OF 60-153

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Investigation of declining artesian pressures in the vicinity of Osage, Weston County, Wyoming

By

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Prepared in cooperation with the
Wyoming State Engineer

OPEN-FILE REPORT 60-153

December 1960

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INVESTIGATION OF DECLINING ARTESIAN PRESSURES IN THE VICINITY OF OSAGE, WESTON COUNTY, WYOMING

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Introduction

The U.S. Geological Survey has been conducting a program of ground-water investigations in Wyoming in cooperation with the Wyoming State Engineer since 1948. These investigations have included regional studies to advance the general knowledge of the State's ground-water resources and local investigations to solve more immediate ground-water problems. As part of this cooperative program, at the request of Mr. Earl Lloyd, Wyoming State Engineer, the writer visited the Osage area during August 1960 to evaluate the extent of the decline in artesian pressures recently reported there and to determine the causes, if possible.

Nature of the problem

Several water wells in the Osage oil field have been flowing for many years. Most of these were originally drilled as oil tests which were utilized to produce water when the tests proved unsuccessful. Few provisions were made to control the flow of the wells. For several years 10 of these wells have furnished adequate supplies of water for domestic and stock use in the area, although it is the opinion of several observers that discharges have declined in some of the wells since they were drilled. In August 1960, it was reported to the Wyoming State Engineer that the flows of water wells in the vicinity of the Osage oil field had decreased alarmingly during the past year and that three wells had ceased to flow. The report asserted that two wells drilled in August and October 1959 to supply water for injection into oil sands were lowering water levels in the area.

Methods of investigation

On August 18 the writer met at Newcastle, Wyo., with Messrs. J. C. Lannon and D. B. Basko of the Oil and Gas Conservation Commission; Mr. Charles Lawrence, member of the State Board of Control; and other interested persons, to discuss the problem. During a brief reconnaissance of the Osage area on August 19-20, a visit was made to the 10 wells indicated by residents in the area to have reduced discharges, to 3 wells whose flows were reportedly unaffected, and to the 2 wells used in the Osage oil field water-flooding project. The discharges of 7 flowing wells and the depth to water in 3 non-flowing wells were measured. These measurements were recorded for future reference. Brief shut-in pressure tests were made on two wells equipped with control valves.

The writer returned to the Osage area in late August to obtain records of earlier production or artesian pressure of the wells. These records, containing as much information as is presently available are given in table 1. The locations of some of the wells tabulated may be only approximately correct owing to the lack of adequate topographic and base maps of the area. Chemical analyses of samples from 13 water wells in the Osage area, collected by the Geological Survey in 1946, were studied in an effort to determine the geologic source of the water from the wells under investigation. These analyses are contained in table 2. A map of the area was prepared, showing the location of wells included in the table of well records and outlining a part of the area of outcrop of the Lakota and Fall River formations, both of Early Cretaceous age. (See fig. 1.)

Fig. 1.--Map of Osage area, Wyoming, showing location of wells and outcrop of the Fall River and Lakota formations.

