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MEMORANDUM ON GROUND-WATER RESOURCES IN THE VICINITY OF CROWELL, TEXAS

By

W. O. George and C. E. Johnson

Prepared in cooperation with the Work Projects Administration and the United States Department of Interior, Geological Survey

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CONTENTS

ILLUSTRATIONS

MEMORANDUM ON GROUND-WATER RESOURCES IN THE VICINITY OF CROWELL, TEXAS

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INTRODUCTION

Location, area, and population

Crowell is near the center of Foard County in the north-central part of Texas, and is the county seat as well as the largest city in the county. The city was incorporated in 1907 and according to the U. S. Census Bureau the population was 1,817 in 1940. The area covered by this investigation includes all of Foard County but most of the work was confined to an area of several square miles along the Pease River and north of the town of Margaret.

Purpose of the investigation

The purpose of the investigation on which this report is based was to determine the possibility of developing a ground-water supply that would be adequate for the needs of Crowell either as a permanent and continuous supply or as an auxiliary supply during periods of drouth when the surface supply is inadequate.

Previous investigations

In the summer of 1936, the Board of Water Engineers in cooperation with the Geological Survey sponsored a project of the Work Projects Administration to make an inventory of the ground-water resources of Foard County. These data were published 1/ in May 1936. With the aid of this inventory, the writers were able to proceed directly with the investigations of the area nearest Crowell, most likely to yield adequate supplies of relatively good water. The area between the Pease River and the town of Margaret was selected for intensive investigations.

History of the water supply of Crowell

According to information obtained from some of the older residents of Crowell, the city obtained its water supply from 1907 to 1921 from a water well about a mile northeast of town, owned by Mr. E. G. Campsey. Mr. Campsey hauled the water in two 300-gallon tanks to consumers in various

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1/ Records of wells, chemical analyses, etc., in Foard County: Texas Board of Water Engineers, 1936.

parts of town and sold from 100 to 150 barrels a day at 25 cents a barrel.

In 1921 the city constructed a complete public water supply system including a standpipe, distributing lines and pumps. The water was obtained from two collecting galleries, one 100 feet long and the other 300 feet long, cut in sandstone across the head of a draw about two miles west of town. The initial yield of this plant was about 50,000 gallons a day. The plant is still in use but the yield is now about 10,000 gallons a day.

In 1926 a dam was built about three miles northwest of Crowell on Raggedy Creek. The reservoir was then 26 feet deep near the dam and had an estimated capacity of 100,000,000 gallons. The dam was raised six feet in 1936 and because of silting the reservoir is now 12 feet deep when full. During a severe drouth in the summer of 1936 various other pits and tunnels in the vicinity of the original pumping plant were constructed but the combined yield of all of the city's sources could not supply the needs of the city and 772,000 gallons of water were brought from Knox City in railway tank cars at a cost of $5,000. Heavy rains ended the drouth in September.

The average daily needs of the city are now about 150,000 gallons a day.

Organization

The present investigation was a project of the Fort Worth District of the Works Projects Administration sponsored by the State Board of Water Engineers in cooperation with the Federal Geological Survey and the City of Crowell. Carl E. Johnson was the field supervisor for the Work Projects Administration under the technical supervision of the author. The project was started August 27, 1940 and was completed April 11, 1941. In all 84 test wells were drilled, two of which were used for pumping tests and 12 for observation wells during the pumping tests. William L. Broadhurst and Clarence R. Follett of the Board of Water Engineers assisted in conducting the pumping tests. Mr. Follett also collected data from another similar area along the Pease River and from the City of Vernon for comparison with the data obtained from this investigation. The chemical analyses of water samples were made by the Work Projects Administration under the direction of E. P. Schoch, Director of the Texas Bureau of Industrial Chemistry, and E. W. Lohr, of the Quality of Water Division of the U. S. Geological Survey. Laboratory permeability tests and mechanical analyses of the material excavated from the wells were also made by the Work Projects Administration under the direction of A. A. Meador of the Texas Board of Water Engineers. All ground-water projects in Texas are made under the general direction of O. E. Meinzer, Geologist in Charge, of the Division of Ground Water.

Acknowledgment

The writers are indebted to the officials of the City of Crowell and the Work Projects Administration for their helpful cooperation.

Walter N. White, Senior Hydraulic Engineer in charge of ground-water

investigations in Texas, visited the project and has made helpful suggestions regarding plans for the work and the preparation of the report.

PRECIPITATION

The precipitation in inches at Crowell, Texas from 1916 to 1940 as recorded by the U. S. Weather Bureau is given in the following table:

Monthly, annual and average precipitation in inches Crowell, Foard County, Texas

Year:	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1916	--	--	--	--	--	--	--	1.00	2.75	2.32	1.44	0.00	--
1917	0.35	0.26	0.10	0.72	2.79	0.10	3.68	1.10	1.17	0.20	0.00	0.00	10.47
1918	0.60	0.58	1.27	1.11	0.10	2.83	0.47	0.20	2.91	4.93	1.55	2.83	19.38
1919	T.	1.84	4.10	5.38	8.67	0.00	4.85	0.80	1.45	11.90	T.	0.00	38.99
1920	1.60	0.75	2.00	1.50	2.25	1.75	0.50	8.00	3.40	4.15	1.54	0.50	27.94
1921	2.00	0.00	1.50	0.40	0.55	7.02	1.90	0.00	2.75	0.00	0.00	0.20	16.32
1922	0.62	0.55	0.85	5.75	3.52	1.00	1.55	0.00	1.50	0.60	0.60	0.00	16.54
1923	1.55	0.85	1.08	3.97	1.82	8.39	0.00	5.32	1.95	9.91	2.31	1.11	38.26
1924	0.00	0.30	3.09	2.28	0.64	4.55	1.85	0.20	1.90	1.97	0.10	0.00	16.88
1925	1.00	0.30	0.00	3.99	3.99	1.20	2.28	3.50	4.01	1.90	1.53	0.60	24.30
1926	1.20	0.00	3.10	4.65	4.30	3.85	3.30	4.27	5.40	2.94	0.50	3.45	36.96
1927	0.60	0.00	2.35	1.05	1.10	3.40	1.90	4.80	5.25	0.00	0.00	0.80	21.25
1928	0.22	2.53	0.92	0.22	3.22	5.80	1.80	1.20	0.00	2.05	0.98	0.00	18.94
1929	0.85	0.22	2.35	0.35	8.85	2.10	5.15	0.20	4.32	1.50	1.60	0.00	27.49
1930	0.78	0.00	1.70	2.90	1.80	0.00	0.00	0.75	1.20	8.08	1.10	3.90	22.21
1931	0.90	3.10	2.25	2.10	1.50	0.70	0.50	0.00	0.00	3.65	3.36	4.40	22.46
1932	2.33	1.66	0.00	2.05	1.06	4.85	3.74	4.25	0.55	1.53	0.20	4.25	26.47
1933	0.00	1.90	0.00	0.00	5.70	0.00	2.25	3.22	2.60	0.00	2.70	0.90	19.27
1934	0.95	0.30	2.90	2.20	3.60	1.55	0.25	3.00	2.90	0.40	2.78	0.00	21.83
1935	0.00	1.16	0.95	0.90	9.81	2.20	0.00	0.80	4.80	2.82	2.36	0.50	26.30
1936	0.40	0.40	0.00	2.15	1.99	0.00	0.00	0.20	13.10	1.10	0.00	0.43	19.77
1937	0.25	0.00	2.60	1.70	2.35	5.33	0.00	4.82	2.55	4.80	0.49	0.45	25.34
1938	0.86	3.54	2.05	0.77	9.66	5.63	0.00	2.22	0.00	0.80	1.20	0.10	26.83
1939	2.61	0.00	2.83	0.98	3.29	2.86	1.70	2.42	0.00	0.96	0.82	0.80	19.27
1940	0.60	2.25	0.00	3.20	4.23	1.00	1.83	4.22*	2.90	3.00	2.67	0.00	--
Average	0.84	0.93	1.58	2.30	3.61	2.76	1.56	2.26	2.62	2.86	1.19	1.01	23.32

The averages for each month show that the greater part of the precipitation falls during the spring and summer months and that November, December, January, and February are relatively dry months. Exceptions to this general trend emphasize the need for a more dependable supply. In 1936 only 0.20 inches of rain fell during the months of June, July, and August. It was at this time that the City was forced to haul water from Knox City. During the following month of September, the rainfall was 13.10 inches. The range of the annual precipitation during the 23 years of observation is from 10.47 to 38.99 inches.

* At Quanah.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

The formations exposed in Foard County belong to the Permian and Quaternary systems. The Permian rocks are exposed over a wide area in north Texas and in general yield very little water, most of which is of poor quality. These rocks are commonly called "red beds". Overlying the Permian in some places are more recent superficial deposits of sand, gravel, and clay which have been deposited by rivers and to a small extent by the wind. These deposits of alluvium are widespread in the eastern half of the county but are too thin in most places to yield much water. There are places along the main streams, however, where these deposits are thick enough to yield supplies large enough for irrigation and for cities. The City of Vernon, on the Pease River in Wilbarger County obtains its water supply exclusively from this kind of a deposit. Several irrigation wells in the northeast corner of Foard County obtain water from similar deposits. The alluvial area north of Margaret is also of similar origin.

In all, 81 test wells were drilled in the area north of Margaret (see fig. 1). These tests revealed that there is a great difference in the thickness of saturated sand in different parts of the area and that the areas of greater thickness are roughly linear as if the sediments had been deposited in old stream channels on the surface of Permian rocks.

The material excavated from the test wells in the alluvial area is predominantly sand and gravel. Balls of clay were found mixed with gravel in some wells. Some clay and sandy clay was encountered in nearly all of the wells but there are no persistent beds of any kind. The sand is predominantly quartz and most of the grains are well rounded. Pebbles up to two inches in diameter were found. The clays and sandy clays are red and a red color persisted in the water for some time after the start of each pumping test. No cementation of the material was noticed while drilling but there was a tendency for the excavated material to "cake" when left on the ground to dry. Logs of the test wells are included in this report.

The following are the results of mechanical analyses of material excavated from the saturated portion of test well 33. The analyses were made under the direction of Mr. A. A. Meador, Engineer, Texas Board of Water Engineers.

MECHANICAL ANALYSES OF SAMPLES FROM SATURATED PORTION OF AQUIFER IN WELL 33

Depth from which sample was taken (feet)	Size in millimeters - percent by weight									
	Larger than 9.42	9.42-6.68	6.68-3.33	3.33-1.65	1.65-0.83	0.83-0.42	0.42-0.21	0.21-0.15	0.15-0.07	0.07-0.05	Less than 0.05
21 to 24	1.1	0.5	2.8	4.2	9.3	40.7	32.5	4.6	2.6	1.0	0.7
24 to 28	1.5	0.0	5.3	6.8	9.8	40.1	30.9	2.1	2.0	0.5	0.1
28 to 33	4.4	2.5	9.0	9.7	11.7	25.6	26.3	5.5	3.4	1.5	0.4
33 to 42	16.3	0.9	2.9	2.7	6.0	37.6	26.6	2.3	3.8	0.7	0.2

DRILLING METHODS

All of the test wells were drilled by hand. The holes were drilled as deep as possible with an Iwan-type auger and as soon as caving started, 4-inch casing was inserted. The 4-inch casing was rotated in the hole and the cuttings were removed from the inside of the casing by means of a sand bucket. A collar with saw-tooth notches was placed at the lower end of the casing so that the pipe served as a drilling tool as well as casing. The casing was cut in lengths of seven feet to facilitate handling. Where beds of clay were encountered a drop auger was used to remove the material inside of the casing. A portable tripod was made of 3 pieces of 4 x 4-inch timbers 20 feet long. A pulley and manila line were used for handling the casing and drilling tools. As each hole was completed the casing was removed and the hole was refilled. It was necessary to use wooden clamps and hydraulic jacks to loosen the casing.

The two wells that were used for pumping tests, wells 33 and 50, required more elaborate equipment (see diagram in fig. 2). Well 50 was drilled in the manner described above and after it was selected as a site for a pumping test, it was re-drilled in a similar manner, using 8-inch casing which had been perforated with slots $\frac{1}{2}$-inch wide and 4 inches long. These slots were closely spaced so that only a skeleton of the original pipe remained. The pipe was then tightly wrapped with No. 9 wire. The slotted and wire-wrapped portion extended from the water table to the clay at the bottom of the hole.

