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GROUND WATER IN KINGFISHER COUNTY, OKLAHOMA

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Norman

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Oklahoma Geological Survey and the
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This report is based on published maps and reports, and on information in the files of the Oklahoma Geological Survey and the U. S. Geological Survey in Norman. Field work in Kingfisher County was limited to four and a half days of geologic reconnaissance and the collection of 11 samples of water by Leon V. Davis, of the Oklahoma Geological Survey. Accordingly, some of the conclusions presented here have been reached through comparison with other areas having similar geological settings, and therefore should be considered as approximate and preliminary.

TOPOGRAPHY AND GENERAL GEOLOGY

Kingfisher County is nearly square, measuring 5 townships on each side. Its surface is a gently rolling plain, across which the Cimarron River has carved a shallow valley. The surface rocks in most of the county are red beds of Permian age belonging to the Hennessey, Duncan, Chickasha, Dog Creek, and Blaine formations. In the trough carved by the Cimarron are river sediments, or alluvium, and these are probably the most favorable source of ground water available in the county. Parallel to the Cimarron on its northeast side is a wide area where older river sediments classified as terrace deposits overlie the red beds. They are considered to be a much better water-bearing formation than the red beds, but are second to the alluvium in respect to safe annual yield.

GROUND WATER IN THE PERMIAN BEDROCKS

The geologic map of Kingfisher County accompanying this report is taken directly from the map by Kite.1/

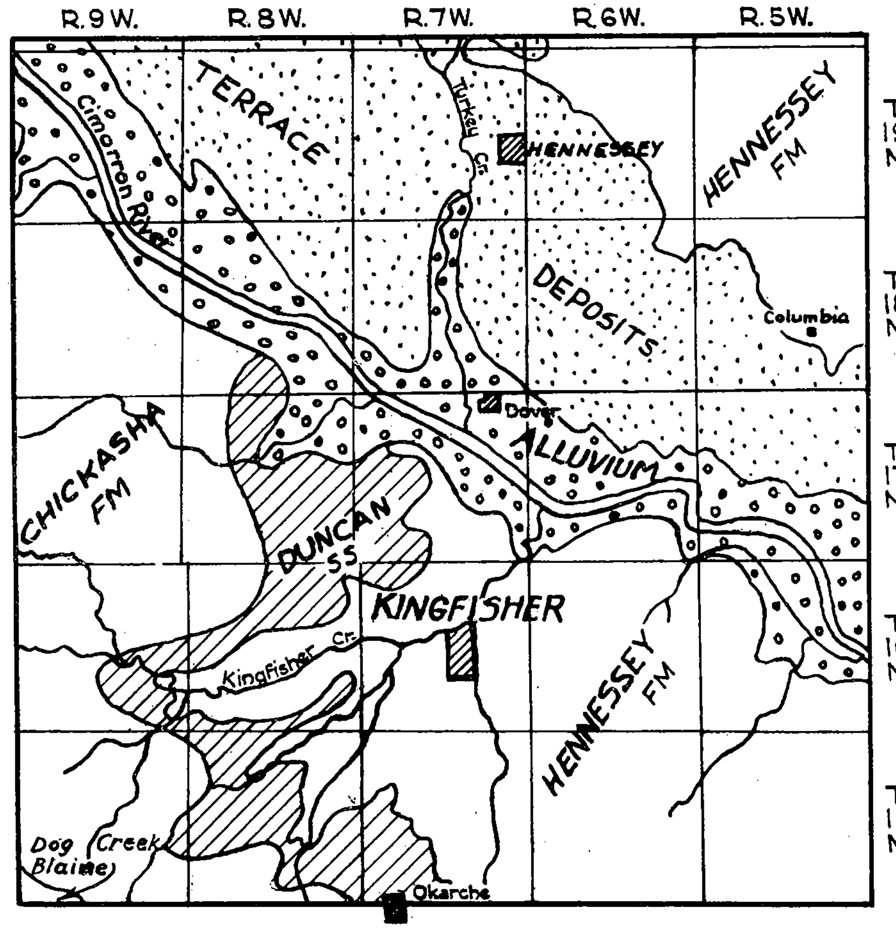
References are to bibliography at back of this report.