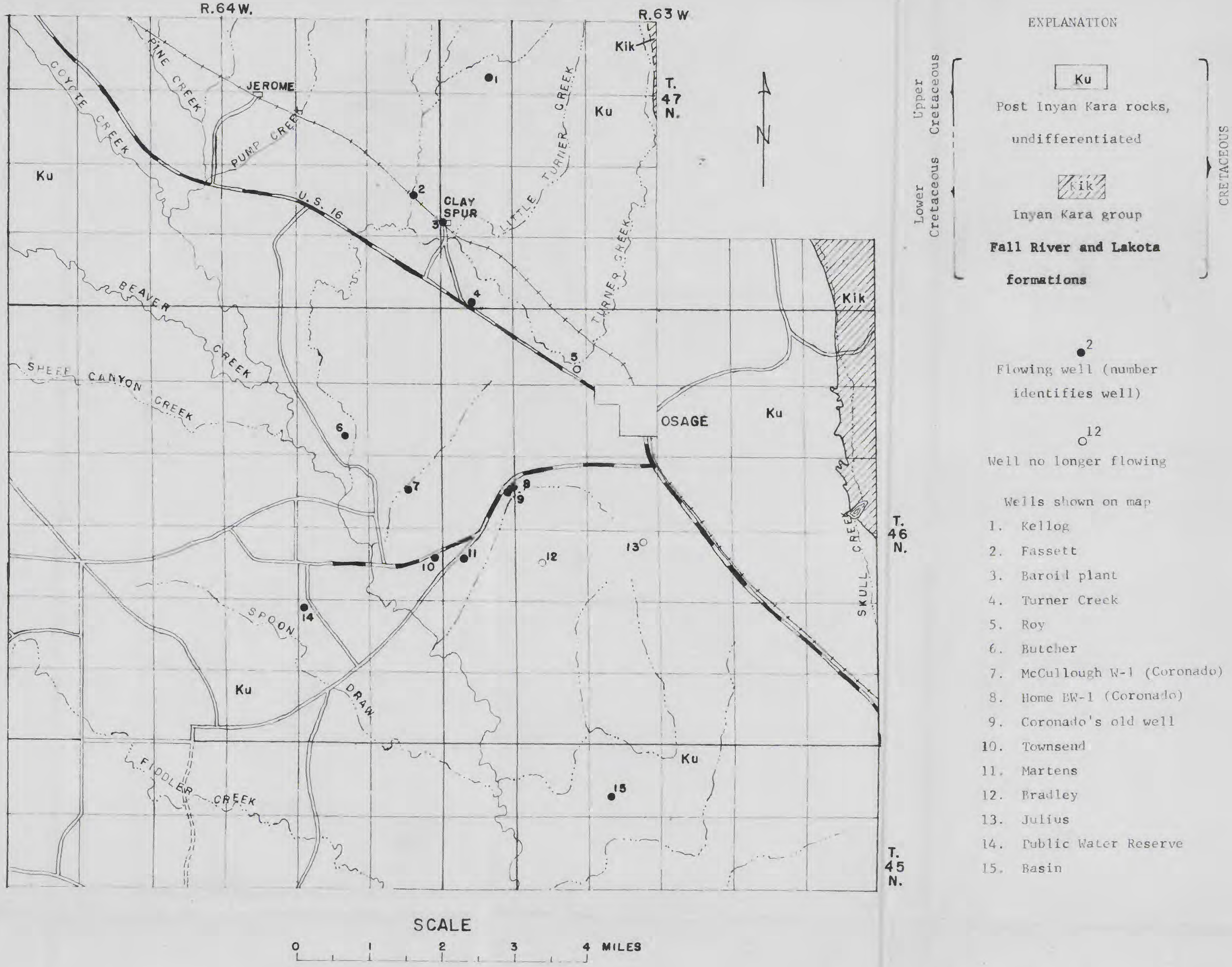

Figure 1.--Map of Osage area, Wyoming, showing location of wells and outcrop of the Fall River and Lakota formations.

Table 1.--Records of wells drilled in the Lakota formation in the vicinity of Osage, Wyoming

Method of lift: F, flows; N, none; P. pump. Distance to water level: E, estimated; R, reported.

Use of water: D, domestic; I, industrial; N, none; S, stock. Discharge: E, estimated; R, reported.