Because of the small yield developed during the pumping test at well 50 a different method was tried for well 33. A much larger hole was drilled by means of an orange-peel bucket and 42-inch steel pipe, sections of which were bolted together. When the 42-inch hole was completed, perforated 12-inch casing was placed in the middle hole. The perforations were $\frac{1}{2}$ x 4-inch slots extending the full length of the saturated sand without wire wrapping. The space between the 12-inch casing and the 42-inch pipe was then filled with coarse gravel and the 42-inch casing was removed.

In both wells, large pits 10 feet deep were dug so that the centrifugal pump could be set nearer the water table. The walls of the pits were supported with timbers to prevent caving.

The arrangement of the observation wells is shown in figure 3. All of the observation wells used in the pumping test were drilled to the Permian clay with 4-inch casing excepting wells 77, 78, 83, and 85. Wells 77, 78, and 83 were drilled to 27, 24, and 34 feet respectively. In well 83 the casing was left in the hole. In all other observation wells ready-made sand points like those used in farm wells in sandy areas were placed inside the 4-inch casing and connected with small pipe which extended above the surface. The screened portion of each sand point was about three feet long. After the sand point was placed at the bottom of the hole, the space between the 4-inch casing and the sand point was filled with gravel and the casing removed. Each observation well was tested with a pitcher pump and by pouring water into the well. All of the observation wells responded to the test except well 83, which was therefore abandoned as an observation well.

QUALITY OF WATER

The quality of water available to the City of Crowell from various sources is indicated in the table of chemical analyses. The following data selected from this table shows the relative mineralization of the water from each source.

Source	Total solids in parts per million
City Reservoir, impounded surface water	600
City wells, San Angelo sandstone	838 a/
Well 64, San Angelo sandstone	5,934
Test wells, north of Margaret	286 to 2,028

a/ From inventory of 1936.

The sample from the City Reservoir was taken when the reservoir was full and probable represents maximum dilution.

The city wells in the San Angelo sandstone may also include surface seepage.

It is difficult to explain the wide range of mineralization of the water obtained from test wells north of Margaret. The values for each well in total parts per million of dissolved solids are shown in figure 4. A comparison between figure 1 and 4 shows that concentration of minerals in the water is in general inversely proportional to the thickness of the saturated portion of the sand.

One might conclude that the greater thickness of saturated sand and gravel permits more rapid movement of water and hence more dilution by recently acquired recharge. On this basis continued pumping might be expected to bring in some of the more highly mineralized water. In each of the two pumping tests samples were obtained at the beginning and at the end of the pumping period. No significant changes were indicated in the analyses. Continued pumping, however, might cause a gradual increase in the mineral content of the water after a longer period of time.

One of the unusual characteristics of the water in the alluvial area is the high percentage of nitrates found in the test wells. Concentration of nitrates often indicate pollution from organic sources or from commercial fertilizers used on the land. It was reported that no commercial fertilizers have been used in this area and the distribution of nitrates in this area bears no relation to human habitation, barn lots or other possible local sources of organic pollution. The concentration of nitrates appears to vary directly with the concentration of other minerals in each sample. These facts suggest that the nitrates were a part of the original sediments when they were deposited.

GROUND WATER IN THE ALLUVIAL AREA NORTH OF MARGARET

Pumping tests

Test wells 33 and 50 were redrilled and used as pumped wells. The arrangement of observation wells with reference to the pumped wells is shown in figure 3. Well 50 was chosen as the pumped well in the first test. A 3-inch centrifugal pump, powered by a gasoline motor, was placed in the pit. The discharge pipe extended above the surface and fire hose was attached to it to carry the water to a point about 200 feet east of the pumped well where the discharge was measured frequently by means of a 60 gallon steel barrel and a stop watch. Seven observation wells were placed in line north and south of the pumped well. Wells 76, 70, 71, 77 and 78 were north of well 50 in the general direction of the slope of the water table and wells 75 and 72 were south of well 50. The north wells were placed 25, 75, 150, 225, and 300 feet respectively from the pumping well. The south wells were 75 feet and 300 feet respectively from the pumping well. Well 82 was placed 75 feet west and well 83, 75 feet east of the pumping well. The water level in well 83 did not fluctuate with changes in the water table, in spite of efforts to produce circulation by means of a pitcher pump and by pouring water into the well, presumably because the casing was open only at the bottom. For that reason the well was not measured. Previous to the pumping test, the relative altitude of the measuring point was determined for each well by means of a level.

Water-level measurements were also made in farm wells in the area to detect any change in the level of the water surface from natural causes. It was observed that there was a maximum fluctuation of 0.02 foot in nearly all wells at the same time, which was probably due to the change in atmospheric pressure.

The pump in well 50 was started at 2:06 p.m., March 13, 1941, and continued until 8:00 a.m., March 23, except for one interruption of one hour and sixteen minutes beginning at 3:25 p.m., March 15. The average yield including shut-down time was 20 gallons a minute. The interruption in the pumping was caused by efforts to increase the yield of the well which apparently caused the pump to break suction. Measurements of all the observation wells were made frequently at the beginning of the test and at greater intervals after the first day. The drawdown and recovery curves for well 50 are shown in figure 5. Well 72 at the south end of the line, 300 feet from well 50, had a maximum drawdown of 0.19 foot and well 70, 300 feet north had a drawdown of 0.09 foot at the end of the pumping test. The drawdown curve shows that the "cone" of unwatered material extended beyond the observation wells farthest from the pumping well and that the ground-water divide was somewhat less than 75 feet south of the pumped well at the end of the pumping test.

A second pumping test was made at the site of test well 33. The site was selected because of the thickness of the saturated material found in the test hole and because of its favorable position with reference to the slope of the water table. It was designed to yield more water than was obtained in well 50 (see fig. 4). The well was pumped during the period from 10:24 a.m.,

April 2, 1941 to 7:27 a.m., April 7, a total of 7,023 minutes, during which the pump was idle 782 minutes. The rate of pumping varied between 23 gallons a minute and 45 gallons a minute. The amount of water pumped was 203,475 gallons, or 28.7 gallons a minute, for the entire pumping period, including shutdown time. Drawdown and recovery measurements were made in the pumped well and in observation wells 81, 82, and 84 as in the test at well 50.

Recharge

The alluvial area as shown in figure 1 covers about 4.2 square miles. With respect to ground water, it is an isolated unit. It is nearly surrounded by stream channels which drain surface water away from it so that the only water that reaches the water table must fall within the area as rain or snow. Beneath the alluvium are beds of relatively impermeable clay. Small amounts of water were found in some of the test wells below the alluvium and outside the alluvial area.

Conditions are unusually favorable for recharge in this area. The soil is sandy and it absorbs water easily. The drainage pattern is poorly developed and no streams cross the area. Sand dunes and sand ridges along the fences retard the run-off of rainfall. During the first pumping test a pit was dug some distance from the pumped well to receive the discharge, so that the rate of pumping could be measured. It was discovered that too much of the water was seeping into the ground to permit an accurate weir measurement. This is evidence that the rate of natural recharge is high.

Movement and discharge

The movement of ground water is in the direction of the slope of the water table and the rate of movement is proportional to the slope. The slope of the water table as indicated in figure 1 by the lines of equal altitude on the water surface, is about 20 feet to the mile. The water moves northeastward toward the river and is discharged chiefly by springs which issue from the alluvial material near its contact with the Permian clay 6 to 10 feet above the normal level of the river. Seeps of water were found along the river wherever this contact was observed. Locally, favorable channels seem to have developed which allow considerable volumes of water to issue as springs. Bledsoe Spring was measured with a weir and found to be discharging 40 gallons a minute but the slope of the river bank made it impossible to find places to set the weir at the other springs. However, it was estimated that Ross Spring was yielding about 20 gallons a minute and the spring at the railroad crossing about 10 gallons a minute. The total discharge of the springs and seeps was estimated to be 200 gallons a minute in August 1940, after a comparatively dry season. The springs have never been known to fail and are reported not to vary much in volume.

Some of the water in the alluvium is probably discharged by transpiration. Nearly all of the area, except the sand dunes, is under cultivation, the chief crops being corn and cotton. The sand dunes support a few scrub oak trees. Therefore, the loss of water by transpiration throughout most of the area is probably not greater than the average for other areas. Along the river where there is a dense growth of willow trees and bush the roots of these trees reach the water table and a considerable volume of water is probably transpired. Considerable amounts of water are also probably lost from the soil by evaporation. Water from light showers is probably evaporated without adding to ground-water storage.

The discharge from farm wells in the area, all of which are shown on figure 1, is probably small. The area may be considered as a unit in which the ground-water system is in natural balance. In this case the amount of water issuing as seeps and springs represents excess recharge over other natural discharge.

Recent measurements of water levels in farm wells in the area show little change from the measurements made in 1936 during a severe drouth.

On the basis of similar areas elsewhere, it was estimated that each cubic foot of saturated material should yield approximately 15 percent of its volume in water or about 1.2 gallons. At this rate the yield per acre for each foot of drawdown would amount to about 50,000 gallons.

The area covered by the reservoir is about 4.2 square miles. At the edges of the area the thickness of the saturated material tapers to a few inches; in the better parts of the area the saturated material is from 15 to 24 feet thick.

CONCLUSIONS

The sands of the alluvial area north of Margaret are believed to contain the most abundant supply of ground water available to Crowell within ten miles of the city. The underground reservoir in these sands is supplied by rainfall on the alluvial area itself. The reservoir is in a state of approximate equilibrium in that the average annual intake from rainfall is balanced by an approximately equal average annual discharge through the springs and seeps near the Pease River. It is estimated that this discharge amounted to about 200 gallons a minute at the time of the investigation which was made at the close of a year of less than average rainfall.

The investigation has shown that the water-bearing sands are relatively permeable and should yield water rather freely to properly constructed wells. Under this condition of equilibrium it is obvious that the amount of water that can be recovered from wells over a long period of years is limited to the quantity that can be intercepted from the discharge of the seeps and springs.

A very large quantity of water is stored in the saturated sands of the area. When pumping is first started the surface of the ground water at the wells will decline and practically all of the water withdrawn by the pumps will come from storage. As pumping progresses the depression in the water table will continue to deepen and expand. More and more water which normally escapes toward the springs will be drawn toward the wells. Thus the natural discharge will be decreased as the water table is lowered but it can not be stopped entirely unless a very large number of wells are drilled and the water table is lowered to the bottom of the water-bearing sands. This could not be accomplished at a cost that would be economically feasible. If 50 percent of the estimated flow of the springs could be recovered continuously from wells, an average of approximately 140,000 gallons a day would become available for Crowell. The maximum recovery can best be accomplished by placing the wells where the greatest saturated thickness of sand was found in the test wells, apparently in channels in the underlying "red beds" surface; and by spacing the wells at considerable distances apart.

The chemical character of the water on the average is probably better than that of any other ground water within a radius of 10 miles of Crowell. In general the mineral content of the water was lowest in the areas where the test wells showed the greatest thickness of saturated material. If these areas were developed to the extent that would cause a widespread lowering of the water table, the mineral content of the water might increase gradually but it is not likely that it would reach the high concentration found in some of the test wells.

LOGS OF TEST WELLS

1. Flat, City of Crowell, H. & T. C. Ry. Co. sur., ½ mile west of Crowell.

	Thickness (feet)	Depth (feet)
Hard sandy red clay	18	18
Gray sand, water bearing	1¼	19½
Hard brittle red shale	16⅝	36
Red clay with blue-gray spots	2	38

Water level, 15 feet below ground level, 24 hours after hole completed. Aug. 30, 1940.

2. Foard County, 1,300 feet east of SW cor. sec. 362, H. & T. C. Ry. Co. sur., blk. A. Altitude at surface, 1362.4 feet.

Coarse-grained red sand	11	11
Red gravel and clay	4	15
Coarse-grained red sand	9	24
Hard red clay	2	26
Red sand and gravel	10	36
Hard cemented gravel	2	38

Water level, 34 feet below ground level, 24 hours after hole completed. Sept. 6, 1940.

3. Hillside, Foard County, 1,800 feet east of SW cor. sec. 362, H. & T. C. Ry. Co. sur., blk. A. Altitude at surface, 1357.4 feet.