It shows the Hennessey formation cropping out in the eastern half of the county, the Duncan sandstone in an irregular north-south outcrop just west of the middle of the county, the Chickasha formation in the western part, and the Dog Creek and Blaine formations in a few square miles of the extreme southwestern part. As described by Kite, these formations consist principally of soft red shales, with some lenticular layers of fine-grained sandstone. Such rock formations can be expected to yield only small supplies of water, in general no more than adequate for household and stock use. The general dip of the rocks in Kingfisher County is westward, and the oldest of the bedrock formations crops out in the east and the youngest in the west.

At depths of several hundred feet beneath the surface in Kingfisher County, a sandstone and shale unit may be found, which is approximately equivalent to the Garber sandstone, a formation that furnishes much water to Noble, Norman, Oklahoma City, and Edmond. It offers only a slight possibility for irrigation in Kingfisher County, however, because in most parts of the county it is too far below the surface for economical pumping, especially as the yield per well is likely to be low. In 1947 it was considered as a possible source of municipal water for the town of Hennessey. The sandstones representing the Garber crop out at the surface about 17 miles east of the town and dip westward so that at Hennessey the lower sandy member of the unit should be about 600 feet or more below the surface. The sandy unit is about 350 feet in thickness but includes some shaly layers. The log of a well in the NW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 21, T. 19 N., R. 5 W., shows sands at 295-310, 430-455, and 470-480 feet. The yield per foot of drawdown would probably be low. As the deeper wells in Oklahoma often have encountered saline water, even in sandstone formations that yield fresh water near the surface, it is possible that the water at a depth of 600 feet at Hennessey might be saline.

GROUND WATER IN ALLUVIUM

Alluvium is the material deposited by a stream. It may consist of gravel, sand, and clay in any proportion



GEOLOGIC MAP OF KINGFISHER COUNTY, OKLA.

(See text for explanation)

and any degree of sorting, and it underlies the flood plain, or "bottom." It is generally thickest near the middle of a valley, and thinnest where the flood plain adjoins the bluffs. Along major rivers it may be more than 100 feet in thickness, but only a few feet along small creeks. In many places the alluvium is an excellent water-bearing formation, both because the coarser portions of it will transmit water freely to wells, and because replenishment of the ground-water supply along a river is likely to be greater than in adjacent areas.

The alluvium along the Cimarron River, in Kingfisher County, underlies a strip from a mile and a half to several miles in width, and it is probably the most prolific water-bearing formation in the county. Little is known about its thickness, except that two wells of the Kingfisher water-supply system, described as half a mile east of U. S. Highway 81 and half a mile north of the Cimarron River, are reported to penetrate 30 feet of material grading from wind-blown sand at the surface down into coarse sand and gravel. By comparison, 30 feet seems thin for the alluvium of a major river. Test drilling in the North Canadian Valley in Canadian County2/ at locations both near and far from the channel showed an average of about 40 feet of alluvium, with a maximum of about 60 feet. Likewise, a well drilled in the Washita Valley at Alex showed 97 feet of alluvium3/ Elsewhere in the Cimarron Valley itself, thicker alluvium has been found. For example, 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 show alluvium ranging from 25 to 75 feet in thickness and consisting mainly of sand with some gravel and only a few thin layers of clay. The logs of these test holes are given at the end of this report.

Although water-bearing sand and gravel will doubtless be found at almost any site on the valley bottom, some places are much more favorable than others. The gravel is thicker, coarser, and cleaner where former channels of the river have been buried, and the wells in such channels will produce much more freely than those at intermediate locations where the water was quiet, allowing fine mud to settle to the bottom. The old channels are long and winding, like the present channel, and probably about as wide. In general, they cannot be found from surface indications alone, but must be sought by intensive test drilling.

Yield of wells. One of the wells recently drilled for the public supply of Kingfisher is reported to have yielded on test 287 gallons per minute, with a drawdown of 12 feet.4/ This is about 24 gallons per minute per foot of drawdown, a moderately high specific capacity.

The City of Stillwater has at times used water from the alluvium of the Cimarron River for public supply.5/ Three wells were drilled for the city in 1937, south of Perkins Corner, in secs. 11 and 12, T. 17 N., R. 2 E., and two more were drilled in 1940. These were 31.4, 34, 36, 39, and 44 feet in depth. Two of the wells are reported to have yielded 255 gallons per minute during 24-hour tests, with drawdowns of 12 feet, and a third well was yielding 228 gallons per minute with 5.1 feet of drawdown at the end of 24 hours of pumping. In other words, the yield on test ranged from 21 to 45 gallons per minute per foot of drawdown. The minimum distance between wells was half a mile, and for long-term operation, the wells were pumped at a rate of 100 gallons per minute, the low rate being adopted mainly to minimize inflow of poor water from the river.

