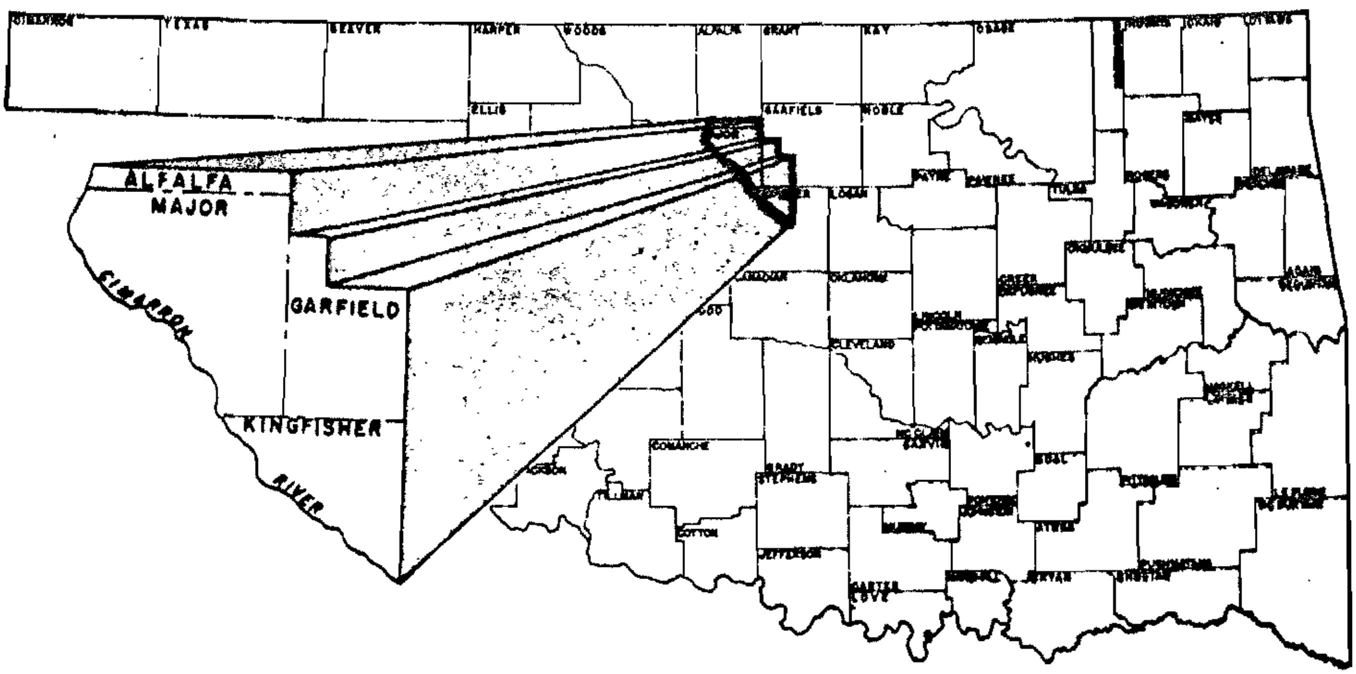
Ground Water Resources

Of The

Cimarron Terrace



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GROUND-WATER RESOURCES OF THE TERRACE DEPOSITS ALONG THE NORTHEAST SIDE OF THE CIMARRON RIVER IN ALFALFA, GARFIELD, KINGFISHER, AND MAJOR COUNTIES OKLAHOMA

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Abstract

The area of investigation discussed in this report is in north-central Oklahoma along the northeast side of the Cimarron River between Cleo Springs, in Major County, and Dover, in Kingfisher County--a distance of 40 miles. It includes about 600 square miles and is the central part of an area 110 miles long, in which the principal aquifer is a deposit of stream-laid sediments known as a terrace deposit. The average annual precipitation is about 28.75 inches, and the normal annual temperature about 60° Fahrenheit. Farming is the principal occupation, and wheat is the major crop. Production of oil from the field near Ringwood is the only major industry.

The rocks at the surface range in age from Permian to Quaternary, terrace deposits of Tertiary or Quaternary age covering most of the area. The primary purpose of this investigation was to ascertain the water-bearing properties of these deposits.

The terrace deposits consist of interfingering lentils of clay, sandy clay, sand, and gravel. Test drilling showed that in some places they are as much as 120 feet thick. Sand and gravel comprise about 42 percent of the saturated sediments, and of these sands and gravels about 39 percent appear to be highly permeable. Wells tapping the terrace deposits supply most of the water for domestic use. The cities of Fairview, Okeene, and Hennessey get their municipal water supplies from these deposits, Enid gets part of its municipal water supply from them, and eight irrigation wells obtain water from them. All the cities and towns except Hennessey are outside the area covered in this investigation. The water, although hard, is mostly of good quality and is suitable for most uses.

Some wells obtain water from cracks and lenticular sandstones in the Permian bedrock. Locally the bedrock yields 200 to 300 gallons of water a minute; however, yields are erratic and in many places the water is highly mineralized.

The alluvium of the Cimarron River and its major tributaries (Eagle Chief Creek and Turkey Creek) yields water freely to some wells. Most of the water is highly mineralized, but some wells yeild water of satisfactory quality.

Aquifer-performance tests were made on nine wells tapping the terrace deposits. Coefficients of transmissibility ranged from 6,200 to 75,800 gallons a day per foot and averaged 36,000 gallons a day per foot. Although the coefficients of storage ranged from 1.8 percent to 13.1 percent and averaged 6.5 percent, they are thought to be low because most of the pumping periods were short and complete drainage within the cones of depression was not possible. The sediments in the upper part of the terrace deposits are fine-grained; they are the sediments that were drained during the pumping tests--not the gravels and coarse sands which yield most of the water pumped from the wells.

It was estimated that 10 percent represents the coefficient of storage in the upper part of the terrace deposits and that 15 percent is a reasonable value for the entire thickness of water-bearing sediments.

The safe yield of the terrace deposits is estimated tentatively as about 137 gallons per minute per square mile. This is based on an estimated recharge of 14.45 percent of the normal rainfall in the area. The amount of water stored in the aquifer averages 3.7 acre-feet per acre. If half the water in storage can be recovered by pumping, withdrawals at the estimated rate of the safe annual yield may continue for a period of 5 years, even if no recharge occurs.

Introduction

The terrace deposits of Oklahoma have long been recognized as a potential source of relatively large supplies of ground water, and deposits along the northeast bank of the Cimarron River are among the most extensive in the State. These deposits supply water for many farm wells and a few irrigation wells as well as for the cities of Waynoka, Okeene, Fairview, Hennessey, and Crescent. Nevertheless, the terrace deposits have been relatively unexploited and little is known about the true value of the ground water in them. Under the terrace deposits are formations that generally yield only small amounts of water, which in most places is of poor quality. As the water of the Cimarron River is too highly mineralized for most uses, the terrace deposits are the most important source of water in this part of Oklahoma.

In 1949 the Oklahoma State Legislature, recognizing the value of the ground-water resources of the State, passed the Oklahoma Ground Water Law (Title 82, secs. 1001-1019 incl., Okla. Statutes, 1951). The Oklahoma Planning and Resources Board is responsible for administering the law and is required to make a hydrographic survey to establish the facts necessary for the adjudication of water rights. The Board is authorized to cooperate with Federal agencies in making such surveys and may accept and use the results of the work of agencies of the Federal Government.

Purpose and Scope of this Investigation

The city of Enid, which is about 5 miles northeast of the area investigated, had planned to drill wells and ultimately to pump 10,000,000 gallons per day from the terrace deposits in the vicinity of Ames. This locality is in the area of terrace deposits flanking the northeast side of the Cimarron River. The investigation was planned to include a study of the occurrence, quantity, and quality of the ground water in the terrace deposits and underlying bedrocks; the effect of withdrawals of this water; and the feasibility of further development for public-supply, industrial, and irrigation uses.

An investigation was begun in January 1950 by the United States

Geolog . Survey and the Oklaho a Plann and Reso r . Board. The work was done under the general adminis r on of A. N. Sayre chief of the Ground Water Branch U. S. Geological Survey; Clarence Burch and Morton R. Harrison, successive Board chairmen and Ira C. Husky, director, Division of Water Resources, Oklahoma Planning and Resources Board. Stuart . Schoff istrict geologist, U. S. Geological Survey, di ectly supervise the work

Location and Extent of the Area

The area investigated is in north-central Oklahoma (fig. 1) and covers abou 600 square mil in parts of Alfalfa, Garfield, Kingfisher, and Major Counties. It is roughly triangular in shape. On the southwest it is bounded by the Cimarron River, on the east by U. S. Highway 81, and on the north by the north line of T. 2 N.

The area is the cen ra part of a larger area in which the principal geologic formation at the surfa is a deposit of stream-laid sand, gravel and clay known as a terra e deposit. T is deposit flanks the Cimarron River on it left or n rtheast, side and extends for 110 miles from nea Waynoka approxima ely o Guthrie. The results of the present inv s igation may be regar ed as suggesting the general geologic and hydrologic conditions in th northwestern and southeastern extremities of the terrace deposit.

Previous Work in the Area

Gould (1905 pp. 1 , 19 , in dis ussing the water resources of Oklahoma, made brief nt on of the plies in Garfield and Kingfisher Counties, and publi he records of we ls from b th counties. Only four of these wells are wit in the area of he pre ent investigation. He also made extensive observat ons concerning the nature of the terrace deposits along the Cim rron River.

A study of irrigation possibilities in the vicinity of Enid, Okla , was made by Schwennesen (1914). Hi publ shed report contained a reconnaissance geologic map and records of 41 wells near Enid. Later a closely related study by Ren k (1924) yield d another reconnaissance map showing terrace deposits around Enid and near Ringwood, 20 miles west of Enid in Major County Renick commented briefly on the lithology, origin, and thicknes of the terrace depos ts and on the yield of wells in them. He gave analyses water from two wells and a spring near Ringwood and from two wells near Enid.

Brief reports on Alfalfa and Major Counties by Clifton (1926, pp. 12-14, 17-19; 1930, pp 8-10, 13-15) were concerned chiefly with the development of oil and gas and the water-bearing terrace depos ts received only casual mention No map was included. A similar report on Garfield County by Clark and Cooper (1927 pp. 7, 8, 10; 1930, pp. 67, 68, 70) makes no mention of terrace deposits but contains a geologic map which shows them.

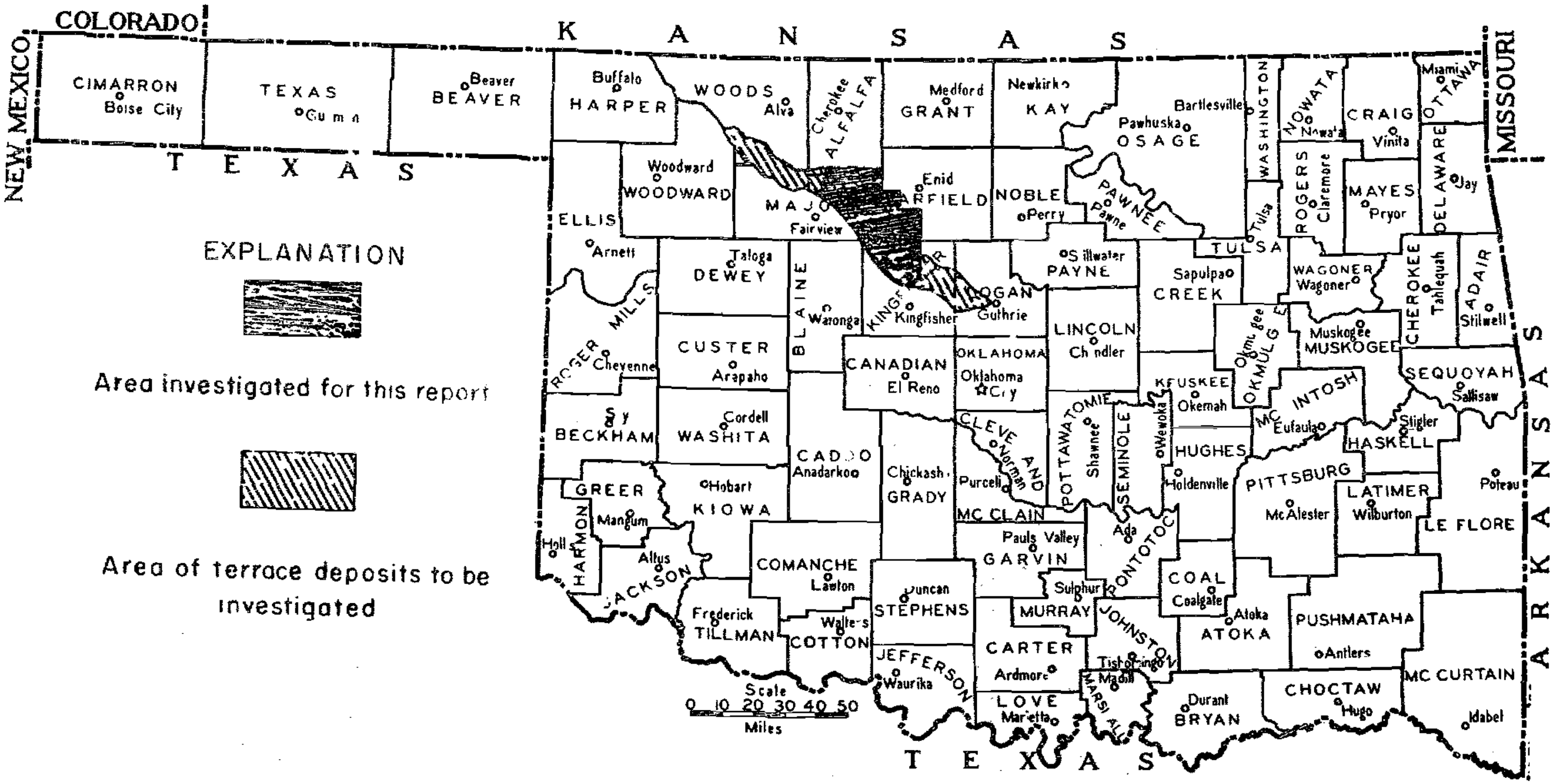


Figure I.– Index map of Oklahoma showing area of this investigation and adjoining area which is to be investigated.

Kite (1927, p. 6; 1930, p. 194) published a geologic map of Kingfisher County on which terrace deposits are shown. His report mentions the presence of these Tertiary or Quaternary sands but gives no details.

Locke, Kopp, and Reed (1934) made a general statement about the stratigraphy of the area and the amount and source of water. They gave partial analyses of water from 22 wells in Alfalfa, Garfield, Major, and Kingfisher Counties, but only 5 were from wells in the area discussed in this report.

As part of the State Mineral Survey, a Works Progress Administration project (1936-37), an inventory was made of water wells in Oklahoma, including the area of this report. This inventory included the location, depth, diameter, depth to water, probable aquifer, and "performance during drought" of each rural well, mostly as reported by the well user. Typewritten tables summarizing these data by counties are on file in the offices of the Oklahoma Geological Survey at Norman.

A report on the ground water in Kingfisher County, based on information in the files of the U. S. Geological Survey at Norman, was made in 1949 (Schoff). The occurrence and quality of ground water was discussed. The report included logs of 28 wells in terrace deposits and alluvium, partial analyses of 12 samples of water, and partial records for 12 wells; however, only 15 of the logs and 10 of the analyses were for wells in the area of this report.

E. T. Archer & Co., Consulting Engineers, Kansas City, Mo., prepared for the city of Enid a comprehensive engineering report (1944) evaluating several possible sources of additional water for public supply and recommending wells in terrace deposits along the Cimarron River. For this report, 152 test wells were drilled.

Alexander & Pollard, Consulting Engineers Oklahoma City, prepared a report (1948) on water-supply investigations for the city of Fairview. Logs of 52 wells drilled in the terrace deposits south and east of Cleo Springs are given in Appendix B.

In June of the same year, 17 test holes were drilled for the city of Hennessey in terrace deposits south of town. This drilling was under the supervision of Hudgins, Thompson, Ball, & Associates, Construction Consultants, Oklahoma City (1948). The logs of these holes are included in Appendix B of this report.

Methods of this Investigation

Field work for the present investigation was started about the end of January 1950. At that time the city of Enid was conducting a test-drill ng program to evaluate the ground water in the Permian strata west o Drummond. Field men of the Geological Survey and the Oklahoma Planning and Resources Board cooperated closely with the engineers of the city and the drilling contractors. Samples of the drill cuttings were collected, pumping tests on three wells were made, and samples of water taken during pumping of the wells were analyzed in the laboratory of the Quality of Water Branch, U. S. Geological Survey, at Stillwater.

Coincident with the start of the test-drilling program, an inventory of wells was begun. Special emphasis was given to finding wells in which the depth to water could be measured, but an attempt was made to obtain a count of all the wells in the area, and more than 1,700 wells were recorded. Of these, 55 were selected as observation wells, in which measurements of water levels were made weekly during the summer of 1950 and monthly thereafter. For 11 weeks, starting February 9, 1950, a recording gage was operated on well 21N8W-19-1, (the system of numbering wells is explained below) which taps the Permian strata. After that it was installed on well 20N9W-4-1, which taps the terrace deposits. A microbarograph was operated for short periods in the recorder shelter at each location to permit correlation of changes in barometric pressure with changes in water level in the wells.

Geologic mapping of the area was started in mid-April and completed in late August 1950. Mapping was done with the aid of aerial photographs, and the geologic contacts were drawn on township plats on a scale of 1 inch to the mile. The base map was prepared from county highway maps, with the drainage from aerial photographs superimposed.

The thickness and lithology of the terrace deposits were determined by drilling 66 test holes, all but 3 of them during June and July 1950. In addition, 116 logs of test holes and wells drilled for the cities of Kingfisher, Hennessey, Enid, and Fairview were collected. All logs of wells and test holes are given in Appendix B. Surface altitudes of test holes, wells, and the upper surface of the Permian bedrock were determined by trigonometric leveling during the course of the investigation. Aquifer-performance tests were made on nine wells that tap the terrace deposits.

Samples of water from 49 wells were analyzed in the U. S. Geological Survey laboratory at Stillwater. This laboratory is a cooperative project of the Oklahoma Planning and Resources Board, the U. S. Geological Survey, Oklahoma A & M College's Engineering Experiment Station, and the Oklahoma Geological Survey. The analyses are given in table 5, together with 11 analyses published in Oklahoma Geological Survey Mineral Report 19, 3 analyses supplied by the Kingfisher Water Co., and 1 analysis supplied by the city of Enid.

Well-Numbering System

The well numbers used in this report are based on the land-survey system of the General Land Office. They locate the well to the nearest square mile and consist of the following elements, in the order indicated: township, range, and section. For example, a well numbered 18N8W-25 is in sec. 25, T. 18 N., R. 8 W. It is the only well recorded for sec. 25. Where several wells have been recorded for the same section, serial numbers have been added to identify the individual wells. Thus, well 1[illegible]N8W-13 is the third well in sec. 1. Test holes and shot holes are numbered in the same way as water wells, and cannot be distinguished from the wells by the type of number used. They can be distinguished, however, by the symbols used on the map (pl. 5) and are properly identified in the table of well records (table). If the location to the nearest 40 acres is desired, it may be found by reference to the table.

Acknowledgments

The writers wish to express appreciation for the cooperation of the officials of the city of Enid and the officials and citizens of the town of Ames. Special acknowledgment is made to Messrs. Ross Taylor, former city manager of Enid, Gerald D. Wilkins, present city manager; L. M. Wells, water superintendent for the city of Enid; John Marler, in charge of the Ames pumping station for the city of Enid; and W. H. Sloan and Willard Britton, president and secretary, respectively, of the Ames Water Right Association.

Special thanks are due the George E. Failing Supply Co. for making available the equipment for the test-drilling program and to J. E. Yarborough, engineer for the company, and his helpers, who operated the drilling machine.

E. E. Hagan and Bob Parks, engineers of E. T. Archer & Co., Consulting Engineers, Kansas City, Mo., were very helpful in supplying logs and other information accumulated by their company. Alexander and Pollard, Consulting Engineers, Oklahoma City, Okla., supplied logs of test holes drilled for the city of Fairview. Herman Smith of Hudgins, Thompson, Ball, & Associates, Construction Consultants, Oklahoma City, Okla., furnished logs of test holes drilled for the city of Hennessey.

The Universal Exploration Co. of Houston, Tex., supplied logs of shot holes in the western part of the area. Hugh Rushton, drilling superintendent for Layne Western Co., Wichita, Kans., and his crew were very cooperative in supplying samples from test holes drilled for the city of Enid. Messrs. V. I. Cooper, J. J. Kennedy, R. V. Sturgeon, L. G. Watson, and Ned Woods were especially helpful in allowing the use of their wells for pumping tests. The cooperation of all the other well owners in supplying information, permitting the use of their wells for observation purposes, and other courtesies, is sincerely appreciated.

Topography and Drainage

The maximum regional relief, as determined from the altitudes of many stations given by Wolfard (1940, pp. 68, 206), is 421 feet. The highest station (in sec. 24, T. 23 N., R. 10 W.) has an altitude of 1,452 feet, and the lowest (in sec. 2, T. 17 N., R. 7 W.) an altitude of 1,031 feet. Maximum relief within small areas--such as a quarter section--is about 70 feet.

In the northeast half of the area, streams have developed a well-integrated dendritic drainage pattern. The interstream divides are flat or gently undulatory. Surface drainage to the Cimarron River is carried by four streams, all flowing southward; from west to east across the area, they are: Eagle Chief Creek, Indian Creek, Hoyle Creek, and Turkey Creek. Eagle Chief, Indian, and Turkey Creeks are perennial streams whose flow is maintained by seepage from the terrace deposits. Hoyle Creek is an intermittent stream whose flow is maintained by seepage from the terrace deposits during a part of the year but is cut off during the summer because of the lowering of the water table--the result of a high rate of evaporation and transpiration. Trees are scarce in this part of the area, where they are confined chiefly to the valleys of intermittent creeks.

In the southwest half of the area, in a strip 7 to 10 miles wide, the topography is dominated by sand dunes. In about one-fourth of this area the surface is gently undulatory, the relief not exceeding 5 feet, but in the rest of it most of the dunes are between 10 and 30 feet high and a few are considerably higher. Most of the higher dunes are along the outside margin of the alluvium bordering the Cimarron River. The highest one measured is in the NE¼ sec. 11, T. 20 N., R. 10 W., and rises to a height of 70 feet. Almost all the dunes have been stabilized by vegetation; the only active ones are along the channel of the Cimarron River. Approximately 30 percent of the southwest half of the area is covered by blackjack oak and brush. Many of the farms are protected by windbreaks consisting of poplar, catalpa, cedar, and other varieties of shrubs and trees. The Cimarron River bottoms are fairly well covered with coarse grasses, sage brush, and other scrubby growth.

Surface drainage within the dune area is only slightly developed. Turkey Creek is the only one of the four major streams flowing across the area that has a well-developed tributary stream within the area. This tributary stream originates outside the dune sand, in sec. 18, T. 19 N., R. 6 W., and enters the area of this report in the NE¼ sec. 1, T. 18 N., R. 7 W. It has a perennial flow maintained by seepage from the terrace deposits.

Only two streams originate within the dune area. One is Preacher Creek, an intermittent stream that heads in sec. 14, T. 19 N., R. 8 W., and joins the Cimarron River in sec. 23, T. 18 N., R. 8 W. The other, also intermittent, heads in sec. 3, T. 23 N., R. 11 W., and disappears in sec. 12, T. 23 N., R. 12 W.

Climate

The area has a subhumid climate (Thornthwaite, 1941, pl. 3). The normal annual temperatures as reported by the U. S. Weather Bureau for Hennessey, Okeene, and Waukomis are 60.4° F., 60.2° F., and 6[illegible].0° F., respectively.

Records of temperature and precipitation have been kept at Hennessey since 18[illegible], at Okeene since 1903, and at Waukomis since 1897. The normal annual precipitation at Hennessey is 28.39 inches; at Okeene, 27.[illegible] inches; and at Waukomis, 30.39 inches. At all three stations the lowest normal precipitation is in January and the highest in May.

A summary of available precipitation and temperature data for the three stations is given in tables 1 and 2.

Agriculture

The area covered by this report is primarily an agricultural district. The principal crop is wheat, and a cover crop of leguminous pea is seeded immediately after the wheat is harvested. Watermelons and grain sorghums rank high in acreage cultivated, and minor amounts of alfalfa and garden produce are grown. Near the Cimarron River, where the sandy soil and hilly topography make cultivation impractical, large tracts of land are used for grazing purposes. Other tracts, near the Cimarron and elsewhere, are covered with native blackjack, sumac, and other types of shrubs.

Industries

The production of oil from a field between Ringwood and the Cimarron River is the most important industry in the area. At the end of November 1950 there were [illegible] producing wells in this field with an average allowable production per well of [illegible] barrels a day. Numerous service industries are associated with the oil field.

About 50 sand or gravel pits in the area are listed in a publication of the Oklahoma State Highway Commission (1937, pp. 66, 67, 127, 143). Some of these pits have probably not been used for years and none is operated continuously. The only other industries in the area are two cotton gins and one flour mill, all in the town of Hennessey.

Population

The area investigated has a population of about 8,350, according to the 1950 census. Hennessey has a population of 1,264 and is the largest city in the area. Other towns and populations are: Waukomis, 537; Ringwood, 331; Drummond, [illegible]; [illegible], [illegible]; Ames, 263; Meno, 76; and Lahoma, 190. No population figures are available for Bison and Dover.

The city of Enid (population 36,107) is outside the area mapped, but part of its municipal water supply comes from within the area. With its demand for water and the need for a surrounding trade territory, the city is a potent factor in determining the future development of the natural resources in the area of this report. Ground water is one of those resources.

Month	Hennessey (1895-1950)			Okeene (1903-1950)			Waukomis (1897-1950)		
	Max.	Min.	Norm.	Max.	Min.	Norm.	Max.	Min.	Norm.
January	6.33	0.00	1.09	4.39	T*	0.99	4.54	T	1.05
February	4.93	T	1.15	4.57	T	1.04	4.65	T	1.19
March	4.61	.00	1.63	4.12	.00	1.52	3.54	.02	1.52
April	8.45	.19	3.12	7.41	.33	2.11	9.67	.53	3.53
May	10.16	.62	4.04	9.99	.27	3.70	10.43	.67	4.10
June	10.01	.23	3.70	11.07	.50	3.69	12.27	.58	4.02
July	10.47	T	2.68	8.65	.05	2.18	10.74	.02	2.77
August	10.79	T	2.60	9.21	.00	2.98	8.10	T	3.15
September	8.10	.07	2.64	8.44	.00	2.69	8.13	T	3.07
October	11.17	T	2.70	8.13	T	2.63	10.68	T	2.93
November	5.06	.00	1.59	6.22	.00	1.73	5.35	.00	1.66
December	5.65	.00	1.30	3.94	T	1.26	4.56	.00	1.30
Annual	44.55	15.66	28.33	44.26	17.97	27.52	44.63	15.55	30.39

* T Trace

Table 1.--Summary of precipitation at Hennessey, Okeene, and Waukomis, in inches.

Month	Hennessey (1895-1950)	Okeene (1903-1950)	Waukomis (1897-1950)
January	36.6	36.6	36.4
February	40.5	40.9	40.0
March	50.4	50.4	50.0
April	60.0	59.4	59.2
May	68.1	70.2	67.4
June	77.4	77.9	77.2
July	82.7	83.2	83.2
August	82.7	82.8	82.0
September	75.1	74.8	74.3
October	62.9	62.1	62.9
November	48.9	49.2	49.2
December	39.0	38.5	38.5
Annual	60.4	60.2	60.0

The average length of the growing season at Hennessey is 214 days, at Okeene, 211 days, and at Waukomis, 214 days.

Table 2.--Normal temperatures in degrees Fahrenheit, at Hennessey, Okeene, and Waukomis.

Geologic Formations and Their Water-Bearing Properties

The rocks exposed in the area range in age from Permian to Quaternary. A mantle of alluvial and eolian sediments of Quaternary age covers most of the area. In the northern part exposures of Permian strata are found only in gullies and road cuts, but in the eastern part, where the alluvial sediments are thinner, exposures of Permian strata are more extensive.

Permian System

The bedrock nearest the surface in the area northeast of the Cimarron River is reddish-brown blocky shale of Permian age, in which are included a few lenticular layers of fine-grained sandstone and Argillaceous siltstone. Irregular light greenish-gray lenses, generally not more than 1 foot thick, are common in the shale. The bedding generally is poorly defined, being clear-cut only where bedding planes have been accentuated by the accumulation of calcareous concretions. One of the most characteristic features of the Permian strata is a mottling of light greenish gray, which commonly takes the form of isolated, nearly circular spots best seen on freshly broken surfaces. In some exposures this mottling is the only criterion for separating the Permian rocks from fine-grained reddish materials in the overlying terrace deposit.

On the forthcoming geologic map of Oklahoma the bedrock underlying the eastern part of the area of this report will be classified as the Cedar Hills sandstone member of the Hennessey shale and that under the western part will be classified as the Flower-pot shale (Miser, 1952, oral communication). These names are widely recognized and accepted by geologists familiar with the stratigraphy of northwestern Oklahoma. They appear to be appropriate, but an intensive study of the stratigraphic relationships involved in this problem of nomenclature and classification was beyond the scope of this investigation.

According to the logs of oil wells drilled in the Ringwood field, as filed with the Oklahoma Corporation Commission, the Permian rocks are more than 3,000 feet thick. Only the upper part, of course, is assignable to the formations named above. According to Kite (1927, p. 8; 1930, p. 196) they have a regional southwest dip of 15 to 20 feet per mile.

Strata so predominantly argillaceous as the Permian normally are not very permeable, but calcareous geodes and thin veins of calcite in surface exposures indicate that there has been some circulation of mineralized water through the rocks. Core samples taken from well 21N9W-24-5 (app. B) reveal many small cavities; the largest are 1.5 inches in diameter. Most of the cavities are lined with drusy calcite. These obviously are the result of subsurface solution and removal by percolating water followed by deposition of calcite which was insufficient to fill the openings. Almost all the Permian strata in this region are calcareous, and the greenish-gray members are usually the most calcareous parts. The removal of soluble materials by subsurface water has increased the permeability of the rocks, and most of the wells in the Permian strata of the area probably get their water from such solution cavities. Locally the Permian strata will yield several hundred gallons of water per minute.

As this report is primarily concerned with water from the terrace deposits, a complete inventory of the wells that tap the Permian strata was not attempted. Nevertheless, of the 1,719 wells inventoried for this report, approximately 330 get their water from the Permian strata. Their yeilds range from barely enough for domestic needs to as much as 350 gallons per minute. The water commonly is highly mineralized, but no simple statement of chemical quality is valid because the chemical characteristics of the water differ widely even in small areas. Analyses of samples from 7 wells in the Permian rocks and from 4 wells deriving water from both the Permian rocks and the terrace deposits are given in table 5.

Unconformity

The Permian bedrock of this area is overlain unconformably by alluvial deposits of Quaternary age. The deposition of the alluvial sediments was preceded by a long period of erosion during which all sediments deposited after about the middle of Permian time were removed. This erosion created an irregular surface on the bedrock as shown by the contour map (pl. 1).

Quaternary System

Alluvial and eolian sediments cover the entire area except in the eastern and northeastern parts, where their continuity has been destroyed by streams which have exposed the underlying Permian strata. On most of the interstream divides a residual layer of alluvial sediments ranges, in observed thickness, from less than 1 foot to at least 15 feet.

In some places the contact between alluvial sediments and the underlying Permian bedrock is not clearly defined because the sandy clay of the alluvial deposits looks very much like the sandy shale of the Permian bedrock. In Tps. 20 and 21 N., R 7 W., the alluvial deposits are thin and colluvium obscures the contact on most of the slopes. In such places the contact has been drawn to conform with the topography (pl.2).

Terrace Deposits

The terrace deposits consist of interfingering lentils of clay, sandy clay, sand, and gravel. The sands and gravels generally are not well sorted, although some of the fine-grained gravels encountered in the lower portions of the test holes were very well sorted. Color of the sediments ranges from black as in some thin sands, through various shades of gray, brown, and reddish-brown. Most of the clays are brown to reddish-brown with either an earthy or a starchy fracture; some are very hard. Much of the clay contains scattered pebbles--a few cobbles of quartz as large as 6 inches in greatest diameter occur in the clay. In some exposures the upper 4 feet contains abundant calcareous nodules (pl. 3).

Plate 3

Exposure of terrace deposits showing scattered gravel at the level of the hammer and nodules of caliche in the upper 4 feet of the exposure, $NW\frac{1}{4}NW\frac{1}{4}$ sec. 18, T. 22 N., R. 7 W.

Cross bedding and poor sorting are characteristic of the sand and gravel (pl. 4). The gravel is predominantly quartz but contains minor amounts of feldspar, ferruginous shale, and small pebbles of black quartzitic sandstone. All these pebbles bear evidence of rounding due to transportation, but some irregular fragments of chalcedony obviously have not been transported, perhaps having been formed in place within the terrace deposits by deposition from circulating waters. Rounded pebbles of red shale and siltstone are common in the first few feet above the Permian red beds.

Plate 4

Exposure of cross-bedded, poorly sorted gravel in terrace deposits, NW$\frac{1}{4}$ sec. 12, T. 22 N., R. 8 W.

The thickness of the terrace deposits differs greatly from place to place because of irregularity of the bedrock surface on which they were deposited and because of erosion subsequent to deposition. It is greatest within the area of dune topography, where the deposits contain enough water to make them a significant aquifer.

The term "terrace," which is used in referring to these sediments, denotes a topographic form that is not well defined in this region at a distance of more than 1 or 2 miles from the Cimarron River. Terraces, which are essentially flat areas with a descending slope on one side and an ascending slope on the other, may have been present at an earlier stage in the development of the Cimarron River basin, but their full topographic expression has been obscured by subsequent erosion and dune formation.

Direct evidence for determining the age of the terrace deposits in the area of this report is not available. Only one fossil was found and it was a badly worn, unidentifiable pelecypod valve, recovered from a test hole. Gould (1905, p. 79), Schwennesen (1914, p. 12), and Renick (1924, p. 17) all regarded these deposits as Tertiary in age, but Kite (1927, p. 6; 1930, p. 194) assigned that part of the terrace deposits occurring in Kingfisher County to the Quaternary. These age assignments were not supported by fossil evidence. Meade (1950, p. 57) reports fossil vertebrates of Quaternary age in high-terrace deposits of the Red River near Frederick, Okla. Meade's evidence is not an adequate basis for assigning the terrace deposits near Ames to the Quaternary, but it is additional evidence for the prevailing opinion among geologists that terrace materials east of the High Plains region are of Quaternary age.

The terrace deposits are the principal aquifer in the area, supplying water to about 1,300 wells inventoried during this investigation. The water is mostly of good quality, except that hardness generally exceeds 200 parts per million. In three or four wells the chloride content of the water is unexpectedly high--216 to 340 parts per million. Some wells in the Ringwood area have been contaminated by gas from nearby oil wells.

Yields of individual wells in the terrace deposits differ considerably. The type of well construction is partly responsible for this, but the nature of the sediments from which the water is obtained is the most important factor. In analyzing the logs of 66 test holes drilled for this investigation it was determined that, on an average, about 42 percent of the saturated sediments in each well are sand and gravel. About 16 percent of the saturated sediments are gravel or coarse sand that should be highly permeable. Wells that tap these sands and gravels usually have the highest yields. For example, irrigation well 19N8W-27-1 is reportedly pumped continuously for periods of a week at the rate of 650 gallons a minute.

Dune Sand

Wind-laid sediments form a strip ranging from 7 to 10 miles in width along the northeast bank of the Cimarron River. Materials at the surface consist mainly of loose to friable, brown to reddish-brown fine to coarse wind-blown sand. This sand stands up well in many road cuts, owing to a small amount of admixed argillaceous material or, in some cases, calcareous cement.

The dunes appear to be genetically related to the Cimarron River. They are found along the northeast side of the river, which is probably due to the fact that prevailing winds are from the southeast in this area. Dune formation has probably always taken place near the river. As evidence of this, the highest and most active dunes are near the edge of the stream channel. Throughout the rest of the dune area vegetation has stabilized the dunes. The present widths of the dune belt were developed as the Cimarron River shifted its bed by cutting laterally to the southwest, while maintaining its southeastward direction of flow. Gould (1905, p. 83) postulated that the dunes were formed in place through the decomposition of older terrace deposits and shifting of the material by gravity and wind. This process would involve a winnowing out of more fine materials, leaving a course residue on the surface of the dunes. Gould believed that the wind could not transport fragments as large as some he found on the dunes. During the present investigation, however, few fragments larger than fine gravel were found on the dunes, and these fragments could be moved by the very high winds that sometimes cross the area. Even Gould's theory does not eliminate the possibility of decomposition and winnowing of more recent alluvium, with pebbles on the dunes as an end result.

Some areas inside the dune topography are mapped as terraces (pl. 2), but they have no significance other than to show that dune relief is very slight or absent in those areas.

The terrace deposits are thickest under the dunes, as much as 120 feet of sediments having been revealed by test drilling. Almost all wells obtaining water from the terrace deposits are in this area. Most of the dune sand is above the water table and therefore is not a source of ground water, but it plays a significant part in the ground-water hydrology of the area because the sandy soil favors a relatively high rate of infiltration.

Alluvium

Alluvium is detrital sediment deposited by streams. As mapped in this area, alluvium is the stream-laid sediment underlying the bottom lands along a stream and is separated from the higher terrace deposits on the basis of a well-defined topographic break. The alluvium may include the sediments underlying one or more low-level terraces. Because influent flow--that is, flow from the stream into the alluvium--may occur under natural conditions or be induced by pumping, the quality of the water in the alluvium may be affected by the quality of the water in the stream.

The alluvium of the Cimarron River is lithologically similar to the terrace sediments. No wells were drilled in the alluvium in the course of this investigation, but the Kingfisher Water Co. furnished logs of three wells in the alluvium in the SW¼ sec. 12, T. 17 N, R. 7 W. These logs show that the sediments grade from wind-laid sand at the surface downward through coarse sand and gravel to bedrock at depths of 31 to 35 feet. According to Schoff (1949), one of the wells drilled for the public supply of Kingfisher is reported to have yielded 298 gallons per minute with a drawdown of 12 feet. The alluvium is much thicker at some other locations. Schoff published logs of nine test holes drilled by the State Highway Department eastward from the west abutment of the bridge over the Cimarron River on U. S. Highway 64 between Woods and Harper Counties. These show alluvium ranging in thickness from 25 to 75 feet, and consisting mainly of sand with some gravel and only a few thin layers of clay.

The alluvium of the tributary streams is similar in origin and in general lithologic characteristics to both the alluvium of the Cimarron River and the terrace deposits. It differs from them in being thinner and less extensive, and it generally is darker and more clayey than the terrace deposits. At some places along Eagle Chief and Turkey Creeks the area underlain by alluvium is nearly a mile wide, but the deposit is thinner than the alluvium of the Cimarron. For this reason, and also because it may contain relatively less coarse material, it probably is not as good a source of ground water.

Turkey Creek has an unusually large alluvial flat, about 4 miles across, in Tps. 21 and 22 N., R. 8 W. This flat often is flooded after heavy rains. The alluvial sediments of the flat average more than 10 feet in thickness but yield little water, which generally is highly mineralized. A measured section of this alluvium is given in appendix A.

About 50 wells that tap water in the alluvium of the Cimarron River were inventoried for this investigation. Analyses of water from well 20N10W-13-1 and from four wells in sec. 12, T. 17N., R. 7 W., are given in table 5. They show the water to be acceptable for public supply. Wells too close to the river or heavily pumped are subject to the encroachment of water from the river, which is highly mineralized. The concentrations of sulfate and chloride are likely to be high in the river water, and both are objectionable (table 3).

	April 8 1951	May 19 1951
Specific conductance (micromhos at 25°C)	11,100	2,690
pH	7.7	7.9
Calcium (Ca)	208	73
Magnesium (Mg)	60	16
Sodium and Potassium (Na + K)	2,050	447
Bicarbonate (HCO_3)	187	100
Sulfate (SW_4)	355	169
Chloride (Cl)	3,390	680
Nitrate (NO_3)	4.2	2.8
Dissolved solids	6,180	1,440
Total hardness (as $CaCO_3$)	848	248
Percent sodium	84	80

Table 3. Analyses of water taken from Cimarron River at the bridge on U. S. Highway 81 south of Dover, Okla. (In parts per million; analyses by the U. S. Geological Survey at Stillwater, Okla.)

Ground Water

The pores of permeable rocks that lie below the land surface generally are partly or completely filled with water called "subsurface water." Below a certain level the pores are completely filled with water, called "ground water;" this zone is calle the "zone of saturation." The permeable rocks that lie above the zone of saturation are said to be in the "zone of aeration." This zone is subdivided into the capillary fringe, at the bottom, the intermediate belt, and the belt of soil water at the top--the last immediately below the land surface.

In one form or another, water occurs almost everywhere. Although at any instant the great bulk of the total water supply is stored in the oceans, a constant circulation is taking place. Evaporation from the surfaces of the oceans, streams, and lakes is nearly continuous. Most of the moisture so evaporated condenses and returns to the earth's surface as rain, snow, or other precipitation. Part of this precipitation is evaporated directly from the earth's surface, part of it returns to the oceans as surface runoff, and part of it infiltrates beneath the surface of the earth. Some of the water that infiltrates into the ground is held by capillarity near the surface and is later evaporated; some is used by vegetation and returned to the atmosphere by transpiration; and some joins the ground water and slowly, by ground-water flow, returns to the streams. This sequence of events is the hydrologic cycle and is represented in figure 2.