Coarse-grained red sand	9	9
Red clay and gravel	3	12
Coarse-grained red sand	5	17
Red sand and pea gravel	1	18
Medium-grained sharp clean dry light-red sand	4	22
Red sand and small gravel	2	24
Hard cemented gravel		24

4. Flat, Foard County, 2,400 feet east of SW cor. sec. 362, H. & T. C. Ry. Co. sur., blk. A. Altitude at surface, 1347.4 feet.

Red sand	4	4
Red gravel and sand	5	9
Coarse-grained dry red sand	2	11
Red sand and gravel	4	15
Cemented red gravel		15

No water.

5. Flat, Foard County, 1,100 feet east of SW cor. sec. 357, H. & T. C. Ry. Co. sur., blk. A. Altitude at surface, 1330.8 feet.

	Thickness (feet)	Depth (feet)
Sandy red clay	2	2
Coarse-grained red sand	13	15
Coarse wet gravel	4	19
Pea gravel and sand	1	20
Bird's eye clay	2	22

Water level, 16.4 feet below ground level, 24 hours after hole completed. Sept. 13, 1940.

6. Flat, Foard County 1,650 feet east of SW cor. sec. 357, H. & T. C. Ry. Co. sur., blk. A. Altitude at surface, 1329.5 feet.

Coarse-grained red and yellow sand	7	7
Red sand and gravel	8	15
Wet gravel	2	17
Red sand and gravel	1	18
Bird's eye red clay	2	20

Water level, 17.9 feet below ground level, 24 hourse after hole completed. Sept. 12, 1940.

7. Flat, Foard County, 2,650 feet east of SW cor. sec. 357, H. & T. C. Ry. Co. sur. Altitude at surface, 1320.5 feet.

Coarse-grained sandy red clay	8	8
Coarse-grained red sand	3	11
Coarse-grained white sand	5	16
Wet gravel and sand	6	22
Bird's eye clay	2	24

Water level, 18 feet below ground level, 24 hours after hole completed. Sept. 15, 1940.

8. Flat, 2,500 feet east of SW cor. sec. 357, H. & T. C. Ry. Co. sur. Altitude at surface 1330.7 feet.

Coarse-grained red sand	8	8
Coarse-grained white sand	6	14
Dry gravel and sand	2	16
Coarse-grained wet white sand	2	18
Wet sand and gravel	1	19
Bird's eye red clay	2	21

(Continued on next page)

Well 8 -- Continued

	Thickness (feet)	Depth (feet)
Water level, 16 feet below ground level, 24 hours after hole completed. Sept. 16, 1940.		

9. Flat, Foard County, 3,000 feet east of SW cor. sec. 357, H. & T. C. Ry. Co. sur. Altitude at surface, 1330.0 feet.

Sandy red clay	11	11
Red sand and gravel	5	16
Coarse-grained white sand	1	17
Coarse-grained red gravel	2	19
Bird's eye red clay	3	22
Water level, 15.7 feet below ground level, 24 hours after hole completed. Sept. 17, 1940.		

10. Flat, Foard County, 3,500 feet east of SW cor. sec. 357, H. & T. C. Ry. Co. sur. Altitude at surface, 1327.8 feet.

Sandy red clay	6	6
Hard white clay	2	8
Coarse-grained brown sand	2	10
Fine pea gravel	1	11
Coarse gravel	2	13
Coarse gravel and sand	4	17
Bird's eye clay	2	19
Water level, 15 feet below ground level, 24 hours after hole completed. Sept. 17, 1940.		

11. Flat, Foard County, 3,500 feet east of SW cor. sec. 357, H. & T. C. Ry. Co. sur. Altitude at surface, 1327.8 feet.

Coarse-grained red sand	5	5
Coarse-grained gray sand	3	8
Coarse gravel	2	10
Gray gravel and sand	4	14
Bird's eye red clay	2	16
Struck rock at 13.5 feet. Water level, 13.5 feet below ground level, 24 hours after hole completed. Sept. 18, 1940.		

12. Flat, Foard County, 4,000 feet east of SW cor. sec. 357, H. & T. C. Ry. Co. sur. Altitude at surface, 1327.7 feet.

Well 12 -- Continued

	Thickness (feet)	Depth (feet)
Fine-grained red sand	10	10
Coarse-grained white sand	1	11
Coarse-grained red sand	3	14
Red sand and gravel	1	15
White sand and gravel	3	18
Bird's eye clay	6	24
Struck rock at 18 feet. Water level, 17.4 feet below ground level, 24 hours after hole completed. Sept. 20, 1940.		

13. Flat, Foard County, 5,000 feet east of SW cor. sec 357, H. & T. C. Ry. Co. sur. Altitude at surface, 1327.2 feet.

Fine-grained red sand	10	10
Red sand and gravel	4	14
Red gravel and sand	4	18
Bird's eye red clay	15	33
Struck first water in clay at 27 feet. Water level, 18 feet below ground level, 24 hours after hole completed. Sept. 20, 1940.		

14. Flat, Foard County, SE cor. sec. 357, H. & T. C. Ry. Co. sur. Altitude at surface, 1325.1 feet.

Fine-grained red sand	12	12
Coarse-grained red sand	2	14
Gray gravel and sand	2	16
Coarse-grained gravel	1	17
Red clay and gravel	3	20
Coarse-grained gray gravel	2	22
Pea gravel and sand	6	28
Bird's eye clay	4	32
Struck water at 17 feet. Water level, 15.7 feet below ground level, 24 hours after hole completed. Sept. 22, 1940.		

15. Flat, Foard County, 500 feet east of SE cor. sec. 357, H. & T. C. Ry. Co. sur. Altitude at surface, 1325.0 feet.

Fine-grained red sand	12	12
Gray sand and gravel	4	16
Coarse-grained gray sand	2	18
Gray sand and gravel	2	20
Sandy red clay	2	22
Coarse-grained red sand	5	27
Coarse-grained white sand	2	29
Bird's eye clay	3	32
Struck water at 19 feet. Water level, 17.5 feet below ground level, 24 hours after hole completed. Sept. 26, 1940.		

16. Flat, Foard County, 1,000 feet east of SW cor. sec. 357, H. & T. C. Ry. Co. sur. Altitude at surface, 1318.5 feet.

	Thickness (feet)	Depth (feet)
Fine-grained red sand	11	11
Fine-grained gray sand	1	12
Coarse-grained red sand	1	13
Red gravel and sand	1	14
Large red gravel	2	16
Bird's eye clay	6	22

Struck water at 17 feet. Water level, 16.4 feet below ground level, 24 hours after hole completed. Sept. 28, 1940.

17. Flat, Foard County, 1,500 feet east of SW cor. sec. 357, H. & T. C. Ry. Co. sur. Altitude at surface, 1317.2 feet.

Fine-grained red sand	12	12
Coarse-grained yellow sand	2	14
Bird's eye clay	11	25

Struck water at 20 feet. Water level, 18.7 feet below ground level, 24 hours after hole completed. Sept. 30, 1940.

18. Flat, Foard County, 3,600 feet east of SW cor. sec. 357, H. & T. C. Ry. Co. sur. Altitude at surface, 1333.5 feet.

Fine-grained red sand	8	8
Sandy red clay	3	11
Coarse-grained gray sand	4	15
White sand	1	16
White sand and gravel	3	19
Red sand and gravel	2	21
Coarse-grained red sand	5	26
Red clay	2	28
Cemented gravel		

Oct. 2, 1940. No water.

19. Flat, Foard County, near center sec. 325, along railroad, H. & T. C. Ry. Co. sur. Altitude at surface, 1323.8 feet.

Sandy red clay and caliche	10	10
Coarse-grained white sand	2	12
White sand and gravel	3	15
Red sand and gravel	1	16
White sand	2	18
Red sand and gravel, 1½-inch pebbles	7	25
Bird's eye clay	1	26

Struck water at 18 feet. Water level, 17.3 feet below ground level, 24 hours after hole completed. Oct. 4, 1940.

20. Flat, Foard County, 1,000 feet northeast of NE cor. sec. 355, H. & T. C. Ry. Co. sur. Altitude at surface, 1329.3 feet.

	Thickness (feet)	Depth (feet)
Fine-grained brown sand	5	5
Reworked red clay and caliche	2	7
Fine-grained red sand	2	9
Big gravel	1	10
Caliche	2	12
Bird's eye clay	6	18

Struck water at 16 feet. Water level, 15.01 feet below ground level, 24 hours after hole completed. Oct. 5, 1940.

21. Flat, Foard County, SE cor. sec. 325, H. & T. C. Ry. Co. sur. Altitude at surface, 1333.2 feet.

Red sand	2	2
Coarse-grained yellow sand	3	5
Reworked red clay and caliche	6	11
Coarse-grained sand and gravel	1	12
Fine-grained red sand	1	13
Coarse-grained red sand	9	22
Red sand and gravel	4	26
Bird's eye clay	1	27

Struck water at 17 feet. Water level, 15.05 feet below ground level, 24 hours after hole completed. Oct. 6, 1940.

22. Flat, Foard County, 500 feet west of SE cor. sec. 325, H. & T. C. Ry. Co. sur. Altitude at surface, 1335.2 feet.

Fine-grained red sand	5	5
Coarse-grained red sand and clay	9	14
Sand and gravel	1	15
Coarse-grained red sand	2	17
Reworked yellow clay	1	18
Sandy clay and gravel	5	23
Coarse-grained red sand	6	29
Red sand and gravel	4	33
Bird's eye clay	1	34

Struck water at 18 feet. Water level, 18.7 feet below ground level, 24 hours after hole completed. Oct. 7, 1940.

23. Flat, Foard County, 1,000 feet west of SE cor. sec. 325, H. & T. C. Ry. Co. sur. Altitude at surface, 1335.0 feet.

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Well 23 -- Continued

	Thickness (feet)	Depth (feet)
Fine-grained red sand	5	5
Fine-grained brown sand	5	10
Coarse-grained red sand and clay	5	15
Red sand and gravel	1	16
Coarse-grained red sand	7	23
Sand and gravel, large pebbles	7	30
Gravel	3	33
Bird's eye clay	1	34

Water level 19.15 feet below ground level, 24 hours after hole completed. Oct. 8, 1940.

24. Flat, Foard County, 1,500 feet west of SE cor. sec. 325, H. & T. C. Ry. Co. sur. Altitude at surface, 1340.6 feet.

Red sand and clay	9	9
Reworked red clay and caliche	6	15
Coarse-grained red sand	2	17
Sand and gravel	2	19
Coarse-grained yellow sand	4	23
Coarse-grained red sand	7	30
Bird's eye clay	2	32

Struck water at 21 feet. Water level, 20.17 feet below ground level, 24 hours after hole completed. Oct. 10, 1940.

25. Flat, Foard County, 2000 feet west of SE cor. sec. 325, H. & T. C. Ry. Co. sur. Altitude at surface, 1341.6 feet.

Coarse-grained hard red sand	5	5
Red clay and sand	8	13
Fine-grained red sand	2	15
Fine-grained brown sand	5	20
Red sand and gravel, large pebbles	1	21
Fine-grained light-red sand	10	31
Sand and pea gravel	5	36
Bird's eye clay	1	37

Struck water at 25 feet. Water level, 23.75 feet below ground level, 24 hours after hole completed. Oct. 11, 1940.

26. Flat, Foard County, 2,500 feet west of SE cor. sec. 325, H. & T. C. Ry. Co. sur. Altitude at surface 1340.8 feet.

	Thickness (feet)	Depth (feet)
Hard red sand	5	5
Red clay and sand	8	13
Fine-grained red sand	2	15
Fine-grained brown sand	5	20
Red sand and gravel	1	21
Coarse-grained light-red sand	10	31
Sand and pea gravel	5	36
Bird's eye clay	1	37

Struck water at 32 feet. Water level, 21.2 feet below ground level, 24 hours after hole completed. Oct. 13, 1940.

27. Flat, Foard County, 3,000 feet west of SE cor. sec. 325, H. & T. C. Ry. Co. sur. Altitude at surface, 1340.8 feet.

Fine-grained yellow sand	4	4
Reworked red clay	9	13
Brown sand	7	20
Red clay and gravel	5	25
Pea gravel	5	30
Red sand, clay and gravel	3	33
Bird's eye clay	1	34

Struck water at 25 feet. Water level, 21.8 feet below ground level, 24 hours after hole completed. Oct. 15, 1940.

