TEXAS BOARD OF WATER ENGINEERS

GROUND-WATER RESOURCES OF THE ODELL SAND HILLS WILBARGER COUNTY, TEXAS

By

Gordon W. Willis, Geologist

and

Doyle B. Knowles, Hydraulic Engineer
United States Geological Survey

Prepared cooperatively by the Geological Survey,
United States Department of the Interior

January 1953

CONTENTS

ILLUSTRATIONS

TABLES

GROUND-WATER RESOURCES OF THE ODELL SAND HILLS, WILBARGER COUNTY, TEXAS

By

Gordon W. Willis and Doyle B. Knowles

ABSTRACT

The gently rolling sand hills in northwestern Wilbarger County, Tex., cover an area of approximately 75 square miles. For convenience of reference, the area has been called the Odell sand hills after the town of Odell in the northwestern part of the area. A mantle of Recent wind-blown sand, which ranges in thickness from a few inches to several feet, covers the surface of the area. In general, the Recent material is above the water table and is not an important water-bearing formation. The main body of the sand hills below the windblown sand consists of sandy clay, caliche, sand, and gravel. This alluvial material, which has not been differentiated from the overlying Recent sand, is a part of the Seymour formation of Pleistocene age and ranges in thickness from a few inches to about 120 feet. It is the principal water-bearing formation. Test drilling within the 70 square miles investigated revealed that the saturated alluvium has a maximum thickness of 85 feet and contains about 225,000 acre-feet or 73 billion gallons of water.

Precipitation on the Odell sand hills amounts to an average of about 24 inches annually. Most of the precipitation falls in showers of low intensity during the growing season when evaporation and transpiration are high and little ground-water recharge results. Consequently, most of the recharge to the ground-water reservoir occurs after infrequent periods of heavy rainfall by penetration through the sandy soil and seepage from depression ponds. It is estimated that the average recharge to the entire sand hills area is about 10,000 acre-feet a year.

The ground water in the Odell sand hills is less mineralized than the water in many similar areas in northern and western Texas. Dissolved solids average 360 parts per million and total hardness averages 223 parts per million in samples of water collected from 37 wells and test holes in the area. A composite sample of water from the water system of the city of Vernon contained 540 parts per million of dissolved solids and had a hardness of 302 parts per million.

Several hundred feet of Permian rocks, which consist of shale, silty clay, and sandstone, lie beneath the sand hills. The rocks are predominantly red and are commonly called redbeds. They are easily distinguished from the overlying alluvium and, so far as known, yield only meager supplies of water that are too highly mineralized for domestic or municipal uses.

INTRODUCTION

LOCATION AND EXTENT OF THE AREA

Wilbarger County is in northern Texas approximately midway between Fort Worth and Amarillo. The Prairie Dog Town Fork of the Red River forms the northern boundary of the county and also the boundary between Oklahoma and Texas. Vernon is the county seat and largest city in the county and had a population of 12,684 in 1950, according to the Census.

The area investigated for this report is in the northwestern part of the county and is referred to as the Odell sand hills after the town of Odell in the northwestern part of the area. (See fig. 1.) The sand hills cover an area of approximately 75 square miles that has roughly the shape of an equilateral triangle. The boundaries of the area are Wanderers Creek on the west, the Prairie Dog Town Fork of the Red River around the apex of the triangle and on the northeast, and the county road passing through White City and Fargo on the south.

PURPOSE OF THE INVESTIGATION

The investigation of the Odell sand hills is a part of the cooperative state-wide study of the ground-water resources of Texas by the Texas Board of Water Engineers and the United States Geological Survey. The purpose of these investigations is to obtain facts regarding the thickness, depth beneath the land surface, and areal extent of the water-bearing formations; to determine the capacity of the formations to absorb, store, transmit, and discharge water; and to determine the chemical character of the ground water. Among those interested in the ground-water supply in the Odell sand hills are the city of Vernon, farmers, and the Wilbarger County Commissioners' Court.

Vernon's water supply is obtained from 30 wells within and near the edge of the city. The capacity of the wells is 2,000,000 gallons a day, and in the summer the demand for water exceeds this amount. It is the desire of the city to develop a water supply of 3,000,000 gallons a day and to use the present city wells as a stand-by supply.

Several farmers in the Odell sand hills are interested in developing wells for irrigation. The "tight-land" area of Permian rocks between the sand hills and the Pease River is an area in which it is difficult to obtain supplies of ground water for domestic and livestock use. If a pipeline is constructed across this area, many of the farmers near the pipeline may desire to obtain water from the system.

The investigation upon which this report is based was made between July 1951 and February 1952. The field studies, except pumping tests, and geologic studies were made by Gordon W. Willis; the pumping tests and hydrologic studies were made by Doyle B. Knowles. The work was done and the report was prepared under the general supervision of W. L. Broadhurst, district geologist of the Geological Survey in charge of ground-water investigations in Texas.

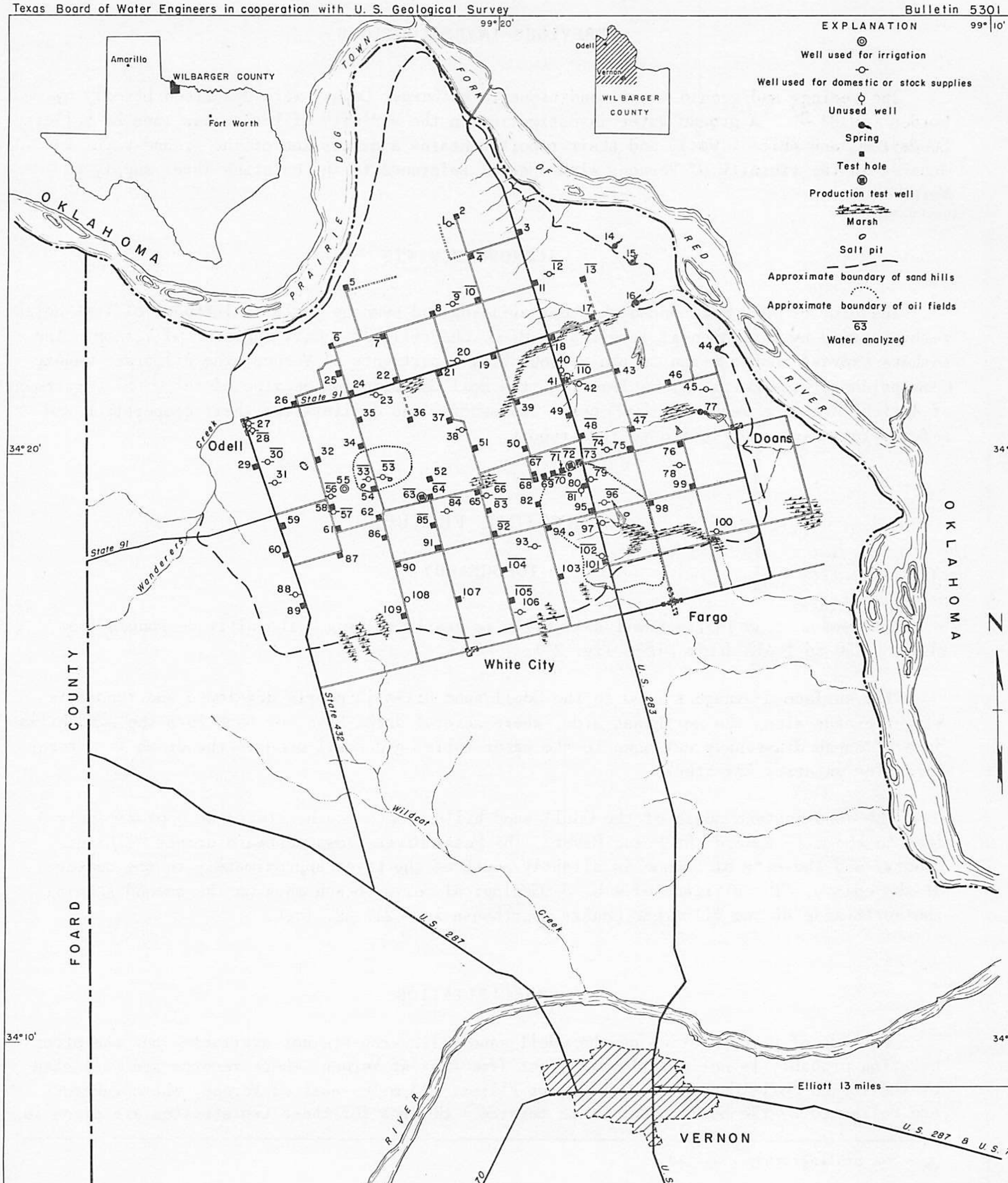

FIGURE 1.- Map of northwestern Wilbarger County, Tex., showing wells, test holes and springs.

PREVIOUS INVESTIGATIONS

The geology and ground-water conditions in Wilbarger County were described briefly by Gordon (1913) [a]. A ground-water investigation in the vicinity of Vernon was made by Follett, Sundstrom, and White (1944), and their report contains a discussion of the ground-water resources in the vicinity of Vernon, with special reference to the existing water supply of Vernon.

ACKNOWLEDGMENTS

The city of Vernon financed the test drilling and pumping tests. Altitudes of test holes were obtained by instrumental leveling by R. B. Sherrill, Jr., City Engineer of Vernon. The authors express appreciation to the various city departments of Vernon, the Wilbarger County Commissioners, the Bureau of Reclamation, the Soil Conservation Service of the U. S. Department of Agriculture, the Vernon Daily Record, landowners, and drillers for their cooperation and information which contributed to this report.

PHYSICAL FEATURES

TOPOGRAPHY

The land surface in the Odell sand hills is gently rolling. The altitude ranges from about 1,250 to 1,415 feet. (See fig. 2.)

The surface drainage system in the Odell sand hills is poorly developed and runoff is slight except along the northeast side, where several draws have cut back into the sand hills. Some of these draws have cut down to the water table, and small dams in the draws form reservoirs for watering livestock.

The land surface south of the Odell sand hills slopes southeastward at approximately 4 feet to the mile toward the Pease River. The Pease River flows eastward across Wilbarger County, and the city of Vernon is slightly south of the river approximately in the center of the county. The altitude of a U. S. Geological Survey bench mark on the second step on the north side of the Wilbarger County courthouse is 1,217.527 feet.

PRECIPITATION

Records of precipitation on the Odell sand hills area are not available, but the precipitation probably is not greatly different from that at Vernon, where records are collected by the Vernon Daily Record, and that near Elliott, 13 miles east of Vernon, where records are collected by the Soil Conservation Service. Records for these two stations are given in

---

a/ See bibliography, page 30.

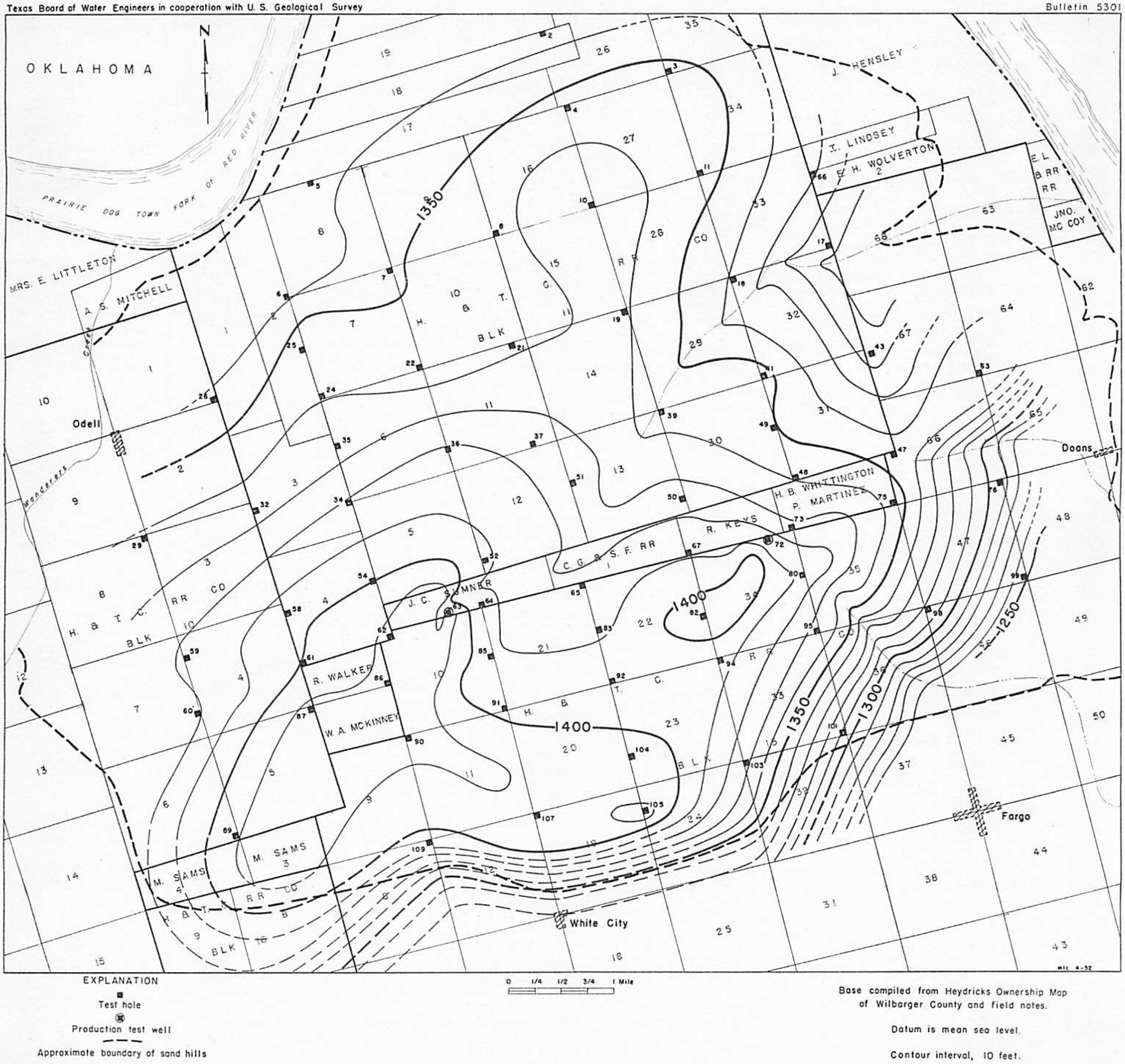

FIGURE 2.- Generalized topographic map of the Odell sand hills.
(From altitudes of test-hole sites)

tables 1 and 2 and are shown graphically in figure 3. The average annual precipitation at Vernon during the 16-year period 1935-50 was 24.88 inches, and the average near Elliott during the 24-year period 1926-49 was 23.55 inches. The greatest annual precipitation of record occurred in 1941 when Vernon had 49.05 inches and the gage near Elliott recorded 43.63 inches. Most of the precipitation falls in showers and thunderstorms of low intensity during the growing season when evaporation and transpiration are high. The monthly average is greatest in May when approximately 18 percent of the annual average falls in Vernon and approximately 16 percent of the annual average falls near Elliott.

Table 1.- Precipitation, in inches, at Vernon, Wilbarger County, Tex.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1935	0.15	1.32	1.73	1.65	6.46	3.65	3.13	0.91	3.93	1.88	1.92	1.10	27.83
1936	.80	T	.22	2.59	3.62	1.20	.27	.00	9.44	1.18	.09	.26	19.67
1937	.53	T	2.46	1.44	1.83	2.13	.79	3.78	1.39	4.88	.73	.49	20.45
1938	.93	3.48	3.00	1.06	7.52	4.52	.06	2.38	.32	1.09	1.20	.32	25.88
1939	3.05	.15	2.64	.35	2.01	2.45	1.44	3.24	.00	.35	.79	.88	17.35
1940	.25	2.13	T	2.64	3.72	2.21	.69	2.53	2.93	2.21	3.11	.74	23.16
1941	1.16	3.28	.90	5.38	10.23	6.14	4.88	3.44	1.35	9.59	.65	1.05	48.05
1942	.17	.59	.89	5.00	1.19	1.85	1.82	2.28	5.30	3.69	.48	2.10	25.36
1943	.08	.12	1.71	3.35	6.18	4.39	.21	1.01	1.94	.06	.83	2.82	22.70
1944	1.64	2.45	1.70	2.29	.41	2.68	1.49	1.69	1.29	2.49	1.85	1.33	21.31
1945	2.89	1.89	1.01	1.85	1.35	2.77	1.99	2.80	5.76	1.18	.65	1.18	25.32
1946	1.18	1.12	1.14	.75	2.34	3.33	.18	1.21	5.89	2.42	2.67	2.91	25.14
1947	.00	.25	.94	3.27	8.02	.90	.84	.29	.62	4.12	1.74	2.43	23.42
1948	.48	1.78	1.45	.90	6.25	5.40	2.95	.09	.00	1.82	.20	.07	21.39
1949	3.69	.80	1.91	1.65	5.29	4.55	.33	2.78	3.39	4.00	.00	.95	29.34
1950	.51	2.16	.01	2.18	4.65	2.39	4.09	2.99	2.68	.00	.00	T	21.66
Ave.	1.10	1.34	1.36	2.27	4.44	3.16	1.57	1.96	2.89	2.56	1.06	1.17	24.88