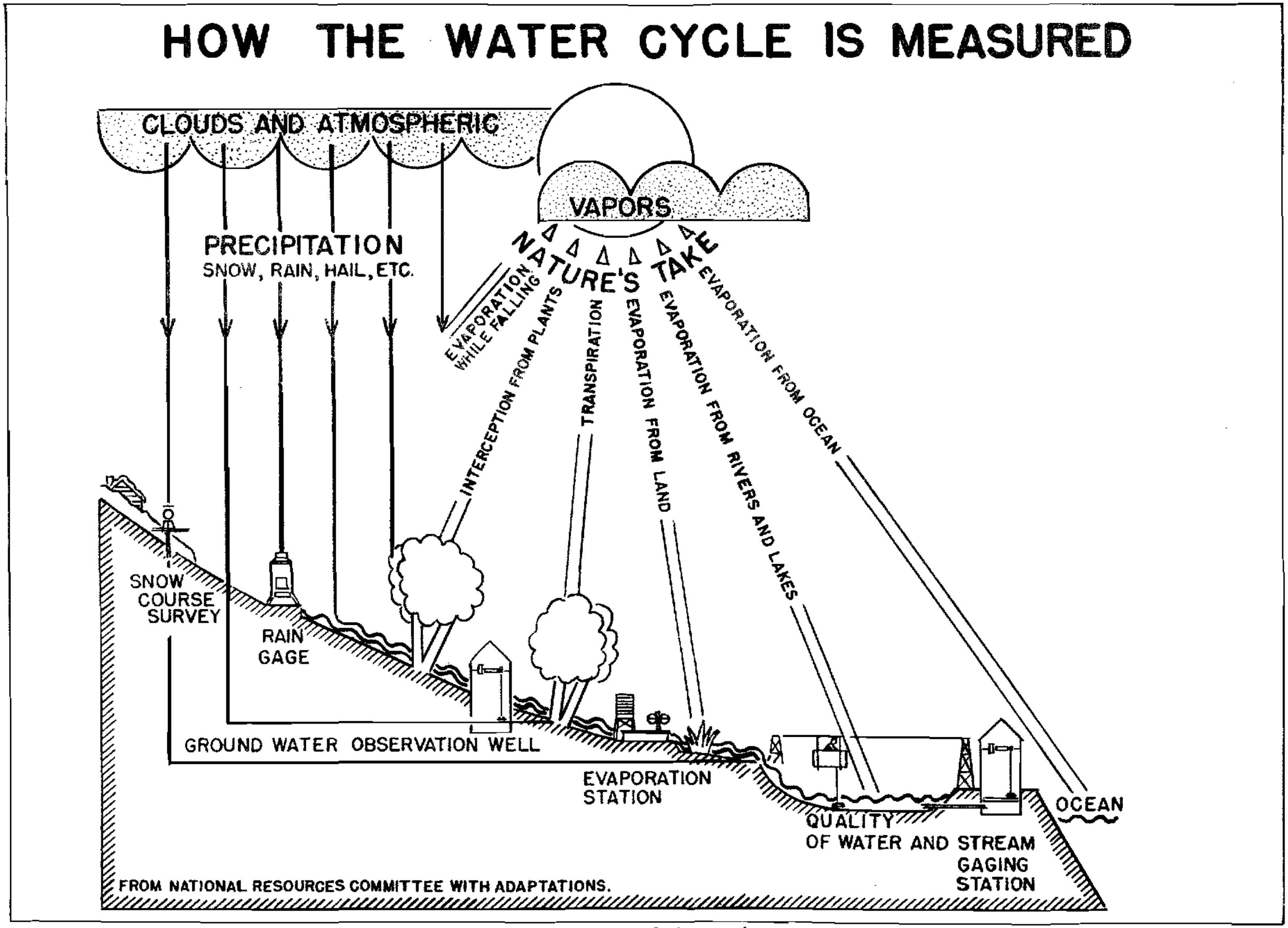
Water-Table and Artesian Conditions

Ground water occurs under either artesian or water-table conditions. Artesian conditions exist when the aquifer contains water that has an artesian pressure head. This pressure head occurs where a water-bearing stratum is overlain by a relatively impervious stratum. Because of this pressure head, water will rise above the upper surface of the aquifer in any well that taps the aquifer.

Water-table conditions exist where the upper surface of the water is not confined by an impermeable bed and the water surface is free to fluctuate. This upper surface of the ground water is the water table. In the area of this report the water in the terrace deposits is largely unconfined and its upper surface is the water table, but the water in the Permian bedrock is confined and is therefore artesian.

Movement of Ground Water

Ground water, like other liquid, has the tendency to seek equilibrium by moving from a point of higher head to one of lower head. The difference in altitude between any two points on the water table is the difference in head at those two points; therefore, the water



Graphic representation of the hydrologic cycle.

loses head as it moves. The material through which the water moves is the aquifer, and the ease with which water moves depends on the permeability of the aquifer. Permeability depends on the size and arrangement of the particles and on the interconnection of the pore spaces, but it is not directly dependent on the pore space or porosity of the material. A fine-grained sediment, such as clay, may have a high porosity but a low permeability because the openings are so small that the force of molecular attraction offers resistance to the movement of water.

The water table is not a plane or level surface, but an irregular sloping surface that corresponds in general with the slope of the land surface. The water table generally has less relief than the land surface and is a subdued replica of the surface topography. The many irregularities in the shape of the water table are caused by differences in permeability and thickness of the water-bearing material and by unequal additions of water to, or removal from, the ground-water reservoir. Where the rate of replenishment, or recharge, is exceptionally high, the water table may form a mound or a ridge from which the water spreads out to surrounding areas. This spreading out takes place slowly because of the resistance to flow through the aquifer. The water table in this area of Oklahoma slopes generally southwest, at right angles to the course of the Cimarron River, and at an average rate of about 18 feet per mile. (See pl. 5).

Fluctuations of Water Level

The water table rises and falls slowly but continuously in response to variations in the recharge to and discharge from the underground reservoir. After replenishment during wet seasons, the water table normally is relatively high. After dry seasons, during which the flow of perennial streams has been maintained by discharge of ground water, the water table normally is lower. Discharge of water by evaporation, by transpiration, or by pumping from wells also will lower the water table. The position of the water table at any one time depends on the balance between recharge and all the forms of discharge. It expresses the net effect of the opposing forces, recharge and discharge, and shows how much water is in storage. The position of the water table is found by measuring depths to water in wells, and changes in it are detected by measuring the depths periodically.

Some fluctuations of water level in wells are due to causes not related to recharge and discharge, such as tides, earthquakes, and variations of atmospheric (barometric) pressure. Of these other causes only the barometric pressure affects water levels significantly in the area covered by this report. To illustrate this effect, a recording gage was installed on well 20N9W-4-1 on April 25, 1950, and a microbarograph, an instrument that gives a constant record of barometric pressure, was kept in the same shelter for 41 days. When converted to the amplitude of a barometer using water instead of mercury and inverted, the barometric fluctuations closely resembled the fluctuations of water level (fig. 3).

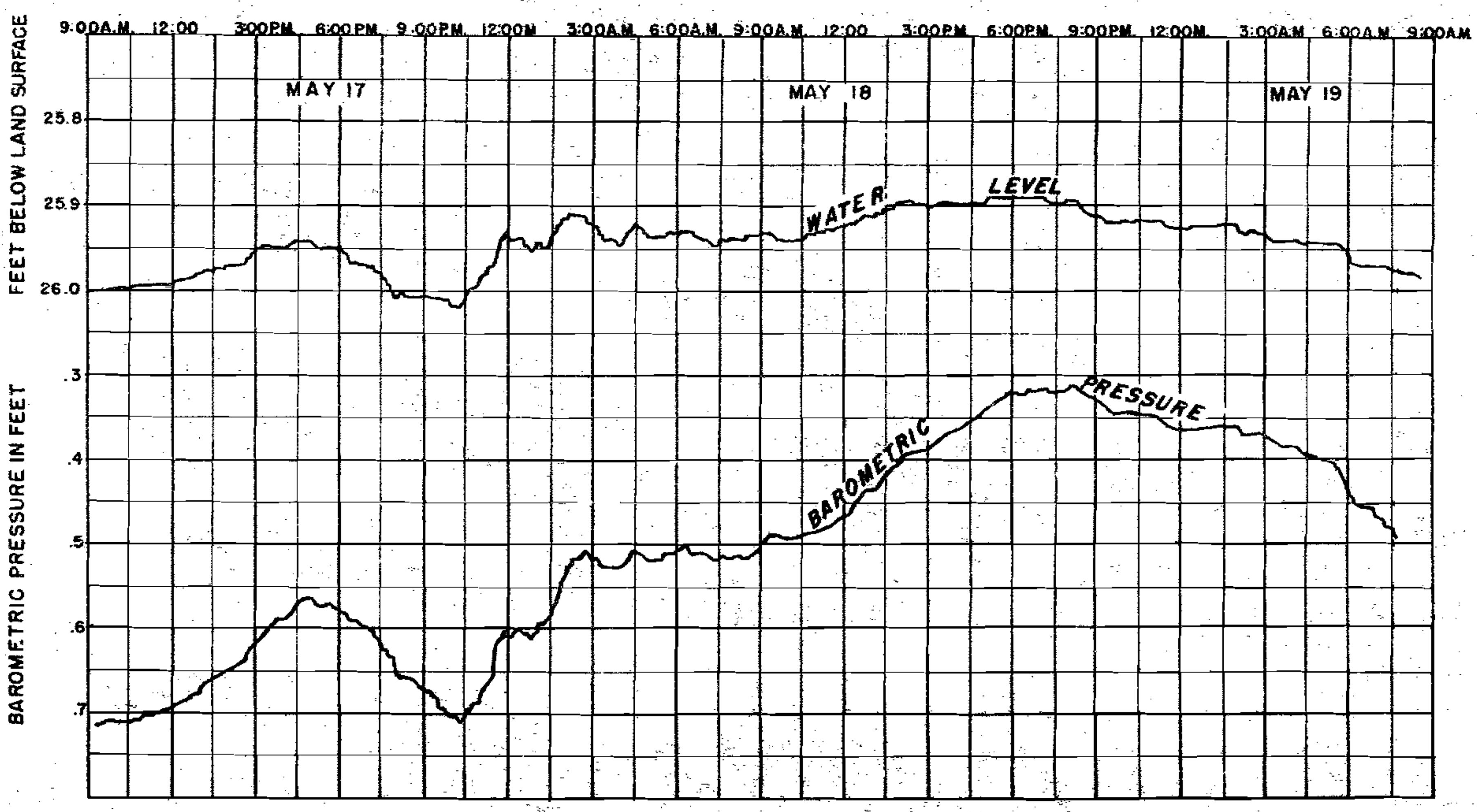


Figure 3.--Water-level fluctuations in well 20N9W-4-1 compared with changes in atmospheric pressure.

Discharge of Ground Water

Ground water is continously being discharged from an aquifer by effluent seepage, evaporation, flow or pumping from wells, underflow in the aquifer, and transpiration by plants.

Effluent Seepage

Discharge by effluent seepage, as the word "effluent" suggests, is that water which flows out of the zone of saturation and into a stream whose surface is lower than the water table. A stream or part of a stream is effluent with respect to ground water if it receives water from the zone of saturation.

Stream measurements taken during periods of no precipitation show that Eagle Chief, Indian, and Turkey Creeks all increase in flow while crossing the terrace deposits (table 4). This increase in flow must be derived from ground-water discharge. Preacher Creek, an intermittent stream, originates within the terrace deposits and its entire flow is derived from effluent seepage, except during time of heavy precipitation. The lower part of Royle Creek also is effluent. Stream measurements taken on all these creeks during a dry period in the fall of 1950 show that ground water was being discharged at the rate of about 13,000,000 gallons a day. Additional ground water is discharged at many places along the Cimarron Valley, especially where the bedrock is exposed or is near the surface. At some of these places there are small springs whose flow generally infiltrates into the alluvium within a short distance, and at other places the water issues so slowly that it is evaporated as fast as it is discharged.

Evaporation

Where the water table is near the land surface ground water may be discharged into the air by evaporation. Factors governing the rate of evaporation are temperature, wind velocity, humidity, type of soil, and depth to water. White (1932, p. 8) found by experiment that the depth of the water table is the principal controlling factor. He compared evaporation at different depths with evaporation from a free water surface, and expressed the evaporation at depth as a percentage of the evaporation from the free water surface. At depths ranging from [illegible] to 85 inches, the evaporation was found to range from 80 to 2 percent, respectively. As the depth to water in the area of this report generally is greater than 85 inches, the amount of water evaporated from the water table is probably small. On the other hand, the loss by evaporation from the belt of soil moisture may be rather large, but most of the water thus discharged does not come from the zone of saturation.

Location of measurement	Date of measurement	Flow (000 gpd)
Eagle Chief Creek		
SW¼ sec. 5, T. 24 N., R. 12 W.	11-14-50	2,146
NW¼NE¼NE¼ sec. 11, T. 23 N., R. 12 W.	10- 5-50	12,345
NW¼NE¼NE¼ sec. 11, T. 23 N., R. 12 W.	9- 6-51	14,671
NW¼NE¼NE¼ sec. 11, T. 23 N., R. 12 W.	1- 9-52	10,481
NW¼NE¼NE¼ sec. 11, T. 23 N., R. 12 W.	2- 5-52	9,889
NE¼ sec. 35, T. 23 N., R. 12 W.	11-14-50	1[illegible],147
SW cor. SE¼SE¼ sec. 2, T. 22 N., R. 12 W.	11-14-50	11,181
Indian Creek		
NW cor. sec. 14, T. 22 N., R. 10 W.	11-13-50	530
NW¼ sec. 20, T. 21 N., R. 10 W.	11-13-50	1,913
Hoyle Creek		
SE¼SE¼ sec. 31, T. 21N., R. 9 W.	10- 2-51	[illegible]54
SE¼SE¼ sec. 31, T. 21 N., R. 9 W.	12-10-51	101
SE¼SE¼ sec. 31, T. 21 N., R. 9 W.	2- 4-52	1[illegible]7
NE¼NE¼ sec. 6, T. 20 N., R. 9 W.	10-30-51	4[illegible]2
NE¼NE¼ sec. 6 T. 20 N., R. 9 W.	1- 8-52	266
SE¼NE¼ sec. 11, T. 20 N., R. 10 W.	7-12-50	21
Preacher Creek		
NW¼NW¼ sec. 13, T. 18 N., R. 8 W.	11-13-50	788
NW¼NW¼ sec. 13, T. 18 N., R. 8 W.	10- 2-51	No flow
NW¼NW¼ sec. 13, T. 18 N., R. 8 W.	10-29-51	1,535
NW¼NW¼ sec. 13, T. 18 N., R. 8 W.	10-30-51	1,073
NW¼NW¼ sec. 13, T. 18 N., R. 8 W.	11-19-51	620
NW¼NW¼ sec. 13, T. 18 N., R. 8 W.	1- 4-52	963
Turkey Creek		
NW cor. sec. 23, T. 19 N., R. 7 W.	11-13-50	5,531
SW¼NW¼ sec. 2, T. 17 N., R. 7 W.	11-13-50	7,303

Table 4.--Measurements of stream flow in Alfalfa, Garfield, Kingfisher, and Major Counties, Okla.

Transpiration

The discharge of water into the atmosphere by plants during the process of growing is called transpiration. The water may be taken into the roots of plants from the belt of soil moisture, the zone of saturation, and the capillary fringe--which in turn is supplied from the zone of saturation.

Computation of the total amount of transpiration in an area involves many variables that are not yet completely understood. Where plants are able to take water from the zone of saturation, transpiration may be a major discharge factor. For example along Preacher Creek many trees and other plants discharge ground water. It was reported that the creek was dry during much of the summer of 1951, while temperatures were high and plants were growing. After the growing season, however, the measured flow of the creek ranged from 620,000 to 1 535,000 gallons per day. Comparable quantities of ground water doubtless drained toward the valley in summer but never appeared as flow, being wholly taken up by transpiration and evaporation. To estimate the transpiration in the entire area of this report, more research and a longer period of observation are needed.

Underflow

Where two aquifers are in contact the water from one may discharge into the other. This sort of discharge occurs between the terrace deposits and the alluvium of the Cimarron River. The water table in the terrace deposits slopes toward the river (pl. 5), and the ground water therefore drains toward the river. As most of the water is at depths too great to permit evaporation, some of it doubtless moves from the terrace deposits into the alluvium and thence to the river.

The rate of underflow depends on the hydraulic gradient and the coefficient of transmissibility of the aquifer; and the amount can be computed by use of Darcy's law (Darcy, Henry, 1856), which may be written

$$Q = T I W$$

Where Q is the flow in gallons a day, T is the coefficient of transmissibility in gallons a day per foot, I is the hydraulic gradient in feet per mile, and W is the width of the aquifer in miles. The average coefficient of transmissibility, adopted elsewhere in this report, is 20 000 gallons a day per foot, the average hydraulic gradient of the water table, as determined from the water-table map (pl. 5), is 18 feet per mile; and the width of the aquifer is 40 miles. The latter is the length of the contact between the terrace deposits and the alluvium. Substituting these values in the equation given above, the quantity of water involved in the underflow is calculated to be 14,400,000 gallons per day.

Pumpage

The discharge of ground water by pumping in 1950 was small compared with the total quantity of water discharged from the aquifer and in comparison with the total quantity of water stored in the aquifer. While the wells were being inventoried for the present investigation, estimates of the amount of water used by typical water users were obtained. These indicate that a total of about 42,000 gallons of water per day was pumped from domestic wells, and about 165 000 gallons per day from stock wells. The eight irrigation wells used approximately 393,000 gallons a day. The amount of water withdrawn for public supply was about 1,000,000 gallons a day. Thus the total daily pumpage was approximately 1,600,000 gallons.

Recharge of Ground Water

Under natural conditions an aquifer may receive water from one or more of several sources. Recharge may be obtained from infiltration of precipitation, from streams that introduce water from outside the catchment area of the aquifer, and from percolation from another aquifer. Infiltration of precipitation is the most important source of recharge in this area, but it will be discussed last to afford a more timely summation of total recharge.

Eagle Chief Creek, Indian Creek, and Turkey Creek are the only streams that bring in water from outside the area, but this water is not added to that in the terrace deposits. Measurements made in these streams during November 1950 show that their flow increases as they cross the terrace deposits (table 4). Therefore, they do not recharge the terrace deposits but drain water from them.

The terrace deposits are underlain by Permian red beds whose low permeability prevents large-scale movement of water. Thus, recharge of the terrace deposits by underflow from the Permian red beds probably is negligible.

The terrace deposits are notably lacking in surface drainage. Only three well-developed streams cross them to empty into the Cimarron River. Even the road ditches seldom contain water. Large areas have no outside drainage, and the predominantly sandy soil favors a high rate of infiltration. Many shallow depressions are excellent intake areas, holding the water that falls on the surface until it evaporates or infiltrates into the ground. Relatively few of them retain water for more than 1 or 2 days after the rain has stopped.

Measurements of the depth to water in 26 observation wells were averaged monthly for the period August 1950 to the end of 1951. A hydrograph of the averages reveals the average fluctuation of the water level. Comparison with the average cumulative departure from normal precipitation, as obtained from U. S. Weather Bureau reports on stations at Hennessey, Okeene, and Waukomis, suggests a relation between departure from normal rainfall and change in ground-water level (fig. 4). The rise of water level in response to rainfall appears to be relatively rapid. Profound conclusions are not justified at this time because of the short period for which water-level records are available, but it is believed that the records provide a reasonable basis for a preliminary estimate of recharge.

How much the ground-water level will rise depends on how much water is added to the reservoir. It also depends on how much space per unit of volume is available in the sediments to receive water. If 10 percent of the volume of the sediments, after they are drained, can be filled with water, the addition of 1 inch of water would cause a rise of 10 inches in ground-water level. Conversely, a rise of 10 inches in ground-water level is equivalent to a layer of water 1 inch deep. If 25 percent of the volume can be filled, more water will go into each cubic foot of sediment and the rise in ground-water level will be 4 inches. This space factor is approximately the same as the specific yield. Elsewhere in this report it has been shown that the specific yield of the saturated sediments in this area of Oklahoma ranges rather widely but in the zone of water-table fluctuation probably averages about 10 percent. Therefore, 10 percent has been used in estimating the amount of recharge represented by the rises in water level shown by the hydrograph.

In the period July 1950 through December 1951 only the heavy rains of August and September 1950 and February, May, and June 1951 caused significant rises in ground-water level. For example, the average rainfall at the Hennessey, Okeene, and Waukomis weather stations during the month of August was 4.76 inches. The rain caused a rise of about 8 inches in the average ground-water level. After allowance for the specific yield, this rise in ground-water level is equal to the addition of a layer of water 0.8 inch deep, amounting to 17 percent of the rain. Estimates for the other months were made in the same way. For the 5 months, the percentage of the rain estimated to have become recharge ranged from 6.62 to 25.95 percent and averaged 14.45 percent.

The normal rainfall for the area is 28.75 inches a year, as obtained by an arithmetic average of the normals for Okeene, Hennessey, and Waukomis. Annual recharge to the aquifer would be 14.45 percent of 28.75 inches, or 4.15 inches. This figure for recharge may be low because the heaviest rains during the period of observation were in the summer months when transpiration and evaporation losses were highest. In years when heavy rains come in late fall or early spring, the recharge may conceivably be higher.

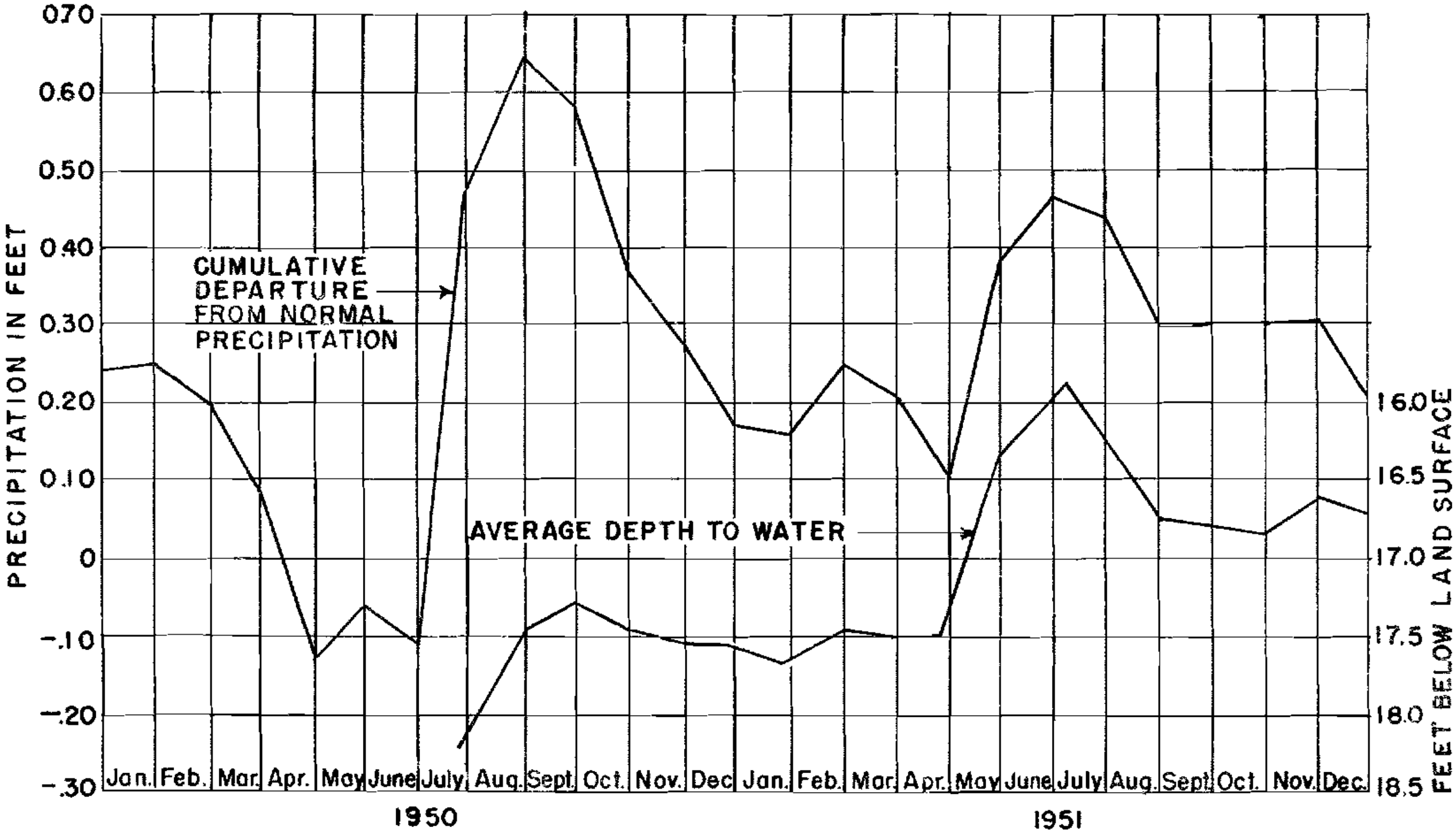


Figure 4.--Fluctuations of average water level in 26 observation wells, and cumulative departure from normal precipitation.

Utilization of Ground Water

Most of the water used in the area for domestic, stock, industrial, and municipal supplies is ground water, but some surface water is taken from Turkey Creek for irrigation of 190 acres, some is pumped from Indian Creek for oil-well-drilling operations, and some creek water is used for stock.

In the 350 square miles considered in this report, 1,719 wells were inventoried. Of these, 953 are domestic wells, 407 are stock wells, 9 are irrigation wells, 23 are public-supply wells, 62 are observation wells, 264 are unused wells, and 1 is a battery of industrial wells. Wells used for both domestic and stock supply, or for domestic supply and small businesses, such as service stations and drugstores, are classified as domestic wells. Table 7 summarizes the wells for which significant data were obtained, together with selected test holes and shot holes.

Domestic-Supply Wells

Domestic wells are the privately owned wells that supply water for home use, such as cooking, washing, and sanitation. Most farm and ranch homes are served by such wells, which average 2.7 to the square mile. Their average yield is estimated to be 45 gallons a day. This estimate of daily use is based on the more reliable reports of several well owners and is weighted to account for the larger use of water from wells equipped with automatic water systems. In four townships where special observations were made it was found that 36.5 percent of the domestic wells are equipped with automatic water systems, but this average is believed to be higher than for the area as a whole.

Most domestic wells that tap the terrace deposits are driven wells 1 1/4 inches in diameter and are finished with well points of the same diameter and 24 to 36 inches long. The average depth of such wells is 59 feet. Where the terrace deposits are thin or lacking, domestic wells are drilled into the bedrock. Most of these wells are 4 to 6 inches in diameter, partly cased with steel or galvanized iron pipe, and open at the bottom. They average 110 feet in depth. Nearly all the domestic wells are equipped with cylinder pumps powered by hand or by windmill, or both, but some are equipped with electrically powered jet and cylinder pumps. Most of the unused wells were originally drilled or driven to supply the needs of farm homes, now abandoned. They reflect the decline in rural population that is evident from the census records.

Stock Wells

Wells used to supply water to stock average 1.1 per square mile. They are of the same construction as the domestic wells, and generally are equipped with cylinder pumps powered by windmills. Many stock wells derive their water from the alluvium of the Cimarron River and some are no deeper than 8 feet. Because of the relative inaccessibility of much of the grazing land, many windmills are turned on and off automatically by a float-actuated mechanism. The average pumpage from stock wells is estimated to be 405 gallons a day.

Some stock is watered from surface streams and some from springs, but the total amount of water so used is relatively small.

Public-Supply Wells

The cities of Enid, Okeene, and Fairview draw ground water from the area of this investigation, and the city of Hennessey draws water from the terrace deposits just east of Highway 81, which is the east boundary of the area investigated.

Enid

In July 1951, Enid had six wells within the area of this investigation, five of them tapping water in the terrace deposits and one in the Permian bedrock. The five wells in the terrace deposits were constructed in July and August of 1950 and have been used intermittently to supplement the city's principal water supply, obtained from similar deposits outside the area. The maximum period of continuous pumping of these wells was about 3 months. The yields of individual wells range from about 3,?00,000 to 8,440,000 gallons per month. From November 1950 to February 1952, inclusive, approximately 150,000,000 gallons was pumped from these wells. The well in the bedrock also is used intermittently to supplement the city's supply. It yields approximately 7,040,000 gallons of water per month. Thus, if all the wells are operated continuously, about 43,000,000 gallons of water is withdrawn from the area in a month, or about 1,400,000 gallons per day. Since field work was completed in the area, Enid has resumed investigation of water in the Permian bedrock and has constructed additional wells in the Drummond locality. The investigation was still active at the time this report was written.

Fairview

Before 1935 Fairview obtained water from springs that issue at the contact of the alluvium and the terrace deposits in the S½ sec. 32, T. 22 N., R. 11 W., and the N½ sec. 5, T. 21 N., R. 11 W. Pits, of brick masonry, collected the water, which flowed to Fairview by gravity. At times these springs yielded as much as 200 gallons per minute, but at other times they declined to practically nothing. In 1935 a well having a reported capacity of 600 gallons per minute was drilled to supplement the springs. A few years later two more wells were drilled, and the springs were abandoned. In 1945 a fourth well was drilled, but it was not put in service until the spring of 1950. In 1950 Fairview was getting all its water from the four wells, two of which are in the terrace deposits and two in the alluvium. Data on yields of individual wells are not available, but it is believed that most of the reported average total yield of 200,000 gallons a day comes from the two wells in the terrace deposits.

Okeene

Okeene has three wells on a 15-acre tract in the SE$\frac{1}{4}$ of sec. 15, T. 19 N., R. 9 W. They obtain water from the terrace deposits and are reported to yield 150 gallons a minute each. They supply approximately 7,500,000 gallons a month or about 250,000 gallons a day.

Hennessey

Hennessey obtains approximately 250,000 gallons of water a day from three wells about 50 feet deep in the terrace deposits in the E$\frac{1}{2}$ sec. 13, T. 18 N., R. 7 W. All were drilled to bedrock and are gravel-packed. During testing after completion in 1949, each well yielded 150 gallons a minute.

Industrial-Supply Wells

The St. Louis & San Francisco Railway Well

The well of the St. Louis & San Francisco Railway (20N10W-13-4), near Ames, obtains water for locomotive boilers from a battery of eight jetted wells spaced approximately 6 feet apart along a 40-foot suction line. The wells are 30 to 40 feet deep and consist of casing 4 inches in diameter with a well point at the bottom, which is 42 inches long and 4 inches in diameter. The suction line connects the wells to a reciprocating pump powered by a 6-horsepower steam engine. The water is pumped at a reported rate of 200 gallons per minute into an overhead storage tank. The average daily pumpage is reported to be 6,500 gallons. This is the only permanent development of ground water for industrial use in the area.

Oil-Well Drilling Water

Other industrial use of water in the area is in the drilling of oil wells. As water for this purpose need not meet rigid standards of chemical quality, the main consideration being adequate quantity, it is drawn from any convenient source. Some has been taken from Indian Creek, some from stock ponds, some from wells already drilled, and some from wells drilled especially for the purpose. A reliable estimate of the amount of water used in drilling is not available because such records generally are not kept. The quantity probably differs considerably from well to well, according to the depth of the oil well and the difficulties encountered. The need for drilling water at any given site lasts only a few months, as a rule.

Warren Petroleum Co.

As this report was being written, the Warren Petroleum Co. was constructing a gasoline refinery near Ringwood, and contemplated development of a water supply from the terrace deposits.

Irrigation Wells

By 1950 irrigation with ground water pumped from wells had been under way for several years, but it had not reached major proportions. In the area of this report nine wells were being used to irrigate about 362 acres, not including small garden plots watered from domestic and stock wells. Of the nine wells, eight tap water in the terrace deposits and irrigate 172 acres. The other well draws water from the alluvium of Turkey Creek, and is used only when the flow of the creek is not enough to irrigate 190 acres. In this area the uneven distribution of rain during the year may mean an excess early in the growing season followed by a deficiency. Irrigation, therefore, may mean the difference between economic success and failure, or between a bumper crop and a mediocre one. It is reported that some of the wells already have proved their worth, although they have been in service only a few seasons. The following paragraphs summarize the principal facts about each well.

Victor Laubhan Well 20N9W-6-1

The Victor Laubhan irrigation well (20N9W-6-1) is about a mile west of Ames. Drilled in 1948, the well is 67 feet deep, has a 10-inch casing slotted in the lower part, and is gravel-walled. The casing terminates upward at the bottom of a pit about 4 feet above the static water level. The pit is about 4 feet square and 4 feet deep. A centrifugal pump set over the pit is driven by an engine that burns butane. The well thus equipped is reported to have yielded 165 gallons per minute continuously for 15 days, with a maximum drawdown of 7 feet; hence the specific capacity is about 24 gallons per minute per foot of drawdown. The water is pumped through a sprinkler system to irrigate 10 acres of truck crops. An analysis of the water from this well (see table 5) shows it to be satisfactory.

C. W. Webber Well 21N9W-32-2

The C. W. Webber irrigation well (21N9W-32-2) is in the town of Ames. Constructed in 1946 by the owner and his son, the 41-foot well was dug to 17 feet and drilled the remaining 24 feet. A circular, steel storage tank 3½ feet in diameter, with both ends removed, serves as casing for the upper 17 feet. The lower drilled portion of the well is cased with 6-inch steel pipe slotted in the lower part to permit water to enter the well. A centrifugal pump driven by a 2-horsepower electric motor is set near the bottom of the dug part of the well. Equipped in this manner the well is reported to yield 60 gallons per minute with 10 feet of drawdown, indicating a specific capacity of 6 gallons per minute per foot of drawdown. The water is used to irrigate 1 acre of truck crops by the flooding method.

J. J. Kennedy Well 21N10W-16-1

The J. J. Kennedy irrigation well (21N10W-16-1) is about 6 miles south and 2 miles west of Ringwood. It was drilled in the spring of 1950, is 39 feet deep, and is finished with 10-inch steel casing, which is slotted in the bottom 10 feet. The well is equipped with a turbine pump driven by a gasoline-powered engine, and is reported to yield 250 gallons per minute. The well was used to irrigate 20 acres during the late summer and early fall of 1950, and for several months during the latter part of 1950 it supplied water for the drilling of two oil wells. A 20-hour aquifer-performance test made in March 1951 suggested that the type of construction of this well limits its production, and that an appropriate well screen should more than double the yield. Details of the test are given on p. 57 in this report. A sample of water collected during the test shows the water to be suitable for irrigation (see table 5).

R. M. and J. W. Scannell Well 21N11W-12-3

The irrigation well owned by R. M. and J. W. Scannell is on Yolo Ranch about 6 miles southeast of Ringwood. It was drilled in 1949 by the George E. Failing Supply Co., is 60 feet deep, and is finished with 45 feet of 8-inch steel casing with 15 feet of 8-inch screen at the bottom. The static water level is reported to be about 17 feet below the land surface. The well is equipped with a turbine pump powered by a 37-horsepower engine that burns propane. R. M. Scannell reported that a test of the well made immediately after completion showed a drawdown of 14 feet after 48 hours of pumping at a rate of 180 gallons per minute. This indicates a specific capacity of about 13 gallons per minute per foot of drawdown. The well was used for irrigation of 40 acres of alfalfa during 1950 and plans were made to double the acreage in 1951.

E. Hildebrand Well 22N11W-17-4

The E. Hildebrand irrigation well (22N11W-17-4) is about 2 miles southeast of Cleo Springs. Constructed by the owner in 1935, it is the oldest irrigation installation still in service in the area; it has been used every year since 1935, except 1951, for the irrigation of 1 acre of truck crops. It consists of a battery of seven 1¼-inch driven wells about 40 feet deep, each equipped with a well point. The wells are in a circular pit 5 feet in diameter and 5 feet deep, being uniformly spaced around the perimeter. Header pipes connect the wells to a centrifugal pump installed at the bottom of the pit. A gasoline engine drives the pump, which is reported to deliver 125 gallons per minute.

L. G. Watson Well 19N8W-27-1

The L. G. Watson irrigation well 19N8W-27-1 is about 7 miles west of Hennessey. It was drilled by the Goe Brothers Drilling Co., Hennessey, Okla., in 1948, is 67 feet deep, and is gravel-walled. It is cased to the bottom with 16-inch steel casing, the lower 15 feet of which is perforated. The static water level is about 18 feet below the land surface. The well is equipped with a 6-inch, 15-stage turbine pump driven by a butane-powered, 30-horsepower engine and yields 600 gallons per minute. The well was pumped in 1950 for the irrigation of 40 acres of alfalfa and plans were laid for adding 40 acres of wheat and vetch. In July 1951, a 24-hour aquifer-performance test was made on this well, the details of which are given on pp. 58 in the section on aquifer-performance tests. The analysis of the water from this well (see table 5) shows it to be suitable for irrigation.

Darrel Goe Well 19N7W-30-2

The Darrel Goe irrigation well (19N7W-30-2) is about 5 miles west of Hennessey. It was drilled by the Goe Brothers Drilling Co. to a depth of 92 feet and has 16-inch steel casing extending to the bottom. The lower 26 feet of casing is slotted and the well is gravel-walled. Equipped with a turbine pump powered by a tractor engine, the well is reported to yield 500 gallons per minute, and is used to irrigate 20 acres.

Bill Barr Well 18N7W-35

The Bill Barr irrigation well (18N7W-35) is half a mile northwest of Dover. Drilled in 1949, it is 43 feet deep and has 36-inch steel casing that is slotted in the interval from 30 to 40 feet below the land surface. The well is equipped with a centrifugal pump powered by a gasoline engine, and is reported to have yielded 660 gallons per minute with a drawdown of 24 feet during a 10-hour test. It taps ground water in the alluvium of Turkey Creek, and is used only when the flow of the creek is too low to supply the water needed for irrigation of 190 acres of alfalfa and truck crops.

Francis Gorton Well 19N7W-9

The Francis Gorton irrigation well (19N7W-9) is about 3 miles northwest of Hennessey. Drilled in 1949 by the Goe Brothers Drilling Co., it is 33 feet deep, is gravel-walled, and is finished with 16-inch steel casing, the lower 20 feet of which is slotted. The well is equipped with a turbine pump powered by a tractor, and is used to irrigate 40 acres.

Well-Drilling Methods

Water wells in the area of this investigation have been drilled, driven, jetted, bored, and dug. The character of the materials to be penetrated has much to do with the method selected, but the depth to water, desired yield, and cost also play a part. Most wells for domestic and stock water are of the driven type. A few wells have been bored, and one was jetted into the alluvium of the Cimarron River. As a general rule, wells are bored only where the rocks are unconsolidated and the water table is relatively near the land surface. Wells are drilled where bedrock must be penetrated or where larger quantities of water are required. Some of the wells along Turkey Creek were dug by hand by early settlers. Some of the public-supply wells were dug with a modern clamshell or orange-peel bucket.

Driven Wells

Driven wells are common in the area because in many places they can be put down by the owner with simple tools and at relatively low cost, and they will yield enough water for domestic or stock use. In general, the method is as follows: A shallow hole is dug with an auger, and a well point coupled to a length of casing is put in the hole. The most common size of well point is 30 inches long and 1 1/4 inches in diameter, and the casing is the same diameter as the well point. A drive cap is then screwed to the top of the casing, and the pipe is driven with a sledge or other driving equipment. More lengths of casing are added and driven down until the desired depth is reached, generally near the base of the terrace deposit in coarse sand or gravel. This method is satisfactory only in the unconsolidated materials of the terrace deposits and alluvium.

Bored Wells

Bored wells are constructed by boring a hole with an auger to some point below the water table where loose water-bearing material is reached. If the well is to be made deeper some other method must be used. This type of well can be put down only where the water table is relatively close to the surface. Only a few wells in the area are of this type.

Jetted Wells

The only well in the area of this report known to have been constructed by jetting is that of the St. Louis & San Francisco Railway (20N10W-13-4), which consists of a battery of eight well points in alluvium. The casing with well point attached was sunk into gravel by turning and forcing downward by hand while water was pumped in at the top and out at the bottom through the screen in the well point. The water carried the cuttings outside the casing to the surface.

Drilled Wells

Most of the wells that go into the Permian bedrock are of the drilled type. The older drilled wells were put down largely by cable-tool (percussion) drilling machines, which employ a heavy bit to pound the rock into small fragments. The drill cuttings are removed by a bailer, which is run in the hole alternately with the bit.

Many of the newer wells have been drilled by the rotary-hydraulic method, the use of which is increasing. Such machines employ a bit attached to the end of a string of hollow pipe, known as a drill stem, which is rotated in the hole by a power-driven kelly and rotary table. A pump forces water, or mud, down the drill stem and out through holes in the bit. The water, or mud, returns to the surface outside the drill pipe, carrying with it the drill cuttings, and then flows by gravity through a ditch into a settling basin, or "slush pit." The coarser cuttings settle to the bottom of the slush pit, and the water--usually mud-laden--is pumped again into the top of the drill stem.

The reverse-rotary method, so-called because the direction of circulation of drilling mud is reversed, was used for drilling four wells for Enid along the right-of-way of the St. Louis & San Francisco Railway. The drilling mud flows by gravity from the slush pit into the drill hole. At the bottom of the hole it is pumped through holes in the bit and thence up the pipe to the surface, bringing the drill cuttings with it. The machine used for drilling the Enid wells had 7-inch drill pipe and a 6-inch centrifugal pump, and it made a hole 36 inches in diameter through unconsolidated terrace deposits to the top of the bedrock. Casing and screen 12 inches in diameter were put in the hole, and the annular space outside the casing was filled with gravel.

Gravel packing of wells in the terrace deposits generally is regarded as basically sound construction, especially if large yields are desired. Whether it is necessary depends on the grain size and degree of uniformity of the water-bearing sand or gravel. These characteristics differ from well to well, and from stratum to stratum in the same well; they can best be appraised by careful examination of drill cuttings from test holes.

Most rural wells drilled into the bedrock are 6 inches in diameter and are cased with 4- or 5-inch galvanized iron casing, which extends only deep enough to prevent caving of loose surficial materials; the lower part generally is left open. The wells drilled into the bedrock for the city of Enid are cased to the bottom, and the casing is slotted opposite the more permeable sections of the bedrock. The wells drilled into the bedrock for the town of Waukomis also are cased to the bottom. The casing is perforated and is surrounded with a gravel wall.

Dug Wells

The dug wells may be divided into two types: true dug wells, made with pick and shovel, and wells dug by power-driven machinery. The first wells put down in the area were dug with pick and shovel, generally close to streams where the water table is at shallow depths. They were several feet in diameter, were lined with brick or rock, and most of them penetrated the zone of saturation only a few feet. In consequence, they often went dry during periods of drought. The principal advantage of such a well is that it affords relatively large storage space and yields water freely for short periods even though the permeability of the aquifer is low. On the other hand, it is a difficult well to construct and make sanitary. Such wells, therefore, are generally considered unsatisfactory.

The well dug by mechanical means can be made to yield large amounts of water from unconsolidated sediments and normally is a more sanitary installation than a well dug by pick and shovel. For these reasons some public-supply wells have been constructed by this method, which begins with digging a shallow hole and setting in it a short length of steel casing, commonly 42 inches or more in diameter. The digging is done within the casing by a power-driven orange-peel or clamshell bucket. As the hole is deepened the casing lowers into it, a new length being added as needed. In the area of this report, most wells of this type are sunk to the top of the bedrock because the coarser beds of sand and gravel are generally at the base of the unconsolidated sediments. The permanent casing may be steel or concrete, 12 to 24 inches in diameter. It and the screen, if any, are centered in the hole, leaving an annular space that is then filled with washed and graded gravel, the size of which is determined by the texture of the water-bearing material and the size of screen openings or slots in the casing. The temporary casing is pulled out while the annular space is being filled with gravel. The wall of gravel prevents the fine sand or mud from being drawn into the well during pumping. The net result is a well similar to a drilled, gravel-walled well, and yields that are comparable.

Ground-Water Conditions Described by Localities

For convenience in description, the area is divided into six localities, within which the ground-water conditions are fairly uniform. These localities are: Cleo Springs, Ringwood, Ames, Drummond, Lacey-Dover, and Waukomis.

Cleo Springs Locality

The Cleo Springs locality is bounded on the west by Eagle Chief Creek, on the east by Indian Creek, and on the south by the Cimarron River. It extends northward to the boundary of the area mapped. Most of it is covered by dune sand and accordingly is hilly. Ground water is pumped for domestic and stock use, for the public supply of Fairview, for irrigation, and for oil-well drilling. The city of Fairview is the major user of water, taking about 200,000 gallons per day. The city wells and the irrigation wells (Scannell and Hildebrand) are described elsewhere in this report.

As revealed by test drilling, the terrace deposits are as much as 88 feet thick (pl. 1), and include considerable thicknesses of coarse sediments; in much of the locality more than 30 feet is in the zone of saturation (pl. 6). It seems apparent that much more ground water is available in the locality than currently is being taken from it.

North of Cleo Springs the water table slopes westward, indicating drainage of ground water into Eagle Chief Creek. Elsewhere the water table has a general southward slope, toward the Cimarron River.

Eagle Chief Creek has a broad alluvial valley along most of its course except at Cleo Springs, where the terrace deposits extend almost to the bank of the stream. Permian red beds exposed under the terrace deposits near Cleo Springs show the terrace deposits to be thin and, hence, of small reservoir capacity. Ground water therefore issues from them in the many springs from which Cleo Springs derives its name.

