made by C. L. Baker 5/; and his report contains two chapters on ground water, tables of water-well logs and analyses, and information on the depths to water in a considerable number of wells, partly determined by measurements.

Since 1936 a part of the State-wide program of ground-water investigations in Texas, which is carried out by the State Board of Water Engineers in cooperation with the Geological Survey, United States Department of the Interior, has been devoted to the High Plains. These investigations have been made possible through appropriations by the State Legislature and allocations of Federal funds to match them on an equal or nearly equal basis, and the work is being done under the direct supervision and with the assistance of W. N. White, district engineer of the Geological Survey in charge of ground-water work in Texas.

The recent investigations in the High Plains have included studies of the geology with special reference to the thickness and character of the water-bearing sands, the source of the ground water, and the recharge and natural discharge of the underground reservoirs. The work has been devoted mostly, however, to obtaining and compiling data regarding the location and development of new irrigation wells, the quantities of water pumped in different parts of the region, the decline or rise of water levels in wells from year to year as related to pumpage and directly or indirectly to the precipitation, and the decline in pumping levels during the irrigation seasons.

1/ Johnson, W. D., The High Plains and their utilization: U. S. Geol. Survey 21st Ann. Rept. pt. 4, Hydrography, pp. 609-741, 1901; 22nd Ann. Rept., pt. 4 Hydrography, pp. 637-669, 1902.

2/ Gould, C. N., The geology and water resources of the eastern portion of the Panhandle of Texas: U. S. Geol. Survey Water-Supply Paper 154, 1906.

3/ Gould, C. N., The geology and water resources of the western portion of the Panhandle of Texas: U. S. Geol. Survey Water-Supply Paper 191, 1907.

4/ Meinzer, O. E., Ground-water resources of Portales Valley, N. Mexico. (manuscript report in files of U. S. Geol. Survey, Washington, D. C.).

5/ Baker, C. L., Geology and underground waters of the Northern Llano Estacado: Univ. Texas Bull. 57, 1915.

This is the sixth mimeographed progress report to be released by the Texas State Board of Water Engineers giving the results of the investigations; the dates of the previous reports are July 1938, December 1940, April 1943, May 1944, and May 1945. A short statement, which summarized the development of irrigation wells in 1945 and the fluctuations of water levels in wells by counties, was released to the press by the State Board of Water Engineers on September 15, 1946.

Between 1936 and 1946 inventories of water wells were made in the following 33 counties in the High Plains: Andrews, Armstrong, Bailey, Briscoe, Carson, Castro, Crosby, Dallam, Dawson, Deaf Smith, Donley, Ector, Floyd, Gaines, Glasscock, Hale, Hansford, Hartley, Hockley, Howard, Lamb, Lubbock, Martin, Midland, Ochiltree, Oldham, Parmer, Potter, Randall, Roberts, Swisher, Terry, and Yoakum. Supplemental inventories of irrigation wells were made during 1945-46 in Deaf Smith, Floyd, Hale, Lubbock, and Swisher Counties. Mimeographed bulletins giving tables of well records, well logs, and water analyses, together with maps showing locations of the wells listed, have been issued for all of those counties.

The progress report for 1940 has been published by the United States Department of the Interior as Geological Survey Water-Supply Paper 889-F. The records of water-level measurements in several hundred observation wells throughout the region, to January 1944, have been published annually in Geological Survey Water-Supply Papers 840, 845, 886, 909, 939, 947, and 989.

PRECIPITATION

Ground water is used for irrigation in the High Plains in Texas chiefly when the precipitation is insufficient for normal plant growth. However, the distribution of the rainfall is irregular and complicates the problems of both the dry-land farmers and the operators of irrigation wells. Although the average annual precipitation in the principal irrigation districts in the High Plains is about 20 inches, the departure from the average in individual years and at different weather stations is very great. On the average, about two-thirds of the moisture falls during the 6 months from April to September, inclusive, comprising the principal growing season.

According to the records of the United States Weather Bureau, the average annual precipitation was 19.34 inches at Lubbock during a period of 33 years, 21.56 inches at Plainview during 51 years, 21.99 inches at Tulia during 39 years, and 18.94 inches at Muleshoe during 23 years. The table on the following page gives the monthly and yearly precipitation at the four stations from 1937 to 1945 and the departure (+ or -) each year from the long-term average.

Monthly and annual precipitation, in inches, and departure (+ or –) from the long-term average at Lubbock, Plainview, Tulia, and Muleshoe, Texas

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total for year	Departure from long-term average
								Lubbock						
1937	0.26	0.01	1.81	2.01	4.00	3.12	1.32	2.06	3.85	3.22	0.07	0.52	22.25	+ 2.98
1938	0.91	1.18	0.49	0.14	1.99	5.89	4.01	0.47	0.63	0.51	0.27	0.03	16.52	– 2.75
1939	2.45	0.19	0.09	0.28	1.82	0.67	1.73	2.75	0.01	0.94	0.18	0.60	11.71	– 7.56
1940	0.23	1.97	T	1.34	1.74	2.06	T	1.57	0.73	1.07	2.35	0.20	13.76	– 5.51
1941	0.55	0.61	3.56	2.23	12.69	4.13	3.68	1.85	4.47	5.89	0.17	0.72	40.55	+21.28
1942	0.04	0.18	0.51	3.25	0.35	1.74	2.58	4.97	7.61	3.39	0.01	2.80	27.43	+ 8.16
1943	0.04	0.02	0.25	0.53	2.71	2.37	3.17	T	1.16	0.10	0.62	1.87	12.84	– 6.43
1944	1.28	1.36	1.09	0.84	3.03	1.75	2.93	2.37	3.73	0.80	1.72	1.64	22.54	+ 3.27
1945	0.69	0.39	0.10	0.46	0.46	0.36	3.08	2.17	2.22	2.26	0.27	0.32	12.78	– 6.49
								Plainview						
1937	0.27	0.09	1.25	0.61	5.16	4.64	1.89	2.45	3.34	1.77	0.05	0.48	22.00	+ 0.44
1938	0.39	1.18	1.33	0.84	1.33	6.42	4.10	1.15	1.11	0.87	0.10	0.07	18.89	– 2.67
1939	1.92	0.14	0.80	0.82	1.89	3.22	0.65	2.75	0.02	0.85	0.08	1.02	14.16	– 7.40
1940	0.32	1.91	0.00	1.68	2.57	0.57	1.40	1.51	0.82	1.45	3.09	0.11	15.43	– 6.13
1941	0.27	1.00	2.30	1.33	7.07	6.03	4.35	2.28	3.65	5.34	0.14	0.58	34.35	+12.79
1942	0.10	0.41	0.60	4.15	0.23	2.01	2.13	4.04	3.29	4.03	0.02	2.71	23.72	+ 2.16
1943	0.05	T	T	1.54	3.66	0.28	6.67	0.03	2.38	0.16	0.80	2.32	17.89	– 3.67
1944	2.22	0.99	0.20	0.76	2.49	4.88	2.14	1.22	3.34	0.65	0.97	1.87	21.73	+ 0.17
1945	0.66	0.54	0.16	1.68	0.71	0.65	2.06	2.74	1.20	1.94	T	0.34	12.68	– 8.88
								Tulia						
1937	0.22	0.26	1.31	0.65	5.64	1.94	1.40	0.77	2.82	0.38	0.04	0.14	15.57	– 6.40
1938	0.37	1.83	1.45	0.30	1.82	2.61	2.57	0.44	1.77	1.30	T	0.11	14.57	– 7.40
1939	1.87	0.10	1.11	1.07	0.87	4.97	0.98	1.92	0.30	1.28	0.04	1.05	15.56	– 6.41
1940	0.26	1.60	0.03	2.55	2.42	1.49	0.25	1.85	0.40	0.69	2.83	0.23	14.60	– 7.37
1941	0.18	0.82	2.03	1.47	3.02	5.59	3.36	2.05	3.39	6.22	0.38	0.50	34.01	+12.04
1942	0.10	0.35	1.10	3.67	0.36	3.82	1.54	4.11	3.54	5.97	0.00	2.88	27.44	+ 5.47
1943	0.09	0.03	0.02	1.57	3.57	3.49	4.91	0.35	——	0.62	1.33	2.67	18.50	– 3.47
1944	1.88	0.80	T	1.48	2.87	3.82	3.16	0.39	3.42	1.23	0.97	2.79	22.81	+ 0.84
1945	0.57	0.52	0.62	2.32	0.21	0.69	2.91	3.70	2.50	1.36	0.00	0.01	15.41	– 6.56
								Muleshoe						
1937	0.08	0.18	1.66	0.95	5.66	2.56	1.24	0.60	4.71	1.28	0.00	0.56	19.48	+ 0.61
1938	0.64	1.24	1.45	0.73	1.63	7.74	1.78	0.54	1.39	2.93	0.34	0.08	20.49	+ 1.62
1939	1.96	0.06	0.40	0.57	2.06	1.82	0.94	3.42	0.05	1.28	0.18	1.34	14.08	– 4.79
1940	0.27	0.65	0.00	1.53	2.63	1.89	0.33	3.97	0.37	0.22	2.04	0.07	13.97	– 4.90
1941	0.24	0.38	3.14	1.99	11.86	5.77	6.92	2.09	3.46	6.37	0.47	0.38	43.52	+24.65
1942	0.02	0.00	1.15	2.96	0.60	2.21	0.98	4.50	2.29	4.94	0.00	1.45	21.10	+ 2.23
1943	0.00	0.50	0.00	0.28	1.67	1.74	3.13	0.21	1.12	1.06	1.10	3.45	14.26	– 4.61
1944	0.57	0.78	0.01	1.14	2.07	4.00	2.21	3.44	4.77	0.12	0.47	0.93	20.51	+ 1.64
1945	0.57	0.13	0.17	0.35	0.64	0.00	1.68	2.50	3.79	1.17	0.00	0.21	11.21	– 7.66

SOURCE, RECHARGE, AND NATURAL DISCHARGE OF GROUND WATER

The following statements regarding the source, recharge, and natural discharge of ground water in the High Plains are taken from Water-Supply Paper 889-F.

Source of the ground water

"Most of the usable ground water in the High Plains is found in the Ogallala formation, a sandy deposit, in many places 200 to 300 feet thick, lying at or near the surface throughout almost the entire region. The formation is composed of silt and fine sand, with some coarse sand and gravel. The coarser sediments, which usually yield water freely to wells, are present at all horizons but are most prominent in the lower part of the formation. They were deposited by streams, some of which had their headwaters in the Rocky Mountains, and by wind. The Ogallala rests on an uneven floor of older rocks, which was eroded into valleys and ridges before the Ogallala was deposited. Nearly everywhere in the High Plains the water in these underlying rocks is highly mineralized and unfit for most uses.

"The beds of the Ogallala formation once extended from the mountains of New Mexico eastward far into Texas, but they have been removed by erosion from much of the territory they once occupied. The areas in which this formation is still present stand up almost like islands, being bounded by the escarpments of the High Plains, both on the east and on the west, and being separated in Texas by the Canadian River which is deeply entrenched in the older rocks. The Ogallala formation has been completely eroded away west of the western escarpment and east of the eastern one and from the canyonlike valley of the Canadian River. The water-bearing sands and gravels of the Ogallala in both of these segments, therefore, are cut off in all directions from any underground connection except through the underlying older rocks, which contain highly mineralized water entirely unlike the fresh water in the Ogallala.

"In parts of the High Plains, wells in the Ogallala yield large quantities of water and in some localities many such wells have been used for years. It is not surprising therefore that a popular theory has developed to the effect that the wells are tapping an inexhaustible supply of water in an underground river which flows beneath the High Plains and has its source in the Rocky Mountains far to the west. As a matter of fact the high yield of the wells is explained by the relatively high permeability of the sands and gravels from which they draw water. The water is contained in interstices between the particles of gravel and grains of sand. Although it is moving, generally in a southeasterly direction, the movement is very slow, perhaps at an average rate of 200 to 300 feet a year and therefore is scarcely comparable to that of a river. Inasmuch as the water-bearing beds are cut off in all directions from outside sources of water except through underlying rocks containing poor water, it follows that the source of the fresh water must be entirely within the High Plains area and must be the rain and snow that fall on its surface.

"Most of the precipitation is dissipated through evaporation or through transpiration by grasses, shrubs, and cultivated crops, but some runs off and a small part moves downward to the underground reservoirs by direct penetration or by seepage from streams and depression ponds."

Recharge of ground water

"Most of the surface of the High Plains is underlain by sediments that are cemented with calcium carbonate and usually called caliche. These deposits probably prevent deep penetration of surface water over most of the High Plains. In places, however, the caliche is thin or has been partly removed by solution, and in such areas the water may move downward to the water table. The principal areas of ground-water recharge apparently are depressions occupied by intermittent ponds, sandy stream beds and adjacent sandy flood plains, and sand-dune areas."

Recharge from depression ponds.- "Depressions, or sinks, ranging from a few feet to 50 feet or more in depth and from a few hundred feet to a mile or more in diameter, are of common occurrence in the Texas High Plains. In some areas these depressions average as much as one to each square mile. During heavy rains, ponds that range in area from a few acres to 100 acres or more are formed in the depressions. Some of the ponds disappear in a short time, others remain for months. Several hundred test holes have been drilled in the beds of depression ponds on the High Plains in connection with the present investigation. These holes were drilled to an average depth of about 30 feet and spaced 100 to 300 feet apart in lines across the depressions. A few were drilled to a depth of about 100 feet. In some of the depressions relatively little caliche was encountered, in others caliche was found all the way across but was relatively soft, and in still others the caliche was so hard it could not be penetrated by the hand drill and was designated by the drillers as rock. In areas where the caliche was absent the sediments penetrated in many of the holes were relatively permeable from the surface to the bottom of the hole. Graphic cross sections illustrating the character of material encountered in some of the test holes are shown in several of the county well inventories.