Table 2.- Precipitation, in inches, near Elliott, Wilbarger County, Tex.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1926	0.41	0.00	1.07	3.80	2.48	2.04	2.91	3.14	6.22	2.80	0.11	3.25	28.23
1927	.82	.95	1.46	2.69	1.71	2.57	4.19	1.38	3.94	1.33	1.21	.75	23.00
1928	.29	2.06	.74	.65	3.14	3.23	1.81	4.06	.00	1.88	1.39	.79	20.04
1929	.25	.55	2.19	.00	3.22	.79	4.17	1.08	1.97	1.54	1.62	.12	17.50
1930	1.70	.00	.94	2.97	2.30	1.30	.89	1.86	1.78	10.18	1.25	1.90	27.07
1931	.92	1.95	2.58	2.44	2.24	.26	2.09	.27	.31	6.67	4.71	2.66	27.10
1932	2.94	2.32	.20	2.43	1.53	4.20	2.78	2.75	1.89	1.61	.25	4.30	27.20
1933	.21	1.28	1.53	1.09	2.74	.77	2.08	3.63	1.13	.30	2.02	1.46	18.24
1934	.51	.55	2.86	2.03	4.19	1.96	.37	.58	4.19	.49	3.61	.06	21.40
1935	.48	1.44	1.26	1.69	6.63	3.52	3.12	.91	3.50	1.98	1.87	1.10	27.50
1936	.20	.00	.15	2.43	3.81	1.40	.20	.00	8.60	1.09	.00	.25	18.13
1937	.41	.20	2.00	1.64	1.73	2.27	.87	3.74	2.07	5.66	.91	.74	22.24
1938	.65	4.03	2.51	1.31	5.10	3.94	1.52	.34	.56	.50	1.24	.13	21.83
1939	2.70	.29	1.97	.60	2.12	3.90	.20	3.80	.00	.42	.82	.70	17.52
1940	.09	1.95	.00	3.40	6.00	1.97	.92	2.04	1.86	3.41	3.32	1.07	26.03
1941	2.32	3.49	.84	4.23	7.86	8.41	2.53	2.46	3.16	6.15	1.06	1.12	43.63
1942	.16	.65	1.09	5.55	.65	2.90	.32	3.44	3.31	3.13	.47	2.12	23.79
1943	.45	1.01	1.84	4.32	4.15	1.38	.15	1.04	1.51	.34	.55	1.31	18.05
1944	2.02	1.89	1.03	1.50	.93	3.40	2.62	1.49	3.04	1.02	1.55	.00	20.49
1945	.28	.00	.00	3.15	1.38	2.18	6.55	.60	8.55	.55	.00	.45	23.69
1946	2.45	.15	1.15	.80	3.35	1.15	1.90	3.10	3.00	.30	2.35	2.50	22.20
1947	.25	.40	.00	3.80	8.70	.55	1.30	.00	.32	1.55	2.05	1.90	20.82
1948	.00	1.90	1.19	2.30	7.42	3.91	1.35	.00	.00	1.89	.50	.00	20.46
1949	4.33	.35	1.93	3.10	4.67	3.03	.00	2.76	3.73	2.64	.00	1.92	28.46
Ave.	1.04	1.14	1.27	2.41	3.67	2.56	1.87	1.85	2.70	2.39	1.37	1.28	23.55

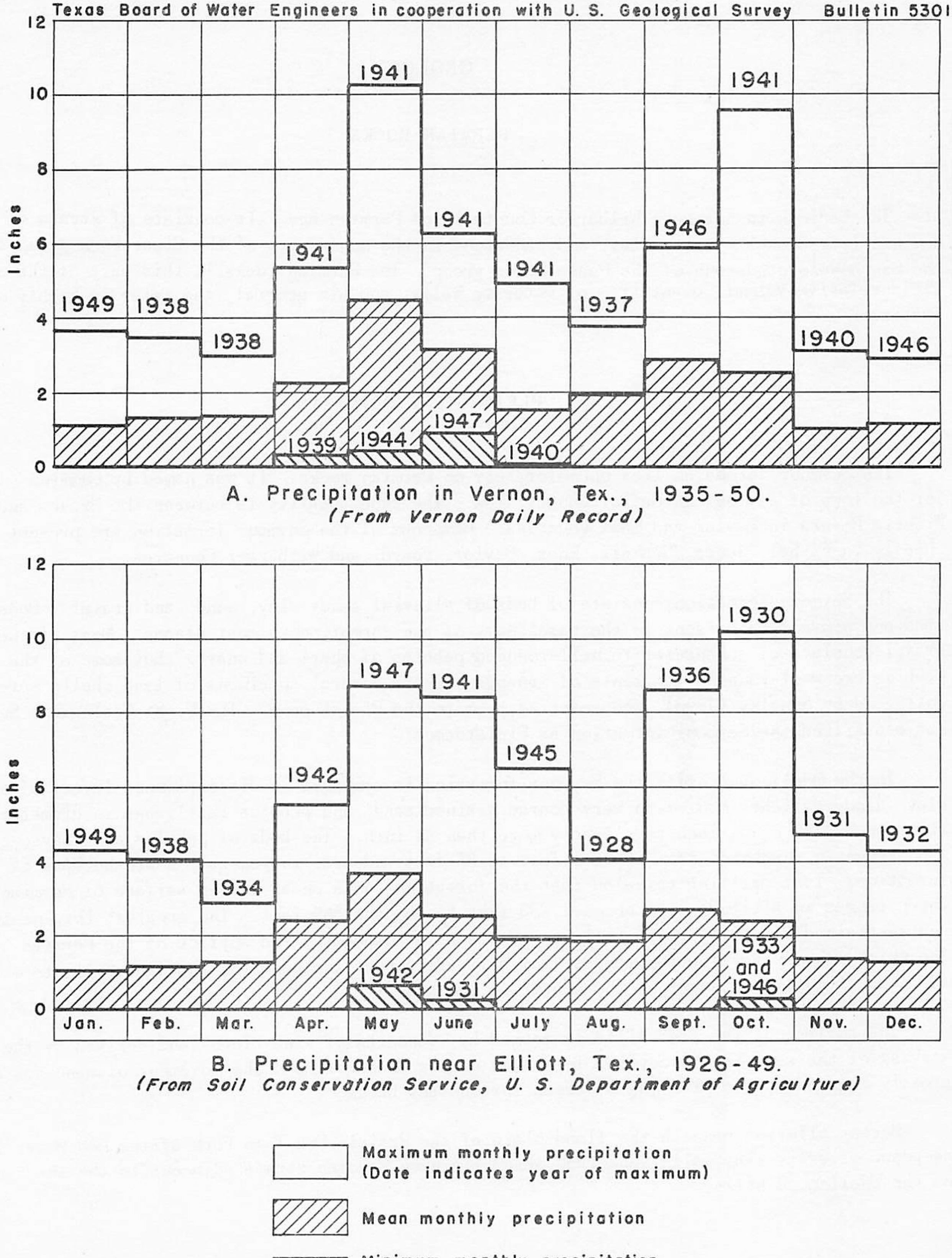

FIGURE 3.- Precipitation near Odell sand hills.

GEOLOGY

PERMIAN ROCKS

The bedrock in northern Wilbarger County is of Permian age. It consists of strata of predominantly red shale, silty clay, and sandstone in the upper part of the Clear Fork group and the San Angelo sandstone of the Pease River group. The Permian rocks in this part of the State yield relatively small quantities of water to wells, and, in general, the water is highly mineralized.

PLEISTOCENE DEPOSITS

The Seymour formation lies unconformably on Permian rocks. It was named by Cummins (1893) for the town of Seymour in Baylor County, Tex. The type locality is between the Brazos and Wichita Rivers in Baylor and Knox Counties. Remnants of the Seymour formation are present chiefly in Fisher, Jones, Haskell, Knox, Baylor, Foard, and Wilbarger Counties.

The Seymour formation consists of beds of alluvial sandy clay, sand, and gravel. Beds of sand and gravel are present in the basal part of the formation in most places. Most of the gravel consists of subangular to well-rounded pebbles of chert and quartz, but some of the pebbles are well-rounded fragments of igneous rocks. Several specimens of land shells were collected by Singley (1893), who referred them to the Pleistocene. The U. S. Geological Survey has classified the Seymour formation as Pleistocene.

In the Odell sand hills the Seymour formation is composed of discontinuous layers of sandy clay, sandy caliche, medium-to very coarse-grained sand, and pebbles that range in diameter from about an eighth of an inch to slightly more than an inch. The beds of pebbles and coarse-grained sand range in thickness from about 1 foot to 85 feet and are, in general, near the base of the formation. Test drilling revealed that the formation rests on an uneven surface of Permian rocks which ranges in altitude from about 1,230 feet to about 1,365 feet. The greatest thicknesses of coarse-grained material are in valleys and other low places on the surface of the Permian strata. The thickness of the alluvium ranges from a few feet near the edges of the sand hills to about 120 feet slightly southeast of the center of the area.

The surface of the sand hills is formed by deposits of wind-blown sand derived by the reworking of the sand in the Seymour formation during Recent time. The movement of sand has been greatly reduced by the planting of trees for shelter belts.

Recent alluvium beneath the flood plain of the Prairie Dog Town Fork of the Red River is composed of silty clay, silt, and sand which lie upon Permian strata adjacent to the lower edge of the Odell sand hills.

METHODS OF INVESTIGATION AND BASIC DATA

INVENTORY OF WELLS

An inventory of 22 water wells in the Odell sand hills was made at the beginning of the investigation in July 1951 to determine the depths to water and the thickness of the alluvium (see tables 6 and 7). The well inventory revealed that the static water levels ranged from about 12 to 39 feet below the surface and that most of the domestic wells did not penetrate the full thickness of the alluvium.

TEST DRILLING

A large part of the ground-water investigation was the drilling and logging of 70 test holes in August 1951. The test holes which were spaced at intervals of half a mile to a mile were drilled with a small portable rotary rig through the alluvium and a few feet into the underlying Permian rocks. The depths of the test holes ranged from 12 to 120 feet. Samples of the materials penetrated by the drill were collected at frequent intervals by Mr. Willis in order to permit study of the character of the alluvium and to determine the top of the Permian rocks. The map in figure 4 shows contours on the buried surface of the Permian rocks. The subsurface contour map shows two distinct buried valleys on the surface of the Permian rocks, as well as an apparently isolated basin or sink hole. Logs of the test holes show that the greatest thicknesses of coarse-grained sand and gravel are in the valleys. (See drillers' logs, table 7.)

The water level in each test hole was measured about 24 hours after the hole was drilled. The depths to water in the test holes ranged from about 5 to 48 feet below the surface. The map in figure 5 shows contours on the water table. An isopachous map showing the thickness of the saturated alluvium was constructed from the difference at each test hole between the altitude of the water level and the altitude of the Permian rocks. (See fig. 6.) Data obtained from the test drilling are shown in figure 7 in the form of an isometric projection.

WATER SAMPLING

Chemical analyses of water from 16 wells and 21 test holes are given in table 8. Galvanized 3-inch casing was set in several of the deeper holes that penetrated thick layers of coarse-grained sand and small gravel. The drilling mud was flushed from these holes by circulating clear water after the casing was set, and samples of water were collected about 24 hours later. The analyses of samples from the 21 test holes were similar to the analyses of the water from the 16 wells and are considered to be representative of the ground water in the sand hills.

TEST PUMPING

Pumping tests made by Mr. Knowles are described in a later section. (See pp. 16-25 ; figs. 8 and 9; and tables 3-5.)

Texas Board of Water Engineers in cooperation with U. S. Geological Survey

Bulletin 5301

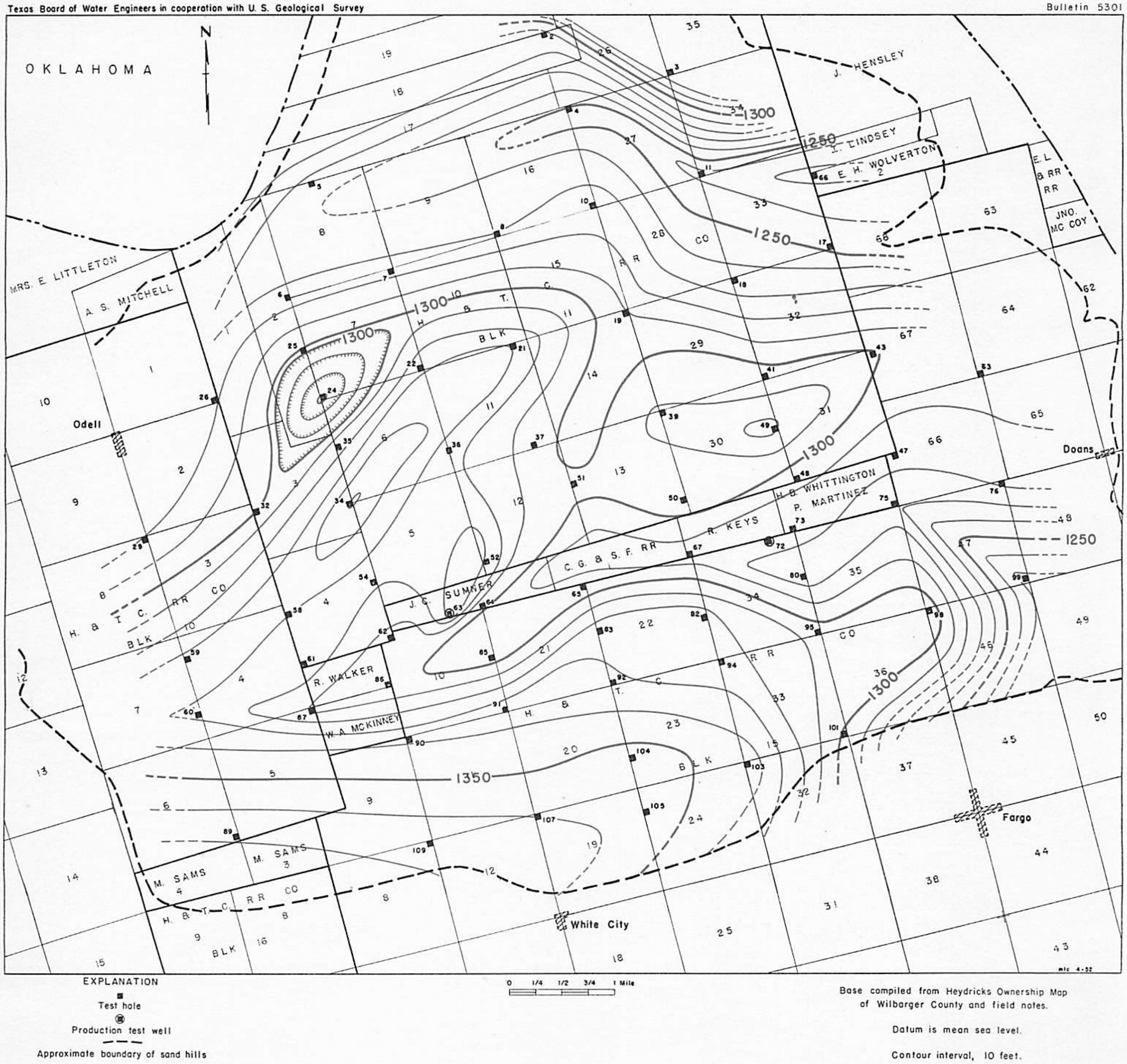

FIGURE 4.-Map showing contours on the Permian rocks beneath the Odell sand hills.

Texas Board of Water Engineers in cooperation with U. S. Geological Survey

Bulletin 5301

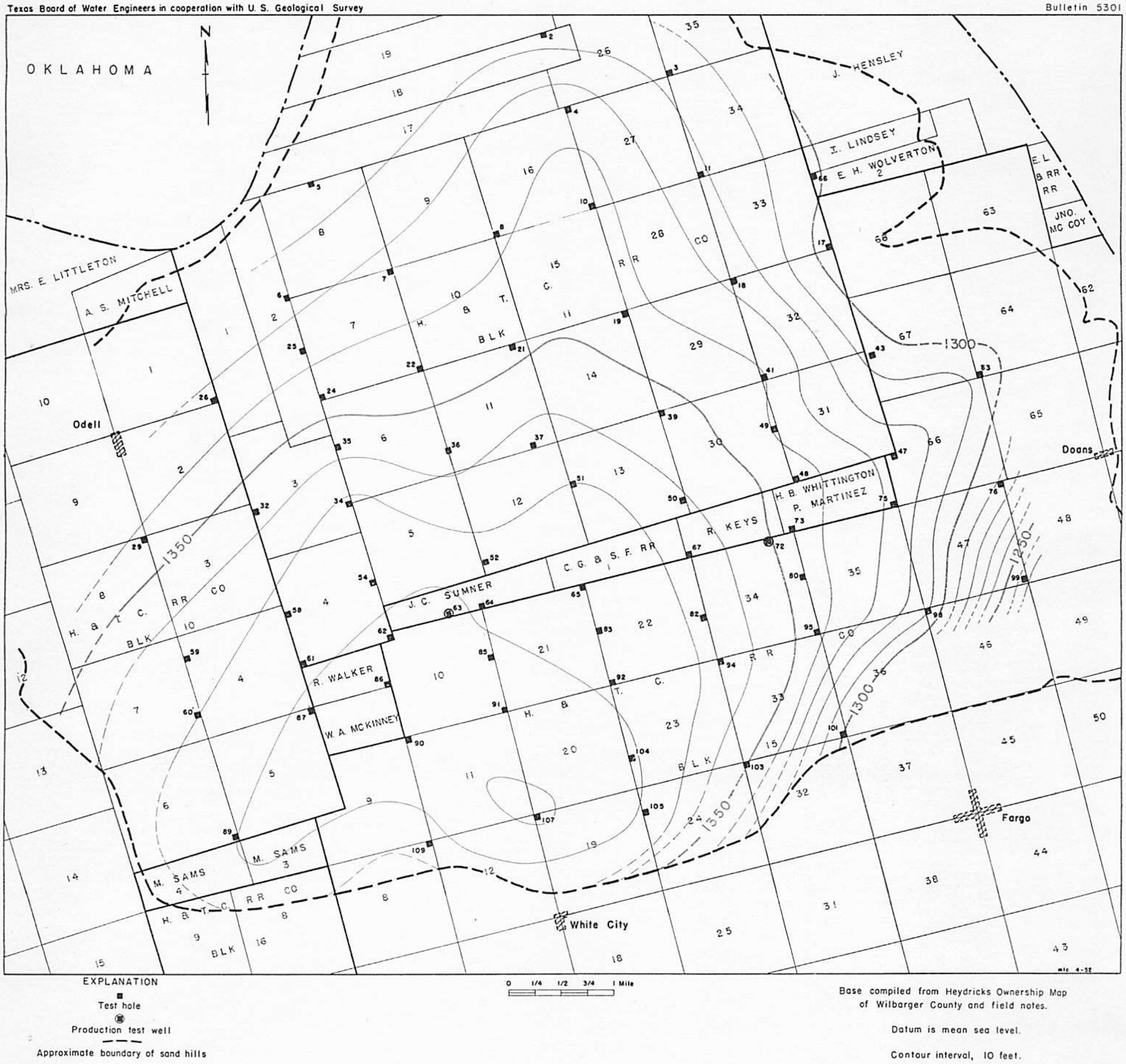

FIGURE 5.-Map showing contours on the water table in the Odell sand hills.