Measurements of the flow of Eagle Chief Creek were made by an engineer of the Surface Water Branch, U. S. Geological Survey, on November 14, 1950, at the following locations

(1) bridge on State Highway 45, 3 mile west of Carmen and upstream from the area of terrace deposits (SW$\frac{1}{4}$ sec. 5, T. 24 N., R. 12 W.);

(2) bridge about 1 mile north of Cleo Springs, within the area of terrace deposits and about 11 miles downstream from locality 1 (NE$\frac{1}{4}$ sec. 35, T. 23 N., R. 12 W.);

(3) bridge a quarter of a mile west of Cleo Springs, just south of the springs and about 2 miles downstream from locality 2 (SE$\frac{1}{4}$ sec. 2, T. [illegible] N., R. 12 W.).

These measurements (table 4) show that about 8,000,000 gallons of water a day was being drained from the terrace deposits between the first two points, and that this was increased by about 1,000,000 gallons a day between locations 2 and 3. Most of the increase of 1,000,000 gallons is believed to have come from the springs at Cleo Springs.

In the northeastern part of the locality, within a mile of Indian Creek, the terrace deposits are too thin to be of value as an aquifer, but small amounts of water may be obtained from wells that penetrate crevices and lenticular sandstones in the underlying bedrock.

Little is known about the ground water in the alluvium along Eagle Chief Creek and the Cimarron River, except that it is sufficient to supply a few domestic and stock wells.

The quality of the water from the terrace deposits is generally satisfactory for most uses (table [illegible]). No analyses have been made of the water from the alluvium or from the bedrock in this locality.

Ringwood Locality

The Ringwood locality is bounded on the west by Indian Creek; on the east by Hoyle Creek and an imaginary line extended northward from the head of Hoyle Creek; and on the south by the Cimarron River. It extends northward to the boundary of the mapped area. South of Ringwood it has a dune topography and north of Ringwood it is thoroughly dissected by the well-developed drainage systems of Indian and Turkey Creeks. Ground water is pumped for domestic and stock use, for irrigation, and for public supply of Enid. Some ground water has been used by the oil industry, especially in drilling operations. The Enid city well and the irrigation wells (Kennedy and Laubhan) are described elsewhere in this report.

The terrace deposits range in thickness from less than 1 foot to about 85 feet (pl. 2). Several of the test holes showed thick beds of coarse sediments near the base of the terrace deposits. South of Ringwood more than 10 feet of the terrace deposits is in the zone of saturation (pl. 6).

Measurements of the flow of Indian Creek were made by an engineer of the Surface Water Branch, U. S. Geological Survey, on November 13, 1950, at the following locations:

(1) bridge on U. S. Highway 60, half a mile north of Ringwood, where Indian Creek enters the terrace deposits (NW cor. sec. 14, T. 22 N., R. 10 W.);

(2) bridge on section-line road near the place where Indian Creek leaves the terrace deposits (N. line sec. 20, T. 21 N., R. 10 W.).

These measurements (table 4) show that about 1,390,000 gallons of water a day was being drained from the terrace deposits between the two locations. Water-table contours (pl. 5) show that the water table slopes to the southwest, toward Indian Creek and the Cimarron River.

North of Ringwood the terrace deposits are thin, and Permian bedrock is exposed in many places. Rural wells generally obtain water from crevices and lenticular sandstones in the bedrock.

The quality of the water from the terrace deposits is generally satisfactory for most uses, but the quality of the water from the Permian bedrock differs greatly within short distances. In some wells tapping the bedrock the water is satisfactory for most uses, but in others it is too highly mineralized for almost any use. Analyses of water from two wells in the same section (22N10W-14-1 and 22N10W-14-2) illustrate clearly the wide range in quality of water from the bedrock (table 5).

Ames Locality

The Ames locality is bounded on the west by Hoyle Creek and an imaginary line drawn northward from the head of Hoyle Creek; on the south by the Cimarron River; and on the east by the east boundary of R. 9 W. It extends northward to the boundary of the area mapped. The southern half of this locality has a dune topography, but the northern half is flat--except where it is dissected by Turkey Creek and its tributaries. The ground-water resources of this locality are more highly developed than those of the other five localities discussed in this report. The city of Enid has five public-supply wells, the city of Okeene has three, and there is one irrigation well (Webber), all tapping water in the terrace deposits. The city of Enid also has one public-supply well that obtains water from the Permian bedrock. These wells are described elsewhere in this report.

Test drilling showed that the terrace deposits are generally less than 60 feet thick and contain a relatively small amount of coarse sediments. In most of this locality, however, more than 20 feet of terrace sediments are in the zone of saturation (pl. 6), and pumping tests have shown coefficients of transmissibility ranging from 6,000 gallons a day per foot to 52,000 gallons a day per foot (see section on pumping tests). Thus, large amounts of water may be obtained locally.

The water-table map (pl. 5) shows a ground-water divide in T. 21 N., R. 9 W. trending along a line between sec. 3 and sec. 36. Ground water north and east of this divide drains into Turkey Creek while south and west of the divide it drains into the Cimarron River.

Hoyle Creek originates within the Ringwood and Ames localities. North of Ames the stream is influent, and carries only surface runoff during and after rains. Beginning about 1 mile north of Ames the bed of Hoyle Creek is very close to the water table and usually contains pools of water. From about 1 mile south of Ames to the alluvial flat of the Cimarron River, a distance of 1½ miles, Hoyle Creek is an effluent stream draining the terrace deposits. Measurements of discharge of Hoyle Creek are given in table 4.

In the northern half of the locality the terrace deposits are thin, and Permian strata are widely exposed along tributaries of Turkey Creek. The Permian rocks furnish small amounts of water to private wells, and a larger amount to one public-supply well of the city of Enid (well 21N9W-24-1). The Enid well yielded about 172 gallons per minute in an aquifer-performance test, but a similar well (21N9W-22-5) yielded less than 50 gallons per minute after several hours pumping, and the drawdown was great. The difference in the performance of the two wells indicates that the hydraulic properties of the Permian rocks are far from uniform.

Water from the terrace deposits is generally suitable for most uses. In some analyses the total hardness is around 400 ppm. The quality of the water from the Permian strata is not predictable. Only one sample of water from a well in these strata was analyzed (well 21N9W-24-1). This water proved to be suitable for most purposes (table 5).

Drummond Locality

The Drummond locality comprises Tps. 20, 21, and 22 N., R. 8 W. The southeastern part of the locality has a dune topography; but the rest is flat except where dissected by Turkey Creek and its tributaries. Ground water in the area is pumped for domestic and stock use and for the public supply of the city of Enid.

Test drilling in the southeast part showed the terrace deposits to be thick but consisting mostly of fine-grained sediments unlikely to yield large quantities of ground water, although they could supply enough locally for domestic use. In the north and east, with the possible exception of the small dune area 2 miles northeast of Drummond, the terrace deposits are too thin to be of much value as an aquifer.

A ground-water divide extends diagonally across T. 20 N., R. 8 W., from sec. 6 to sec. 36. North and east of this divide the ground water drains into Turkey Creek whereas south and west of the divide it drains into the Cimarron River (pl. [illegible]).

Near Drummond, in Tps. 21 and 22 N., R. 8 W., Turkey Creek crosses an extensive alluvial flat known as the "Drummond Flat." The alluvial deposits cover an area of about [illegible] square miles and range in thickness from less than 1 foot to about [illegible] feet. They are generally so fine-grained that large yields cannot be obtained from them.

The bedrock yields small to moderate quantities of water from crevices and sandstone lenses. Most wells in the bedrock are artesian and the water flows at the surface from two of them ([illegible] and 21-8W-20). The city of Enid has constructed several wells tapping this source.

Little is known about the quality of the water in the terrace deposits or alluvium, except that some wells in alluvium are reported to yield very salty water (table [illegible]). The quality of the water from the Permian strata is not predictable. Although most of the water is satisfactory for domestic and public use, some wells yield water that is extremely high in chloride. The chloride content of the water from well [illegible] increased from [illegible] ppm to [illegible] ppm during [illegible] hours of pumping; therefore, if water from the Permian bedrock is used for irrigation or is mixed with water from other sources for public supply, its chloride content should be tested periodically to verify its suitability.

Lacey-Dover Locality

The Lacey-Dover locality comprises T. 17 N., R. 7 W., and Tps. 18 and 19 N., Rs. 7 and 8 W. Of the localities investigated, it offers the greatest possibilities for future ground-water development. In 1956, however, most of the wells were of small diameter, adequate only for furnishing domestic and stock water supplies. The city of Hennessey was using three wells for public water supply, and three wells were being pumped for irrigation (Watson, Goe, and Gorton). These six wells are in the terrace deposits. One irrigation well (Bar) taps water in alluvium. The municipal and irrigation wells are described elsewhere in this report.

In much of the locality the terrace deposits are fine grained and probably will yield only moderate amounts of water, but test drilling revealed considerable well-sorted sand and gravel at several locations (app. F). Such materials should yield water freely. The terrace deposits are more than 50 feet thick in most of the area west of Turkey Creek (pl. 2). They reach a maximum recorded thickness of 120 feet in test hole 19N8W-, about 2½ miles northeast of the town of Lacey. The terrace deposits are thickest over an old channel in the bedrock that trends diagonally across T. 19 N., R. 8 W., from sec. 5 to sec. 25, about 7 miles northeast of the Cimarron River. East of Turkey Creek, the terrace deposits are thinner than on the west side but they are a potential source of ground water from about 1 mile south of Hennessey to Dover.

The water-table map (pl. 5) shows that in the west half of the locality the ground water drains to the south and southwest, toward the Cimarron River. In the east half, the ground water flows to the south toward the Cimarron River and to the east into Turkey Creek, which flows into the Cimarron River.

Preacher Creek, which heads within the locality, is an effluent stream that drains the terrace deposits. It does not flow during hot dry periods, but a measurement of its discharge taken at the bridge on the north line of sec. 13, T. 18 N., R. 8 W. by an engineer of the Surface Water Branch, U. S. Geological Survey, on November 13, 1950, showed that about 788,000 gallons a day was being drained from the terrace deposits (table 4).

Alluvial deposits of the streams tributary to the Cimarron River are generally fine grained, but the alluvium of Turkey Creek is reported to contain some fairly coarse sediments. Moderate amounts of ground water may be obtained from it.

Permian strata are exposed in the northeast part, and some wells obtain water from crevices and sandstone lenses in them.

The quality of the water from the terrace deposits is generally satisfactory for most uses although some of it is hard (table 5).

An analysis of the water from well 1?N7W-23, which taps the alluvium of Turkey Creek, shows a hardness of 79_ ppm, and a high concentration of chloride (table 5). At one time this well furnished water for Hennessey, but the quality of the water was unsatisfactory, and the well was abandoned in favor of wells in the terrace deposits about 4 miles south of the city. The city of Kingfisher is supplied by four wells in sec. 12, T. 17 N., R. 7 W., in the alluvium of the Cimarron River.

The water from them is satisfactory for most uses (table 5).

Little is known about the quality of the water from the bedrock, but it can be expected to differ considerably from one well to another.

Waukomis Locality

The Waukomis locality comprises Tps. 20 and 21 N., R. 7 W. It is flat except in the western and southern parts where it is dissected by Turkey Creek and its tributaries, and in the northeastern part where it is dissected by tributaries of Skeleton Creek.

The terrace deposits are widespread in this locality but are too thin and too fine grained to be of much value as a source of ground water.

Permian strata are exposed in many places and are the principal source of ground-water supply. The town of Waukomis uses two wells which obtain water from the bedrock in sec. 23, T. 21 N., R. 8 W. The wells are reported to yield about 10 gallons a minute each.

The alluvium along Turkey Creek underlies areas up to a mile wide. As the creek has cut through the terrace deposits, the alluvium probably consists of sand and gravel from those deposits mixed with fine sand and clay from the Permian bedrock. Where the sand and gravel are clean and saturated, they may yield water in sufficient quantity for domestic and stock use. The quality of this water has not been determined.

Little is known about the quality of the water from the Permian bedrock, but it probably differs considerably from well to well. Only one sample of water from such a well was analyzed. It proved to be very hard and high in sulfate (table 5, well 21N7W-23-1).

Quality of Water

Chemical analyses of water from 64 wells in the area of this report are listed in table 5. The wells chosen for sampling are scattered widely and the analyses represent the quality of ground water in all localities of the area investigated.

The following discussion of the chemical constituents of ground water has been summarized from several papers published by the Quality of Water Branch of the U. S. Geological Survey.

Dissolved Solids

The figures given under "dissolved solids" show approximately the total quantity of dissolved mineral matter as determined by evaporating a measured quantity of water and weighing the residue after it has been dried at 180° C.

Table 5.--Chemical analysis of water in parts per million from wells in Alfalfa, Garfield, Kingfisher, and Major Counties, Okla.

A., Alluvium; R.b., Red beds; T.d., Terrace deposits.

Well No.	Total depth (feet)	Aquifer	Date collected	Water temperature (°F.)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)		Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$ Total	Hardness as $CaCO_3$ Non-carbonate	Percent sodium	Specific conductance (micromhos at 25° C.)
17N7W-12-1*	35	A.	12-13-50	...	5	....	41	13		199		0	412	125	85	...	......	883	155	...	..	....
12-2*	33	A.	5-23-49	...	5	....	37	12		213		0	420	122	96	...	......	907	141	...	..	....
12-3*	31	A.	5-23-49	...	6	....	37	12		216		0	412	130	99	...	......	913	141	...	..	....
12-4	.....	A.	7-10-45	65	..	....	46	33		89		16	208	141	69	...	1.8	529	250	...	..	....
18N7W- 1-1	45	T.d.	7- 9-45	65	..	....	72	18		40		6	208	10	74	...	55	434	254	...	..	....
1-2	68	T.d.,R.b.	7-10-45	65	..	....	198	55		156		0	419	34	414	...	120	1,290	720	...	..	....
8-2	24	T.d.	10- 4-50	...	..	....	58	15		25		0	185	20	53	...	17	326	206	55	21	534
13-1	50	T.d.	12-13-50	...	22	0.00	114	34	93		3.0	0	266	25	250	0.3	26	825	424	206	32	1,300
13-4	45	T.d.	7-10-45	64	..	....	32	10		22		0	121	12	19	...	38	246	121	...	..	....
15-2	53	T.d.	10- 5-50	...	..	....	91	25		42		0	275	13	36	...	162	578	330	104	22	809
24-1	45	T.d.	7-10-45	64	..	....	102	40		79		0	289	39	216	...	12	740	419	...	..	....
24-2	50	T.d.,R.b.	7-10-45	64	..	....	144	32		172		0	296	36	381	...	59	1,250	491	...	..	....
26	35	T.d.	7-10-45	65	..	....	50	30		101		22	254	49	108	...	26	596	248	...	..	....
28	31	T.d.	10- 4-50	...	..	....	35	9.1		15		0	117	14	4.0	...	50	202	125	29	20	314
18N8W-11-1	25	T.d.	10- 4-50	...	..	....	156	37		167		0	344	136	340	...	1.3	1,100	541	259	40	1,770
19N7W-23	60	A.	7- 9-45	61	16	.15	160	96	421		17	0	577	272	690	.4	2.0	2,060	794	...	..	....
25	50	R.b.	7- 9-45	64	..	....	60	32		194		0	334	117	208	...	9.7	905	281	...	..	....
30-1	81	T.d.	10- 5-50	61	..	....	62	15		73		0	298	39	57	...	12	434	216	0	42	713
36-1	47	T.d.	7- 9-45	...	..	....	146	38		45		0	204	18	226	...	141	870	520	...	..	....
36-2	50	T.d.	7- 9-45	64	..	....	52	12		73		0	356	8	20	...	11	344	180	...	..	....
19N8W- 5	82	T.d.	10- 4-50	...	..	....	85	14		55		0	367	28	32	...	16	444	270	0	31	711
10-1	94	T.d.	10- 5-50	62	..	....	82	21		39		0	239	36	99	...	2.8	460	291	95	23	742
20	48	T.d.	10- 5-50	63	..	....	76	13		50		0	288	25	58	...	10	409	243	7	31	670
27-1	67	T.d.	7-27-51	62	24	.00	76	15	57		3.4	0	272	40	78	.0	12	453	251	28	33	749
34	54	T.d.	10- 5-50	62	..	....	84	15		59		0	309	38	67	...	24	465	271	18	32	752
19N9W-10-1	32	T.d.	4-17-51	61	21	.00	52	11	35		1.9	0	242	13	12	.6	2.0	270	175	0	30	462
11	27	T.d.	10- 4-50	...	..	....	51	12		16		0	203	13	37	...	5.8	282	202	35	15	466
15-1	45	T.d.	10- 6-50	62	21	.00	68	17	73		3.0	0	327	59	46	.3	.5	439	240	0	39	727
20N8W-23	104	R.b.	12-13-50	...	..	....	44	20		19		0	228	16	6	...	26	242	192	5	18	424
20N9W- 3-1	32	T.d.	6- 7-50	64	..	....	111	34		65		0	397	47	122	...	15	635	417	92	25	1,070
6-1	67	T.d.	6- 7-50	62	..	....	74	16		33		0	306	24	15	...	32	360	250	0	22	597
6-2	67	T.d.	1-16-51	62	..	....	95	23		42		0	366	24	66	...	5.8	472	332	32	22	778
25	86	T.d.	6- 7-50	64	..	....	32	7.6		33		0	178	8.6	19	...	1.0	211	111	0	39	342
28-1	45	T.d.	6- 7-50	64	..	....	52	12		23		0	232	9.1	13	...	13	257	179	0	22	428
20N10W- 3-1	21	T.d.	6- 7-50	62	..	....	70	18		31		0	314	1.3	39	...	2.3	337	249	0	21	596
12-3	60	T.d.	1-16-51	62	..	....	90	22		42		0	358	27	58	...	3.7	427	315	22	22	729
12-4	55	T.d.	1-16-51	62	..	....	95	25		36		0	359	21	69	...	5.5	471	340	46	19	774
12-5	52	T.d.	1-16-51	62	..	....	57	18		74		0	374	17	36	...	1.3	404	216	0	43	677
13-1	33	A.	6- 7-50	59	..	....	62	21		51		0	316	12	56	...	1.4	360	241	0	31	647
21N7W-23-1	52	R.b.	12-13-50	...	26	.00	298	66	194		8.8	0	259	1,030	111	.5	5.0	1,960	1,020	803	29	2,350
21N8W-19-2*	122	T.d.,R.b.	11- -49	...	..	....	42	30		191		0	255	63	260	.3	2.5	746	228	19	65	1,320
19-3	180	R.b.	3-14-50	62	15	.00	61	42		327		...	245	210	432	.5	5.5	1,240	324	124	69	2,090
21N9W-20-2	49	T.d.	4-20-51	61	24	.00	70	16	67		3.7	0	338	28	40	.2	25	436	240	0	37	726
24-1	191	R.b.	2-17-50	62	22	.00	63	24	56		2.6	0	272	29	61	.7	40	426	256	33	32	718
28-1	59	T.d.	1-16-51	62	..	....	112	30		42		0	303	38	133	...	24	608	403	154	19	948
29-1	48	T.d.	6- 7-50	62	..	....	56	15		66		0	306	29	27	...	32	397	201	0	42	650
33-1	53	T.d.	6- 7-50	62	..	....	94	26		25		0	286	43	67	...	27	474	342	107	14	767
21N10W- 4-1	55	T.d.	6- 8-50	...	..	....	49	11		39		0	208	15	12	...	60	303	168	0	33	489
5	42	T.d.	6- 9-50	63	..	....	52	12		38		0	238	18	28	...	11	296	179	0	32	500
16-1	39	T.d.	3- 8-51	62	17	.00	62	12	36		.9	0	254	19	22	.1	40	316	204	0	28	543
21-1	14	T.d.	6- 7-50	60	..	....	61	16		17		0	232	18	8.8	...	42	295	218	28	15	479
26	51	T.d.	6- 8-50	...	..	....	76	15		62		0	339	29	42	...	22	430	251	0	35	710
21N11W-12-1	60	T.d.	10- 6-50	62	..	....	81	19		28		0	295	24	46	...	12	396	280	38	18	639
22N8W-18	40	T.d.	12-13-50	...	..	....	89	59		211		0	462	80	270	...	100	1,040	464	86	50	1,760
22N9W-17	80	R.b.	12-15-50	...	..	....	119	44		170		0	748	32	143	...	.1	867	478	0	44	1,510
22N10W-14-1	184	R.b.	12-14-50	...	..	....	254	131		1,320		0	118	1,240	1,880	...	1.7	5,080	1,170	1,080	71	7,700
14-2	206	R.b.	12-14-50	...	..	....	38	41		42		0	291	32	54	...	9.5	367	264	25	26	680
16	43	T.d.	10- 5-50	61	..	....	101	30		12		0	326	25	42	...	60	578	376	108	6	835
22N11W- 8-1	62	T.d.	6-12-50	61	..	....	60	12		22		25	170	13	28	...	16	286	199	18	19	463
14-1	..	T.d.	8- 7-50	...	..	....	54	12		27		0	196	22	30	...	20	282	184	24	24	457
22-1	67	T.d.	8- 7-50	...	..	....	63	12		18		0	226	13	26	...	13	297	206	22	16	485
25-1	61	T.d.	8- 7-50	...	..	....	63	11		22		0	192	19	35	...	30	300	202	45	19	501
32-1	57	T.d.	10- 6-50	61	23	.00	64	12	20		1.8	0	237	16	17	.3	12	279	209	15	17	462
23N12W-14-1	48	R.b.	12-15-50	...	..	....	482	114		1,300		0	117	3,840	260	...	40	6,270	1,670	1,580	63	7,040

*Analyses submitted by Oklahoma Testing Laboratories.

Hardness

Hardness is the characteristic of water that receives the most attention with reference to industrial and domestic use. It is usually recognized by the quantity of soap required to produce lather. Hard water is objectionable because it forms a scale in boilers, water heaters, radiators, and pipes, thereby decreasing the rate of heat transfer and creating the possibility of boiler failure and loss of flow. Hardness is caused almost entirely by compounds of calcium and magnesium. Other constituents such as iron, manganese, aluminum, barium, strontium, and free acid also cause hardness, but they are not usually found in appreciable quantities in most natural waters.

Water having a hardness of less than about 50 parts per million is generally rated as soft, and does not require softening except for special use. Hardness of 50 to 150 parts per million does not seriously interfere with the use of water for most purposes, but it slightly increases the consumption of soap. Therefore, its removal, by a softening process, is profitable for laundries or other industries using large quantities of soap. Water having a hardness in the upper part of this range will cause considerable scale in steam boilers. Hardness above 150 parts per million can be detected by anyone, and in areas where it is above 300 parts per million it is common practice to soften water for household use or to install cisterns for storing soft rain water. Where municipal supplies are softened an attempt is generally made to reduce the hardness to about 80 parts per million.

Water from wells in the terrace deposits of this area is less mineralized than water from the underlying Permian strata and is generally of lower hardness. For example, total hardness, as shown in table 5, ranges from 111 to 541 parts per million in water from the terrace deposits and from 192 to 1,670 parts per million in water from the Permian strata.

Iron

Iron is present in most ground water, but generally only in comparatively small amounts. Water containing more than a few tenths of a part per million iron is objectionable because of its reddish appearance after exposure to the air and because the iron stains fabrics and porcelain or enameled ware. Such water, therefore, may require treatment. Excessive iron may interfere with the efficient operation of exchange-silicate water softeners. None of the 11 analyses that show iron content (table 5) indicate an objectionable quantity.

Sodium and Potassium

Moderate quantities of sodium and potassium have little effect on the suitability of water for most industrial or domestic uses. More than 50 parts per million of the two may cause foaming in steam boilers. If the proportion of sodium salts is excessively high in water used for irrigation, soils and crops may be injured. Water from the terrace deposits generally has less sodium and potassium than water from alluvium or Permian strata.

Carbonate and Bicarbonate

Carbonate and bicarbonate affect the usability of water mainly when they are in combination with other dissolved matter. Bicarbonate is the principal dissolved constituent in most natural water, especially that from limestone aquifers. A high concentration of sodium bicarbonate will cause foaming in boilers.

Sulfate

Sulfate may be dissolved in water passing through gypsum. It also may be formed by the oxidation of the sulfides of lead, zinc, and iron. When combined with calcium and magnesium, sulfate contributes to noncarbonate hardness, and hence to boiler scale and to the cost of softening water. Sulfate in excess of 500 parts per million may have a laxative effect. Only four samples of water contained more than 250 parts per million of sulfate, the suggested limit for drinking water (U. S. Public Health Service, 1946). Three contained more than 1,000 parts per million and were from wells in the red beds; the other contained 272 parts per million and was from a well in the alluvium of Turkey Creek.

Chloride

Chloride combined with sodium is common salt, and both generally are present in ground water. Chloride in small amounts has little effect on the usefulness of water, but concentrations of 300 parts per million and more give water a salty taste perceptible to most people, and therefore undesirable for domestic use. Heavy concentrations of chloride may impart corrosiveness to water, requiring frequent replacement of water pipe or measures to prevent corrosion, such as the lining of pipe with a noncorroding material. Two analyses of water from the terrace deposits, three from the red beds, three from the red beds and the terrace deposits, and one from the alluvium show a chloride content greater than 250 parts per million, the suggested limit.

Fluoride

The principal effect of fluoride in water is on the dental health of children, and it is beneficial or detrimental according to the concentration. In concentrations of about 1.0 part per million, fluoride is believed by many health authorities to lessen tooth decay, but in higher concentrations it may contribute to a permanent dental defect known as mottled enamel, which appears in teeth in the formative stage, that is, in the teeth of children up to about 12 years of age.

Of the analyses given in table 5, only 12 determinations of fluoride were made. The highest concentration of fluoride was only 0.7 ppm.

Nitrate

Nitrate in water is considered a final oxidation product of nitrogenous material and, in some instances, may indicate previous contamination by sewage or other organic matter. It has been reported that as much as 2 parts per million of nitrate in boiler water tends to decrease intercrystalline cracking of boiler steel.

Water containing an excessive amount of nitrate has been suspected of causing a form of cyanosis ("blue baby") (Waring, F. H., 1949, p. 147) when used in the preparation of formulas for feeding infants. The Oklahoma State Health Department now considers water containing less than 10 parts per million nitrate nitrogen (approximately 45 parts per million when reported as nitrate) as safe for use.

Of the analyses in table 5, nine show a nitrate content of more than 45 parts per million and 24 of more than 20 parts per million. No attempt was made to discover if any cases of cyanosis have been reported from the area but the possibility that such cases may occur should be recognized.

The origin of the nitrates has not been determined. Possibly some of the relatively high figures for nitrate content can be explained by pollution or by infiltration from commercial fertilizer, but such reasoning cannot explain all the high figures. George and Hastings (1951, p. 456) in a study of more than 20,000 determinations of nitrate content in water from wells in Texas concluded that the presence of "abnormal nitrates" (more than 20 ppm) does not appear to be related to rainfall, geography, cultivation, or the kind or age of the reservoir rocks.

Hydrogen-ion Concentration (pH)

The degree of acidity or alkalinity of water is indicated by the hydrogen-ion concentration and is expressed as pH. A pH of 7.0 indicates that the water is neutral, being neither acid nor alkaline. Figures progressively lower than 7.0 indicate increasing acidity whereas those progressively higher than 7.0 indicate increasing alkalinity. As the pH increases the corrosive activity of the water decreases. The pH of eight samples of water from wells that obtain water from the terrace deposits in this area ranged from 7.1 to 7.8, and the pH of two samples from wells that obtain water from the Permian bedrock were 7.7. These 10 samples were the only ones for which pH was determined.

Suitability for Drinking

Standards by which to judge the suitability of water for drinking have been established by the U. S. Public Health Service (1946, pp. 382-383). They indicate the maximum concentration of certain constituents, in parts per million, that is acceptable for water in interstate traffic. Among the constituents included in table 5, six are considered significant and the maximum limits for them are given below.

Constituent	Parts per million
Magnesium (Mg)............................	125
Chloride (Cl).............................	250
Sulfate (SO_4)............................	250
Fluoride (F)..............................	1.5
Dissolved solids..........................	500 (1,000 acceptable)
Iron and manganese together...............	0.3

By the above standards, all but 10 of the analyses given in table 5 show the water to be satisfactory for drinking. Of the 10 unsatisfactory waters, 4 were from wells tapping the Permian bedrock, 3 from wells tapping both the Permian bedrock and the terrace deposits, 2 from wells tapping the terrace deposits, and 1 from a well tapping the alluvium of Turkey Creek.

Suitability for Irrigation

Whether a water is satisfactory for irrigation depends on several factors in addition to the mineral content of the water, among them the amount of water applied to the soil, the precipitation, the drainage, and the physical and chemical characteristics of the soil. This subject is discussed by Smith (1942, pp. 16-18). The total amount of dissolved mineral matter, and the percent of sodium in the water suggest whether a water may be used satisfactorily in irrigation. Figure 5 affords a graphical method of appraising a water. If plotted on this figure, the analyses representing water from the terrace deposits fall either in the "excellent to good" area or in the "good to permissible" area.

The importance of adequate soil drainage was pointed out by Magistad and Christiansen (1944), who stated: "Soil salinity may be handled by the farmer on an account basis. Salt in the irrigation water is sometimes added at rates as high as 2 tons to 1 acre-foot. It is removed primarily by the drainage water. If the additions exceed the losses, salt is accumulating in the soil. The losses are difficult to measure, but in a few small areas with tile drains this has been done. In general, the conception of a salt balance is beneficial because it so clearly demonstrates the need for drainage. The place of some particular salts or ions in such a balance sheet has not been determined. For instance, a considerable proportion of the calcium entering a soil in the irrigation water may precipitate as calcium carbonate, which is

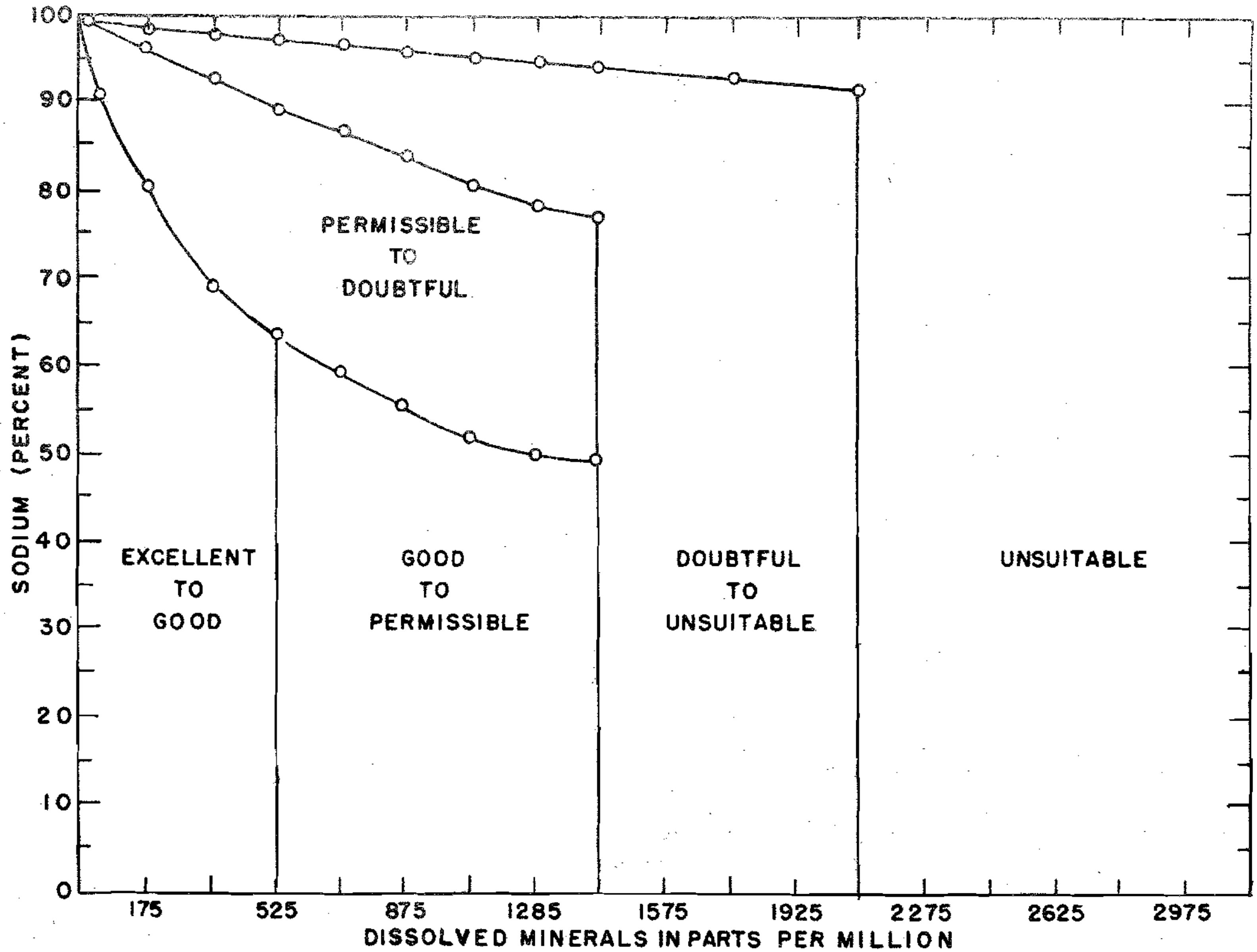


Figure 5.--Diagram for interpreting analyses of irrigation water (after Wilcox, L. V., 1948; modifications by T. B. Dover, U. S. Geol. Survey).

almost inert so far as salinity is concerned. Some calcium and sulfate is precipitated as calcium sulfate, which is only partly soluble. Actually, a salt that is precipitated is removed almost as effectively as though it disappeared with the drainage water."

Test Drilling

Information on the thickness and lithology of the terrace deposits is available from 280 test holes that have been drilled in the area of this report. The test holes were drilled for the cities of Enid, Hennessey, and Fairview, and the town of Ames. In addition, 66 test holes were drilled for this investigation.

City of Enid

Since October 1944 the city of Enid has had 204 test holes drilled in the area of this investigation, in five different projects, the first and largest being the drilling of 152 test holes between October 1944 and February 1946. This drilling was done with a rotary drilling machine owned by the city of Enid and was supervised by E. T. Archer & Co., Consulting Engineers.

The 152 test holes, aggregating 5,900 feet, were drilled within an area of 194 square miles extending southeast from Aline, in sec. 35, T. 24 N., R. 12 W., to the NE cor. sec. 10, T. 19 N., R. 9 W. The depth to bedrock ranged from 3 to 81 feet and averaged 38.8 feet. At 27 locations none of the terrace material was saturated. The average saturated thickness in 125 holes was 12.0 feet, and the maximum was 35 feet. The engineers classed 42 of the test sites as favorable and concluded that 27.5 percent of the area is underlain by good water-bearing material.

In November 1949 the city had 10 test holes drilled west of Drummond to investigate the possibility of developing a water supply from some aquifer beneath the terrace deposits. These holes ranged in depth from 40 to 150 feet and averaged 109 feet. Sandstones ranging in thickness from 10 to 30 feet and averaging 19 feet were penetrated in 7 of the 10 holes. No correlation of these sandstones was possible from one location to another, and they are interpreted as lenses in the shale. Their value as aquifers is doubtful. It is believed that these wells obtain most of their water from crevices and solution cavities in the bedrock.

Toward the end of January 1950, the city employed the Layne-Western Co. of Wichita, Kans., to drill 21 additional test holes in the same locality, under the direction of E. T. Archer & Co. The purpose was further appraisal of the ground-water supply in the Permian bedrock. A truck-mounted rotary drilling machine was used, and engineers of the U. S. Geological Survey and the Oklahoma Planning and Resources Board observed the work and sampled the drill cuttings. Wells were constructed at 3 of the 7 locations tested and 14 holes were drilled as observation wells adjacent to these 3 wells. The terrace deposits ranged in thickness from 35 to 67 feet and averaged 48.? feet; they are mostly fine-grained sediments unlikely to yield water in large quantities. No sandstone was encountered in the bedrock in any of the holes; but many crevices and solution channel were encountered and these doubtless account for the permeability of the rock.

In June 1950 the Layne-Western Co. was employed by the city for further testing under the direction of E. . Archer & Co., this time in the terrace deposits. A truck-mounted rotary machine was used for the drilling of three test holes ranging from 6 75 feet in depth and averaging 66 feet. An engineer of the Oklahoma Planning and Resources Board collected samples of the drill cuttings which were examined microscopically in the laboratory.

In July 1950 the city had 18 test holes drilled in the terrace deposits along the St. Louis & San Francisco Railway right-of-way southwest of the SE¼ sec. ?, T. 21 N., R. 9 W. In them the thickness of the terrace deposits ranged from 20 to 85 feet and averaged 53.6 feet. In one test hole no saturated terrace deposit was found. In the other 17 holes, the saturated zone ranged up to 39.5 feet in thickness and averaged 23 feet.

Town of Ames

In April 19 the town of Ames, with the cooperation of the George E. Failing Supply Co. of Enid, drilled seven test holes within the town limits to explore possibilities for a municipal water supply. A truck-mounted rotary drilling machine was used. The depth to bedrock ranged from 37 to 51 feet and averaged 4 feet. The thickness of gravel and coarse sand ranged from 3 to 21 feet and averaged 12. feet. Although some water-bearing material was encountered in each hole, the arrangement and thickness differed greatly from place to place

City of Hennessey

In June 1948 the city of Hennessey had 17 test holes drilled under the supervision of Hudgins, Thompson, Ball, & Associates, of Oklahoma City. The area tested is 2 to 5 miles south of Hennessey on either side of U. S. Highway 81, and totals about 7 square miles. The 17 holes ranged in depth from 3 to 66 feet and averaged 5 feet. They demonstrated lack of uniformity in both lithology and thickness of the terrace deposits. About 63 percent of the terrace material in the holes was sand, and about percent of the sand was reported as coarse. The layers of sand were not uniform in thickness, but ranged from to 67 feet. It is estimated that 63 percent of all the sand and 98 percent of the coarse sand is below the water table.

City of Fairview

In 1947 the city of Fairview had 52 test holes drilled under the supervision of Alexander & Pollard, consulting engineers, in T 22 N., Rs 11 and 12 W. These holes penetrated terrace deposits and reached bedrock at depths ranging from 21 to 73 feet and averaging 44 6 feet. In some, no water-bearing beds were penetrated. In the others a maximum thickness of 35 feet of water-bearing beds was found and the average was 16.4 feet. Of the total of 780 feet of water-bearing material penetrated 244 feet (31 percent) was gravel and coarse sand.

This Investigation

As part of the cooperative investigation by the Geological Survey and the Oklahoma Planning and Resources Board, 66 test holes were drilled in June and July 1950 under an arrangement between The Board and the George E. Failing Supply Co. of Enid. The area tested lies between sec 27, T. 18 N R. 7 W., and sec T. 23 N., R. 11 W. The test sites were those for which well logs from other sources were not available, and all were within the area of dune topography. A truck-mounted rotary hydraulic machine was used for drilling holes about 4 inches in diameter and drill cuttings were collected by hand from the shallow ditch between test hole and slush pit. Logs were written on the spot, and then were revised after microscopic examination of the cuttings. The logs of these test holes given in appendix B therefore are composites of field and laboratory observations. The test holes penetrated the terrace deposit and bedrock was encountered at depths ranging from to 120 feet and averaging 59 feet. About 42 percent of the saturated sediment sand and gravel, and about 15 percent of the saturated sediments were classified as gravel or coarse sand that should be highly permeable.

Aquifer-Performance Tests

The amount of water a well will yield depends on the hydraulic properties of the aquifer. The coefficient of transmissibility is defined as the rate of flow of water in gallons per day through a vertical strip of the aquifer 1 foot wide and extending the full saturated height, under a hydraulic gradient of 100 percent at a temperature of 60° F. The coefficient of storage is the volume of water yielded from storage in each vertical column of the aquifer and associated beds having a base 1 foot square as the water level drops 1 foot. These coefficients can be determined directly from aquifer-performance tests. For this investigation three tests were made on wells tapping water in the Permian bedrock and nine on wells obtaining water from the terrace deposits. The tests were analyzed by methods in general use by the U S Geological Survey.

Wells in Permian Bedrock

Aquifer-performance tests were made on three wells that obtain water from Permian strata. All were drilled as public-supply wells for the city of Enid.

On February 17, 1950, a 5-hour aquifer-performance test was made on Enid well 21N9W-24-1; on March 13 and 14, 1950, a 24-hour test was conducted on Enid well 21N8W-19-3; and on March 18, 1950, a 10-hour test was made on Enid well 21N9W-22-1. Measurements of discharge in wells 21N9W-24-1 and 21N8W-19-3 were made at regular intervals by taking piezometric readings on the discharge pipes, but in well 21N9W-22-1 they were made by noting the time needed to fill a 5-gallon container. Water-level measurements in adjacent wells were made at frequent intervals during the tests. Small samples of water for preliminary analysis were taken at regular intervals to determine if any change in chemical character occurred as pumping continued; 1-gallon samples for routine chemical analysis were taken from wells 21N9W-24-1 and 21N8W-19-3 just before pumping stopped. The analyses of the 1-gallon samples are given in table 5. For the tests each discharge well was equipped with a turbine pump powered by a gasoline engine.

City of Enid Well 21N9W-24-1

City of Enid well 21N9W-24-1 had been drilled by rotary-hydraulic methods to a depth of 195 feet. It was cased with 16-inch steel casing to a depth of 20 feet and with 12-inch steel casing from the surface to 191 feet. On the basis of an electric log made by the Schlumberger Well Surveying Corp., the 12-inch casing was slotted by cutting torch at depths of 95-105 feet, 130-140 feet, and 150-190 feet. The well was pumped at an average rate of 172 gallons per minute. For observations of water-level fluctuations, two wells, both 190 feet deep, were drilled at distances of 30 and 141 feet northeast of the pumped well, and were in a straight line passing northeast and southwest through the pumped well. They were cased with 2-inch steel casing in which slots were cut at depths comparable to those of the slotted sections of casing in the pumped well. A third well, 20 feet deep, was drilled 35 feet northeast of the pumped well. In it the casing was slotted at a depth of 15-20 feet. This well tapped only the terrace deposits and water levels in it were observed in order to ascertain whether ground water leaked from the terrace deposits down into the bedrock during the test.

City of Enid Well 21N8W-19-3

City of Enid well 21N8W-19-3 was drilled to a depth of 180 feet. It was cased through the terrace deposits with 16-inch steel casing. From the surface to a depth of 160 feet it was cased with 12-inch steel casing, and below that, with 20 feet of galvanized iron screen. This well was pumped at an average rate of 200 gallons per minute. For measurement of ground-water levels in the vicinity, four observation wells were drilled. Two of these, 180 feet deep, were, respectively, 42 and 116 feet southeast of, and in line with, the pumped well, and were cased with 2-inch steel casing slotted opposite the aquifer. The other two, 20 feet deep, were, respectively, 35 feet northwest and 35 feet southeast of the pumped well, and were cased with 2-inch steel casing, the lower part of which was slotted. These two wells tapped only the terrace deposits, and water levels in them were measured to ascertain whether ground water leaked from the terrace deposits down into the bedrock during the test.

City of Enid Well 21N9W-22-5

City of Enid well 21N9W-22-5 was drilled to a depth of 184 feet. It was cased through the terrace deposits and 5 feet into the bedrock--a depth of 40 feet--with 36-inch steel casing. From the surface to a depth of 184 feet it was cased with 12-inch steel casing. On the basis of an electric log made by the Schlumberger Well Surveying Corp., the 12-inch casing was screened at depths of 93-103 feet, 118-128 feet, and 152-182 feet. This well was pumped at rates ranging from 50 to 150 gallons per minute. For observation of water levels in the vicinity, three observation wells were drilled at distances of 40, 60, and 120 feet southeast of the pumped well, to depths of 178, 31, and 171 feet, respectively. Each was cased with 2-inch steel casing slotted opposite the aquifer. The well 31 feet deep tapped only the terrace deposits and served as a check on possible leakage from the terrace deposits down into the bedrock. The two deep wells were in a straight line passing southeast and northwest through the pumped well.