The yields cited above should be considered as a report on what is known of individual wells in the Cimarron Valley, not necessarily as indicating the maximum possible yield. A larger pump in the same wells might have produced more water, or a larger well designed for greater production might have yielded more. Wells in the alluvium of the Arkansas River at Ponca City are reported to yield about 1,700 gallons per minute,6/ but this probably is much more than can be obtained generally.

Quality of the water. The hardness of the water from one of the new wells drilled for Kingfisher is reported as about 205 parts per million as $CaCO_3$.7/ The analyses for 22 water samples identified as coming from

alluvium in Kingfisher County are tabulated by Smith,8/ and the range in concentration of the principal constituents may be summarized as follows:

Constituent	Concentration, in parts per million Minimum	Maximum
Calcium carbonate ($CaCO_3$)	60	290
Magnesium carbonate ($MgCO_3$)	3	82
Magnesium sulfate ($MgSO_4$)	25	128
Sodium sulfate (Na_2SO_4)	4	375
Sodium chloride (NaCl)	34	396
Total dissolved solids	341	895
Total hardness (as $CaCO_3$)	142	433

Water levels. Measurements of water levels in wells tapping ground water in the alluvium along the Cimarron in Kingfisher County have not been made by the Geological Survey, but reports obtained by the State Mineral Survey9/ indicate that the static water levels range from 5 to about 25 feet below the surface, depending mainly on the elevation of the floodplain surface channel above the river.

Likewise, the available data are inadequate to show whether water levels in the alluvium in Kingfisher County are rising or falling progressively, but the studies of water-level fluctuations elsewhere in Oklahoma suggest that, under the present conditions of low demand for water, the fluctuations are mainly seasonal and there is no progressive decline. That is, the water levels rise during rainy seasons until the ground-water reservoir is more or less full and then decline through succeeding dry seasons, without significant long-range trends. This situation would change if heavy pumping for irrigation were begun, but even then it might take several years for permanent effects to appear.

Except near the Cimarron channel itself, the water levels under natural conditions may be expected to fluctuate during the year through a moderate range, generally not exceeding 5 feet, but under heavy pumping the difference between the highest and lowest levels for the year will become greater.

Movement of ground water. In the absence of the large amount of data required for the preparation of a water-table map, a detailed description of the movements of the ground water in the alluvium in Kingfisher County is impossible. However, it is certain that, as in other alluvial deposits, the general movement is down the valley, with a component toward the river at most times but away from the river during periods of high water.

Amount of underflow. The volume of water moving through the alluvium may not be large. In the North Canadian Valley,10/ for example, the underflow has been measured as only about a quarter of a million gallons of water per day, and the alluvium there can be considered more as a storage reservoir than as a conduit. As the underflow is controlled by the cross-sectional area of the water-bearing formation at right angles to the slope of the water table, by that slope itself (hydraulic gradient), and by the permeability of the material, it may differ greatly from one part of the same valley to another. The measurement in the North Canadian Valley cannot, therefore, be accepted as applicable in the Cimarron Valley, but it is suggestive. The amount of underflow is not a direct measure of the water that can be pumped from the ground-water reservoir.

Recharge and discharge. The ground water in the alluvium is replenished by the rain that falls on the flood plain, by the flood waters in the channel or on the flood plain, by surface runoff from adjacent slopes, and by water discharged onto the flood plain or carried across it by tributaries.

