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Report on a water supply for the proposed Southwestern Reformatory at El Reno, Oklahoma

By

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United States Geological Survey

June, 1931

Open-File Report 31-1

Contents

Illustration

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Summary and recommendations

It appears impracticable to develop a surface-water supply for the proposed reformatory because of a lack of reservoir sites and the drying up of the North Canadian River during the summer. The "Red Beds," consisting of shale, sand, and gypsum, underlie the location, but after a study of logs of oil tests and several deep water tests it was concluded that salt water would probably be found below 400 to 600 feet and that only an inadequate supply of poor water could probably be developed above that depth. The valley of the North Canadian is underlain by alluvial deposits of clay, sand, and gravel, from which an adequate supply of water could probably be developed. This would be the least expensive and most reliable source, but the water is very hard and may also require chlorination. The hills north of the North Canadian River are capped by a layer of sand that is estimated to be 60 to 80 feet thick in some places. There are many small springs issuing from these sands at their contact with the underlying "Red Beds." The water in this sand is relatively soft and generally low in mineral matter. The installation of gravel-walled wells in the sand area is recommended, provided test holes show a sufficient thickness of saturated water-bearing sand.

Plan No. 1. - Drill four test holes in the river alluvium approximately at the places marked by crosses on the map in secs. 25 and 36, T. 13 N., R. 8 W., all on the Fort Reno reservation. Samples should be collected from every foot of these test holes. More than four test holes might be necessary and the bids should call for a price per foot with a minimum of four tests. The average depth will probably be 40 feet, but it may be necessary to drill to 50 feet to reach the "Red Beds." The estimated cost is $1 per foot.

Install a gravel-walled well with tile or concrete casing in the most favorable site as determined from the samples from the test holes. Install the necessary pumps, pipe line, and distribution system. A second well will probably be desired as a stand-by. Plan No. 1 will probably require a chlorinating plant and a water softening plant to make the water fit for domestic and laundry use and even then it will probably cause trouble because of its content of mineral matter. All well sites may be submerged during floods, and the pumps must therefore be placed on high concrete structures.

Plan No. 2. - If practicable, obtain options to buy the water rights, after tests have been made, on secs. 2 and 11, the W. ½ sec. 12, the NE. ¼ sec. 14, and the NW. ¼ of sec. 13. The maximum value of the land for farming purposes is estimated at $30 per acre and it ought to be possible to buy the water rights for much less.

Drill four test holes in the Tertiary sands in the places marked by crosses on the map in secs. 11 and 13, collecting samples at every foot. More than four test holes might be necessary and the bids should call for a price per foot with a minimum of four tests. The depth will probably not be over 80 feet but it may be necessary to drill 100 feet to reach the basal "Red Beds." The estimated cost is $1 per foot.

Drill and develop a gravel-walled well to the bottom of the sand, probably 60 to 80 feet, in the most advantageous place as determined by the test holes. Iron or steel casing may be used in this well as there is probably no corrosive action. A second well may be needed to produce the required supply. It should be spaced at least one-fourth mile and preferably one-half mile from the first well. Install the necessary pumps, pipe line, and distribution system.

This plan will furnish first class water that will require no chemical treatment for use in boilers; it will require no softening for use in the laundry and probably no chlorination for drinking purposes. Its disadvantages are that it will require a much longer pipe line and a river crossing that might be washed out in time of flood.

Plan No. 3. - Combine Plans Nos. 1 and 2, by developing first one well in the alluvium and later one or more wells in the Tertiary sands.

It is believed that Plan No. 3 presents the best method of development for it will furnish an adequate supply for construction purposes in the quickest time, and when fully developed it will furnish an ample supply of water that will require no treating plant for any intended use, with the well in the gravel as a stand-by plant for emergencies.

Introduction

The investigation on which this report is based was made in response to a request from the Bureau of Prisons, United States Department of Justice, for advice in regard to the development of a water supply for the proposed Southwestern Reformatory on the Fort Reno Military Reservation, 2 miles west of El Reno, Oklahoma. The tract set aside for the reformatory includes sec. 12 and the eastern half of sec. 11, T. 12 N., R. 8 W., and is about 1,000 acres in area. The proposed building site is in the north-central part of sec. 12, on a flat-topped hill just north of well No. 69. (See Plate 1.)

It is understood that a maximum of 1,200 inmates is contemplated for this reformatory and that a water supply of about 120,000 gallons a day, or 85 gallons a minute, will be required in the summer. However, the potential capacity of the wells should be somewhat greater than 85 gallons a minute to allow for decline in yield.