"The bottom of most of the depressions is covered with deposits of silt and soil, in places resembling gumbo and ranging from 2 to 10 feet in thickness. After the ponds become dry, fractures and crevices several feet in depth frequently develop in their beds. In some of the depressions small sinks, apparently developed by solution channeling in the underlying caliche deposits, are present. These crevices and solution channels may provide a pathway for the downward movement of water for a time after the ponds are filled, although they may become sealed after water has stood over them for several days. The bottom area of most of the depressions is usually surrounded by a sandy belt which absorbs water readily. Gages were placed in several of the ponds during the summers of 1937 and 1938, and the rate of decline of the water levels was observed at regular intervals for several months. In some of the ponds the rate of decline was small and apparently was due mostly to losses from evaporation. In others it was at first quite rapid, amounting in some cases to 2 inches or more a day for 10 days or so after the rains and then gradually slowed down. ***"

Recharge from streams.- "The streams that head in the High Plains are intermittent or ephemeral. After exceptionally heavy rains these streams carry large quantities of water, but generally only a comparatively small part of the water reaches the eastern escarpment or rim of the High Plains. For example, after heavy rains in May 1937, the discharge of Running Water Draw at Plainview reached a peak of about 1,200 second-feet but the maximum flow 15 miles below Plainview was only about 80 second-feet. Apparnetly nearly all the water was absorbed by the soil, and a part percolated downward to the water table. Again, rains of almost cloudburst intensity fell in western Bailey County near the head of Blackwater Draw in June 1938, but no water flowed in the draw in Lamb County, 30 miles to the east. ***"

Recharge in sand-hill areas. - "Sand dunes of wide extent occur in parts of the High Plains. They produce a rolling topography of low hills and ridges with intervening valleys of varying widths. Nearly all the rain that falls on the dune-covered areas is absorbed by the sand and on that account no lines of drainage, or only meager ones, have been developed. These conditions are favorable for ground-water recharge, and the sand-dune areas generally are believed to be among the best collecting areas for ground water in the Texas High Plains. Considerable evidence of this already has been obtained, and the subject is still under study. Among the largest of the sand-dune areas is one that extends eastward from Roosevlet County, N. Mex., across Bailey and Lamb Counties and a part of Hale County, Tex. Sand-dune areas of varying extent also cover parts of Yoakum, Terry, Lynn, Dallam, Hartley, Oldham, and other counties of the region."

Natural discharge of ground water

"Before pumping was started the ground-water reservoirs of the High Plains were in a state of approximate equilibrium. The average annual recharge was balanced by an approximately equal average annual discharge. The greater part of the natural discharge occurred through springs and seeps along the eastern escarpment of the High Plains and along the bluffs on either side of the Canadian River. A part of the water was discharged by evaporation and the transpiration of trees, grasses, and shrubs in shallow water-table areas on the High Plains, and a small amount was lost by evaporation from water-table lakes."

Discharge from escarpment springs and seeps. - "Most of the springs along the escarpment, or rimrock, appear at or near the contact between the water-bearing sands and gravels and the underlying older clays and shales. They generally occur in the ravines and canyons, and in places give rise to streams of considerable size. In some places where the sands and gravels rest directly on older sandstone or conglomerate, the water issues from joints, fractures, or solution channels in those rocks. The greater part of the springs occur within 1 to 3 miles of the top of the escarpment but a few, most of them small, appear along the streams at greater distances. An outstanding exception is Roaring Springs, in Motley County, which issues from conglomerate about 9 miles to the east of the escarpment and has a comparatively large discharge.

"In 1938-39, studies of ground-water discharge were made along a 75-mile stretch of the escarpment extending southward from Quitaque Creek to Double Mountain Fork of the Brazos River across parts of Briscoe, Floyd, Motley, Dickens, and Crosby Counties. This survey occupied the time of two or three men for several weeks. All known springs and seeps were visited and the more important ones were mapped.***The discharge of the springs and seeps was estimated, and the losses of ground water by evaporation and transpiration, not taken into account in the measurements, were estimated. From these data the total discharge of ground water along the 75-mile stretch of the escarpment was estimated as about 12,000 gallons a minute, or around 17 million gallons a day. This is the equivalent of about 53 acre-feet a day or about 19,000 acre-feet a year."

Discharge in shallow water-table areas on the High Plains. - "In connection with the investigation along the escarpment a study was made of ground-water discharge in a part of the High Plains comprising about 9,000 square miles and extending approximately 120 miles to the northwest from the 75-mile stretch of the escarpment described in the preceding section. This is in the up-slope direction of the water table. The greater number of irrigation wells in the High Plains are in this area.

"Some natural discharge occurs here by evaporation from ponds in deep depressions. These ponds are fed in part by surface water and in part by ground water and on this account the amount of ground water discharge from them cannot be accurately computed. The total discharge, however, is believed to be relatively small. Most of the ground-water discharge in the territory occurs in shallow water-table areas along the Double Mountain Fork of the Brazos River, Running Water Draw, and Tierra Balnca Creek. In the western and middle parts of the High Plains these streams carry storm water only. Farther east near the escarpment where they have cut deep canyonlike valleys, in places to a level below the water table, they have small perennial flows of spring water. This water was taken into account in the computations of spring discharge along the escarpment. In numerous places along these streams ground water in considerable quantities is consumed by the growth of marsh grasses and sedges, sub-irrigated alfalfa, salt grass, and various meadow grasses, and by trees of which cottonwood and willow are the most common.

"During the summers of 1937, 1938, and 1939 the lands covered by the different kinds of grasses and sub-irrigated alfalfa that use ground water were roughly mapped, and estimates were made of the amount they consume annually, in acre-feet to the acre. Marsh grasses and sedges probably use most water to the acre. Sub-irrigated alfalfa probably comes next, but in most places it has a rather light growth and apparently is using considerably less water than irrigated alfalfa in the adjacent territory. The salt grass and meadow grasses have a rather dense growth in places, but on the average the stand is light and consumption of ground water probably small. Considerable loss occurs from evaporation in fields of marsh grasses and sedges, but in other areas the loss is small.***"

Total natural discharge from the area.- "From the measurements and estimates described above, the total natural discharge of ground water from the area has been estimated to be at the rate of 25,000 to 30,000 acre-feet a year, representing only a small fraction of an inch over 9,000 square miles of the area."

DEVELOPMENT OF IRRIGATION FROM WELLS SINCE 1934

Irrigation from wells in the High Plains in Texas was started near Plainview in 1911. By 1914 about 140 irrigation wells had been completed in three districts -- Plainview, Hereford, and Muleshoe. The development as a whole was only moderately successful, and during the next 20 years, from 1914 to 1934, only about 160 additional pumping plants were installed, many of the older ones being unused during that period. A part of the lack of success was due to the high cost and relatively low efficiency of the low-speed pumps and oil-burning power units then in use. Following the advent of the moderately-priced high-speed turbine pump, powered by a small automobile engine with direct drive, the efficiency of the pumping plants rose sharply.

About 1934 began a period of rapid increase in the number of irrigation well installations. The rate of development, which had increased materially during 1934 and 1935, was accelerated in 1936 and became still more rapid in 1937, when 550 new wells were put into operation. The rate of development declined somewhat in 1938 and 1939, but it was again accelerated in 1940 and the first part of 1941. There was a sharp decline in the number of new wells drilled in the latter part of 1941 and in 1942, because of the small requirements for irrigation resulting from the exceptionally heavy rainfall in 1941 and the above-average and well-distributed rainfall in 1942. Since 1942 the completion of new pumping plants has steadily increased and the development has spread in nearly all directions from the original fields; the old districts have practically merged into one huge irrigated region embracing parts of 16 counties (see fig. 1).

The following tables give the approximate number of wells in operation and acres irrigated from the start of irrigation in 1911, and the number of wells in each county in 1945.

Estimated number of irrigation wells and acres irrigated from wells in the High Plains in Texas, by years

Year	Approximate number of wells in operation	Approximate number of acres irrigated
1910	0	0
1914	139	16,000
1934	296	35,000
1936	600	80,000
1937	1,150	160,000
1938	1,500	200,000
1939	1,700	230,000
1940	2,180	256,000
1941	2,560	---
1942	2,680	---
1943	2,950	400,000
1944	3,500	450,000
1945	4,300	550,000
1946	5,500 a/	650,000 a/

Estimated number of irrigation wells at the end of 1945, by counties

County	Approximate number of wells in operation 1945	County	Approximate number of wells in operation 1945
Bailey	200	Randall	70
Briscoe	30	Swisher	527
Castro	290		
Crosby	90	Armstrong, Dawson, Gaines, Lynn, Martin, Terry	100
Dallam	40		
Deaf Smith	405		
Floyd	418		
Hale	1,005		
Hockley	115		
Lamb	390		
Lubbock	590		
Parmer	30		
		TOTAL	4,300

a/ Preliminary estimate.

FLUCTUATIONS OF WATER LEVELS IN WELLS AND THEIR SIGNIFICANCE

In the areas of pumping most of the water is withdrawn from sands that lie from 100 to 300 feet below the land surface, but the water table is generally less than 80 f et below the surface. When a well is pumped a cone-shaped depression is formed in the water table, which gradually sparead to increasingly greater distances from the well; and when many closely-spaced wells are pumped the cones of depression join and cause a decline of the water table over a wide area. The water that drains out as the water table declines moves downward to replace the pumped water and represents a loss from the volume formerly in storage. If, however, in any given area the ground water is replenished by infiltration from the surface and by lateral movement from outside areas more rapidly than it is withdrawn, water is added to storage and the water table rises. Thus the changes in the water table, shown by fluctuations of the water levels in wells, are a measure of the changes in storage in the ground-water reservoir.

Since 1937 water-level measurements have been made periodically in several hundred observation wells in the High Plains. Some of these wells are used for irrigation, some are used for domestic purposes and stock, and some are unused. Until 1940 most of the measurements were made at intervals of 1 to 3 months. It has been found, however, that the most dependable information regarding net annual losses from storage or additions to storage in the ground-water reservoir in the pumping districts and closely adjacent territory can be obtained by comparing water-level measurements that are made in successive years in the late winter before irrigation on a large scale has been started. Therefore, the measurements at other times during the year have been dropped, but the late winter measurements are made each year and it is planned to continue them indefinitely.

In recent years all the pumping districts south of Herefore have become larger and have merged into one large district (see map, fig. 1), and discussion of water-level fluctuations under the former plan - by districts - is not practical. Therefore, in the more recent reports it has been deemed advisable to treat the subject by smaller units. The paragraphs below contain brief discussions by counties, giving the net changes in water levels based on late winter (February and March) measurements from 1943 to 1946 and from 1938 to 1946.

The tables on pages 22 to 39 and the hydrographs, figures 2 to 9, inclusive, give the results of measurements in 165 representative wells by counties, including measurements made in January 1947 in 145 wells. Most of the measurements were started in 1936 or 1937. A few were started in 1934, or even as far back as 1914.

Bailey County

Decline in water levels from 1943 to 1946.- The records of water-level measurements in 21 selected observation wells in Bailey County show net declines ranging from 2.6 to 8.2 feet and averaging 5.6 feet from February 1943 to February 1946. These wells are distributed fairly evenly over the irrigation district that extends from Blackwater Draw northward to the southern boundary of Parmer County.

Net change in water levels from 1938 to 1946.- Records of the same 21 wells show fluctuations in water levels ranging from a rise of 3.6 feet to a decline of 1.8 feet and an average net rise of 0.7 foot from 1938 to 1946.

Table of water-level measurements.- Records of water-level measurements in 12 representative wells in the irrigation district are given in the table on page 22 .

Illustrations.- Records of water-level measurements from 1934 to 1947 in three representative wells that are not listed in the table are shown graphically in figure 2.

Summary.- The outstanding fact shown by these records is the exceptionally large rise due to recharge during the wet year 1941. This rise has been well-maintained and the water levels are above the average for the 5 years 1936-40, inclusive.

Castro County

Decline in water levels from 1943 to 1946.- In the older irrigation district in the northwestern part of the county, the records of water levels in nine observation wells show declines ranging from 0.6 foot to 8.0 feet and averaging 3.9 feet between February 1943 and February 1946. In the newer irrigation district in the south-central and southeastern parts of the county the water levels in nine observation wells during the same period had an average decline of 1.4 feet.

Net changes in water levels from 1938 to 1946.- Records of water levels in nine observation wells in the older irrigation district in the northwestern part of the county show declines ranging from 1.3 to 5.4 feet and averaging 3.5 feet between 1938 and 1946. There are no comparable records of the fluctuations of water levels during this period in the newer irrigation area in the south-central and southeastern parts of the county.

Table of water-level measurements.- Records of measurements in nine representative wells are given in the table on page 23 .

Illustrations.- The records of water-level measurements from 1936 or 1937 to 1947 in four wells in the irrigation area in the northwestern part of the county that are not listed in the table are shown graphically in figure 3.

Summary.- The measurements in Castro County show a general downward trend in water levels from the beginning of the records until the spring of 1941, a substantial rise during 1941 and 1942, and then a continuation of the decline since the spring of 1943.

Crosby County

Decline in water levels from 1943 to 1946.- Records of water-level measurements in February 1943 and February 1946 are available for only four observation wells in Crosby County, which show an average decline of about 2.0 feet.

Net change in water levels from 1938 to 1946.- Measurements are available for five observation wells in the county from 1938 to 1946. They show an average net rise of 0.3 foot.

Table of water-level measurements.- Records of water-level measurements in three of the wells near the east edge of the irrigation district are given in the table on page 23.

Illustrations.- The records of water-level measurements from 1937 to 1947 in three wells that are not listed in the table are shown graphically in figure 4.

Summary.- According to the few available records the water levels in observation wells near the edge of the irrigated area in Crosby County rose considerably during 1941 and 1942. They have declined somewhat since 1943 but in general are still slightly higher than they were at the start of the measurements in 1937.

Deaf Smith County

Decline in water levels from 1943 to 1946.- Water-level measurements in 34 observation wells distributed fairly evenly over the irrigation district that covers most of the southeast quarter of the county show declines ranging from 1.0 foot to 7.6 feet and averaging 3.1 feet between February 1943 and February 1946.

Net changes in water levels from 1938 to 1946.- Measurements in 34 wells show declines ranging from 0.4 foot to 10.5 feet and averaging 3.8 feet from 1938 to 1946. The maximum decline occurred in the older irrigated area in the vicinity of Hereford, where the records of 10 wells show a net decline ranging from 4.3 feet to 10.5 feet and averaging 7.1 feet.

Table of water-level measurements.- Records of water-level measurements in 19 wells in Deaf Smith County, spaced so as to give representative fluctuations of the water table for most of the irrigated area, are given in the table on page 24.

Illustrations.- The records of water-level measurements from 1936 or 1937 to 1947 in five wells in the irrigation area are shown graphically in figure 5. These wells are located as follows, with reference to Hereford: Well 220, 12 miles northeast; well 245, 5 miles northeast; well 283, 3 miles west; well 315, 3 miles east; and well 322, 3 miles south.

Summary.- In Deaf Smith County, from the beginning of the records until the spring of 1941, there was a regional net decline in water levels each year. During 1941-42, two years of above-average rainfall and light pumping, the water levels recovered somewhat. In 1943, with the return of heavy pumping, the downward trend was resumed. Outside the most heavily-pumped districts the net decline since 1936-37 has been comparatively small.

Floyd County

Decline in water levels from 1943 to 1946.- The records of water levels in 34 observation wells show declines ranging from 1.0 foot to 11.1 feet and averaging 6.3 feet from February 1943 to February 1946. The wells are distributed fairly evenly over the irrigation district that covers the western one-third of the county. The maximum decline occurred in the older irrigated area between Aiken and Lockney, where the records of five wells show declines of 10 feet or more during the 3-year period.

Net change in water levels from 1938 to 1946.- Records of measurements in the same 34 wells show declines ranging from about 1.0 foot to 16.2 feet and averaging 7.5 feet from the spring of 1938 to February 1946.

Table of water-level measurements.- Records of measurements in 18 wells, spaced to give representative fluctuation of the water table for the greater part of the irrigated area in Floyd County, are given in the table on page 25.