Wells in Terrace Deposits

Aquifer-performance tests were made on nine wells that obtained water from the terrace deposits. Four of these were public-supply wells used by the city of Enid and five were privately owned wells.

Public-Supply Wells

In the winter of 1950-51 aquifer-performance tests were made on four public-supply wells of the city of Enid, all of which penetrate the terrace deposits to the underlying bedrock. All are 12 inches in diameter and are gravel-packed; they range in depth from 52 to 65 feet. All but one were drilled by the reverse-hydraulic rotary method; well 21N9W-28-1 was bored to the water table and then was deepened to bedrock with an orange-peel bucket.

The wells were pumped from November 24, 1950 to January 16, 1951, with short interruptions for minor repairs. They discharged into a main line leading to the Enid reservoir near Ames, and were equipped with meters for measuring the water pumped. Drawdown measurements in the observation wells were made daily, to the nearest 0.5 inch, by an employee of the Enid Water Department, and intermittently, to the nearest 0.01 foot, by an employee of either the Oklahoma Planning and Resources Board or the U. S. Geological Survey. At the end of 54 days the pumped wells were shut off one at a time in order that measurements of water level could be made in the adjacent observation wells at frequent intervals in the period immediately following the shutdown when the recovery of levels was most rapid. As the rate of recovery of water levels decreased, the intervals between measurements were lengthened. In this manner, three men were able to make sufficient measurements of water level to define accurately the recoveries in all the observation wells. A 1-liter sample of water, for chemical analysis, was taken from each pumped well shortly before pumping stopped.

City of Enid Well 21N9W-20-1

Well 21N9W-20-1 was 59 feet deep and was equipped with a turbine pump powered by a $7\frac{1}{2}$-horsepower electric motor. Observation wells were 31 feet southwest and 250 feet northeast of the pumped well. The nearer well was 63 feet deep and had steel casing 2 inches in diameter; the other was 59 feet deep and had steel casing 2 inches in diameter.

City of Enid Well 20N10W-12-3

Well 20N10W-12-3 was 60 feet deep and was equipped with a turbine pump powered by a 15-horsepower electric motor. Observation wells were 50 and 250 feet southwest of the pumped well. The nearer well was 60 feet deep and had steel casing 6 inches in diameter; the other was 53 feet deep and had steel casing 2 inches in diameter.

City of Enid Well 20N10W-12-5

Well 20N10W-12-5 was 52 feet deep and was equipped with a turbine pump powered by a $7\frac{1}{2}$-horsepower electric motor. Observation wells were 50 and 250 feet northeast of the pumped well. The nearer well was 50 feet deep and had steel casing 6 inches in diameter, the other was 52 feet deep and had steel casing 2 inches in diameter.

City of Enid Well 20N9W-6-2

Well 20N9W-6-2 was 67 feet deep and was equipped with a turbine pump powered by a 25-horsepower electric motor. Observation wells were 50 and 250 feet southwest of the pumped well. The nearer well was 65 feet deep and had steel casing 6 inches in diameter; the other was 60 feet deep and had steel casing 2 inches in diameter.

Privately Owned Wells

Aquifer-performance tests were made in 1950 and 1951 on five privately owned wells, which ranged in depth from 52 to 67 feet. All except the Woods well penetrated the terrace deposits to the underlying bedrock, and all were gravel-packed. Measurements of water level were made in these wells and in nearby observation wells at frequent intervals. Of the five wells tested, two (Kennedy and Watson) were used for irrigation in 1950. The other three had been tested on completion but had not been put into regular service.

V. I. Cooper Well 20N9W-5-6

On July 25 and 26, 1950, an aquifer-performance test was made on the V. I. Cooper well (20N9W-5-6). The well was 55 feet deep and 24 inches in diameter; a gravel envelope 30 inches in outside diameter surrounded the casing, which was concrete with 7 feet of concrete screen at the bottom. The pump used for the test was the mud pump of a rotary-hydraulic drilling machine. It was attached to a jet by a $1\frac{1}{2}$-inch-diameter steel pipe and the well discharged into a canvas tank. The pump drew water from this tank, recycling it through the jet. The overflow from the tank was the water actually withdrawn and was measured by a triangular weir placed in a ditch dug to carry the overflow to the drainage ditch along the road.

For observation of ground-water levels near the well, six other wells were provided. These were in a straight north-south line passing through the pumped well, three on each side at distances of 10, 30, and 60 feet. They were about 55 feet deep and consisted of $1\frac{1}{4}$-inch iron pipe with sand points 24 inches long at the bottom.

The well was pumped for 19 hours at an average rate of 37 gallons per minute, and discharge measurements were made at frequent intervals. Samples of water for chemical analysis were taken at regular intervals.

J. J. Kennedy Well 21N10W-16-1

On March 7 and 8, 1951, an aquifer-performance test was conducted on the J. J. Kennedy well (21N10W-16-1). The well was 39 feet deep and had steel casing 10 inches in diameter, which was slotted with a cutting torch to provide openings for the water to enter. The well was equipped with a turbine pump powered by a gasoline engine, and the water was discharged through about 400 feet of aluminum pipe, 4 inches in diameter, into the drainage ditch along the road. Discharge was measured by noting the time necessary for a certain volume of water to be discharged into a tank 42 inches in diameter.

For observation of ground-water levels in the vicinity of the pumped well, six wells consisting of $1\frac{1}{4}$-inch iron pipe with well points 18 inches long were provided. These were in a straight line passing north and south through the pumped well, three on each side at distances of 100, 200, and 300 feet. The northernmost well was 41 feet deep and each of the others was 31 feet deep.

The well was pumped for 20 hours at an average rate of 154 gallons per minute, and the discharge measured at 30-minute intervals. Small samples of water for preliminary analysis were taken at intervals, and a 1-gallon sample for routine chemical analysis was taken just before the pump was stopped.

. V Sturgeon Well 19N9W-10-1

On April 16 and 17, 1951, an aquifer-performance test was conducted on the R V Sturgeon well (19N9W-10-1) The well was 32 feet deep and had a steel casing 15 inches in diameter which was perforated opposite the water-bearing sand. For the test the well was equipped with a turbine pump powered by a gasoline engine. The water was discharged into a ditch and formed a pool about 00 feet southeast of the well. Discharge was measured by noting the time necessary t l a -gallon bucket.

For observation of ground-water levels in the vicinity of the pumped well, six wells consisting of $1\frac{1}{4}$-inch iron pipe with well points 18 inches long were provided. These were in a straight line passing north and south through the pumped well. e on each side at distances of 40, 100, and 180 feet. The depths of the wells from north to south were 31, 36, 31, 31, 21 and 21 feet respectively.

The well was pumped 24 hours at an average rate of 71 gallons a minute. Discharge measurements were made at regular intervals, and samples of water for chemical analysis were taken periodically.

Ned Woods Well 21N9W-20-2

On April 19 and 20, 1951, an aquifer-performance test was made on the Ned Woods well (21N9W-20-2) The well was 52 feet deep and had a concrete casing 24 inches in diameter and a concrete screen. For the test the well was equipped with a turbine pump powered by gasoline engine. Water was discharged into a drainage ditch along the road and measurements of discharge were made by piezometric readings on the discharge pipe.

For observation of ground-water levels in the vicinity of the pumped well, five wells consisting of $1\frac{1}{4}$-inch iron pipe with well points 18 inches long were provided These were in a straight line at distances of 50,25, and 10 feet west and 1 and 25 feet east of the pumped well. The depths of the observation wells, from west to east, were 55, 52, 51 92, and 55 feet respectively.

The well was pumped $22\frac{1}{2}$ hours at an average rate of 84 gallons per minute. Discharge measurement were made at regular intervals, and samples of water for chemical analysis were taken periodically.

L. G. Watson Well 19N8W-27-1

On Ju 27 and 28 1951, an aquifer-performance test was made on the L. G. Watson well 19N8W- 7-1). The well was 67 feet deep and had a steel casing 1 inches in diameter, perforated through the bottom 15 feet. It was equipped with a turbine pump powered by a butane engine. The well was being used for irrigation during the test and discharged into a 6-inch main line that supplied laterals and irrigated 20 acres by sprinkling Discharge was measured by averaging the time required to fill a 3-gallon bucket from the end sprinklers on each lateral, and multiplying by the number of sprinklers. This procedure was the most feasible under the circumstances, but the results are probably only an approximation, especially as a considerable quantity of water was lost by leakage at the joints along more than three-quarters of a mile of main line and laterals.

For observation of ground-water levels in the vicinity of the pumped well, six wells consisting of 1¼-inch iron pipe with well points 18 inches long were provided. The observation wells were drilled in a straight line at distances of 200, 100, and 10 feet west and 100, 150, and 200 feet east of the pumped well. The depths of the observation wells from west to east were 63, 62, 71, 63, 62, and 54 feet.

The well was pumped for 24 hours at an approximate rate of 600 gallons per minute. Samples of water for chemical analysis were taken at intervals throughout the test.

Interpretation of Aquifer-Performance Tests

The drawdowns measured in the observation wells were analyzed by the generalized graphical method of Cooper and Jacob (1946, pp. 527, 528). Coefficients of transmissibility and storage were determined for each test and are sumarized in the following table.

Table 6.--Summary of results of aquifer-performance tests

Well no.	Coefficient of transmissibility (gdp/ft)	Coefficient of storage
21N9W-28-1	31,000	0.131
20N9W-6-2	43,000	.051
20N10W-12-3	15,000	.083
20N10W-12-5	12,000	.064
19N8W-27-1	60,000	.018
20N9W-5-6	6,000	.040
19N9W-10-1	29,000	.056
21N9W-20-2	52,000	.022
21N10W-16-1	76,000	.116
Average	36,000	.065

Wells in Permian Strata

Aquifer-performance tests were made on three wells obtaining water from the bedrock, but they do not provide reliable coefficients of transmissibility and storage. As the water occurs in crevices, the aquifer is not homogeneous throughout and therefore one of the conditions assumed by the formula is not met. Furthermore, in the test made on well 21N9W-24-1 there was leakage of water from the overlying terrace deposits, as shown by the drawdown of water level in the observation well tapping the terrace deposits 35 feet northeast of the pumped well. The second test (well 21N8W-19-3) did not show such leakage, but the well had not been developed to its full capacity before the test began. There were surges of muddy water and correspondingly reduced declines or even rises of water level in the observation wells. The third test, on well 21N9W-22-, was completely unsatisfactory. The pumping rate was low and uneven, and the drawdown was high.

Wells that will yield sufficient water of satisfactory quality for municipal or irrigation use can be developed in the Permian bedrock. Good well sites can be found best by test drilling. The effect of pumping such wells can be determined by maintaining records of their discharge for comparison with fluctuations of water level in other wells nearby.

Wells in the Terrace Deposits

Table 6 shows that both transmissibility and storage coefficients differ considerably from well to well. The coefficients of transmissibility range from 6,000 to 76,000 gallons per day per foot and average 36,000 gallons per day per foot. The coefficients of storage range from 0.018 to 0.131 and average 0.065. Such large differences are to be expected in an aquifer having large differences in thickness and lithology. Clearly the coefficients based on these tests should be used with careful regard for their applicability, if improper design of wells is to be avoided. In large-scale development of the aquifer, performance tests in each well could lead to accurate figures for the average coefficients of transmissibility and storage, which in turn would permit selection of the most favorable pumping rates.

The wells tested by pumping were in some of the more favorable locations. Some of the sites had been selected by test drilling; others may have been selected without information on subsurface conditions but they also proved favorable. Thus the average figure for the coefficient of transmissibility as determined in the pumping tests may be too high. If aquifer-performance tests were made at sites uniformly distributed over the area--at intervals of 1 or 2 miles, as are the test holes--they undoubtedly would reveal coefficients of transmissibility both higher and lower than those obtained in this investigation, but the average would probably be lower. For this reason, a figure of 20,000 gallons per day per foot has been adopted as an acceptable average coeff[illegible]ient of transmiss[illegible]bility for use in computat[illegible]ons appl[illegible]able to the area as a whole. It is believed to be co[illegible]servativ[illegible]. Computations based on it should, therefore, have [illegible] factor of safe[illegible]y.

The coefficie[illegible]ts of storage given in [illegible]able 6 are prob[illegible]bly too low because pump[illegible]g periods were short ex[illegible]ept in test in the [illegible] wells. In the shorte[illegible] tests complete drainage of the [illegible]nitial[illegible]y sat[illegible]ra[illegible]ed se[illegible]ime[illegible]ts withi[illegible] the cone of depre[illegible]s[illegible]on was n[illegible] possible be[illegible]ore pumping s[illegible]oppe[illegible] and the r[illegible]overy of the wat[illegible]r le[illegible]e[illegible] bega[illegible]. F[illegible]r example, [illegible] 1942, p. 135) [illegible]tates that the spe[illegible]fic [illegible]ield (coeff[illegible]cient of [illegible]torage) [illegible] det[illegible]rmined from a 24-hour pum[illegible]ing t[illegible]st on an ir[illegible]igatio[illegible] well near Gothenbu[illegible]g, Nebr., was only 16 per[illegible] of the specific y[illegible]eld determined in labora[illegible]ory te[illegible]t[illegible] of the same ma[illegible]erial, where drainage was [illegible]omplete.

The per[illegible]od of pum[illegible]ing in the [illegible]e[illegible]ts in the Enid wells was ap[illegible]roxi-mately 51 days and the coeffic[illegible]en[illegible]s of stor[illegible]ge der[illegible]ved f[illegible]om these tests shoul[illegible] be close[illegible] to the true figu[illegible]e than any others. They average 0.082. Even [illegible] figure may be [illegible]omewhat too low because [illegible]i[illegible]h one exception th[illegible] we[illegible]l[illegible] are where [illegible]h[illegible] water t[illegible]b[illegible]e is in f[illegible]ne-grained sand, silt, [illegible]r clay. Th[illegible] only mate[illegible][illegible]ls that [illegible] drained of the[illegible] water were these [illegible]-grained mat[illegible]rials, and the coefficients of st[illegible]rage apply to the[illegible], not [illegible] the coarse sand and gravels that yield most of the wat[illegible]r pumped from t[illegible] wells. I[illegible] is [illegible]oncluded, therefore, th[illegible]t a figure of 10 percent may fairly represent the coe[illegible]f[illegible]ient [illegible]f st[illegible]rage in the upper part of the te[illegible]ce depos[illegible]ts within [illegible]h[illegible] range of fluct[illegible]at[illegible]ons of the water table and within the normal range of drawdowns in the r[illegible]ck[illegible] sur-rounding pumping wells, but that 15 per[illegible]e[illegible]t may be a more rea[illegible]onable f[illegible]g[illegible]re for the entire thi[illegible]kness of water-bearing material.

Expectable Yields

Because the water-bearing materials of the terrace deposits differ in lithology and thickne[illegible]s [illegible]rom place to place, the yields from wells will differ considerab[illegible]y. The high[illegible]st yield reported in t[illegible] area is from L. C. Watson's irrig[illegible]tion well (19N8W-27-1). It yie[illegible]ded approxi-mately 600 gallons per minute durin[illegible] an aqu[illegible]fer-performance test on July 27 and 28, 19[illegible]1. Drawdown in t[illegible]e well was about 13 fee[illegible] after 24 hours of pumping. The map showing c[illegible]ntours on the bedro[illegible]k (pl. 1) shows this well to be in a buried [illegible]hannel although [illegible]ot in [illegible]he deepest part. Several test holes in the same l[illegible]cality p[illegible]net[illegible]ate th[illegible]ck[illegible]r water-bearing materials a[illegible]d more gr[illegible]vel [illegible]han was [illegible]ound in the Watson well. Properly constru[illegible]ted we[illegible]ls a[illegible] the[illegible]e more favo[illegible]able loc[illegible]t[illegible]ons would undoubtedly yield more than 600 [illegible]allons pe[illegible] minute, perh[illegible]ps as much as 1.000 gallons per minute. We[illegible]ls with [illegible]uch y[illegible]elds wo[illegible]ld be the except[illegible]on[illegible] of course, r[illegible]he[illegible] than the rule, but yie[illegible]ds [illegible] 100 to 300 gallons per minute are probable in most of the area of water-bearing terrace deposits.

Ef[illegible]luent seepage [illegible]rom the te[illegible]race deposits into streams has considerably lowered the w[illegible]ter table locally and there[illegible]y has reduced the thickness of water-bearing material. Near such streams, therefore, only small yields may be obtained from wells. The same is probably true of areas in the Cimarron Valley along the boundary between the terrace deposits and Cimarron River alluvium. A notable exception is an area in the Cimarron Valley south of Ringwood. Here the Permian bedrock crops out above the alluvial bottoms at an unusally high altitude, higher than the surface of the bedrock to the north and east. It constitutes an impermeable ridge or dam, and obstructs the southwestward movement of ground water in the terrace deposits. Water backs up behind it and spills over or around the ends. The bedrock surface behind the "dam" has been channeled deeply and contains a thick deposit of terrace materials, especially promising for the development of wells with high yields. The highest coefficient of transmissibility in the entire area was obtained in a test of the Kennedy irrigation well (21N10W-16-1), which is in this channel.

Ground-Water Storage

Although ground water moves from areas of recharge to areas of discharge, the movement is very slow--less than 1 foot a day on the average. Consequently, the water-bearing rocks may be regarded as a huge underground reservoir.

The amount of stored water depends on the thickness and extent of the saturated material and on its porosity. Some of the water is held by molecular attraction and so may be considered as permanently stored. It will not drain out, and it is not included in computing the coefficient of storage, which is a measure of the amount of stored water that, theoretically, can be recovered by pumping from wells. From the Aquifer-performance tests it was concluded that 15 percent is a reasonable figure for the coefficient of storage of the entire thickness of saturated materials in this area.

The average thickness of water-bearing material penetrated by the test holes is 24.65 feet. On the basis of the foregoing assumptions, the amount of ground water stored per acre equals 24.65 x 0.15, or 3.7 acre-feet, and the total stored in the 350 square miles of terrace deposits is about 830,000 acre-feet, or more than 270 billion gallons. The amount stored per acre differs greatly from locality to locality because of differences in the thickness of the water-bearing material. For example, the average thickness of the water-bearing material in T. 19 N., R. 8 W., is 61.8 feet and the ground water in storage is estimated to be 9.27 acre-feet per acre.

Under actual conditions the quantity of water stored in the terrace deposits will vary with the fluctuations of the water table. Not all the stored water can be recovered by pumping from wells, but the large amount of water stored in the terrace deposits, especially in the more favored localities, means that pumping could be continued through periods of protracted drought. Here as elsewhere, however, pumping cannot exceed the average annual rate of replenishment indefinitely.

Effect of Pumping on the Water Table

When a well is pumped the hydraulic head in the well is lowered, a hydraulic gradient is set up toward the well from all sides, and water flows into the well. The water table around the well assumes a shape somewhat like an inverted cone, which is called the cone of depression.

As pumping continues, the cone of depression expands and water from progressively greater distances percolates toward the well. If no recharge occurs, the cone will continue to expand, at a decreasing rate, until the limits of the formation are reached, or until the water level in the well approaches the bottom of the formation. Recharge to the formation may halt the development of the cone of depression. If the rate of discharge is less than the capacity of the aquifer and if a well is pumped continuously at a constant rate, the cone of depression around the well will reach a state of dynamic equilibrium. The cone then will expand during dry periods and shrink during periods of recharge

The shape and size of the cone of depression around a well being pumped depends on the rate and duration of pumping, the hydraulic properties of the aquifer, the extent of the aquifer, and the amount of recharge. The lowering of the water table at any point within the cone of depression is directly proportional to the rate of pumping. That is, other conditions being the same, the drawdown at a certain distance from a well being pumped at 200 gallons per minute will be twice the drawdown caused by a pumping rate of 100 gallons per minute. Similarly, the drawdown at any point within the cone of depression will increase with further pumping until a condition of equilibrium is reached.

The coefficient of transmissibility governs the depth of the cone of depression in relation to the diameter of the base of the cone. If the coefficient is low the hydraulic gradient will be relatively steep and the cone will be deep but not broad. If the coefficient is high the cone will be broad but shallow (pl. 8).

The coefficient of storage is related to the volume of water withdrawn from the cone of depression. Theoretically, the volume of dewatered material within the cone of depression multiplied by the coefficient of storage should equal the total volume of water pumped. In nature, however, the water drains slowly from the dewatered part of the aquifer, and the volume of the cone of depression during the early stages of its development must exceed the theoretical volume in order to yield the water pumped. As pumping continues, the draining is more and more complete, and the actual volume of the cone of depression approaches more closely the theoretical volume.

To illustrate the expansion of the cone of depression, drawdown curves have been prepared according to the Theis nonequilibrium formula (Wenzel, 1942, pp. 87-89) showing the expected drawdown at various distances from the pumped well for periods of 1, 10, 30, and 300 days (pl. 7). In the computations it is assumed that the aquifer is of infinite extent, that the coefficient of transmissibility is 20,000 gallons per day per foot, that the coefficient of storage is 10 percent, and that the pumped well discharges 100 gallons per minute continuously. The figure of 10 percent is used for the coefficient of storage because it represents the coefficient of storage in the upper part of the terrace deposits--within the normal range of drawdowns in the rocks surrounding pumped wells.

Rock formations are not of infinite extent. They all terminate somewhere; that is, they have boundaries. If the cone of depression around a pumped well expands until it meets a formation boundary, its further development depends on the nature of the boundary and the possibilities for recharge. If the boundary is at a stream or lake from which water may enter the formation, an essentially stable hydraulic gradient will develop between the source of recharge and the pumped well, and much of the water supplied to the well will come from the source of recharge. If the supply for recharge is ample, the cone of depression will then stabilize, and expansion of it will stop. If, on the other hand, the boundary is the edge of the formation or is an impermeable fault plane, no water will be available for recharging the aquifer. Expansion of the cone of depression will be stopped at such a boundary because there is no room for it, but in other directions the expansion will be accelerated because more water must come from those directions if the discharge rate is to be maintained. At the same time, the drawdown rate in the well being pumped will be accelerated.

So far as is known, the only boundaries affecting a cone of depression in the terrace deposits are the edges of the deposits and the streams that nearly or entirely cut through them. In most of the area the cone of depression of the average well is not likely to expand to any of the known boundaries.

Because the coefficients of transmissibility and storage of the terrace deposits differ greatly from place to place in the area considered in this report, an average drawdown curve that would be generally useful in planning development of a well field cannot be prepared. If large quantities of water are sought, adequate preliminary test drilling and test pumping afford the best means of getting the facts on which to base specifications for wells, well spacing, pumps, and power.

To illustrate the diversity that may be encountered, two curves have been prepared according to the Theis nonequilibrium formula (Wenzel, 1942, pp. 87-89), both showing the expected drawdown at the end of 100 days of continuous pumping at a rate of 100 gallons a minute (pl 8). For one of the curves it is assumed that the coefficient

Plate 7.

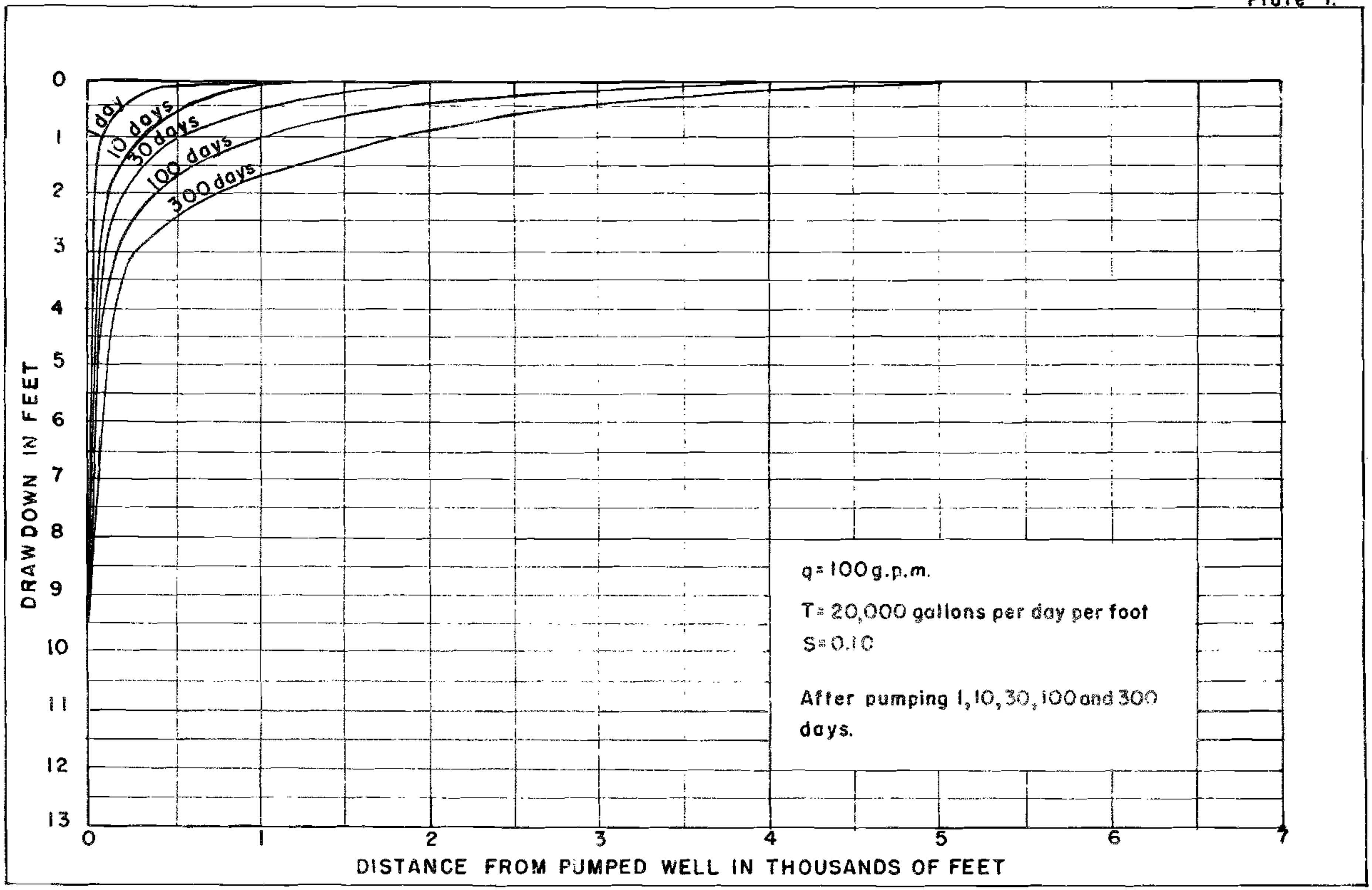


Plate 7.--Theoretical drawdown of the water level in an infinite aquifer, computed from the Theis nonequilibrium formula, after periods of 1, 10, 30, 100, and 300 days.

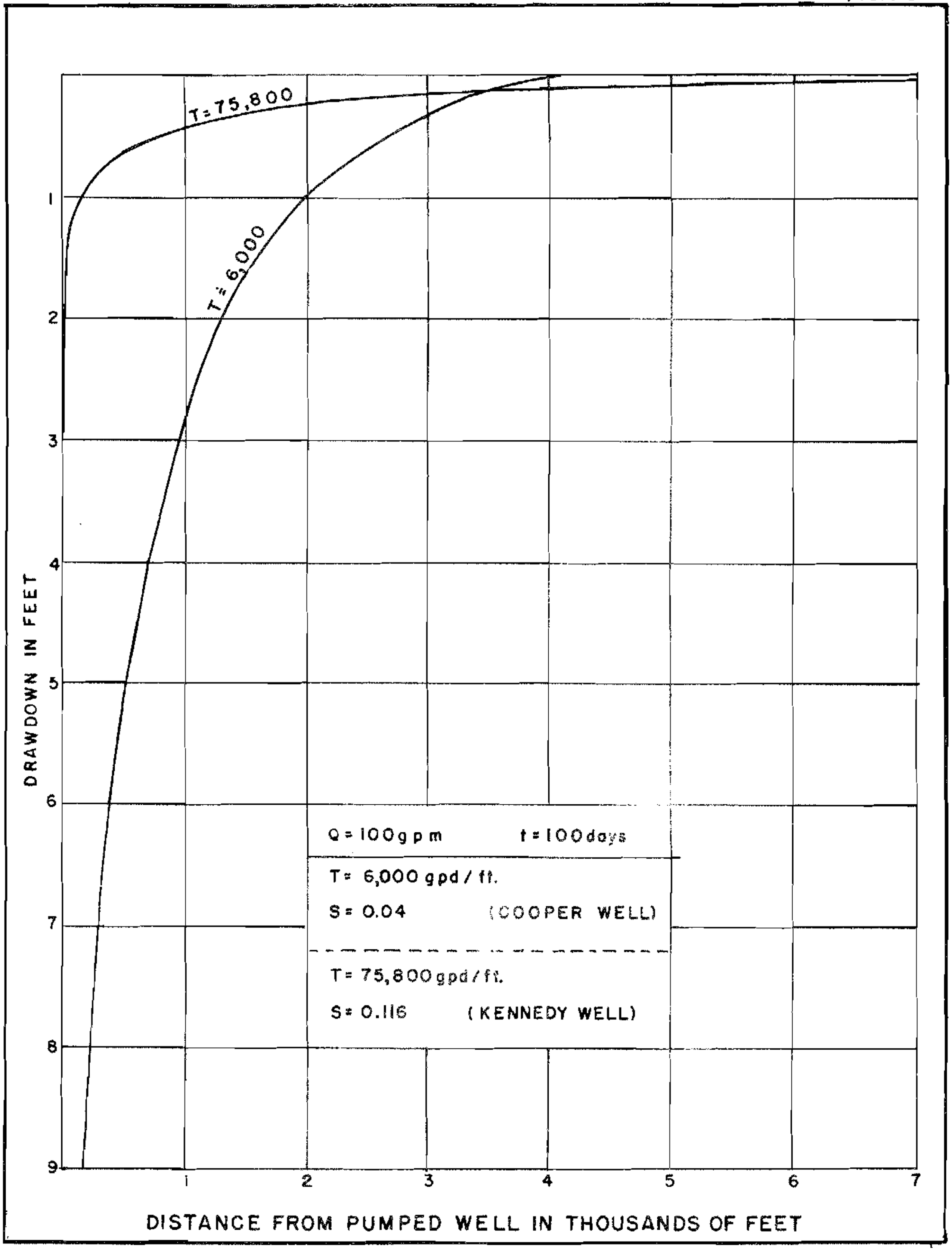


Plate 8.--Theoretical drawdowns of the water level in an infinite aquifer, computed according to the Theis nonequilibrium formula. The Cooper well represents the poorest conditions, and the Kennedy well the best conditions, revealed by the aquifer-performance tests described in this report.

of transmissibility is 6,000 gallons a day per foot and the coefficient of storage is 0.04. These are approximately the coefficients at the V. I. Cooper well (20N9W-5-6), which, of the tests, indicated the lowest coefficients. For the other curve, the assumed coefficients of transmissibility and storage are 75,800 gallons per day per foot and 0.116, respectively. These are approximately the coefficients determined in the test at the J. J. Kennedy well (21N10W-16-1), which yielded the most favorable results of all the tests made. The first curve shows a deep cone of depression with a small radius; the second curve shows a shallow cone with a large radius.

Estimate of Safe Yield

In 1949 the Oklahoma State Legislature passed the Oklahoma Ground-Water Law (House Bill 487, 1949). In section 7 of this law, the safe annual yield of a ground-water basin is defined as the average annual recharge of the basin. In a newly developed basin there is usually a large amount of stored water that can be withdrawn. The safe yield can be exceeded for a time without apparent ill effect, but there is a limit to the amount of this stored water that can be withdrawn without adversely affecting water levels in the basin. As this limit is approached, the rate at which withdrawals can be made becomes the amount of average recharge that can be intercepted by pumping. Because, under natural conditions and over a long period, the recharge equals the natural discharge, the safe yield is the amount of natural discharge that can be salvaged.

An analysis of short-term records of fluctuations of the ground-water level suggests that in the area of this report the recharge amounts to about 14.45 percent of the annual precipitation (see section on recharge of ground water). Continued study is needed of the complex relationships of precipitation, recharge, and discharge as evidenced over several years, however, before this or any other figure can be well founded.

The average annual precipitation for the area, based on the averages at three stations reported by the Weather Bureau, is about 28.75 inches. If 14.45 percent fairly represents the fraction of this annual precipitation that becomes ground water (see p. 28), the average annual recharge is about 220 acre-feet per square mile. This amounts to 137 gallons per minute per square mile, which should also be the amount lost from the ground-water reservoir by natural discharge. Where water is put on the land for irrigation, a part seeps into the ground to become ground water again and is available for re-use.

Losses of ground water are due to transpiration, evaporation, effluent seepage, and underflow. The average amount lost through transpiration is probably small per unit area because in general the water table is 15 feet or more below the land surface--out of reach of most plants--and the localities wherein plants are believed to take water from the zone of saturation represent only a small fraction of the total area investigated. The amount lost through evaporation also is believed to be small (see section on discharge). The losses due to effluent seepage and underflow are not known accurately, but they could be recovered in part by strategically located wells that would intercept the water before it could reach the places of natural discharge.

From the above it is clear that the natural discharge cannot yet be accurately estimated, and the figure of 137 gallons per minute per square mile is only a tentative estimate of the recharge. However, this estimate is conservative and most of the discharge is believed to be salvageable; hence, 137 gallons per minute per square mile appears to be a reasonable estimate for the safe yield of the terrace deposits.

The safe yield of the aquifer is not to be confused with the maximum yield of individual wells. The yield of wells is governed by the ability of the aquifer to transmit to the wells whatever water already is in it. Not until the water stored in the aquifer has been depleted beyond the limits of practical recovery can the safe yield of the aquifer limit the yield of a well, and then only approximately. Individual wells can be pumped at rates many times greater than the average safe yield of the aquifer as expressed above in gallons per minute per unit of area, simply because the aquifer is capable of delivering the water in it faster than it may be receiving water. The extra water comes either by drawing recharge water from outlying parts of the aquifer or--if such recharge is being fully utilized--by drawing water from storage. If the draft is on water in storage, and is long continued, practical exhaustion of the underground reservoir will result.

What applies to one well also applies to a well field, provided that the field does not embrace the entire aquifer or its output does not exceed the sum of the total salvaged natural discharge and the amount of water returned to the aquifer from irrigation. Clearly, then, it would be possible to develop a large supply of water by constructing wells of appropriate design in one of the more favorable localities in the terrace deposits. The yield from this well field might exceed by several times the recharge received in the immediate vicinity of the field, but pumping could continue indefinitely if recharge received in a large surrounding area could be diverted to the field.

Conclusions

The terrace deposits along the Cimarron River are among the best aquifers in the State. In 1950 the total pumpage of ground water from them was only a fraction of their safe yield, and considerable further development is possible without creating overdraft. Yields of individual wells differ considerably from place to place because of wide differences in the lithology and thickness of the saturated sediments. On the average, wells can be expected to yield from 100 to 300 gallons per minute, but locally they may yield more than 1,000 or less than 50 gallons per minute.

An analysis of the probable amount of ground-water recharge in the area suggests that the safe yield may average about 137 gallons per minute per square mile. This figure is strictly preliminary. If all the water available under the designation "safe yield" were to be used for irrigation and applied at a net consumptive rate of 2 acre-feet per acre, about a sixth of the entire area could be irrigated.

The amount of ground water stored in the terrace deposits averages about 3.7 acre-feet per acre. If half the water in storage can be recovered by pumping, withdrawals at the rate of the safe annual yield may continue for a period of 5 years, even if no recharge occurs. The significance of this statement is that the amount of water in storage is enough to outlast most droughts. The amount in storage differs greatly from place to place, of course, and in some localities doubtless is insufficient for a protracted drought; in most places, however, the stored water is believed to be adequate to sustain a rate of pumping greater than the estimated safe yield for considerable periods without excessive lowering of water levels or decline in yields.

The ground water in the terrace deposits is very hard, but otherwise it generally is of good quality and is satisfactory for many different uses.

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Table 7.--Records of wells, test holes, and shot holes in parts of Alfalfa, Garfield, Kingfisher, and Major Counties, Okla.

Well no: well-numbering system described on p. 6 and 7.
* Chemical Analysis shown in Table 5.
** Well logs listed in appendix B.
Type: Dd, drilled; Dn, driven; B, bored; Dg, dug.
Type of casing: B, brick; C, concrete; G I, galvanized iron; I, iron; R, rock; S, steel; T, tile.

Pump: C, cylinder; Cf, centrifugal; J, jet; N, none; S, suction; T, turbine.
Power: B, butane; E, electric; G, gasoline; H, hand; P, propane; S, steam; W, wind.
Use of water: D, domestic; I, irrigation; In, industrial; N, none; O, observation; P, public supply; S, stock.

Well no.	Location	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Type of Casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Pump and power	Use of water	Date of measurement	Depth below land surface (feet)	Altitude above mean sea level (feet): Land surface	Altitude above mean sea level (feet): Water surface	Altitude above mean sea level (feet): Red bed surface
T.17N., R.7W.															
17N7W-12-1 * **	SE¼SE¼	Kingfisher Water Co.	Dd	35	—	—	Sand, gravel	Alluvium	—	P	—	—	—	—	—
12-2 * **	SE¼SW¼	Kingfisher Water Co.	Dd	33	—	—	Sand, gravel	Alluvium	—	P	—	—	—	—	—
12-3 * **	NE¼SW¼	Kingfisher Water Co.	Dd	31	—	—	Sand, gravel	Alluvium	—	P	—	—	—	—	—
12-4 *	NE¼SW¼	Kingfisher Water Co.	Dn	—	—	—	Sand	Alluvium	W	S	—	—	—	—	—
T.18N., R.7W.															
18N7W- 1-1 *	NW¼NE¼	Irl Landaker	Dd	45	—	—	Sand	Terrace deposits	W	D, S	—	—	—	—	—
1-2 *	SE¼SE¼	F. W. Muir	Dd	68	6	—	Sand	Terrace deposits and red beds	W	D, S	—	—	—	—	—
1-3 **	N½ cor.	City of Hennessey	Dd	46	—	—	Sand	Terrace deposits	—	—	—	—	1180	—	1134
1-4 **	S½ cor.	City of Hennessey	Dd	39	—	—	Sand	Terrace deposits	—	—	—	—	1107.3	—	1068.3
1-5 **	SE cor.	City of Hennessey	Dd	55	—	—	Clay	Terrace deposits	—	—	—	—	1136.5	—	1081.5
4	NE¼SE¼	W. Stribel	Dg	26	36	B	—	Terrace deposits	N	O	7/31/50	13.25	1097.4	1084.15	—
8-1 **	NE cor.	U. S. G. S.	Dd	60	4	—	Sand, gravel	Terrace deposits	N	O	—	18.5	1137.5	1119.0	1082.5
8-2 *	SE¼	Danny Stiger	Dn	24	2	—	Sand, gravel	Terrace deposits	C, E	D, S	—	—	—	—	—
10-1	NE¼SE¼	J. Goetzinger	Dd	30	6	G I	—	Red beds	C, H	O	7/17/50	21.22	1097.1	1075.88	—
10-2	NE¼SE¼	J. Goetzinger	Dd	68	6	S	Shale	Red beds	C; W	S	7/17/50	26.08	1101.3	1075.22	—
10-3	SW¼SW¼	R. M. Deweese	Dg	28	60	B	—	Alluvium	C, W	S	7/14/50	21.56	—	—	—
12-1 **	NW cor.	City of Hennessey	Dd	44	—	—	Sand	Terrace deposits	—	—	—	—	1111.9	—	1067.9
12-2 **	SW cor.	City of Hennessey	Dd	37	—	—	Sand	Terrace deposits	—	—	—	—	1101.9	—	1964.9
12-3 **	S½ cor.	City of Hennessey	Dd	48	—	—	Sand	Terrace deposits	—	—	—	—	1116.6	—	1968.6
12-4 **	SE cor.	City of Hennessey	Dd	53	—	—	Sand	Terrace deposits	—	—	—	—	1117.5	—	1066.5
13-1 *	SW cor. NE¼	City of Hennessey	Dg	50	12	C	Sand	Terrace deposits	T, E	P	—	25	1113.0	—	—
13-2	NW¼SE¼	City of Hennessey	Dg	59	12	C	—	—	T, E	P	1949	29	1117	1088	—
13-3	NW¼SE¼	City of Hennessey	Dg	62	12	C	—	—	T, E	P	1949	26	1114	1088	—
13-4 *	NE¼NW¼	J. M. Patterson	Dg	45	—	—	Gravel	Terrace deposits	C, W.	D, S	—	—	—	—	—
13-5 **	W½ cor.	City of Hennessey	Dd	41	—	—	Sand	Terrace deposits	—	—	—	—	1097.3	—	1056.3
13-6 **	S½ cor.	City of Hennessey	Dd	65	—	—	Sand	Terrace deposits	—	—	—	—	1118.4	—	1053.4
13-7 **	Center	City of Hennessey	Dd	58	—	—	Sand	Terrace deposits	—	—	—	—	1117.0	—	1059.0
13-8 **	SW cor. NE¼	City of Hennessey	Dd	58	—	—	Sand	Terrace deposits	—	—	—	—	1117.0	—	1059.0
13-9 **	SW¼NE¼	City of Hennessey	Dd	56	—	—	Sand	Terrace deposits	—	—	—	—	1116.0	—	1060.0
14-1	NW¼NE¼	C. H. Moery	Dd	42	8	S	Sand	Terrace deposits	C, E	D	7/17/50	23.34	—	—	—
14-2 **	NW cor.	City of Hennessey	Dd	33	—	—	Sand	Terrace deposits	—	—	—	—	1098.0	—	1065.0
15-1	NW¼NW¼	W. F. Winters	Dg	29	42	—	—	Alluvium	C, W	S	7/14/50	18.61	—	—	—
15-2 *	NE¼NE¼	D. Rothmire	Dn	53	6	G I	—	Terrace deposits	J, E	D, S	8/1/50	31.71	1097.4	1065.69	—
17 **	SE cor.	U. S. G. S.	Dd	50	4	—	Sand	Terrace deposits	—	—	—	16.5	1100.7	1084.20	1052.7
19 **	NE¼NW¼	U. S. G. S.	Dd	48	4	—	Sand, gravel	Terrace deposits	N	O	—	26.8	1103.9	1077.1	1053.9
21	SW¼SE¼	H. B. Stinson	Dd	57	5	S	Sand	Terrace deposits	N	O	7/17/50	30.74	1081.1	1050.36	—
23-1	NE¼NW¼	J. B. Bradbury	Dd	72	5	S	—	Red beds	C, W	S	—	—	—	—	—
23-2 **	NE cor.	City of Hennessey	Dd	38	—	—	Sand	Terrace deposits	—	—	—	—	1100.7	—	1062.7
24-1 *	NW¼NE¼	City of Hennessey	Dn	45	—	—	—	Terrace deposits	W	D, S	8/10/45	17.5	—	—	—
24-2 *	SE¼SW¼	Jake Iven	Dd	50	4	—	—	Terrace deposits and red beds	W	D, S	—	—	—	—	—
24-3 **	SE cor.	City of Hennessey	Dd	56	—	—	—	Terrace deposits	—	—	—	—	1124.5	—	1068.5
26 *	NE¼NE¼	A. F. Romerman	Dn	35	—	—	—	Terrace deposits	W	D, S	—	—	—	—	—
27 **	NE cor.	U. S. G. S.	Dd	48	4	—	Gravel	Terrace deposits	N	O	—	15.6	1078.1	1062.5	1036.1
28 *	SW¼	V. A. McKeever	Dn	31	1½	—	—	Terrace deposits	C, E	—	—	—	—	—	—
29 **	SE cor.	U. S. G. S.	Dd	47	4	—	Gravel	Terrace deposits	—	—	—	14.1	1039.7	1025.6	995.7
35	SW¼SW¼	B. Barr	Dd	43	36	—	Gravel	Alluvium	Cf, G	I	—	—	—	—	—
T.18N., R.8W.															
18N8W- 1 **	SE cor.	U. S. G. S.	Dd	55	4	—	Sand, gravel	Terrace deposits	—	—	—	27.6	1146.9	1119.3	1091.9
3 **	NE cor.	U. S. G. S.	Dd	59	4	—	Sand, gravel	Terrace deposits	—	—	—	23.3	1159.6	1136.3	1104.4
4 **	SW cor.	U. S. G. S.	Dd	43	4	—	Sand, gravel	Terrace deposits	—	—	—	—	1115.7	—	1079.7
11-1 *	SE¼	Baker Estate	—	25	1½	—	—	Terrace deposits	—	—	—	18.0	—	—	—
11-2 **	SW cor.	U. S. G. S.	Dd	32	4	—	Clay, sand	Terrace deposits	—	—	—	18.5	1078.6	1060.1	1049.6
13	NW¼NW¼	Donald Perigo	Dn	9	1½	S	—	Terrace deposits	N	O	8/3/50	.89	1090.4	1089.51	—
T.18N., R.9W.															
18N9W-12 **	NE cor.	U. S. G. S.	Dd	37	4	—	Gravel	Terrace deposits	—	—	—	—	1075.3	—	1043.3
T.19N., R.7W.															
19N7W- 9	SE¼NE¼	Francis Gorton	Dd	33	16	—	Sand, gravel	Terrace deposits	T, G	I	—	—	—	—	—
18	SW¼NW¼	—	Dd	24	6	G I	—	—	C, W	N	8/3/50	18.73	1204.7	1185.97	—
23 *	SW¼SW¼	City of Hennessey	Dg	60	216	—	—	Alluvium	—	P	—	—	—	—	—
25 *	NE¼NW¼	City of Hennessey	Dg	50	120	B	Shale, sand	Red beds	T, E	P	8/9/45	41	—	—	—
29 **	SE cor.	U. S. G. S.	Dd	80	—	—	Gravel	Terrace deposits	N	O	—	16.8	1150.0	1133.2	1076.0

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Pump: C, cylinder; Cf, centrifugal; J, jet; N, none; S, suction; T, turbine.
Power: B, butane; E, electric; G, gasoline; H, hand; P, propane; S, steam; W, wind.
Use of water: D, domestic; I, irrigation; In, industrial; N, none; O, observation; P, public supply; S, stock.