Texas Board of Water Engineers in cooperation with U. S. Geological Survey

Bulletin 5301

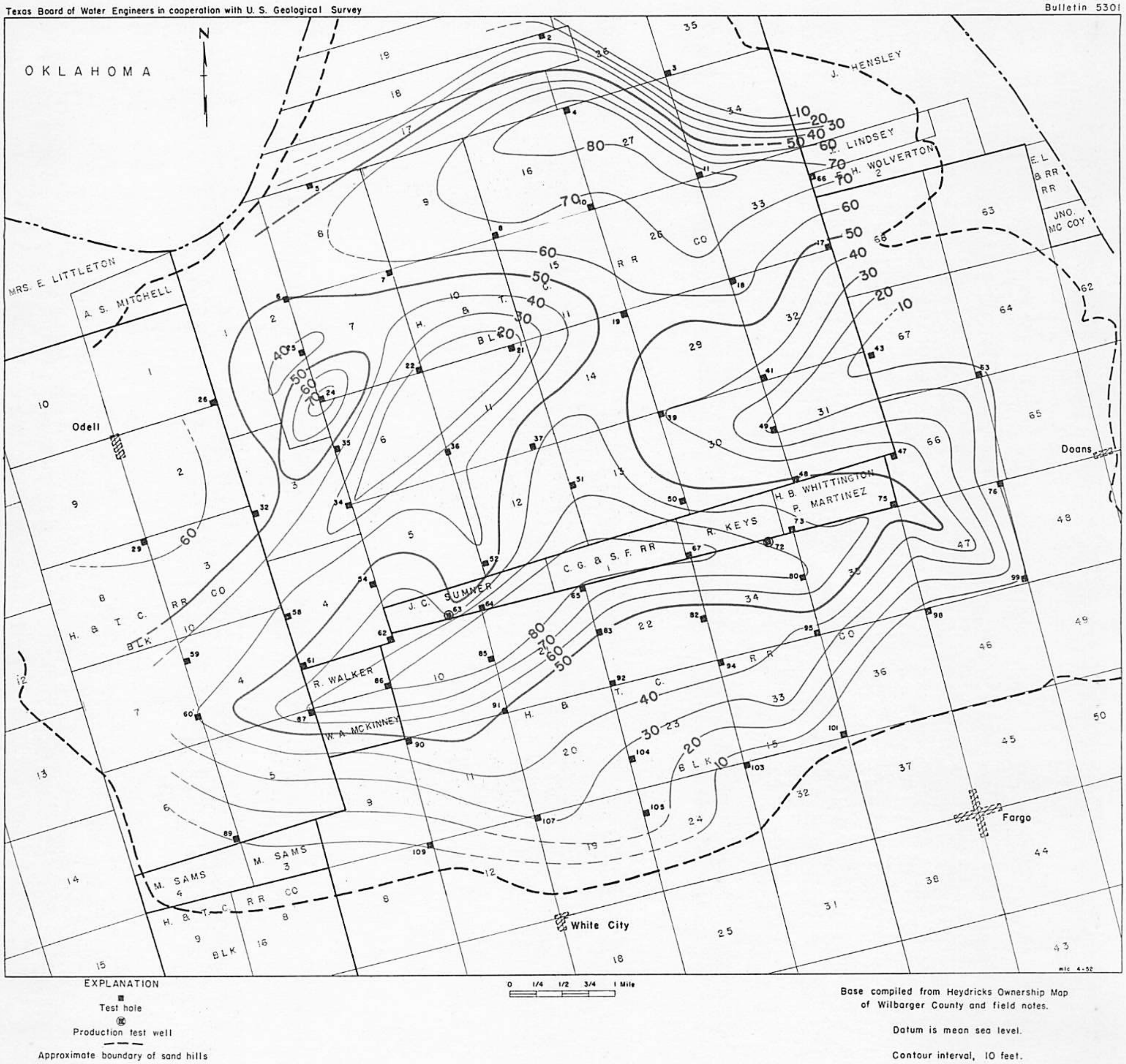

FIGURE 6. - Isopachous map of saturated alluvium in the Odell sand hills.

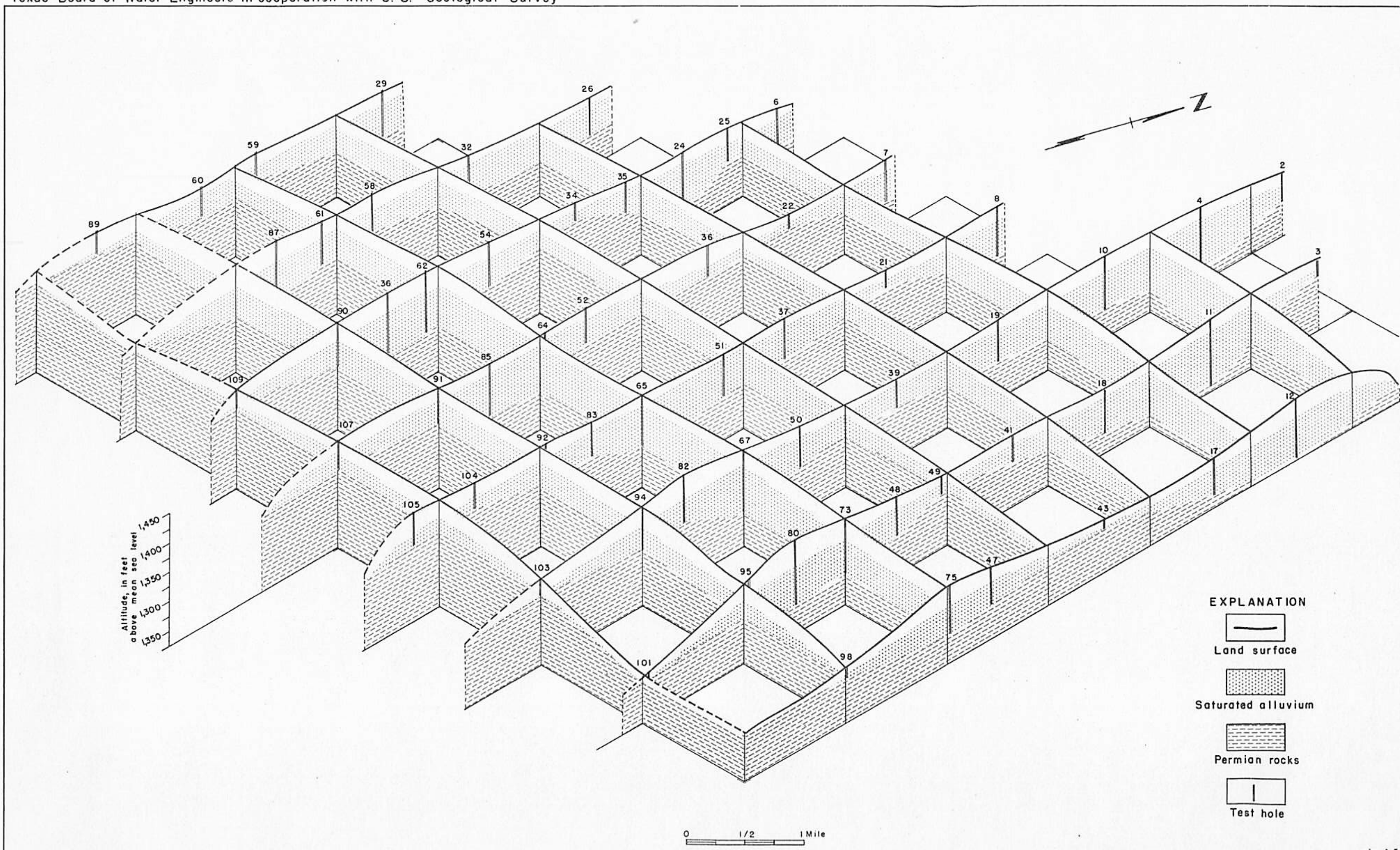

FIGURE 7.- Isometric projection of cross sections in the Odell sand hills.

GROUND WATER

GROUND-WATER STORAGE

Test drilling and measurements of static water levels revealed that the saturated thickness of alluvium ranges from a few inches near the edges of the sand hills to about 85 feet in the interior. Study of the isopachous map (fig. 6) indicates that approximately 1,500,000 acre-feet of alluvium is saturated with water within the 70 square miles investigated. An area of approximately 5 square miles in the northern part of the sand hills was not investigated.

The capacity of a water-bearing material to yield water from storage by gravity is called its specific yield and is the ratio of the volume of water a saturated material will yield by gravity to its own volume. The specific yield of the alluvium in the Odell area could not be determined from the studies made. However, the specific yield of the Ogallala formation of Pliocene age in the High Plains of Texas has been found to average about 15 percent (Alexander, Broadhurst, and White, 1943), which is believed to be in the right order of magnitude for the Seymour formation in the Odell sand hills. If the specific yield of the saturated alluvium in the sand hills is 15 percent, the volume of water in storage in the area investigated is 15 percent of 1,500,000 or about 225,000 acre-feet. It is feasible to recover only a part of this water through wells.

A buried valley in the Permian rocks extends from west to east across the southern part of the sand hills. The valley has an area of about 13 square miles and is filled with sand and gravel about 40 to 120 feet thick. The thickness of saturated material in the valley ranges from about 30 to 85 feet, and the average saturated thickness is about 60 feet. The volume of saturated sand and gravel in the valley is, therefore, about 480,000 acre-feet and the volume of water, assuming a specific yield of 15 percent, about 72,000 acre-feet.

Another buried valley extends from west to east across the northern part of the area. Although the valley was not thoroughly explored, the information so far gathered indicates that the quantity of water in storage may be comparable to that in the valley in the southern part of the sand hills.

RECHARGE TO AND DISCHARGE FROM THE GROUND-WATER RESERVOIR

Recharge to the ground-water reservoir is derived from precipitation that falls on the sand hills, mainly that of relatively infrequent heavy rains. After heavy rains much of the runoff collects in depressions on the surface of the sand hills. The soil and underlying material are predominantly sandy from the surface to the water table, and conditions are favorable for the infiltration of water. The ground-water reservoir is full in parts of the area where the water table is at or very near the surface, and precipitation that falls either runs off or is evaporated.

A state of dynamic equilibrium exists in a ground-water reservoir under natural conditions. That is, over a long period the average annual losses are equal to the average annual additions from recharge. If this were not true, the water table would decline until the reservoir contained no water or the water table would rise until it reached the surface. In this area the average annual discharge from seeps and springs around the edges of the Odell sand hills and by evaporation and transpiration is a measure of the average annual recharge.

Transpiration accounts for a large part of the annual discharge of ground water. Shelter belts cover about 600 acres, native vegetation covers about 6,000 to 8,000 acres, and subirrigated alfalfa covers about 1,000 acres. The shelter belts consist of cottonwood, elm, locust, pine, cedar, and bois d'arc trees. The native vegetation on the sand hills consists mainly of shin oak, sand sage, and wild plum bushes, but around the edges it consists chiefly of saltcedar, saltgrass, tule, and willow. The water table is about 20 feet or less below the surface of the sand-hills area. A large part of the natural vegetation; the trees in the shelter belts; and in places, the field crops have access to the water table.

Lakes formed by dams across small draws and marshes cover about 1,900 acres. Water is lost from ground-water storage in these areas by direct evaporation as well as by transpiration.

Water is lost from ground-water storage by seeps and springs around the edges of the sand hills. Wanderers Creek, along the western edge of the sand hills, is a perennial stream from the point where it enters the sand hills to the point where it discharges into the Prairie Dog Town Fork of the Red River.

It was beyond the scope of this investigation to determine the discharge from the springs and seeps around the edges of the sand hills, the use of water from ground-water storage by the vegetation, or the loss of water by evaporation from the marshy areas and small lakes where the water table is near or at the surface. It is possible, however, to approximate roughly these losses from storage. The movement of ground water is from a high point on the water table in the south-central part of the area toward the edges of the sand hills (fig. 5). On the basis of the average thickness of saturated sand, the capacity of the sand to transmit water, as determined from pumping tests (see next section), and the slope of the water surface, it was computed that about 2,800 acre-feet of water a year passes that part of the 1,350-foot contour within the sand hills shown on the water-table map in figure 5. Ground water is moving across this contour from an area of about 20 square miles. These computations indicate that the average contribution from each square mile is about 140 acre-feet a year. If the average annual discharge from each square mile of the entire sand-hills area is 140 acre-feet, the total discharge is about 10,000 acre-feet a year or about 9,000,000 gallons a day. The average annual discharge from the sand hills should be approximately equal to the average annual recharge. The recharge, therefore, is about 2.5 inches a year or about 10 percent of the average annual precipitation.

PUMPING TESTS

Pumping tests are made to determine the hydraulic characteristics of aquifers. These characteristics govern the ability of the aquifer to transmit water and to yield water from storage. Information on these characteristics, called the transmissibility and storage coefficients, can be used to predict the effects of pumping from wells.

A pumping test was made in November 1951 on well 63 (location shown on fig. 1). Water-level measurements were made periodically in well 63 and in two nearby observation wells for about 20 hours prior to the test. Well 63 was then pumped for 48 hours at an average rate of 165 gallons a minute. Water levels were measured in the wells at frequent intervals during the period of pumping and for about 26 hours after pumping ceased. Hydrographs of these wells and their relative locations are shown in figure 8.

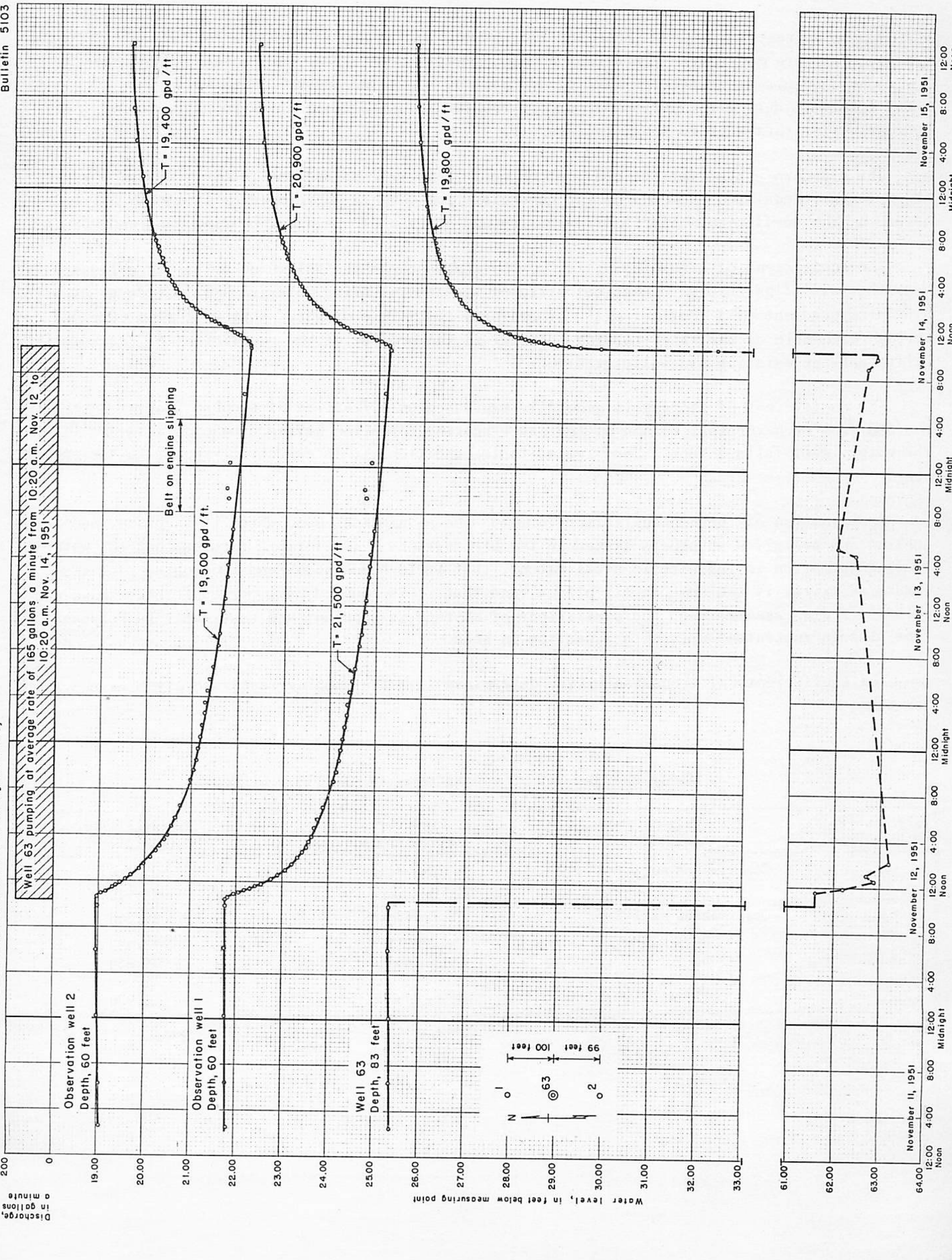

FIGURE 8. - Results of pumping test on well 63.

A pumping test was made in February 1952 on well 72 (location shown on fig. 1). Water-level measurements were made periodically for about 22 hours prior to the test. Well 72 was then pumped for about 45 hours at an average rate of 430 gallons a minute. Water levels were measured at frequent intervals during the period of pumping and for about 32 hours after pumping stopped. The hydrograph for this well is shown in figure 9.

The drawdown curves for the observation wells near well 63 and the recovery curves for all the wells were analyzed by means of the nonequilibrium formula, developed by Theis (1935), to determine the coefficients of transmissibility and storage of the water-bearing sand and gravel.

The coefficient of transmissibility may be expressed as the volume of water, in gallons a day, that will flow through a vertical strip of the water-bearing material 1 mile wide under a hydraulic gradient of 1 foot per mile. Therefore, the volume of water that will flow each day through each mile of the water-bearing material is the product of the coefficient of transmissibility and the existing hydraulic gradient.

The coefficient of storage is generally expressed as a fraction of a cubic foot of water discharged from each vertical column of the water-bearing formation having a base of 1 square foot as the water level falls 1 foot. Under water-table conditions it is essentially equal to the specific yield.