Only part of the rain that falls on the flood plain becomes ground water, for some of it evaporates, some drains into the river channel, and some is transpired into the atmosphere by plants. Just how large a fraction seeps into the ground is problematical. The normal annual precipitation at Kingfisher is about 30 inches, and if 20 percent (6 inches) reaches the water table, the annual recharge from this source would be 0.5 acre-foot per acre, or 320 acre-feet per square mile. On the other hand, hydrologists who have been

studying the ground water of the High Plains have found that only a very small fraction of the average annual precipitation becomes ground water. Theis11/ concluded from several computations that in the western part of the Texas Panhandle and northeastern New Mexico, the average annual recharge is less than 0.5 inch. Cady12/ estimated the amount of water moving through selected cross sections of the aquifer in Box Butte County, Nebraska, and concluded that the recharge is between 0.75 inch and slightly more than 1 inch per year. As the normal annual precipitation in Kingfisher County is at least twice that of the areas considered by Theis and Cady, it may be fair to take 1 or 2 inches per year as the minimum average recharge resulting from precipitation. This would be approximately 50 to 100 acre-feet of water per square mile. Because the data of Theis and Cady are mostly for areas where the water table is much farther below the surface than it is in the Cimarron Valley, the figure of 50 to 100 acre-feet may be rather conservative.

Under natural conditions, flood waters in the river channel probably make only rather temporary additions to the ground water in the alluvium. During floods some water moves into the sands and gravels adjacent to the channel, building up an appreciable mound or ridge that may persist for some time after the flood has passed. Ultimately these ridges disappear as the water drains back into the channel. A pumping well on the flood plain within a few hundred feet of the water-table ridge would increase the rate of recharge by withdrawing water that otherwise would return to the channel.

The volume of water reaching the ground-water reservoir from flood waters standing on the flood plain is small, because it is not often that floods overflow large areas beyond the river banks. While such overflow lasts, however, the rate of recharge is high. Runoff from adjacent slopes probably also makes only a small contribution during the year as a whole.

The amount of water recharged from tributary streams should be greater than that coming from the floods, especially where the streams flow throughout most of the year, but the effects will be local rather than general. Recharge from this source may materially alter the chemical character of the water.

Although the recharge cannot be set down as a definite and well-proved quantity of water, it is apparent that the conditions for recharge are about as favorable along the Cimarron River as anywhere in the county. Probably the average annual recharge is considerably more than 50 but somewhat less than 320 acre-feet per square mile. It should be repeated that pumping for irrigation might increase the annual recharge because, by dewatering part of the aquifer, it would create storage space ready to receive water when rains and floods come. Wells near the river tend to salvage waters in the channel that otherwise would continue downstream.

The ground water in the alluvium along the Cimarron River is discharged naturally by evaporation where the water table is near the surface, by transpiration where the water table is within reach of plant roots, and by effluent seepage into the river channel. The amount of this discharge has not been measured, but under natural conditions it should approximately balance the recharge. Theoretically, all the natural discharge can be salvaged by pumping without depleting the reservoir, but in practice some of it is certain to escape--indeed, must be allowed to escape to prevent the building up of the salt content.

In addition, some water is now discharged from the reservoir artificially by pumping. Although an inventory of water wells and pumping has not been made in the area, it is believed that the pumping at present, both for irrigation and for municipalities, is only a fraction of the safe yield. It may have salvaged a fraction of the natural discharge, and locally it may have increased the recharge in the manner indicated previously.

Permissible pumpage. It appears likely that considerable water could be pumped from the alluvium of the Cimarron River in Kingfisher County without serious

depletion, but it is obviously unwise to make an unqualified statement of the available quantity solely on the basis of the available information. An optimistic view is possible, however, because of the known good results elsewhere. The alluvium along the North Canadian River, for example, for years has been the source of water supply for the City of El Reno, which currently uses about 1,300,000 gallons per day. This is 475,000,000 gallons per year, or about 1,460 acre-feet. In addition, the towns farther upstream -- Calumet, Geary, Watonga, and others as far as Beaver -- obtain their water supplies from the alluvium, and some irrigation with ground water has been carried on for years, as at Laverne. At times the water levels in the El Reno well field have declined considerably, but they have recovered satisfactorily in subsequent rainy seasons.

At times the City of Oklahoma City has resorted to wells in the alluvium of the North Canadian to supplement its surface reservoirs. For protracted periods in 1944, about 3,500,000 gallons per day was being pumped. The water levels declined enough to indicate that local overdevelopment had occurred, and that this rate could not be maintained indefinitely. It might have been continued, however, if the wells had been more widely spaced. When pumping in the Oklahoma City wells was discontinued as unnecessary, the water levels gradually returned to their previous level.

Ample supplies of ground water are also obtained from the alluvium along other main streams in Oklahoma. Pauls Valley, for example, has been pumping about 300,000 gallons of water per day from wells on the Washita River bottoms.