Well no.	Location	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Type of Casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Pump and power	Use of water	Date of measurement	Depth below land surface (feet)	Altitude above mean sea level (feet): Land surface	Altitude above mean sea level (feet): Water surface	Altitude above mean sea level (feet): Red bed surface
19N7W-30-1 *	SE¼	Norman Boettler	Dn	81	2	—	Sand	Terrace deposits	C, W	D, S	--	--	--	--	--
30-2 **	SW¼SE¼	Darrel Goe	Dd	75	16	S	—	Terrace deposits	T, G	I	8/3/50	42.19	1182.7	1140.51	--
31-1	SW¼SW¼	C. R. Throckmorton	Dd	68	7	S	Gravel	Terrace deposits	J, E	D	7/14/50	30.47	—	—	—
31-2 **	NW cor.	U. S. G. S.	Dd	84	4	—	Gravel	Terrace deposits	—	--	--	17.7	1159.5	1141.8	1081.5
36-1 *	SE¼SW¼	A. W. Woods	Dg	47	—	—	Sand	Terrace deposits	C, W	S	7/9/45	29.0	—	—	—
36-2 *	SE¼NW¼	Caulk	Dd	50	6	--	—	Terrace deposits	C, W	S	8/9/45	42.5	—	—	—
T.19N., R.8W.															
19N8W- 3-1	NE¼NE¼	John Hladik	Dd	48	5	G I	Sand	Terrace deposits	N	O	7/10/50	21.26	1227.8	1206.54	--
3-2 **	SE cor.	U. S. G. S.	Dd	95	4	—	Gravel	Terrace deposits	—	—	—	23.4	1208.3	1184.9	1115.3
4 **	SW cor.	U. S. G. S.	Dd	128	—	—	Gravel	Terrace deposits	—	—	—	31.3	1218.0	1186.7	1098.0
5 *	NW¼	Cecil Botts	Dn	82	1¼	—	—	Terrace deposits	C, W	D, S	—	—	—	—	—
6 **	SW cor.	U. S. G. S.	Dd	73	—	—	Sand, gravel	Terrace deposits	—	—	—	19.6	1198.5	1178.9	1129.5
8 **	NE cor.	U. S. G. S.	Dd	95	4	—	Sand, gravel	Terrace deposits	—	—	—	29.0	1219.8	1190.8	—
10-1 *	SE cor.	Dunbar High School	Dn	94	1¼	—	—	Terrace deposits	C, E	P	—	—	—	—	—
10-2 **	NE cor.	U. S. G. S.	Dd	95	4	—	Sand	Terrace deposits	—	—	—	21.4	1207.6	1186.2	1112.6
12 **	NE cor.	U. S. G. S.	Dd	22	4	—	Clay	Terrace deposits	—	—	—	13.3	1225.7	1212.4	1210.7
14-1 **	SW¼SW¼	U. S. G. S.	Dd	65	1¼	S	Gravel	Terrace deposits	N	O	7/14/50	22.26	1193.0	1170.74	1098.0
14-2 **	SW cor.	U. S. G. S.	Dd	115	4	—	Gravel	Terrace deposits	—	—	7/28/50	33.3	1204.3	1171.0	1089.3
17 **	SE¼SE¼	U. S. G. S.	Dd	85	4	—	Gravel	Terrace deposits	—	—	—	16.5	1190.1	1173.6	1112.1
20 *	NW cor.	E. F. Berard	Dn	48	1¼	—	—	Terrace deposits	C, E	D	—	—	—	—	—
24 **	NE cor.	U. S. G. S.	Dd	95	4	—	Sand	Terrace deposits	N	—	—	10.9	1188.2	1177.3	1098.2
27-1 *	NE¼SE¼	L. G. Watson	Dd	67	16	S	Sand, gravel	Terrace deposits	T, B	I, O	7/14/50	17.54	1170.3	1152.76	—
27-2 **	NE¼SE¼	U. S. G. S.	Dd	74	4	—	Sand, gravel	Terrace deposits	—	—	—	—	1170.3	—	1098.3
31 **	NW cor.	U. S. G. S.	Dd	53	4	—	Sand, gravel	Terrace deposits	—	—	—	—	1151.5	—	1100.5
33 **	NW cor.	U. S. G. S.	Dd	47	4	—	Sand, gravel	Terrace deposits	—	—	—	—	1158.5	—	1111.5
34 *	NW¼NW¼	Harold Collier	Dn	54	1¼	—	—	Terrace deposits	C, E	D	—	—	—	—	—
T.19N., R.9W.															
19N9W- 4	NE cor.	City of Enid	Dd	42	--	—	—	Terrace deposits	—	--	—	15.0	1166.1	1151.1	1124.1
5	NE cor.	City of Enid	Dd	38	—	—	—	Terrace deposits	—	--	—	28.0	1160.1	1132.1	1122.1
6	NE cor.	City of Enid	Dd	44.5	—	—	—	Terrace deposits	—	--	—	12.0	1126.2	1114.2	1081.7
7	NE cor. NW¼	City of Enid	Dd	48	--	—	—	Alluvium	—	--	—	14.0	—	—	—
8	NE cor.	City of Enid	Dd	32	—	—	—	Alluvium	—	—	—	4.0	—	—	—
9	NE cor.	City of Enid	Dd	49	—	--	—	Terrace deposits	—	--	—	15.0	1147.5	1132.5	1098.5
10-1 *	NW¼NE¼	R. V. Sturgeon	Dd	32	15	S	Sand	Terrace deposits	N	O	7/5/50	16.69	1149.8	1133.11	—
10-2 **	NW¼NE¼	U. S. G. S.	Dd	36	4	—	Sand	Terrace deposits	—	—	4/16/51	16.38	1150.5	1134.12	1115.5
10-3	NE cor.	City of Enid	Dd	35	—	—	—	Terrace deposits	—	—	—	16.0	1156.2	1140.2	1121.2
11 *	SE¼	G. W. Sturgeon	Dd	27	1¼	--	—	Terrace deposits	C, E	D	—	—	—	—	—
14 **	NW cor. NE¼	U. S. G. S.	Dd	43	4	—	Gravel	Terrace deposits	—	—	—	9.6	1148.7	1139.1	1117.7
15-1 *	SW¼SE¼	City of Okeene	Dg	45	12	C	Gravel	Terrace deposits	—	P	—	—	—	—	—
15-2	SW¼SE¼	City of Okeene	Dd	50	18	S	—	Terrace deposits	T, E	P	—	—	—	—	—
15-3	NW¼SE¼	City of Okeene	Dd	50	18	—	Gravel	Terrace deposits	T, E	P	—	—	—	—	—
22 **	NE cor.	U. S. G. S.	Dd	64	4	—	Gravel	Terrace deposits	—	—	—	27.4	1119.8	1092.4	1067.8
24-1	NE¼NE¼	U. S. G. S.	B	18	1¼	S	Sand	Terrace deposits	N	O	7/6/50	12.6	1162.9	1152.3	—
24-2 **	NE¼NE¼	U. S. G. S.	Dd	43	—	—	Sand	Terrace deposits	—	—	—	—	1164.4	—	1126.4
26 **	NE cor.	U. S. G. S.	Dd	43	4	--	Sand	Terrace deposits	—	—	—	—	1132.1	—	1103.1
27	NE cor.	City of Enid	Dd	29	—	—	—	Terrace deposits	—	—	—	13.0	—	—	—
T.20N., R.8W.															
20N8W- 6 **	NW cor.	U. S. G. S.	Dd	48	4	—	Sand	Terrace deposits	—	—	—	23.6	1260.9	1237.3	1212.9
7 **	SE¼NE¼	U. S. G. S.	Dd	95	4	—	Sand	Terrace deposits	—	—	—	22.3	1274.8	1252.5	—
17 **	SW cor.	U. S. G. S.	Dd	87	4	—	Sand	Terrace deposits	—	—	—	29.8	1257.0	1227.2	1178.0
18 **	NW cor.	U. S. G. S.	Dd	22	4	--	Sand, clay	Terrace deposits	—	—	—	15.7	1254.2	1238.5	—
19 **	SE cor.	U. S. G. S.	Dd	87	4	—	Sand	Terrace deposits	—	—	—	29.3	1241.7	1212.4	1162.7
23 *	SW¼SW¼	Harry Christmas	Dd	104	6	G I	Shale	Red beds	J, E	D	—	—	—	—	—
26 **	SW cor.	U. S. G. S.	Dd	43	4	—	Clay	Terrace deposits	—	—	—	25.4	1258.7	1233.3	1220.7
27 **	NW cor.	U. S. G. S.	Dd	64	4	--	Sand	Terrace deposits	—	—	—	16.8	1256.5	1239.7	1210.5
29 **	SE cor.	U. S. G. S.	Dd	95	4	--	Sand	Terrace deposits	—	—	—	20.8	1224.8	1204.0	—
T.20N., R.9W.															
20N9W- 2-1 **	NW cor.	City of Enid	Dd	140	--	--	Sand	Red beds	—	—	11/12/49	36.0	1247.4	1211.4	1212.4
2-2 **	NW cor. SW¼	City of Enid	Dd	230	--	--	Sand, shale	Red beds	—	—	—	—	1244.1	—	1177.1
2-3 **	SE cor.	U. S. G. S.	Dd	49	—	—	—	Terrace deposits	N	O	—	27.8	1252.9	1225.1	1203.9
3-1 *	SW¼SW¼	Raymond Suit	Dn	32	1¼	S	Gravel	Terrace deposits	—	D	—	—	—	—	—
3-2	NE cor.	City of Enid	Dd	50	—	—	—	—	—	—	—	—	—	—	—
4-1 **	NE cor.	George Suit	Dg	60	24	C	Sand, gravel	Terrace deposits	N	O	1/30/50	23.94	1225.70	1201.76	1165.7

Table 7.--Records of wells, test holes, and shot holes in parts of Alfalfa, Garfield, Kingfisher, and Major Counties, Okla.

Well no: well-numbering system described on p. 6 and 7.
* Chemical Analysis shown in Table 5.
** Well logs listed in appendix B.
Type: Dd, drilled; Dn, driven; B, bored; Dg, dug.
Type of casing: B, brick; C, concrete; G I, galvanized iron; I, iron; R, rock; S, steel; T, tile.

Pump: C, cylinder; Cf, centrifugal; J, jet; N, none; S, suction; T, turbine.
Power: B, butane; E, electric; G, gasoline; H, hand; P, propane; S, steam; W, wind.
Use of water: D, domestic; I, irrigation; In, industrial; N, none; O, observation; P, public supply; S, stock.

Well no.	Location	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Type of Casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Pump and Power	Use of water	Date of measurement	Depth below land surface (feet)	Altitude above mean sea level (feet): Land surface	Altitude above mean sea level (feet): Water surface	Altitude above mean sea level (feet): Red bed surface
20N9W- 4-2	NE cor.	City of Enid	Dd	59	--	--	--	Terrace deposits	--	--	--	23.0	1227.7	1204.7	1168.7
5-1	NE cor.	City of Enid	Dd	55	--	--	--	Terrace deposits	--	--	--	24.0	1226.7	1202.0	1171.0
5-2 **	NW¼NE¼	Town of Ames	Dd	50	--	--	Gravel	Terrace deposits	--	--	--	--	1213.7	--	1163.7
5-3 **	NE¼NW¼	Town of Ames	Dd	48	--	--	--	Terrace deposits	--	--	--	--	1207.3	--	1159.3
5-4 **	NE¼NW¼	City of Enid	Dd	38	--	--	Sand	Terrace deposits	--	--	--	--	1202.0	--	1164.0
5-5	SW¼NW¼	City of Enid	Dd	--	--	--	--	Terrace deposits	--	--	--	--	1180.0	--	--
5-6	SW cor.	V. I. Cooper	Dg	54	24	C	Sand, gravel	Terrace deposits	N	O	1/30/50	7.99	1174.3	1166.31	--
5-7 **	SW cor.	U. S. G. S.	Dd	62	4	--	Sand, gravel	Terrace deposits	--	--	--	8.4	1174.3	1165.9	1112.3
6-1 *	NE¼NW¼	Laubhan	Dd	67	10	S	Gravel	Terrace deposits	Cf, B	I, O	5/5/50	7.92	1180.6	1172.68	--
6-2 *	NW¼SE¼	City of Enid	Dd	67	12	S	Gravel	Terrace deposits	T, E	P	9/12/50	6.32	1169.0	1162.68	--
6-3 **	NE¼SE¼	City of Enid	Dd	60	--	--	Sand	Terrace deposits	--	--	--	9.0	1175.0	1166.0	1115.5
6-4 **	NW¼SE¼	City of Enid	Dd	70	--	--	Sand, gravel	Terrace deposits	--	--	--	6.0	1170.0	1164.0	1100.0
6-5 **	SE¼SW¼	City of Enid	Dd	65	--	--	Sand	Terrace deposits	--	--	--	8.0	1168.0	1160.0	1108.0
6-6	NE cor.	City of Enid	Dd	27	--	--	--	Terrace deposits	--	--	--	9.0	1188.2	1179.2	1161.2
6-7	NW¼SE¼	City of Enid	Dd	65	6	S	--	Terrace deposits	N	O	10/26/50	6.00	1171.8	1165.8	--
6-8	NW¼SE¼	City of Enid	Dd	60	2	S	--	Terrace deposits	N	O	10/26/50	5.25	1170.7	1165.45	--
7-1	NE cor. NW¼	City of Enid	Dd	40	--	--	--	Terrace deposits	--	--	--	5.0	1171.7	1166.7	1131.7
7-2 **	NW¼NW¼	City of Enid	Dd	70	--	--	Sand, gravel	Terrace deposits	--	--	--	9.0	1162.0	1153.0	1102.0
7-3	NE cor.	City of Enid	Dd	54	--	--	--	Terrace deposits	--	--	--	7.0	1175.3	1168.3	1121.3
8	NE cor.	City of Enid	Dd	47	--	--	--	Terrace deposits	--	--	--	16.0	1208.7	1192.7	1161.7
9	NE cor.	City of Enid	Dd	46	--	--	--	Terrace deposits	--	--	--	23.0	1218.0	1195.0	1172.0
10	NE cor.	City of Enid	Dd	55	--	--	--	Terrace deposits	--	--	--	34.0	1235.0	1201.0	1180.0
12	SE¼SW¼	Ernest Craun	Dd	120	6	S	--	Red beds	J, E	D, S	--	--	--	--	--
13	SE¼NE¼	George Patten	Dd	35	6	G I	--	Terrace deposits	N	O	5/18/50	22.12	1249.4	1227.28	--
14	NW¼NW¼	Hallie Bowles	Dg	22	60	C	--	Terrace deposits	N	O	4/27/50	13.4	1229.4	1216.00	--
15	NE cor.	City of Enid	Dd	50	--	--	--	Terrace deposits	--	--	--	25.0	1223.3	1198.3	1173.3
16	NE cor.	City of Enid	Dd	55	--	--	--	Terrace deposits	--	--	--	23.0	1214.0	1191.0	1159.0
17-1	NE cor.	City of Enid	Dd	42	--	--	--	Terrace deposits	--	--	--	17.0	1200.2	1183.2	1158.2
17-2	SW¼SW¼	W. E. Suit	Dd	30	3	S	--	Terrace deposits	--	--	2/27/50	25.28	1185.80	1160.52	--
18	NE cor.	City of Enid	Dd	37	--	--	--	Terrace deposits	--	--	--	10.0	1175.5	1165.5	1138.5
19	NE¼NE¼	City of Enid	Dd	46	--	--	--	Terrace deposits	--	--	--	34.0	1209.3	1175.3	1163.3
20-1	NE cor.	City of Enid	Dd	53.5	--	--	--	Terrace deposits	--	--	--	20.5	1199.0	1178.5	1145.5
20-2 **	NE cor. NW¼	City of Enid	Dd	80	--	--	Sand, gravel	Terrace deposits	--	--	--	--	--	--	--
21	NE cor.	City of Enid	Dd	57	--	--	--	Terrace deposits	--	--	--	28.0	1214.0	1186.0	1157.0
22-1	NE cor.	City of Enid	Dd	74	--	--	--	Terrace deposits	--	--	--	26.9	1219.4	1192.5	1145.4
22-2	NE cor. NW¼	City of Enid	Dd	66	--	--	--	Terrace deposits	--	--	--	32.0	1220.0	1188.0	1154.0
23	NE cor.	City of Enid	Dd	54	--	--	--	Terrace deposits	--	--	--	16.0	1225.7	1209.7	1171.7
24	NE¼SE¼	Helen Melton	Dd	61	2	S	--	--	N	O	5/2/50	38.0	1241.9	1203.9	--
25 *	SW¼SE¼	Earl Crawford	Dd	86	4	--	Gravel	Terrace deposits	E	D, S	--	--	--	--	--
26-1	NE cor.	City of Enid	Dd	68	--	--	--	Terrace deposits	--	--	--	25.0	1215.9	1190.9	1147.9
26-2	NE¼NW¼	L. M. Sturgeon	Dn	53	1¼	S	--	Terrace deposits	N	O	5/2/50	24.44	1214.1	1189.66	--
27	NE cor.	City of Enid	Dd	71	--	--	--	Terrace deposits	--	--	--	38.0	1225.6	1187.6	1154.6
28-1 *	SW¼NW¼	William Cotton	Dn	45	1¼	--	Gravel	Terrace deposits	E	D	--	--	--	--	--
28-2	NE cor.	City of Enid	Dd	54	--	--	--	Terrace deposits	N	O	--	22.0	1203.6	1181.6	1149.6
29	NE cor.	City of Enid	Dd	60	--	--	--	Terrace deposits	--	--	--	27.0	1195.1	1168.1	1135.1
31-1	NE cor.	City of Enid	Dd	38	--	--	--	Terrace deposits	--	--	--	32.0	1182.7	1150.7	1144.7
31-2	NE cor. NW¼	City of Enid	Dd	25	--	--	--	Terrace deposits	--	--	--	6.0	--	--	--
31-3	NE cor. SW¼	City of Enid	Dd	23	--	--	--	Terrace deposits	--	--	--	4.0	1117.4	1113.4	1094.4
31-4	NE cor. SE¼	City of Enid	Dd	40	--	--	--	Terrace deposits	--	--	--	11.0	1124.9	1113.9	1084.9
32-1	NE cor.	City of Enid	Dd	55	--	--	--	Terrace deposits	--	--	--	26.0	1181.6	1155.6	1126.6
32-2	NW¼SE¼	City of Enid	Dd	56	--	--	--	Terrace deposits	--	--	--	35.0	1184.0	1149.0	1128.0
33	NE cor.	City of Enid	Dd	42	--	--	--	Terrace deposits	--	--	--	12.0	1190.9	1178.9	1148.9
34	NE cor.	City of Enid	Dd	41	--	--	--	Terrace deposits	--	--	--	16.0	1188.5	1172.5	1147.5
36	NE cor.	City of Enid	Dd	58	--	--	--	Terrace deposits	--	--	--	21.0	1208.2	1187.2	1150.2
T.20N., R.10W.															
20N10W-1	NE cor.	City of Enid	Dd	33	--	--	--	Terrace deposits	--	--	--	10.0	1186.1	1176.1	1153.1
3-1 *	NE¼SE¼	Kenneth Fisher	Dn	21	1¼	--	Gravel	Terrace deposits	C, H	N	--	--	--	--	--
3-2	NE¼SE¼	Kenneth Fisher	Dn	27	1¼	S	--	Terrace deposits	N	O	5/19/50	18.09	1156.7	1138.61	--
3-3	NE cor.	City of Enid	Dd	49	--	--	--	Terrace deposits	--	--	--	19.0	1178.8	1159.8	1129.8
11	NE cor.	City of Enid	Dd	33	--	--	--	Terrace deposits	--	--	--	10.0	1163.0	1153.0	1130.0
12-1	NE cor.	City of Enid	Dd	45	--	--	--	Terrace deposits	--	--	--	15.0	1171.9	1156.9	1126.9
12-2 **	NE¼NE¼	City of Enid	Dd	60	--	--	Sand, gravel	Terrace deposits	N	O	--	10.3	1165.0	1154.7	1110.0
12-3 *	NE¼NE¼	City of Enid	Dd	60	12	S	--	Terrace deposits	T, E	P	--	--	--	--	--

Table 7.--Records of wells, test holes, and shot holes in parts of Alfalfa, Garfield, Kingfisher, and Major Counties, Okla.

Well no: well-numbering system described on p. 6 and 7.
* Chemical Analysis shown in Table 5.
** Well logs listed in appendix B.
Type: Dd, drilled; Dn, driven; B, bored; Dg, dug.
Type of casing: B, brick; C, concrete; G I, galvanized iron; I, iron; R, rock; S, steel; T, tile.

Pump: C, cylinder; Cf, centrifugal; J, jet; N, none; S, suction; T, turbine.
Power: B, butane; E, electric; G, gasoline; H, hand; P, propane; S, steam; W, wind.
Use of water: D, domestic; I, irrigation; In, industrial; N, none; O, observation; P, public supply; S, stock.

Well no.	Location	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Type of Casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Pump and Power	Use of Water	Date of measurement	Depth below land surface (feet)	Altitude above mean sea level (feet): Land surface	Water surface	Red bed surface
20N10W-12-4 *	SW¼NE¼	City of Enid	Dd	55	12	S	--	Terrace deposits	T, E	P	--	--	--	--	--
12-5 *	SE¼SW¼	City of Enid	Dd	52	12	S	--	Terrace deposits	T, E	P	--	--	--	--	--
12-6 **	NW¼SE¼	City of Enid	Dd	90	--	--	Gravel	Terrace deposits	--	--	--	--	1160.0	--	1100.0
12-7 **	NE¼SW¼	City of Enid	Dd	60	--	--	Gravel	Terrace deposits	--	--	--	--	1160.0	--	1105.0
12-8 **	SE¼SW¼	City of Enid	Dd	60	--	--	Gravel	Terrace deposits	--	--	--	16.0	1151.0	1135.0	1101.0
12-9	NE¼NE¼	City of Enid	Dd	52	6	S	--	Terrace deposits	N	O	9/21/50	8.69	1166.5	1157.81	--
12-10	NE¼NE¼	City of Enid	Dd	53	2	S	--	Terrace deposits	N	O	9/21/50	--	--	1157.09	--
12-11	SW¼NE¼	City of Enid	Dd	--	6	S	--	Terrace deposits	N	O	--	--	--	--	--
12-12	SE¼SW¼	City of Enid	Dd	50	6	S	--	Terrace deposits	N	O	9/21/50	16.49	1152.2	1135.71	--
12-13	SE¼SW¼	City of Enid	Dd	52	2	S	--	Terrace deposits	N	O	9/21/50	15.44	1152.7	1137.26	--
12-14	SW¼NE¼	City of Enid	Dd	54	--	--	--	Terrace deposits	--	--	--	--	1160.0	--	1106.0
13-1 *	NW¼NW¼	Allaspach	Dn	33	1¼	--	Gravel	Alluvium	C, H	D	--	--	--	--	--
13-2	NE cor.	City of Enid	Dd	53	--	--	--	Terrace deposits	--	--	--	24.0	1176.4	1152.4	1123.4
13-3 **	NE¼NW¼	City of Enid	Dd	60	--	--	Gravel	Terrace deposits	--	--	--	--	1140.0	--	1090.0
13-4	NW cor. SW¼	St. L.-S. F. Ry. Co.	Dd	30-40	4	S	--	Alluvium	S, S	In	--	--	--	--	--
14-1	NE cor.	City of Enid	Dd	28	--	--	--	Alluvium	--	--	--	4.0	1134.1	1130.1	1106.1
14-2 **	NE¼SE¼	City of Enid	Dd	40	--	--	Gravel	Alluvium	--	--	--	4.0	1120.0	1116.0	1087.0
24	NE cor.	City of Enid	Dd	40	--	--	--	Terrace deposits	--	--	--	34.0	1186.1	1152.1	1146.1
25	NE cor.	City of Enid	Dd	29	--	--	--	Terrace deposits	--	--	--	23.0	--	--	--
T.21N., R.7W.															
21N7W-23-1 *	NW cor.	City of Waukomis	Dd	52	10	S	Shale	Red beds	T, E	P	--	--	--	--	--
23-2	NW¼NW¼	City of Waukomis	Dd	53	8	S	Shale	Red beds	T, E	P	--	--	--	--	--
T.21N. R.8W.															
21N8W- 6	SW¼SE¼	R. Munkres	Dg	11	36	R	--	Alluvium	N	O	3/6/50	5.19	1207.7	1202.51	--
18-1	SW¼SE¼	H. W. Dierkson	Dg	--	--	--	--	--	C, H	O	3/3/50	2.64	1215.8	1213.16	--
18-2 **	NE cor. SE¼	City of Enid	Dd	230	--	--	Shale	Red beds	--	--	--	--	--	--	--
18-3	NE cor.	Nellie Goodhue	Dd	169	1	S	Shale	Red beds	N	N	--	Flows	--	--	--
19-1 **	NW cor.	City of Enid	Dd	110	12	S	Shale	Red beds	T, E	P	2/8/50	15.80	1240.5	1224.7	1190
19-2 * **	NW cor. SW¼	City of Enid	Dd	122	8	S	Shale	Terrace deposits and red beds	N	O	--	10.34	1238.5	1228.16	1203.5
19-3 *	SW cor.	City of Enid	Dd	180	12	S	Shale	Red beds	N	O	3/30/50	10.78	1242.7	1231.92	--
19-4 **	SW cor.	City of Enid	Dd	100	--	--	Shale	Red beds	N	O	--	14.6	1242.7	1228.1	1203.7
19-5	NE¼NW¼	C. C. Dierkson	Dg	22	24	R	--	Terrace deposits	C, W	S, O	3/27/50	13.32	1233.5	1220.18	--
19-6 **	SE cor. SW¼	City of Enid	Dd	150	--	--	Shale	Red beds	--	--	--	--	1237.3	--	1187.3
19-7	SE¼SE¼	Raymond Dick	Dg	16	40	B	--	Terrace deposits	C, W	S	3/27/50	4.55	1220.1	1215.55	--
19-8 **	NE cor. NW¼	City of Enid	Dd	100	--	--	Shale	Red beds	N	--	--	--	1233	--	1198
20	SW¼NW¼	--	Dd	--	--	--	Shale	Red beds	N	N	--	Flows	--	--	--
21	SE¼SE¼	--	Dd	73	6	G I	Shale	Red beds	C, H	N	3/7/50	48.00	--	--	--
30 **	NE cor. NW¼	City of Enid	Dd	310	--	--	Shale	Red beds	--	--	--	--	1232.7	--	1172.7
31-1	SE¼NE¼	Paul Gregory	Dd	28	6	G I	--	Terrace deposits	N	O	4/6/50	14.60	1245.6	1231.0	--
31-2	SW¼SW¼	Lula Allen	Dd	36	6	G I	Gravel	Terrace deposits	C, E	D, S	3/29/50	23.53	--	--	--
T.21N., R.9W.															
21N9W- 1	SE¼NE¼	C. E. Stull	B	15	5½	G I	Sand	Terrace deposits	N	O	4/5/50	11.42	1229.1	1217.68	--
4-1 **	NE cor.	U. S. G. S.	Dd	43	4	--	Clay	Terrace deposits	--	--	--	23.7	1320.6	1296.9	1289.6
4-2	SW¼SW¼	Louis Ott	Dd	163	6	S	Shale	Red beds	N	O	5/8/50	66.94	1315.5	1248.56	--
4-3	SW¼SE¼	Louis Ott	Dd	115	6	S	Shale	Red beds	N	O	5/8/50	31.5	1305.0	1273.50	--
5 **	NW¼NW¼	U. S. G. S.	Dd	53	4	--	Sand	Terrace deposits	--	--	--	25.2	1308.5	1283.3	1255.5
7	NE cor.	City of Enid	Dd	66	4	--	--	Terrace deposits	--	--	--	60.0	1299.6	1239.6	1233.6
9 **	NW cor.	U. S. G. S.	Dd	43	4	--	Clay	Terrace deposits	--	--	--	27.5	1295.2	1267.7	1262.2
10-1 **	NE cor.	U. S. G. S.	Dd	38	4	--	Clay	Terrace deposits	--	--	--	18.7	1318.8	1300.1	1285.8
10-2	SE cor.	I. Fyffe	Dd	71	4	S	--	--	N	O	2/28/50	22.64	1313.4	1290.76	--
13	NW¼NW¼	W. D. Fyffe	Dd	53	6-2	S	--	--	N	O	4/7/50	34.68	1274.5	1239.82	--
14-1	SW¼SW¼	George Crow	Dd	103	4	G I	Shale	Red beds	N	O	5/9/50	25.57	1307.4	1281.83	--
14-2 **	NE cor.	U. S. G. S.	Dd	54	4	--	Sand	Terrace deposits	--	--	--	32.1	1283.4	1251.3	1235.4
15 **	NW cor.	U. S. G. S.	Dd	59	4	--	Sand	Terrace deposits	--	--	--	32.0	1314.6	1282.6	1255.6
19-1	NE cor.	City of Enid	Dd	53	--	--	--	Terrace deposits	--	--	--	42.0	1251.5	1209.5	1198.5
19-2	NW¼NE¼	U. S. G. S.	B	13	1¼	I	--	Terrace deposits	N	N	7/6/50	8.69	1224.3	1215.61	--
20-1	NE cor.	City of Enid	Dd	56	--	--	--	Terrace deposits	--	--	--	34.0	1250.5	1216.5	1194.0
20-2 *	SE cor.	Ned Woods	Dg	49	24	C	Sand, gravel	Terrace deposits	N	O	1/30/50	19.90	1234.6	1214.70	--
20-3 **	SE cor.	U. S. G. S.	Dd	95	4	--	Sand, gravel	Terrace deposits	--	--	4/18/51	20.28	1234.2	1213.92	1142.2
22-1 **	NW cor.	City of Enid	Dd	40	--	--	Sand	Terrace deposits	--	--	--	--	1283.8	--	--
22-2	SW cor. NW¼	City of Enid	Dd	178	2	S	Shale	Red beds	N	O	4/6/50	31.59	1272.7	1241.11	--
22-3	SW cor. NW¼	City of Enid	Dd	31	2	S	--	--	N	O	5/25/50	21.90	1273.2	1251.30	--

Table 7.--Records of wells, test holes, and shot holes in parts of Alfalfa, Garfield, Kingfisher, and Major Counties, Okla.

Well no: well-numbering system described on p. 6 and 7.
* Chimical Analysis shown in Table 5.
** Well logs listed in appendix B.
Type: Dd, drilled; Dn, driven; B, bored; Dg, dug.
Type of casing: B, brick; C, concrete; G I, galvanized iron; I, iron; R, rock; S, steel; T, tile.

Pump: C, cylinder; Cf, centrifugal; J, jet; N, none; S, suction; T, turbine.
Power: B, butane; E, electric; G, gasoline; H, hand; P, propane; S, steam; W, wind.
Use of water: D, domestic; I, irrigation; In, industrial; N, none; O, observation; P, public supply; S, stock.

Well no.	Location	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Type of Casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Pump and power	Use of water	Date of measurement	Depth below land surface (feet)	Altitude above mean sea level (feet): Land surface	Altitude above mean sea level (feet): Water surface	Altitude above mean sea level (feet): Red bed surface
21N9W-22-4 **	SW cor. NW¼	City of Enid	Dd	171	2	S	Sand, shale	Red beds	—	—	—	—	1275.2	—	1228.2
22-5 **	SW cor. NW¼	City of Enid	Dd	184	36	S	Shale	Red beds	—	—	—	—	—	—	—
22-6 **	NW cor. SW¼	City of Enid	Dd	45	—	—	Sand	Terrace deposits	—	—	—	—	1275.2	—	—
23-1 **	NE cor. NW¼	City of Enid	Dd	130	—	—	Shale	Red beds	—	—	—	39.7	1310.0	1270.3	1280.0
23-2 **	SW cor. NW¼	City of Enid	Dd	140	—	—	Sand, shale	Red beds	—	—	—	—	—	—	—
24-1 *	SE cor. SW¼	City of Enid	Dd	191	12	S	Sand, shale	Red beds	T, B	P	2/17/50	13.75	1251.5	1237.75	1060.50
24-5 ** **	SE¼SE¼	George E. Failing Co.	Dd	194	—	S	Sand, shale	Red beds	—	—	—	4.10	1237.9	1233.80	1207.9
25-1	NE¼NE¼	City of Enid	Dd	—	—	—	—	—	—	—	—	—	1256.5	—	1206.5
25-2	SE¼NE¼	W. L. Summers	Dd	126	6-2	—	Shale	Red beds	C, W	S, O	2/27/50	15.82	1249.9	1234.08	—
25-3	SW¼SW¼	Mrs. Bessie Turner	—	24	3	G I	—	—	C, H	O	4/10/50	18.85	1269.5	1250.65	—
25-4 **	NW cor	City of Enid	Dd	120	—	—	Sand, shale	Red beds	—	—	—	—	1288.0	—	1238.0
25-5	SE¼SE¼	Mrs. Oscar Turner	Dg	31	36	B	—	Terrace deposits	C,W,E	D, S	5/10/50	20.07	—	—	—
27-1 **	SW¼SW¼	City of Enid	Dd	62	6	G I	Gravel	Terrace deposits	N	C	7/5/50	30.58	1239.7	1209.12	1179.7
27-2 **	SE¼SE¼	City of Enid	Dd	—	—	—	Sand, clay	Terrace deposits	—	—	—	—	1270.0	—	1250.0
27-3 **	NW¼SW¼	City of Enid	Dd	—	—	—	Sand, clay	Terrace deposits	—	—	—	—	—	—	—
27-4 **	SW¼SW¼	City of Enid	Dd	—	—	—	Clay	Terrace deposits	—	—	—	—	—	—	—
28-1 *	SE¼SE¼	City of Enid	Dg	59	12	S	—	Terrace deposits	T, E	P	—	—	—	—	—
28-2 **	SE¼SE¼	City of Enid	Dd	70	—	—	Sand	Terrace deposits	—	—	—	24.5	1230.0	1205.5	1170.0
28-3	NE cor.	City of Enid	Dd	30	—	—	—	Terrace deposits	—	—	—	22.0	1261.2	1239.2	1231.2
28-4	SE¼SE¼	City of Enid	Dd	59	2	S	—	Terrace deposits	N	O	—	—	1235.6	1204.99	—
28-5	SE¼SE¼	City of Enid	Dd	63	6	G I	—	Terrace deposits	N	O	7/5/50	25.17	1232.6	1207.43	—
29-1 *	SE¼NW¼	E. D. Reynolds	Dd	48	1¼	—	Gravel	Terrace deposits	C, W	D	—	—	—	—	—
29-2	NE cor.	City of Enid	Dd	54.5	—	—	—	Terrace deposits	—	—	—	21.0	1233.8	1212.8	1179.3
30-1	NE cor.	City of Enid	Dd	47	—	—	—	—	—	—	—	29.0	1235.0	1206.0	1188.0
30-2	NE cor. NW¼	City of Enid	Dd	50	—	—	—	—	—	—	—	18.0	1220.7	1202.7	1170.7
30-3	NW¼NE¼	U. S. G. S.	Bd	21	1¼	I	Sand	Terrace deposits	N	O	7/6/50	13.35	1216.9	1203.15	—
31-1	NE cor.	City of Enid	Dd	50	—	—	—	Terrace deposits	—	—	—	12.0	1205.7	1193.7	1155.7
31-2	NE cor. NW¼	City of Enid	Dd	42	—	—	—	—	—	—	—	11.0	1217.8	1206.8	1175.8
31-3	NE¼NE¼	Detrick	Dd	43	4	S	—	—	N	O	4/17/50	37.73	1201.1	1163.37	—
31-4	SE cor.	J. A. Pierce	—	19	5½	G I	Sand	Terrace deposits	N	O	4/17/50	5.42	1185.9	1180.48	—
31-5	NW¼NW¼	H. S. Horsington	—	10	30	B	—	Terrace deposits	C, W	S	4/17/50	6.94	—	1202.1	—
32-1	NE cor. NW¼	City of Enid	Dd	29	—	—	—	Terrace deposits	—	—	—	13.0	1215.1	1202.1	1186.1
32-2	SE¼SW¼	C. W. Webber	Dd	—	42-6	S	Gravel	Terrace deposits	Cf, E	I	5/17/50	18.52	—	—	—
32-3 **	NE¼SW¼	Town of Ames	Dd	37	4	—	Sand, gravel	Terrace deposits	—	—	—	—	1213.9	—	1176.9
32-4 **	SE¼SW¼	Town of Ames	Dd	37	4	—	Sand	Terrace deposits	—	—	—	—	1210.5	—	1173.5
32-5 **	SE¼SW¼	Town of Ames	Dd	46	4	—	Sand, gravel	Terrace deposits	—	—	—	—	1205.8	—	1159.8
32-6 **	SE¼SW¼	Town of Ames	Dd	53	4	—	Gravel	Terrace deposits	—	—	—	—	1210.4	—	1157.4
32-7 **	SE¼SW¼	Town of Ames	Dd	51	4	—	Sand, gravel	Terrace deposits	—	—	—	—	1211.4	—	1160.4
32-8 **	SW¼SE¼	City of Enid	Dd	45	12	S	Sand, gravel	Terrace deposits	—	—	—	21.5	1220.0	1198.5	1175.0
32-9 **	NE¼SE¼	City of Enid	Dd	60	—	—	Gravel	Terrace deposits	—	—	—	26.0	1224.0	1198.0	1169.0
33-1 *	NE¼NE¼	A. L. Turner	Dn	53	1¼	—	Gravel	Terrace deposits	C, G	S	—	—	—	—	—
33-2 **	SW¼NE¼	City of Enid	Dd	60	—	—	Gravel	Terrace deposits	—	—	—	—	1225.0	—	1170.0
33-3 **	SW¼NW¼	City of Enid	Dd	55	—	—	Sand, gravel	Terrace deposits	—	—	—	—	1229.0	—	1174.0
33-4	NE cor.	City of Enid	Dd	65	—	—	—	—	—	—	—	33.0	1234.0	1201.0	1169.0
36-1	SW¼NW¼	Ezra Gregory	Dd	102	2	S	—	Red beds	N	O	4/11/50	43.57	1285.8	1242.23	—
36-2 **	SW cor.	U. S. G. S.	Dd	43	4	—	Clay	Terrace deposits	—	—	—	30.0	1264.5	1234.5	1232.5
T.21N., R.10W.															
21N10W-3	NE¼NE¼	Glenn Johnson	Dd	165	8	S	Sand	Red beds	N	N	5/23/50	36.73	1262.8	1226.07	—
4-1 *	SE¼SE¼	E. Palmer	Dn	55	—	S	Gravel	Terrace deposits	—	D	—	—	—	—	—
4-2	NE cor.	City of Enid	Dd	3	—	—	—	—	—	—	—	—	1226.6	—	1223.6
5 *	NW¼NE¼	Pete Straw	Dn	42	2	—	Gravel	Terrace deposits	C, W	D	—	—	—	—	—
6-1	NE cor.	City of Enid	Dd	48	—	—	—	—	—	—	—	33.0	1263.4	1230.4	1215.4
6-2	NW cor.	—	Dd	—	—	—	—	—	—	—	—	—	1260.0	—	1208.0
6-3	SW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1260.0	—	1212.0
6-4	NW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1260.0	—	1212.0
6-5	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1252.0	—	1214.0
6-6	SW cor.	—	Dd	—	—	—	—	—	—	—	—	—	1249.0	—	1213.0
7-1	NE cor.	City of Enid	Dd	51	—	—	—	—	—	—	—	26.0	1241.4	1215.4	1190.4
7-2	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1244.0	—	1210.0
7-3	SW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1219.0	—	1167.0
7-4	NW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1215.0	—	1160.0
7-5	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1206.0	—	1158.0
7-6	NE cor. SW¼	City of Enid	Dd	41	—	—	—	—	—	—	—	20.0	1230.3	1210.3	1189.3

Table 7.--Records of wells, test holes, and shot holes in parts of Alfalfa, Garfield, Kingfisher, and Major Counties, Okla.

Well no: well-numbering system described on p. 6 and 7.
* Chemical Analysis shown in [illegible]
** Well logs listed in appendix B.
Type: Dd, drilled; Dn, driven; B, bored; Dg, dug.
Type of casing: B, brick; C, concrete; G I, galvanized iron; I, iron; R, rock; S, steel; T, tile.

Pump: C, cylinder; Cf, centrifugal; J, jet; N, none; S, suction; T, turbine.
Power: B, butane; E, electric; G, gasoline; H, hand; P, propane; S, steam; W, wind.
Use of water: D, domestic; I, irrigation; In, industrial; N, none; O, observation; P, public supply; S, stock.