No. on Map	Owner or name of well	Location	Date drilled	Depth	Method of lift	Use of water	Distance to water level above (+) or below land surface (feet)	Dis-charge (gpm)	Date of measure-ment	Remarks
1	Kellog............	SE¼ sec.18,T. 47 N.,R. 63 W.	....	.....	F	S	+	7	9/19/60	Flow reported unchanged.
2	Fassett...........	SW¼NE¼ sec.25,T. 47 N.,R. 64 W.	....	.....	F	S	+	10 E	..do...	.....Do....................
3	Baroid............	SW¼SW¼ sec.30,T. 47 N.,R. 63 W.	....	600-700	F	D	+ 30 E	8.5	9/25/60	.....Do....................
4	Turner Creek......	SE¼SW¼ sec.31,T. 47 N.,R. 63 W.	....	.....	F	S	+	4	9/18/60	Flow reported diminished.
5	Roy...............	SE¼SE¼ sec. 5,T. 46 N.,R. 63 W.	....	.....	N	N	+ 0.92	N	..do...	Flow ceased early 1960.
6	Butcher...........	NW¼SE¼ sec.11,T. 46 N.,R. 64 W.	1942	1,800	F	D	+	6	..do...	Flow 1946 estimated 42 gpm.
7	McCullough W-1....	NESW¼SW¼ sec.13,T. 46 N.,R. 64 W.	1959	1,927	P	I	+150 R	73 R	9/15/59	Flow reported 58 gpm, August 1959.
8	Home BW-1.........	SE¼NE¼ sec.18,T. 46 N.,R. 63 W.	1959	1,104	F	I	+ 70 R	10 R	10/30/59	Flow restricted from original yield of 20 gpm.
9	Coronado..........	..........do..................	1925	1,030	F	D	+	25 R	2/11/46	....
							+	7.5	9/25/60	
10	Townsend..........	SE¼NE¼ sec.24,T. 46 N.,R. 64 W.	....	1,852	F	D,S	+ 46	42 R	2/ 1/46	
							+	25	9/25/60	....
11	Martens...........	SE¼NW¼ sec.19,T. 46 N.,R. 63 W.	....	1,645	F	D	+	21 R	2/11/46	
							+	7	9/18/60	....
12	Bradley...........	SE¼NW¼ sec.20,T. 46 N.,R. 63 W.	....	1,775	P	S	+	21 R	2/11/46	
							0.98	5 E	9/26/60	Flow ceased early 1960.
13	Julius............	NE¼NE¼ sec.21,T. 46 N.,R. 63 W.	....	1,500	P	D	+	21 R	2/11/46	
							3.64	5 R	9/26/60	Flow ceased January 1960.
14	Public Water Res...	NW¼NW¼ sec.26,T. 46 N.,R. 64 W.	1945	2,560	F	D,S	+	21 R	2/11/46	
							+	2.5	9/18/60	....
15	Basin.............	SW¼ sec. 4,T. 45 N.,R. 63 W.	....	.....	F	D,S	+	40	9/19/60	Flow reported diminished.

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Table 2.--Chemical analyses of water from the Fall River and Lakota formations in the vicinity of Osage, Wyoming

No. on Map	Owner or name of well	Location	Depth (feet)	Geologic source	Date of collection	Temperature (°F)	pH	Dissolved solids	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)
[a] 5	Roy..............	SE¼SE¼ sec. 5, T.46 N., R.63 W.	.....	Lakota	2/11/46	60	...	1,245	...	..	415	255	631	26
[a] 6	Butcher..........	NW¼SE¼ sec.11, T.46 N., R.64 W.	1,800	...do...	...do..	76	...	2,013	...	..	701	170	1,289	29
[b] 6	.....do..........	..........do................	1,800	...do...	8/19/60	..	8.1	2,104	8	..	688	183	1,271	32
[b] 7	McCullough W-1....	NE SW¼ SW [redacted]¼ sec.13, T.46 N., R.64 W.	1,927	...do...	...do..	..	7.7	653	3	..	225	195	307	12
[b] 8	Home BW-1........	SE¼NE¼ sec.18, T.46 N., R.63 W.	1,104	...do...	...do..	..	7.6	832	3	..	281	220	403	14
[a] 9	Coronado.........	..........do................	1,030	...do...	2/11/46	65	...	2,180	231	74	349	160	1,332	86
[b] 9	.....do..........	..........do................	1,030	...do...	3/14/58	..	7.9	1,560	5	1	486	194	861	13
[a] 10	Townsend.........	SE¼NE¼ sec.24, T.46 N., R.64 W.	1,852	...do...	1/22/46	77	...	734	...	..	263	220	362	10
[a] 11	Martens..........	SE¼NW¼ sec.19, T.46 N., R.63 W.	1,645	...do...	...do..	67	...	2,376	...	..	810	185	1,512	25
[a] 12	Bradley..........	SE¼NW¼ sec.20, T.46 N., R.63 W.	1,775	...do...	2/11/46	63	...	986	...	..	336	220	508	19
[a] 13	Julius	NE¼NE¼ sec.21, T.46 N., R.63 W.	1,500	...do...	...do..	58	...	1,209	...	..	488	205	703	114
[a] 14	Public Water Res..	NW¼NW¼ sec.26, T.46 N., R.64 W.	2,560	...do...	1/22/46	77	...	787	...	..	279	205	401	15
[a] --	Bock Estate	NW¼ sec.31, T.46 N., R.63 W.	1,900	Fall River	...do..	80	...	1,917	...	..	652	205	1,160	29

[a] Analysis by U.S. Geological Survey, Casper, Wyoming.