Illustrations.- The records of water-level measurements from 1934-36 to 1947 in four wells in the irrigated area are shown graphically in figure 6. The wells are located as follows, with reference to Lockney: Well 5, 11 miles northwest; well 120, 5 miles northwest; well 421, $3\frac{1}{2}$ miles west; well 519, 8 miles south.

Summary.- In Floyd County, from the beginning of the measurements until the spring of 1941, a net decline was recorded each year. During 1941-42, two years of above-average rainfall and light pumping, the water levels recovered somewhat. In 1943, with the return of heavy pumping, the downward trend was resumed at an accelerated rate and is still in effect.

Hale County

Decline in water levels from 1943 to 1946.- The records of water levels in 49 observation wells show declines ranging from 0.2 foot to 9.1 feet and averaging 4.6 feet from February 1943 to February 1946. The wells are distributed fairly evenly over the irrigated parts of the county. The maximum decline occurred in the older irrigated area in the northeastern part of the county, where the records of eight wells show declines of more than 7 feet between February 1943 and February 1946.

Net changes in water levels from 1938 to 1946.- Measurements of the water levels in 49 observation wells in the principal irrigated areas show declines ranging from a fraction of a foot to 11.4 feet and averaging 5.3 feet between the spring of 1938 and February 1946. However, during the same interval the records of five wells in the southwestern and south-central parts of the county, where the pumpage is light, show rises ranging from 0.3 foot to 2.0 feet and averaging 1.4 feet.

Table of water-level measurements.- Records of measurements in 22 wells, spaced to give representative fluctuation of the water table for most of the irrigated district, are given in the table on page 26.

Illustrations.- The records of water-level measurements from 1934-36 to 1947 in five wells in the irrigated areas are shown graphically in figure 7. The wells are located as follows, with reference to Plainview: Well 123, 10 miles west; well 246, 1 mile north; well 317, 6 miles northeast; well 357, $3\frac{1}{2}$ miles east; well 946, 16 miles southeast.

Summary.- From the beginning of the records until the spring of 1941 there was a gradual but persistent decline of water levels in the principal irrigated areas of Hale County. During 1941-42, two years of above-average rainfall and light pumping, the water levels recovered somewhat. In 1943, with the return of heavy pumping, the downward trend in most of the wells was resumed and is still in effect.

Hockley County

Decline in water levels from 1943 to 1946.- The records of water levels in four observation wells in the older irrigated area in the northeastern part of Hockley County near Anton show declines ranging from 3.3 feet to 6.5 feet and averaging 5.4 feet from the spring of 1943 to February 1946.

Net change in water levels from 1938 to 1946.- In the older irrigation area in the vicinity of Anton the records of three observation wells show a rise and two show a decline, the average being a rise of about 2 feet.

Table of water-level measurement.- Records of measurements in eight representative wells are given in the table on page 27 .

Illustrations.- The records of water-level measurements from 1937 to 1947 in one representative well (No. 28) in the irrigated area in the northeastern part of the county are shown graphically in figure 4.

Summary.- The water levels in Hockley County were, in general, higher in February 1946 than they were at the start of the measurements in 1937-39, according to the few available records.

Lamb County

Net change in water levels from 1943 to 1946.- The records of water levels in seven observation wells in the northwestern part of the county, north of the sand hills, show declines ranging from 1.1 feet to 6.4 feet and averaging 4.6 feet from February 1943 to February 1946. Records of 11 wells in the north-central and northeastern parts of the county, for the same period, shows declines ranging from 0.3 foot to 3.1 feet and averaging 1.6 feet. One well, No. 76, shows a rise of 1.5 feet. South of the sand hills, in the central and southeastern parts of the county, records of three wells show declines averaging 2.6 feet and one well shows a rise of 2.0 feet.

Net changes in water levels from 1938 to 1946.- In the northwestern part of the county the records of water levels in six observation wells show rises ranging from 0.2 foot to 2.6 feet and averaging 1.3 feet from 1938 to 1946. During the same period the records of two wells in the northeastern part of the county show declines of 0.5 foot and 1.0 foot whereas another well No. 76, shows a rise of 6.6 feet. In the southeastern part of the county, three wells show an average rise of 3.3 feet and another shows a decline of 0.9 foot.

Table of water-level measurements.- Records of measurements in seven wells are given in the table on page 28 .

Summary.- The water levels in Lamb County, according to the available records, rose considerably in 1941 and 1942, and they were substantially higher in February 1946 than they were at the start of the measurements in 1936-37.

Lubbock County

Net change in water levels from 1943 to 1946.- The records of water-level measurements in 26 observation wells distributed over an area of about 700 square miles, including areas of both heavy and light pumping, have been studied as a basis for computing the net rise and fall of the water table in Lubbock County from February 1943 to February 1946. The records show declines ranging from a fraction of a foot to 7.8 feet and averaging 3.1 feet. Only three wells in the county show rises, of 0.1, 0.2, and 0.4 foot, respectively. Considering the entire county, which includes unpumped, lightly-pumped, and heavily-pumped areas, it is estimated that the average decline of the water table in the county amounted to about 2 feet during the 3-year period.

Net change in water levels from 1938 to 1946.- Near the city of Lubbock and within a relatively small area west and northwest of the city, eight observation wells show declines ranging from 0.4 foot to 5.4 feet and averaging about 1.3 feet between the spring of 1938 and February 1946. In the Lubbock municipal wells the decline has been considerably greater. Throughout the remainder of the county 18 observation wells show rises ranging from 0.3 foot to 4.7 feet and averaging about 1.8 feet. Considering the entire county, the observation wells show an average rise of about 0.9 foot.

Table of water-level measurements.- Records of water-level measurements in 20 widely-distributed wells are given in the table on page 29 .

Illustrations.- Records of water-level measurements from 1936-37 to 1947 in five wells in Lubbock County that are not listed in the table are shown graphically in figure 8. The distance and direction of these wells from Lubbock are as follows: well 37, 17 miles northeast; well 64a, 10½ miles north; well 118, 9 miles west; well 219, 9½ miles northeast; well 355, 13½ miles southwest (see map, fig. 1). Although the wells are widely distributed the hydrographs show similar trends as follows: a slight decline from 1937 to 1941; a pronounced rise from 1941 to 1943; and a general decline from 1944 to 1947.

Summary.- With the exception of a few wells near the heavily-pumped city of Lubbock well fields and a relatively small area west and northwest of the city, the observation wells in the county for which records are available show that the water table rose considerably during 1941 and 1942; and that, in general, it has declined throughout the county since 1943.

Swisher County

Decline in water levels from 1943 to 1946.- The water-level measurements in 16 observation wells in Swisher County show declines ranging from a fraction of a foot to 6.0 feet and averaging 3.2 feet from February 1943 to February 1946.

Net change in water levels from 1938 to 1946.- Measurements of water levels in 14 observation wells show declines ranging from 0.9 foot to 9.3 feet and averaging 4.6 feet from 1938 to 1946. In the northwestern part of the county, where only a few irrigation wells have proved to be satisfactory, well 2 shows a rise of 0.1 foot.

Table of water-level measurements.- Records of measurements in 14 typical observation wells are given in the table on page 30 . These wells are distributed throughout the irrigation district.

Illustrations.- The records of measurements from 1934-37 to 1947 in five wells in the district that are not listed in the table of water-level measurements are shown graphically in figure 9. These wells are located as follows, with reference to Tulia: well 36, 4½ miles northwest; well 255, 14 miles southeast; well 332, 7½ miles south; well 368, 14½ miles south; well 429, 13 miles southwest.

Summary.- Throughout most of the irrigated area in Swisher County the water levels in observation wells declined from the start of the measurements until the spring of 1941; they rose, or the decline was retarded, during 1941 and 1942; and in general the levels have continued to decline since 1943.

Summary of declines in water levels from 1943 to 1946, by counties

From February 1943 to February 1946, the records of water-level measurements in about 255 representative observation wells in the irrigated areas showed average declines as follows, by counties:

Declines in water levels from 1943 to 1946, by counties

County	Number of wells	Average decline in feet
Bailey	21	5.6
Castro	18	3.9
Crosby	4	1.9
Deaf Smith	34	3.1
Floyd	34	6.3
Hale	49	4.6
Hockley	4	5.4
Lamb	19	2.9
Lubbock	26	3.1
Swisher	16	3.2

Summary of net changes in water levels from 1938 to 1946, by counties

From the spring of 1938 to February 1946, the records of water-level measurements in 208 observation wells in the irrigated areas for which comparable measurements are available show average net changes as follows, by counties:

Net changes in water levels from 1938 to 1946, by counties

County	Number of wells	Average decline or rise, in feet: Decline	Average decline or rise, in feet: Rise
Bailey	21		0.7
Castro	9	3.5	
Crosby	5		0.3
Deaf Smith	34	3.8	
Floyd	34	7.5	
Hale	49	5.3	
Hockley	5		2.0
Lamb	11		2.1
Lubbock	26		0.9
Swisher	14	4.6	

NOTE: Measurements of water levels in 145 wells in the counties listed above were made in January 1947, after the discussion on pages 9 to 15 was written.

The average decline in those wells from 1946 to 1947, by counties, is given in the following table, and discussed in the Addendum on page 31 .

Declines in water levels from 1946 to 1947, by counties

County	Number of wells	Average decline, in feet
Bailey	10	1.9
Castro	7	2.1
Crosby	4	1.9
Deaf Smith	22	1.3
Floyd	20	4.2
Hale	46	2.2
Hockley	3	+1.1
Lamb	4	1.3
Lubbock	18	2.1
Swisher	12	2.1

LOSSES OR GAINS IN STORAGE

In order to compute the volume of water gained or lost from storage as the water table rises or declines, it is necessary to know the specific yield of the material in which the fluctuations take place. The specific yield of a water-bearing formation is the ratio of (1) the volume of water which, after being saturated, it will yield by gravity to (2) its own volume. During the present investigation in the High Plains, values of 14.1 and 14.5 percent were obtained for the Plainview and Hereford districts, respectively, for the average specific yield of the materials unwatered during the 3-year, period 1938-41. (See progress report for 1943, pp. 15-17.) However, the specific yield may be somewhat greater if the material is allowed to drain for a longer period.

If the figure 15 percent is used as the average specific yield of the material unwatered, the amount of water lost from storage from each square mile for each foot of decline of the water table is as follows:

$$\frac{15 \times 640}{100} = 96 \text{ acre-feet}$$

The significance of this may be seen in the following example. During 1943, 1944, and 1945 the draft on the underground reservoir was heavy and the observation wells in Lubbock County had an average decline of 3.1 feet. Most of these observation wells are in the pumping district, but a few of them are in outlying areas where there is little or no pumping. Considering the entire county, with due regard to the unpumped, lightly-pumped, and heavily-pumped areas, it is estimated that the average decline of the water table amounted to about 2 feet. Lubbock County has an area of 892 square miles or 570,880 acres. With an average water-table decline of 2 feet, a total of 2 times 570,880 or 1,141,760 acre-feet of saturated material must have been unwatered during the 3-year period, 1943-46; and if the sands and gravels yield 15 percent of their own volume, the total amount of water removed from storage in Lubbock County from 1943 to 1946 (between spring measurements) amounted to 171,264 acre-feet or about 81 percent of the total volume of water pumped during the period, which was estimated to be about 210,000 acre-feet.

What is the safe limit of pumping in the High Plains? This question has been asked many times by land owners, pumping-plant operators, and others who are interested in the development of the region. It can be answered satisfactorily only after many facts are known for each locality, including the thickness and permeability of the water-bearing sands, the soil characteristics affecting recharge from rainfall to the underground reservoir, and the grouping and spacing of the wells.

Until recently the heavy pumping was confined to certain relatively small districts surrounded by large areas with little or no pumping. The Plainview pumping district, for example, was separated by wide undeveloped belts from the Lubbock district on the south, the Littlefield district on the southwest, and the Hereford district on the northwest; and all of these districts in turn were widely separated from the Muleshoe district. Under those conditions the depletion of the underground reservoir by heavy pumping was partly offset and the decline in water levels was retarded by contributions of water supplied by lateral movement from the adjacent unpumped areas. In recent years the pumping districts have spread out and some of them have merged or may soon merge until the separating belts disappear. When this occurs the contributions from the former unpumped areas cease.

Some idea of the magnitude of depletion of the underground reservoir, resulting from different rates of pumping, can be obtained by making certain assumptions. For example, let it be assumed that four irrigation wells of average capacity are operated in each square mile within the boundaries of the irrigated region; that each well supplies 130 acres at the rate of 1-acre-foot per acre, representing approximately the present average; that recharge is balanced by natural discharge, so that all the water used for irrigation is withdrawn from storage. At such a rate of withdrawal, 520 acre-feet of water would be removed from storage annually under each square mile. Using this figure, and 15 percent as the average specific yield of the saturated beds, the average annual decline of the water table would be about 5.4 feet, as shown below;

$$\frac{520}{640} \div 0.15 = 5.4 \text{ feet}$$

If, on the average, two pumping plants are operated per square mile the average annual decline would be about 2.7 feet, or one-half the amount indicated in the example above.

In very wet years, such as 1941, the decline would be retarded, owing to reduction in pumpage and to some extent by natural discharge; and in some localities where the soils are exceptionally sandy, such as parts of Bailey, Lamb, and Lubbock Counties, a temporary rise might occur. However, in dry years and years of average rainfall the decline would be expected to continue.

The total area within the exterior boundaries of the irrigated districts in the High Plains amounts to about 3,000,000 acres. It is estimated that during 1945 about 4,300 wells were pumped to irrigate 550,000 acres. Hence approximately 18.5 percent of the total area was irrigated, and the average was one well to about 700 acres. If the wells had been equally spaced throughout the region and if the unwatered material has a uniform specific yield of 15 percent, the pumpage during 1945 would have caused the water table to decline about 1.2 feet, as indicated below:

$$\frac{130}{700} \div 0.15 = 1.2 \text{ feet}$$

However, the wells are not evenly spaced and the declines in water levels have been greatest in the areas of heaviest pumping. For example, in an area of 50 square miles in west-central Floyd County there is an average of about one well to each 200 acres, and the records of water-level measurements indicate an average decline of about 5 feet from February 1945 to February 1946. In the lightly-pumped areas where the average is less than one well to 700 acres, the average decline during 1945 was less than 1.2 feet.

DECLINES IN PUMPING LEVELS

Recent studies have shown that in the High Plains, where irrigation wells of large capacity are being developed at an unprecedented rate, the decline in pumping levels in wells during periods of heavy withdrawal is a better index to the amount of local overdraft than the average net decline of the water table from year to year. For example, the records of measurements in 34 observation wells spaced throughout the irrigation district in Floyd County, including irrigation wells, domestic wells, and unused wells at considerable distances from any pumping plant, show that the water table had an average net decline of 7.5 feet during the 8-year period from the spring of 1938 to the spring of 1946; whereas the pumping levels in 66 wells spaced throughout the irrigation district had an average decline of 24 feet from the summer of 1938 to the summer of 1946. In other words, the static levels had declined from an average of 55 feet below the surface in 1938 to 62.5 feet in 1946, an average lowering of 14 percent; while the pumping levels had declined from an average of 97 feet in 1938 to 121 feet in 1946, an average lowering of 25 percent.