28. Flat, Foard County, 3,500 feet west of SE cor. sec. 325, H. & T. C. Ry. Co. sur. Altitude at surface, 1349.6 feet.

Fine-grained yellow sand	6	6
Gray sand	6	12
Red clay and gravel	2	14
Sandy red clay	7	21
Yellow sand	7	28
Red sand and boulders	1	29
Sandy red clay	8	37
Red sand and gravel	3	40
Bird's eye clay	1	41

Struck water at 30 feet. Water level, 29.95 feet below ground level, 24 hours after hole completed. Oct. 16, 1940.

29. Foard County, SE cor. sec. 363, H. & T. C. Ry. Co. sur. Altitude at surface, 1358.0 feet.

	Thickness (feet)	Depth (feet)
Coarse-grained yellow sand	12	12
Sandy red clay	10	22
Bird's eye red clay	8	30

Water level, 20.5 feet below ground level, 24 hours after hole completed. Oct. 22, 1940.

30. Flat, Foard County, 1,500 feet north of SE cor. sec. 363, H. & T. C. Ry. Co. sur. Altitude at surface, 1333.8 feet.

Coarse-grained red sand	10	10
Bird's eye clay	20	30

Water level, 20.8 feet below ground level, 24 hours after hole completed. Oct. 24, 1940.

31. Flat, Foard County, 1,500 feet west of SE cor. sec. 363, H. & T. C. Ry. Co. sur. Altitude at surface, 1365 feet.

Coarse-grained red sand	7	7
Sandy gray clay	6	13
Coarse-grained red sand	3	16
Wet red clay	5	21
Bird's eye clay	3	24

Struck water at 16 feet. Water level, 14.95 feet below ground level, 24 hours after hole completed. Oct. 26, 1940.

32. Flat, Foard County, 1,300 feet east of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1333.6 feet.

Coarse-grained red sand	5	5
Red sand and clay	3	8
Coarse-grained red sand pebbles	4	12
Red sand and gravel	4	16
Coarse-grained white sand	1	17
Coarse-grained white sand and gravel	2	19
Coarse-grained gray sand	6	25
White sandstone	1	26
Red sand and gravel	2	28
Bird's eye clay	1	29

Struck water at 23 feet. Water level, 19.25 feet below ground level, 24 hours after hole completed. Nov. 1, 1940.

33. Flat, Foard County, 1,800 feet north of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1329.2 feet.

	Thickness (feet)	Depth (feet)
Gray sand	5	5
Sandy red clay	5	10
Coarse-grained red sand	2	12
Red sand and pea gravel	2	14
White sand and pea gravel	4	18
Red clay and pea gravel	1	19
Gray sand and gravel, large pebbles	1	20
Tan-colored sand	4	24
Coarse-grained sand and gravel	4	28
Fine-grained gray sand	2	30
Sand and gravel, large pebbles	4	34
Sand and gravel	5	39
Bird's eye clay	1	40

Struck water at 21 feet. Water level, 19.9 feet below ground level, 24 hours after hole completed. Nov. 4, 1940.

34. Flat, Foard County, 500 feet southwest of SE cor. sec. 356, along railroad, H. & T. C. Ry. Co. sur. Altitude at surface 1338.3 feet.

Coarse-grained red sand	3	3
Sandy gray clay	2	5
Coarse-grained gray sand	2	7
Fine-grained yellow sand	5	12
Red clay and sand	1	13
Yellow sand and gravel	4	17
Coarse-grained red sand	5	22
Coarse-grained yellow sand	3	25
Coarse-grained white sand and gravel	2	27
Coarse-grained red sand	7	34
Red sand and gravel	2	36
Cobble gravel, 4-inch pebbles	2	38
Bird's eye clay	2	40

Struck water at 23 feet. Water level, 19.6 feet below ground level, 24 hours after hole completed. Nov. 16, 1940.

35. Flat, Foard County, 1,000 feet southwest of SE cor. sec. 356, along railroad, H. & T. C. Ry. Co. sur. Altitude at surface, 1341.8 feet.

Coarse-grained red sand	5	5
Red sand and clay	8	13
Fine-grained tan colored sand	5	18

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Well 35 -- Continued

	Thickness (feet)	Depth (feet)
Coarse-grained wet sand	10	28
Red sand and pea gravel	2	30
Red sand	4	34
Red sand and gravel	2	36
Bird's eye clay	2	38

Water level, 19.35 feet below ground level, 24 hours after hole completed. Nov. 17, 1940.

36. Flat, Foard County, 1,500 feet southwest of SE cor. sec. 356, along railroad, H. & T. C. Ry. Co. sur. Altitude at surface, 1344.8 feet.

Red sand and clay	7	7
Reworked red clay	6	13
Red sand and clay	5	18
Coarse-grained gray sand	3	21
Red sand and clay	9	30
Coarse-grained red sand and gravel	1	31
Sand and pea gravel	2	33
Red clay and gravel	2	35
Bird's eye clay	1	36

Struck water at 25 feet. Water level, 21.0 feet below ground level, 24 hours after hole completed. Nov. 18, 1940.

37. Flat, Foard County, 2,000 feet southwest of SE cor. sec. 356, along railroad, H. & T. C. Ry. Co. sur. Altitude at surface, 1346.3 feet.

Coarse-grained red sand	10	10
Red clay and sand	4	14
Fine-grained yellow sand	3	17
Red sand and pea gravel	10	27
Pea gravel	6	33
Red clay and gravel	3	36
Bird's eye clay	4	40

Struck water at 23 feet. Water level, 22.9 feet below ground level, 24 hours after hole completed. Nov. 20, 1940.

38. Flat, Foard County, 2,500 feet southwest of SE cor. sec. 356, along railroad, H. & T. C. Ry. Co. sur. Altitude at surface, 1353.1 feet.

Well 38 -- Continued

	Thickness (feet)	Depth (feet)
Coarse-grained red sand	7	7
Coarse-grained white sand	3	10
Coarse-grained yellow sand	10	20
Coarse-grained red sand	4	24
Red sand and gravel	2	26
Fine-grained dark-red sand	1	27
Coarse-grained red sand	2	29
Coarse-grained red sand and yellow sand	6	35
Sandy white clay	2	37
Reworked red clay	1	38
Bird's eye clay	2	40

Struck water at 28 feet. Water level, 26.7 feet below ground level, 24 hours after hole completed. Nov. 22, 1940.

39. Flat, Foard County, 3,000 feet southwest of SE cor. sec. 356, along railroad, H. & T. C. Ry. Co. sur. Altitude at surface, 1352.6 feet.

Coarse-grained red sand	6	6
Yellow sand and clay	4	10
Coarse-grained red sand	7	17
Red sand and clay	8	25
Coarse-grained red sand	8	33
Bird's eye clay	1	34

Struck water at 27 feet. Water level, 25.7 feet below ground level, 24 hours after hole completed. Nov. 23, 1940.

40. Flat, Foard County, 3,500 feet southwest of SE cor. sec. 356, along railroad, H. & T. C. Ry. Co. sur. Altitude at surface, 1362.3 feet.

Fine-grained yellow sand	9	9
Red sand and gravel	10	19
Reworked red clay	7	26
Sticky blue clay	1	27
Bird's eye clay	1	28

Struck water at 24 feet. Water level, 23.6 feet below ground level, 24 hours after hole completed. Nov. 24, 1940.

41. Flat, Foard County, 1,800 feet east of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1332.6 feet.

(Continued on next page)

41 - Continued

	Thickness (feet)	Depth (feet)
Coarse-grained hard red sand	9	9
Sandy red clay	7	16
Coarse-grained red sand and gravel	5	21
Coarse-grained yellow sand	6	27
Sandy red clay and gravel	5	32
Pea gravel	2	34
Bird's eye clay	2	36

Struck water at 23 feet. Water level, 19.9 feet below ground level, 24 hours after hole completed. Nov. 25, 1940.

42. Flat, Foard County, 1,000 feet south of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1333.2 feet.

Coarse-grained yellow sand	6	6
Sandy red clay	4	10
Coarse-grained red sand	3	13
Fine-grained red sand	6	19
Coarse-grained gray sand	3	22
Sticky blue clay	1	23
Bird's eye clay	1	24

Water level, 18.2 feet below ground level, 24 hours after hole completed. Nov. 26, 1940.

43. Flat, Foard County, 1,500 feet south of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1338.1 feet.

	Thickness (feet)	Depth (feet)
Coarse-grained red sand	2	2
Coarse-grained yellow sand	6	8
Red sand and clay	4	12
Coarse-grained yellow sand	6	18
Sandy red clay	3	21
Bird's eye clay	1	22

Struck water at 20 feet. Water level, 18.2 feet below ground level, 24 hours after hole completed. Nov. 30, 1940.

44. Flat, Foard County, 2,000 feet south of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1342.1 feet.

	Thickness (feet)	Depth (feet)
Coarse-grained red sand	2	2
Reworked soft red clay	15	17
Red clay	4	21
Bird's eye clay	2	23

Struck water at 19 feet. Water level, 17.8 feet below ground level, 24 hours after hole completed. Dec. 1, 1940.

45. Flat, Foard County, 2,500 feet south of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1340.6 feet.

Reworked red clay	14	14
Bird's eye clay	9	23

Struck water at 23 feet. Water level, 22 feet below ground level, 24 hours after hole completed, Dec. 2, 1940.

46. Flat, Foard County, 3,800 feet south of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1340.6 feet.

Coarse-grained yellow sand	9	9
Red clay and gravel	8	17
Coarse-grained red sand	1	18
Coarse-grained white sand	4	22
Red clay	11	33
Bird's eye clay	1	34

Struck water at 31 feet. Water level, 26.9 feet below ground level, 24 hours after hole completed, Dec. 3, 1940.

47. Flat, Foard County, 2,500 feet east of SE cor. sec. 356, T. & T. C. Ry. Co. sur. Altitude at surface 1328.1 feet.

Coarse-grained yellow sand	7	7
Red clay and gravel	4	11
Coarse-grained red sand	5	16
Coarse-grained sand and gravel	2	18

Well 47 -- Continued

	Thickness (feet)	Depth (feet)
Fine-grained red sand	10	28
Coarse-grained red sand and pea gravel	9	37
Bird's eye clay	1	38

Struck water at 16.0 feet. Water level, 16.0 feet below ground level, 24 hours after hole completed. Dec. 4, 1940.

48. Flat, Foard County, 3,200 feet east of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1330.6 feet.

Fine-grained gray sand	4	4
Hard gray clay	4	8
Red sand and clay	2	10
Reworked red clay	4	14
Sticky light blue clay	1	15
Red clay	2	17
Hard red clay	8	25
Hard blue clay	3	28
Bird's eye clay	2	30

Struck water at 20 feet. Water level, 18.5 feet below ground level, 24 hours after hole completed, Dec. 5, 1940.

49. Flat, Foard County, 2,600 feet east and 1,300 feet south of SE cor. sec, 356 H. & T. C. Ry. Co. sur. Altitude at surface, 1333.6 feet.

Gray surface sand	5	5
Coarse-grained yellow sand	1	6
Red clay and caliche	2	8
Gray sand and gravel	4	12
Coarse-grained red sand and gravel	3	15
Coarse-grained brown sand	1	16
Coarse-grained red sand	2	18
Coarse-grained red sand and pea gravel	5	23
Clean pea gravel	1	24
Pea gravel and sand	4	28
Pea gravel	1	29
Bird's eye clay	2	31

Struck water at 21 feet. Water level, 19.35 feet below ground level, 24 hours after hole completed, Dec. 7, 1940.

50. Flat, Foard County, 2,300 feet east and 1,350 feet north of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1323.9 feet.

	Thickness (feet)	Depth (feet)
Dark-colored sandy soil	3	3
Gray sand and clay	6	9
Brown sand and clay	2	11
Coarse-grained light-red sand	1	12
Yellow sand and clay	1	13
Coarse-grained dark-brown sand	1	14
Coarse-grained red sand	4	18
Fine-grained red sand	5	23
Coarse-grained red sand and pea gravel	9	32
Coarse-grained gray sand	1	33
Pea gravel, small pieces of clay	4	37
Coarse-grained gray sand	2	39
Coarse gravel	1	40
Bird's eye clay	1	41

Struck water at 17 feet. Water level, 15.4 feet below ground level, 24 hours after hole completed. Dec. 7, 1940.