[b] Analysis by Chemical and Geological Laboratories, Casper, Wyoming

Data resulting from investigation

The Lakota formation is the principal source of ground water in the Osage area. It crops out as interbedded sandstone and shale on the lower flanks of the Black Hills about 3 miles northeast of the town of Osage. Lenticular coal seams occur in the shales in some areas, and coal was mined for several years at Cambria about 12 miles east of Osage. The steep southwesterly dip of strata, however, causes the Lakota to lie at depths ranging from 568 feet in the old community well at Osage to 2,440 feet in well 14 about 5 miles southwest.

Wells drilled into the Lakota normally flow, but yields generally are small. Records of flows exceeding 50 gpm (gallons per minute) are unusual.

The water in the Lakota formation is characteristically of the sodium sulfate type and generally contains high concentrations of bicarbonate and iron. Total dissolved solids normally exceed 1,000 ppm (parts per million) and concentrations exceeding 2,000 ppm are not uncommon. A comparison of the analytical results shows that the chemical quality of the water, though consistently of the sodium sulfate type, differs greatly between wells.

The Fall River formation, which overlies the Lakota, also yields water in the Osage area, but artesian pressures reportedly are not as great as those encountered in the Lakota formation. Because of lower artesian head and the popular opinion that water in the Fall River formation is of poor quality, wells generally were cased to shut out water from the Fall River formation. The chemical analysis of one sample of water from the Fall River is given in table 2. This well, which is reported to be in the SE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 31, T. 46 N., R. 63 W., could not be located in the field and, therefore, is not shown on the accompanying map (fig. 1).

All the wells supplying domestic and stock needs in the Osage oil field reportedly yield water from the Lakota formation. There are several other flowing wells in and near the Osage field which are unused except where the water forms marshy areas or accumulates in low places, and thus provides water for stock during a part of the year. These wells have been flowing continuously for many years, and relatively little of the water has been utilized during this period.

The discharges of 10 wells measured during the investigation (table 1) ranged from 2.5 gpm to about 40 gpm. The average discharge of 9 of the wells, excluding the well yielding 40 gpm, was about 8.7 gpm. Records of discharges obtained in 1946 for some of these wells, although apparently only estimates, indicate that flows have decreased appreciably in the 14 years since 1946. Except for wells 6 and 10, there are no records of initial yields of these wells. The discharge of well 6 in 1946 showed no decrease in flow since it was drilled in 1942, whereas well 10 was reported to yield only about 30 percent of its original flow. No records have been obtained since 1946, so the rate of decline of head in the Osage area is not known.

The two wells drilled for a water-flooding project in the Osage oil field (wells 7 and 8) produce water from the Lakota formation. Well 7, drilled in August 1959, had a reported initial flow of about 2,000 barrels a day (58 gpm) and a shut-in pressure of 65 psi (pounds per square inch). At the time of the writer's visit the well had been pumped continuously at a rate of about 75 gpm since November 1959. The pumping level on August 19, 1960 was 25.71 feet below the base of the pump, or about 24 feet below the land surface. A pressure of 65 psi is equivalent to about 150 feet of artesian head; thus, the drawdown of water level at a discharge of 75 gpm is about 175 feet, and the yield of the well is approximately 0.43 gpm per foot of drawdown after about 9 months of pumping. Well 8, drilled in October 1959, flowed about 20 gpm when completed and had a shut-in pressure of 30 psi. However, the flow of this well is controlled, and the yield has been restricted to 10 gpm since February 1960. There is no way to compare the present discharge of the well with the yield in November 1959. A brief shut-in test made August 19, 1960 showed the well to have a pressure of 26.5 psi 4 hours after the flow was shut off. This indicates a decline in artesian pressure of about 3.5 psi, or a drop in artesian head of about 8 feet. It is believed that a longer shut-in period might have produced higher pressures, but it was impossible to prolong the test without endangering the water-flooding project.