GROUND WATER IN ALLUVIUM OF MINOR STREAMS

Although the ground water in the alluvium along the tributaries to the Cimarron River locally may be adequate in quantity for irrigation, some of it may be too highly mineralized for such use. Turkey Creek, which flows into the Cimarron from the north appears to be highly mineralized. If the ground water in the adjacent alluvium is not already highly mineralized, heavy pumping from wells tapping the alluvium would quickly draw mineralized water from the creek into the wells. One of the municipal wells of Hennessey is about 100 feet from Turkey Creek, and the water from the creek should be able to move readily from the creek to the well. Water from the well contains 2060 parts per million of dissolved solids (Table III, no. 2).

A similar situation seems to apply along Kingfisher Creek, on the opposite side of the Cimarron River, as indicated by the analysis of a sample of water collected from the Grady Meade irrigation well in April, 1948, by the U. S. Bureau of Reclamation. The well is in the NW$\frac{1}{4}$ NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 2, T. 16 N., R. 7 W., and begins in the alluvium of Kingfisher Creek about 4 miles upstream from its confluence with the Cimarron River. The well is reported to be 47 feet deep, and although it may end in the Permian bedrock, it probably receives ground water principally from the alluvium. The analysis shows 3040 parts per million of dissolved solids, (Table III, Analysis no. 12)

GROUND WATER IN TERRACE DEPOSITS

The terrace deposits in Kingfisher County occupy a strip from 4 to 10 miles in width paralleling the Cimarron River on its northeast side. They consist of materials laid down by an ancient stream, probably the Cimarron before it made its present trough. Accordingly, the description given for the present-day alluvium is applicable also to the terrace deposits, and test drilling is just as important in finding the thicker, coarser, and more permeable deposits.

The thickness of the terrace deposits differs greatly from place to place because of the uneven surface of the bedrock below, and because of erosion of the land surface. Reports obtained by the State Mineral Survey indicate depths of farm wells in the area ranging from about 25 feet to about 70 feet, but some of the deeper wells may have entered the red beds and therefore are not a reliable indication of the thickness of the terrace deposits.

Yield of wells. Little is known about the yields of individual wells in the terrace deposits, but the cities of Alva and Waynoka obtain adequate municipal water supplies in them farther to the northwest. Enid has pumped water from an isolated area of the same kind of sediments for many years. Recently, the daily consumption has been about 2,500,000 gallons, but at this rate the water levels have declined progressively, indicating that the safe yield of the present development may have been exceeded despite the fact that pumping rates have been kept down to 150 gallons per minute per well, or less.

Quality of water. The quality of the water in the terrace deposits is generally better than that in the red beds and probably better than most of the water in the alluvium, but it is variable, as shown in the table of chemical analyses at the end of this report.

Water levels. The depths to the water table in the terrace deposits have not been measured, but the reports obtained by the State Mineral Survey indicate static levels of 20 to 50 feet below the surface. As in the alluvium, the principal fluctuations of water level are doubtless more or less seasonal, controlled by the balance between recharge and discharge, but will show new trends if heavy pumping occurs.

Movement of ground water. The ground water in the terrace deposits moves with the slope of the water table, that is, from higher to lower. In places it moves toward the Cimarron River; in other places, toward tributary streams; and in still other places, parallel with the trend of the Cimarron. The general direction is probably southwestward. The rate of movement has not been determined.

Recharge and discharge. Recharge to the terrace deposits comes entirely from precipitation on the surface. The deposits are above the Cimarron, hence can receive no water from floods in the channel. They are on a relatively flat bench, with no adjacent slopes from higher lands permitting surface runoff to reach them. The streams that cross their outcrop in general bring no water but instead drain water from them. Therefore, the amount of the annual recharge is the fraction of the annual precipitation that seeps downward to the water table, and should be about the same as the corresponding recharge to the alluvium -- estimated on a previous page as ranging possibly from 50 to 320 acre-feet per square mile per year. No large-scale pumping of water from the terrace deposits in Kingfisher County is known, although many farm wells draw on the water.

Permissible pumpage. The safe yield of the groundwater reservoir in the terrace deposits cannot be estimated from the data now available, but it is believed to be less than the safe yield of the alluvium because it receives recharge from fewer sources; also, little or no additional recharge can be induced by pumping. A tentative figure of 50 to 100 acre-feet per square mile per year might be adopted until more data are available. Full development, of course, would require wells scattered over the entire area to be developed.