Well no.	Location	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Pump and power	Use of water	Date of measurement	Depth below land surface (feet)	Altitude above mean sea level (feet): Land surface	Altitude above mean sea level (feet): Water surface	Altitude above mean sea level (feet): Red bed surface
21N10W-8	NE cor. NW¼	City of Enid	Dd	5	—	—	—	—	—	—	—	—	1241.1	—	1236.1
10 **	SE cor.	U. S. G. S.	Dd	80	4	—	Sand, clay, gravel	Terrace deposits	—	—	—	30.8	1247.8	1217.0	1167.8
12-1	NW¼NW¼	S. H. Black	Dd	124	5	S	Gravel	Terrace deposits	N	O	4/18/50	33.73	1262.0	1228.27	—
12-2 **	NW cor.	U. S. G. S.	Dd	82	4	—	Sand, gravel	Terrace deposits	—	—	—	48.7	1269.7	1221.0	1187.7
12-3 **	SE cor.	U. S. G. S.	Dd	53	1½	I	Gravel	Terrace deposits	N	O	—	40.4	1262.1	1221.7	1179.1
16-1 *	SW¼SW¼	J. J. Kennedy	Dd	39	10	S	Gravel	Terrace deposits	T, G	I	—	23.98	1220.1	1196.12	—
16-2 **	SW¼SW¼	U. S. G. S.	Dd	45	4	—	Gravel	Terrace deposits	—	—	—	—	1214.8	—	1174.8
17	NE cor.	City of Enid	Dd	6	—	—	—	Terrace deposits	—	—	—	5.0	1216.1	1211.1	1210.1
18-1	NE cor.	City of Enid	Dd	31	—	—	—	—	—	—	—	19.0	1227.5	1208.5	1196.5
18-2	NW cor.	—	Dd	—	—	—	—	—	—	—	—	—	1204.0	—	1152.0
18-3	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1199.0	—	1167.0
18-4	SW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1197.0	—	1152.0
18-5	NW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1186.0	—	1142.0
18-6	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1185.0	—	1143.0
19	NE cor. NW¼	City of Enid	Dd	22	—	—	—	—	—	—	—	4.0	1169.6	1165.6	1147.6
20-1	NE cor.	City of Enid	Dd	30	—	—	—	—	—	—	—	17.0	1211.6	1194.6	1181.6
20-2	NE cor. NW¼	City of Enid	Dd	19	—	—	—	—	—	—	—	15.0	1175.1	1160.1	1156.1
20-3	NW¼NW¼	City of Enid	Dd	9	—	—	—	—	—	—	—	—	1175.1	—	1166.1
21-1 *	SW cor SE¼	W. H. Winfree	Dn	14	1½	—	Gravel	Terrace deposits	C, W	S	—	—	—	—	—
21-2	NE cor.	City of Enid	Dd	35	—	—	—	—	—	—	—	27.0	1236.0	1209.0	1201.0
21-3	SW¼SW¼	City of Enid	Dd	14	—	—	—	—	—	—	—	12.0	1158.5	1146.5	1144.5
21-4	SE cor.	N. A. Morris	Dg	41	24	C	Gravel	Terrace deposits	N	O	1/30/50	21.11	1213.6	1192.49	1173.6
22	NE cor.	City of Enid	Dd	46	—	—	—	—	—	—	—	36.0	1245.6	1209.6	1199.6
24 **	NW cor.	U. S. G. S.	Dd	53	1½	I	Gravel	Terrace deposits	N	O	7/6/50	34.71	1247.9	1213.19	1194.9
25	NE cor.	City of Enid	Dd	44	—	—	—	—	—	—	—	32.0	1229.5	1197.5	1185.5
26 *	NE¼NW¼	Clifford Mason	Dn	51	1½	—	Gravel	Terrace deposits	C, E	D	—	—	—	—	—
27	NE cor.	City of Enid	Dd	47	—	—	—	—	—	—	—	37.0	1242.0	1205.0	1195.0
28	NW¼NW¼	City of Enid	Dd	16	—	—	—	—	—	—	—	2.5	1157.5	1155.0	1141.5
34	NE cor.	City of Enid	Dd	45	—	—	—	—	—	—	—	35.0	1224.9	1189.9	1179.9
36	NE cor.	City of Enid	Dd	41	—	—	—	—	—	—	—	12.0	1211.0	1199.0	1170.0
T.21N., R.11W.															
21N11W-1	NE ¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1260.0	—	1210.0
2	NE cor.	City of Enid	Dd	50	—	—	—	—	—	—	—	25.0	1262.7	1237.7	1212.7
5-1	S½NW¼	City of Fairview	Dd	40	14-16	S	Gravel	Alluvium	T, E	P	—	—	—	—	—
5-2	S½NW¼	City of Fairview	Dd	40	14-16	S	Gravel	Alluvium	T, E	P	—	—	—	—	—
12-1 *	SW¼SW¼	R. M. & J. W. Scannell	Dd	60	8	S	Gravel	Terrace deposits	C, E	D, S	—	—	—	—	—
12-2	NE cor.	City of Enid	Dd	34	—	—	—	—	—	—	—	25.0	1244.3	1219.3	1210.3
12-3	SW¼SW¼	J. W. Scannell	Dd	60	8	S	Gravel	Terrace deposits	T, P	I	—	—	—	—	—
12-4	NE cor. NW¼	City of Enid	Dd	30	—	—	—	—	—	—	—	18.0	1234.6	1226.6	1204.6
12-5	NE cor. SE¼	City of Enid	Dd	58	—	—	—	—	—	—	—	25.0	1215.4	1190.4	1157.4
13-1	NE cor.	City of Enid	Dd	53	—	—	—	—	—	—	—	20.0	1208.6	1188.6	1155.6
13-2	NE cor. SE¼	City of Enid	Dd	39	—	—	—	—	—	—	—	15.0	1192.7	1177.7	1153.7
14-1	NE cor.	City of Enid	Dd	57	—	—	—	—	—	—	—	21.0	1212.0	1191.0	1155.0
14-2	NE cor. SE¼	City of Enid	Dd	35	—	—	—	—	—	—	—	14.0	—	—	—
24	NE cor.	City of Enid	Dd	32	—	—	—	—	—	—	—	14.0	1182.7	1168.7	1150.7
T.22N., R.8W.															
22N8W-18 *	NE¼NE¼	M. W. Wood	Dg	40	42	B	Sand	Terrace deposits	J, E	D	—	—	—	—	—
T.22N., R.9W.															
22N9W-17 *	NE¼NE¼	R. A. Mueller	Dd	80	8	G I	Shale	Red beds	E	D	—	—	—	—	—
T.22N., R.10W.															
22N10W-4 **	NW cor.	U. S. G. S.	Dd	43	4	—	Clay	Terrace deposits	—	—	—	22.3	1365.7	1343.4	1328.7
7 **	NE cor.	U. S. G. S.	Dd	95	4	—	Sand	Terrace deposits	—	—	—	31.7	1363.4	1331.7	1275.4
9 **	SW cor.	U. S. G. S.	Dd	37	4	—	Clay	Terrace deposits	—	—	—	22.3	1312.6	1290.3	1275.6
14-1 *	NW cor.	O. W. Campbell	Dd	184	6-4	S	Shale	Red beds	J, E	D	—	—	—	—	—
14-2 *	SW¼SW¼	A. L. McFaden	Dd	206	6	S	Shale	Red beds	T, E	P	—	—	—	—	—
16 *	SE¼	Henry Stricklin	Dn	43	1½	—	—	Terrace deposits	C, W	S	—	—	—	—	—
17	SE¼SE¼	C. A. Dittrick	Dg	40	6	G I	Sand	Terrace deposits	N	O	7/3/50	31.77	1304.0	1272.23	—
18-1	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1351.0	—	1269.0
18-2	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1341.0	—	1264.0
18-3	SW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1342.0	—	1270.0
18-4	NW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1334.0	—	1264.0
18-5	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1334.0	—	1264.0
19 **	NE cor.	U. S. G. S.	Dd	80	1½	S	Gravel	Terrace deposits	N	O	7/6/50	38.87	1312.1	1273.23	1233.2

Table 7.--Records of wells, test holes, and shot holes in parts of Alfalfa, Garfield, Kingfisher, and Major Counties, Okla.

Well no: well-numbering system described on p. 6 and 7.
* Chemical Analysis shown in Table 5.
** Well logs listed in appendix B.
Type: Dd, drilled; Dn, driven; B, bored; Dg, dug.
Type of casing: B, brick; C, concrete; G I, galvanized iron; I, iron; R, rock; S, steel; T, tile.

Pump: C, cylinder; Cf, centrifugal; J, jet; N, none; S, suction; T, turbine.
Power: B, butane; E, electric; G, gasoline; H, hand; P, propane; S, steam; W, wind.
Use of water: D, domestic; I, irrigation; In, industrial; N, none; O, observation; P, public supply; S, stock.

Well no.	Location	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Pump and power	Use of water	Date of measurement	Depth below land surface (feet)	Altitude above mean sea level (feet): Land surface	Altitude above mean sea level (feet): Water surface	Altitude above mean sea level (feet): Red bed surface
22N10W-25 **	NW cor.	U. S. G. S.	Dd	64	4	—	Sand	Terrace deposits	—	—	—	23.5	1307.8	1284.3	—
28	NE cor.	City of Enid	Dd	5	—	—	—	—	—	—	—	—	1252.7	—	1247.7
29 **	NE cor.	U. S. G. S.	Dd	69	1½	I	Gravel	Terrace deposits	N	O	7/6/50	35.92	1294.9	1258.98	1225.9
30-1	SW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1315.0	—	1243.0
30-2	SW cor. NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1302.0	—	1250.0
30-3	NW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1297.0	—	1245.0
31-1	NE cor.	City of Enid	Dd	60	—	—	—	—	—	—	—	—	1290.6	—	1230.6
31-2	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1278.0	—	1226.0
31-3	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1275.0	—	1206.0
31-4	SW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1269.0	—	1199.0
34 **	SE cor.	U. S. G. S.	Dd	64	4	—	Gravel	Terrace deposits	—	—	—	45.0	1270.0	1225.0	1211.0
35	NE¼NW¼	Glenn Hays	Dd	50	18	T	Gravel	Terrace deposits	N	O	6/19/50	34.20	1263.1	1228.90	—
36 **	NE cor.	U. S. G. S.	Dd	47	4	—	Sand	Terrace deposits	—	—	—	35.1	1317.4	1282.3	1270.4
T.22N., R.11W.															
22N11W-1-1	NE¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1403.0	—	1347.0
1-2	SE¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1388.0	—	1338.0
1-3	NE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1389.0	—	1342.0
1-4	NE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1375.0	—	1333.0
1-5	SE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1375.0	—	1330.0
3 **	SW cor.	U. S. G. S.	Dd	67	—	—	Gravel	Terrace deposits	—	—	—	22.1	1333.5	1311.4	1266.5
5-1	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1319.0	—	1247.0
5-2	SW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1326.0	—	1253.0
5-3	NW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1318.0	—	1254.0
5-4	NW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1312.0	—	1240.0
5-5	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1309.0	—	1257.0
6	NE cor. NW¼	City of Enid	Dd	47	—	—	—	—	—	—	—	26.0	1304.1	1278.1	1257.1
7-1	NE cor.	City of Enid	Dd	41	—	—	—	—	—	—	—	26.0	1308.3	1282.3	1267.3
7-2 **	NW¼NE¼	City of Fairview	Dd	—	—	—	—	—	—	—	—	—	1304.8	—	1251.8
7-3 **	NW¼NW¼	City of Fairview	Dd	45	—	—	—	—	—	—	—	25.0	1300.5	1275.5	1255.5
8-1 *	SE¼NW¼	Lloyd Weaver	Dn	62	1¼	—	Gravel	Terrace deposits	C, H	D	—	—	—	—	—
8-2 **	N½ cor.	City of Fairview	Dd	70	—	—	—	—	—	—	—	32.0	1316.0	1284.0	1246.0
8-3	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1307.0	—	1259.0
8-4	SW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1308.0	—	1246.0
8-5	SW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1306.0	—	1244.0
8-6	NW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1304.0	—	1246.0
8-7	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1300.0	—	1246.0
8-8	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1291.0	—	1243.0
8-9	SE¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1295.0	—	1245.0
8-10	SW¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1289.0	—	1244.0
8-11	SW¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1299.0	—	1251.0
8-12	SE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1306.0	—	1244.0
9-1 **	NE cor.	City of Fairview	Dd	64	—	—	—	—	—	—	—	25.0	1326.1	1301.1	1262.1
9-2 **	N½ cor.	City of Fairview	Dd	58	—	—	—	—	—	—	—	21.0	1317.8	1296.8	1259.8
9-3 **	NW cor.	City of Fairview	Dd	56	—	—	—	—	—	—	—	18.5	1308.3	1289.8	1252.3
9-4 **	E½ cor.	City of Fairview	Dd	65	—	—	—	—	—	—	—	31.5	1329.8	1298.3	1264.8
9-5 **	SE cor.	City of Fairview	Dd	60	—	—	—	—	—	—	—	27.0	1320.6	1293.6	1260.6
9-6	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1300.0	—	1238.0
9-7	SE¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1320.0	—	1248.0
9-8	SE¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1322.0	—	1250.0
9-9	SW¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1318.0	—	1254.0
9-10	SE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1319.0	—	1257.0
10-1	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1323.0	—	1264.0
10-2	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1327.0	—	1269.0
10-3	SE¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1331.0	—	1269.0
10-4	SW¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1335.0	—	1283.0
10-5	SE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1333.0	—	1275.0
11-1	NE cor.	City of Enid	Dd	52	—	—	—	—	—	—	—	37.0	1350.4	1313.4	1298.4
11-2	SW cor.	—	Dd	—	—	—	—	—	—	—	—	—	1332.0	—	1262.0
11-3	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1336.0	—	1270.0
11-4	SE¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1337.0	—	1269.0
11-5	SW¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1347.0	—	1280.0
11-6	SE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1344.0	—	1278.0
11-7	SE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1342.0	—	1277.0

Table 7.--Records of wells, test holes, and shot holes in parts of Alfalfa, Garfield, Kingfisher, and Major Counties, Okla.

Well no: well-numbering system described on p. 6 and 7.
* Chemical Analysis shown in Table 5.
** Well logs listed in appendix B.
Type: Dd, drilled; Dn, driven; B, bored; Dg, dug.
Type of casing: B, brick; C, concrete; G I, galvanized iron; I, iron; R, rock; S, steel; T, tile.

Pump: C, cylinder; Cf, centrifugal; J, jet; N, none; S, suction; T, turbine.
Power: B, butane; E, electric; G, gasoline; H, hand; P, propane; S, steam; W, wind.
Use of water: D, domestic; I, irrigation; In, industrial; N, none; O, observation; P, public supply; S, stock.

Well no.	Location	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Pump and power	Use of water	Date of measurement	Depth below land surface (feet)	Altitude above mean sea level (feet): Land surface	Altitude above mean sea level (feet): Water surface	Altitude above mean sea level (feet): Red bed surface
22N11W-12-1	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1342.0	—	1276.0
12-2	SE¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1342.0	—	1277.0
12-3	SW¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1339.0	—	1277.0
12-4	SW¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1341.0	—	1261.0
12-5	SE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1340.0	—	1260.0
12-6	SE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1354.0	—	1286.0
12-7	NE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1356.0	—	1288.0
12-8	SE¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1363.0	—	1301.0
12-9	SE¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1368.0	—	1306.0
12-10	NE¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1370.0	—	1318.0
14-1 *	NE¼	A. M. Watkins	Dn	—	1½	—	—	Terrace deposits	C, W	D, S	—	—	—	—	—
14-2	NE cor.	City of Enid	Dd	61	—	—	—	Terrace deposits	—	—	—	45	1345.8	1300.8	1284.8
16-1 **	NE¼NW¼	City of Fairview	Dd	69	—	—	—	Terrace deposits	—	—	—	32	1314.9	1282.9	1245.9
16-2 **	E¼ cor.	City of Fairview	Dd	62	—	—	—	Terrace deposits	—	—	—	30	1314.8	1284.8	1252.8
17-1 **	NW¼NW¼	City of Fairview	Dd	50	—	—	—	Terrace deposits	—	—	—	17	1291.6	1274.6	1241.6
17-2 **	NW¼NE¼	City of Fairview	Dd	52	—	—	—	Terrace deposits	—	—	—	16	1297.2	1281.2	1245.2
17-3 **	N¼ cor.	City of Fairview	Dd	46	—	—	—	Terrace deposits	—	—	—	10	1287.25	1277.25	1241.25
17-4	NW¼NW¼	Ed Hilderbrand	Dn	41	1½	S	—	Terrace deposits	Cf, G	I	—	—	—	—	—
17-5 **	W¼ cor.	City of Fairview	Dd	32	—	—	—	Terrace deposits	—	—	—	13	1271.2	1258.2	1239.2
17-6	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1289	—	1235
17-7	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1287	—	1239
17-8	SW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1281	—	1236
17-9	NW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1279	—	1233
17-10	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1292	—	1247
18-1	NE cor. NW¼	City of Enid	Dd	49	—	—	—	Terrace deposits	—	—	—	28	1297.6	1269.6	1248.6
18-2 **	NW cor.	City of Fairview	Dd	48	—	—	—	Terrace deposits	—	—	—	25	1290.3	1265.3	1242.3
18-3 **	NW¼NE¼	City of Fairview	Dd	44	—	—	—	Terrace deposits	—	—	—	18	1287.6	1269.6	1243.6
18-4 **	NW¼NW¼	City of Fairview	Dd	45	—	—	—	Terrace deposits	—	—	—	25	1289.8	1264.8	1244.8
19-1	NE cor.	City of Enid	Dd	37	—	—	—	Terrace deposits	—	—	—	25	1282.3	1257.3	1245.3
19-2	NE cor. NW¼	City of Enid	Dd	20	—	—	—	Terrace deposits	—	—	—	4	1262.6	1258.6	1242.6
19-3 **	NW¼NE¼	City of Fairview	Dd	28	—	—	—	Terrace deposits	—	—	—	18.5	1272.6	1254.1	1244.6
19-4 **	NW¼NW¼	City of Fairview	Dd	38	—	—	—	Terrace deposits	—	—	—	8	1260.4	1252.4	1222.4
20-1	NE cor.	City of Enid	Dd	63	—	—	—	Terrace deposits	—	—	—	40	1315.0	1275.0	1252.0
20-2**	NE cor.	City of Fairview	Dd	63	—	—	—	Terrace deposits	—	—	—	38	1298.7	1260.7	1235.7
20-3 **	NW¼NE¼	City of Fairview	Dd	67	—	—	—	Terrace deposits	—	—	—	42.5	1301.3	1258.8	1234.3
20-4 **	NW¼NW¼	City of Fairview	Dd	52	—	—	—	Terrace deposits	—	—	—	34	1290.0	1256.0	1238.0
20-5 **	W¼ cor.	City of Fairview	Dd	35	—	—	—	Terrace deposits	—	—	—	25	1275.2	1250.2	1240.2
20-6	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	128[illegible]	—	1237.0
20-7	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1288	—	1236
20-8	SW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1279	—	1231
20-9	NW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1278	—	1238
20-10	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1278	—	1233
20-11	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1275	—	1234
21-1	NE cor.	City of Enid	Dd	68	—	—	—	Terrace deposits	—	—	—	33	1310.4	1277.4	1242.4
21-2 **	NE cor.	City of Fairview	Dd	68	—	—	—	Terrace deposits	—	—	—	33	1309.4	1276.4	1241.4
21-3 **	N¼ cor.	City of Fairview	Dd	70	—	—	—	Terrace deposits	—	—	—	33	1306.6	1273.6	1236.6
21-4 **	E¼ cor.	City of Fairview	Dd	66	—	—	—	Terrace deposits	—	—	—	30	1303.3	1273.3	1237.3
21-5 **	NE cor. SW¼	City of Fairview	Dd	62	—	—	—	Terrace deposits	—	—	—	37	1299.0	1262.0	1237.0
21-6 **	SW¼SW¼	City of Fairview	Dd	59	—	—	—	Terrace deposits	—	—	—	41	1293.8	1252.8	1234.8
21-7 **	SE cor.	City of Fairview	Dd	60	—	—	—	Terrace deposits	—	—	—	34.5	1301.1	1266.6	—
21-8 **	SE¼SE¼	City of Fairview	Dd	62	—	—	—	Terrace deposits	—	—	—	31	1300.1	1269.1	1238.1
21-9 **	SE¼SE¼	City of Fairview	Dd	66	—	—	—	Terrace deposits	—	—	—	—	1299.4	—	1233.4
21-10**	SW¼SE¼	City of Fairview	Dd	73	—	—	—	Terrace deposits	—	—	—	48	1308.4	1260.4	1235.4
22-1 *	SE¼	H. P. Schroeder	Dn	67	1½	—	—	Terrace deposits	C	D	—	—	—	—	—
22-2 **	SW¼SW¼	City of Fairview	Dd	38	—	—	—	Terrace deposits	—	—	—	33.5	1299.2	1265.7	—
23	NE cor.	City of Enid	Dd	73	—	—	—	Terrace deposits	—	—	—	42	1328.7	1286.7	1255.7
24-1	NE¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1324	—	1256
24-2	NE¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1321	—	1249
24-3	SE¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1319	—	1249
24-4	NE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1318	—	1246
24-5	SE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1315	—	1245
25-1 *	SE¼SE¼	J. J. Balks	Dd	61	6	—	—	Terrace deposits	—	D, S	—	—	—	—	—
25-2	NE¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1316	—	1251

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Type: Dd, drilled; Dn, driven; B, bored; Dg, dug.
Type of casing: B, brick; C, concrete; G I, galvanized iron; I, iron; R, rock; S, steel; T, tile.

Pump: C, cylinder; Cf, centrifugal; J, jet; N, none; S, suction; T, turbine.
Power: B, butane; E, electric; G, gasoline; H, hand; P, propane; S, steam; W, wind.
Use of water: D, domestic; I, irrigation; In, industrial; N, none; O, observation; P, public supply; S, stock.

Well no.	Location	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Pump and power	Use of water	Date of measurement	Depth below land surface (feet)	Altitude above mean sea level (feet): Land surface	Altitude above mean sea level (feet): Water surface	Altitude above mean sea level (feet): Red bed surface
22N11W-25-3	SE¼SE¼	--	Dd	—	—	—	—	—	—	—	—	—	1288	—	1223
26-1	NE cor.	City of Enid	Dd	75	—	—	—	—	—	—	—	40	1313.4	1273.4	1238.4
26-2 **	SW cor.	U. S. G. S.	Dd	85	—	—	Sand	Terrace deposits	—	—	—	32.8	1277.7	1244.9	1196.7
28 **	NE¼NE¼	City of Fairview	Dd	39	—	—	—	—	—	—	—	34	1298.7	1264.7	—
29-1 **	W½ cor.	City of Fairview	Dd	34	—	—	—	—	—	—	—	17	1260.7	1243.7	1226.7
29-2	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1270	—	1230
29-3	SW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1266	—	1232
29-4	NW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1262	—	1227
29-5	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1257	—	1225
29-6	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1255	—	1222
29-7	SE¼SW¼	City of Fairview	Dd	38	14	S	Gravel	Terrace deposits	T, E	P	10/26/50	19.18	—	—	—
30-1	NE cor.	City of Enid	Dd	31	—	—	—	—	—	—	—	17	1274.7	1257.7	1243.7
30-2 **	NE cor.	City of Fairview	Dd	30	—	—	—	—	—	—	—	18	1265.3	1247.3	1235.3
30-3 **	NW¼NE¼	City of Fairview	Dd	28	—	—	—	—	—	—	—	20	1267.6	1247.6	1239.6
32-1 *	NE¼NW¼	City of Fairview	Dd	57	12	S	Gravel	Terrace deposits	T, E	P	—	—	—	—	—
32-2 **	NE cor.	City of Fairview	Dd	46	—	—	—	Terrace deposits	—	—	—	34	1274.9	1240.9	1228.9
32-3 **	NE¼NE¼	City of Fairview	Dd	44	—	—	—	Terrace deposits	—	—	—	32.5	1273.5	1241.0	1229.5
32-4 **	NW¼NE¼	City of Fairview	Dd	42	—	—	—	Terrace deposits	—	—	—	32	1272.7	1240.7	1230.7
32-5 **	NW¼NE¼	City of Fairview	Dd	42	—	—	—	—	—	—	—	30.5	1271.0	1240.5	1229.0
32-6 **	N¼ cor.	City of Fairview	Dd	41	—	—	—	—	—	—	—	27.5	1264.4	1236.9	1223.4
32-7 **	NE¼NW¼	City of Fairview	Dd	37	—	—	—	—	—	—	—	25.5	1256.3	1230.8	1219.3
32-8 **	NW¼NW¼	City of Fairview	Dd	28	—	—	—	—	—	—	—	19	1251.4	1232.4	1223.4
32-9 **	NW¼NW¼	City of Fairview	Dd	26	—	—	—	—	—	—	—	19.5	1253.0	1233.5	1227.0
32-10**	NW cor.	City of Fairview	Dd	27	—	—	—	—	—	—	—	18.5	1251.0	1232.5	1224.0
32-11	NE¼NW¼	City of Fairview	Dd	36	12	S	—	Terrace deposits	N	O	3/8/50	21.70	1264.7	1243.0	—
33-1 **	N¼ cor.	City of Fairview	Dd	50	—	—	—	—	—	—	—	37.5	1279.6	1242.1	1229.6
33-2 **	NW¼NE¼	City of Fairview	Dd	52	—	—	—	—	—	—	—	39	1282.5	1243.5	1230.5
34	NE cor.	City of Enid	Dd	81	—	—	—	—	—	—	—	36	1277.7	1241.7	1196.7
36-1	NE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1265	—	1199
36-2	SE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1261	—	1203
T.22N., R.12W.															
22N12W-1-1	NW¼NE¼	City of Enid	Dd	18	—	—	—	—	—	—	—	5	1253.6	1248.6	1235.6
1-2	NE cor. SE¼	City of Enid	Dd	26	—	—	—	—	—	—	—	13	1283.0	1270.0	1257.0
2-1	NE cor.	City of Enid	Dd	25	—	—	—	—	—	—	—	15	1242.6	1227.6	1217.6
2-2	SE¼NE¼	City of Enid	Dd	30	—	—	—	—	—	—	—	17.5	1241.0	1223.5	1211.0
2-3	NE cor. NW¼	City of Enid	Dd	29	—	—	—	—	—	—	—	13	1239.9	1226.9	1210.9
5	NE cor. SW¼	City of Enid	Dd	24	—	—	—	—	—	—	—	10	—	—	—
7	NE cor. NW¼	City of Enid	Dd	22	—	—	—	—	—	—	—	11	—	—	—
9	NE¼NE¼	City of Enid	Dd	24	—	—	—	—	—	—	—	5	1236.0	1231.0	1212.0
10	NE¼NE¼	City of Enid	Dd	36	—	—	—	—	—	—	—	13	1239.0	1226.0	1203.0
11-1	NW¼NE¼	City of Enid	Dd	12	—	—	—	—	—	—	—	—	1232.5	—	1220.5
11-2	NE cor. NW¼	City of Enid	Dd	33	—	—	—	—	—	—	—	20	1242.4	1222.4	1209.4
11-3	SE¼NW¼	City of Enid	Dd	19	—	—	—	—	—	—	—	9	1233.5	1224.5	1214.5
11-4	NE¼SE¼	City of Enid	Dd	25	—	—	—	—	—	—	—	13	1236.9	1223.9	1211.9
12-1	NE cor.	City of Enid	Dd	42	—	—	—	—	—	—	—	28	1301.6	1273.6	1259.6
12-2	NE cor. NW¼	City of Enid	Dd	29	—	—	—	—	—	—	—	23	1283.4	1260.4	1254.4
12-3 **	N¼ cor.	City of Fairview	Dd	30	—	—	—	—	—	—	—	22.5	1281.0	1258.5	1251.0
12-4 **	NW cor.	City of Fairview	Dd	21	—	—	—	—	—	—	—	14	1265.3	1251.3	1244.3
13-1	NE cor.	City of Enid	Dd	44	—	—	—	—	—	—	—	20	1290.0	1270.0	1246.0
13-2	NE cor. NW¼	City of Enid	Dd	42	—	—	—	—	—	—	—	20	1284.8	1264.8	1242.8
13-3 **	NW¼NW¼	City of Fairview	Dd	21	—	—	—	—	—	—	—	—	1266.4	—	1245.4
14	NE cor.	City of Enid	Dd	29	—	—	—	—	—	—	—	18	1254.4	1236.4	1225.4
15	NE cor.	City of Enid	Dd	25	—	—	—	—	—	—	—	8	1227.1	1219.1	1202.1
24	NE cor.	City of Enid	Dd	15	—	—	—	—	—	—	—	12	1276.3	1264.3	1261.3
T.23N., R.10W.															
23N10W-31-1	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1387	—	1347
31-2	SE¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1385	—	1340
31-3	SE¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1386	—	1342
31-4	SW¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1387	—	1347
31-5	SE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1387	—	1342
31-6	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1400	—	1346
31-7	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1398	—	1343
31-8	NW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1391	—	1349

Table 7.--Records of wells, test holes, and shot holes in parts of Alfalfa, Garfield, Kingfisher, and Major Counties, Okla.

Well no: well-numbering system described on p. 6 and 7.
* Chemical Analysis shown in Table 5.
** Well logs listed in appendix B.
Type: Dd, drilled; Dn, driven; B, bored; Dg, dug.
Type of casing: B, brick; C, concrete; G I, galvanized iron; I, iron; R, rock; S, steel; T, tile.

Pump: C, cylinder; Cf, centrifugal; J, jet; N, none; S, suction; T, turbine.
Power: B, butane; E, electric; G, gasoline; H, hand; P, propane; S, steam; W, wind.
Use of water: D, domestic; I, irrigation; In, industrial; N, none; O, observation; P, public supply; S, stock.

Well no.	Location	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Pump and power	Use of water	Date of measurement	Depth below land surface (feet)	Altitude above mean sea level (feet): Land surface	Altitude above mean sea level (feet): Water surface	Altitude above mean sea level (feet): Red bed surface
23N10W-31-9	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1389	—	1337
T.23N., R.11W.															
23N11W-6-1	NE cor.	City of Enid	Dd	42	—	—	—	—	—	—	—	17	1348.8	1331.8	1306.8
6-2	NW cor.	Roy Calhoun	B	26	6	G I	—	—	C, H	D, S	8/7/50	13.51	—	—	—
7 **	SE cor.	U. S. G. S.	Dd	95	4	—	Gravel	Terrace deposits	—	—	2/21/52	9.2	1339.9	1330.7	1251.9
8 **	NE cor.	U. S. G. S.	Dd	75	4	—	Sand	Terrace deposits	—	—	—	18.2	1365.9	1347.7	1292.9
21 **	NW¼NW¼	U. S. G. S.	Dd	80	4	—	Sand, gravel	Terrace deposits	—	—	—	20.5	1347.6	1327.1	1268.6
25-1	SE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1389	—	1349
25-2	SW¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1387	—	1349
25-3	SE¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1380	—	1348
25-4	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1376	—	1344
25-5	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1376	—	1346
26-1	SE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1367	—	1335
26-2	SW¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1363	—	1327
27-1	SW¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1346	—	1278
27-2	SE¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1346	—	1283
29	SE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1346	—	1268
30-1	NE cor.	City of Enid	Dd	41	—	—	—	—	—	—	—	—	1327.0	—	1286.0
30-2	NE¼NE¼	City of Enid	Dd	33	—	—	—	—	—	—	—	—	1322.6	—	1289.6
32-1	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1337	—	1255
32-2	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1339	—	1259
32-3	NE¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1337	—	1256
32-4	NW¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1344	—	1262
32-5	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1330	—	1258
32-6	SW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1331	—	1256
32-7	NW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1329	—	1257
32-8	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1324	—	1257
32-9	SW¼SW¼	—	Dd	—	—	—	—	—	—	—	—	—	1330	—	1255
33-1	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1339	—	1271
33-2	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1345	—	1272
33-3	NE¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1342	—	1271
33-4	NW¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	—	—	—
33-5	NE¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1349	—	1281
33-6	NE¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1347	—	1266
34-1	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1346	—	1281
34-2	NW¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1347	—	1270
34-3	NE¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1349	—	1269
35-1	NW¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1350	—	1275
35-2	NE¼NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1353	—	1301
35-3	NE cor. NW¼	—	Dd	—	—	—	—	—	—	—	—	—	1355	—	1307
36-1	SE¼NE¼	—	Dd	—	—	—	—	—	—	—	—	—	1394	—	1347
36-1	NE¼SE¼	—	Dd	—	—	—	—	—	—	—	—	—	1392	—	1354
T.23N., R.12W.															
23N12W-1-1	NE cor.	City of Enid	Dd	29	—	—	—	—	—	—	—	14	1319.6	1305.6	1290.6
1-2	NW¼NW¼	City of Enid	Dd	14	—	—	—	—	—	—	—	—	1279.7	—	1265.7
12	NE cor.	City of Enid	Dd	32	—	—	—	—	—	—	—	9	1319.3	1310.3	1287.3
13	NE cor.	City of Enid	Dd	26	—	—	—	—	—	—	—	11	1317.4	1306.4	1291.4
14-1 *	NW cor.	J. W. Elkins	Dd	48	12	T	Shale	Red beds	C, W	S	12/15/50	19.43	—	—	—
14-2	NE cor.	City of Enid	Dd	26	—	—	—	—	—	—	—	9	1277.2	1268.2	1251.2
15	SE¼SE¼	City of Enid	Dd	22	—	—	—	—	—	—	—	7	1261.5	1254.5	1239.5
23	NE cor.	City of Enid	Dd	37	—	—	—	—	—	—	—	12	1272.5	1260.5	1235.5
24	NE cor.	City of Enid	Dd	41	—	—	—	—	—	—	—	24	1323.0	1299.0	1282.0
25	NE cor.	City of Enid	Dd	39	—	—	—	—	—	—	—	19	1301.2	1282.2	1262.2
26-1	NE cor.	City of Enid	Dd	37	—	—	—	—	—	—	—	21	1257.5	1236.5	1220.5
26-2	NE cor. SE¼	City of Enid	Dd	13	—	—	—	—	—	—	—	—	1254.7	—	1241.7
27-1	NE cor.	City of Enid	Dd	19	—	—	—	—	—	—	—	12	1263.0	1251.0	1244.0
27-2	SW¼SE¼	City of Enid	Dd	41	—	—	—	—	—	—	—	18	1288.7	1270.7	1247.7
34	NE cor.	City of Enid	Dd	26	—	—	—	—	—	—	—	21	1282.1	1261.1	1256.1
35-1	NE cor.	City of Enid	Dd	32	—	—	—	—	—	—	—	13	1241.7	1228.7	1209.7
35-2	SE¼NE¼	City of Enid	Dd	10	—	—	—	—	—	—	—	—	1240.2	—	1230.2
35-3	NE cor. SW¼	City of Enid	Dd	19.5	—	—	—	—	—	—	—	16.5	1270.6	1254.1	1251.1
36-1	NE cor.	City of Enid	Dd	31	—	—	—	—	—	—	—	16	1288.3	1272.3	1257.3
36-2	NW¼NW¼	City of Enid	Dd	9	—	—	—	—	—	—	—	—	1241.7	—	1232.7

Appendix A.--Measured stratigraphic sections

Section of bedrock exposed in SE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 24, T. 19 N., R. 7 W.

	Ft.	in.
Clay, brown and gray.	4	
Shale, reddish-brown with greenish-gray spots, fissile, calcareous.		8
Shale, reddish-brown with greenish-gray spots, massive calcareous; shows conchoidal fracture.	3	
Shale, reddish-brown with greenish-gray spots, fissile, calcareous.	1	2
Shale, reddish-brown with greenish-gray spots, massive, calcareous; shows conchoidal fracture.	4	
Shale, reddish-brown with greenish-gray spots, fissile, calcareous.		6
Shale, reddish-brown with greenish-gray spots, massive, calcareous; shows conchoidal fracture	3	
Siltstone, reddish-brown with greenish-gray spots, argillaceous, massive, calcareous; shows blocky fracture		2
Shale, reddish-brown with greenish-gray spots, massive, calcareous; show conchoidal fracture	4	

Section of bedrock exposed in SW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 21, T. 21 N., R. 10 W.

	Ft.	in.
Shale, reddish-brown with greenish-gray spots, narrow bands of platy and fissile shale interbedded, calcareous; shows blocky to conchoidal fracture.	7	
Shale, reddish-brown with greenish-gray spots, silty, thin-bedded, calcareous.		8
Shale, reddish-brown with greenish-gray spots, calcareous; shows conchoidal fracture.	2	
Shale, mottled, reddish-brown and light-greenish-gray, silty, calcareous.		10
Siltstone, light-greenish-gray, massive		6
Siltstone, light-greenish-gray; platy, calcareous		6
Shale, reddish-brown with greenish-gray spots, silty, calcareous.		6
Siltstone, light greenish-gray, massive, calcareous; shows blocky fracture.	1	3
Siltstone, mottled, reddish-brown and greenish-gray, argillaceous, calcareous		3
Shale, reddish-brown with greenish-gray spots, massive, calcareous; shows conchoidal fracture.		4
Siltstone, reddish-brown with greenish-gray spots, argillaceous, calcareous		1

Section of bedrock exposed in $SW\frac{1}{4}SW\frac{1}{4}$ sec. 21, T. 21 N., R. 10 W. Continued

	Ft.	in.
Shale, reddish-brown with greenish-gray spots, massive, calcareous; shows conchoidal fracture.	4	
Siltstone, reddish-brown with greenish-gray spots, argillaceous, calcareous; shows blocky fracture.		6
Shale, reddish-brown with greenish-gray spots, silty, calcareous; shows blocky to conchoidal fracture.	2	
Siltstone, reddish-brown with greenish gray spots, argillaceous, calcareous		2
Shale, reddish-brown with greenish-gray spots, silty, platy, calcareous.	5+	

Section of alluvium in $SE\frac{1}{4}SW\frac{1}{4}$ sec. 17, T. 21 N., R. 8 W.

Clay, brown to reddish-brown, sandy; shows earthy fracture; calcareous concretions	3	
Clay, grayish-brown, calcareous; shows earthy fracture		4
Sand, brown, very fine, silty, argillaceous, calcareous		2
Clay, grayish-brown, sandy; shows earthy fracture; calcareous concretions	1	
Clay, reddish-brown, sandy; shows earthy fracture; calcareous concretions	2	
Clay, gray, plastic; calcareous concretions	1	

Section of terrace deposits in $SE\frac{1}{4}$ sec. 22, T. 22 N. R. 8 W.

Soil and clay, gray to grayish-brown.	2	
Clay, reddish-brown, porous, some carbonized plant remains; contains pebble and sand lenses	10	
Sand, black, friable, conglomeratic		1-6
Sand, brownish-orange on weathered surface, dark-reddish-brown on fresh surface, argillaceous; contains some disseminated gravel.	5	
Clay, brownish-orange, sandy.	3	

Appendix B: Logs of Test Holes and Wells

The logs on the following pages record the materials penetrated in the drilling of 182 test holes and wells. All the logs are of test holes except those for wells 19N7W-30-2, 21N8W-19-1, and 21N9W-24-1. They are arranged by townships, south to north and ranges, east to west. Within a township they are arranged by section number and by serial number within the section. Those logs described as sample logs were made by field and microscopic analysis of the drill cuttings by Joseph E. Barclay. Those logs described as drillers' logs were made by field analysis of the drill cuttings by the well driller. The altitudes refer to ground level at the mouth of the hole and are in feet above mean sea level.

17N7W-12-1. 1,432 feet east and 390 feet north of SW cor. Driller's log supplied by Kingfisher Water Co.

	Thickness (feet)	Depth (feet)
Sand	8	8
Sand, fine	9	17
Sand, fine; gravel, fine	5	22
Sand, coarse; gravel, fine	8	30
Gravel, fine	2	32
Gravel, coarse	3	35
Red beds	-	--

17N7W-12-2. 1,432 feet east and 890 feet north of SW cor. Driller's log supplied by Kingfisher Water Co.

Sand, red	6	6
Sand, very fine	10	16
Sand, white; gravel, fine	9	25
Sand, coarse	3	28
Sand, very coarse	5	33
Red beds	--	--

17N7W-12-3. 1,432 feet east and 1,390 feet north of SW cor. Driller's log supplied by Kingfisher Water Co.

Sand	5	5
Sand, very fine	4	9
Sand, coarse; gravel, fine	16	25
Sand, very coarse; gravel, coarse	6	31
Red beds	--	--

18N7W-1-3. N$\frac{1}{4}$ cor. Altitude, 1,180. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

Clay, red	10	10
Clay, red; shale	20	30
Sand, red	6	36
Sandstone, red	10	46

18N7W-1-4. S$\frac{1}{4}$ cor. Altitude, 1,107.3. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

Soil, sandy	10	10
Clay, sandy	8	18
Clay	0.5	18.5
Sand, coarse, water-bearing	10.5	29
Shale	--	--

18N7W-1-5. SE cor. Altitude, 1,136.5. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

Sand	20	20
Clay, sandy	20	40
Clay	15	55

18N7W-8-1. Altitude, 1,137.5. 50 feet south and 15 feet west of NE cor. Sample log.

Clay, gray, sandy	6	6
Sand and clay, gray and brown	10	16
Sand and clay, reddish-brown	6	22
Clay, reddish-brown and gray, sandy	5	27
Sand, brown, fine	5	32
Clay, reddish-brown, sandy	11	43
Sand and clay, brown; gravel, medium; caliche	12	55
Red beds	--	--

18N7W-12-1. NW cor. Altitude, 1,111.9. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

	Thickness (feet)	Depth (feet)
Clay	5	5
Sand, red	15	20
Sand, coarse	4	24
Sand, very coarse	8	32
Clay	1	33
Sand, reddish, coarse	7	40
Sand, coarse; shale	4	44

18N7W-12-2. SW cor. Altitude, 1,101.9. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

Clay	18	18
Sand, coarse	7	25
Sand, very coarse	12	37

18N7W-12-3. S$\frac{1}{4}$ cor. Altitude, 1,116.6. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

Soil, sandy; sand, fine; clay	32	32
Sand, coarse	16	48
Clay, red	--	--

18N7W-12-4. SE cor. Altitude, 1,117.5. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

Sand, red, fine	23	23
Clay	21	44
Sand, coarse	6	50
Clay	1	51
Shale	2	53

18N7W-13-5. W$\frac{1}{4}$ cor. Altitude, 1,097.3. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

Clay, sandy	21	21
Sand, coarse	7	28
Sand, fine	13	41

18N7W-13-6. S$\frac{1}{4}$ cor. Altitude, 1,118.4. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

Sand, fine	58	58
Sand, coarse	7	65
Shale	--	--

18N7W-13-7. Center. Altitude, 1,117.0. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

Sand, fine	20	20
Sand	5	25
Clay, sandy	15	40
Sand, yellowish, coarse	10	50
Sand, white, coarse	8	58

18N7W-13-8. SW cor. NE$\frac{1}{4}$. Altitude, 1,117.0. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

Sand, fine	20	20
Clay, sandy	15	35
Clay and sand	5	40
Sand, coarse	15	55
Sand, fine	3	58

18N7W-13-9. SW$\frac{1}{4}$SW$\frac{1}{4}$NE$\frac{1}{4}$. Altitude, 1,116.0. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

	Thickness (feet)	Depth (feet)
Sand, fine	10	10
Sand and clay	10	20
Sand, fine	10	30
Sand, coarse	20	50
Sand, fine	6	56

18N7W-14-2. NW cor. Altitude, 1,098.0. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

Clay, sandy	18	18
Sand, coarse	15	33

18N7W-17. 10 feet west and 55 feet north of SE cor. Altitude, 1,100.7. Sample log.