51. Flat, Foard County, 2,600 feet east and 1,300 feet south of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1331.2 feet.

Yellow sand	2	2
Gray clay and caliche	3	5
Red clay, sand, and caliche	5	10
Soft red clay	1	11
Coarse-grained yellow sand	1	12
Coarse-grained red sand	5	17
Bird's eye clay	6	23

Struck water at 19 feet. Water level, 18.1 feet below ground level, 24 hours after hole completed. Dec. 9, 1940.

52. Flat, Foard County, 2,600 feet east and 2,200 feet south of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1334.3 feet.

Yellow sand	2	2
Sandy red clay	5	7
Coarse-grained red sand	12	19
Red sand and gravel	3	22
Bird's eye clay	1	23

Struck water at 22 feet. Water level, 19.4 feet below ground level, 24 hours after hole completed. Dec. 9, 1940.

53. Flat, Foard County, 2,600 feet east and 3,000 feet south of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1336.4 feet.

Coarse-grained yellow sand	5	5
Sandy red clay	8	13
Coarse-grained brown sand and gravel	1	14
Fine-grained yellow sand	4	18
Sand and coarse gravel	3	21

53. - Continued

	Thickness (feet)	Depth (feet)
Pea gravel	1	22
Red clay	4	26
Blue clay	2	28
Red clay	2	30
Bird's eye clay	1	31

Struck water at 26 feet. Water level, 21.3 feet below ground level, 24 hours after hole completed. Dec. 10, 1940.

54. Flat, Foard County, 2,600 feet east and 3,600 feet south of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1336.8 feet.

Yellow sand	2	2
Sandy red clay	7	9
Coarse-grained yellow sand	4	13
Red clay and gravel	5	18
Coarse-grained yellow sand	2	20
Fine-grained yellow sand	1	21
Red clay and gravel	2	23
Pea gravel and sand	6	29
Clean white sand	1	30
Coarse-grained red sand	3	33
Pea gravel	3	36
Bird's eye clay	2	38

Struck water at 25 feet. Water level, 23.6 feet below ground level, 24 hours after hole completed. Dec. 12, 1940.

55. Flat, Foard County, 2,600 feet east and 4,100 feet south of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1337.0 feet.

Yellow sand	2	2
Red clay and sand	10	12
Coarse-red sand	1	13
Fine-grained yellow sand	12	25
Coarse-grained red sand	6	31
Pea gravel and clay	2	33
Fine-grained yellow sand	10	43
Red clay and gravel	3	46
Bird's eye clay	1	47

Struck water at 27 feet. Water level, 22.6 feet below ground level, 48 hours after hole completed. Dec. 13, 1940.

56. Flat, Foard County, 2,600 feet east and 4,700 feet south of SE cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1328.3 feet.

Sandy dark-red soil	7	7
Red clay and clay	2	9
Clay and caliche	2	11
Coarse-grained red sand	1	12
Red clay and gravel	2	14
Pea gravel and sand	2	16
Coarse-grained red sand	3	19
Fine-grained red sand	8	27
Fine-grained gray sand and pea gravel	8	35
Pea gravel and pieces of clay	1	36
Bird's eye clay	1	37

Struck water at 16 feet. Water level, 14.3 feet below ground level, 50 hours after hole completed. Dec. 14, 1940.

57. Flat, J. L. Orr, 1,700 feet west and 650 feet north of SE cor. sec. 325, H. & T. C. Ry. Co. sur. Altitude at surface, 1329.0 feet.

	Thickness (feet)	Depth (feet)
Sandy red soil	7	7
Hard red clay and caliche	2	9
Bird's eye red clay	17	26

Struck water at 20 feet. Water level, 21 feet below ground level, 48 hours after hole completed. Dec. 20, 1940.

58. Flat, J. L. Orr, 750 feet west and 850 feet north of SE cor. sec. 325, H. & T.C. Ry. Co. sur. Altitude at surface, 1325.6 feet.

Sandy dark-colored soil	3	3
Sandy gray clay	8	11
Coarse-grained white sand	2	13
Bird's eye clay	12	25

Struck water at 18 feet, water level, 19.1 feet below ground level, 48 hours after hole completed, Dec. 20, 1940.

59. Gentle slope, H. Fot, 1,980 feet west and 300 feet south of NE cor. sec. 277, H. & T. C. Ry. Co. sur., 5.2 miles east of Margaret. Altitude at surface, 1382.6 feet.

Sandy dark-colored soil	1	1
Fine-grained yellow water sand	8	9
Coarse-grained red sand	1	10
Fine-grained yellow sand	4	14
Bird's eye clay	3	17

Struck water at 6 feet. Water level, 7.2 feet below ground level, 24 hours, after hole completed, Dec. 21, 1940.

60. Gentle slope, H. Fot, 1,980 feet west and 600 feet south of NE cor. sec. 277, H. & T. C. Ry. Co. sur., 5.2 miles east of Margaret. Altitude at surface, 1386.5 feet.

Well 60 -- Continued

	Thickness (feet)	Depth (feet)
Sandy dark-colored soil	4	4
Fine-grained red sand	7	11
Bird's eye clay	7	18

Struck water at 2.0 feet. Water level, 2.9 feet below ground level, 24 hours after hole completed. Dec. 21, 1940.

61. Gentle slope, Harry Schlagel, sec. 429, H. & T. C. Ry. Co. sur., 2½ miles north of Crowell. Altitude at surface, 1563.0 feet.

Coarse-grained red sand	3	3
Hard red clay	9	12
Red clay, pieces of red sand rock	2	14
Sandy hard blue clay	2	16
Hard red clay	3	19
Hard sandstone	4	23
Bird's eye clay	3	26

Water level, 8.3 feet below ground level, 48 hours after hole completed. Dec. 30, 1940.

62. Gentle slope, Harry Schlagel, 300 feet north of sec. 429, H. & T. C. Ry. Co. sur., 2½ miles north of Crowell. Altitude at surface, 1552.8 feet.

Red clay	2	2
Sandy blue clay	6	8
Sandy hard red clay	18	26
Bird's eye clay	6	32

Small supply at 8 feet. Water level, 7.8 feet below ground level, 24 hours after hole completed. Dec. 31, 1940.

64. Flat, Foard County, 3-3/4 miles west of Crowell.

Hard black soil	4	4
Yellow clay and caliche	4	8
Hard red clay	3	11
Sandy hard red clay	2	13
Sandy hard gray clay	4	17

Continued

Well 64 -- Continued

	Thickness (feet)	Depth (feet)
Hard red sandstone	1	18
Red sandstone, thin bedded	3	21
Hard blue-gray sandstone	4	25
Hard blue sandstone	6	31
Sandy dark-red shale	2	33
Sandy hard gray shale	1	34
Fine-grained gray sandstone	2	36
Red sandstone, thin bedded	10	46
Gray sandstone	6	52
Red sandstone	5	57
Bird's eye clay	5	62

Struck water at 34 feet, water level, 30 feet below ground level, 60 hours after hole completed, Feb. 7, 1941.

65. Flat, Foard County, 800 feet from south line and 2,450 feet from west line sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1335.2 feet.

Fine-grained yellow sand	4	4
Coarse-grained red sand	7	11
Coarse-grained red sand and small gravel	3	14
Coarse-grained red sand and large gravel	6	20
Coarse-grained wet sand	2	22
Coarse-grained sand and red gravel	2	24
Clean white pea gravel	4	28
Gray sand and pea gravel	2	30
Bird's eye clay	2	32

Struck water at 20 feet, water level, 19.6 feet below ground level, 24 hours after hole completed. Jan. 10, 1941.

66. Flat, Foard County, 1,750 feet from south line and 2,450 feet from west line sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1335.2 feet.

Sandy coarse-grained red soil	4	4
Coarse-grained yellow sand	2	6

Well 66 -- Continued

	Thickness (feet)	Depth (feet)
Coarse-grained gray sand	2	8
Red sand and caliche	2	10
Coarse-grained yellow sand	3	13
Red sand and boulders	2	15
Red sand and large gravel	2	17
Coarse-grained wet red sand	4	21
Coarse-grained gray sand and pea gravel	7	28
Coarse-grained gray sand and gravel	7	35
Large gravel and sand	2	37
Bird's eye clay	2	39

Struck water 18 feet. Water level, 18 feet below ground level, 24 hours after hole completed. Jan. 12, 1941.

67. Flat, Foard County, 2,450 feet from west line and 2,950 feet from south line sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1332.4 feet.

Coarse-grained red sand	5	5
Coarse-grained yellow sand	4	9
Sandy red clay	2	11
Red sand and gravel	5	16
Coarse-grained gray sand	5	21
Sandy red clay and gravel	2	23
Gray sand and gravel	2	25
Sandy red clay and large gravel	5	30
Bird's eye clay	2	32

Struck water at 20 feet. Water level, 19.3 feet below ground level, 24 hours after hole completed. Jan. 17, 1941.

68. Flat, J. J. Orr, 1,250 feet from west line and 2,900 feet from south line sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1336.9 feet.

Sandy red soil	3	3
Coarse-grained yellow sand	3	6
Sandy gray clay	6	12
Coarse-grained yellow sand	1	13
Reworked soft red clay	8	21
Bird's eye clay	2	23

Struck water at 15 feet. Water level, 14.7 feet below ground level, 24 hours after hole completed. Jan. 15, 1941.

69. Flat, Foard County, 2,900 feet north of S. cor. sec. 356, H. & T. C. Ry. Co. sur. Altitude at surface, 1348.9 feet.

	Thickness (feet)	Depth (feet)
Sandy dark-red soil	3	3
Coarse-grained red sand	3	6
Coarse-grained yellow sand	1	7
Sandy red clay	5	12
Sandy coarse-grained red clay	4	16
Coarse-grained yellow sand	4	20
Red sand and gravel	2	22
Red sand and large gravel	2	24
Reworked soft red clay	2	26
Bird's eye clay	2	28

Water level, 19.9 feet below ground level, 24 hours after hole completed. Jan. 17, 1941.

70. Flat, A. L. Dunn, 75 feet north of well 50. H. & T. C. Ry. Co. sur. Altitude at surface, 1324.0 feet.

Sandy dark-colored sand	3	3
Dark red sand	2	5
Sandy gray clay	3	8
Coarse-grained light red sand	6	14
Sandy yellow clay	2	16
Coarse-grained red sand	3	19
Red sand and pea gravel	1	20
Coarse-grained red sand	4	24
Coarse-grained red sand and gravel	4	28
Fine-grained red sand	4	32
Coarse-grained red sand and pea gravel	3	35
Red clay and gravel	2	37
Pea gray gravel	2	39
Bird's eye clay	1	40

Observation well for pumping test, Set 1½-inch well point with 2-inch pipe on top of clay. Struck water at 16 feet. Water level, 15.8 feet below ground level, 24 hours after hole completed. Feb. 1, 1941.

71. Flat, A. L. Dunn, 150 feet north of well 50. H. & T. C. Ry. Co. sur. Altitude at surface, 1324.1 feet.

	Thickness (feet)	Depth (feet)
Sandy brown soil	4	4
Sandy clay and caliche	5	9
Sandy red clay	4	13
Coarse-grained red sand	2	15
Coarse-grained red sand and gravel	3	18
Coarse-grained red sand	9	27
Coarse-grained sand and pea gravel	4	31
Coarse-grained red sand	1	32
Coarse-grained red sand and pea gravel	5	37
Pea gray gravel	2	39
Large gravel	2	41
Bird's eye clay	1	42

Observation well for pumping test, Set 1½-inch well point with 2-inch pipe at 41 feet. Struck water at 17 feet. Water level, 16.33 feet below ground level, 24 hours after hole completed. Feb. 8, 1941.

73. Flat, A. L. Dunn, 3,100 feet from south line, 100 feet from west line sec. 325, H. & T. C. Ry. Co. sur. Altitude at surface, 1321.3 feet.

Dark red soil	4	4
Sandy red clay	2	6
Coarse-grained red sand	1	7
Sandy red clay	3	10
Sandy gray clay and caliche	4	14
Coarse-grained gray sand	3	17
Coarse-grained gray sand and pea gravel	2	19
White pea gravel	2	21
Fine-grained red sand	3	24
Coarse-grained gray sand and gravel	4	28
Gray sand	1	29
Red re-worked clay	3	32
Bird's eye clay	1	33

Struck water at 16 feet. Water level, 16.3 feet below ground level, 24 hours after hole completed. Feb. 13, 1941.