Test drilling and pumping near Hennessey. In June 1948, 17 test holes were drilled for the town of Hennessey in an area of about 7 square miles on either side of U. S. Highway 81 from 2 to 5 miles south of the town. This testing, which was conducted under the supervision of Hudgins, Thompson, Ball, and Associates, of Oklahoma City, demonstrated the lack of uniformity in both character and thickness that is typical of terrace deposits. However, a pumping test indicated that good yields can be obtained from the terrace deposits where they include permeable water-bearing sands.

The logs of 16 of the test holes are given in Table II, together with logs of holes drilled for the pumping test. The log of test hole 13 was not reported. The well pumped for the test was logged with the nearest of the three observation wells. Thus, altogether, 19 logs are available for the area, representing 968 feet of drilling. Three of the test holes were considered to be outside the area of the terrace deposits, because they failed to encounter much terrace material. Their logs suggest that the mapping of the north boun-

dary of the terrace deposits near Hennessey needs revision.

The 17 holes in terrace deposits ranged from 37 to 66 feet in depth and averaged 51 feet. Of the terrace materials penetrated in the drilling, about 63 percent was sand, and about 46 percent of the sand was reported as "coarse." The layers of sand were not uniform, but ranged from 3 to 65 feet thick. Although information on the position of the water table is meager, it is estimated that about 63 percent of all the sand, and 98 percent of the coarse sand, is below the water table.

The test holes encountered the bedrock at different altitudes, indicating that the terrace materials were deposited on an uneven, perhaps channeled surface.

Along U. S. Highway 81 in sec. 13, T. 18 N., R. 7 W., the ground water in the terrace deposits is very hard--346 parts per million[13]--but the sands yield water freely. A 6-inch well with 6 feet of slotted casing opposite the water-bearing sand was constructed near the middle of the section, and three observation wells were put down in a line at distances of 8, 200, and 400 feet north of it. The three logs representing the locality show an average of 7 feet of fine sand and 18 feet of coarse sand in the zone of saturation. The pump was operated for 6 hours, and the discharge is reported as 112 gallons per minute, with a drawdown of 8 feet in the water level in the pumped well. This gives a specific capacity of about 14 gallons per minute per foot of drawdown. It is further reported that the drawdown in the observation well 8 feet away was 1.5 feet, but that no drawdown was observed in the wells 200 and 400 feet away. At such distances, however, no substantial drawdown should be expected without pumping for a much longer period.

Softer water was found along the west edge of the area that was tested, but the water-bearing sands are thinner, as in the NE¼ sec. 15, T. 18 N., R. 7 W. A well constructed there penetrated only 5 feet of water-bearing sand and yielded only about half as much water as in the test described above.

CONCLUSIONS

The Permian red beds in Kingfisher County afford little reasonable prospect for water for irrigation or other uses requiring large quantities of water.

The alluvium along the Cimarron River is believed to be a ground-water reservoir of considerable capacity and productiveness. It has more opportunities for recharge than other formations in Kingfisher County, and the available chemical analyses indicate that the water is of moderately good quality.

The terrace deposits bordering the Cimarron on the northeast are similar in lithologic character to the alluvium, but receive recharge principally from a single source, namely, precipitation on their surface. The coarser portions should yield water rather freely to wells, but the volume of water that can be pumped annually without causing permanent depletion is probably less than in the alluvium.

TEST WELLS IN CIMARRON RIVER ALLUVIUM

Logs 1 through 9 in the following table are for test holes of the Oklahoma State Highway Commission, drilled in the course of testing before construction of a bridge across the Cimarron River on U. S. Highway 64, between Woods and Harper Counties, Oklahoma. Test hole 1 was at the west abutment and test hole 9 at the east abutment.