The level to which water in an artesian aquifer can rise above the top of the water-bearing bed due to artesian pressure is called the piezometric surface. In areas where this imaginary plane is above the land surface, wells will flow.

The lack of a sufficiently detailed topographic map of the Osage area made it impossible to determine accurately the relative elevations of the land surface at the wells discussed in the report without resorting to instrumental leveling. There are appreciable differences in the elevations of many of the wells in the Osage oil field because of the irregularity of the land surface and its general slope away from the Black Hills. The unevenness of the land surface is not reflected by the piezometric surface of the confined water in the Lakota formation which forms a rather uniform and smoothly-sloping surface. Artesian pressures decline as the water moves farther from the area of recharge owing to some loss of pressure required to overcome the mounting friction of water movement through the aquifer. Consequently, wells drilled in topographically high areas in the Osage field normally have lower artesian heads above the land surface than wells drilled at lower elevations. Where the land surface approaches the elevation of the piezometric surface, wells may be expected to have weak flows which may fluctuate or cease entirely in response to relatively small changes in artesian pressure within the aquifer.

Approximate elevations at the sites of the three wells that have ceased to flow were measured with a surveying aneroid altimeter. Well 5 and well 12 are at an elevation of about 4,250 feet above sea level; well 13 is at about 4,280 feet. These elevations are appreciably greater than those of the remaining wells in the Osage oil field. For example, well 8 is nearly 100 feet lower topographically than well 12, which ceased to flow early in 1960. Most of the other flowing wells in the Osage oil field are at even lower elevations than well 8.

Information obtained on the three wells drilled into the Lakota formation to provide water for the town of Upton, 14 miles northwest of Osage, indicates that these wells flowed when completed in 1954, 1956, and 1958. Mr. Harry Clingan, the city electrician, stated that pumps on two of the wells were removed in late 1958. When the pumps were replaced in early 1960, the static water level was approximately 100 feet below the land surface. One of these wells is more than a mile from the one municipal well that continued to pump during this period. The well supplying the American Colloid Plant west of Upton reportedly has declined in yield since it was drilled.

Conclusions

As a result of the ground-water investigation in the vicinity of Osage, it is concluded that the flows of many, if not all, of the water wells in the Osage oil field have decreased since the wells were drilled. At three wells artesian pressures have declined to the point where the wells no longer flow. The diminished flows may be due to several factors.

1. The rate of discharge from the Lakota formation exceeds the rate of recharge. This condition may be the result of recent increased withdrawal from the aquifer, of a decrease in recharge following several years of subnormal precipitation, or of a combination of these two factors.

2. During the time since many of these wells were drilled (20 to 30 years in most cases) the highly mineralized water may have caused a deterioration of the casing, permitting water in the Lakota formation to escape into overlying aquifers such as the Fall River formation where the artesian pressure normally is less.

3. Caving of the wall rock into the well as a result of casing failure may have sealed off some of the water-bearing sands in the aquifer.

4. Perforations in casings that are still intact may have been reduced in size or completely sealed by incrustation of insoluble chemical compounds or deposits of iron-forming bacteria, as water from both the Lakota and Fall River formations contain relatively large amounts of iron. A slimy coating of organic material may be deposited in perforations or in the adjacent wall rock where aquifers contain beds of coal or other carbonaceous material.

Continuing studies in the Osage area

Owing to the decline of artesian pressures of flowing wells in the Osage area, it would be desirable to make semiannual measurements of flows, artesian pressures, and water levels for a continuing record. The records could be analyzed periodically to determine the trend of movement of the piezometric surface and thus provide data on which to plan future water development in the area. It would be beneficial, where mechanically possible, to control the flows of wells now in use and to plug wells which are of no economic value. Careful supervision of future drilling to the Lakota formation in the area could reduce the possibility of interference between wells and the danger of locally lowering artesian pressures to the point where wells no longer flow. It might be feasible to attempt cleaning out some of the older wells in an effort to increase their flows.