Sand and clay, brown	32	32
Clay, red and brown, sandy, calcareous; gravel, fine	11	43
Gravel, medium; clay, red and brown, sandy, calcareous	5	48
Red beds	---	---

18N7W-19. 10 feet south and 100 feet east of NW cor. NE$\frac{1}{4}$NW$\frac{1}{4}$. Altitude, 1,103.9. Sample log.

Clay, brown, sandy	6	6
Sand and clay, brown	5	11
Sand and clay, brown and gray	16	27
Clay, gray, sandy	5	32
Clay, brown and gray	5	37
Sand and clay, brown; gravel, fine	6	43
Sand and clay, brown; gravel, medium	7	50
Red beds	---	---

18N7W-23-2. NE cor. Altitude, 1,100.7. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

Clay and sand	14	14
Sand, coarse	24	38
Shale	---	---

18N7W-24-3. SE cor. Altitude, 1,124.5. Driller's log supplied by Hudgins, Thompson, Ball & Associates.

Sand, fine	15	15
Sand, fine; clay	10	25
Clay, coarse, sandy	5	30
Clay, yellow, sandy	6	36
Sand, red, fine	4	40
Sand	3	43
Sand, coarse	13	56
Shale	---	---

18N7W-27. 500 feet south and 15 feet west of NE cor. Altitude, 1,078.1. Sample log.

Clay, gray, sandy	6	6
Sand and clay, brown	5	11
Clay, brown and gray, sandy	5	16
Sand, brown, coarse; gravel, fine	6	22
Sand, brown, coarse	5	27
Sand, brown, coarse; gravel, fine	5	32
Gravel, medium; sand, medium; clay, red	5	37
Gravel, medium	5	42
Red beds	---	---

18N7W-29. 50 feet north and 20 feet west of SE cor. Altitude, 1,039.7. Sample log.

	Thickness (feet)	Depth (feet)
Sand, very fine	11	11
Clay, brown and gray, sandy; caliche	5	16
Gravel, arkosic, medium; sand, medium	6	22
Gravel, arkosic, medium; sand and clay, brown, calcareous	5	27
Gravel, medium; sand and clay, brown, calcareous	10	37
Sand, medium; gravel, medium, calcareous	7	44
Red beds	---	---

18N8W-1. 60 feet north and 20 feet west of SE cor. Altitude, 1,146.9. Sample log.

Sand and clay, brown	6	6
Clay, reddish-brown, sandy	5	11
Clay, brown, sandy, fine	5	16
Clay, brown and gray, sandy	11	27
Sand, very fine	5	32
Clay, gray and brown, sandy	16	48
Gravel, medium; sand, medium, calcareous	7	55
Red beds	---	---

18N8W-3. 120 feet south and 15 feet west of NE cor. Altitude, 1,159.6. Sample log.

Sand and clay, gray	6	6
Sand and clay, reddish-brown and gray	10	16
Sand, very fine	11	27
Clay, reddish-brown, sandy	5	32
Sand and clay, reddish-brown	6	38
Clay, brown, sandy; gravel, fine	5	43
Sand, very fine	5	48
Gravel, medium; sand, medium	5	53
Clay, reddish-brown, sandy; gravel, medium	6	59
Red beds	---	---

18N8W-4. 75 feet north and 10 feet east of SW cor. Altitude, 1,115.7. Sample log.

Sand, very fine	30	30
Clay, brown, sandy, calcareous	2	32
Gravel, medium; sand, medium; caliche	4	36
Red beds	---	---

18N8W-11-2. 20 feet north and 70 feet east of SW cor. Altitude, 1,078.6. Sample log.

Sand, very fine	6	6
Clay, brown and gray, sandy, calcareous	5	11
Sand and clay, grayish-brown	5	16
Clay, brown, sandy	13	29
Red beds	---	---

8N9W-12. 10 feet south and 10 feet west of NE cor. Altitude, 1,075.3. Sample log.

	Thickness (feet)	Depth (feet)
Clay, brown, sandy, calcareous	6	6
Sand and clay, brown; gravel, fine, calcareous	5	11
Sand, medium; gravel, medium, calcareous	11	22
Sand, coarse; gravel, fine, calcareous	10	32
Red beds	--	--

19N7W-29. 75 feet west and 15 feet north of SE cor. Altitude, 1,150.0. Sample log.

Clay, brown, sandy, calcareous	6	6
Clay, brown and gray, sandy	16	22
Sand, very fine	10	32
Sand and clay, brown; caliche	11	43
Sand and clay, gray, calcareous	10	53
Gravel, medium; sand, medium	11	64
Sand, coarse; gravel, fine	5	69
Sand and clay, brown; gravel, medium	5	74
Red beds	--	--

19N7W-30-2. SW¼SE¼. Irrigation well. Altitude, 1,182.7. Driller's log supplied by owner.

Sand	5	5
Clay, sandy	33	38
Sand, fine	5	43
Clay, red and blue, hard, sandy	29	72
Sand, medium	20	92
Red beds	--	--

19N7W-31-2. 100 feet south and 20 feet east of NW cor. Altitude, 1,159.5. Sample log.

Clay, grayish-brown, sandy	6	6
Sand and clay, light-brown	5	11
Clay, brown and gray, sandy	11	22
Sand and clay, reddish-brown	5	27
Sand and clay, brown and dark-gray	5	32
Sand and clay, light-brown; caliche	16	48
Sand and clay, light-brown; gravel, medium; caliche	5	53
Gravel, medium; sand, medium	5	58
Gravel, medium; sand and clay	20	78
Red beds	--	--

19N8W-3-2. 5 feet north and 60 feet west of SE cor. Altitude, 1,208.3. Sample log.

Sand and clay, gray	6	6
Sand and clay, gray; gravel, fine	5	11
Clay, gray, sandy	11.	22
Sand, very fine	5	27
Clay, brown and gray, sandy	5	32
Sand, very fine	5	37
Clay, brown and gray, sandy	6	43
Sand, very fine	15	58
Clay, reddish-brown, sandy	21	79
Clay, reddish-brown, sandy; gravel, fine	6	85
Gravel, medium; clay, reddish-brown, sandy	7	92
Red beds	--	--

19N8W-4. 75 feet north and 8 feet east of SW cor. Altitude, 1,218.0. Sample log.

	Thickness (feet)	Depth (feet)
Sand and clay, brown	6	6
Clay, reddish-brown, sandy	16	22
Clay, brown, sandy	5	27
Sand and clay, brown	10	37
Sand, brown, medium	6	43
Sand and clay, brown	10	53
Sand, very fine	11	64
Sand and clay, brown	10	74
Sand, very fine	5	79
Clay, brown, sandy	6	85
Gravel, medium, sand and clay	5	90
Gravel, medium; sand, medium	5	95
Gravel, medium; clay, brown and gray, calcareous	16	111
Clay, brown and gray, sandy, calcareous	5	116
Clay, reddish-brown; gravel, fine, calcareous	4	120
Red beds	--	--

19N8W-6. 390 feet north and 15 feet east of SW cor. Altitude, 1,219.8. Sample log.

Sand, brown, fine	6	6
Sand and clay, brown	5	11
Sand, brown, medium	5	16
Clay, brown and gray, sandy	11	27
Sand, brown, medium	10	37
Sand and clay, reddish-brown	6	43
Sand, brown, coarse	5	48
Sand and clay, brown	5	53
Sand, medium	5	58
Sand, coarse; gravel, fine	6	64
Sand; clay, red; gravel	5	69
Red beds	--	--

19N8W-8. 80 feet south and 15 feet west of NE cor. Altitude, 1,219.8. Sample log.

Clay, brown, sandy	6	6
Sand, brown, medium	10	16
Clay, brown, sandy	6	22
Sand, brown, fine	5	27
Sand, very fine	5	32
Sand, medium	6	38
Sand, very fine	26	64
Clay, brown, sandy	26	90
Gravel, medium	5	95

19N8W-10-2. 60 feet south and 15 feet west of NE cor. Altitude, 1,207.6. Sample log.

Clay, dark gray, sandy	9	9
Sand, coarse; gravel, fine	2	11
Clay, gray and brown, sandy	11	22
Clay, brown, sandy	5	27
Sand, very fine	37	64
Clay, red, sandy	10	74
Sand, very fine; caliche	16	90
Sand, fine; caliche	5	95

19N8W-12. 55 feet south and 15 feet west of NE cor. Altitude, 1,225.7. Sample log.

Clay, brown	6	6
Clay, reddish-brown and gray, sandy	9	15
Red beds	--	--

1 N8W-14-1. 23 feet east and 750 feet north of SW cor. Altitude, 1,193.0. Sample log.

	Thickness (feet)	Depth (feet)
Sand, gray, medium	6	6
Sand and clay, reddish-brown	10	16
Sand, brown, coarse	6	22
Sand and clay, brown	31	53
Sand and clay, red, calcareous; gravel, fine	11	64
Clay and sand, grey	5	69
Clay, gray, sandy; gravel, medium	5	74
Gravel, medium	21	95

19N8W-14-2. 50 feet east and 75 feet north of SW cor. Altitude, 1,204.[illegible].

Sand, brown, medium	6	6
Sand and clay, brown; gravel, fine	5	11
Sand, very fine	5	16
Sand and clay, brown; gravel, fine	16	32
Sand, very fine	11	43
Sand and clay, brown, calcareous; gravel, fine	5	48
Clay, brown, sandy	5	53
Clay, grayish-brown, sandy; gravel, medium	5	58
Clay, brown and gray, sandy	6	64
Sand and clay, brown	5	69
Clay, brownish-gray, sandy	16	85
Clay, brownish-gray, sandy; gravel, fine	5	90
Gravel, medium	5	95
Clay, brown, sandy; gravel, fine	5	100
Gravel, medium; sand, medium	15	115
Red beds	--	--

19N8W-17. 570 feet north and 15 feet west of SE cor. Altitude, 1,190.1. Sample log.

Sand, brown, coarse	11	11
Sand, brown, medium	5	16
Clay, brown and gray, sandy	6	22
Sand, very fine	5	27
Clay, reddish-brown, silty	5	32
Clay, reddish-brown, sandy	5	37
Clay, brown and gray, sandy	11	48
Clay, brown and gray, sandy, calcareous	5	53
Clay, reddish-brown, sandy, calcareous	5	58
Clay, brown and gray, sandy; caliche	6	64
Sand, red, medium; gravel, medium	10	74
Clay, red; gravel, medium	4	78
Red beds	--	--

19N8W-24. 195 feet south and 15 feet west of NE cor. Altitude, 1,188.2. Sample log.

Sand, very fine	6	6
Sand and clay, reddish-brown	16	22
Clay, brown, sandy	31	53
Sand, very fine	6	59
Clay, brown and gray, sandy	5	64
Sand, very fine; clay, brown	11	75
Sand, very fine; caliche	10	85
Clay and sand, reddish-brown; gravel, fine	5	90
Red bed	--	--

19N8W-27-2. 1,480 feet north and 780 feet wes of [illegible] cor. Altitude, 1,[illegible]70.[illegible]. Sample log.

	Thickness (feet)	Depth (feet)
Soil; sand, brown, medium	[illegible]	6
Sand, brown, medium	21	27
Sand, brown, clayey	5	32
Sand, brown, medium	11	43
Sand, brown, fine		48
Sand, medium; clay, brown and gray	5	53
Sand, brown, fine	13	66
Gravel, medium	6	72
Red beds	--	--

19N8W-31. 25 feet east and 10 feet south of NW cor. Altitude, 1,151.5. Sample log.

Sand, very fine	16	16
Sand, brown, medium	6	22
Clay, brown and black, sandy	15	37
Clay, brown, sandy	6	43
Gravel, medium; sand and clay, brown, calcareous	8	51
Red beds	--	--

19N8W-33. 15 feet south and 100 feet east of NW cor. Altitude, 1,158.5. Sample log.

Sand, very fine	6	6
Sand and clay, brown	5	11
Sand, very fine	5	16
Sand and clay, brown; gravel, fine	11	27
Clay, brown, sandy	5	32
Clay, brown and gray, sandy; gravel, medium	5	37
Gravel, medium; sand, medium	10	47
Red beds	--	--

19N9W-10-2. 250 feet south and 1,890 feet west of NE cor. Altitude, [illegible],150.5. Sample log.

Sand and clay, gray	6	6
Clay, brown, sandy	6	12
Clay, brown and gray, sandy	10	22
Sand, coarse	5	27
Gravel, fine; sand, coarse; caliche	8	35
Red beds	--	--

19N9W-14. 10 feet south and 35 feet east of NW cor. NE¼. Altitude, 1,148.7. Sample log.

Sand and clay, dark-gray, calcareous	6	6
Sand, clay, brown and gray	5	11
Sand and clay, brown	5	16
Clay, brown, sandy	6	22
Gravel, medium; sand, medium; caliche	9	31
Red beds	--	--

19N9W-22. 65 feet south and 5 feet west of NE cor. Altitude, 1,119.8. Sample log.

	Thickness (feet)	Depth (feet)
Sand, very fine	6	6
Sand, brown, medium	5	11
Sand, very fine	5	16
Sand and clay, brown	6	22
Sand, medium; gravel, fine	5	27
Gravel, medium; sand, medium	16	43
Sand, medium; gravel, medium	5	48
Gravel, medium; sand, medium, calcareous	4	52
Red beds	--	--

19N9W-24-2. 650 feet south and 15 feet west of NE cor. Altitude, 1,164.4. Sample log.

Clay, brown, sandy	11	11
Sand, fine; caliche	11	22
Sand, very fine	5	27
Clay, red, sandy; gravel, fine	5	32
Clay, red; sand and gravel, fine to medium	6	38
Red beds	--	--

19N9W-26. 15 feet west and 15 feet south of NE cor. Altitude, 1,132.1. Sample log.

Sand, brown, medium, calcareous	6	6
Sand, dark-brown, medium, silty, calcareous	5	11
Sand and clay, coarse, calcareous	11	22
Sand, very fine	7	29
Red beds	--	--

20N8W-6. 85 feet east and 20 feet south of NW cor. Altitude, 1,260.9. Sample log.

Sand, gray, medium	6	6
Clay, brown, sandy	16	22
Sand, very fine	21	43
Clay, reddish-brown	5	48
Red beds	--	--

20N8W-7. 333 feet south and 225 feet west of E¼ cor. Altitude 1,274.8. Sample log.

Sand, brown, medium	6	6
Sand, very fine	5	11
Sand and clay, brown, calcareous	16	27
Clay, brown and gray, sandy	15	42
Sand, very fine	6	48
Clay, reddish-brown and gray, sandy	5	53
Clay, reddish-brown, sandy	11	64
Clay, red, sandy	5	69
Clay, red, sandy, calcareous	5	74
Clay, brown, sandy	5	79
Clay, brown, sandy, calcareous	6	85
Sand, very fine	10	95

20N8W-17. 110 feet east and 15 feet north of SW cor. Altitude, 1,257.0. Sample log.

	Thickness (feet)	Depth (feet)
Sand and clay, gray	6	6
Clay, dark-brown and gray, sandy	5	11
Sand and clay, gray and brown	5	16
Clay, brown and gray, sandy	6	22
Clay, brown and black, sandy	5	27
Clay, gray, sandy	5	32
Sand, very fine	6	38
Sand and clay, grayish-brown	5	43
Sand, very fine	21	64
Clay, brown, sandy	10	74
Clay, red, sandy	5	79
Red beds	--	--

20N8W-18. 100 feet east and 12 feet south of NW cor. Altitude, 1,254.2. Sample log.

Sand and clay, brown	6	6
Sand and clay, reddish-brown	5	11
Clay, reddish-brown, sandy	11	22

20N8W-19. 85 feet west and 20 feet north of SE cor. Altitude, 1,241.7. Sample log.

Sand, brown, medium	6	6
Clay, brown, sandy, calcareous	5	11
Clay, brown, sandy	22	33
Sand, very fine	41	74
Shale, red and gray; gravel, medium	5	79
Red beds	--	--

20N8W-26. 35 feet east and 15 feet north of SW cor. Altitude, 1,258.7. Sample log.

Clay, gray and brown, sandy	6	6
Sand and clay, brown, calcareous	5	11
Clay, gray and brown, sandy	5	16
Clay, reddish-brown and gray, sandy	11	27
Clay, reddish-brown, sandy	5	32
Clay, brown and gray, sandy	6	38
Red beds	--	--

20N8W-27. 110 feet east and 15 feet south of NW cor. Altitude, 1,256.5. Sample log.

Clay, dark-gray and brown, sandy, calcareous	6	6
Clay, brown, sandy	10	16
Sand and clay, reddish-brown and dark-gray	6	22
Sand, very fine	5	27
Clay, reddish-brown, silty	19	46
Red beds	--	--

20N8W-29. 75 feet north and 15 feet west of SE cor. Altitude, 1,224.8. Sample log.

Clay, brown, sandy	11	11
Clay, brown, sandy, calcareous	5	16
Sand, brown, medium	27	43
Sand and clay, brown	10	53
Sand, very fine	5	58
Clay, brown and gray, sandy	6	64
Sand, brown, medium	10	74
Sand and clay, brown	5	79
Clay, brown, sandy	6	85
Clay, brown, sandy, calcareous	5	90
Clay, red, sandy	5	95

20N9W-2-1. NW cor. Altitude 1,247.4. Driller's log supplied by city of Enid.

	Thickness (feet)	Depth (feet)
Clay and sand	10	10
Sand	25	35
Red bed	--	--

20N9W-2-2. NW cor. SW¼. Altitude, 1,244.1. Sample log.

Sand and clay, brown and gray	10	10
Sand and clay, grayish-brown	5	15
Sand and clay, gray and brown	5	20
Clay, brown and gray, sandy	10	30
Sand and clay, brown and gray	5	35
Clay, brown, silty, sandy	10	45
Clay, brown and gray, silty, sandy	15	60
Clay, reddish-brown, silty, sandy; gravel, fine	7	67
Red beds	--	--

20N9W-2-3. 70 feet west and 10 feet north of SE cor. Altitude 1,252.9. Sample log.

Clay, brown and gray, sandy	32	32
Sand, very fine	17	49
Red beds	--	--

20N9W-4-1. NE cor. Altitude, 1,225.7. Driller's log supplied by the city of Enid.

Sand and clay	33	33
Sand	8	41
Sand and gravel	15	56
Sand, coarse	4	60
Red beds	--	--

20N9W-5-2. SW¼NW¼NW¼NE¼. Altitude, 1,213.7. Driller's log supplied by J. E. Yarborough.

Sand and topsoil	11	11
Sand, fine	11	22
Clay, white, soft	26	48
Gravel	2	50

20N[illegible]-5-3. SE¼NW¼NE¼NW¼. Altitude, 1,207.3. Driller's log supplied by J. E. Yarborough.

Sand	27	27
Rock, gray, hard	5	32
Sand; gravel	16	48
Red beds	--	--

20N9W-5-4. NE¼NE¼NW¼. Altitude, 1,202.0. Driller's log supplied by city of Enid.

Sand, fine	27	27
Sand, coarse	11	38
Red beds	--	--

20N9W-5-7. 45 feet east and 55 feet north of SW cor. Altitude, 1,174.3. Sample log.

Sand and clay, gray, calcareous; gravel, medium	6	6
Sand and clay, brown, calcareous	16	22
Sand, very fine	21	43
Sand, medium; gravel, medium, calcareous	15	58
Gravel, medium	4	62
Red beds	--	--

20N9W-6-3. NE¼NE¼SE¼. Altitude, 1,175.0. Driller's log supplied by city of Enid.

	Thickness (feet)	Depth (feet)
Sand, fine	35	35
Sand, coarse	25	60
Red beds	--	--

20N9W-6-4. NW¼SW¼SE¼. Altitude, 1,170.0. Driller's log supplied by city of Enid.

Sand	5	5
Sand, fine	5	10
Clay, gray	5	15
Clay, sandy	5	20
Sand, fine	10	30
Sand, coarse	5	35
Gravel, medium	15	50
Sand, coarse	15	65
Gravel and clay	4.5	69.5
Red beds	--	--

20N9[illegible]. SE¼SE¼SW¼. Altitude, 1,168.0. Driller's log supplied by city of Enid.

Sand	5	5
Sand, fine	5	10
Clay, sandy	5	15
Clay, black	10	25
Clay and sand	5	30
Sand, coarse	15	45
Sand, medium	5	50
Sand, fine	5	55
Sand, medium	5	60
Red beds	--	--

20N9W-7-2. NE¼NW¼NW¼. Altitude, 1,1[illegible]2.0. Driller's log supplied by city of Enid.

Sand	5	5
Clay, sandy	10	15
Clay, black	10	25
Sand, fine	10	35
Sand, coarse	10	45
Gravel, fine; clay	5	50
Sand, medium	10	60
Red beds	--	--

20N9W-20-[illegible]. NE cor. NW¼. Sample log.

Sand and clay, brown	10	10
Sand, brown, medium	5	15
Sand and clay, brown	10	25
Sand, medium; clay, brown, sandy	5	30
Sand, medium; clay, grayish-brown, sandy, calcareous	5	35
Sand, medium; gravel and clay, calcareous	5	40
Sand, medium; gravel, fine, calcareous	5	45
Sand, coarse; gravel, medium, calcareous	5	50
Sand, coarse; gravel, fine	5	55
Sand, medium; gravel and clay, calcareous	25	80

20N10W-12-2. SE¼NE¼NE¼. Altitude, 1,165.0. Driller's log supplied by city of Enid.

	Thickness (feet)	Depth (feet)
Soil	5	5
Sand	5	10
Clay, blue	10	20
Clay, gray; sand	5	25
Sand, white, coarse	5	30
Gravel and sand, white	15	45
Sand and gravel, yellow	10	55
Red beds	—	—

20N10W-12-6. NW¼NW¼SE¼. Altitude, 1,160.0. Driller's log supplied by city of Enid.

Sand	10	10
Sand, fine	5	15
Sand, medium	25	40
Sand, coarse	5	45
Gravel, fine	10	55
Gravel, fine; clay	5	60
Clay	25	85
Red beds	—	—

20N10W-12-7. SE¼NE¼SW¼. Altitude, 1,160.0. Driller's log supplied by city of Enid.

Sand	10	10
Sand, fine	5	15
Sand, medium	10	25
Sand, medium; clay	5	30
Sand, coarse	5	35
Gravel, fine	5	40
Gravel, medium	5	45
Gravel, fine; clay	10	55
Red beds	—	—

20N10W-12-8. SE¼SE¼SW¼. Altitude, 1,151.0. Driller's log supplied by city of Enid.

Sand	5	5
Sand, fine	15	20
Sand, clayey	5	25
Clay, red	5	30
Sand, medium	5	35
Sand, coarse	5	40
Gravel	5	45
Gravel, medium	5	50
Red beds	—	—

20N10W-13-3. SW¼NE¼NW¼. Altitude, 1,140.0. Driller's log supplied by city of Enid.

Sand	10	10
Clay, sandy	5	15
Clay, gray	5	20
Clay, black	5	25
Sand, medium	5	30
Gravel, fine	10	40
Sand, coarse	5	45
Gravel, fine	5	50
Red beds	—	—

20N10W-14-2. SE¼NE¼SE¼. Altitude, 1,120.0. Driller's log supplied by city of Enid.

Sand, fine	10	10
Gravel, coarse	23	33
Red beds	—	—

21N8W-18-2. NE cor. SE¼. Sample log.

	Thickness (feet)	Depth (feet)
Clay, brownish-gray, sandy	10	10
Clay, gray, sandy	5	15
Clay, gray, sandy, calcareous	5	20
Clay, brown and gray, sandy, calcareous	15	35
Red beds	—	—

21N8W-19-1. NW cor. Public-supply well. Altitude, 1,240.5. Driller's log supplied by city of Enid.

Sand and clay	10	10
Sand	10	20
Sand and clay	10	30
Sand, fine; clay	10	40
Red beds and sand, fine	20	60

21N8W-19-2. NW cor. SW¼. Altitude, 1,238.5. Driller's log supplied by city of Enid.

Sand, fine	10	10
Clay and sand	25	35
Red beds	—	—

21N8W-19-4. 100 feet east and 100 feet north of SW cor. Altitude, 1,242.7. Sample log.

Clay, brown, sandy	5	5
Clay, brown, sandy; caliche	10	15
No sample	5	20
Clay, brown, sandy; caliche	5	25
Clay, brown and gray, sandy; caliche	5	30
Clay, brown, sandy; caliche	5	35
Clay, brown and gray, sandy, calcareous	4	39
Red beds	—	—

21N8W-19-6. SE cor. SW¼. Altitude, 1,237.3. Driller's log supplied by city of Enid.

Sand	20	20
Sand and clay	10	30
Clay and sand	10	40
Clay and sand, fine	10	50
Red beds	—	—

21N8W-19-7. NE cor. NW¼. Altitude, 1,233. Driller's log supplied by city of Enid.

Sand and clay	10	10
Sand and gravel	10	20
Sand	10	30
Clay, gray	5	35
Red beds	—	—

21N8W-30. 70 feet south and 48 feet west of NE cor. NW¼. Altitude, 1,232.7. Sample log.

Clay, gray, sandy, calcareous	10	10
Sand, medium, calcareous	5	15
Sand, red, medium; clay, red	15	30
Clay, brown, calcareous, sandy	10	40
Clay, gray and brown, calcareous	10	50
Silt, reddish-brown; clay, calcareous	5	55
Clay, gray and brown, calcareous, sandy	5	60
Red beds	—	—

21N9W-4-1. 15 feet south and 150 feet west of NE cor. Altitude, 1,320.6. Sample log.

	Thickness (feet)	Depth (feet)
Clay, dark-gray, sandy	6	6
Clay, brown and gray, sandy	21	27
Clay, brownish-red, calcareous	4	31
Red beds	--	--

21N9W-5. 580 feet east and 12 feet south of NW cor. Altitude, 1,308.5. Sample log.

Sand, gray, medium	6	6
Clay and sand, grayish-brown, calcareous	16	22
Clay, gray, sandy	5	27
Sand, very fine	11	38
Clay, brownish-red, sandy, calcareous	10	48
Clay, brownish-red, sandy	5	53
Red beds	--	--

21N9W-9. 20 feet east and 90 feet south of NW cor. Altitude, 1,295.2. Sample log.

Sand and clay, brown and gray	6	6
Sand, very fine	16	22
Clay, brown, sandy	11	33
Red beds	—	—

21N9W-10-1. 50 feet south and 15 feet west of NE cor. Altitude, 1,318.8. Sample log.

Sand and clay, brown and gray	11	11
Clay, brown and gray, sandy	5	16
Clay, brownish-red, sandy	17	33
Red beds	--	--

21N9W-14-2. 15 feet south and 85 feet west of NE cor. Altitude, 1,283.4. Sample log.

Sand, brown, medium	6	6
Sand and clay, brown	16	22
Sand, very fine	16	38
Clay, reddish-brown, sandy	10	48
Red beds	--	--

21N9W-15. 65 feet south and 15 feet east of NW cor. Altitude, 1,314.6. Sample log.

Sand, coarse	6	6
Clay, gray, sandy; gravel, fine	5	11
Clay, gray, sandy	11	22
Sand and clay, brown and gray; gravel, fine	5	27
Clay, brown, sandy	16	43
Clay, reddish-brown, sandy	16	59
Red beds	--	--

21N9W-20-3. 65 feet north and 50 feet west of SE cor. Altitude, 1,234.2. Sample log.

	Thickness (feet)	Depth (feet)
Clay, gray and brown, sandy	6	6
Clay, grayish-brown, sandy; gravel, fine	5	11
Sand and clay, gray	5	16
Clay, gray and brown, sandy	6	22
Sand, very fine	5	27
Sand and clay, brown	5	32
Sand, medium; gravel, medium	5	37
Sand, medium; gravel, medium, calcareous	6	43
Sand and clay, brown; gravel, medium	10	53
Sand and clay, reddish-brown; gravel, medium	5	58
Clay, reddish-brown, sandy, calcareous	6	64
Clay, reddish-brown, sandy, calcareous; gravel, fine	5	69
Clay, reddish-brown and white, sandy, calcareous	5	74
Clay, reddish-brown, sandy, calcareous; gravel, fine	5	79
Clay, reddish-brown and gray, calcareous	6	85
Clay, reddish-brown, sandy, calcareous; gravel, fine	7	92
Red beds	--	--

21N9W-22-1. NW cor. Altitude, 1,283.8. Driller's log supplied by city of Enid.

Sand and clay	10	10
Sand	30	40

21N9W-22-4. 25 feet north and 65 feet east of SW cor. NW¼. Altitude, 1,275.2. Sample log.

Sand, brown, medium	35	35
Clay, red, sandy	5	40
Sand, red, very fine; clay, red	7	47
Red beds	--	--

21N9W-22-5. SW cor. NW¼. Sample log.

Sand, brown, medium	5	5
Sand, reddish-brown, medium	15	20
Sand and clay, reddish-brown	5	25
Sand, reddish-brown, medium	5	30
Sand and clay, reddish-brown	5	35
Clay, silty, calcareous; sand, gray, fine	11	46
Red beds	--	--

21N9W-22-6. NW cor. SW¼. Altitude, 1,275.2. Driller's log supplied by city of Enid.

Sand and clay	10	10
Sand	35	45

21N9W-23-1. NE cor. NW¼. Altitude, 1,310.0. Driller's log supplied by city of Enid.

Clay and sand	20	20
Clay and red beds	10	30

21N9W-23-2. SW cor. NW¼. Driller's log supplied by city of Enid.

	Thickness (feet)	Depth (feet)
Sand and clay	10	10
Clay and sand, white	10	20
Sand; clay, sandy	10	30
Clay and sand	10	40
Sand and clay	10	50
Red beds	--	--

21N9W-24-1. Public-supply well. 125 feet north and 95 feet west of SE cor. SW¼. Altitude, 1,251.5. Sample log.

	Thickness (feet)	Depth (feet)
Sand, reddish-brown, medium	5	5
Sand, reddish-brown, medium; caliche	5	10
Sand, reddish-brown, medium	5	15
Sand, fine	5	20
Sand and clay, reddish-brown	5	25
Sand and clay, reddish-brown, calcareous	5	30
Clay, reddish-brown, sandy; caliche	13	43
Red beds	--	--

21N9W-24-5. NE¼SE¼SE¼. Altitude, 1,237.9. Samples and cores supplied by Geo. E. Failing Supply Co.

	Thickness (feet)	Depth (feet)
Sand, brown, fine, argillaceous	10	10
Sand, brown, medium, argillaceous	20	30
Shale, reddish-brown mottled with gray, silty, sandy, calcareous; shows earthy fracture	20	50
Shale, reddish-brown mottled with gray, calcareous; shows earthy fracture	10	60
Shale, reddish-brown, mottled with gray, sandy, calcareous; shows earthy fracture	10	70
Sandstone, light-gray, fine-grained, calcareous	0.5	70.5
Sandstone, mottled gray and red, fine-grained, argillaceous, calcareous	1.5	72
Shale, red mottled with gray, hard, silty; calcite in veins; shows conchoidal fracture	2	74
Shale, red mottled with gray, sandy, calcareous; shows earthy fracture	3	77
No sample	4.5	81.5
Shale, gray to red, sandy; shows earthy fracture; small cavities lined with drusy calcite	0.5	82
Sandstone, banded red and brown mottled with gray, very fine-grained, argillaceous, calcareous; a few small cavities	15	97
Shale, banded gray and red, silty, fissile, calcareous; a few small cavities	1	98
Siltstone, red mottled with gray, argillaceous; shows earthy fracture; many small cavities lined with drusy calcite	3	101
No sample	1	102
Shale, red, silty, calcareous; shows earthy fracture, a few small cavities	4	106
No sample	1	107

21N9W-24-5. NE¼SE¼SE¼.--continued

	Thickness (feet)	Depth (feet)
Shale, red, silty, calcareous; shows earthy fracture; a few small cavities	1	108
Shale, gray, silty, calcareous, shows earthy fracture; a few small cavities	0.5	108.5
Shale, mottled red and gray, silty, calcareous; shows earthy fracture; a few small cavities	0.5	109
Shale, red, mottled with gray, calcareous; shows starchy fracture; a few small cavities	3	112
Shale, banded reddish-brown and gray, fissile, calcareous, a few small cavities	1	113
No sample	1	114
Shale, red mottled with gray, calcareous; shows earthy fracture; cavities up to 1 inch in diameter	4	118
Shale, red mottled with gray; shows earthy fracture; calcite crystals in cavities and cracks	2.5	120.5
Siltstone, gray with reddish-brown mottling, argillaceous, fissile, calcareous; a few small cavities	1.5	122
No sample	1	123
Siltstone, mottled red and gray, argillaceous, calcareous, cavities up to 1 inch in diameter	2	125
Shale, red mottled with gray; shows earthy fracture; cavities up to 1 inch in diameter with drusy calcite	3	128
Shale, red, shows earthy fracture; cavities up to 1 inch in diameter	3	131
Siltstone, red with gray mottling, argillaceous	2.5	133.5
Shale, red mottled with gray, silty; shows earthy fracture	4	137.5
Siltstone, red mottled with gray, argillaceous, blocky to fissile, calcareous; cavities up to 1 inch in diameter	3	140.5
No sample	2.5	143
Siltstone, red mottled with gray, argillaceous, fissile, cavities up to 1 inch in diameter	4	147
No sample	1	148
Siltstone, gray mottled with red, blocky to fissile argillaceous	2.5	150.5
No sample	0.5	151
Shale, red, hard; shows conchoidal fracture	2	153
Shale, reddish-brown and red, mottled with gray; shows earthy to conchoidal fracture	5	158
Shale, banded red and brown, silty, calcareous, shows earthy fracture	1	159
Shale, reddish-brown, calcareous, shows earthy to conchoidal fracture	4	163
Shale, bluish-gray to reddish-brown, calcareous; shows earthy fracture	1	164
Shale, red, calcareous, shows earthy fracture; cavities up to 1 inch in diameter	1	165
No sample	1.5	166.5

21N9W-24-5. NE¼SE¼SE¼.—continued

	Thickness (feet)	Depth (feet)
Shale, red, calcareous, shows earthy fracture; cavities up to 1 inch in diameter	1.5	168
Siltstone, reddish-brown and gray, argillaceous, calcareous; shows earthy fracture	1	169
No sample	0.5	169.5
Shale, red, hard, silty, calcareous; shows earthy fracture; a few small cavities	2	171.5
Shale, red, silty, calcareous; thin veins of satinspar gypsum; a few small cavities	1.5	173
Siltstone, bluish-gray and red, calcareous, argillaceous	0.5	173.5
No sample	2.5	176
Shale, red, hard, calcareous; shows conchoidal fracture; thin sheets of selenite gypsum	2	178
Shale, red, hard, calcareous; shows conchoidal fracture; gypsum in veins and nodules	5	183
Shale, bluish-gray and red, calcareous, shows blocky fracture; thin veins of gypsum	1.5	184.5
No sample	1	185.5
Shale, red mottled with grayish-blue, hard; shows earthy to conchoidal fracture; gypsum in veins and nodules	2.5	188
Shale, bluish-gray mottled with red, shows earthy fracture	1	189
Shale, red, hard, calcareous; shows earthy to conchoidal fracture; thin veins of gypsum	6	195

21N9W-25-4. NW cor. Altitude, 1,288. Driller's log supplied by city of Enid.

Sand and clay	10	10
Clay and sand	10	20
Sand	20	40
Sand	10	50
Red beds	—	—

21N9W-27-1. NE¼SW¼SW¼. Altitude, 1,239.7. Driller's log supplied by city of Enid.

Sand	5	5
Clay, sandy	5	10
Clay, red	5	15
Sand, fine	25	40
Clay, red	5	45
Gravel, fine	15	60
Red beds	—	—

21N9W-27-2. NE¼SE¼SE¼. Altitude, 1,270.0. Driller's log supplied by city of Enid.

Sand	10	10
Sand, fine	5	15
Clay, red	5	20
Red beds	—	—

21N9W-27-3. NW¼SW¼. Sample log.

	Thickness (feet)	Depth (feet)
Sand, brown, medium; clay, brown, sandy	10	10
Sand and clay, brown	10	20
Sand, brown, coarse	5	25
Sand and clay, brown	10	35
Sand and clay, brown, calcareous	5	40
Clay, brown, sandy; caliche	5	45
Clay, brown, sandy; caliche; gravel, fine	5	50
Sand and clay, brown; gravel, fine; caliche	13	63
Red beds	—	—

21N9W-27-4. NW cor. SW¼SW¼. Sample log.

Clay and sand, brown and gray	5	5
Clay and sand, brown and gray; caliche	5	10
Clay, brown, sandy	10	20
Clay, brown and gray, sandy	20	40
Clay, brown and gray, sandy	10	50
Gravel, medium; clay, brown and sandy	10	60
Red beds	—	—

21N9W-28-2. SW¼SE¼SE¼. Altitude, 1,230.0. Driller's log supplied by city of Enid.

Sand	10	10
Clay, gray	5	15
Clay, sandy	5	20
Sand, fine	15	35
Clay, sandy	5	40
Sand, coarse	20	60
Red beds	—	—

21N9W-32-3. SW¼SE¼NE¼SW¼. Altitude, 1,213.9. Driller's log supplied by J. E. Yarborough.

Sand and topsoil	11	11
Sand, fine	11	22
Sand, coarse; gravel, fine	15	37
Red beds	—	—

21N9W-32-4. NW¼NE¼SE¼SW¼. Altitude, 1,210.5. Driller's log supplied by J. E. Yarborough.

Sand and topsoil	11	11
Sand	5	16
Sand, coarse	6	22
Sand, fine	10	32
Sand, coarse	5	37
Red beds	—	—

21N9W-32-5. NW¼NW¼SE¼SW¼. Altitude, 1,205.6. Driller's log supplied by J. E. Yarborough.

Sand and topsoil	11	11
Sand, fine	14	25
Clay, streaks	4	29
Sand, coarse	3	32
Sand, coarse; gravel, fine to coarse	11	43
Sand, coarse; gravel	3	46
Red beds	—	—

21N9W-32-6. SW¼SE¼SE¼SW¼. Altitude, 1,210.4. Driller's log supplied by J. E. Yarborough.

	Thickness (feet)	Depth (feet)
Sand and topsoil	11	11
Sand	21	32
Sand and gravel	11	43
Gravel	10	53
Red beds	—	—

21N9W-32-7. NE¼SE¼SE¼SW¼. Altitude, 1,211.4. Driller's log supplied by J. E. Yarborough.

Sand	22	22
Sand, fine	15	37
Sand and gravel	14	51
Red beds	—	—

21N9W-32-8. NW¼SE¼SW¼SE¼. Altitude, 1,220.0. Driller's log supplied by city of Enid.

Topsoil	5	5
Sand	5	10
Sand, fine	5	15
Clay, red; sand	5	20
Clay, red	5	25
Sand, yellow, fine; gravel, coarse	20	45
Red beds	—	—

21N9W-32-9. SE¼NE¼SE¼. Altitude, 1,224.0. Driller's log supplied by city of Enid.

Sand	5	5
Clay, sandy	10	15
Clay, red, sandy	20	35
Clay, gray	5	40
Gravel, fine	5	45
Gravel, medium	5	50
Gravel, medium; clay	5	55
Red beds	—	—

21N9W-33-2. NW¼SW¼NE¼. Altitude, 1,225.0. Driller's log supplied by city of Enid.

Sand	5	5
Clay, blue	5	10
Clay, sandy	10	20
Sand, fine	10	30
Sand, medium	5	35
Clay, sandy	5	40
Gravel, fine	15	55
Red beds	—	—

21N9W-33-3. SE¼SE¼SW¼NW¼. Altitude, 1,229.0. Driller's log supplied by city of Enid.

Topsoil	5	5
Sand	5	10
Sand and clay, gray	5	15
Sand, yellow, fine	5	20
Sand, yellow, medium	20	40
Sand, white; gravel, coarse	15	55
Red beds	—	—

21N9W-36-2. 15 feet north and 100 feet east of SW cor. Altitude, 1,264.5. Sample log.

	Thickness (feet)	Depth (feet)
Sand, brown, medium	6	6
Clay, brown and gray, sandy	10	16
Sand, very fine	11	27
Clay, brown and gray, sandy	5	32
Red beds	—	—

21N10W-10. 15 feet north and 90 feet west of SE cor. Altitude, 1,247.8. Sample log.

Sand, brown, medium	6	6
Sand, brown, medium; gravel, fine	10	16
Clay, brown, sandy	6	22
Sand, brown, medium; gravel, fine	11	33
Sand, brown, medium	5	38
Sand, brown, medium; gravel, fine	5	43
Sand, very fine	5	48
Clay, grayish-brown, sandy, calcareous	5	53
Clay, brown, sandy; gravel fine	5	58
Clay, gray, sandy; gravel, medium	6	64
Clay, dark-gray, sandy; gravel, medium	5	69
Clay, black; gravel, medium	5	74
Clay, brown and black; gravel, medium	6	80
Red beds	—	—

21N10W-12-2. 15 feet south and 215 feet east of NW cor. Altitude, 1,269.7. Sample log.

Clay, brown, sandy	11	11
Sand, brown, medium	9	20
Clay, brown, sandy	2	22
Sand, brownish-red, medium	5	27
Clay, brownish-red, silty	6	33
Sand, brownish-red, medium	5	38
Clay, brownish-red, sandy	5	43
Sand, brownish-red, medium	5	48
Sand, very fine	5	53
Sand, brownish-red, medium	6	59
Sand, very fine	5	64
Gravel, medium	5	69
Sand, medium; gravel, fine	13	82
Red beds	—	—

21N10W-12-3. 20 feet north and 130 feet west of SE cor. Altitude, 1,262.1. Sample log.

Sand, brown, medium	6	6
Clay, grayish-brown, sandy	21	27
Clay, brown, sandy	16	43
Sand, very fine	10	53
Gravel, medium; sand and clay, red	11	64
Gravel, medium, sandy	19	83
Red beds	—	—

21N10W-16-2. 700 feet north and 726 feet east of SW cor. Altitude, 1,214.8. Sample log.

Clay, brown, sandy	11	11
Clay, brown, sandy; sand, medium	5	16
Sand, coarse; gravel, fine	11	27
Sand, coarse; gravel, fine, argillaceous, calcareous	5	32
Sand, coarse; gravel, medium	8	40
Red beds	—	—

21N10W-24. 15 feet south and 110 feet east of NW cor. Altitude, 1,247.9. Sample log.

	Thickness (feet)	Depth (feet)
Sand, brown, medium	6	6
Sand and clay, brownish-red	5	11
Sand, very fine	21	32
Sand, brownish-red, coarse; caliche	1	33
Clay, brown, calcareous	8	41
Clay and sand, brown, calcareous; gravel, fine	2	43
Sand, brown, calcareous; gravel, fine	10	53
Red beds	--	--

22N10W-4. 160 feet south and 7 feet east of NW cor. Altitude, 1,365.7. Sample log.

Clay, gray, sandy	6	6
Clay, reddish-brown, sandy, calcareous	5	11
Clay, reddish-brown, sandy, caliche	16	27
Shale, reddish-brown, silty, calcareous	5	32
Shale, brown, sandy, calcareous	5	37

22N10W-7. 20 feet south and 45 feet west of NE cor. Altitude, 1,363.4. Sample log.

Clay, brown and gray, sandy	22	22
Sand and clay, brown	15	37
Sand, brown, medium	16	53
Sand and clay, brown	11	64
Clay, reddish-brown, sandy	10	74
Clay, brown, sandy; caliche	5	79
Clay, red, sandy; gravel, fine	9	88
Red beds	--	--

22N10W-9. 100 feet north and 15 feet east of SW cor. Altitude, 1,312.6. Sample log.