74. Flat, A. L. Dunn, 700 feet north of 33, H. & T. C. Ry. Co. sur.

	Thickness (feet)	Depth (feet)
Red surface sand	4	4
Sandy red clay	10	14
Red sand and gravel	4	18
Gray sand and gravel	10	28
Gray reworked clay	3	31
Gray clay	2	33
Red reworked clay	3	36
Bird's eye clay	1	37

Struck water at 17 feet. Water level, 17.3 feet below ground level, 24 hours after hole completed. Feb. 14, 1941.

75. Flat, A. L. Dunn, 95 feet south of 50, H. & T. C. Ry. Co. sur. Altitude at surface, 1324.0.

Sandy red soil	3	3
Sandy gray clay	6	9
Gray sand	1	10
Red sand	6	16
Sandy red clay	3	19
Coarse-grained sand and gravel	9	28
Coarse-grained gray sand	5	33
Sandy clay	1	34
Coarse-grained sand and pea gravel	4	38
Sand and pea gravel	2	40
Bird's eye clay	1	41

Set 1-inch well point with 1-inch pipe at 40 feet. Struck water at 1 foot. Water level, 15.6 feet below ground level, 24 hours after hole completed. Mar. 3, 1941.

76. Flat, A. L. Dunn, 25 feet north of 50, H. & T. C. Ry. Co. sur. Altitude at surface, 1324.1 feet.

Sandy gray soil	4	4
Sandy gray clay	7	11
Red sand	3	14
Brown sand	1	15
Coarse-grained red sand	2	17
Red sand	7	24
Fine-grained red sand	4	28

Well 76 -- Continued

	Thickness (feet)	Depth (feet)
Sand and pea gravel	6	34
Sand and clay	1	35
Sand and pea gravel	5	40
Bird's eye clay	1	41

Set 1 well point with 2-inch pipe at 40 feet. Water level, 16 feet below ground level, 24 hours after hole completed. March 7, 1941.

77. Flat, A. L. Dunn 225 feet north of 50, H. & T. C. Ry. Co. sur. Altitude at surface, 1324.2 feet.

Sandy gray soil	3	3
Sandy red clay	6	9
Gray sand and gravel	1	10
Coarse-grained red sand	2	12
Sand and gravel	4	16
Dark-red sand	6	22
Coarse-grained sand and pea gravel	5	27

Set 2-inch point with 2-inch pipe at 27 feet. Water level, 16.6 feet below ground level, 24 hours after hole completed. Mar. 6, 1941.

78. Flat, A. L. Dunn, 300 feet north of 50, H. & T. C. Ry. sur. Altitude at surface, 1324.0 feet.

Sandy dar-colored soil	3	3
Red sand	1	4
Gray clay	5	9
Red sand	3	12
Sandy red clay	7	19
Pea gravel and sand	3	22
Red sand	2	24

Set 2-inch point with 2-inch pipe at 24 feet. Water level, 16.6 feet below ground level, 24 hours after hole completed. Mar. 7, 1941.

79. Flat, A. L. Dunn, 500 feet north of 73, H. & T. C. Ry. Co. sur. Altitude at surface, 1320.6 feet.

	Thickness (feet)	Depth (feet)
Sandy dark-colored soil	4	4
Sandy gray clay	5	9
Coarse-grained gray sand	9	18
Fine-grained gray sand	1	19
Gray sand, pea gravel	3	22
Red sand and clay	7	29
Bird's eye clay	1	30

Water level 16.1 feet below ground level, 24 hours after hole completed. Mar. 9, 1941.

80. Flat, A. L. Dunn, 75 feet south of 33, H. & T. C. Ry. Co. sur. Altitude 1328.8 feet.

Dark-colored sand	9	9
Red sand and gravel	2	11
Red sand	6	17
Gray sand	2	19
Coarse-grained red sand	1	20
Red sand, gravel, clay	3	23
Fine-grained red sand	5	28
Red and gray sand, gravel	8	36
Gravel	1	37
Bird's eye clay	3	40

Water level, 20.8 feet below ground level, 24 hours after hole completed. Mar. 29, 1941.

81. Flat, A. L. Dunn, 150 feet north of 33, SE¼ sec. 356, H. & T. C. Ry. Co. sur. Altitude 1332.68.

Dark-red sand	3	3
Red sand	4	7
Red sand and clay	2	9
Gray sand	9	18
Red sand and gravel	9	27
Fine-grained red sand	10	37
Bird's eye clay	2	39

Water level, 21.5 feet below ground level, 24 hours after hole completed.

82. Flat, A. L. Dunn, 75 feet west of 50, H. & T. C. Ry. Co. sur.

	Thickness (feet)	Depth (feet)
Sandy red soil	3	3
Sand, clay	3	6
Red sand	11	17
Sand and gravel	1	18
Red sand and gravel	15	33

Set 2-inch point with 2-inch pipe at 33 feet. Water level, 18.8 feet below measuring point, 28 hours after hole completed. Mar. 8, 1941.

83. Flat. A. L. Dunn, 75 feet east of 50, H. & T. C. Ry. Co. sur.

Soil	2	2
Sandy gray clay	7	9
Red sand and gravel	9	18
Red sand	11	29
Red sand and lea gravel	5	34

Left open hole with 4-inch casing at 34 feet.

84. Flat, A. L. Dunn, 75 feet north of 33, H. & T. C. Ry. Co. sur. Altitude at surface, 1329.0.

Sandy red soil	4	4
Sandy red clay	7	11
Green sand and gravel	7	18
Gray sand and gravel	3	21
Red sand and gravel	4	25
Coarse-grained gray sand	2	27
Gray sand	6	33
Gravel and sand	4	37
Bird's eye clay	1	38

Water level, 19.9 feet below ground level, 24 hours after hole completed. Mar. 25, 1941.

PARTIAL ANALYSES OF WATER OBTAINED DURING INVESTIGATION OF WATER SUPPLY FOR CROWELL, TEXAS

(Analyzed at The University of Texas under the direction of E.P.Schoch and E.W.Lohr. Results are in parts per million)

Well	Owner	Depth of well (ft.)	Date of collection	Total dissolved solids	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na + K) (calc.)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Total hardness as $CaCO_3$ (calc.)
1	City of Crowell	18	July 31, 1940	1,382	206	72	153	250	597	210	21	0.4	809
3	Foard County	34	Sept. 4, 1940	1,355	125	88	200	275	427	220	159	0.6	674
5	do.	18	Sept. 7, 1940	1,265	104	65	238	268	434	230	62	-	530
6	do.	17	do.	497	44	40	79	275	116	53	29	0.6	275
7	do.	17	Sept.10, 1940	717	78	47	108	293	213	97	30	-	389
8	do.	18	Sept.11, 1940	596	57	42	95	305	144	58	50	-	316
9	do.	17	Sept.16, 1940	662	79	50	80	281	175	82	58	-	401
10	do.	16	Sept.13, 1940	643	75	57	80	299	159	82	54	-	396
11	do.	14	Sept.17, 1940	684	78	57	81	293	182	100	42	-	430
12	do.	18	Sept.18, 1940	832	86	63	115	281	248	146	36	-	474
13	do.	28	Sept.19, 1940	850	98	64	107	287	252	155	32	0.6	510
14	do.	18	Sept.20, 1940	1,399	166	98	161	256	586	220	42	0.4	815
15	do.	19	do.	722	86	64	69	238	240	110	35	0.9	480
16	do.	17	Sept.24, 1940	911	91	60	141	287	310	142	26	-	472
17	do.	19	Oct. 3, 1940	776	90	47	117	366	233	71	38	-	419
19	do.	18	Oct. 5, 1940	1,066	119	68	160	354	334	190	20	0.9	577
20	do.	16	Oct. 8, 1940	1,086	155	78	109	348	365	185	22	0.5	708
21	do.	15	May 7, 1940	730	73	36	129	232	252	96	29	0.8	333
22	do.	19	Oct. 10, 1940	1,117	112	49	205	305	427	146	27	0.9	480
23	do.	20	do.	1,339	156	63	203	329	349	215	191	-	649
24	do.	21	Oct. 11, 1940	1,075	113	45	203	317	349	195	b/	-	468
25	do.	25	Oct. 17, 1940	868	105	34	154	305	307	116	b/	0.8	401
26	do.	32	do.	2,028	196	84	379	409	806	320	42	0.4	837
27	do.	25	Oct. 22, 1940	993	82	47	190	275	415	92	32	-	399
28	do.	32	do.	930	93	34	83	378	84	52	93	0.3	371
29	do.	22	Oct. 25, 1940	576	90	42	53	275	108	90	58	-	396
30	do.	22	Oct. 31, 1940	470	46	36	72	201	81	93	38	-	262
31	do.	16	Oct. 25, 1940	691	129	49	57	275	58	250	b/	0.3	525
32	do.	23	Nov. 2, 1940	609	80	43	66	244	196	54	50	-	377
33	do.	23	do.	370	64	29	29	244	73	35	20	-	278
33	do.	40	Apr. 3, 1941	372	70	28	25	256	68	34	20	0.5	292
33	do.	40	Apr. 7, 1941	367	75	29	16	250	68	35	20	0.5	303

a/ Sulfate less than 10 parts per million.
b/ Nitrate less than 20 parts per million.

Partial analyses of water obtained during investigation of water supply for Crowell, Texas--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Total dissolved solids	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na + K) (calc.)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Total hardness as $CaCO_3$ (calc.)
34	Foard County	23	Nov. 6, 1940	807	88	38	140	305	261	91	38	0.7	379
35	do.	22	Nov. 7, 1940	856	97	49	127	287	300	100	43	-	445
36	do.	25	Nov. 11, 1940	377	63	26	33	256	61	15	55	1.1	266
37	do.	23	do.	645	95	57	57	226	229	76	32	-	446
38	do.	28	Nov. 15, 1940	438	79	34	50	311	108	41	24	-	336
39	do.	27	Nov. 14, 1940	1,677	235	127	141	275	714	305	20	0.1	1,108
40	do.	24	Nov. 15, 1940	1,573	208	108	169	258	607	330	25	-	961
41	do.	23	Nov. 17, 1940	330	56	27	20	136	77	24	33	-	252
42	do.	20	Nov. 18, 1940	265	51	21	14	201	34	11	35	-	213
43	do.	20	Nov. 21, 1940	286	49	29	18	281	22	8	22	-	243
44	do.	21	Nov. 22, 1940	390	67	37	28	342	34	30	26	-	318
45	do.	22	do.	351	60	19	46	299	50	10	b/	-	227
46	do.	31	do.	2,760	288	119	444	303	1,398	280	72	-	1,209
47	do.	20	Dec. 3, 1940	447	63	39	33	244	119	40	28	-	319
48	do.	25	Dec. 4, 1940	581	75	39	36	433	89	42	37	-	349
49	do.	221	Dec. 5, 1940	334	55	31	25	268	50	21	20	-	264
50	W. A. Dunn	20	do.	306	58	32	3	214	77	26	b/	-	275
50	do.	22	Mar. 8, 1941	350	76	24	15	250	66	18	28	-	290
50	do.	40	Mar. 11, 1941	358	72	23	24	250	70	13	28	-	274
50	do.	40	Mar. 23, 1941	351	55	25	37	250	66	16	28	0.8	240
51	Foard County	19	Dec. 9, 1940	451	64	44	40	329	57	52	32	-	342
52	do.	22	Dec. 8, 1940	361	62	33	21	299	28	10	60	-	290
53	do.	26	Dec. 11, 1940	1,106	166	86	111	323	452	114	38	-	686
54	do.	25	Dec. 10, 1940	322	59	45	3	372	27	5	b/	-	333
55	do.	27	Dec. 12, 1940	300	42	33	28	299	42	8	b/	-	240
56	do.	16	do.	323	57	29	26	336	21	5	20	-	263
57	do.	25	Dec. 16, 1940	455	55	37	60	329	73	28	40	-	288
58	do.	25	Dec. 17, 1940	721	77	45	117	348	199	82	30	-	378
59	H. Fox	12	Dec. 18, 1940	629	60	37	125	390	92	100	23	-	303
60	do.	5	do.	375	58	28	45	293	58	42	b/	-	262
61	Harry Schlagel	9	Dec. 20, 1940	577	95	54	36	372	172	37	b/	-	458
62	do.	15	do.	667	104	53	60	403	188	50	b/	-	477
64	Foard County	34	Feb. 7, 1941	5,934	652	243	959	110	2,830	1,180	b/	-	2,630

a/ Sulfate less than 10 parts per million.
b/ Nitrate less than 20 parts per million.