The author, who was assigned to this work by the United States Geological Survey, arrived in Oklahoma City April 21, 1931, and spent one week in field work in the area. After a conference with Dr. C. N. Gould, State Geologist of Oklahoma, it was decided that the possible sources of ground water to be investigated were the "Red Beds" underlying the whole area, the Tertiary sands capping the hills north of the North Canadian River, and the river alluvium in the North Canadian River Valley. The area in which field work was done is shown on Plate 1 and includes approximately 105 square miles, lying chiefly north and west of El Reno, the county seat of Canadian County.

Acknowledgments for valuable assistance rendered and for information furnished are due to J. O. Parr, of Hawk and Parr, Consulting Architects of Oklahoma City; C. N. Gould, State Geologist of Oklahoma, of Norman; C. E. Bretz, Superintendent and Engineer of the Oklahoma City Water Department; F. T. Beckett, Engineer Maintenance of Way, The Chicago, Rock Island and Pacific Railway Co., El Reno; Mr. Bender, City Manager of El Reno; Secretary of the Chamber of Commerce of El Reno; Mr. Lester, Chief

Clerk at Fort Reno; C. W. Ruckman, Chief Clerk of the Concho Indian Reservation; and the following drillers of Oklahoma City and vicinity: The Shuler Co., Mr. Wyatt, and Mr. Watson. Several logs were copied from the files of the Conservation Commission in the State Capitol.

Topography and drainage

This part of Oklahoma is characterized by wide alluvial valleys with meandering streams that flow eastward and with relatively wide drainage areas on the south sides and narrow areas on the north sides of the streams. The North Fork of the Canadian River, which flows through the area under consideration, has a valley averaging about 2½ miles in width. It is 5 to 8 miles south to the South Canadian divide but only 2 miles north to the Cimarron divide. The streams had at one time cut valleys much deeper than their present ones and are now filling their old valleys with alluvial deposits. They have wide meandering channels with low banks. The entire valley becomes the river channel during high floods. The altitude of the South Canadian divide is about 1,460 feet, that of the reformatory site is about 1,440 feet, that of the river north of the reformatory is about 1,320 feet, and that of the sand hills along the Cimarron divide is about 1,460 feet. The surface declines rapidly north of these sand hills and has an altitude of only 1,180 feet in the extreme northeast corner of the area.

The bed of the Cimarron is much lower than the bed of the North Canadian and is evidently cutting much faster. Gould describes the valley of the North Fork of the Canadian as follows:[1/]

1/ Gould, C. N., Geology and water resources of Oklahoma: U. S. Geol. Survey Water-Supply Paper 148, p. 20, 1905.

"Its valley is, on the average, 200 feet higher than the Cimarron. The hills on either side are usually low, often not over 100 feet in height, and in many instances the headwaters of streams flowing into the Cimarron approach within less than 2 miles of the North Canadian. Sand hills occur practically all along the north slope, and the south bluff is often cut into red-beds canyons."

Climate

The following table gives the annual rainfall, in inches, at Fort Reno or at Oklahoma City from 1883 to 1930:

1883	36.64	1899	43.66	1915	45.37
1884	38.39	1900	37.12	1916	27.45
1885	38.30	1901	19.18	1917	18.36
1886	14.19	1902	40.12	1918	37.64
1887	25.57	1903	35.20	1919	34.18
1888	20.91	1904	43.78	1920	29.00
1889	34.57	1905	42.54	1921	24.94
1890	28.57	1906	34.66	1922	31.56
1891	26.77	1907	28.79	1923	48.25
1892	33.51	1908	52.03	1924	29.08
1893	29.40	1909	25.76	1925	24.12
1894	17.28	1910	17.27	1926	39.37
1895	22.78	1911	19.83	1927	27.23
1896	19.23	1912	22.55	1928	26.53
1897	25.56	1913	36.01	1929	33.00
1898	35.88	1914	20.11	1930	38.43

48 years of record.

Mean annual rainfall at Oklahoma City given as 31.59 inches

Maximum " " " " " " " 53.03 "

Minimum " " " " " " " 15.44 "

The evaporation is high in this area and reduces considerably the effects of the rainfall on the water supply.

Three long droughts of three years each are shown in the Oklahoma City records during the last 48 years — one from 1886-88 with an annual average of 20.22 inches of rainfall; one from 1894-96 with an average of 19.76 inches; and one from 1910-12 with an average of 19.88 inches.

Geology

"Red Beds." - The entire area is underlain by what are commonly called the "Red Beds". These beds, which are of Permian age, have been given this name because of their prevailing red color. The general strike of the formations is a little west of north and the dip is about 30 feet to the mile toward the southwest.