The yields and the pumping levels of several hundred irrigation wells in the Plainview, Hereford, and Muleshoe districts were measured during the summers of 1936-39. The pumping levels in many of the same wells were again measured in August 1946. Almost without exception the pumping levels in 1946 had declined from the previous measurement. That is, the actual distance that the water had to be raised to the surface was greater. Although the yields were not measured in 1946, many of the pumps were reported to be delivering less water than they were 8 or 10 years before.

The following table summarizes the measurements of the pumping levels in about 285 irrigation wells in the High Plains.

Declines in pumping levels in wells

County	1938 Average pumping level in feet	1946 Average pumping level in feet	1938 to 1946 Average decline in pumping level in feet
Bailey	37	53	16
Castro	106	120	14
Deaf Smith	92	108	16
Floyd	97	121	24
Hale	87	97	10
Swisher	102	107	5
City of Lubbock (Municipal wells)	93	118	25

In the spring of 1938 a pumping test was made on three wells about 7 miles north of Plainview. All wells were idle for some time and the static water level in each well was measured. One well was then pumped at the rate of 1,100 gallons a minute for 148 hours. Just before pumping was stopped, the water level in the pumped well had been lowered 24.1 feet; the water level in a well 237 feet from the pumped well had been lowered 9.5 feet; and in the other well, which was 460 feet from the pumped well, the water level had been lowered 2.7 feet. Thus it was found that the cone of depression, which had spread in all directions from the pumped well, extended substantially beyond the observation well 460 feet from the pumped well.

The effect that one well has on a nearby well depends not only on the distance between the wells but also upon the rate of withdrawal and the characteristics of the water-bearing formation in the area. Future studies in the High Plains will include numerous pumping tests in order to determine the drawdown in wells caused by their own pumping plus the additional drawdown caused by the pumping of nearby wells.

SUMMARY

A very large quantity of water, which has accumulated over a long period of time, is stored in the underground reservoir formed by the beds of sand and gravel that lie below the surface of the High Plains in Texas. The source of the water in storage is the precipitation on the Plains. A part of the ground water is discharged continuously through seeps and springs and by evaporation and the growth of plants in the localities where the water table is near the surface. This natural discharge is approximately balanced through a long term of years by the small part of the rainfall upon the area that penetrates to the water table. So far there is no evidence that the natural discharge has been materially reduced as the result of pumping from wells, but if pumping continues such a reduction must eventually occur.

Irrigation from wells in this region was started in 1911 near Plainview, Hale County. By 1914 about 140 irrigation wells had been drilled in the three principal districts, near Plainview, Hereford, and Muleshoe, respectively. In the 7 years from 1919 to 1926 the raingall in most of the region was above average and comparatively little irrigation was practiced. Interest was revived during a period of several years of low rainfall that began in 1927, and according to the available records 296 wells were pumped to irrigate about 35,000 acres in 1934. Since that time the development has grown by leaps and bounds, and it is conservatively estimated that 4,300 wells were pumped to irrigate about 550,000 acres in 1945. Pumpage for irrigation during the 3-year period 1943-45 probably exceeded the entire pumpage during the preceding 32 years, from 1911 to 1942.

Records of water-level measurements in a few wells show very little change of the water table from 1914 to 1934 (see tables of water levels, pp. 22 to 30). The present investigation, which includes water-level measurements in several hundred observation wells, was started in the spring of 1937, but during that year pumping had begun before the measurements were made. The water table declines during the irrigation season and recovers somewhat during the winter, so that comparison of measurements made during February or March, just before the start of spring irrigation, gives the best index to the net annual decline of the water table caused by removal of water from storage. During 1941 the rainfall throughout most of the High Plains was very heavy, and the water table in most of the region rose from a fraction of a foot in some places to 15 feet or more in others. Therefore, in this report, the water-level fluctuations are discussed by periods from 1943 to 1946 and from 1938 to 1946. For convenience to the reader, summaries of water-level fluctuations for these periods are given in the tables on pages 15 and 16.

Some idea of the magnitude of depletion of the underground reservoir can be obtained if we assume that four irrigation wells of average capacity are operated in each square mile within the boundaries of the irrigated region and that all the water comes from storage. If each well pumps 130 acre-feet of water and the water-bearing material has a specific yield of 15 percent, the average annual decline of the water table would be 5.4 feet. In an area of 50 square miles in Floyd County there is an average of about one well to each 200 acres, or a little more than three wells to the square mile; and the records of water-level measurements within the area indicate an average decline of about 5 feet from February 1945 to February 1946.

Recent studies have shown that the decline in pumping levels during periods of heavy withdrawals is a better index to the amount of local overdraft than the average net decline of the water table from year to year. Future studies will include numerous pumping tests in order to determine the drawdowns in wells caused by their own pumping plus the additional drawdown caused by the pumping of nearby wells.

Water levels in representative wells in Bailey County, Texas, (see map, fig. 1)
(Depth in feet below measuring point)

Date of measurement	Well number											
	5-A	25	33	36	45	49	69	79	92	95	117	131
1914												18.3
1934 Nov.						24.3					35.4	
1936 May						26.2	16.8	24.6	24.1	25.7	35.7	
Nov.		23.3	28.2	19.6		25.1	16.3	24.1	23.3	24.7		
1937 Mar.						24.8		24.0			35.8	21.3
May		25.3	30.4		20.8		15.9	21.6	22.2	24.9	35.7	
Nov.	64.5	22.3	29.0	17.9	20.0	23.9	16.4	23.4	21.9	24.2	35.6	21.0
1938 Mar.		22.5	28.8	17.6	19.9	23.9		23.6	22.1	24.4	35.7	21.2
Dec.	64.4	20.8	29.0	17.0	19.6	23.7		22.9	21.5	24.6	35.3	
1939 Mar.	64.2	20.4	28.7	17.2	19.1	23.1	15.5	22.8	21.1	24.4	35.9	22.2
Dec.	64.2	22.0	30.9	19.0	20.6	24.5	16.7	24.3	22.3	25.1	36.7	21.9
1940 Mar.	64.1	21.9	30.1	18.8	20.3	24.2	17.5	24.4	22.0	24.9	36.6	21.8
Nov.	64.3	24.9	33.3	20.0	21.8	27.0	17.9	25.5	24.7	26.3	39.1	23.6
1941 Mar.	64.3	23.9	32.9	19.7	21.5	25.3	17.8	25.2	23.5	25.9	37.2	22.7
Nov.	40.2	16.6	29.0	13.9	11.5	18.9	9.0	17.2			33.5	12.7
1942 Mar.	54.6	15.4	27.4	12.5	12.4	18.1	8.8	17.1	15.3	18.7	31.3	12.6
Nov.		15.6	28.1				8.4	18.0	15.3	18.7	29.8	12.4
1943 Feb.		16.1		13.1	13.3	17.7	8.8	18.4	15.4	18.7	29.8	12.9
1944 Feb.	63.4	19.1		16.0	16.2	20.4	12.0	21.9	17.6	20.6	30.9	15.9
1945 Feb.	63.5	20.6	30.2	16.5	16.5	20.8	12.8	22.1	18.2	21.2	31.3	17.1
1946 Feb.	63.5	23.8	33.7	19.4	19.4	23.1				23.6	32.9	19.6
1947 Jan.	64.6	24.7	35.8	20.6		25.2	18.6		22.2	25.4	35.3	20.8

NAMES OF OWNERS: Well 5-A, Gus Schrader; 25, C. A. Wagner; 33, Mrs. J. W. Gregory; 36, J. M. Murrah; 45, H. M. Schofner; 49, Jess Mitchell; 69, E. R. Hart; 79, D. F. Cox; 92, L. H. McConnell; 95, E. R. Hart; 117, H. L. Dempster; 131, R. D. Precure.

Water levels in representative wells in Castro and Crosby Counties, Texas, (see map, fig. 1)
(Depth in feet below measuring point)

Date of measurement	Castro County: Well number 18	32	48	52	58	202	394	465	587	Crosby County: Well number 1	2	3
1936 Apr.		65.2	66.4									
June		64.9	63.4									
1937 May		64.8								114.3	107.2	136.1
Dec.	66.2	63.8	69.0	72.1								
1938 Mar.	67.3	63.6	62.4	71.8						114.3	107.2	136.1
Dec.		64.4	62.7	71.6	154.0	105.4						
1939 Mar.		63.7	61.3		154.2	105.3	93.7	101.8	18.8	114.2	107.1	
Dec.		64.9	79.2	71.6	154.1	105.1				114.1	107.1	135.7
1940 Mar.		64.5	64.4	71.6	154.0	105.2				114.2	107.2	135.8
Nov.		68.2	78.9		154.2		93.2	98.6	16.4		107.1	135.5
1941 Mar.		66.0	65.9	79.6	154.1	105.5						
Dec.	69.2	64.2	63.2	75.2	154.0							
1942 Feb.	68.7	63.2	62.3		154.0	104.4				113.5		
Nov.	67.9	62.7	60.5	74.9	153.5	103.4					105.9	
1943 Feb.	68.0	62.6	59.7	71.8	153.4		93.1	98.3	17.1	113.3	105.8	
1944 Feb.	69.1	63.8	60.8	74.6	153.9	103.0	93.7	97.8	17.3	113.4	105.7	135.3
1945 Feb.	70.0	65.1	60.5	73.5	152.8	105.1	94.0	97.5	17.9			135.0
1946 Feb.	70.7	67.8	67.7	75.6	152.8	103.7	95.2	97.4	19.2	113.8		136.3
1947 Jan.	69.7	66.1	68.8	80.3	152.6	103.9	95.1	100.0		114.5	107.9	138.1

NAMES OF OWNERS: Well 18, Frio Public Schools; 32, W. A. Springer; 48, J. M. Richardson; 52, C. G. Maples; 58, Unknown; 202, Frank Huseman; 394, Temple Rogers; 465, J. K. Tidmore; 587, Peter Peterson.

Well 1, J. T. Vaughan; 2, C. B. Travis; 3, New Home School.

Water levels in representative wells in Deaf Smith County, Texas, (see map, fig. 1)
(Depth in feet below measuring point)

Date of measurement	Well number 113	207	212	217	235	237	247	261	265	281	288	302	311	336	340	431	486	502	513
1914								47.0											
1934 Nov.						42.7							54.8						
1936 Apr.			71.4	84.9		42.5		53.6			60.0	53.3	55.8	88.3	73.6				
June		54.1	71.6		53.4	42.2							52.0		73.8				
1937 Mar.						44.0							48.9			68.9	72.0		
May		58.7		92.8	57.3			54.8	66.1		70.3			88.6	74.5				
Dec.	99.0	54.6	71.3	105.4	52.9	45.4	21.8	51.2	64.6		64.7	53.8		87.4		68.9		94.3	79.3
1938 Mar.	98.9	54.4	72.5	93.3	52.7	44.2	22.3	52.7	63.9	65.7	63.1	53.3	51.5	87.5	77.6	68.9		96.2	79.4
Dec.	98.8	55.0	72.1	92.3	53.4	44.7	22.2	52.9	65.0	65.7	64.1	53.2	51.7	86.9	78.6			95.6	79.5
1939 Mar.	98.8	54.5	71.7	88.9	53.1	44.1	22.6	51.0	64.1	65.5	61.9	53.1	50.5	86.8	77.2	69.3	72.3	96.3	79.5
Dec.	98.7	55.1	75.6	93.7	54.0		23.7	53.1	66.7			54.8	52.4	87.9	83.5	70.0		96.7	80.8
1940 Mar.	98.7	55.0		91.6	53.7	45.2	23.8	52.8	65.2	67.4	65.0	54.2	51.7	87.5				96.2	79.9
Nov.	98.8	56.1	81.7		55.9	48.9		55.8	76.1		72.6	55.7		88.7	86.0	72.5		103.1	
1941 Mar.	99.1	55.9	75.6	93.0	54.6	46.8	24.5		67.4	70.2	68.1	55.1	52.9	88.6	80.4	72.2	77.2	99.8	
Dec.				89.2	50.6	45.8	19.7			68.6		53.8					75.8		
1942 Feb.	99.2		72.9	88.9	51.3	45.6	20.2	54.5	[illegible]		66.0	53.5	49.6	87.6	79.5	71.0	76.1	98.5	80.7
Nov.	98.9		72.0	88.8	52.1	45.3	22.6	55.0	66.6		68.5	54.0			78.8				
1943 Feb.	99.0		72.1	88.3	52.0	44.8	22.9	54.7	66.7		65.9		49.1	88.0	73.7	70.9			81.8
1944 Feb.	100.2	55.8	72.7	89.8	53.6	45.0	24.1	57.8	67.5	69.0	69.1	55.0	50.4	89.0	79.5	72.3	77.7	100.2	82.6
1945 Feb.	101.1	55.8	71.3	89.2	53.9	45.2	24.9	57.0	68.3	70.5	68.8	55.6	50.8	90.1		73.1	77.1	98.6	83.1
1946 Feb.	102.2	56.1	74.5	90.6	54.2	46.5	25.5	58.4	70.3	74.0	72.6	56.5	51.3	91.8	81.8	74.2	79.0	101.8	83.7
1947 Jan.	100.3	57.2	76.3	91.6	54.9	48.2	25.8	62.4	72.6	75.6	76.3	56.5	51.4	94.0		75.2	80.5	103.1	85.3

NAMES OF OWNERS: Well 113, A. S. Higgins; 207, Chas. B. Miles; 212, Alfred May; 217, Leslie L. Neal; 235, Lewis A. Smith; 237, B. A. Donelson; 247, R. R. Lindsey; 261, D. L. McDonald; 265, Rieneaur Brothers; 281, Jerry Keith; 288, Lee Hopson; 302, F. G. Collier; 311, H. H. Broadman; 336, Geo. M. Clingan; 340, Felix Urbanszyk; 431, S. J. Barclay; 486, M. L. Parker; 502, Carl H. Schroeder; 513, A. E. Acton.