Partial analyses of water obtained during investigation of water supply for Crowell, Texas--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Total dissolved solids	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na + K) (calc.)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Total hardness as $CaCO_3$ (calc.)
65	Foard County	24	Jan. 10, 1941	1,364	210	77	313	378	766	270	42	-	842
66	do.	26	do.	1,145	136	77	141	378	479	86	40	-	657
67	do.	22	Jan. 14, 1941	581	83	53	41	287	151	49	64	-	423
67	do.	22	Jan. 29, 1941	626	103	48	45	299	174	62	47	-	455
68	J. L. Orr	15	Jan. 15, 1941	385	62	36	29	317	37	23	42	-	302
69	Foard County	20	Jan. 17, 1941	314	65	23	24	305	33	19	b/	-	259
70	W. A. Dunn	20	do.	343	74	27	9	323	76	19	24	-	297
71	do.	28	Feb. 7, 1941	368	73	27	20	250	74	18	32	0.8	292
73	A. L. Dunn	20	Feb. 10, 1941	449	72	41	84	244	129	28	34	0.7	351
74	do.	22	Feb. 11, 1941	408	72	32	27	256	97	24	30	-	310
75	do.	25	Feb. 23, 1941	345	67	27	17	226	78	19	27	-	277
76	do.	25	Mar. 3, 1941	403	74	23	36	232	101	23	27	-	279
78	do.	20	Mar. 8, 1941	364	70	22	31	262	62	17	35	-	264
79	do.	20	Mar. --, 1941	505	84	46	28	317	94	36	60	0.8	399
144	C. H. White	18	Oct. 22, 1940	528	63	35	85	372	134	27	b/	1.2	301
145	W. T. Dunn	26	Jan. 24, 1941	311	63	29	10	278	28	11	32	-	279
147	W. L. Dunn	20	Nov. 4, 1940	805	114	81	138	293	254	98	36	-	373
148	Dunn Est.	23	Jan. 27, 1941	785	127	48	75	299	255	100	33	-	515
149	W. T. Dunn	21	Jan. 36, 1941	915	97	82	104	372	291	120	38	-	581
150	W. A. Dunn	24	do.	321	64	30	16	305	49	12	b/	-	283
	-- Bledsoe	Spring	Oct. 16, 1940	1,003	120	84	95	230	408	160	33	-	644
	A.T.S.F. Ry.	Spring	do.	495	95	55	63	273	231	80	24	-	463
	City of Crowell	Lake	do.	600	155	15	7	69	383	6	b/	-	449

a/ Sulfate less than 10 parts per million.
b/ Nitrate less than 20 parts per million.

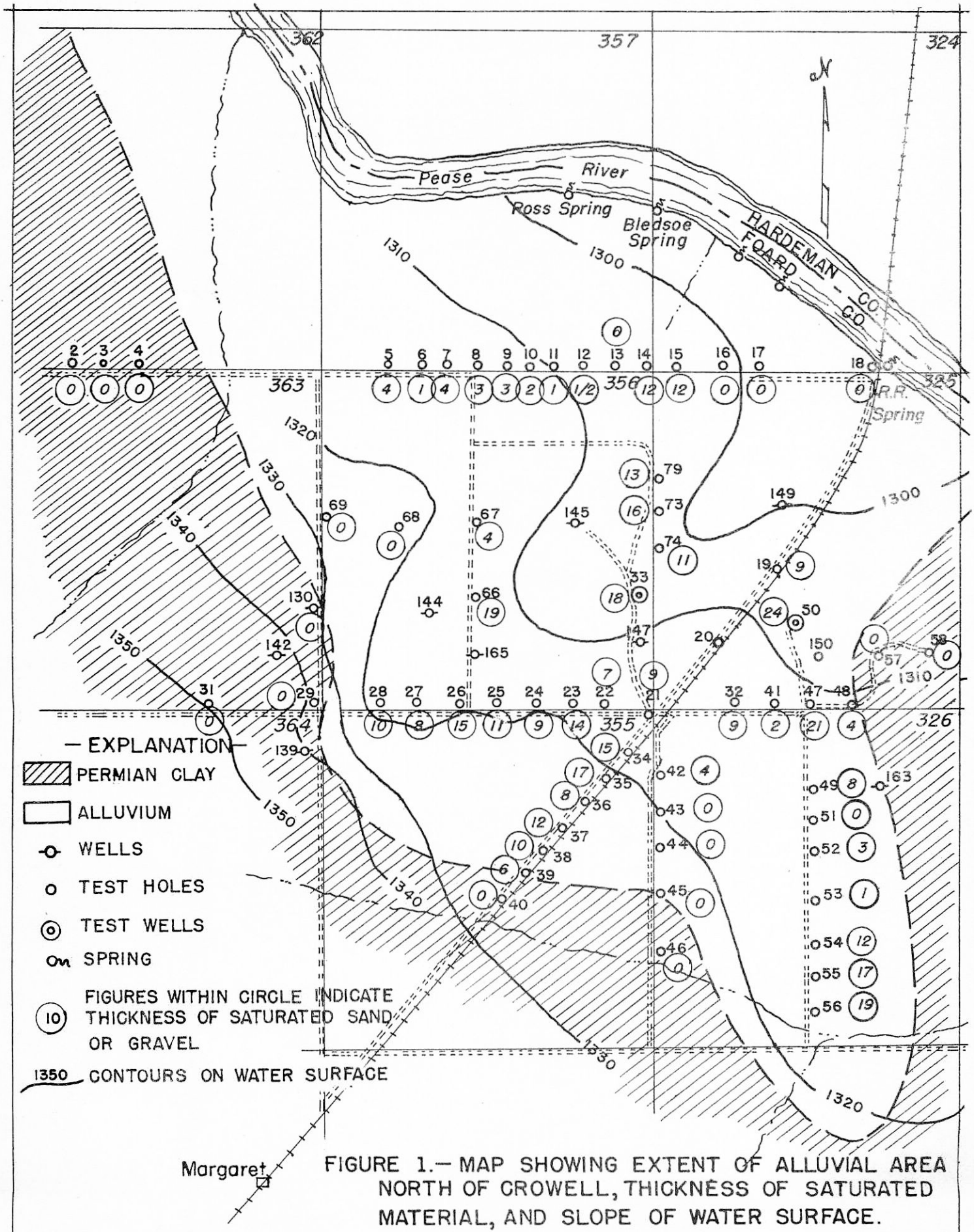


FIGURE 1.— MAP SHOWING EXTENT OF ALLUVIAL AREA NORTH OF CROWELL, THICKNESS OF SATURATED MATERIAL, AND SLOPE OF WATER SURFACE.

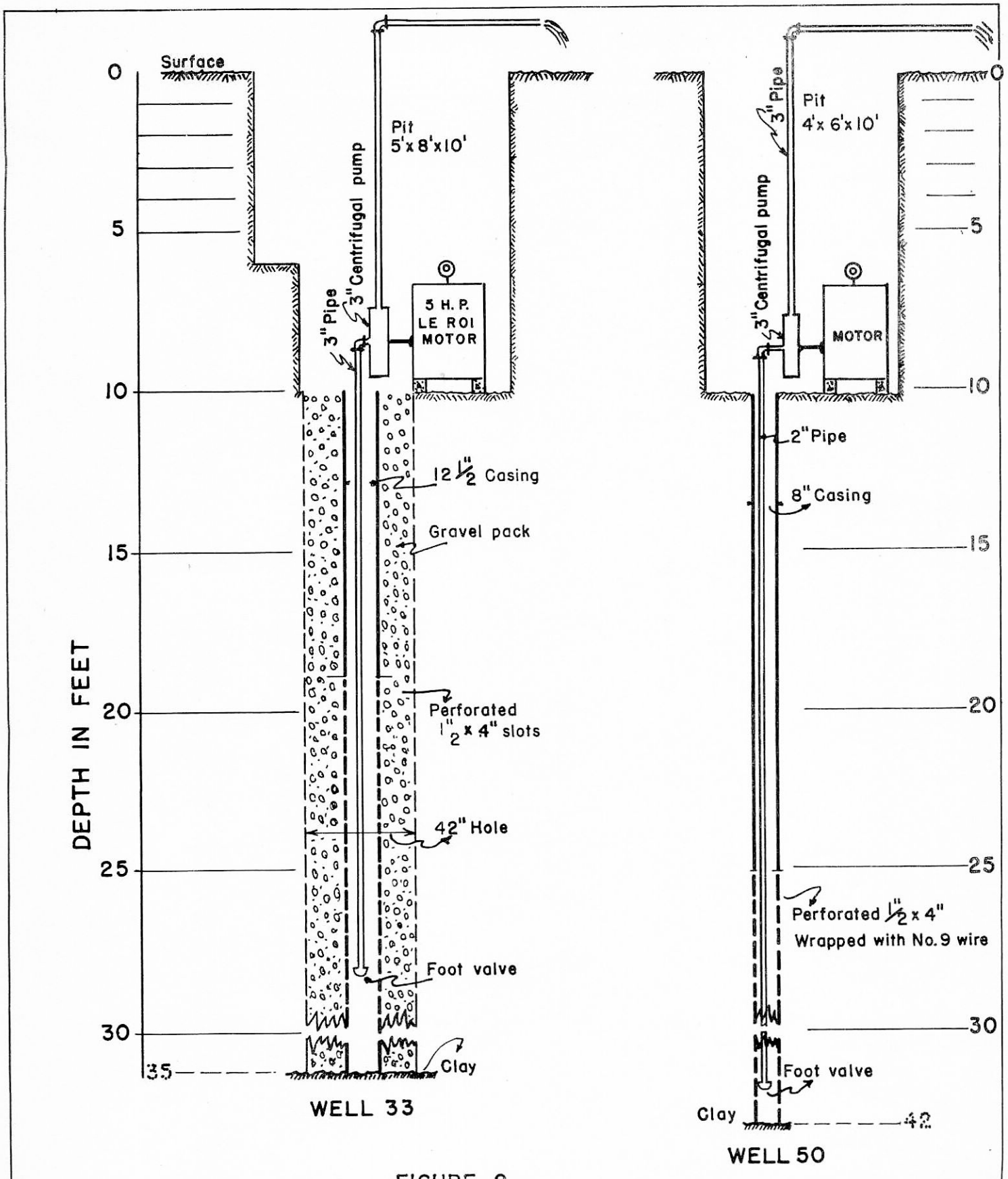


FIGURE 2.