A discussion of the nonequilibrium formula, the assumptions upon which it is based, and its application are given in papers listed in the bibliography. The formula assumes that the water-bearing formation is infinite in areal extent, that it is homogeneous and isotropic, that its transmissibility is the same at all places, and that it is bounded by impermeable beds above and below. It also assumes that the coefficient of storage is constant and that water is released from storage instantaneously with a decline in head.

The coefficients of transmissibility determined from the pumping tests are given in the following table:

Table 3.- Results of pumping tests in Odell sand hills

Well causing interference	Well observed	Limb of hydrograph analyzed	Transmissibility (gpd/ft)
63	Observation well 1	Drawdown	21,500
63	do.	Recovery	20,900
63	Observation well 2	Drawdown	19,500
63	do.	Recovery	19,400
63	63	do.	19,800
72	72	do.	46,900

Texas Board of Water Engineers in cooperation with U. S. Geological Survey

Bulletin 5301

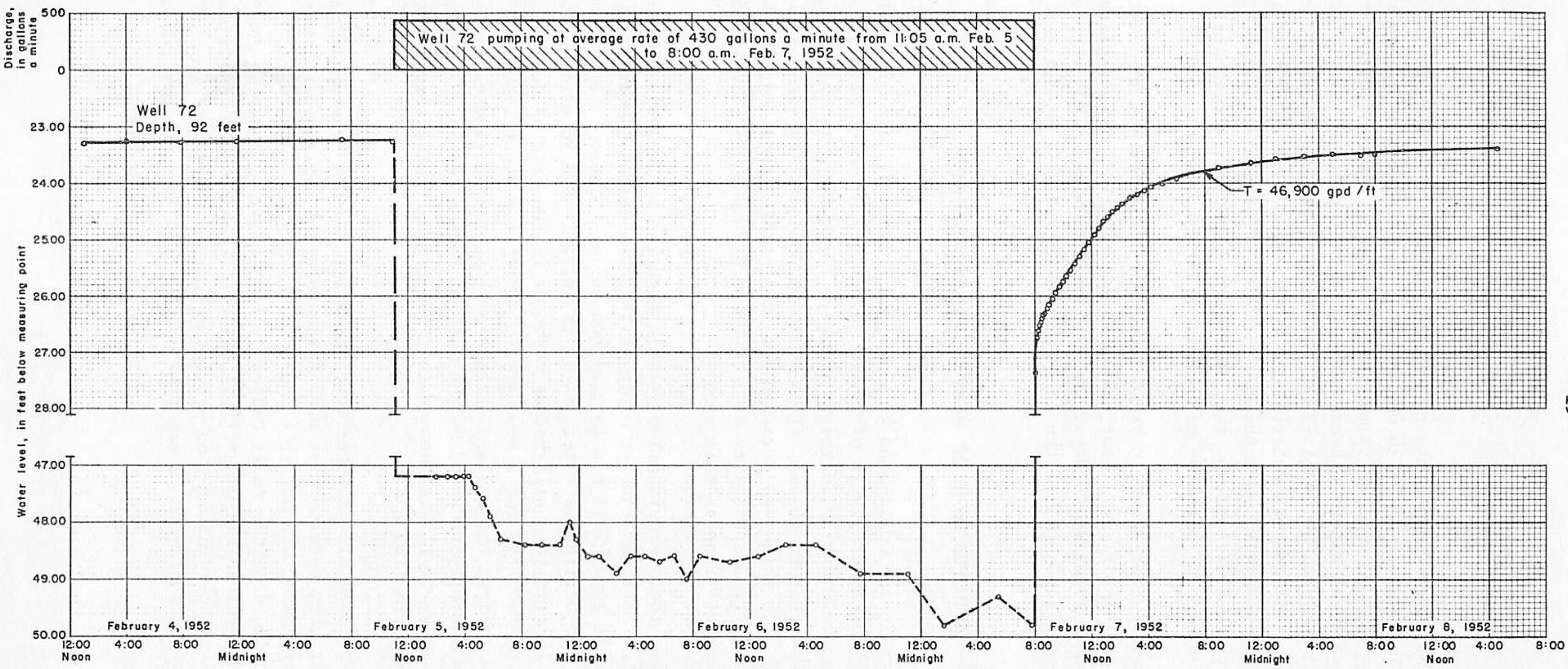

FIGURE 9.- Results of pumping test on well 72.

Table 3 indicates that the coefficients of transmissibility from the pumping test on well 63 check rather closely and average about 20,000 gpd/ft. The coefficient of transmissibility obtained from the pumping test on well 72 is more than double that computed from the pumping test on well 63. This was to be expected because the Seymour formation is a heterogeneous unconsolidated mass of sand and gravel. Well 72 penetrated 10 feet more saturated material than well 63, and the logs show that coarser material was encountered in well 72 than in well 63. Study of the available data indicates that the coefficients of transmissibility obtained from the two pumping tests may possibly express the range to be expected in that part of the Seymour formation having a saturated thickness of 60 feet or more.

The coefficient of storage or specific yield could not be determined from the pumping tests that were made. Under water-table conditions water drains slowly from the saturated material and a long pumping period is required to determine the specific yield. However, analysis of the data from the test on well 63 confirm the existence of water-table conditions.

APPLICATION OF PUMPING-TEST RESULTS

The two pumping tests in the Odell sand hills showed a range in transmissibility from about 20,000 to 47,000 gpd/ft. The lower figure of 20,000 gpd/ft may be more nearly representative of the main part of the Seymour formation in this area where large-capacity wells can be developed. If the pumping period had been long enough, it is believed the specific yield would have been in the order of magnitude of 0.15 which was obtained for water-table conditions in the High Plains of Texas. A coefficient of transmissibility of 20,000 gpd/ft and a specific yield of 0.15 were used for the purpose of computations in this report.

As has been explained, the nonequilibrium formula used in the analysis of the pumping-test data assumes that the water-bearing beds are of infinite areal extent. However, the ground-water reservoir in the Odell sand hills has lateral boundaries. These lateral boundaries will not materially influence the decline in water levels in wells in the interior of the sand hills when pumping begins, but in time they will become a factor in the rate of decline of the water levels. The length of time required for a boundary to affect the water levels increases with the distance of the boundary from the wells. Therefore, long-term estimates of declines in water levels must include the effect caused by the lateral boundaries of the ground-water reservoir. For purposes of computation it was assumed that the edge of the reservoir is approximately at the 10-foot isopach shown in figure 6.

In determining the drawdown of the water level in a well caused by its own pumping, the nonequilibrium formula may give results that are at considerable variance with the observed drawdown. In order to eliminate this possible source of error, the specific capacity of a well is used to determine the drawdown in it caused by its own pumping during the first day. The specific capacity of a well is the quantity of water it will yield for each foot of drawdown. The 1-day specific capacity of well 63 was 4.4 gallons a minute per foot of drawdown, and the 1-day specific capacity of well 72 was 17.0 gallons a minute per foot of drawdown.

Computations were made to show the effect that withdrawals of about 3,000,000 gallons a day would have on the water table in the Odell sand hills. It was assumed that this amount of water would be withdrawn from seven wells being pumped continuously at a rate of 300 gallons a minute each. If these wells were closely spaced, the mutual interference between them would make it impossible to maintain this rate of discharge for a long period. Computations were made to show the effect on the water table if the seven wells were spaced in a line only 500 feet apart, as compared to the effect on the water table if they were spaced in a line 2,000 feet apart. The assumed well sites are in the buried valley in the southern part of the sand hills where conditions are favorable for the development of large supplies of ground water. The locations of these hypothetical wells with respect to nearby test holes are shown in figure 10. The results of the computations for the 500-foot well spacing are given in table 4 and for the 2,000-foot well spacing, in table 5.

A specific capacity of 15 gallons a minute per foot of drawdown was used to compute the drawdowns due to their own pumping for the first day. This specific capacity is in the order of magnitude of that obtained in the pumping test for well 72, and it is reasonable to assume that wells having comparable specific capacities can be developed in parts of the Odell sand hills. The computed pumping levels in tables 4 and 5 would be increased if it is not possible to develop wells having a specific capacity as high as 15 gallons a minute per foot of drawdown.

Table 4.- Theoretical future drawdowns and pumping levels produced by pumping an average of about 3 million gallons a day from seven wells spaced 500 feet apart

Coefficient of transmissibility, T = 20,000 gpd/ft.
Coefficient of storage, S = 0.15

End of 3 months (each well pumped at average rate of 300 gpm continuously)

	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7
Drawdown caused by other wells (feet)	10	14	16	17	16	14	10
Drawdown caused by geologic boundaries (feet)	0	0	0	0	0	0	0
1/ Drawdown caused by pumping well itself (feet)	28	28	28	28	28	28	28
Approximate static water level, Aug. 1951 (feet below land surface)	6	6	6	6	6	6	6
Computed pumping level (feet below land surface)	44	48	50	51	50	48	44
Approximate depth to Permian rocks (feet below land surface)	92	91	90	90	90	90	91

End of 1 year (each well pumped at average rate of 300 gpm continuously)

	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7
Drawdown caused by other wells (feet)	21	26	29	30	29	26	21
Drawdown caused by geologic boundaries (feet)	0	0	0	0	0	0	0
1/ Drawdown caused by pumped well itself (feet)	30	30	30	30	30	30	30
Approximate static water level, Aug. 1951 (feet below land surface)	6	6	6	6	6	6	6
Computed pumping level (feet below land surface)	57	62	65	66	65	62	57
Approximate depth to Permian rocks (feet below land surface)	92	91	90	90	90	90	91

1/ Drawdown at end of first day based on 1-day specific capacity of 15 gallons a minute per foot of drawdown.

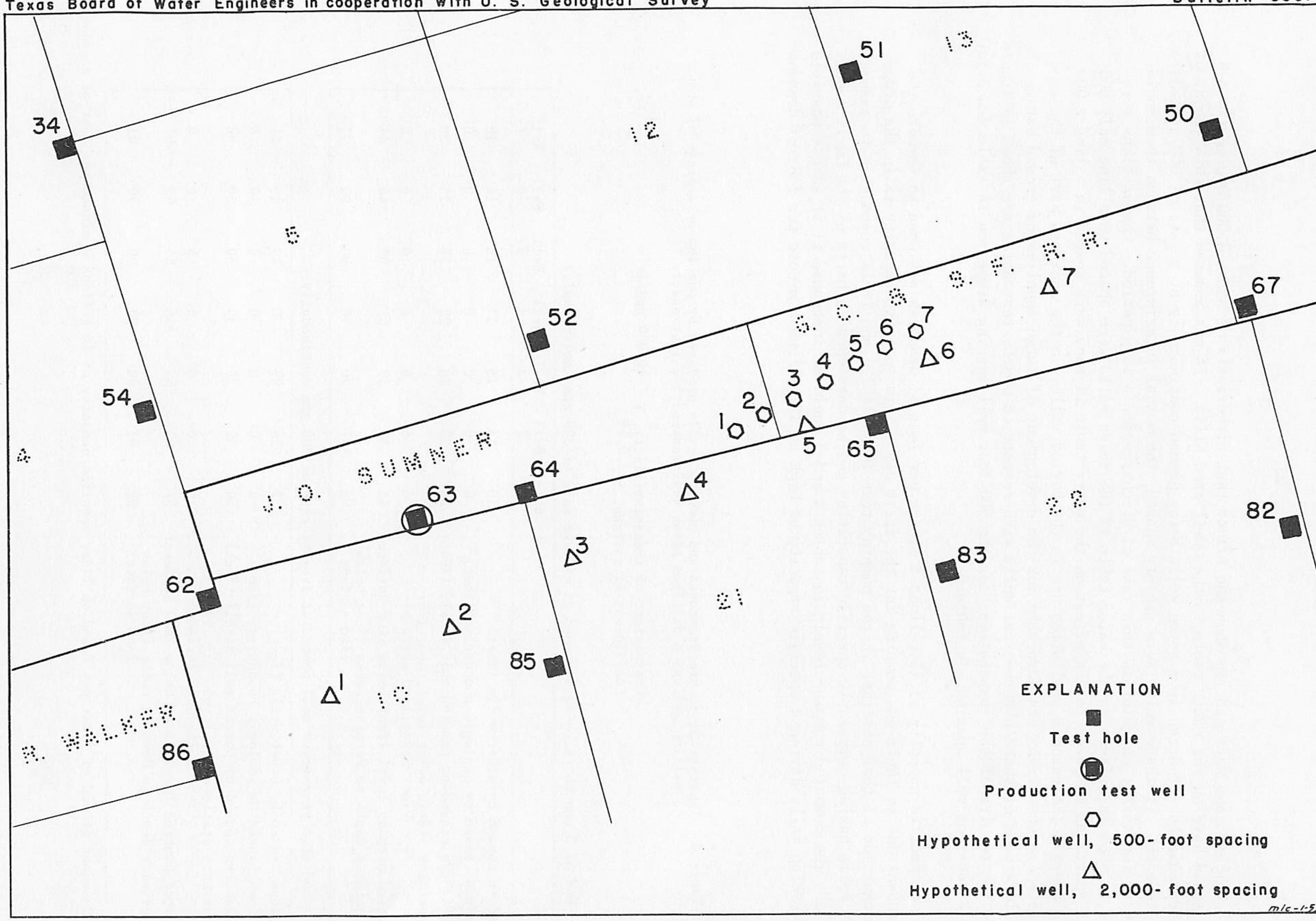

FIGURE 10. - Locations of hypothetical wells and nearby test holes.

Table 4.- Theoretical future drawdowns and pumping levels produced by pumping an average of about 3 million gallons a day from seven wells spaced 500 feet apart -- Continued

End of 5 years (each well pumped at average rate of 300 gpm continuously)

	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7
Drawdown caused by other wells (feet)	36	42	45	46	45	42	36
Drawdown caused by geologic boundaries (feet)	0	0	0	0	0	0	0
1/ Drawdown caused by pumping well itself (feet)	33	33	33	33	33	33	33
Approximate static water level, Aug. 1951 (feet below land surface)	6	6	6	6	6	6	6
Computed pumping level (feet below land surface)	75	81	84	85	84	81	75
Approximate depth to Permian rocks (feet below land surface)	92	91	90	90	90	90	91

Table 5.- Theoretical future drawdowns and pumping levels produced by pumping an average of about 3 million gallons a day from seven wells spaced 2,000 feet apart

Coefficient of transmissibility, T = 20,000 gpd/ft.

Coefficient of storage, S = 0.15

End of 3 months (each well pumped at average rate of 300 gpm continuously)

Drawdown caused by other wells (feet)	1	2	2	2	2	2	1
Drawdown caused by geologic boundaries (feet)	0	0	0	0	0	0	0
1/ Drawdown caused by pumping of well itself (feet)	28	28	28	28	28	28	28
Approximate static water level, Aug. 1951 (feet below land surface)	28	24	12	8	7	8	10
Computed pumping level (feet below land surface)	57	54	42	38	37	38	39
Approximate depth to Permian rocks (feet below land surface)	111	108	97	94	92	91	94

End of 1 year (each well pumped at average rate of 300 gpm continuously)

Drawdown caused by other wells (feet)	4	6	7	7	7	6	4
Drawdown caused by geologic boundaries (feet)	0	0	0	0	0	0	0
1/ Drawdown caused by pumping of well itself (feet)	30	30	30	30	30	30	30
Approximate static water level, Aug. 1951 (feet below land surface)	28	24	12	8	7	8	10
Computed pumping level (feet below land surface)	62	60	49	45	44	44	44
Approximate depth to Permian rocks (feet below land surface)	111	108	97	94	92	91	94

1/ Drawdown at end of first day based on 1-day specific capacity of 15 gallons a minute per foot of drawdown.

Table 5.- Theoretical future drawdowns and pumping levels produced by pumping an average of about 3 million gallons a day from seven wells spaced 2,000 feet apart -- Continued

End of 5 years (each well pumped at average rate of 300 gpm continuously)

	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7
Drawdown caused by other wells (feet)	11	16	18	19	18	16	11
Drawdown caused by geologic boundaries (feet)	0	0	0	0	0	0	0
1/ Drawdown caused by pumping of well itself (feet)	33	33	33	33	33	33	33
Approximate static water level, Aug. 1951 (feet below land surface)	28	24	12	8	7	8	10
Computed pumping level (feet below land surface)	72	73	63	60	58	57	54
Approximate depth to Permian rocks (feet below land surface)	111	108	97	94	92	91	94

1/ Drawdown at end of first day based on 1-day specific capacity of 15 gallons a minute per foot of drawdown.

Table 4 shows the theoretical pumping levels for seven wells, each pumping 300 gallons a minute continuously and spaced in a line 500 feet apart, at the end of 3 months, 1 year, and 5 years. Computations indicate that before the end of 20 years the pumping levels would be at the base of the water-bearing material and the yield of the wells could not be maintained at 300 gallons a minute. The wells are assumed to be located where the saturated material is more than 80 feet thick. If it were necessary to locate the wells where the water-bearing material were not as thick, the pumping levels would be at the top of the Permian rocks in a much shorter time.

Table 5 shows the theoretical pumping levels for seven wells pumping 300 gallons a minute continuously and spaced 2,000 feet apart at the end of 3 months, 1 year, and 5 years. Computations show that the pumping levels would be about 15 feet above the base of the water-bearing material at the end of 20 years. Therefore, the assumed rate of pumping probably could be maintained if the wells were spaced 2,000 feet apart and were developed where the saturated material is of comparable thickness, provided that wells can be developed to have a specific capacity of 15 gallons a minute per foot of drawdown.

The estimates of the declines in water levels given in tables 4 and 5 are based on the assumption that all the water comes from storage - that is, the estimate that there is no recharge. From this standpoint, therefore, the estimates are conservative. However, because some of the other assumptions of the nonequilibrium formula are not fulfilled and the effect of these deviations may be in the opposite direction, the figures should be used with caution. For example, it is assumed that there would be no pumping except from the seven wells. However, it is believed that the estimates are probably of the right order of magnitude and may serve as a basis for the proper development of the ground-water resources of this area.