Water levels in representative wells in Floyd County, Texas, (see map, fig. 1)
(Depth in feet below measuring point)

Date of measurement	Well number 14	32	57	111	120	140	143	410	416	441	446	459	463	510	525	603
1914				47.0		47.0	51.4	41.7	51.2							
1934 Apr.												44.3	46.4			
1936 Apr.	58.9		61.1				57.7	49.4								
1937 Apr.								51.8								
May	59.7	91.2	60.9	54.8	57.4		61.2						51.1		41.0	176.1
Dec.	59.9		61.5				61.1				43.4	46.9	49.7	41.2	40.8	
1938 Mar.	60.3			56.7		53.0	60.6	52.4		63.1	43.4	47.8	49.4		40.6	175.7
Dec.				53.3	59.6	53.9	61.7	50.1	63.2		43.7	48.4	51.1	43.7	40.9	174.2
1939 Mar.				52.9	58.5	53.8	61.0	49.6	63.0	63.7	43.7	48.3	50.4	43.1	40.8	176.4
Dec.			62.6	61.3	62.3	55.3	64.0	53.5	65.8		44.1	49.7	53.4	47.3	41.6	
1940 Mar.	62.8	90.2	62.8	54.9	60.4	55.3	63.0	51.5	65.4	64.5	44.2	49.6	52.4	45.8	41.6	175.6
Nov.		91.5	63.9	57.9	63.3	58.0	67.1	55.1	71.5		45.2	51.9	55.7	51.9	42.4	176.4
1941 Mar.		91.0		57.0	63.2	57.8		54.0	69.1	65.6	45.1	51.6	54.6	50.7	42.6	176.3
Nov.		91.8	63.5		61.3	55.5	64.2		66.4		44.1	48.9	51.4	43.0	39.9	
1942 Mar.	60.2	90.4		55.2	60.3	55.4	63.1	50.9	65.5	64.2		48.5	50.7	41.9	38.5	175.9
Oct.	61.0	90.9	62.8	56.4	61.6	57.4	64.6	52.0	67.7			48.8	51.5	43.4	37.9	175.6
1943 Feb.	61.1	90.2	63.0	55.4	60.7	56.1	63.4	50.9	65.6	63.7	42.2	48.4	50.4	42.0	37.5	175.8
1944 Feb.	63.8		63.9	56.6	62.2	58.4	64.9	52.3	68.1	64.7	42.4	50.3	51.8	44.6	37.8	
1945 Feb.	65.3	92.0	65.0	58.1	64.1	61.0	67.2	54.9	71.2	66.0	43.4	51.9	54.5	47.8	39.5	175.5
1946 Feb.	66.6	92.7	67.5	60.3	67.9	66.1	70.5	57.7	75.8	67.4	45.2	55.7	57.2	50.8	41.3	
1947 Jan.	67.6	94.6	70.6	63.6	73.4	74.5	77.9	63.7	84.1	68.7	46.9	60.9	63.0	54.2	43.1	

NAMES OF OWNERS: Well 14, Herman R. King; 32, Frank Whitfill; 57, T. L. Wilhite; 111, T. L. & D. Company; 120, Francis Carthel; 140, Wayne Holt; 143, Plainview-Lockney Farms; 410, W. C. McGrede; 416, John Spear; 441, Federal Land Bank; 446, W. J. King; 459, — Jackson; 463, T. L. & D. Company; 510, W. R. Crow; 525, O. W. Fry; 603, Gladys Fox.

Water levels in representative wells in Hale County, Texas, (see map, fig. 1)
(Depth in feet below measuring point)

Date of	Well number																				
measurement	202	210	223	238	259	307	330	338	370	427	428	436	449	462	467	552	567	828	834	923	936
1914		62.5			23.7					43.0			57.5	36.5							
1934 Apr.	64.1					61.6										58.4					
1936 Apr.	67.8		49.6	50.7	19.4		44.6	45.5	41.8	49.0	52.5	52.8	57.8			61.3	52.4				43.2
June				50.8										40.8							
1937 Apr.										47.7		54.4	59.0	42.1		59.9	52.9				44.5
May		63.6	55.2							50.6	49.9										
Dec.	65.3						44.8	45.5	43.1	48.3	47.9	51.3		39.4	33.9	58.6	52.1			55.0	44.7
1938 Mar.	65.2	64.5	51.7	52.1	17.8	63.4	45.4	45.5	42.9	47.8	47.8	51.1	57.8	39.9	33.3	58.6	52.2		77.2	55.0	44.4
Dec.	66.6				18.5	64.4	45.2	46.0	43.0	49.8		52.6	58.4	42.2	34.4	59.5	52.8			55.5	46.0
1939 Mar.	66.1	64.8	52.3	52.5	18.6	63.9		45.9	42.9	49.2		52.2	58.3	41.8	34.2	59.3	52.8	73.1	77.3	55.4	
Dec.	67.0		54.6	53.6	19.7	66.2	47.2	47.2	44.0	51.3	52.1	54.3	59.4	44.4	36.0	60.2	53.2		77.4	55.8	47.8
1940 Mar.	66.7	65.8	53.8	53.5	19.9	65.1	46.0	47.2	44.0	50.7	50.6		59.0	44.1	35.5	60.0	53.6	73.7	77.5	55.9	47.3
Nov.	68.6		57.1	55.9	21.7	68.4	46.7	48.7	45.3	53.4	53.3	57.3	61.9	48.0	39.8	61.3	53.9	[illegible]	77.9	56.7	50.1
1941 Mar.	68.0	67.0	55.4	55.4	20.8	66.5	46.7	48.6	45.3	52.5	52.5	56.3	60.9	46.4	38.0	62.1	54.1	74.2	77.9	56.7	49.0
Nov.	67.9		54.7	54.9	15.3	66.2	46.2	47.0	44.2	50.1		53.5	60.1	37.6	36.0	60.0	53.0		77.2	54.5	46.4
1942 Mar.	67.3	66.6	53.8	54.2	16.3	65.3	46.0	46.4	43.6	49.0	48.1	52.0	60.1	37.8	34.5	59.3	52.5	73.0	76.9	53.9	45.5
Oct.	67.8		55.2	55.0	16.9	66.4	46.8	47.1		49.0	48.8	53.0	60.8	39.7	34.3	59.6	53.1	[illegible]	76.7	53.8	45.9
1943 Feb.	66.9	66.8	53.9	54.7	16.8	65.5	46.8	46.6	44.2	48.6	48.4	52.2	60.0	39.0	33.7	59.2	53.1	72.6	76.6	53.2	44.1
1944 Feb.	68.2	68.3	55.0	55.8	19.5	67.2	47.3	48.7	45.7	50.3	50.2	53.8	60.7	42.1	35.7	59.8	54.0	72.9	76.7	53.0	45.4
1945 Feb.	68.7	69.1	56.1	56.9	21.0	67.6	48.9	50.1	47.2	53.0	52.5	56.6	61.7	45.3	38.1	60.6	54.5	73.3	76.8	53.7	46.2
1946 Feb.	70.0	71.3	58.0	59.3	22.9	69.3	50.3	51.8	49.3	54.9	54.6	59.6	62.7	48.1	39.2	63.3	55.4	76.4	78.8	54.7	48.8
1947 Jan.	72.2	74.5	62.6	62.3	23.3	71.6	52.2	52.8	52.7	57.4	57.9	64.0	64.6	52.7	41.2	62.8	56.5	79.0	80.4	55.8	50.8

NAMES OF OWNERS: Well 202, T. L. & D Company; 210, Dr. McKinley Howell; 223, T. L. & D. Company; 238 Dr. McKinley Howell; 259, C. S. Ebeling; 307, T. L. & D. Company; 330, E. H. Cox; 338, Dr. J. H. Stewart; 370, D. A. Reading; 427, C. M. Smith; 428, C. M. Smith; 436, I. B. Rankin; 449, G. A. Benefield; 462, R. F. Keniston; 467, M. E. Courtney; 552, H. S. Dunaway; 567, J. B. Maxey; 828, John Bowling; 834, M. E. Kesler; 923, D. C. Bayley; 936, B. E. Porter.

Water levels in representative wells in Hockley County, Texas, (see map, fig. 1)
(Depth in feet below measuring point)

Date of measurement		Well number							
		5	7	24	25	29	126	434	587
1937	June	93.3							
	July		88.9						
	Aug.			28.6	29.3	28.9			
1938	Jan.			28.2	29.2	29.5			
	Apr.				29.3	29.8	29.4	134.7	
	Oct.			27.0	29.0	29.3	27.9		
1939	Mar.			27.2	29.1	30.0	28.2		93.1
	Oct.	92.2	87.8		29.1	29.6	27.7		
1940	Mar.	92.7	87.6	27.1	29.3		28.3		
	Dec.			28.4	30.4	31.6	29.0		93.4
1941	Mar.			28.5	30.6	32.0	29.0		
	July			23.2					
	Nov.	90.4			27.4	27.3	23.4		91.6
1942	Mar.			22.5	27.1	27.7	23.6		
	July				26.9		23.9		91.3
1943	Feb.	90.5		18.3	24.6	25.7	21.5		
1944	Feb.	87.9	85.6	20.7	24.6	25.6	22.8	132.1	91.3
1945	Mar.	87.5	85.2	22.7	26.3	28.0	24.1	132.1	91.0
1946	Feb.	87.4	84.3	24.4		32.2	24.8	131.7	
1947	Jan.	87.2	84.3	22.7		34.7	21.8	132.0	93.0

NAMES OF OWNERS: Well 5, Santa Fe Railroad Company; 7, -- Picard; 24, Roy Hughen; 25, Texas Highway Department; 29, A. L. Lindsey; 126, W. M. Alexander; 434, C. E. Flowers; 587, Texas Land and Mortgage.

Water levels in representative wells in Lamb County, Texas, (see map, fig. 1)
(Depth in feet below measuring point)

Date of measurement		Well number								
		3a	13	16	30	60	76	243	322	341a
1934	Nov.	28.0	22.2							
1936	May	34.2	21.3	37.6	24.0					
	Nov.	30.7	19.9		24.5					
1937	Mar.				23.7					
	May					70.6	80.3	79.0	41.9	
	Nov.								41.9	
1938	Mar.	29.8	18.7	36.0	23.1		79.5	78.8	41.8	42.8
	Dec.	30.4	19.7							
1939	Mar.	29.9	19.5		23.3	70.9	79.7	78.7	41.9	43.4
	Dec.	30.8	20.2	36.5	23.6					
1940	Mar.		20.1	36.3	23.7					
	Nov.	32.6	21.1	37.5	24.0	72.9		78.7	42.1	
1941	Mar.	31.3	21.4	37.0	24.0	72.0	79.2	78.7	42.1	44.4
	Nov.	25.4	11.0	32.0	17.0	71.0		77.4	38.5	
1942	Mar.	23.7	11.1	30.7	17.4	70.3	75.7	76.4	37.8	41.2
	Nov.	22.9	11.7	29.9	17.2	68.8	74.9			
1943	Feb.	22.7	12.1	29.5	17.7	68.3	74.4	76.3	36.8	40.2
1944	Feb.	24.5	16.2	30.9	20.0	69.5	73.8	76.3	36.4	39.7
1945	Feb.	25.5	16.9	32.0	20.7	69.6		76.3	37.8	40.5
1946	Feb.	27.2	18.5	33.0	22.0	71.4	72.9	76.6	40.9	43.6
1947	Jan.	30.0		35.5	21.8	71.9		75.6		44.9

NAMES OF OWNERS: Well 3a, J. O. Crawford; 13, John Fryie; 16, E. K. Warren; 30, J. M. Young; 60, S. A. Davis; 76, S. E. Gladden; 243, Les Barker; 322, Yellowhouse Land Company; 341a, Yellowhouse Land Company.

Water levels in representative wells in Lubbock County, Texas, (see map, fig. 1)
(Depth in feet below measuring point)

Date of measurement	74a	81	107	121	123	128	138	139	156	185	188	222	223	228	301	339	369	395	403
	Well number																		
1936 Dec.		44.5			63.8	42.9			40.5								81.6		
1937 Feb.												53.7	47.2	70.9	58.5				
Mar.										61.8	78.2								
Apr.			51.3				45.7	28.2											
Dec.		44.3		75.0	63.4	41.9	41.4	26.8	40.2							62.2			
1938 Jan.		44.2	50.7					26.9		61.7				70.6			81.5	45.0	40.3
June	33.1						41.5			61.9	79.1	53.2	47.8	70.6				44.9	40.1
Dec.	35.4	44.3		75.1	64.2	41.5	41.0		40.0	61.8							81.1		
1939 Jan.	35.2		50.8					26.8		61.8	78.1		47.8		57.4	62.3			
Mar.	35.4	45.5		75.4			41.0	26.9		61.8	78.5	53.1	47.8	70.4	57.3			45.0	39.7
Dec.	35.5	47.4		76.8	65.1	42.8	41.2	25.4	41.2	62.5	79.4	53.0	47.8	70.3	57.6				41.2
1940 Feb.											77.9					63.0			41.1
Mar.	35.6	46.9	50.1	76.9			41.3	25.9	41.4	62.5		53.0	47.9	70.3				47.2	
Nov.	36.3	48.1			66.5	45.0	41.6	27.1	43.4		79.4		47.8	70.4	58.3	64.3	81.7	51.4	43.1
1941 Jan.	36.1	46.7		77.5	67.5	43.9			42.3		78.6		47.8	70.4		64.0		49.0	42.8
Mar.	36.5	47.2	50.6	79.0	66.1	47.3	41.8	27.2	42.3		78.5	53.1	47.8	70.4	58.1	64.0		48.8	42.7
Dec.		41.8																	
1942 Mar.	31.5		46.4	75.6	63.6	40.1	37.7	23.8	38.2			50.6	43.3	68.0		61.6	75.3		36.5
Dec.		42.6		74.3		39.0	36.0	22.4	38.4		77.0					60.7		42.9	34.5
1943 Jan.												48.6	43.0	67.7				43.1	33.8
Feb.	29.7	42.0	44.3	73.9	62.6	38.4	35.9	22.4	37.8						51.0	60.4	75.0		
1944 Feb.	32.2	43.3	45.0	74.4	63.1	38.7		23.3	41.2	61.8	76.2	47.5	43.0	67.6	50.4	60.0	76.7	41.4	35.6
1945 Feb.	32.6	42.5	46.1	74.7	63.6	40.1	37.5	24.8	41.2	62.4	75.3	48.1	43.1	67.8	50.9	60.0	76.5	46.2	35.5
1946 Feb.	33.5	44.0	47.1		65.2	42.5	39.8	26.4	45.6	63.8	78.7	48.6	42.8		52.6	62.0	77.5		38.1
1947 Jan.	34.0	44.1		78.4	69.8	46.1	38.4	26.5	51.3		77.0	52.1	42.6		54.4	64.2	80.6		41.1

NAMES OF OWNERS: Well 74a, J. S. George; 81, J. E. Vickers; 107, B. G. Lokey; 121, — Brown; 123, R. C. Robbs; 128, Rufus Rush; 138, Edith Collie; 139, D. L. Watkins; 156, J. M. Phillips; 185, W. H. Massey; 188, State of Texas Experiment Station No. 8; 222, R. T. Groves; 223, W. C. Grimes; 228, G. H. Hutchings; 301, S. D. Stewart; 339, J. E. Hinson; 369, J. P. Clark; 395, H. W. Stanton; 403, J. E. Smiley.