TABLE I

Logs of Test Wells in Cimarron River Alluvium

Test No.	Location	Description of Material	Thickness (feet)	Depth (feet)
1	At west abutment	Sand	25.8	25.8
		Red beds	....	....
2	270 feet east of west abutment	Sand	25	25
		Red beds	....	....
3	540 feet east of west abutment	Sand	28.75	28.75
		Red beds	....	....
4	850 feet east of west abutment	Sand	56	56
		Red beds	....	....
5	1,740 feet east of west abutment	Sand	35	35
		Clay	2	37
		Coarse sand and gravel	33.5	70.5
		Red beds	....	....
6	2,010 feet east of west abutment	Sand	15	15
		Clay, gray	3	18
		Sand	4	22
		Gravel	1	23
		Sand and gravel in layers	42	65
		Red beds	....	....
7	2,250 feet east of west abutment	Sand	23	23
		Clay and gravel	2	25
		Sand and fine gravel	34.4	59.4
		Red beds	....	....
8	2,340 feet east of west abutment	Sand	20	20
		Gravel, fine	2	22
		Sand	11.5	33.5
		Gravel	8	41.5
		Red beds	....	....
9	At east abutment	Sand	19	19
		Gravel	2	21
		Sand	9	30
		Gravel	7	37
		Red beds	....	....

TEST HOLES NEAR HENNESSEY

The following logs represent test holes and observation wells drilled in an area 2 to 5 miles south of the town of Hennessey. All except test holes 1, 7, and 13 are believed to have penetrated terrace deposits. The log of observation well 1 represents both the observation well and the pumped well 8 feet distant.

TABLE II
Logs of Holes Drilled in Testing for Hennessey

Test No.	Location & Altitude	Description	Thickness (feet)	Depth (feet)
1	N¼ cor. sec. 1	Clay, red	10	10
	T. 18 N., R. 7 W.	Clay, red, and shale	20	30
	Altitude - 1180	Sand, red	6	36
		Sandstone, red	10	46
2	S¼ cor. sec. 1	Soil, sandy	20	20
	T. 18 N., R. 7 W.	Clay, sandy	8	28
		Clay	0.5	28.5
	Altitude - 1107.3	Sand, coarse, water-bearing	10.5	39
		Shale	....	....
3	S¼ cor. sec. 12	Soil, sandy; fine sand; some clay	32	32
	T. 18 N., R. 7 W.			
	Altitude - 1116.6	Sand, coarse	16	48
		Red clay		
4	S¼ cor. sec. 13	Sand, fine	58	58
	T. 18 N., R. 7 W.	Sand, coarse	7	65
		Shale	....	....
	Altitude - 1118.4			
5	SW cor. sec. 18	Sand, fine	10	10
	T. 18 N., R. 6 W.	Sand, red	20	30
		Clay	1	31
	Altitude - 1118.2	Clay and sand	6	37
		Sand, coarse, red	8	45
		Sand, coarse	9	54
		Sand, fine, red	10	64
		Shale	....	....
6	SE cor. sec. 12	Sand, fine, red	23	23
	T. 18 N., R. 7 W.	Clay	21	44
		Sand, coarse	6	50
	Altitude - 1117.5	Clay	1	51
		Shale	2	53
7	SE cor. sec. 1	Sand	20	20
	T. 18 N., R. 7 W.	Clay, sandy	20	40
		Clay	15	55
	Altitude - 1136.5			
8	NW cor. sec. 12	Clay	5	5
	T. 18 N., R. 7 W.	Sand, red	15	20
		Sand, coarse	4	24
	Altitude - 1111.9	Sand, very coarse	8	32
		Clay	1	33
		Sand, coarse reddish	7	40
		Sand, coarse some shale	4	44
		Hard shale	....	....
9	SW cor. sec. 12	Clay	18	18
	T. 18 N., R. 7 W.	Sand, coarse	7	25
	Altitude - 1101.9	Sand, very coarse	12	37
10	W¼ cor. sec. 13	Clay, sandy	21	21
	T. 18 N., R. 7 W.	Sand, coarse	7	28
		Sand, fine	13	41
	Altitude - 1097.3			
11	NE cor. sec. 23	Clay and sand	14	14
	T. 18 N., R. 7 W.	Sand, coarse	24	38
		Shale	....	....
	Altitude - 1100.7			
12	NW cor. sec. 14	Clay, sandy	18	18
	T. 18 N., R. 7 W.	Sand, coarse	15	33
	Altitude - 1098.0			
13	NW cor. sec. 11	(log not reported)		
	T. 18 N., R. 7 W.			
14	SW cor. sec. 20	Sandy _____?	43	43
	T. 18 N., R. 6 W.	Sand, coarse	23	66
	Altitude - 1118.1			