It has been estimated that about 10,000 acre-feet of water a year is now being discharged through seeps and springs around the edges of the sand hills and by evaporation and transpiration. This quantity, if correct, represents the perennial yield of the Odell sand hills if all the natural discharge were captured. The water table would have to be lowered below the roots of the vegetation that now use water from ground-water storage in order to capture all the natural discharge. It would also have to be lowered sufficiently to eliminate the present loss of water by seeps and springs around the edges of the sand hills. A large number of wells would be required to capture all the natural discharge. Many of the wells would necessarily have low yields where the saturated material is thin. However, if only a third of the 10,000 acre-feet of water a year now being lost could be captured, a ground-water development of 3,000,000 gallons a day would be possible for an indefinite period of time.

The water table is at or near the surface in parts of the sand hills. In these areas the ground-water reservoir is full and no water can be added. Precipitation that occurs is rejected - that is, it either runs off or is evaporated. Lowering the water table in these areas would create storage space in the ground-water reservoir and tend to increase the natural recharge.

If the city of Vernon, irrigation farmers, or others develop wells in the Odell sand hills, it would be desirable to make further pumping tests as the development proceeds to verify the coefficients of transmissibility and storage used in this report. Records should be kept of the pumpage and the decline in water levels so that the estimated declines can be properly evaluated as pumping from the Odell sand hills proceeds.

EFFECT OF PUMPING ON THE WATER TABLE IN SIMILAR AREAS NEAR CROWELL AND CHILDRESS

Investigations of the ground-water resources were made in the vicinity of Crowell in Foard County in 1940-41 and in the Michie sand hills area in Childress County in 1945-46. These areas are somewhat similar to the Odell sand hills. Test drilling and other studies revealed that the thickness of alluvium ranged from a few inches to about 40 feet in the area near Crowell and from a few inches to about 200 feet in the Michie sand hills. The greatest thicknesses of saturated sand and gravel were in buried valleys and depressions in the underlying Permian rocks. Production wells were drilled where the saturated sand and gravel was thick, and pumping tests were made. From the results of these investigations, the spacing of additional production wells and rates of pumping for specific water requirements were determined.

Measurements of the static water levels and pumping levels were made at regular intervals and records of pumping rates were kept. These records are an aid in determining the amount of future development that is feasible and in determining whether changes in well spacing and rates of pumping should be made in the well fields.

Records of rates of pumping and water levels in two wells each in the Crowell and Childress well fields are shown graphically in figures 11 and 12. The records are not complete, but they illustrate the effects of changes in the rates of pumping and aid in the operation of the well fields.

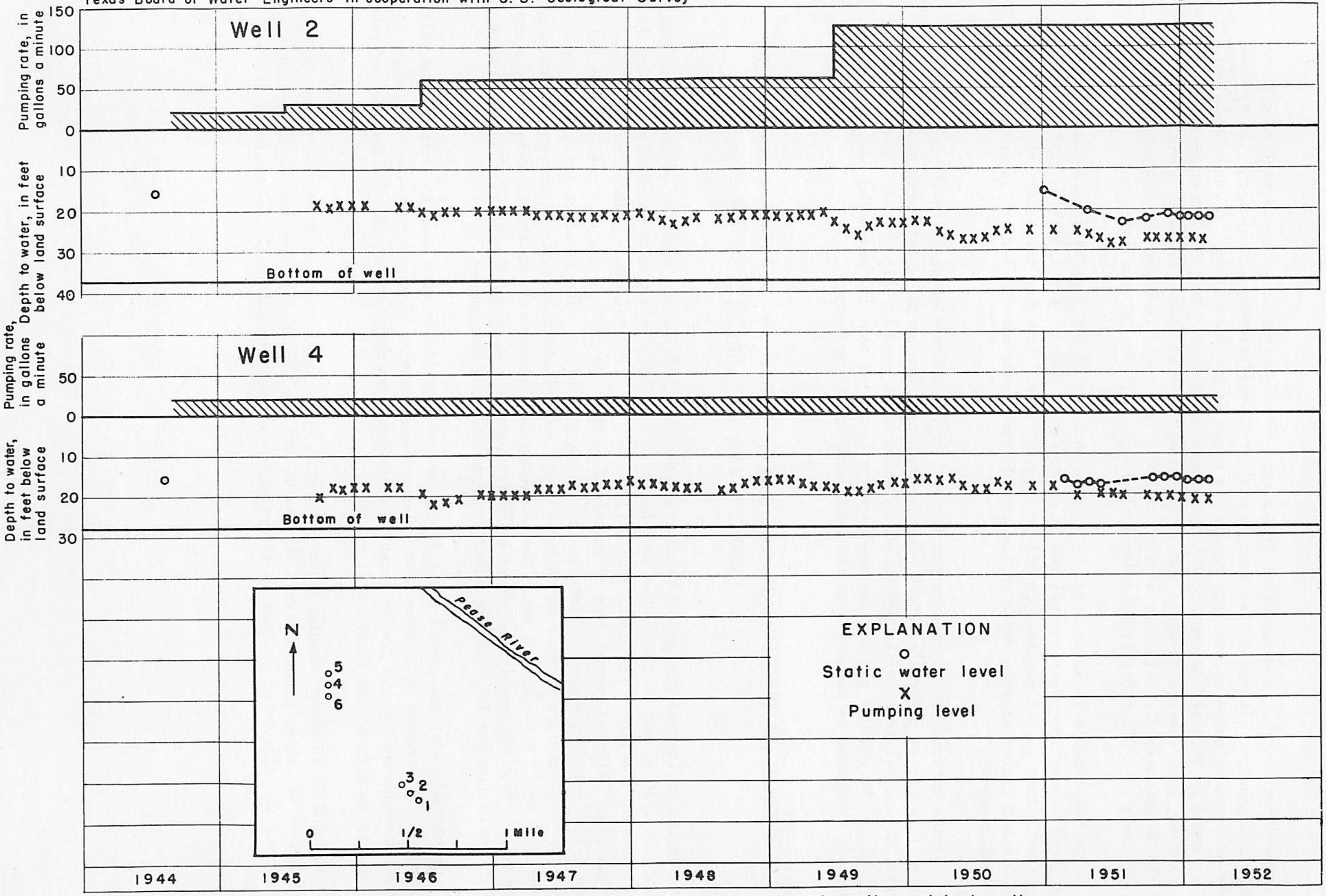

FIGURE 11. - Rate of pumping and water levels, Crowell municipal wells.

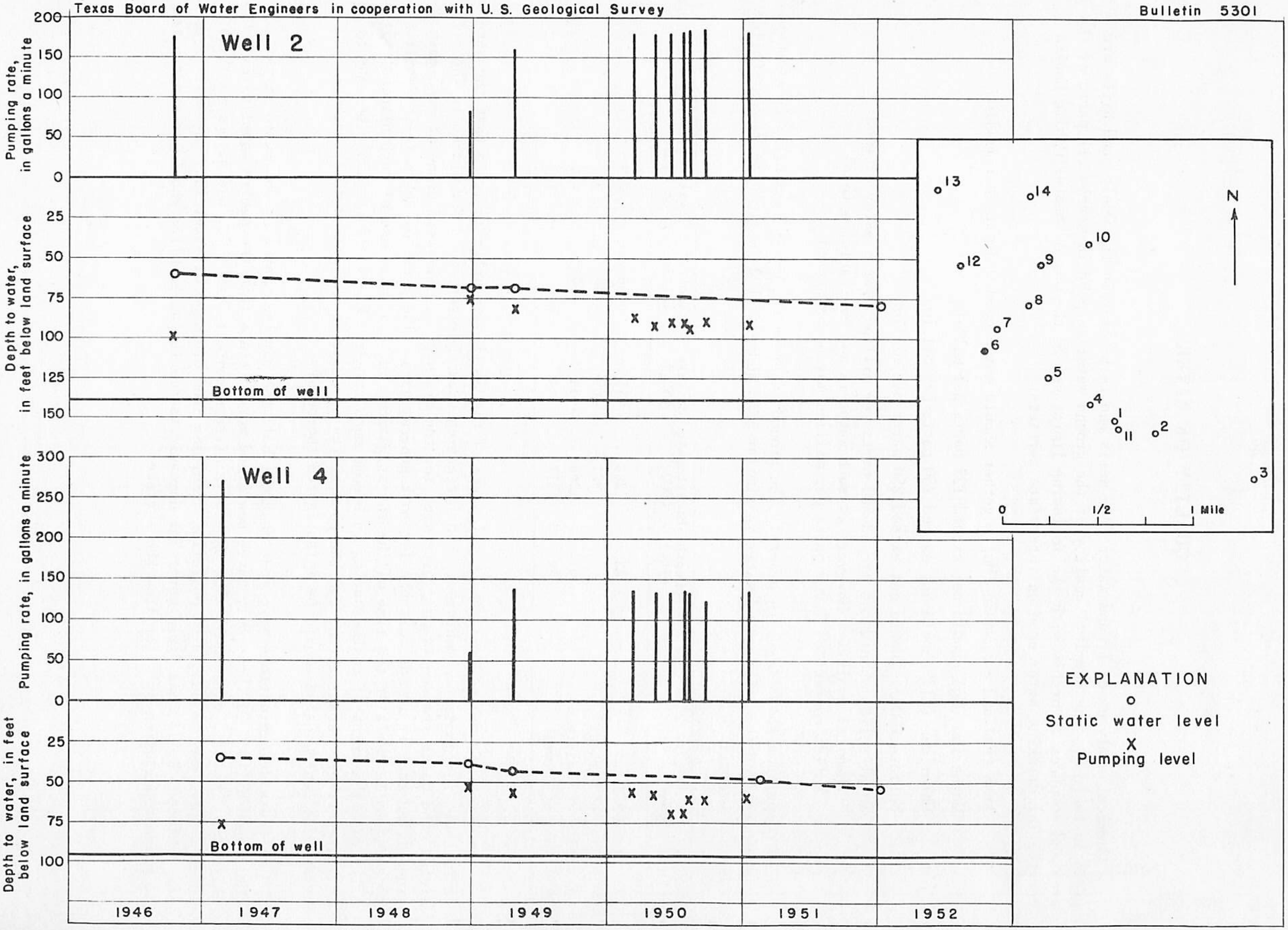

FIGURE 12.- Rate of pumping and water levels, Childress municipal wells.

QUALITY OF WATER

Chemical analyses of ground water from wells and test holes in the Odell sand hills are given in table 8. The chemical quality of the ground water is good in nearly all parts of the area and compares favorably with the following limits set by the United States Public Health Service for drinking water used on interstate carriers.

Iron (Fe) and manganese (Mn) together should not exceed 0.3 part per million.

Magnesium (Mg) should not exceed 125 parts per million.

Chloride (Cl) should not exceed 250 parts per million.

Sulfate (SO_4) should not exceed 250 parts per million.

Total solids should not exceed 500 parts per million, for a water of good chemical quality. However, if such water is not available, a total solids content of 1,000 parts per million may be permitted.

A comparison shows that, in general, the ground water in the Odell sand hills is slightly less mineralized than the ground water in similar sand and gravel deposits near Vernon, Childress, and Crowell.

Well	Owner	Depth (ft.)	Bicarbonate (HCO_3)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$
63	Leon Brooks	83	284	15	456	289
-	City of Vernon	--	321	65	540	302
6	City of Childress	107	266	38	470	275
5	City of Crowell	28	317	44	487	338

Analyses of samples from nearly all parts of the Odell sand hills indicate that the water is suitable for domestic, municipal, and irrigation uses; however, in a few places in the oil fields, the water from wells near pits used for the disposal of oil-field brine is so highly mineralized that it is not suitable for most general uses. The areas of contaminated water appeared to be small at the time of the investigation but continued use of such disposal pits will cause the areas of contamination to become much larger. Every effort should be made to prevent further contamination, and the possibility of removing the ground water that has already been contaminated should be investigated thoroughly.

Nitrate determinations were made on about half the samples that were collected in the Odell sand hills. Of these only three contained more nitrate than the public supplies of Childress, Crowell, or Vernon. The excessive nitrate content of 90, 78, and 55 ppm in these three samples may be caused by pollution resulting from drainage of water into the wells from the surface. Wells that yield water for domestic and municipal supplies should be constructed to prevent pollution by water from the surface.

CONCLUSIONS

The data accumulated in the ground-water investigation of the Odell sand hills during 1951-52 indicate that the area contains favorable sites from which supplies of water can be obtained for domestic, municipal, or irrigation use.

Analysis of the available data shows that approximately 1,500,000 acre-feet of saturated sand and gravel is contained in the 70 square miles investigated. If the saturated material has a specific yield of 15 percent, approximately 225,000 acre-feet of water is now in storage.

It is estimated that about 10,000 acre-feet of water a year is being discharged from seeps and springs around the edges of the sand hills and by evapotranspiration. This quantity of water is approximately equal to the average annual recharge and is equivalent to about 2.5 inches a year over the entire area. The perennial yield of the Odell sand hills would be 10,000 acre-feet of water a year if all the natural discharge could be captured. If one-third of the natural discharge were captured, a continuous withdrawal of 3,000,000 gallons a day could be maintained indefinitely. A much larger withdrawal could be made for several years by taking water from storage and unwatering the alluvium.

A buried valley in the southern part of the sand hills is one of the most favorable areas for developing large-capacity wells. Computations based largely on data obtained from two pumping tests indicate that seven wells spaced in a line 500 feet apart probably could not maintain yields of 300 gallons a minute. The computations indicate that it would be more desirable to space large capacity wells at least 2,000 feet apart.

The chemical quality of the ground water throughout the Odell sand hills, except for small areas contaminated by oil-field brine, is within the limits recommended by the U. S. Public Health Service for interstate carriers, and the water is less mineralized than the municipal supplies of Childress, Crowell, and Vernon.

BIBLIOGRAPHY

1. ALEXANDER, W. H., Jr., BROADHURST, W. L., and WHITE, W. N., 1943, Progress report on ground water in the High Plains of Texas: Texas Board of Water Eng. duplicated report, p. 16, 34 pp.

2. BARNES, J. R., and OTHERS, 1949, Geology and ground water in the irrigated region of the southern High Plains in Texas: Progress report no. 7: Texas Board of Water Eng., duplicated report, 51 pp.

3. CUMMINS, W. F., 1893, in Notes on the geology of northwest Texas: Texas Geol. Survey 4th Ann. Rept., pt. 1, p. 181.

4. FOLLETT, C. R., SUNDSTROM, R. W., and WHITE, W. N., 1944, Ground-water resources in the vicinity of Vernon, Tex.: Texas Board of Water Eng., duplicated rept., 43 pp.

5. GORDON, C. H., 1913, Geology and underground water of the Wichita region, north-central Texas: U. S. Geol. Survey Water-Supply Paper 317, pp. 30-34.

6. JACOB, C. E., 1940, On the flow of water in an elastic artesian aquifer: Am. Geophys. Union Trans., pt. 2, pp. 574-586.

7. MEINZER, O. E., and WENZEL, L. K., 1942, Ground water Chapter 10 in Hydrology, Physics of the Earth Ser., vol. 9, pp. 385-478, New York, McGraw-Hill Book Co., Inc.

8. SINGLEY, J. A., 1893, in Notes on the geology of northwest Texas: Texas Geol. Survey 4th Ann. Rept., pt. 1, pp. 186-190.

9. THEIS, C. V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage: Am. Geophys. Union Trans., pt. 2, pp. 519-524.

10. ____________ 1938, The significance and nature of the cone of depression in ground-water bodies: Econ. Geology, vol. 33, pp. 889-902.

11. U. S. PUBLIC HEALTH SERVICE, 1946, Drinking water standards: U. S. Public Health Service, vol. 61, no. 11, pp. 371-384.

12. WENZEL, L. K., 1942, Methods for determining permeability of water-bearing materials: U. S. Geol. Survey Water-Supply Paper 887.

Table 6.- Records of wells, test holes, and springs in Odell sand hills, Wilbarger County, Tex.

All wells are drilled unless otherwise noted in the remarks column.

Method of lift: B, bucket; C, cylinder; E, electric; G, gasoline; H, hand; J, jet; T, turbine; W, windmill.
Use of water : D, domestic; Irr, irrigation; N, not used; P, public supply; S, stock.

Well	Location			Owner	Driller	Date completed	Altitude of land surface (ft.)	Depth of well (ft.)	Diameter of well (in.)	Water level		Method of lift	Use of water	Remarks a/
	Section	Block	Survey							Below land surface datum (ft.)	Date of measurement			
1	½ mile W of NE cor. 18	11	H.& T.C. R.R. Co.	Mrs. John Minarik	--	Old	--	31	36	23.7	July 19, 1951	C,W	D,S	Dug. Concrete casing to 31 feet.
2	¼ mile W of NE cor. 18	11	do.	do.	Wiseman Drilling Co.	1951	1,336	51	4½	20.0	Aug. 16, 1951	None	N	Test hole. See log.
3	SW cor. 35	11	do.	State of Texas	do.	1951	1,353	43	4½	--	--	None	N	Test hole in highway R.O.W. See log.
4	NW cor. 27	11	do.	Wilbarger County	do.	1951	1,356	107	4½	19.3	Aug. 16, 1951	None	N	Test hole in county road R.O.W. Temp. 66° F. See log.
5	NW cor. NE¼ 8	11	do.	J. F. Watson	do.	1951	1,338	72	4½	23.7	Aug. 11, 1951	None	N	Test hole. See log.
6	1 mile S of NE cor. 2	11	do.	Wilbarger County	do.	1951	1,340	66	4½	13.6	do.	None	N	Test hole in county road R.O.W. See log.
7	NE cor. 7	11	do.	do.	do.	1951	1,349	73	4½	14.8	do.	None	N	Test hole in county road R.O.W. Temp. 68° F. See log.
8	SW cor. 16	11	do.	do.	do.	1951	1,358	92	4½	19.6	Aug. 7, 1951	None	N	Test hole in county road R.O.W. Temp. 66° F. See log.
9	SE¼SW¼ 16	11	do.	Elwin Bingham	W. E. Turner	1949	--	112	7	24.2	Feb. 2, 1952	C,W	D,S	Steel casing to 112 feet.
10	SE cor. 16	11	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,367	92	4½	23.0	Aug. 16, 1951	None	N	Test hole in county road R.O.W. Temp. 67° F. See log.
11	SW cor. 34	11	do.	State of Texas	do.	1951	1,353	117	4½	--	--	None	N	Test hole in highway R.O.W. Temp. 66° F. See log.
12	SE¼SE¼ 34	11	do.	Mrs. Jewel Rape	W. E. Turner	--	--	113	6	29.0	Feb. 1, 1952	C,W	D,S	Steel casing to 113 feet.
13	NW cor. 2	--	E.H.Wolverton	C. D. Watts	Wiseman Drilling Co.	1951	1,331	104	4½	27.7	Aug. 7, 1951	None	N	Test hole. Temp. 66° F. See log.