DIAGRAM OF WELLS AND EQUIPMENT

USED IN PUMPING TESTS

CROWELL, TEXAS

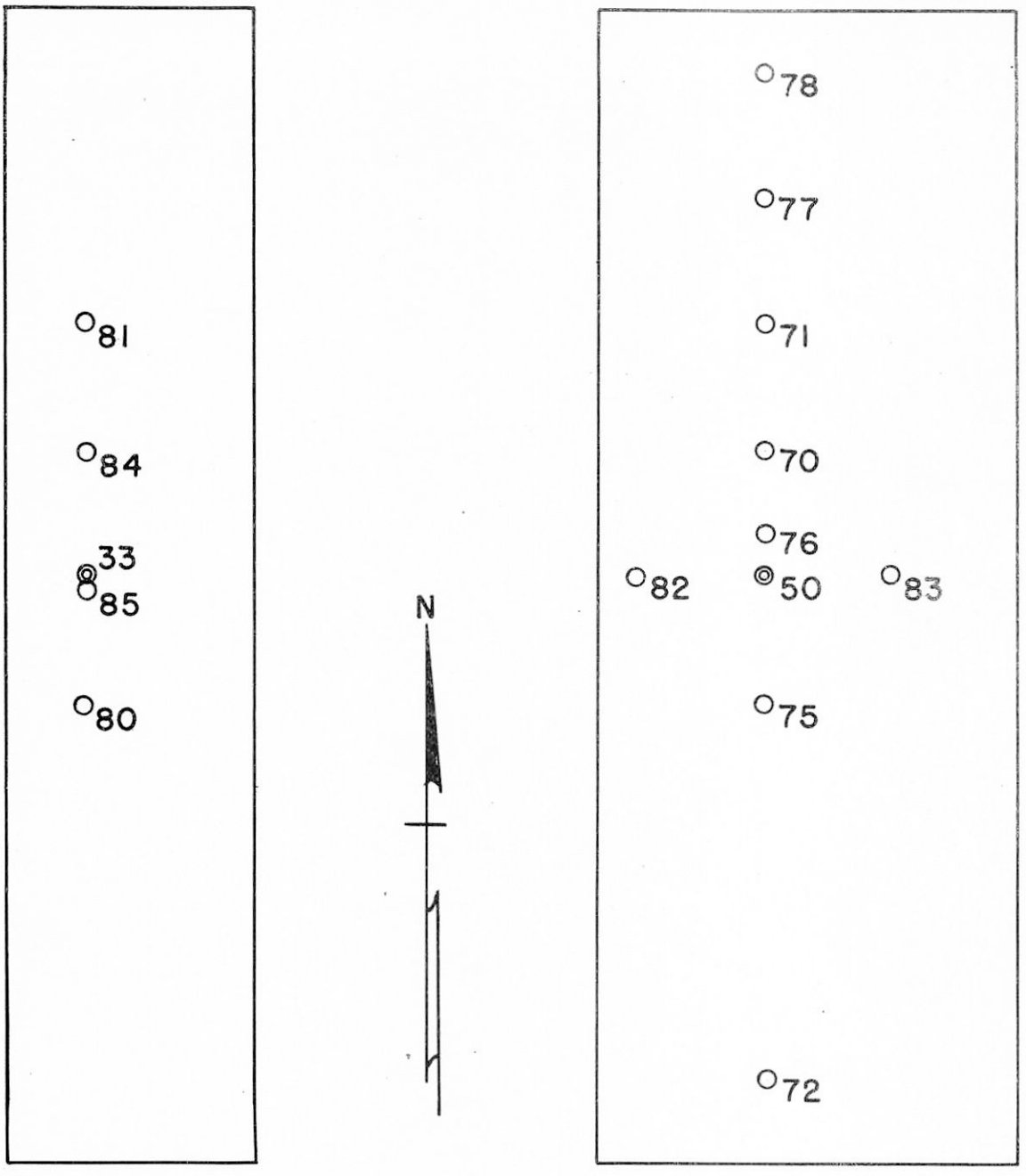


Figure 3 - ARRANGEMENT OF WELLS USED IN PUMPING TEST IN ALLUVIUM AREA NORTH OF CROWELL, TEXAS

EXPLANATION

○ Observation well

◎ Pumping well

0 100 200 300 Feet

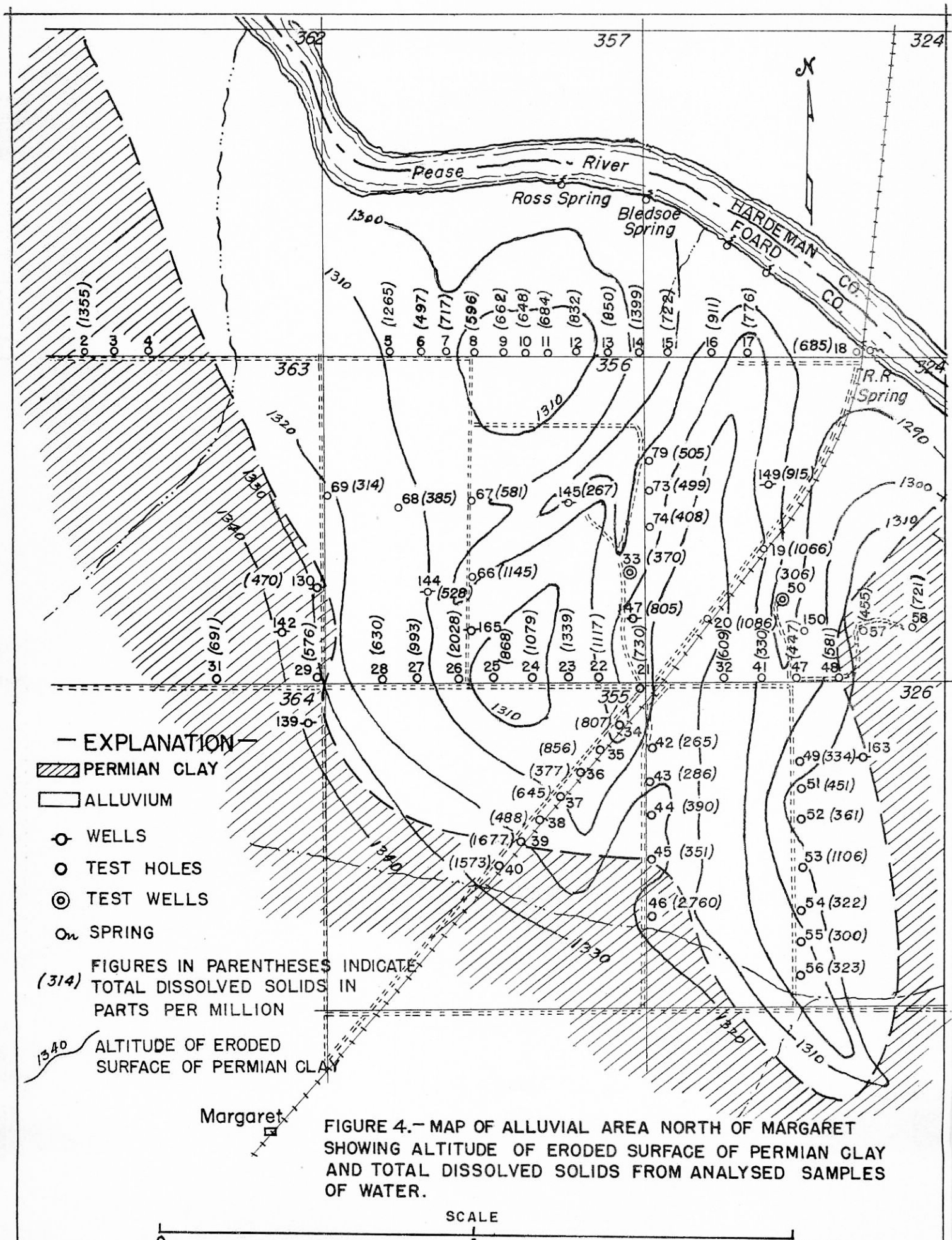
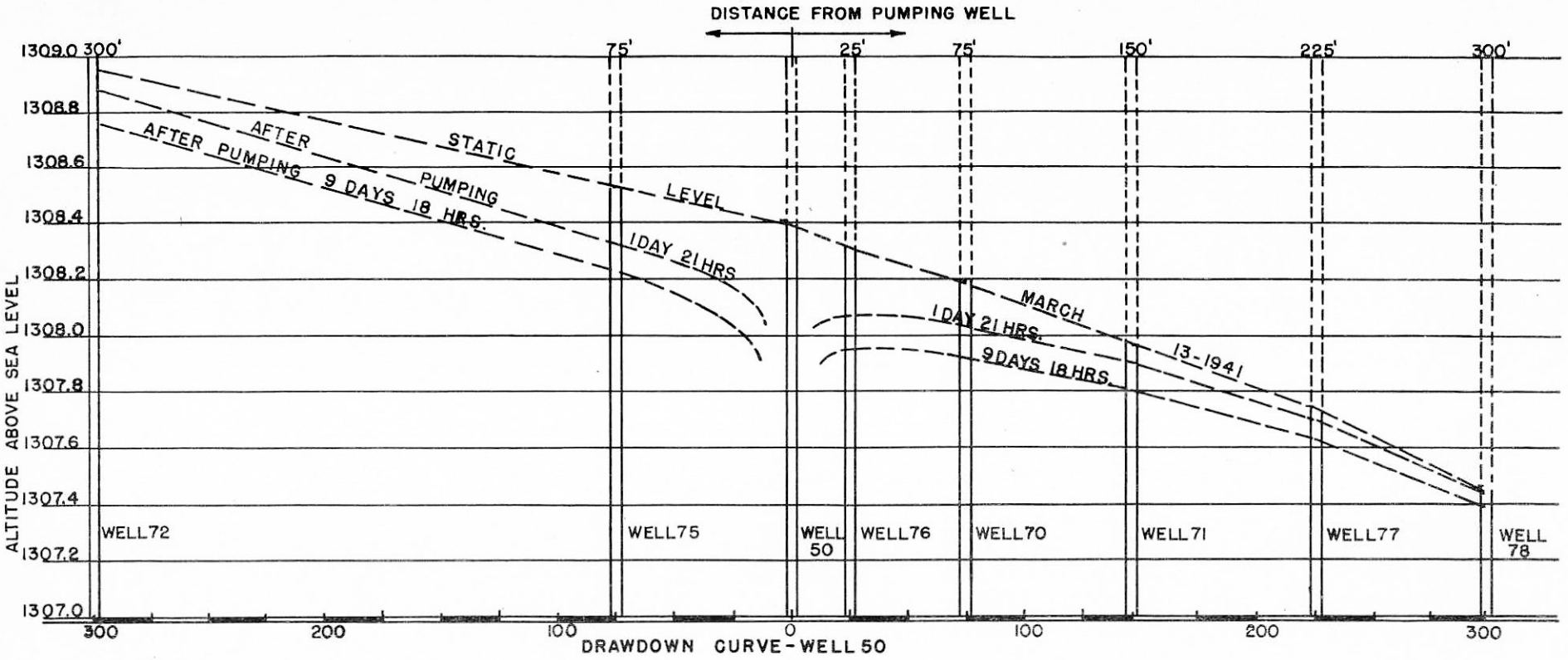


FIGURE 4.— MAP OF ALLUVIAL AREA NORTH OF MARGARET SHOWING ALTITUDE OF ERODED SURFACE OF PERMIAN CLAY AND TOTAL DISSOLVED SOLIDS FROM ANALYSED SAMPLES OF WATER.



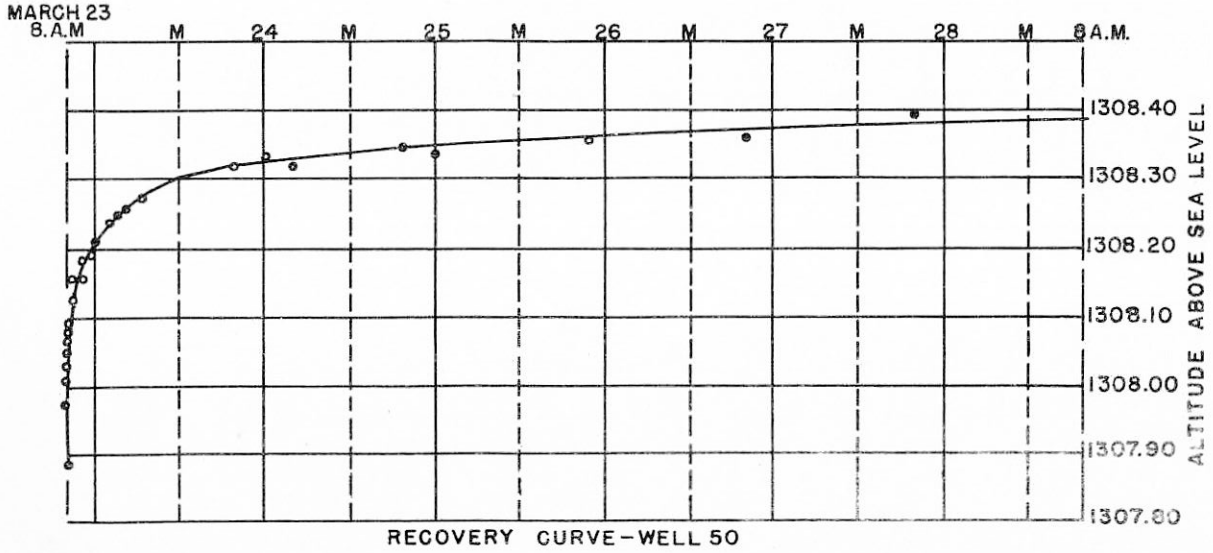


Figure 5

GROUND-WATER INVESTIGATION
IN THE VICINITY OF
CROWELL, TEXAS

DRAWDOWN AND RECOVERY
CURVE FOR WELL 50