Test No.	Location & Altitude	Description	Thickness (feet)	Depth (feet)
15	NE cor. sec. 19	Sand, red	10	10
	T. 18 N., R. 6 W.	Clay, sandy	10	20
		Clay	10	30
	Altitude - 1120.2	Clay, sandy	17	47
		Sand, coarse	8	55
16	SE cor. sec. 24	Sand, fine	15	15
	T. 18 N., R. 7 W.	Sand, fine; some clay	10	25
	Altitude - 1124.5	Clay, coarse, sandy	5	30
		Clay, yellow and sand	6	36
		Sand, fine, red	4	40
		Sand	3	43
		Sand, coarse	13	56
		Shale	....	....
17	N¼ cor. sec. 30	Sandy ____?	20	20
	T. 18 N., R. 6 W.	Sand and clay	27	47
		Sand, coarse	9	56
	Altitude - 1115.5			
Obs. 1	near mid. sec. 13	Sand, fine	20	20
	T. 18 N., R. 7 W.	Sand	5	25
		Clay, sandy	15	40
	Altitude - 1117.0	Sand, coarse, yellowish	10	50
		Sand, coarse, white	8	58
Obs. 2	SW cor. NE¼ sec. 13	Sand, fine	20	20
	T. 18 N., R. 7 W.	Clay, sandy	15	35
		Clay and sand	5	40
	Altitude - 1117.0	Sand, coarse	15	55
		Sand, fine	3	58
Obs. 3	SW¼SW¼NE¼ sec. 13	Sand, fine	10	10
	T. 18 N., R. 7 W.	Sand and clay	10	20
		Sand, fine	10	30
	Altitude - 1116.0	Sand, coarse	20	50
		Sand, fine	6	56

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3. Reported by the Sawyer Drilling Company, Chickasha.

4. Reported by the Sawyer Drilling Company, Chickasha.

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11. Theis, C. V., "Amount of Ground-water Recharge in the Southern High Plains," Am. Geophys. Union Trans., pp. 564-568, 1937.

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TABLE III

Chemical Analyses, in Parts per Million, of Water from Terrace Deposits and Alluvium in Kingfisher County (Sample No. 1 collected April 1, 1948; others, July 9-10, 1945.)

Well No.	Location (Sec.)	Total Depth (ft.)	Type of well, Diameter	Water Temp.	Aquifer
	T. 19 N., R. 9 W.				
1	NW¼ 25	50	Dug, 10'	64°F.	Hennessey shale & sand
	T. 19 N., R. 7 W.				
2	SW¼ 22	60	Dug, 18'	61°F.	Alluvium
3	NW¼ 36	50	Dug, 6'	64°F.	High terrace sand
4	SW¼ 36	47	Dug		High terrace sand
	T. 18 N., R. 7 W.				
5	NE¼ 1	48	Drilled	65°F.	High terrace sand
6	SE¼ 1	68	Drilled, 6" Windmill	65°F.	High terrace sand
7	NW¼ 13	45		64°F.	High terrace sand
8	NE¼ 24	45	Dug-driven, Windmill	64°F.	
9	SW¼ 24	50		64°F.	
10	NE¼ 26	35	Windmill	65°F.	Low terrace sand
	T. 17 N., R. 7 W.				
11	SW¼ 12			65°F.	Alluvium
	T. 16 N., R. 7 W.				
12	NW¼ 2	47	Irrigation		Alluvium

TABLE III (con't)

Well No.	Hardness as $CaCO_3$ (calc.)	Total Solids	Fe	Ca	Mg	Na/K	CO_3	HCO_3	SO_4	Cl	F	NO_3
1	281	905		60	32	194	3.9	334	117	208		9.7
2	794	2,060	0.15	160	96	438	0	577	272	690	.41	2.0
3	180	344		52	12	73	0	356	8	20		11
4	520	870		146	38	45	0	204	18	226		141
5	254	434		72	18	40	5.9	208	10	74		55
6	720	1,290		198	55	156	0	419	34	414		120
7	121	246		32	10	22	0	121	12	19		38
8	419	740		102	40	79	0	289	39	216		12
9	491	1,250		144	32	172	0	296	36	381		59
10	348	596		50	30	101	22	254	49	108		26
11	250	529		46	33	89	16	208	141	69		1.8
12	1,200	3,040		336	88	536		305	1,010	750	0.4	8.0

Well 2: 100 feet from Turkey Creek; receives underflow of poor quality water from creek. Silica (SiO_2), 16 p.p.m.