Table 6.- Records of wells, test holes, and springs in Odell sand hills, Wilbarger County--Continued

Well	Location			Owner	Driller	Date completed	Altitude of land surface (ft.)	Depth of well (ft.)	Diameter of well (in.)	Water level		Method of lift	Use of water	Remarks a/
	Section	Block	Survey							Below land surface datum (ft.)	Date of measurement			
14	--	--	J. Hensley	Roy O. Watts	--	--	--	Spring	--	+	Feb. 28, 1951	Flowing	S	Seeps near base of Seymour formation.
15	--	--	E.H.Wolverton	do.	--	--	--	Spring	--	+	Feb. 9, 1952	Flowing	S	Do.
16	SW¼NE¼ 68	15	H.& T.C. R.R. Co.	do.	--	--	--	Spring	--	+	do.	Flowing	S	Do.
17	SE cor. 33	11	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,311	70	4½	16.1	Aug. 24, 1951	None	N	Test hole in county road R.O.W. Temp. 66° F. See log.
18	NW cor. 32	11	do.	State of Texas	do.	1951	1,338	74	4½	10.2	Aug 17, 1951	None	N	Test hole in highway R.O.W. See log.
19	NE cor. 14	11	do.	do.	do.	1951	1,361	72	4½	17.3	Aug. 15, 1951	None	N	Test hole in highway R.O.W. Temp. 67° F. See log.
20	SW¼SW¼ 15	11	do.	H. B. Farrell	--	Old	--	57	6	27.1	July 18, 1951	C,H	D	
21	1/8 mile W of NE cor.	11	do.	State of Texas	Wiseman Drilling Co.	1951	1,359	37	4½	28.4	Aug. 10, 1951	None	N	Test hole in highway R.O.W. Temp. 66° F. See log.
22	SE cor. 7	11	do.	do.	do.	1951	1,353	26	4½	7.8	Aug. 11, 1951	None	N	Test hole in highway R.O.W. See log.
23	NE cor. NW¼ 6	11	do.	Mrs. Florence Fain	--	Old	--	29	6	11.9	July 18, 1951	C,W	D,S	
24	SW cor. 7	11	do.	State of Texas	Wiseman Drilling Co.	1951	1,360	93	4½	15.0	Aug. 10, 1951	None	N	Test hole in highway R.O.W. See log.
25	7/8 mile N of SE cor. 2	11	do.	Wilbarger County	do.	1951	1,358	58	4½	21.3	Aug. 11, 1951	None	N	Test hole in county road R.O.W. See log.
26	SE cor. 1	10	do.	State of Texas	do.	1951	1,343	64	4½	10.3	Aug. 14, 1951	None	N	Test hole in highway R.O.W. See log.
27	NW cor. 2	10	do.	G. B. Newton	--	--	--	52	6	34.6	July 18, 1951	C,W	D	Steel casing to 52 feet.
28	1/8 mile S of NW cor. 2	10	do.	W. E. Turner	W. E. Turner	--	--	84	7	--	--	J,E	D	Steel casing to 84 feet, perforated from 78 to 84 feet.
29	NE cor. 8	10	do.	State of Texas	Wiseman Drilling Co.	1951	1,363	82	4½	19.0	Aug. 13, 1951	None	N	Test hole in highway R.O.W. See log.
30	NW cor. 3	10	do.	Truman Castleberry	--	--	--	23	6	b/20	--	B,H	D	Galvanized iron casing to 23 feet. Temp. 67° F.

Table 6.- Records of wells, test holes, and springs in Odell sand hills, Wilbarger County--Continued

Well	Location: Section	Location: Block	Location: Survey	Owner	Driller	Date completed	Altitude of land surface (ft.)	Depth of well (ft.)	Diameter of well (in.)	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks a/
31	SW¼NW¼ 3	10	H.& T.C.R.R. Co.	Nelson Johnson	--	--	--	49	8	13.3	July 18, 1951	C,W	S	
32	½ mile N of SW cor. 3	11	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,367	68	4½	9.5	Aug. 14, 1951	None	N	Test hole in county road R.O.W. See log.
33	¼ mile S of NE cor. 4	11	do.	E. H. Pigg	--	--	--	--	--	--	--	C,W	D	Well near salt-water disposal pit. Texas Co. lease.
34	½ mile N of SE cor. 3	11	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,382	33	4½	11.4	Aug. 10, 1951	None	N	Test hole in county road R.O.W. See log.
35	SW cor. NW¼ 6	11	do.	do.	do.	1951	1,366	53	4½	9.3	Aug. 11, 1951	None	N	Do.
36	¼ mile N of SE cor. 6	11	do.	W. F. Shelton	do.	1951	1,382	59	4½	25.5	do.	None	N	Test hole. See log.
37	¼ mile W of SE cor.	11	do.	Wilbarger County	do.	1951	1,376	74	4½	11.7	Aug. 7, 1951	None	N	Test hole in county road R.O.W. Temp. 67° F. See log.
38	¼ mile S of NE cor. 12	11	do.	I. W. Boyd	--	--	--	33	8	19.5 20.5	July 19, 1951 Feb. 1, 1952	C,W	D,S	
39	NW cor. 30	11	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,359	48	4½	6.4	Aug. 15, 1951	None	N	Test hole in county road R.O.W. See log.
40	¼ mile N of SW cor. 32	11	do.	Cleve Hamilton	--	--	--	25	2	16.9	Feb. 1, 1952	None	N	Driven.
41	SW cor. 32	11	do.	State of Texas	Wiseman Drilling Co.	1951	1,352	52	4½	11.3	Aug. 17, 1951	None	N	Test hole in highway R.O.W. Temp. 67° F. See log.
42	¼ mile E of NE cor. 31	11	do.	Rufus Key	H. A. Ross	1947	--	21	6	13.1	July 8, 1951	C,H	D	Bored.
43	NW¼SW¼ 67	15	do.	Cleve Hamilton	Wiseman Drilling Co.	1951	1,316	17	4½	9.9	Aug. 24, 1951	None	N	Test hole. See log.
44	NW¼SW¼ 62	15	do.	Mrs. V. McCaleb Overton	--	--	--	Spring	--	+	Feb. 8, 1952	Flowing	S	Seeps near base of Seymour formation.
45	Cen. NW¼ 65	15	do.	Leslie Hamilton	--	1950	--	45	6	34.2	July 18, 1951	J,E	D	Galvanized iron casing to 45 feet.
46	SW cor. 64	15	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,354	60	4½	46.1	Aug. 24, 1951	None	N	Test hole in county road R.O.W. See log.

Table 6.- Records of wells, test holes, and springs in Odell sand hills, Wilbarger County--Continued

Well	Location			Owner	Driller	Date completed	Altitude of land surface (ft.)	Depth of well (ft.)	Diameter of well (in.)	Water level		Method of lift	Use of water	Remarks a/
	Section	Block	Survey							Below land surface datum (ft.)	Date of measurement			
47	NW¼SW¼ 66	15	H.& T.C.R.R. Co.	Wilbarger County	Wiseman Drilling Co.	1951	1,347	72	4½	21.3	Aug. 24, 1951	None	N	Test hole in county road R.O.W. Temp. 67° F. See log.
48	SW cor. 31	11	do.	State of Texas	do.	1951	1,360	68	4½	14.5	Aug. 17, 1951	None	N	Test hole in highway R.O.W. Temp. 67° F. See log.
49	SE cor. NE¼ 30	11	do.	do.	do.	1951	1,350	45	4½	11.9	do.	None	N	Test hole in highway R.O.W. See log.
50	1/8 mile N of SE cor. 13	11	do.	Wilbarger County	do.	1951	1,376	71	4½	14.7	Aug. 15, 1951	None	N	Test hole in county road R.O.W. See log.
51	3/8 mile S of NW cor. 13	11	do.	do.	do.	1951	1,375	75	4½	5.3	Aug. 7, 1951	None	N	Test hole in county road R.O.W. Temp. 66° F. See log.
52	1/8 mile N of SW cor. 12	11	do.	J. O. Henry	do.	1951	1,391	63	4½	15.7	Aug. 12, 1951	None	N	Test hole. Temp. 65° F. See log.
53	NW cor. SW¼ 5	11	do.	T. O. & J. O. Morgan	--	1950	--	70	--	--	--	--	D,S	Well near salt-water disposal pit.
54	SE cor. NE¼ 4	11	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,400	79	4½	22.5	Aug. 10, 1951	None	N	Test hole in county road R.O.W. See log.
55	NE cor. of SW¼SW¼ 4	11	do.	L. E. Key	W. E. Turner	1950	--	65	44	18.9 18.8 20.0	Feb. 27, 1951 July 18, 1951 Feb. 9, 1952	T,G	Irr	Dug. Steel casing to 65 feet, 24-inch to 16-inch. Gravel-walled.
56	3/8 mile S of NW cor. 4	11	do.	do.	do.	1950	--	59	6	12.2 12.3	Feb. 27, 1951 July 18, 1951	C,E	D,S	
57	SW cor. NW¼ 4	11	do.	do.	--	--	--	65	8	--		C,W	D	Steel casing to 65 feet. Temp. 66° F.
58	SW cor. NW¼ 4	11	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,397	68	4½	21.0	Aug. 14, 1951	None	N	Test hole in county road R.O.W. See log.
59	¼ mile S of NW cor. 4	10	do.	State of Texas	do.	1951	1,383	51	4½	14.8	Aug. 9, 1951	None	N	Test hole in highway R.O.W. Temp. 67° F. See log.
60	¼ mile N of SE cor. 7	10	do.	do.	do.	1951	1,380	52	4½	9.6	do.	None	N	Test hole in highway R.O.W. See log.
61	SW cor. 4	11	do.	Wilbarger County	do.	1951	1,401	77	4½	22.5	Aug. 8, 1951	None	N	Test hole in county road R.O.W. Temp. 65° F. See log.
62	SE cor. 4	11	do.	do.	do.	1951	1,412	106	4½	30.4	do.	None	N	Test hole in county road R.O.W. Temp. 66° F. See log.

Table 6.- Records of wells, test holes, and springs in Odell sand hills, Wilbarger County--Continued

Well	Location: Section	Location: Block	Location: Survey	Owner	Driller	Date completed	Altitude of land surface (ft.)	Depth of well (ft.)	Diameter of well (in.)	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks a/
63	5/8 mile E of SW cor. 2	--	J.C. Sumner	Leon Brooks	W. E. Turner	1951	1,413	83	44	25.2	Feb. 1, 1952	None	N	Dug. Steel casing to 83 feet, perforated from 50 to 80 feet, gravel-walled from 46 to 82 feet. Measured drawdown 38.5 feet after pumping 48 hours at 165 gpm Nov. 1951. See log.
64	5/8 mile W of SE cor. 2	--	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,391	92	4½	12.7	Aug. 8, 1951	None	N	Test hole in county road R.O.W. Temp. 66° F. See log.
65	NE cor. 21	15	H.& T.C.R.R. Co.	do.	do.	1951	1,385	92	4½	10.5	Aug. 6, 1951	None	N	Test hole in county road R.O.W. See log.
66	1/8 mile S of NW cor. 22	15	do.	Mrs. Gertrude Condon	W. E. Turner	1949	--	95	6	10.7 12.9	July 19, 1951 Feb. 2, 1952	C, W	D, S	Steel casing to 95 feet.
67	SW cor.	--	R. Keys	Wilbarger County	Wiseman Drilling Co.	1951	1,389	109	4½	21.2	Aug. 8, 1951	None	N	Test hole in county road R.O.W. Temp. 66° F. See log.
68	NW cor. 34	15	H.& T.C.R.R. Co.	Mrs. V.K.McCaleb	W. E. Turner	1951	--	85	7	28.5	Feb. 1, 1951	None	N	Test hole.
69	NE cor. NW¼NW¼ 34	15	do.	do.	do.	1951	--	105	7	42.5	do.	None	N	Do.
70	3/8 mile E of NW cor. 34	15	do.	do.	do.	1951	--	120	7	48.1	do.	None	N	Do.
71	NW cor. NE¼ 34	15	do.	do.	do.	1951	--	103	7	32.5	do.	None	N	Do.
72	NW cor. NE¼NE¼ 34	15	do.	do.	do.	1951	--	92	44	23.3	do.	None	N	Dug. Steel casing to 92 feet, perforated from 60 to 90 feet. Gravel-walled from 20 to 90 feet. Measured drawdown, 26.5 feet after pumping 45 hours at 430 gpm Feb. 7, 1952. Temp. 65° F. See log.
73	1/8 mile W of SW cor.	--	H.B.Worthington, P.Martinez	State of Texas	Wiseman Drilling Co.	1951	1,373	92	4½	27.6	Aug. 8, 1951	None	N	Test hole in highway R.O.W. See log.

Table 6.- Records of wells, test holes, and springs in Odell sand hills, Wilbarger County--Continued

Well	Location: Section	Location: Block	Location: Survey	Owner	Driller	Date com-plet-ed	Altitude of land surface (ft.)	Depth of well (ft.)	Diam-eter of well (in.)	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks [a/]
74	½ mile W of SE cor.	--	H.B.Worth-ington, P.Martinez	R. H. Newsom	W. E. Turner	1948	--	86	8	30.7 28.5	Aug. 8, 1951 Feb. 1, 1952	J,E	D,S	Steel casing to 86 feet.
75	SE cor.	--	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,357	86	4½	28.0	Aug. 8, 1951	None	N	Test hole in county road R.O.W. See log.
76	NE cor. 47	15	H.& T.C.R.R. Co.	do.	do.	1951	1,296	16	4½	6.6	do.	None	N	Do.
77	Cen. S½ 65	15	do.	Rod & Gun Club	--	--	--	Spring	--	+	Feb. 28, 1951	Flowing	P	Seeps near base of Seymour formation. Water impounded for recreation.
78	3/8 mile S of NE cor. 47	15	do.	Mrs. P. M. Emmett	--	--	--	30	36	23.0	July 18, 1951	J,E	D,S	Dug. Concrete casing to 30 feet.
79	3/8 mile S of NW cor. 35	15	do.	-- Bond	--	--	--	60	--	--	Aug. 17, 1951	J,E	D	Well near salt-water disposal pit. Anderson & Prichard Oil Co. lease.
80	SE cor. NE¼ 34	15	do.	State of Texas	Wiseman Drilling Co.	1951	1,388	113	4½	--	--	None	N	Test hole in highway R.O.W. See log.
81	NE cor. SE¼ 34	15	do.	Dodson & Chillicothe	--	--	--	94	6	40.5 42.4	Aug. 16, 1951 Feb. 1, 1952	None	N	Steel casing to 94 feet.
82	3/8 mile N of SE cor. 22	15	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,407	83	4½	38.8	Aug. 15, 1951	None	N	Test hole in county road R.O.W. See log.
83	SW cor. NW¼ 22	15	do.	do.	do.	1951	1,389	64	4½	11.4	Aug. 6, 1951	None	N	Do.
84	Cen. NW¼ 21	15	do.	T. B. Priddy Estate	--	--	--	90	--	[b/]11	Apr. 11, 1951	--	D,S	Steel casing to 90 feet, perforated from 80 to 90 feet.
85	SE cor. NE¼ 10	15	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,391	94	4½	8.9	Aug. 13, 1951	None	N	Test hole in county road R.O.W. Temp. 66°F. See log.
86	3/8 mile S of NE cor.	--	R. Walker	do.	do.	1951	1,413	110	4½	28.4	Aug. 10, 1951	None	N	Do.
87	NE cor. 5	10	H.& T.C.R.R. Co.	do.	do.	1951	1,415	106	4½	34.1	Aug. 14, 1951	None	N	Do.
88	SE cor. NE¼ 6	10	do.	R. D. King	--	--	--	51	--	25.4	July 18, 1951	C,W	D,S	
89	SE cor. 6	10	do.	State of Texas	Wiseman Drilling Co.	1951	1,410	42	4½	29.5	Aug. 14, 1951	None	N	Test hole in highway R.O.W. See log.
90	NW cor. 11	15	do.	Wilbarger County	do.	1951	1,413	76	4½	--	--	None	N	Test hole in county road R.O.W. See log.