Clay, brown, sandy	6	6
Clay, gray, sandy	5	11
Clay, dark grayish-brown, sandy	11	22
Clay, brown, silty	5	27
Clay, reddish-brown, sandy	10	37
Red beds	--	--

22N10W-19. 180 feet south and 8 feet west of NE cor. Altitude, 1,312.1. Sample log.

Clay, brown and gray, sandy	22	22
Clay, dark brown and gray, sandy	5	27
Clay, brown and gray, sandy	5	32
Clay, reddish-brown, sandy	5	37
Sand, very fine	16	53
Clay, brown, sandy	11	64
Gravel, medium; sand, coarse	10	74
Gravel, medium; sand and clay, red	5	79
Red beds	--	--

22N10W-25. 80 feet south and 10 feet east of NW cor. Altitude, 1,307.8. Sample log.

No sample	22	22
Sand, brown, medium	21	43
Sand and clay, brown	10	53
Clay, reddish-brown, sandy	10	63

22N10W-29. 85 feet south and 15 feet west of NE cor. Altitude, 1,294.9. Sample log.

	Thickness (feet)	Depth (feet)
Clay, brown, sandy	6	6
Clay, brown and gray, sandy	5	11
Clay, reddish-brown, sandy	5	16
Clay, brown, sandy	6	22
Clay, red, sandy	5	27
Clay, brown, sandy	5	32
Clay and sand, reddish-brown and gray	21	53
Clay, red, sandy; gravel, fine	5	58
Sand and clay, red; gravel, fine	6	64
Gravel, medium; sand, coarse	5	69
Red beds	--	--

22N10W-34. 35 feet north and 65 feet west of SE cor. Altitude, 1,270.0. Sample log.

Clay, reddish-brown, sandy	6	6
Sand, fine; caliche	5	11
Clay, red, sandy	21	32
Sand, red, medium	6	38
Sand, red, medium; gravel, fine	10	48
Gravel, medium	5	53
Sand, medium	4	57
Gravel, medium	2	59
Red beds	--	--

22N10W-36. 15 feet south and 35 feet west of NE cor. Altitude, 1,317.4. Sample log.

Sand and clay, gray	6	6
Sand, brown, medium	16	22
Clay and sand, brown	11	33
Sand and clay, brown	10	43
Clay, brownish-red, sandy, calcareous	4	47
Red beds	--	--

22N11W-3. 65 feet north and 10 feet east of SW cor. Altitude, 1,333.5. Sample log.

Sand, medium; gravel, fine	6	6
Sand and clay, brown; gravel, fine	5	11
Clay, brown, sandy; gravel, fine	5	16
Clay, brown, sandy	6	22
Sand and clay, brown; gravel, medium	10	32
Clay, brown, sandy; gravel, fine	5	37
Clay, brown, sandy	6	43
Clay, gray and brown, sandy, calcareous; gravel, medium	5	48
Clay, gray, sandy, calcareous; gravel, fine	5	53
Clay, gray, sandy; gravel, medium; caliche	5	58
Gravel, medium; sand, coarse	9	67
Red beds	--	--

22N11W-7-2. 1,320 feet west of NE cor. Altitude, 1,304.8. Driller's log supplied by Alexander & Pollard.

Sand, fine; clay streaks	20	20
Clay, red and white, sandy	18	38
Rocks	2	40
Sand, fine	7	47
Sand, fine; gravel	6	53

22N11W-7-3. 1,320 feet east of NW cor. Altitude, 1,300.5. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, fine; clay streaks; gravel	45	45
Red beds	--	--

22N11W-8-2. N$\frac{1}{4}$ cor. Altitude, 1,316.0. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, fine; clay streaks	55	55
Sand, fine	5	60
Sand, coarse; gravel	6	66
Sand, medium	4	70
Red beds	--	--

22N11W-9-1. NE cor. Altitude, 1,326.1. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, fine	3	3
Clay, sandy; sand streaks	44	47
Rock	2	49
Clay, yellow, sandy	10	59
Sand, coarse; gravel	3	62
Sand, fine	2	64
Red beds	--	--

22N11W-9-2. N$\frac{1}{4}$ cor. Altitude, 1,317.8. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, fine	3	3
Clay, sandy	6	9
Sand, red, fine	19	28
Clay, white, sandy	7	35
Sand, fine	17	52
Sand, coarse; gravel	6	58
Red beds	--	--

22N11W-9-3. NW cor. Altitude, 1,308.3. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, fine; clay streaks	42	42
Sand, coarse; gravel	14	56
Red beds	--	--

22N11W-9-4. E$\frac{1}{4}$ cor. Altitude, 1,329.8. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, fine; clay streaks	40	40
Rocks	2	42
Clay, red and white, sandy	3	45
Sand, fine	7	52
Clay, red, sandy	3	55
Clay, yellow, sandy	7	62
Sand, medium	3	65
Red beds	--	--

22N11W-9-5. SE cor. Altitude, 1,320.6. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, fine; clay streaks; rock at 38 feet	60	60
Red beds	--	--

22N11W-16-1. 0.4 mile east of NW cor. Altitude, 1,314.9. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, brown, fine	17	17
Clay, sandy	5	22
Sand, fine	24	46
Clay, sandy	11	57
Sand, fine	6	63
Sand, coarse; gravel	6	69
Red beds	--	--

22N11W-16-2. E$\frac{1}{4}$ cor. Altitude, 1,314.8. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, fine; clay streaks	60	60
Sand, medium	2	62
Red beds	--	--

22N11W-17-1. 1,320 feet east of NW cor. Altitude, 1,291.6. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, brown, fine	16	16
Clay, sandy	7	23
Sand, fine; clay; gravel (trace)	27	50
Red beds	--	--

22N11W-17-2. 1,320 feet west of NE cor. Altitude, 1,297.2. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, brown, fine; clay streak	28	28
Clay, sandy	17	45
Sand, medium	5	50
Sand, coarse; gravel	2	52
Red beds	--	--

22N11W-17-3. N$\frac{1}{4}$ cor. Altitude, 1,287.25. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, fine	20	20
Clay, sandy	12	32
Sand, fine	9	41
Sand, coarse; gravel	5	46
Red beds	--	--

22N11W-17-5. W$\frac{1}{4}$ cor. Altitude, 1,271.2. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, fine	17	17
Clay, black, sandy	11	28
Sand, coarse; gravel	4	32
Red beds	--	--

22N11W-18-2. NW cor. Altitude, 1,290.3. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, fine	21	21
Clay, sandy	7	28
Sand, fine	3	31
Sand, coarse; gravel	7	38
Sand, medium	6	44
Sand, coarse; gravel	4	48
Red beds	--	--

22N11W-18-3. 1,320 feet west of NE cor. Altitude, 1,287.6. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, brown, fine	6	6
Sand, fine; clay streaks	29	35
Sand, fine	4	39
Sand, coarse; gravel	5	44
Red beds	--	--

22N11W-18-4. 1,320 feet east of NW cor. Altitude, 1,289.8. Driller's log supplied by Alexander & Pollard.

Sand, brown, fine	6	6
Clay, sandy	5	11
Sand, fine; clay streaks	19	30
Clay, blue, sandy	8	38
Sand, coarse; gravel	7	45
Red beds	--	--

22N11W-19-3. 1,320 feet west of NE cor. Altitude, 1,272.6. Driller's log supplied by Alexander & Pollard.

Sand, brown, fine	9	9
Clay, sandy, tough	6	15
Sand, white, fine	1	16
Sand, coarse; gravel	12	28
Red beds	--	--

22N11W-19-4. 1,320 feet east of NW cor. Altitude, 1,260.4. Driller's log supplied by Alexander & Pollard.

Sand, brown, fine	21	21
Clay, black, sandy	17	38
Red beds	--	--

22N11W-20-2. NE cor. Altitude, 1,298.7. Driller's log supplied by Alexander & Pollard.

Sand, brown, fine	7	7
Clay, red, sandy	7	14
Clay, white, sandy	1	15
Sand, red, fine; clay streaks	13	28
Clay, sandy	4	32
Sand, fine; clay streaks	24	56
Sand, coarse; gravel	7	63
Red beds	--	--

22N11W-20-3. 1,320 feet west of NE cor. Altitude, 1,301.3. Driller's log supplied by Alexander & Pollard.

Sand, brown, fine	14	14
Clay, sandy	4	18
Sand, fine	13	31
Clay, sandy	4	35
Sand, fine; clay streaks	24	59
Sand, coarse; gravel	8	67
Red beds	--	--

22N11W-20-4. 1,320 feet east of NW cor. Altitude, 1,290.0. Driller's log supplied by Alexander & Pollard.

Sand, brown, fine	8	8
Clay, sandy	3	11
Sand, red, fine; clay	33	44
Sand, coarse	5	49
Sand, coarse; gravel	1	50
Clay, red	2	52
Red beds	--	--

22N11W-20-5. W½ cor. Altitude, 1,275.2. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, fine	15	15
Clay, red, sandy	6	21
Sand, coarse; gravel	14	35
Red beds	--	--

22N11W-21-2. NE cor. Altitude, 1,309.4. Driller's log supplied by Alexander & Pollard.

Sand, fine; clay streaks	58	58
Sand, coarse; gravel	10	68
Red beds	--	--

22N11W-21-3. N¼ cor. Altitude, 1,306.6. Driller's log supplied by Alexander & Pollard.

Sand, brown, fine; clay	12	12
Sand, red, fine	37	49
Clay	7	56
Sand, fine	2	58
Sand, coarse; gravel	12	70
Red beds	--	--

22N11W-21-4. E¼ cor. Altitude, 1,303.3. Driller's log supplied by Alexander & Pollard.

Sand, fine; clay streaks	33	33
Clay, sandy	17	50
Sand, fine; clay streak	16	66
Red beds	--	--

22N11W-21-5. Center. Altitude, 1,299.0. Driller's log supplied by Alexander & Pollard.

Sand, fine; clay streaks, sandstone layer at 45 feet	59	59
Sand, medium	3	62
Red beds	--	--

22N11W-21-6. 1,000 feet east of SW cor. Altitude, 1,293.8. Driller's log supplied by Alexander & Pollard.

Sand, fine; clay streaks	45	45
Rock	3	48
Sand, fine; clay streaks	7	55
Sand, medium	4	59
Red beds	--	--

22N11W-21-7. SE cor. Altitude, 1,301.1. Driller's log supplied by Alexander & Pollard.

Sand, fine; clay streaks	35	35
No sample	25	60

22N11W-21-8. 400 feet north of SE cor. Altitude, 1,300.1. Driller's log supplied by Alexander & Pollard.

Sand, fine; clay streaks	62	62
Red beds	--	--

22N11W-21-9. 60 feet north of SE cor. Altitude, 1,299.4. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, fine; clay streaks	35	35
Clay, red and white, sandy	10	45
Sand, fine; clay streaks	17	62
Sand, fine	4	66
Red beds	—	—

22N11W-21-10. 1,320 feet west of SE cor. Altitude, 1,308.4. Driller's log supplied by Alexander & Pollard.

Sand, fine	15	15
Clay, sandy	15	30
Sand, fine	5	35
Clay, sandy	7	42
Sandstone	3	45
Clay, sandy	14	59
Sand, red, fine, hard	10	69
Sand, fine	4	73
Red beds	—	—

22N11W-22-2. 100 feet west of SW cor. Altitude, 1,229.2. Driller's log supplied by Alexander & Pollard.

Sand, fine	5	5
Clay, gray, sandy	6	11
Sand, red, fine	14	25
Clay, red and white, sandy	13	38
Rock	—	—

22N11W-26-2. 90 feet north and 18 feet east of SW cor. Altitude, 1,277.7. Sample log.

Sand, grayish-brown, medium	6	6
Sand and clay, brown; gravel, fine	5	11
Sand and clay, brown; gravel, fine; caliche	5	16
Clay, brown and gray, sandy	6	22
Sand and clay, brown; gravel, fine	5	27
Clay, brown and gray, sandy	5	32
Clay, reddish-brown, sandy	5	37
Sand and clay, reddish-brown	11	48
Sand and clay, brown	5	53
Sand, brown, medium	5	58
Sand, brown, coarse	6	64
Sand, brown, medium	10	74
Sand and clay, brown	5	79
Gravel, fine	2	81
Red beds	—	—

22N11W-28. 95 feet south of NE cor. Altitude, 1,298.7. Driller's log supplied by Alexander & Pollard.

Sand, fine	5	5
Clay, gray, sandy	6	11
Sand, red, fine	19	30
Clay, red and white, sandy	8	38
Sand or limestone; drill could not go farther	1	39

22N11W-29-1. W¼ cor. Altitude, 1,260.7. Driller's log supplied by Alexander & Pollard.

Sand, fine	7	7
Clay, sandy	8	15
Sand, coarse; gravel	9	24
Sand, fine	6	30
Sand, coarse; gravel	4	34
Red beds	—	—

22N11W-30-2. NE cor. Altitude, 1,265.3. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, brown, fine	5	5
Clay, red, sandy	9	14
Clay, red	1	15
Sand, fine	5	20
Sand, coarse	3	23
Sand, coarse; gravel	7	30
Red beds	—	—

22N11W-30-3. 1,320 feet west of NE cor. Altitude, 1,267.6. Driller's log supplied by Alexander & Pollard.

Sand, brown, fine	9	9
Clay, red, sandy	11	20
Sand, fine	3	23
Sand, coarse; gravel	5	28
Red beds	—	—

22N11W-32-2. NE cor. Altitude, 1,274.9. Driller's log supplied by Alexander & Pollard.

Sand, brown, fine	15	15
Clay, brown, sandy	15	30
Sand, fine	8	38
Sand, coarse; gravel	8	46
Red beds	—	—

22N11W-32-3. 660 feet west of NE cor. Altitude, 1,273.5. Driller's log supplied by Alexander & Pollard.

Sand, brown	11	11
Clay, blue, sandy	4	15
Sand, fine; clay streaks	20	35
Sand, coarse; gravel	9	44
Red beds	—	—

22N11W-32-4. 1,320 feet east of N¼ cor. Altitude, 1,272.7. Driller's log supplied by Alexander & Pollard.

Sand, brown	8	8
Clay, blue, sandy	3	11
Clay, brown, sandy	7	18
Sand, fine; clay	15	33
Sand, coarse; gravel	9	42
Red beds	—	—

22N11W-32-5. 660 feet east of N¼ cor. Altitude, 1,271.0. Driller's log supplied by Alexander & Pollard.

Sand, brown	7	7
Clay, sand	26	33
Sand, fine	4	37
Sand, coarse; gravel	5	52
Red beds	—	—

22N11W-32-6. N¼ cor. Altitude, 1,264.4. Driller's log supplied by Alexander & Pollard.

Sand, brown	8	8
Clay, gray, sandy	6	14
Sand, red, fine	6	20
Clay, red, sandy	5	25
Sand, fine	10	35
Sand, coarse; gravel	2	37
Clay, red, sandy	3	40
Sand, coarse; gravel	1	41
Red beds	—	—

22N11W-32-7. 1,980 feet east of NW cor. Altitude, 1,256.3. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, brown; soil	6	6
Sand, fine	3	9
Clay, sandy	5	14
Sand, hard, medium	6	20
Sand, coarse; gravel	17	37
Red beds	--	--

22N11W-32-8. 1,320 feet east of NW cor. Altitude, 1,251.4. Driller's log supplied by Alexander & Pollard.

Sand, brown; soil	5	5
Clay, red, sandy	4	9
Sand, fine	4	13
Sand, coarse; gravel	5	18
Clay, sandy	3	21
Sand, fine	1	22
Clay, sandy; sand, coarse; gravel	6	28
Red beds	--	--

22N11W-32-9. 660 feet east of NW cor. Altitude, 1,253.0. Driller's log supplied by Alexander & Pollard.

Sand, brown; soil	5	5
Clay, black, sandy	2	7
Clay, tan, sandy	3	10
Sand, red, coarse; gravel	3	13
Sand, coarse; gravel	6	19
Clay, red; sand and gravel	6	25
Sand, coarse; gravel	1	26
Red beds	--	--

22N11W-32-10. NW cor. Altitude, 1,251.0. Driller's log supplied by Alexander & Pollard.

Sand, brown, fine; soil	5	5
Sand, fine	4	9
Sand, coarse; gravel	6	15
Clay, red; sand	8	23
Sand, coarse; gravel	2	25
Clay, red	2	27
Red beds	--	--

22N11W-33-1. N¼ cor. Altitude, 1,279.9. Driller's log supplied by Alexander & Pollard.

Sand, fine	13	13
Clay, brown, sandy	7	20
Clay, red, sandy	20	40
Sand, medium; gravel	10	50
Red beds	--	--

22N11W-33-2. 1,320 feet west of NE cor. Altitude, 1,282.5. Driller's log supplied by Alexander & Pollard.

Sand, brown, fine	9	9
Clay, brown, sandy	11	20
Clay, red, sandy	25	45
Sand, medium; gravel	4	49
Clay	1	50
Sand, medium; gravel	2	52
Red beds	--	--

22N12W-12-3. N¼ cor. Altitude, 1,281.0. Driller's log supplied by Alexander & Pollard.

Sand, fine; clay streaks	20	20
Sand, coarse; gravel	10	30
Red beds	--	--

22N12W-12-4. NW cor. Altitude, 1,265.3. Driller's log supplied by Alexander & Pollard.

	Thickness (feet)	Depth (feet)
Sand, fine	6	6
Sand, coarse; gravel	15	21
Red beds	--	--

22N12W-13-3. 1,320 feet east of NW cor. Altitude, 1,266.4. Driller's log supplied by Alexander & Pollard.

Sand, brown, fine	10	10
Sand, coarse; gravel	11	21
Red beds	--	--

23N11W-7. 30 feet north and 15 feet west of SE cor. Altitude, 1,339.9. Sample log.

Sand, fine	2	2
Clay, grayish-brown, sandy	4	6
Sand and clay, gray	5	11
Clay and sand, brown and gray calcareous	5	16
Sand, light-brown, medium	6	22
Sand and clay, brown, calcareous	5	27
Clay, brown, sandy, calcareous	5	32
Sand and clay, brown, calcareous	5	37
Clay, reddish-brown and gray, sandy, calcareous	6	43
Gravel, medium; sand, coarse	5	48
Sand, coarse; gravel, medium	5	53
Sand, gravel, and clay, reddish-brown	5	58
Gravel, medium	21	79
Gravel, medium; clay, reddish-brown and gray, calcareous	6	85
Sand and gravel, medium	3	88
Red beds	--	--

23N11W-8. 126 feet south and 12 feet west of NE cor. Altitude, 1,365.9. Sample log.

Sand, very fine	6	6
Sand, brown, fine	5	11
Sand, very fine	11	22
Sand and clay, brown	5	27
Clay, brown, sandy	5	32
Sand, very fine	5	37
Clay, brown, sandy, calcareous; gravel, medium	6	43
Clay, brown, sandy; gravel, medium	5	48
Sand, very fine	10	58
Clay, brown, sandy, calcareous	11	69
Clay, reddish-brown, calcareous; gravel, medium	4	73
Red beds	--	--

23N11W-21. 320 feet south and 8 feet east of NW cor. Altitude, 1,347.6. Sample log.

Sand and clay, brown	6	6
Clay, brown and gray, sandy	10	16
Sand, very fine	16	32
Clay, brown and gray, sandy	5	37
Clay, gray, sandy	6	43
Sand, very fine	21	64
Sand, medium; gravel, medium	10	74
Sand and clay, reddish-brown; gravel, medium	5	79
Red beds	--	--

IRRIGATION WELLS COMPLETED AS OF AUGUST 1, 1953

KINGFISHER COUNTY

Appendix C

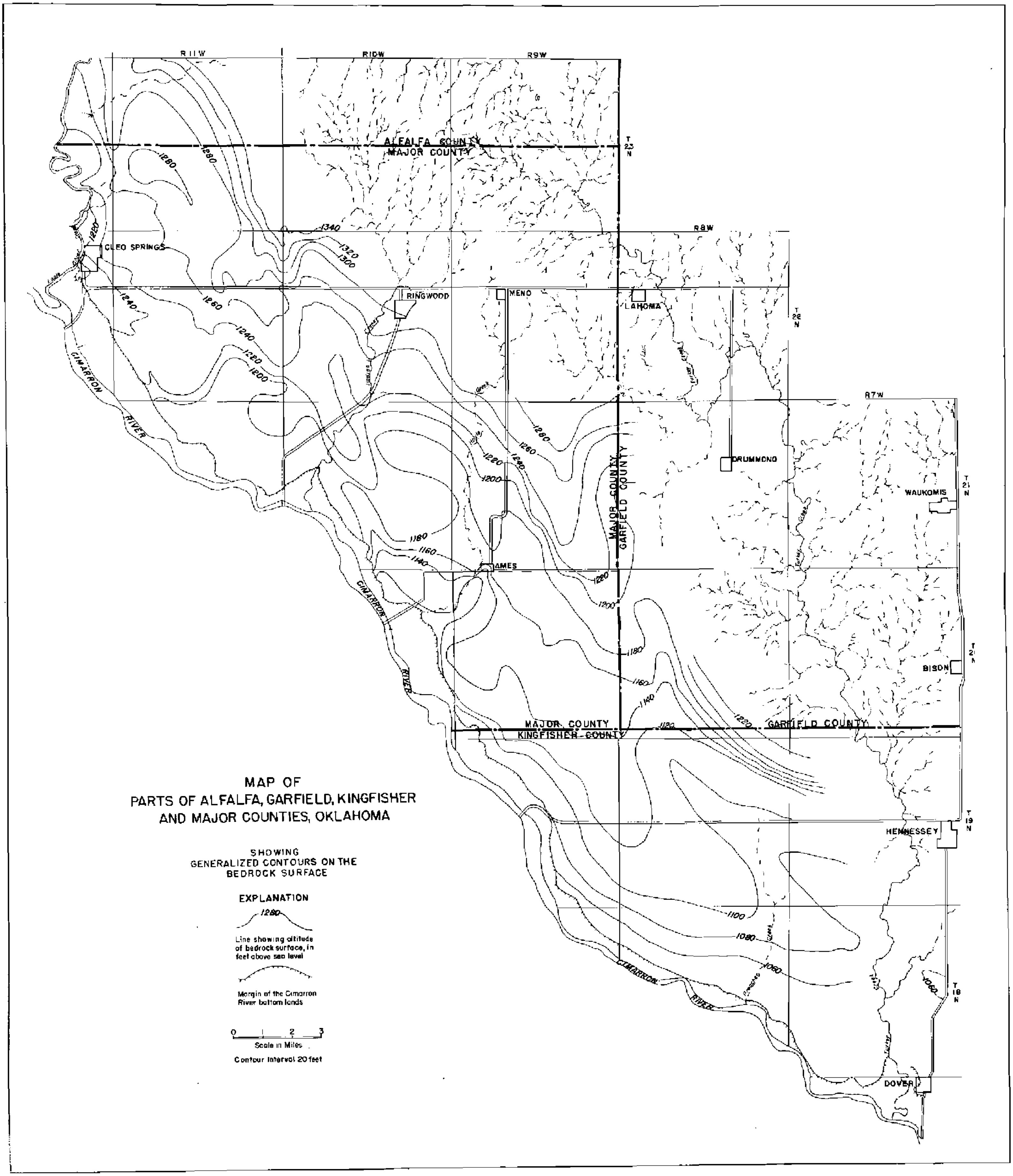
Owner	Location	Date	Acres Irrigated	Type of Rig	Total Depth	Diameter	Casing	Finish	Type of Pump	Reported Yield-GPM
Francis Gorton, Hennessey	9-19N-7W	5/6/49	40	Rotary	34'	30"	34' of 16"	Perforated	Turbine	200
H. S. Stringer, Hennessey	30-19N-7W	May 1949	80	Rotary	91'	16"	91' of 16"	Screen	Turbine	600
Walt Stribble, Hennessey	4-18N-7W	12/1/52	30	Rotary	44'	31"	44' of 16"	Perforated	Turbine	125
B. Throckmorton, Hennessey	6-18N-7W	2/24/53	40	Rotary	61'	32"	61' of 16"	Perforated	Turbine	400
Bill Barr, Dover	35-18N-7W	1952	160	Dug	41'	8"	30'	Sandpoint	Centrifugal	1,200
Lee Foultz, Dover	1-17N-7W	1949	1	Driven	28'	2"	28' of 2"	Sandpoint	Centrifugal	--
Bill Barr, Dover	2-17N-7W	1951	10	Driven	38'	2"	38' of 2"	Sandpoint	Centrifugal	--
Pete Towne, Dover	2-17N-7W	Dec. 1952	50	Driven	38'	4"	38' of 4"	Sandpoint	Centrifugal	600
Pete Towne, Dover	2-17N-7W	July 1951	40	Cable	38'	8"	38' of 8"	Perforated	Centrifugal	130
Earl McNally, Dover	2-17N-7W	May 1951	2	Rotary	40'	8"	40' of 8"	Perforated	--	--
Emma L. Purdy, Dover	2-17N-7W	May 1948	26	Driven	27'	2"	27' of 2"	Sandpoint	Centrifugal	250
W. D. Kenyon, Dover	2-17N-7W	May 1947	10	Cable	40'	6"	40'	--	Centrifugal	150
W. D. Kenyon, Dover	2-17N-7W	May 1945	30	Driven	30'	2"	30' of 2"	Sandpoint	Centrifugal	250
W. D. Kenyon, Dover	2-17N-7W	May 1945	35	Driven	30'	2"	30' of 2"	Sandpoint	Centrifugal	250
W. D. Kenyon, Dover	2-17N-7W	May 1947	30	Cable	35'	12"	35'	Gravel	Centrifugal	250
J. R. Cheney, Dover	2-17N-7W	5/7/37	40	Dug	50'	20'	50' of 40"	Gravel	Centrifugal	1,200
Glen Johnston, Dover	7-17N-6W	1946	80	Driven	30'	2"	30' of 2"	Sandpoint	Centrifugal	450
Roy Counts, Dover	10-17N-6W	11/20/52	35	Rotary	50'	26"	50' of 12"	Perforated	Turbine	150
Glen Johnston, Dover	17-17N-6W	1948	80	Driven	40'	2"	40' of 2"	Sandpoint	Centrifugal	450
W. D. Kenyon, Dover	18-17N-6W	May 1941	40	Driven	35'	2"	35' of 2"	Sandpoint	Centrifugal	400
W. D. Kenyon, Dover	18-17N-6W	May 1940	15	Driven	35'	$1\frac{1}{4}$"	35' of $1\frac{1}{4}$"	Sandpoint	Centrifugal	150
W. D. Kenyon, Dover	18-17N-6W	May 1947	35	Driven	35'	2"	36' of 2"	Sandpoint	Centrifugal	250
Glen Johnston, Dover	18-17N-6W	1946	75	Driven	38'	2"	38' of 2"	Sandpoint	Centrifugal	500
Virgil Ingle, Dover	32-18N-6W	Sept. 1952	80	Rotary	73'	21"	65' of 12"	Perforated 10'	Turbine	265
G. H. Stewart, Hennessey	22-19N-8W	--	80	Rotary	75'	32"	60' of 16"	Perforated	Turbine	900
G. H. Stewart, Hennessey	22-19N-8W	2/22/53	70	Rotary	75'	32"	75' of 16"	Perforated	Turbine	800
Al D. Racer, Hennessey	14-19N-8W	10/5/52	160	Rotary	82'	32"	82' of 18"	Perforated	Turbine	1,500
Mason Stanbaugh, Waucomis	16-19N-8W	2/15/53	80	Rotary	87'	30"	87' of 16"	Perforated	Turbine	500
Delmer Beadle, Hennessey	16-19N-8W	Nov. 1952	80	Rotary	75'	26"	75'	Perforated	Turbine	600
Warner Elrod, Hennessey	30-19N-8W	Oct. 1952	80	Rotary	56'	26"	56' of 16"	Perforated	Turbine	600
Al D. Racer, Hennessey	22-19N-8W	10/22/52	160	Rotary	76'	32"	76' of 18"	Perforated	Turbine	1,000
George Yeoman	24-18N-7W	Oct. 1952	120	Rotary	62'	24"	62' of 12"	Perforated	Turbine	345
J. C. McCann, Dover	32-18N-6W	7/29/53	80	Rotary	61'	30"	61' of 16"	Perforated	Turbine	500

IRRIGATION WELLS COMPLETED AS OF AUGUST 1, 1953

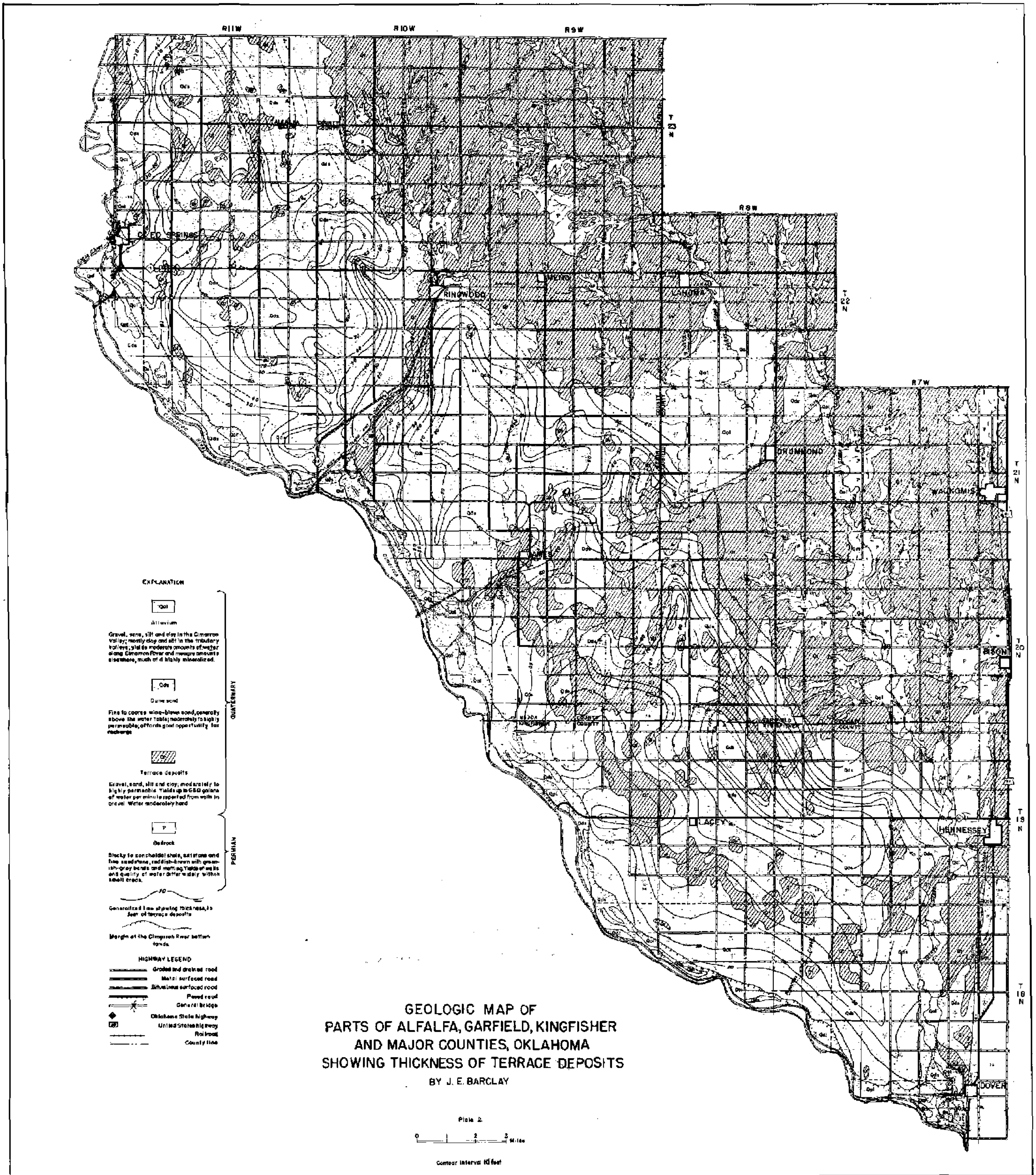
MAJOR COUNTY

Appendix C: Continued

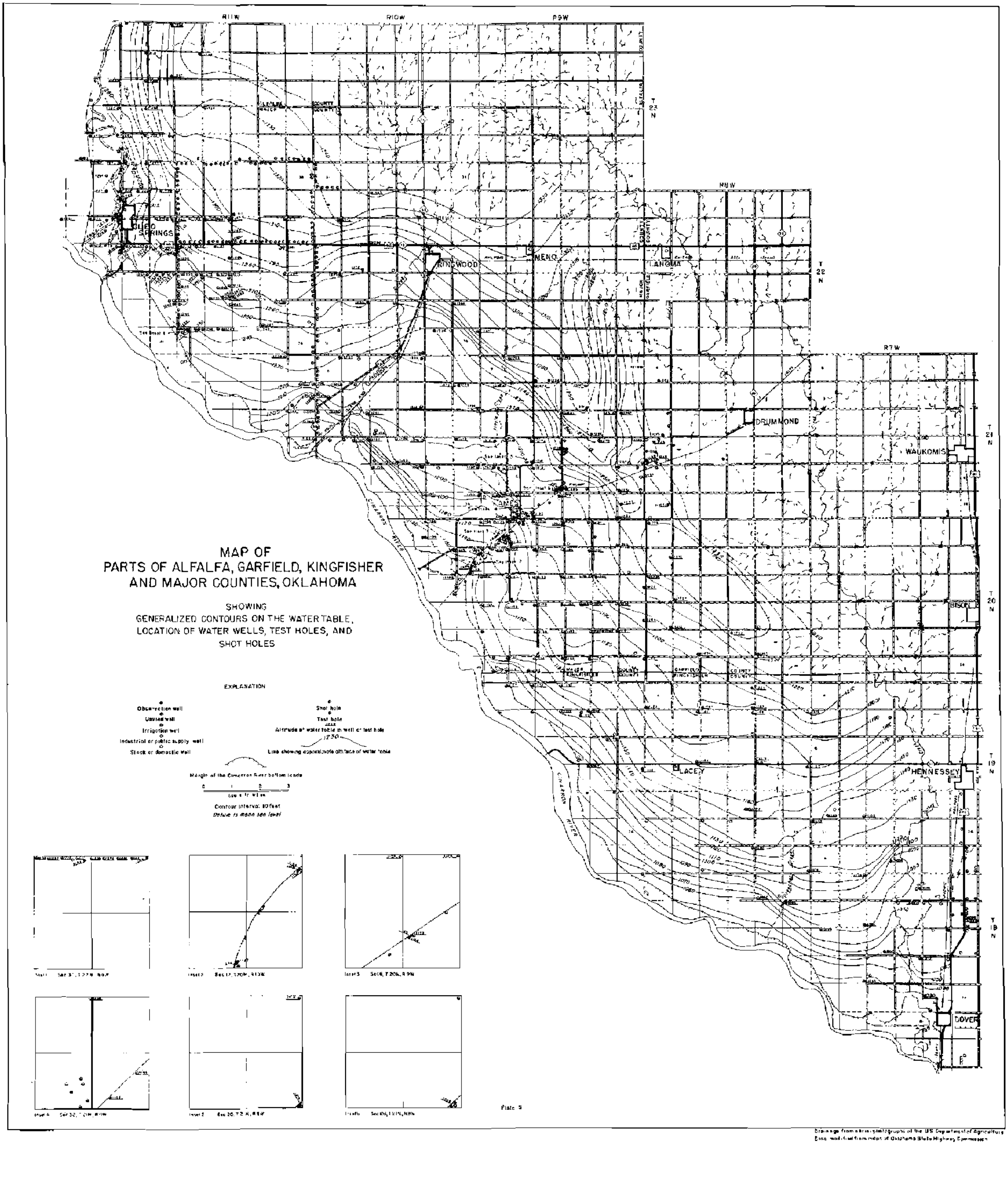
Owner	Location	Date	Acres Irrigated	Type of Rig	Total Depth	Diameter	Casing	Finish	Type of Pump	Reported Yield-GPM
I. E. Hall, Ames	2[illegible]-21N-9W	5/3/53	50	Rotary	57'	36"	57' of 16"	12'-16" wire	Turbine	880
Leo Harms, Cleo Springs	7-22N-11W	2/1/52	8	Rotary	49'	10"	49' of 6"	gravel pack	Centrifugal	180
Frank Fuller	35-21N-10W	Jan. 1953	40	Rotary	70'	12"	70'	gravel pack	--	325
Ned Wood, Ames	20-21N-9W	May 1948	60	Dug	53'	52"	Conc. to 53'	gravel pack	Turbine	1,000
Pete Jantz, Ringwood	7-21N-10W	1/1/53	60	Rotary	60'	12"	60'	gravel pack	Turbine	700
V. J. [illegible], Cleo Springs	5-22N-11W	4/1/53	40	Rotary	74'	24"	74' of 16"	gravel pack	Turbine	400
B. H. Basar, Ames	32-21N-9W	7/4/53	30	Rotary	35'	30"	--	gravel pack	Turbine	300
E. B. [illegible], Isabella	8-21N-10W	--	--	--	51'	9"	51' of 9"	gravel pack	--	--
Charles [illegible]rinson, Ringwood	6-21N-10W	Apr. 1953	80	Rotary	60'	14"	50' of 14"	gravel pack	Turbine	550
P. [illegible]. Britton, Ames	4-20N-9W	4/15/51	90	Rotary	82'	19"	82' of 12"	10' Perforated	Turbine	350
H. J. Bowman, Ames	5-20N-9W	Mar. 1953	200	Rotary	56'	32"	56' of 16"	12' of well screen	Turbine	500
T. E. Hall, Ames	8-20N-9W	5/9/53	20	Rotary	52'	28"	52' of 12"	10' - 12" wire wound screen	Turbine	400
H. L. Myers, Ames	21-20N-9W	Nov. 1952	68	Rotary	59'	--	59' of 12"	Perforated	Turbine	450
Robert Malone, Ames	34-20N-9W	12/22/52	60	Rotary	50'	18"	51' of 18"	Perforated	Turbine	500
Walter Laubach, Wichita Kan.	2-20N-10W	1/12/53	80	Rotary	60'	18"	60' of 12"	Perforated	Turbine	300
Victor Laubhan, Ames	6-20N-9W	Mar. 1948	30	Rotary	67'	--	67' of 10"	gravel pack	Centrifugal	250



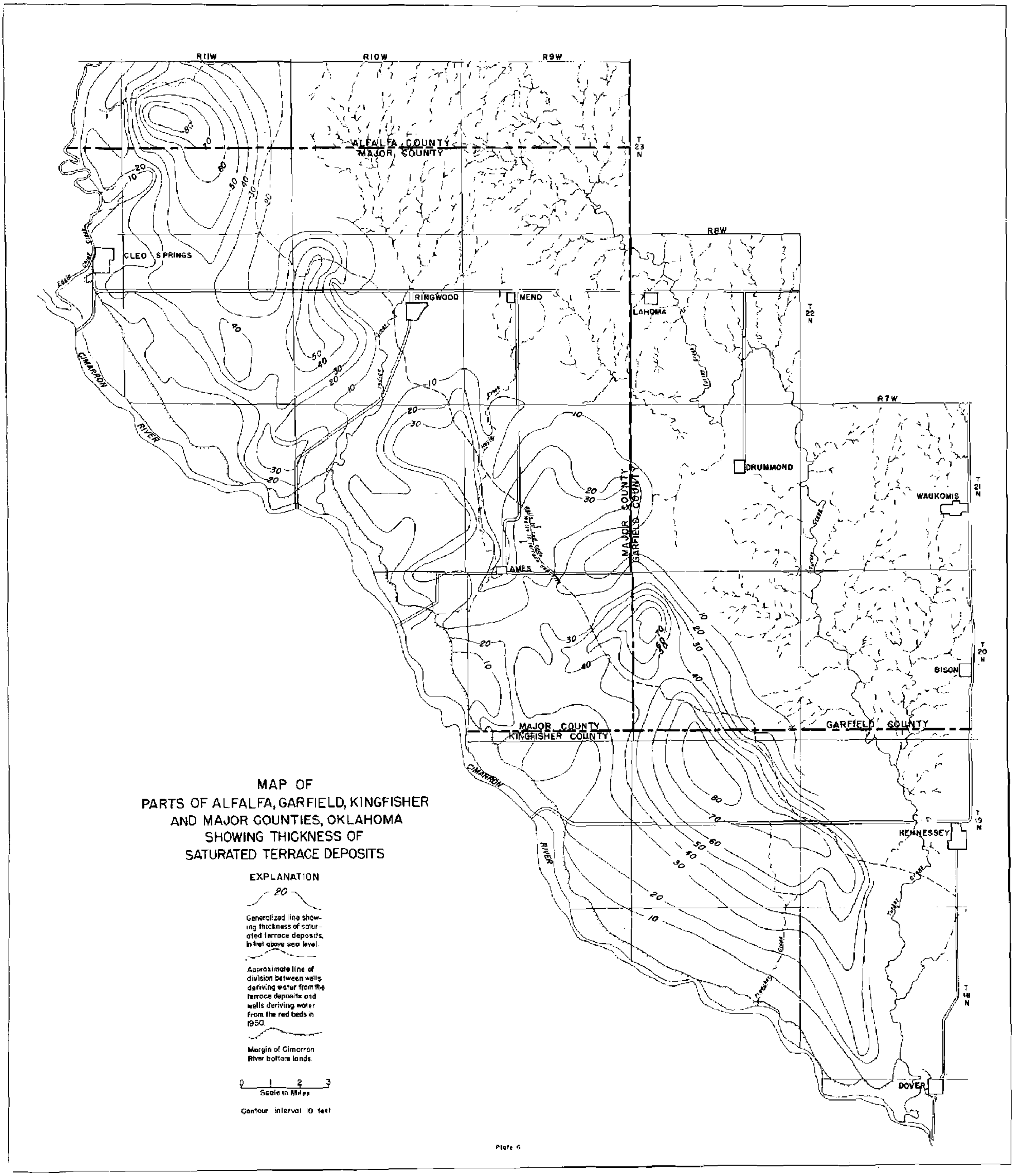
MAP OF
PARTS OF ALFALFA, GARFIELD, KINGFISHER
AND MAJOR COUNTIES, OKLAHOMA
SHOWING
GENERALIZED CONTOURS ON THE
BEDROCK SURFACE
EXPLANATION
1280
Line showing altitude of bedrock surface, in feet above sea level
Margin of the Cimarron River bottom lands
0 1 2 3
Scale in Miles
Contour Interval 20 feet
R11W
R10W
R9W
R8W
R7W
ALFALFA COUNTY
MAJOR COUNTY
GARFIELD COUNTY
KINGFISHER COUNTY
CLEO SPRINGS
RINGWOOD
MENO
LAHOMA
DRUMMOND
WAUKOMIS
AMES
BISON
HENNESSEY
DOVER
CIMARRON RIVER



Drainage from aerial photographs of the U.S. Department of Agriculture
Base modified from maps of Oklahoma State Highway Commission



Drainage from aerial photographs of the US Department of Agriculture
Base modified from maps of Oklahoma State Highway Commission



MAP OF
PARTS OF ALFALFA, GARFIELD, KINGFISHER
AND MAJOR COUNTIES, OKLAHOMA
SHOWING THICKNESS OF
SATURATED TERRACE DEPOSITS

EXPLANATION

20 — Generalized line showing thickness of saturated terrace deposits, in feet above sea level.

Approximate line of division between wells deriving water from the terrace deposits and wells deriving water from the red beds in 1950.

Margin of Cimarron River bottom lands.

Plate 6

GEOLOGIC CROSS SECTIONS THROUGH PARTS OF GARFIELD, KINGFISHER AND MAJOR COUNTIES, OKLAHOMA