Water levels in representative wells in Swisher County, Texas, (see map, fig. 1)
(Depth in feet below measuring point)

Date of measurement	Well number													
	2	16	38	108	258	301	302	323	354	359	370	380	383	421
1934 Apr.				74.8			67.7						72.2	
1936 Apr.					51.1							54.5	74.6	
June									61.6		72.7			
1937 Apr.						31.4								60.0
May		61.5	55.3		51.7			63.2	61.9			54.6	77.7	
Dec.		61.5		75.6		31.9	69.1			75.7		54.1	73.9	
1938 Mar.	78.5	61.9	55.4		52.1	32.4		64.4	62.2	76.7	73.5	54.5	74.2	
Dec.	78.6	61.8			52.5	32.7		65.3	62.3	77.0	73.3		73.8	
1939 Mar.	78.3	61.7	56.0		52.5	32.4	68.7	65.3	62.4	77.1	73.4	54.8	73.3	61.9
Dec.	78.4	62.0				32.9	69.4		62.6	77.7	74.2	55.1	75.3	
1940 Mar.	78.4	62.1	56.3		53.8	33.0	69.1	66.7	62.7	77.3	74.1	55.2	74.2	
Nov.	78.6	62.8			55.1	33.4	70.8		63.0		75.2	55.7	76.8	
1941 Mar.	78.6	62.4				33.5	69.7	68.0	63.2	78.2	75.3	55.7	75.2	62.9
Nov.	78.5	61.2			54.8	30.0	68.1	68.3	62.8	77.9	76.0		75.2	
1942 Mar.	78.5	61.3			54.6	30.4			62.6	77.7	75.8		75.0	
Oct.	78.3	61.7	55.4			31.0	68.3	67.8		78.7	77.2		75.7	60.9
1943 Feb.	78.3	61.0	55.3	75.6	54.7	31.1	68.2	67.5	63.3	78.0	76.5		74.7	60.2
1944 Feb.	78.3	61.1	54.3		55.6	32.3	63.8	68.2	64.1	78.7	78.6		76.4	61.7
1945 Feb.	78.3	61.3	55.0	76.3	57.0	33.1	69.2	69.0	64.2	79.5	81.0	56.4	77.8	62.1
1946 Feb.	78.2	62.5	56.7	77.6	58.9		70.0	70.2	65.1	81.5	82.5		80.4	64.7
1947 Jan.	78.5	63.4		79.2	61.6		63.7		67.0	84.1	86.0		83.3	65.4

NAMES OF OWNERS: Well 2, I. Irlbeck; 16, C. M. Brant; 38, J. B. Johnson; 108, D. D. Augspurger; 258, B. A. Dubbert; 301, W. T. Adams; 302, J. D. Vaughn; 323, J. L. Guest; 354, V. A. Beck; 359, Unknown; 370, T. L. & D. Company; 380, Joe Bontke; 383, T. L. & D. Company; 421, A. U. Perryman.

ADDENDUM

January 31, 1947

During January 1947, since the foregoing progress report was written, measurements of water levels were made in 163 representative observation wells in and around the principal areas of well irrigation of the South Plains, and tentative estimates were made of the number of new irrigation wells put into operation and the total acreage irrigated during 1946.

In accordance with the usual program, some of the measurements of water levels were made in domestic and stock wells that had been shut down for a few hours, some were made in irrigation wells that had been idle for 4 months or more, and some were made in wells that had been unused for several years. Some of the wells that were measured are in the heavily pumped districts and others are in areas of light pumping. Some are in localities of exceptionally heavy recharge near intermittent ponds, stream channels, sand hills, or in areas of very sandy soils. Still others are in localities more or less remote from pumping or from known areas of important recharge.

Of the 163 wells measured, 146 showed declines. The maximum, minimum, and average declines are given below by counties, without reference to the location of the wells as regards intensity of pumping, lack of pumping, or conditions affecting recharge.

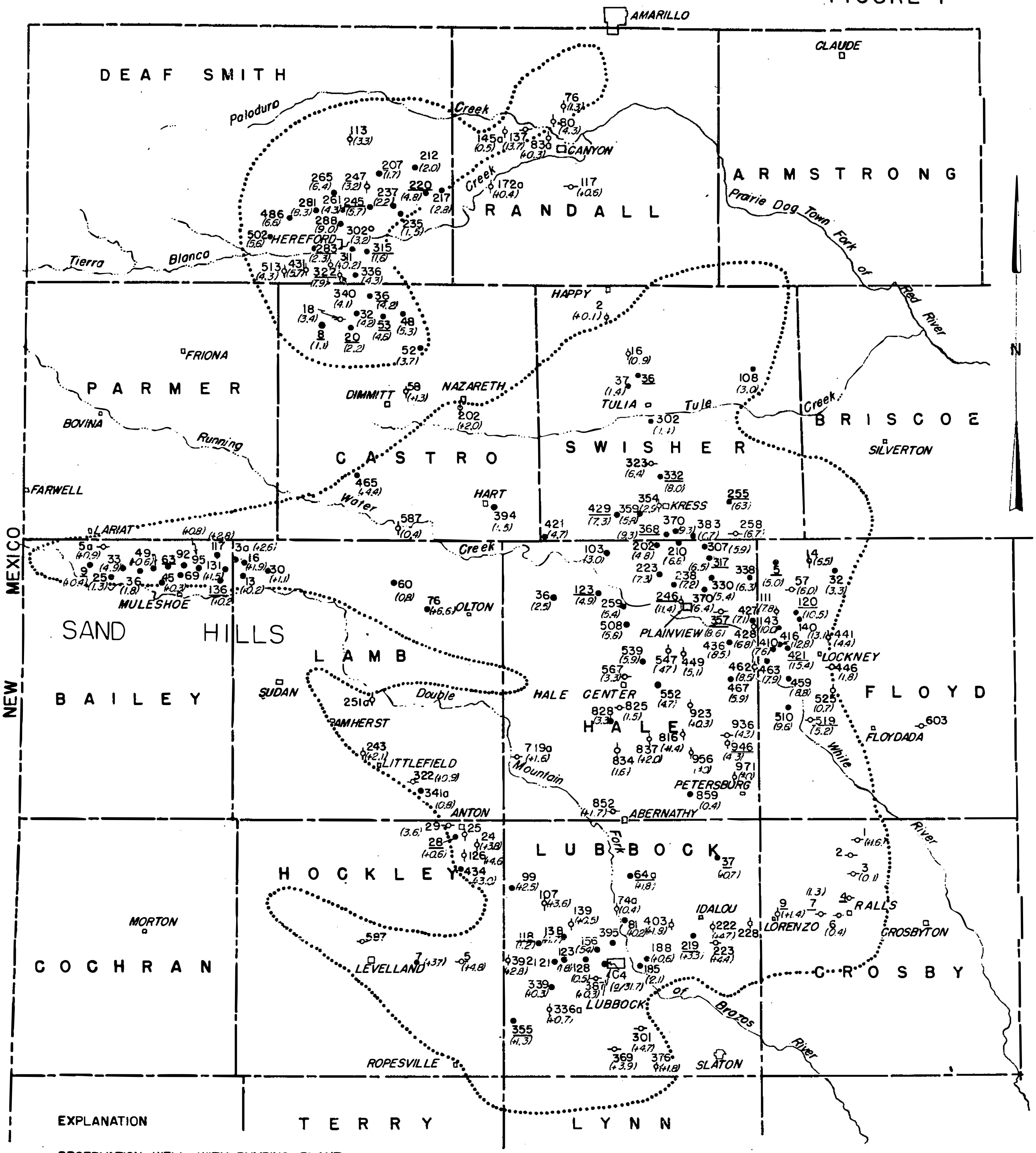
Decline of water levels in observation wells, by counties, from February 1946 to January 1947

County	Number of wells	Minimum decline	Maximum decline	Average decline
Bailey	10	0.7	4.8	1.9
Castro	7	0.5	4.7	2.1
Crosby	4	0.7	3.3	1.9
Deaf Smith	22	0.1	4.8	1.3
Floyd	20	1.0	8.4	4.2
Hale	46	0.2	4.6	2.2
Hockley	3	0.3	2.5	1.1
Lamb	4	0.5	2.8	1.3
Lubbock	18	0.1	3.5	2.1
Swisher	12	0.3	3.5	2.1

Fifteen of the observation wells showed rises ranging from a fraction of a foot to 3 feet, and they are located as follows: 3 in Castro County, 1 in Hale County, 3 in Hockley County, 2 in Lamb County, 4 in Lubbock County, and 2 in Swisher County.

Although detailed inventories of the irrigation wells completed and the acres irrigated during 1946 have not been made, it is tentatively estimated that about 1,200 new wells were installed and used during a part of the irrigation season of 1946, making a total of about 5,500 wells, and that at least 650,000 acres of land was under irrigation. Rainfall on most of the irrigated region during the first 8 months of 1946 was exceptionally light, and pumpage during the year reached an all-time high.

FIGURE-I



EXPLANATION

- OBSERVATION WELL WITH PUMPING PLANT
- OBSERVATION WELL UNUSED
- OBSERVATION WELL WITH WINDMILL
- 100 HYDROGRAPH IN THIS REPORT
- BOUNDARIES OF PRINCIPAL AREAS OF WELL IRRIGATION
- (2.5) DECLINE OF WATER LEVEL FROM FEB. 1938 TO FEB. 1946
- (+1.0) RISE OF WATER LEVEL FROM FEB. 1938 TO FEB. 1946
- 9/ DECLINE OF WATER LEVEL FROM 1925 TO 1946 (LUBBOCK CITY WELL)