Table 6.- Records of wells, test holes, and springs in Odell sand hills, Wilbarger County--Continued

Well	Location: Section	Location: Block	Location: Survey	Owner	Driller	Date completed	Altitude of land surface (ft.)	Depth of well (ft.)	Diameter of well (in.)	Water level: Below land surface datum (ft.)	Water level: Date of measurement	Method of lift	Use of water	Remarks a/
91	SE cor. 10	15	H.& T.C.R.R. Co.	Wilbarger County	Wiseman Drilling Co.	1951	1,399	64	4½	13.5	Aug. 13, 1951	None	N	Test hole in county road R.O.W. See log.
92	SW cor. 22	15	do.	do.	do.	1951	1,396	72	4½	18.0	Aug. 6, 1951	None	N	Do.
93	NW cor. SE¼NE¼ 23	15	do.	Anderson Estate	--	Old	--	65	6	35.6	Feb. 2, 1952	C,H,W	D,S	Steel casing to 65 feet.
94	NW cor. 33	15	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,393	70	4½	24.1	Aug. 15, 1951	None	N	Test hole in county road R.O.W. See log.
95	SE cor. 34	15	do.	State of Texas	do.	1951	1,366	60	4½	23.5	Aug. 17, 1951	None	N	Test hole in highway R.O.W. See log.
96	SW cor. 35	15	do.	-- Goodpasture	--	--	--	38	--	--	--	J,E	D	Amerada Oil Company camp.
97	SW cor. NW¼NW¼ 36	15	do.	Wilbarger County	W. E. Turner	1948	--	50	14	13.1	July 18, 1951	J,E	D,P	Steel casing to 50 feet. Supplies North-side School.
98	NW cor. 46	15	do.	do.	Wiseman Drilling Co.	1951	1,318	13	4½	7.4	Aug. 24, 1951	None	N	Test hole in county road R.O.W. See log.
99	SE cor. 47	15	do.	do.	do.	1951	1,251	26	4½	15.7	do.	None	N	Do.
100	SW cor. 49	15	do.	Catherine M. Pierce Estate	--	--	--	31	36	21.3	July 18, 1951	C,H	D,S	Dug.
101	SE cor. 33	15	do.	State of Texas	Wiseman Drilling Co.	1951	1,308	15	4½	7.9	Aug. 15, 1951	None	N	Test hole in highway R.O.W. See log.
102	1/8 mile N of SE cor. 33	15	do.	Anderson Estate	--	--	--	16	48	11.8 12.4	Aug. 16, 1951 Feb. 1, 1952	J,E	D,S	Dug. Galvanized iron casing to 16 feet. Temp. 70° F.
103	NW cor. 32	15	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,371	26	4½	20.2	Aug. 15, 1951	None	N	Test hole in county road R.O.W. See log.
104	SW cor. NW¼SW¼	15	do.	do.	do.	1951	1,402	52	4½	19.6	Aug. 6, 1951	None	N	Do.
105	SW cor.	15	do.	do.	do.	1951	1,411	63	4½	31.8	do.	None	N	Do.
106	SW cor. NW¼ 24	15	do.	M. M. Dunson	W. E. Turner	--	--	57	6	38.2	July 19, 1951	J,E	D,S	Steel casing to 57 feet.
107	NW cor. 19	15	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,408	49	4½	15.5	Aug. 13, 1951	None	N	Test hole in county road R.O.W. See log.
108	SW cor. NW¼SW¼ 11	15	do.	J. R. White	--	--	--	42	6	32.1	July 19, 1951	None	N	Galvanized iron casing to 42 feet.
109	NE cor. 8	15	do.	Wilbarger County	Wiseman Drilling Co.	1951	1,398	34	4½	20.8	Aug. 9, 1951	None	N	Test hole in county road R.O.W. See log.
110	SW cor. 32	15	do.	Cleve Hamilton	--	--	--	50	7	b/12	Aug. 17, 1951	J,E	D,S	

a/ R.O.W. Right-of-way.

b/ Reported by owner or driller.

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County, Tex.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well 2					
Mrs. John Minarik, ¼ mile west of NE corner, section 18, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,336 feet.					
Sand, fine-to medium-grained	38	38	Shale, hard, red, silty, and hard red shale	3	51
Clay, sandy	2	40			
Caliche, hard, sandy	8	48			
Well 3					
State of Texas, SW corner, section 35, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,353 feet.					
Sand, fine-to medium-grained	12	12	Shale, hard, red and gray	14	43
Sand, medium-to very coarse-grained .	17	29			
Well 4					
Wilbarger County, NW corner, section 27, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,356 feet.					
Sand, fine-to medium-grained	24	24	Sand, very coarse-grained, and granules 2-4 mm	10	102
Clay, sandy, red and white	14	38	Gravel, pebbles 2-20 mm, and very coarse-grained sand ...	4	106
Sand, medium-to coarse-grained	26	64	Shale, hard, red	1	107
Sand, fine-to medium-grained, and clay	10	74			
Sand, coarse-to very coarse-grained, granules 2-4 mm, and pebbles 5-10 mm	18	92			
Well 5					
J. F. Watson, NW corner, NE¼, section 8, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,338 feet.					
Sand, fine-to medium-grained	40	40	Sand, very coarse-grained, granules 2-4 mm, and pebbles 5-10 mm	13	71
Caliche, hard, sandy	3	43	Shale, hard, gray and red ...	1	72
Sand, medium-to very coarse-grained ..	15	58			
Well 6					
Wilbarger County, 1 mile S of NE corner, section 2, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,340 feet.					
Sand, fine-to medium-grained	15	15	Sand, very coarse-grained, granules 2-4 mm, and pebbles 5-10 mm	9	65
Sand, medium-to very coarse-grained ...	41	56	Shale, hard, red	1	66

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well 7					
Wilbarger County, NE corner, section 7, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,349 feet.					
Sand, fine-to coarse-grained	24	24	Sand, coarse-to very coarse-grained, granules 2-4 mm, and pebbles 5-10 mm	24	72
Caliche, hard, white and yellow	16	40	Shale, hard, red	1	73
Sand, coarse-to very coarse-grained	2	42			
Clay, sandy, gray	2	44			
Caliche, hard, sandy	4	48			
Well 8					
Wilbarger County, SW corner, section 16, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,358 feet.					
Sand, fine-to medium-grained, and clay, sandy	82	82	Shale, hard, red	5	92
Sand, very coarse-grained, granules 2-4 mm, and pebbles 4-12 mm	5	87			
Well 10					
State of Texas, SE corner, section 16, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,367 feet.					
Sand, fine-to medium-grained	67	67	Gravel, pebbles 5-15 mm, and granules 2-4 mm	5	91
Caliche, hard, sandy	11	78	Shale, hard, red	1	92
Sand, very coarse-grained, granules 2-4 mm, pebbles 5-10 mm	8	86			
Well 11					
State of Texas, SW corner, section 34, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,353 feet.					
Sand, fine-to coarse-grained	32	32	Sand, coarse-to very coarse-grained, granules 2-4 mm	18	110
Clay, sandy, red and white	10	42	Gravel, granules 2-4 mm, pebbles 5-10 mm, and very coarse-grained sand	5	115
Sand, fine-to coarse-grained	10	52	Shale, hard, red	2	117
Sand, fine-to medium-grained	10	62			
Clay, sandy, red and white	12	74			
Sand, fine-to medium-grained	6	80			
Sand, coarse-to very coarse-grained	7	87			
Gravel, very coarse-grained, sand, granules 2-4 mm, and pebbles 5-15 mm	5	92			

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County--Continued

	Thickness (feet)	Depth (feet)
Well 13		
C. D. Watts et. al., NW corner, section 2, E. H. Wolverton survey. Altitude of land surface 1,331 feet.		
Sand, fine-to medium-grained	16	16
Clay, sandy	10	26
Sand, fine-to coarse-grained	20	46
Clay, sandy, red	25	71
Sand, medium-to very coarse-grained	16	87
Gravel, pebbles 5-12 mm, granules 2-4 mm, and very coarse-grained sand	5	92
Sand, coarse-to very coarse-grained	6	98
Gravel, granules 2-4 mm, pebbles 5-10 mm, and very coarse-grained sand	5	103
Shale, red	1	104
Well 17		
Wilbarger County, SE corner, section 33, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,311 feet.		
Sand, fine-to coarse-grained	13	13
Clay, sandy white	3	16
Caliche, sandy	5	21
Clay, sandy, brown	22	43
Sand, medium-to very coarse-grained	13	56
Gravel, granules 2-4 mm, pebbles 5-10 mm, and very coarse-grained sand	6	62
Sandstone, hard, red	8	70
Well 18		
State of Texas, NW corner, section 32, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,338 feet.		
Sand, fine-to coarse-grained	18	18
Clay, sandy, white and gray	14	32
Sand, fine-to medium-grained	11	43
Caliche, hard, sandy, and sandy clay	13	56
Sand, medium-to very coarse-grained, and granules 2-4 mm	14	70
Sand, coarse-to very coarse-grained, granules 2-4 mm, and pebbles 5-6 mm	3	73
Sandstone, hard, red	1	74
Well 19		
State of Texas, NE corner, section 14, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,361 feet.		
Sand, fine-to medium-grained, and clay, sandy	68	68
Gravel, granules 2-4 mm, pebbles 5-10 mm, and very coarse-grained sand	3	71
Shale, hard, red	1	72

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County--Continued

	Thickness (feet)	Depth (feet)
Well 21		
State of Texas, 1/8 mile W of NE corner, section 11, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,359 feet.		
Sand, fine-to medium-grained	18	18
Caliche, hard, sandy	2	20
Clay, sandy, white	2	22
Sand, fine-to medium-grained	6	28
Gravel, granules 2-4 mm, pebbles 5-20 mm	2	30
Shale, hard, red	7	37
Well 22		
State of Texas, SE corner, section 7, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,353 feet.		
Sand, fine-to medium-grained	8	8
Caliche, hard, sandy	5	13
Sand, fine-to medium-grained	7	20
Clay, sandy	5	25
Shale, hard, red	1	26
Well 24		
State of Texas, SW corner, section 7, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,360 feet.		
Sand, fine-to medium-grained	76	76
Gravel, pebbles 5-10 mm, granules 2-4 mm, and very coarse-grained sand	10	86
Gravel, pebbles 5-25 mm, and granules 2.4 mm	6	92
Shale, hard, red, silty	1	93
Well 25		
Wilbarger County, 7/8 mile N of SE corner, section 2, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface, 1,358 feet.		
Sand, fine-to medium-grained	32	32
Sand, medium-to very coarse-grained	24	56
Gravel, pebbles 5-10 mm, and granules 2-4 mm	1	57
Shale, hard, red	1	58
Well 26		
State of Texas, SE corner, section 1, block 10, H. & T. C. R.R. Co., survey. Altitude of land surface 1,343 feet.		
Sand, fine-to medium-grained	39	39
Clay, sandy, brown	2	41
Sand, medium-to coarse-grained	4	45
Clay, sandy, brown	2	47
Sand, medium-to coarse-grained	12	59
Sand, coarse-to very coarse-grained, and granules 2-4 mm	4	63
Shale, hard, red	1	64

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well 29					
State of Texas, NE corner, section 8, block 10, H. & T. C. R.R. Co., survey. Altitude of land surface 1,363 feet.					
Sand, fine-to medium-grained	48	48	Gravel, pebbles 5-20 mm, granules 2-4 mm, and very coarse-grained sand	6	81
Clay, brown, silty and sandy	14	62	Shale, hard, red	1	82
Clay, gray	8	70			
Clay, brown, silty	5	75			
Well 32					
Wilbarger County, ½ mile N of SW corner, section 3, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,367 feet.					
Sand, fine - to medium-grained, fossils	5	5	Sand, medium-to coarse-grained, fossils	15	67
Caliche, sandy	30	35	Shale, hard, red	1	68
Sand, hard, red, fine-to medium-grained	17	52			
Well 34					
Wilbarger County, ½ mile N of SE corner, section 3, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,382 feet.					
Sand, fine-to medium-grained	6	6	Clay, white and red, sandy	8	30
Clay, gray, sandy	4	10	Sand, fine-to coarse-grained, and granules 2-4 mm	2	32
Sand, fine-to medium-grained	2	12	Shale, hard, red	1	33
Clay, white and red, sandy	7	19			
Sand, fine-to medium-grained	3	22			
Well 35					
Wilbarger County, SW corner, NW¼, section 6, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,366 feet.					
Sand, fine-to medium-grained	41	41	Shale, hard, red	1	53
Sand, medium-to very coarse-grained, and granules 2-4 mm	11	52			
Well 36					
W. F. Shelton, ¼ mile N of SE corner, section 6, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,382 feet.					
Sand, fine-to medium-grained	13	13	Sand, coarse-to very coarse-grained, granules 2-4 mm, and pebbles 5-8 mm	2	58
Clay, brown and gray	7	20	Shale, hard, red	1	59
Sand, fine-to medium-grained	9	29			
Clay, red, silty	8	37			
Clay, white and yellow sandy	12	49			
Sand, medium-to coarse-grained	7	56			

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well 37					
Wilbarger County, ¼ mile W of SE corner, section 11, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,376 feet.					
Sand, fine-to medium-grained	54	54	Caliche, hard, sandy	4	71
Sand, fine-to medium-grained cemented with red clay, hard	13	67	Shale, hard, red	3	74
Well 39					
Wilbarger County, NW corner, section 30, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,359 feet.					
Sand, fine-to medium-grained	5	5	Gravel, granules 2-4 mm, pebbles 5-20 mm, and very coarse-grained sand	8	47
Clay, brown and gray, sandy	24	29	Shale, hard, red	1	48
Caliche and clay, sandy	10	39			
Well 41					
State of Texas, SW corner, section 32, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,352 feet.					
Sand, fine-to medium-grained, and sandy clay	18	18	Gravel, granules 2-4 mm, pebbles 5-15 mm, and very coarse-grained sand	9	47
Clay, red and white sandy	14	32	Shale, red, sandy	5	52
Sand, coarse-to very coarse-grained .	6	38			
Well 43					
Cleve Hamilton, NW¼SW¼ section 67, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,316 feet.					
Soil	3	3	Sand, fine-grained	2	14
Clay, sandy	7	10	Sandstone and shale, hard, red	3	17
Caliche, sandy	2	12			
Well 46					
Wilbarger County, SW corner, section 64, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,354 feet.					
Sand, fine-to medium-grained	22	22	Gravel, pebbles 5-20 mm, granules 2-4 mm, and coarse-to very coarse-grained sand	9	59
Sand, medium-to very coarse-grained, granules 2-4 mm	28	50	Shale, hard, red	1	60

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County--Continued

Well 47

Wilbarger County, NW¼SW¼ section 66, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,347 feet.

	Thickness (feet)	Depth (feet)
Sand, fine-to very coarse-grained	32	32
Sand, medium-to very coarse-grained, granules 2-4 mm	13	45
Gravel, pebbles 5-10 mm, granules 2-4 mm, coarse-to very coarse-grained sand	15	60
Gravel pebbles 5-25 mm, granules 2-4 mm	5	65
Shale, hard, red	7	72

Well 48

State of Texas, SW corner, section 31, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,360 feet.

	Thickness (feet)	Depth (feet)
Sand, fine-to medium-grained	7	7
Clay, red and gray, sandy	6	13
Caliche, hard, sandy	6	19
Sand, fine-to coarse-grained	5	24
Clay, red	2	26
Sand, coarse-to very coarse-grained	13	39
Sandstone cemented with red clay	3	42
Sand, medium-to very coarse-grained	8	50
Caliche	1	51
Gravel, pebbles 5-25 mm, granules 2-4 mm	16	67
Shale, hard, red	1	68

Well 49

State of Texas, SE corner NE¼, section 30, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,350 feet.

	Thickness (feet)	Depth (feet)
Sand, fine-grained and clay, sandy	25	25
Caliche, sandy	5	30
Sandstone and sandy shale, hard, red and gray	15	45

Well 50

Wilbarger County, 1/8 mile N of SE corner, section 13, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,376 feet.

	Thickness (feet)	Depth (feet)
Sand, fine-to coarse-grained	40	40
Sand, coarse-to very coarse-grained	9	49
Gravel, granules 2-4 mm, very coarse-grained sand, and pebbles 5-6 mm	3	52
Sand, coarse-to very coarse-grained	10	62
Sand, very coarse-grained, and granules 2-4 mm	4	66
Gravel, very coarse-grained sand, granules 2-4 mm, and pebbles 5-10 mm	4	70
Shale, hard, red	1	71

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well 51					
Wilbarger County, 3/8 mile S of NW corner, section 13, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,375 feet.					
Sand, fine-to medium-grained	12	12	Gravel, granules 2-4 mm, pebbles 5-20 mm, and very coarse-grained sand ...	11	74
Sand, coarse-to very coarse-grained ..	51	63	Shale, hard, red	1	75
Well 52					
J. O. Henry, 1/8 mile N of SW corner, section 12, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,391 feet.					
Sand, fine-to medium-grained	15	15	Sand, medium-to very coarse-grained, and granules 2-4 mm	42	62
Clay, white and red, sandy	5	20	Shale, hard, red	1	63
Well 54					
Wilbarger County, SE corner NE¼, section 4, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,400 feet.					
Sand, fine-to medium-grained	50	50	Gravel, granules 2-4 mm, and pebbles 5-10 mm	8	78
Caliche, sandy, soft	10	60	Shale, hard, red	1	79
Sand, coarse-to very coarse-grained ..	10	70			
Well 58					
Wilbarger County, SW corner NW¼, section 4, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,397 feet.					
Sand, fine-to medium-grained	27	27	Shale, hard, red	1	68
Clay, white and red, sandy	25	52			
Gravel, pebbles 5-12 mm, and very coarse-grained sand	15	67			
Well 59					
State of Texas, ¼ mile S of NW corner, section 4, block 10, H. & T. C. R.R. Co., survey. Altitude of land surface 1,383 feet.					
Sand, fine-to medium-grained	24	24	Gravel, pebbles 5-25 mm, granules 2-4 mm	4	50
Clay, red, sandy	3	27	Shale, hard, red	1	51
Caliche, hard, sandy	3	30			
Sand, coarse-to very coarse-grained, granules 2-4 mm, and pebbles 5-8 mm ..	16	46			

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County--Continued

	Thickness (feet)	Depth (feet)
Well 60		
State of Texas, ¼ mile N of SE corner, section 7, block 10, H. & T. C. R.R. Co., survey. Altitude of land surface 1,380 feet.		
Sand, fine-to medium-grained	25	25
Sand, coarse-to very coarse-grained, granules 2-4 mm, and pebbles 5-8 mm .	9	34
Gravel, pebbles 6-12 mm, and very coarse-grained sand	3	37
Sand, very coarse-grained	4	41
Gravel, pebbles 5-25 mm, granules 2-4 mm	10	51
Shale, hard, red	1	52
Well 61		
Wilbarger County, SW corner, section 4, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,401 feet.		
Sand, fine-to medium-grained	20	20
Clay, red, sandy	19	39
Sand, very coarse-grained, granules 2-4 mm, and pebbles 5-8 mm	19	58
Gravel, pebbles 5-13 mm, and very coarse-grained sand	8	66
Gravel, pebbles 8-20 mm	10	76
Shale, hard, red	1	77
Well 62		
Wilbarger County, SE corner, section 4, block 11, H. & T. C. R.R. Co., survey. Altitude of land surface 1,412 feet.		
Sand, fine-to medium-grained	24	24
Clay, red, sandy	4	28
Sand, coarse-grained	18	46
Sand, very coarse-grained, granules 2-4 mm, and pebbles 5-8 mm	40	86
Gravel, pebbles 8-20 mm	6	92
Sand, very coarse-grained, and granules 2-4 mm	6	98
Gravel, pebbles 5-10 mm	7	105
Shale, hard, red	1	106
Well 63		
Leon Brooks, 5/8 mile E of SW corner, section 2, J. C. Sumner survey. Altitude of land surface 1,413 feet.		
Soil	3	3
Sand, red, fine-grained	12	15
Sand, blue, fine-grained	5	20
Sand, red and blue, fine-grained	5	25
Sand, red, fine-grained	5	30
Sand, red, and caliche	5	35
Sand, red, coarse-grained, and clay ...	5	40
Sand, red, fine-grained	5	45
Sand, white, coarse-grained	10	55
Sand, white, coarse-grained, fine-grained gravel, and clay	5	60
Sand, white, coarse-grained and fine-grained gravel	15	75
Sand, red, yellow and blue, coarse-grained, and fine-grained gravel	7	82
Shale, red	1	83

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County--Continued

	Thickness (feet)	Depth (feet)
Well 64		
Wilbarger County, 5/8 mile W of SE corner, section 2, J. C. Sumner survey. Altitude of land surface 1,391 feet.		
Sand, fine-to medium-grained	30	30
Gravel, granules 2-4 mm, pebbles 5-15 mm, and very coarse-grained sand	5	35
Sand, very coarse-grained	33	68
Sand, very coarse-grained, granules 2-4 mm, and pebbles 5-8 mm	22	90
Shale, hard, red	2	92
Well 65		
Wilbarger County, NE corner, section 21, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,385 feet.		
Sand, fine-to coarse-grained, and sandy clay	62	62
Gravel, granules 2-4 mm, pebbles 5-20 mm, and very coarse-grained sand	16	78
Sand, very coarse-grained	8	86
Gravel, granules 2-4 mm, pebbles 5-20 mm, and very coarse-grained sand	4	90
Shale, hard, red	2	92
Well 67		
Wilbarger County, SW corner, R. Keys survey. Altitude of land surface 1,389 feet.		
Sand, fine-to medium-grained	18	18
Clay, sandy	5	23
Sand, fine-to very coarse-grained	7	30
Clay, sandy	13	43
Caliche, hard, sandy	3	46
Sand, medium-to very coarse-grained, granules 2-4 mm, and pebbles 5-10 mm	19	65
Caliche and clay, sandy	18	83
Gravel, pebbles 5-25 mm, granules 2-4 mm, and very coarse-grained sand	22	105
Shale, hard red	4	109
Well 72		
Mrs. V. K. McCaleb, NW corner, NE¼NE¼ section 34, block 15, H. & T. C. R.R. Co., survey.		
Soil	3	3
Sand, red, fine-to coarse-grained	9	12
Sand, yellow, fine-to coarse-grained	3	15
Sand, brown, fine-to coarse-grained	15	30
Sand, white, fine-to very coarse-grained, and granules 2-4 mm	20	50
Sand, white and pink, fine-to coarse-grained, hard	10	60
Sand, white, fine-to very coarse-grained, granules 2-4 mm, and layers of hard sand	19	79
Sand, hard, white	3	82
Gravel, granules 2-4 mm, pebbles 5-40 mm, and medium-to very coarse-grained sand	8	90
Shale, hard, red	2	92

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well 73					
State of Texas, 1/8 mile W of SW corner, H. B. Worthington and R. Martinez survey. Altitude of land surface 1,373 feet.					
Sand, fine-to medium-grained	20	20	Gravel, pebbles 5-15 mm, granules 2-4 mm	4	91
Clay, white, silty	28	48	Shale, hard, red	1	92
Sand, coarse-to very coarse-grained, granules 2-4 mm	39	87			
Well 75					
Wilbarger County, SE corner, H. B. Worthington and P. Martinez survey. Altitude of land surface 1,357 feet.					
Sand, fine-to medium-grained	30	30	Gravel, pebbles 5-15 mm, granules 2-4 mm	8	84
Sand, coarse-to very coarse-grained, granules 2-4 mm	36	66	Shale, hard, red	2	86
Gravel, pebbles 5-15 mm, and granules 2-4 mm	4	70			
Sand, coarse-to very coarse-grained, and granules 2-4 mm	6	76			
Well 76					
Wilbarger County, NE corner, section 47, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,296 feet.					
Sand, fine-to medium-grained	4	4	Sand, coarse-to very coarse-grained	1	15
Clay, black peat	4	8	Shale, hard, red	1	16
Clay, gray	6	14			
Well 80					
State of Texas, SE corner, NE¼ section 34, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,388 feet.					
Sand, fine-to medium-grained	23	23	Gravel, granules 2-4 mm, pebbles 5-8 mm, and very coarse-grained sand	3	81
Clay, sandy	9	32	Clay, red	1	82
Sand, fine-to coarse-grained	5	37	Sand, medium-to very coarse-grained	24	106
Clay, red, silty, and sandy	14	51	Gravel, pebbles 5-15 mm, granules 2-4 mm, and very coarse-grained sand	6	112
Sand, coarse-to very coarse-grained, and granules 2-4 mm	19	70	Shale, hard, red	1	113
Clay, red, silty	2	72			
Sand, very coarse-grained, granules 2-4 mm	6	78			

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County--Continued

Well 82

Wilbarger County, 3/8 mile N of SE corner, section 22, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,407 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand, fine-to medium-grained	25	25	Sand, coarse-to very coarse-grained, granules 2-4 mm, pebbles 5-6 mm	8	66
Clay, sandy, brown	18	43	Sand, coarse-to very coarse-grained	16	82
Sand, medium-to coarse-grained	15	58	Shale, hard, red	1	83

Well 83

Wilbarger County, SW corner NW¼ section 22, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,389 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand, fine-to medium-grained	52	52	Gravel, granules 2-4 mm, and pebbles 5-20 mm	2	61
Sand, coarse-to very coarse-grained, and granules 2-4 mm	7	59	Shale, hard, red	3	64

Well 85

Wilbarger County, SE corner NE¼ section 10, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,391 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand, fine-to medium-grained	7	7	Sand, very coarse-grained and granules 2-4 mm	22	88
Clay, gray and red, sandy	20	27	Gravel, pebbles 8-20 mm, granules 2-4 mm, and very coarse-grained sand	5	93
Sand, medium-to coarse-grained	31	58	Shale, hard, red	1	94
Clay, red, sandy	3	61			
Sand, medium-to very coarse-grained ...	5	66			

Well 86

Wilbarger County, 3/8 mile S of NE corner, R. Walker survey. Altitude of land surface 1,413 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand, fine-to medium-grained	12	12	Gravel, pebbles 5-12 mm, granules 2-4 mm	9	95
Clay, red, sandy	45	57	Sand, very coarse-grained	10	105
Sand, medium-to very coarse-grained ...	22	79	Gravel, pebbles 5-25 mm, granules 2-4 mm	4	109
Sand, coarse-to very coarse-grained, granules 2-4 mm, and pebbles 5-10 mm	7	86	Shale, hard, red	1	110

Well 87

Wilbarger County, NE corner, section 5, block 10, H. & T. C. R.R. Co., survey. Altitude of land surface 1,415 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand, fine-to medium-grained	35	35	Sandstone	4	105
Clay, red, sandy	9	44	Shale, hard, red	1	106
Sand, fine-to coarse-grained	39	83			
Gravel, pebbles 5-10 mm, granules 2-4 mm, and very coarse-grained sand	18	101			

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well 89					
State of Texas, SE corner, section 6, block 10, H. & T. C. R.R. Co., survey. Altitude of land surface 1,410 feet.					
Sand, fine-to medium-grained	10	10	Sand, coarse-to very coarse-grained, granules 2-4 mm, and pebbles 5-8 mm	6	41
Clay, red and gray, sandy	11	21	Shale, hard, red	1	42
Sand, fine-to coarse-grained	14	35			
Well 90					
Wilbarger County, NW corner, section 11, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,413 feet.					
Sand, fine-to medium-grained	20	20	Sand, very coarse-grained, granules 2-4 mm, and pebbles 5-10 mm	5	75
Clay, red, sandy	5	25	Shale, hard, red	1	76
Sand, fine-to medium-grained, hard	12	37			
Clay, red, sandy	9	46			
Sand, coarse-to very coarse-grained	24	70			
Well 91					
Wilbarger County, SE corner, section 10, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,399 feet.					
Sand, fine-to medium-grained	33	33	Gravel, pebbles 8-20 mm, granules 2-4 mm, and very coarse-grained sand	3	63
Sand, medium-to very coarse-grained	19	52	Shale, hard, red	1	64
Clay, red, sandy	2	54			
Sand, coarse to very coarse-grained, granules 2-4 mm, and pebbles 5-8 mm	6	60			
Well 92					
Wilbarger County, SW corner, section 2, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,396 feet.					
Sand, fine-to medium-grained	12	12	Gravel, granules 2-4 mm, pebbles 5-20 mm, and very coarse-grained sand	10	65
Clay, sandy, and fine-grained sand	40	52	Shale, hard, red	7	72
Sand, coarse-to very coarse-grained	3	55			

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well 94					
Wilbarger County, NW corner, section 33, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,393 feet.					
Sand, fine-to medium-grained, and layers of sandy clay	28	28	Sand, coarse-to very coarse-grained	3	59
Caliche, sandy	4	32	Clay, red, sandy	3	62
Sand, fine-to medium-grained	9	41	Gravel, granules 2-4 mm, pebbles 5-20 mm, and very coarse-grained sand	7	69
Sand, coarse-to very coarse-grained, granules 2-4 mm, and pebbles 5-12 mm	15	56	Shale, hard, red	1	70
Well 95					
State of Texas, SE corner, section 34, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,366 feet.					
Sand, fine-to medium-grained	10	10	Gravel, pebbles 5-15 mm, and granules 2-4 mm	9	59
Sand, coarse-to very coarse-grained, and granules 2-4 mm	40	50	Shale, hard, red	1	60
Well 98					
Wilbarger County, NW corner, section 46, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,318 feet.					
Sand, fine-to medium-grained	12	12	Shale, hard, red	1	13
Well 99					
Wilbarger County, SE corner, section 47, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,251 feet.					
Sand, fine-to very coarse-grained	10	10	Sand, fine-to medium-grained	7	25
Clay, red, sandy	8	18	Shale, hard, red	1	26
Well 101					
State of Texas, SE corner, section 33, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,308 feet.					
Sand, fine-to medium-grained, and sandy clay	10	10	Shale, hard, red	5	15

Table 7.- Drillers' logs of wells and test holes in Odell sand hills, Wilbarger County--Continued

	Thickness (feet)	Depth (feet)
Well 103		
Wilbarger County, NW corner, section 32, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,371 feet.		
Sand, fine-to coarse-grained	20	20
Sand, coarse-to very coarse-grained, granules 2-4 mm, and pebbles 5-10 mm	5	25
Shale, hard, red	1	26
Well 104		
Wilbarger County, SW corner NW¼SW¼ section 23, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,402 feet.		
Sand, fine-to medium-grained	10	10
Clay, gray and red, sandy	22	32
Gravel, granules 2-4 mm, and pebbles 5-15 mm, very coarse-grained sand	13	45
Sand, very coarse-grained	2	47
Shale, hard, red	5	52
Well 105		
Wilbarger County, SW corner NW¼NW¼, section 24, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,411 feet.		
Sand, fine-to medium-grained	28	28
Sand, fine-to medium-grained, and thin layers of caliche	10	38
Clay, soft red	4	42
Sand, coarse-to very coarse-grained, and granules 2-4 mm	8	50
Gravel, granules 2-4 mm, and pebbles 5-6 mm	8	58
Shale, hard, red	5	63
Well 107		
Wilbarger County, NW corner, section 19, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,408 feet.		
Sand, fine-to medium-grained	6	6
Clay, sandy	8	14
Sand, medium-grained, and clay	8	22
Clay, red, sandy	14	36
Sand, fine-to medium-grained and clay	12	48
Shale, hard, red	1	49
Well 109		
Wilbarger County, NE corner, section 8, block 15, H. & T. C. R.R. Co., survey. Altitude of land surface 1,398 feet.		
Sand, fine-to medium-grained	15	15
Clay, red, sandy	5	20
Caliche, hard, sandy	5	25
Sand, medium-to very coarse-grained	5	30
Caliche, hard, sandy	3	33
Shale, hard, red	1	34

Table 8.- Analyses of water from wells and test holes in Odell sand hills, Wilbarger County, Tex.
(Analyses in parts per million except Specific conductance, pH, and Percent sodium)

Well	Owner	Depth of well (ft.)	Date of collection	Specific conductance (Micromhos at 25° C.)	pH	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Percent sodium
4	Wilbarger County	107	Aug. 19, 1951	611	7.7	--	--	--	--	--	190	---	80	--	--	--	122	--
6	do.	66	do.	765	8.2	--	--	--	--	--	197	--	67	--	--	--	208	--
7	do.	73	do.	670	8.9	--	--	--	--	--	a/148	--	90	--	--	--	92	--
b/9	Elwin Binghan	112	Apr. 11, 1951	556	--	--	--	74	19	14	254	24	41	--	2.8	332	262	11
10	Wilbarger County	92	Aug. 19, 1951	639	8.1	--	--	--	--	--	187	--	69	--	--	--	138	--
12	Mrs. Jewel Rape	113	Aug. 17, 1951	578	8.1	22	--	74	20	14	259	32	34	--	5	365	266	10
13	C. D. Watts et.al.	104	Aug. 31, 1951	229	7.6	--	--	--	--	--	166	--	5	--	--	--	136	--
b/28	W. E. Turner	84	Apr. 11, 1951	942	--	--	--	82	31	75	331	85	88	--	13	566	332	33
30	Truman Castleberry	23	Aug. 13, 1951	474	8.2	--	--	--	--	--	241	--	3.2	--	--	--	230	--
b/33	E. H. Pigg	--	Apr. 11, 1951	18,000	--	--	--	1,240	242	2,340	237	34	6,340	--	19	11,600	4,090	55
47	Wilbarger County	72	Aug. 27, 1951	470	7.6	--	--	--	--	--	216	--	9.8	--	--	--	126	--
48	State of Texas	68	Aug. 19, 1951	527	8.5	11	--	6	4.6	94	118	23	84	--	.2	325	34	86
b/53	T. O. & J. O. Morgan	70	Apr. 11, 1951	619	--	--	--	74	21	14	265	30	24	--	25	358	271	10
b/56	L. E. Key	59	Jan. 20, 1951	609	--	--	--	75	21	30	291	30	17	--	55	396	274	19
57	do.	65	Aug. 13, 1951	593	7.8	19	--	68	20	13	248	29	16	--	30	373	252	10
63	Leon Brooks	83	Nov. 15, 1951	738	7.6	24	.01	78	23	36	284	39	59	--	15	456	289	21
64	Wilbarger County	92	Aug. 31, 1951	247	9.7	22	--	23	1.2	27	a/102	24	8	--	1	156	62	48
66	Mrs. Gertrude F. Condon	95	Aug. 7, 1951	840	7.5	26	--	70	28	61	311	62	68	--	8.5	470	290	31
67	Wilbarger County	109	Aug. 27, 1951	320	7.4	14	--	40	9.5	--	139	--	15	--	.2	238	139	--
c/68	Mrs. V. K. McCaleb	85	Feb. 8, 1952	994	6.2	--	--	--	--	--	8	--	267	--	--	--	282	--
c/69	do.	105	do.	741	7.5	--	--	--	--	--	128	--	101	--	--	--	152	--
c/70	do.	120	do.	760	7.2	--	--	--	--	--	66	--	159	--	--	--	164	--
c/71	do.	103	do.	728	7.7	--	--	--	--	--	75	--	146	--	--	--	72	--
d/72	do.	92	Feb. 2, 1952	5,860	7.5	29	--	378	83	692	246	50	1,780	--	17	3,140	1,280	54
d/72	do.	92	Feb. 7, 1952	5,530	7.5	30	--	332	73	666	176	53	1,680	--	15	2,940	1,130	56
e/	--	Pit	Feb. 8, 1952	171,500	5.8	11	--	16,590	2,460	--	33	328	120,800	1.0	--	195,000	51,990	70
73	State of Texas	92	Aug. 31, 1951	738	8.1	--	--	--	--	--	191	--	60	--	--	--	190	--
74	R. H. Newsom	86	Aug. 10, 1951	868	7.5	--	--	--	--	--	278	--	94	--	--	--	304	--
79	-- Bond	60	Aug. 17, 1951	573	7.8	21	--	75	14	23	263	22	27	--	21	358	244	17
81	Dodson & Chillicothe	94	Aug. 16, 1951	376	7.8	4.3	--	19	7.2	45	98	3	62	--	5	209	77	56
83	Wilbarger County	64	Aug. 6, 1951	327	9.1	--	--	--	--	--	a/100	--	20	--	--	--	54	--
b/84	T. B. Priddy Estate	90	Apr. 11, 1951	718	--	--	--	81	24	34	339	26	38	--	19	431	300	20
85	Wilbarger County	94	Aug. 19, 1951	504	8.1	14	--	38	12	51	167	27	19	--	78	321	144	43
92	do.	72	Aug. 6, 1951	262	9.1	--	--	--	--	--	a/46	--	20	--	--	--	56	--

Table 8.- Analyses of water from wells and test holes in Odell sand hills, Wilbarger County--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Specific conductance (Micromhos at 25° C.)	pH	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Percent sodium
96	-- Goodpasture	38	Aug. 16, 1951	642	7.5	--	--	--	--	--	298	--	18	--	--	--	248	--
102	Anderson Estate	16	do.	693	7.7	--	--	--	--	--	358	--	14	--	--	--	276	--
104	Wilbarger County	52	Aug. 5, 1951	598	7.8	--	--	--	--	--	274	--	28	--	--	--	138	--
105	do.	63	do.	532	7.6	18	--	46	14	45	237	36	28	--	.2	321	172	36
110	Cleve Hamilton	50	Aug. 17, 1951	599	7.7	24	--	68	22	31	273	24	4.8	--	90	398	260	21
b/	City of Vernon	--	Apr. 10, 1951	879	--	--	--	70	31	79	321	54	72	--	65	540	302	36
	City of Childress Well 6	107	Sept.17, 1947	--	7.7	16	.25	74	22	59.8	266	84	44	.8	38	470	275	--
	City of Crowell Well 5	28	June 21, 1945	--	7.7	17	.05	68	41	43	317	88	29	1	44	487	338	--

a/ Includes a small amount of carbonate recomputed to bicarbonate.

b/ Sample collected by U. S. Bureau of Reclamation.

c/ Contains no bromide or iodide.

d/ Contains 5± 1 ppm bromide and no iodide.

e/ Salt-water disposal pit approximately 200 yards SW of well 72. Contains 450±50 ppm bromide and 14± 1 ppm iodide.