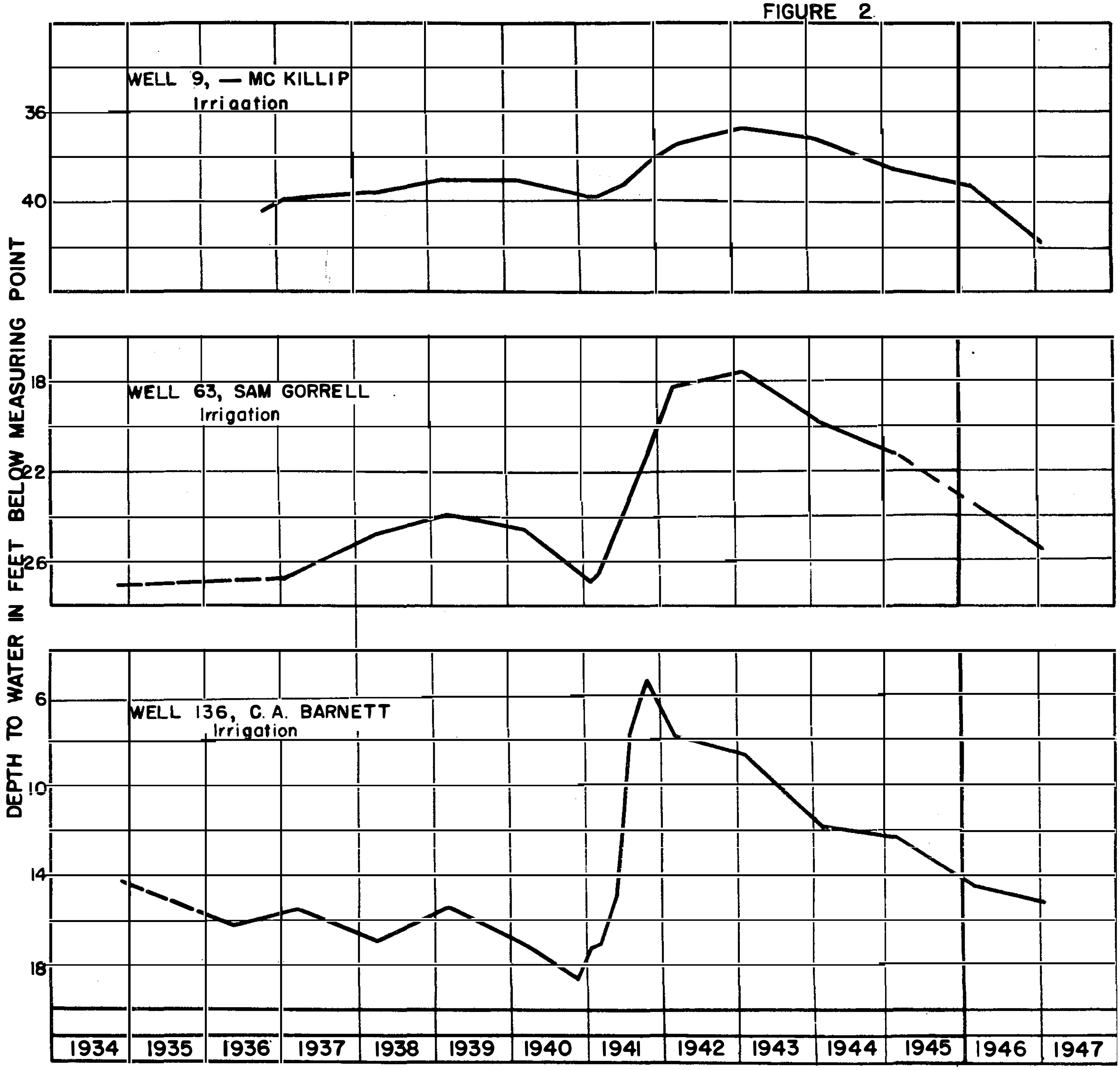
REPRESENTATIVE OBSERVATION WELLS IN IRRIGATED AREAS OF TEXAS HIGH PLAINS

10 5 0 10 20

SCALE OF MILES

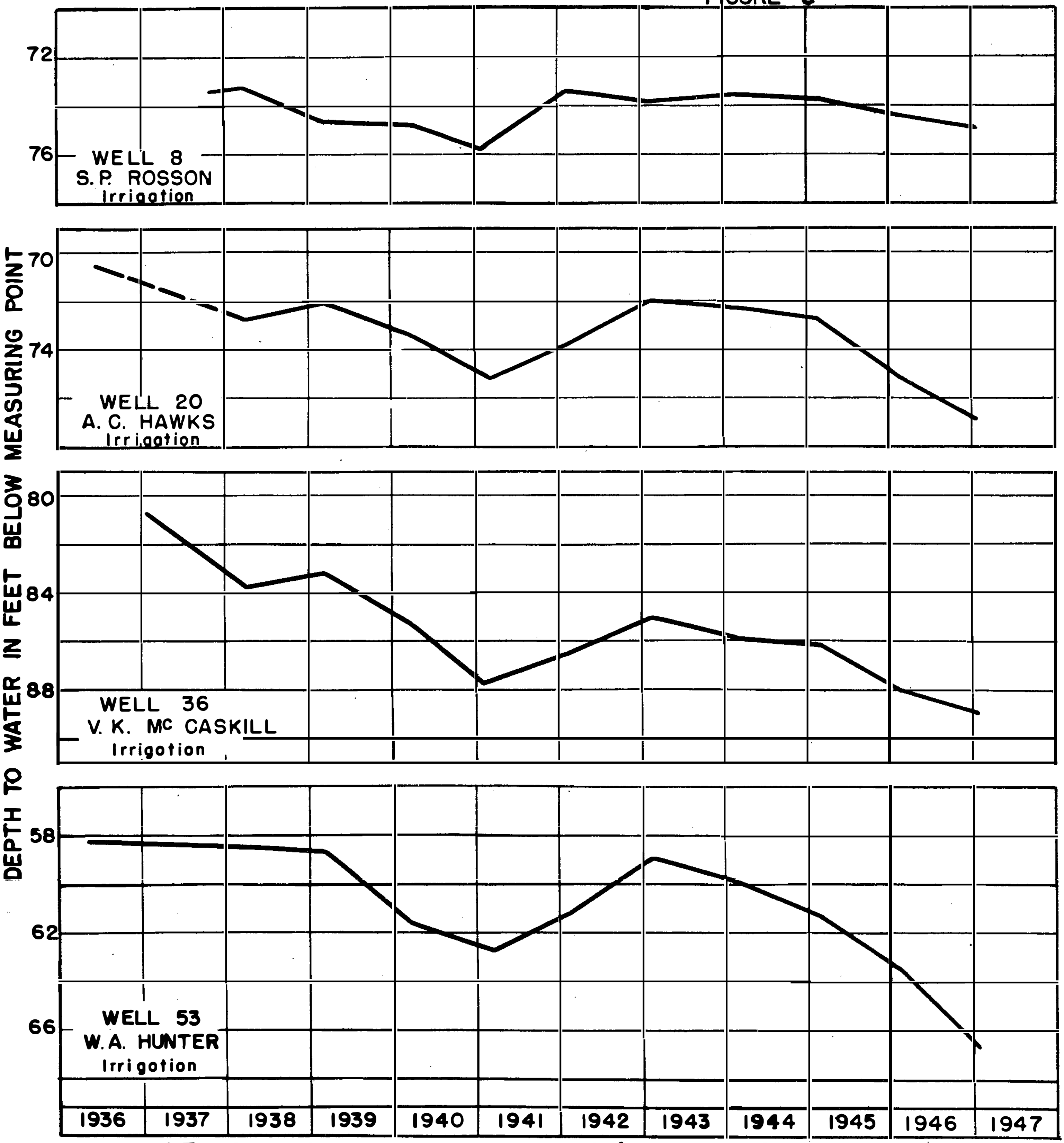
MAC 10-46

FIGURE 2



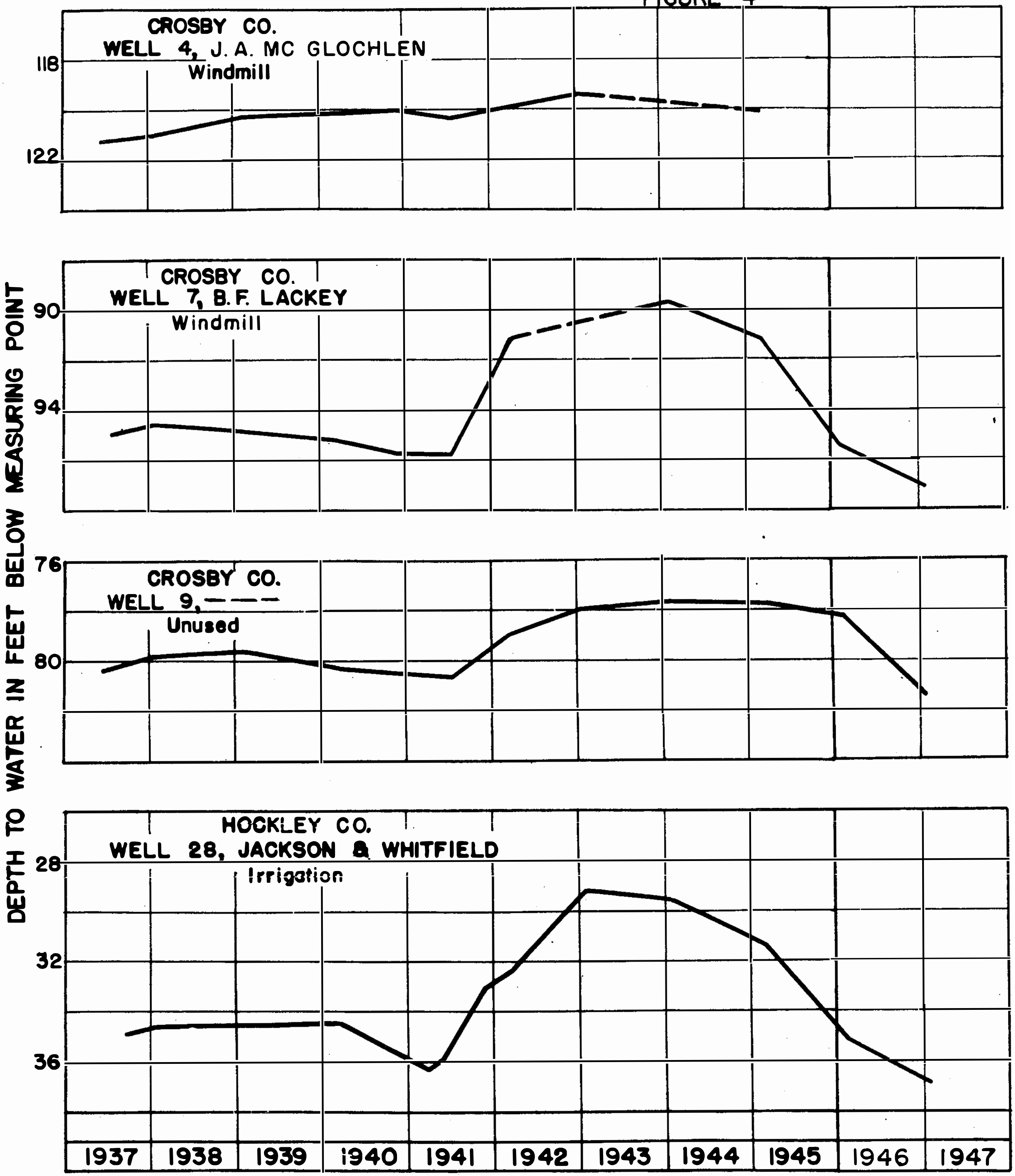
DEPTH TO WATER IN WELLS IN BAILEY COUNTY, TEXAS
(For location of wells see Fig. 1.)

FIGURE 3



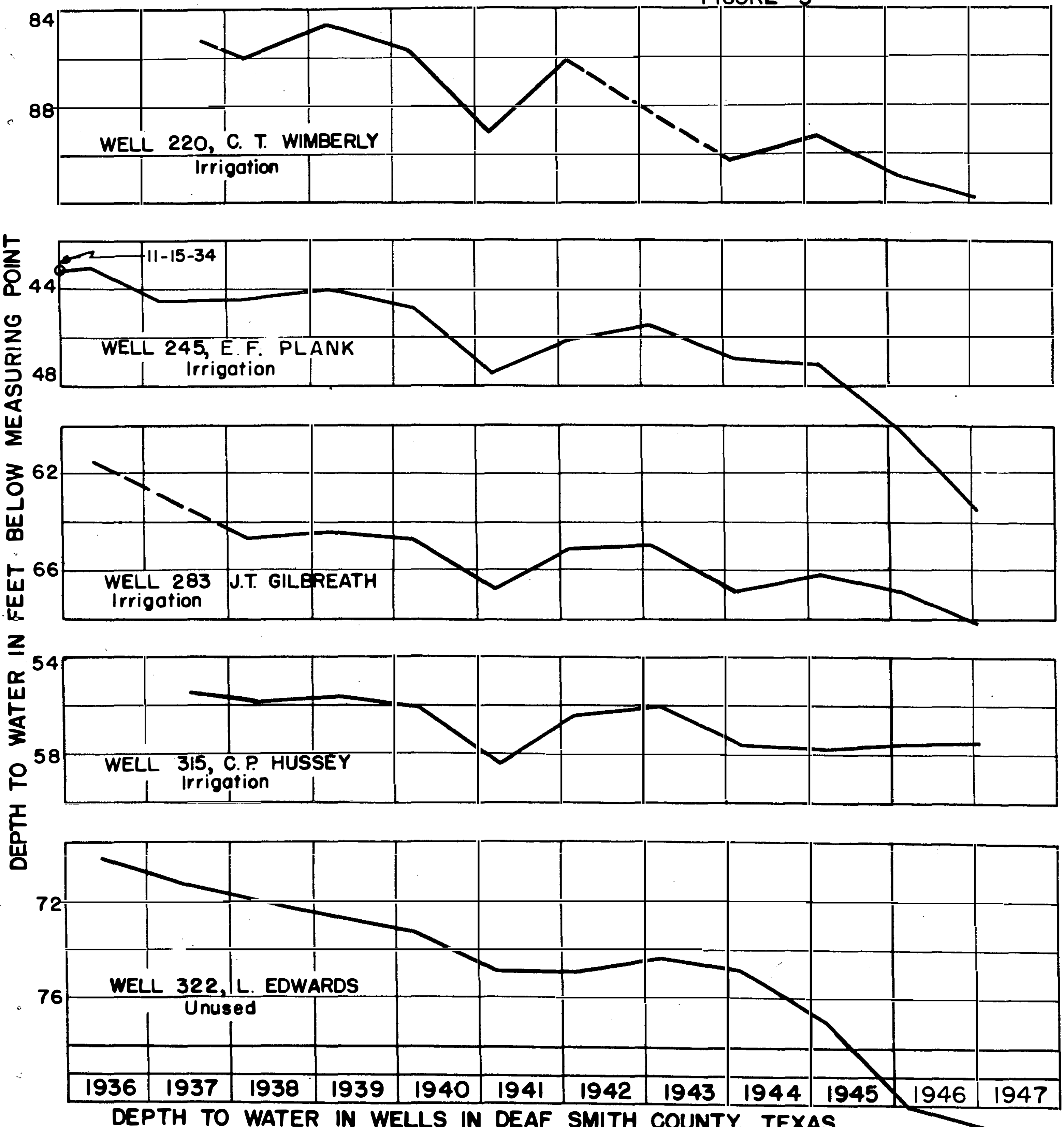
DEPTH TO WATER IN WELLS IN CASTRO COUNTY, TEXAS
(For location of wells see Fig. 1)

FIGURE 4



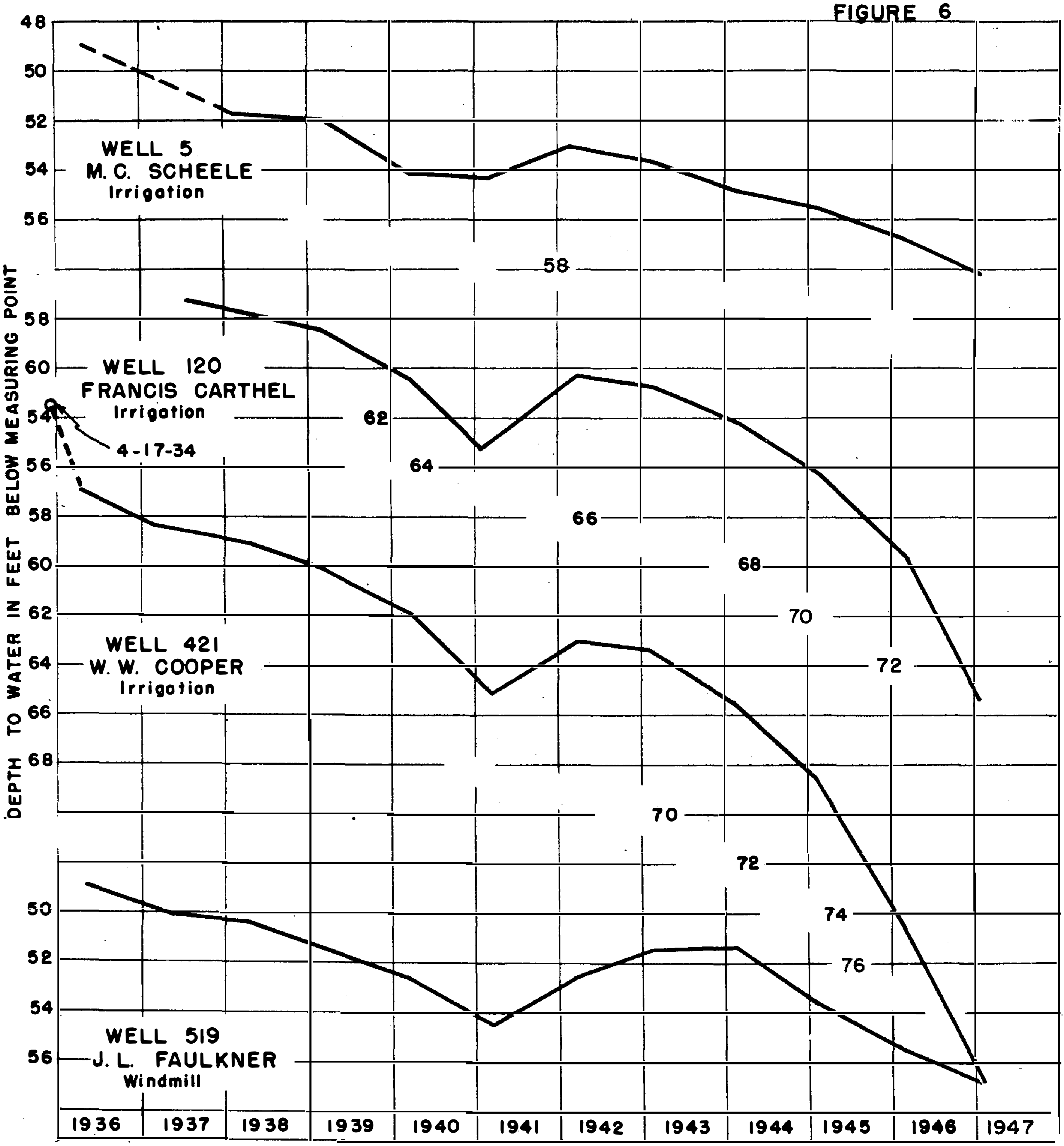
DEPTH TO WATER IN WELLS IN CROSBY & HOCKLEY COUNTIES, TEX.
(For location of wells see Fig. 1)

FIGURE 5

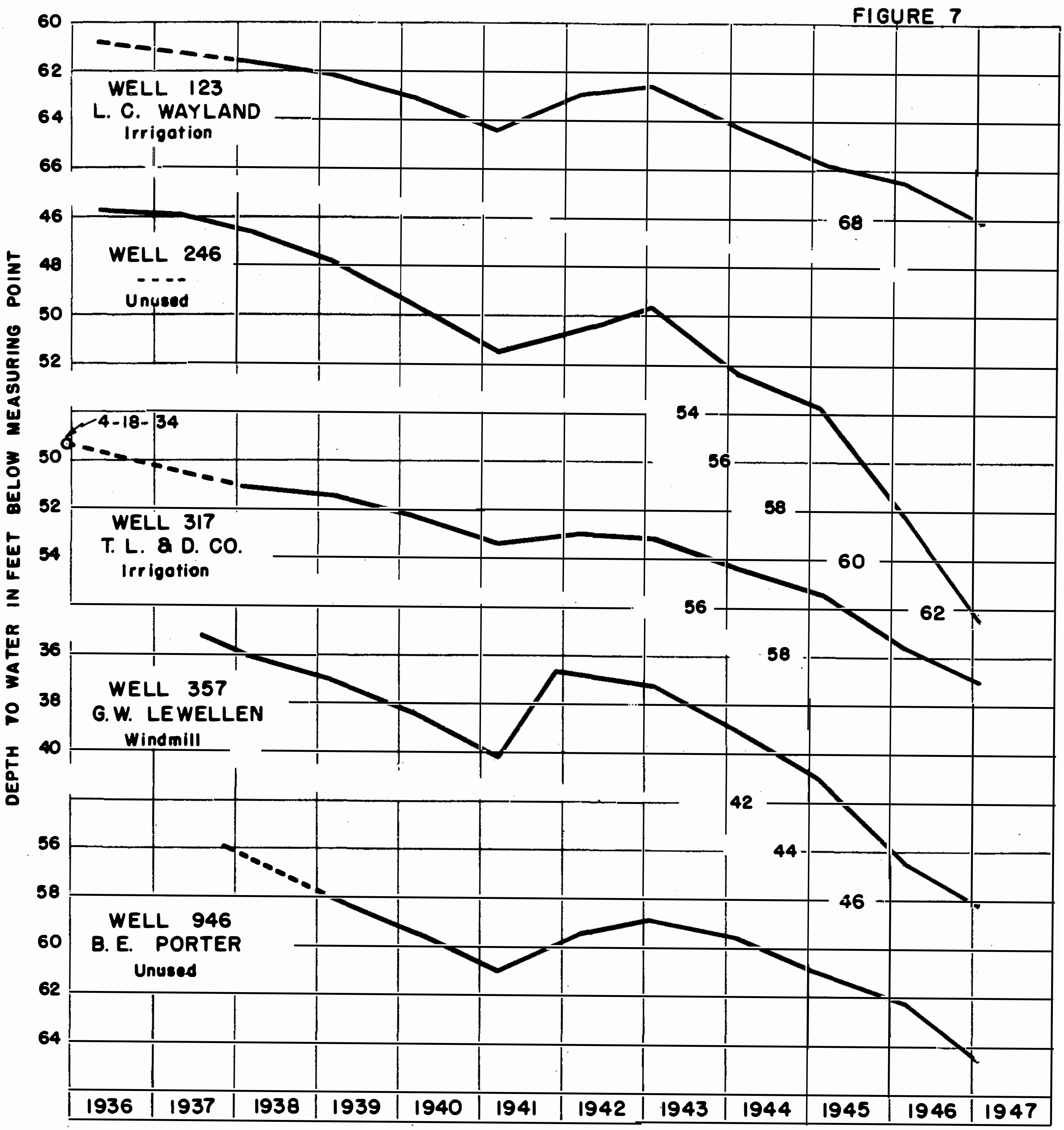


DEPTH TO WATER IN WELLS IN DEAF SMITH COUNTY, TEXAS
(For location of wells see Fig. 1.)

FIGURE 6

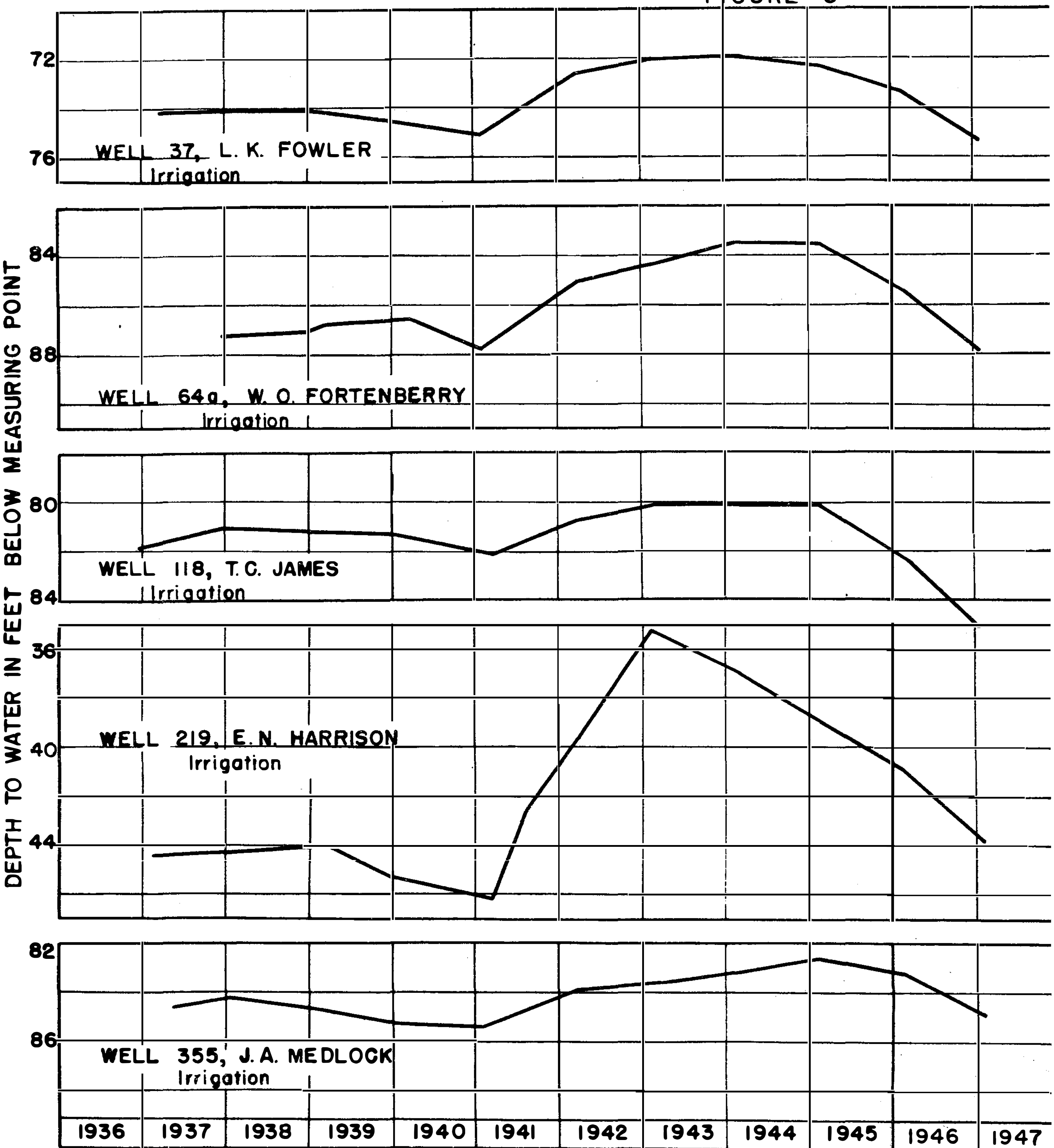


DEPTH TO WATER IN WELLS IN FLOYD COUNTY, TEXAS
(For location of wells see Fig. 1)



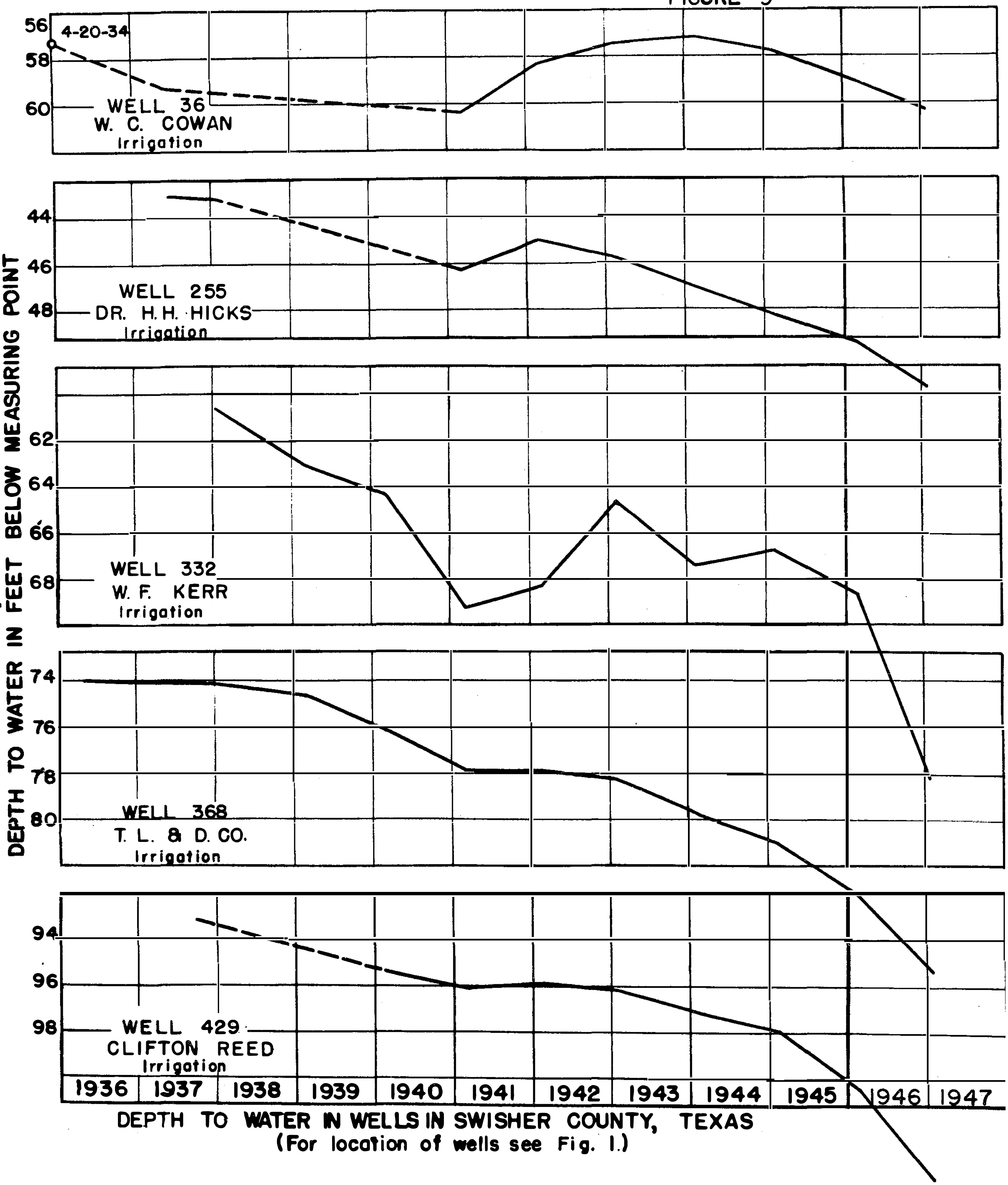
DEPTH TO WATER IN WELLS IN HALE COUNTY, TEXAS
(For location of wells see Fig. 1.)

FIGURE 8



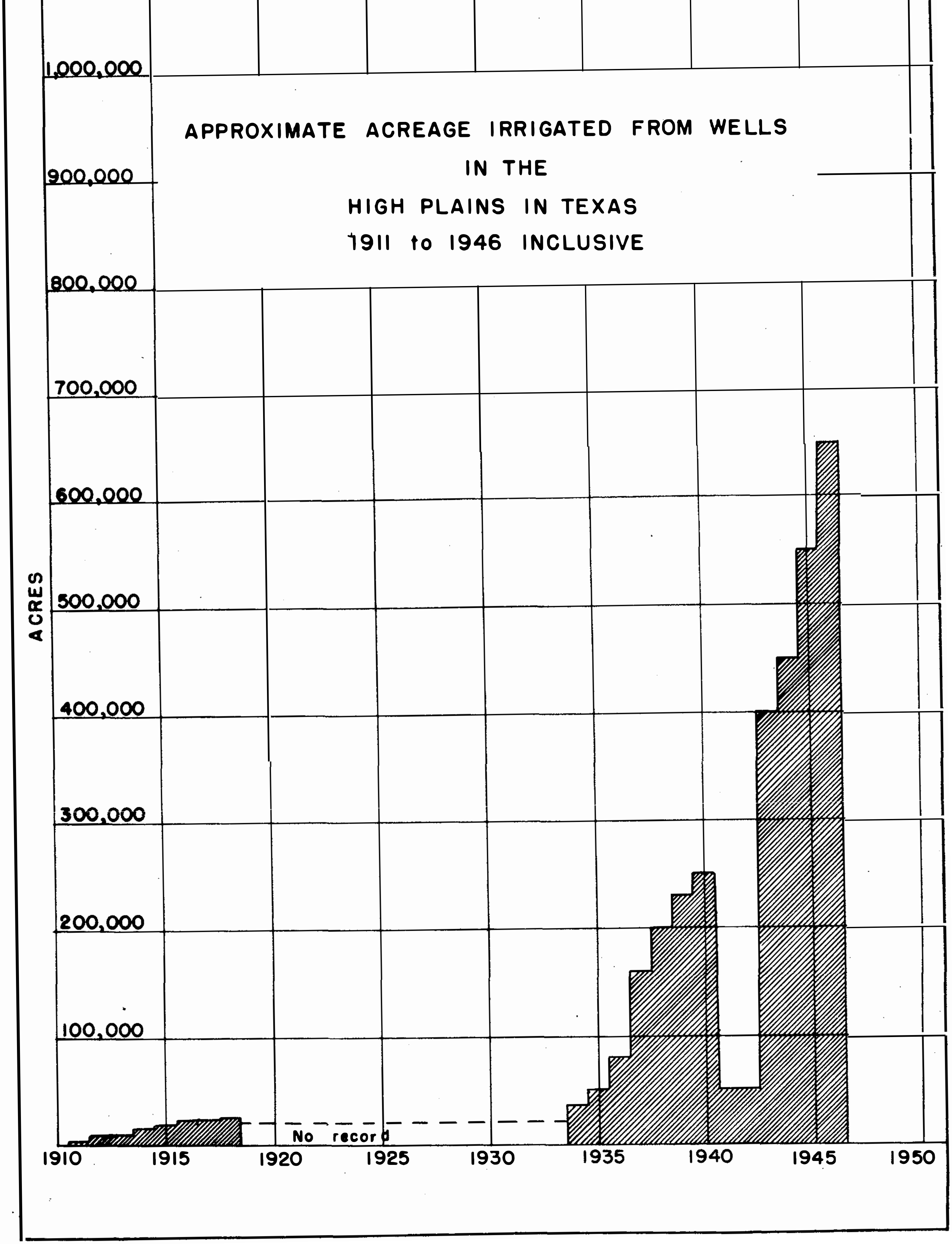
DEPTH TO WATER IN WELLS IN LUBBOCK COUNTY, TEXAS
(For location of wells see Fig. 1.)

FIGURE 9



DEPTH TO WATER IN WELLS IN SWISHER COUNTY, TEXAS
(For location of wells see Fig. 1.)

FIGURE 10


APPROXIMATE ACREAGE IRRIGATED FROM WELLS
IN THE
HIGH PLAINS IN TEXAS
1911 to 1946 INCLUSIVE
ACRES
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
No record
1910
1915
1920
1925
1930
1935
1940
1945
1950