Tertiary sands. - The Tertiary sands cap all of the high hills to the north of the North Canadian and a very thin remnant of these sands also caps a few of the highest hills south of the river. The area covered by these outcrops is shown on Plate 1. These sands are presumed to be the remnant of the alluvial blanket spread over this area during Tertiary times by streams from the Rocky Mountains. This blanket has probably had contributions from other sources besides the streams, the principal one being sand blown from the stream beds by the prevailing southerly winds and deposited on the hills to the north of the streams. These sands are quite coarse, and small pebbles are often found in them, especially near the base. In some localities the sands appear to be finely bedded as if deposited in a lake with fine silt layers interstratified. Farther northwest these sands are known to be as much as 100 feet thick but in this area they are probably not more than 70 or 80 feet thick. The "Red Bed" plain upon which they were deposited was probably not entirely level and therefore the thickness of the sands is probably quite variable.

River alluvium. - The river alluvium is found under the entire flood plain of the river. This ranges in thickness from 30 feet to as much as 60 feet, and in character from medium-sized gravel to black silt and clay. The best description of this alluvium is given by Phillips[3/] as the result

3/ Phillips, Hiram, Alvord, J. W., and Billingsley, J. W., Report to the Mayor and Board of Commissioners of Oklahoma City on an improved water supply for the city, p. 214, 1913.

of three lines of test holes across the valley near Oklahoma City.

"1st. Lying immediately above the shale, moderately coarse sand 5 to 10 feet in thickness and of effective size varying from 0.20 to 0.30 millimeter. The occurrence of material coarse enough to be designated as gravel is very rare. Fine sand and clay are only very occasionally met with on the bottom, next to the shale.

"2d. Discontinuous belts of black clay and gravel and clay and fine sand mixed, as well as beds of quicksand, all varying in thickness from less than a foot to perhaps 10 feet.

"3d. A broad belt of very fine sand (effective size less than 0.20 millimeter) 15 to 20 feet in thickness and extending throughout the central portion of the valley.

"4th. Towards the sides of the valley this sand belt is usually overlain and interspersed by clay deposits varying from a few feet to 20 or more feet in thickness. These clay beds extend in some cases as far as 3,000 feet out from the edge of the river alluvium.

"5th. A top layer of surface soil, in some cases clayey and impervious, and in others sandy. This layer is usually not more than 2 or 3 feet in thickness."

Some time after the "Red Beds" were laid down and tilted, as they are at present, a broad deep channel, practically level on the bottom but with a slightly deeper winding channel which has been found in a few places was eroded out of the "Red Beds." Then because of a lower gradient or less water flowing in the stream, the river changed from erosion to depositing and filled in the old channel above the present level of the fill. This was eroded down somewhat by the present river leaving a terrace along the "Red Bed" hills with the present river in a still deeper meandering cut through the fill.

Water supply

Surface water supply. - There are two possible sources of surface water supply: the North Canadian River and reservoirs for storing flood waters on some of the creeks flowing northward into the river. None of these creeks have perennial streams and the supply would have to be entirely from flood waters. Because of the large fluctuation in the annual rainfall and the long periods of drought, large storage capacity would be required. All of these creeks have relatively small drainage areas and only small reservoir sites are available. Several of these small reservoir sites on the creeks have been developed at Fort Reno to store water for stock use and to provide fishing for recreation. These reservoirs are shown on Plate 1. They were built in 1922 to 1924 and have not been dry since that time, but it is doubtful if they would stand up under steady use, especially since they are reported to reduce their size over one-half during the summer and there has been no long drought since they were installed.

Gould[4/] states that "The North Canadian has perhaps the best water of any of the larger streams in Oklahoma, owing chiefly to two causes -- first, the river is fed largely by Tertiary springs; and, second, it does not flow through regions of salt springs." The main obstacles to use of the surface flow of the North Canadian are the fact that many times during the summer and fall, when the demand for water is the highest, there is no surface flow in the river at all and there is no good reservoir site that could be cheaply developed to store flood water from the river.

4/ Gould, C. N., Op. cit., p. 92.

The chemical character of the Canadian River water is very changeable. The chemical character of the water during floods varies with the section of the drainage system from which the flood came. The following is an analysis, in parts per million, of the Oklahoma City municipal supply in 1921 (North Canadian River water):[5]

5/ Collins, W. D., The industrial utility of public water supplies in the United States: U. S. Geol. Survey Water-Supply Paper 496, pp. 50-51, 1923.

Hardness (calc. as $CaCO_3$)	534
Calcium	135
Magnesium	48
Sodium and potassium	58 a/
Bicarbonate	330
Sulphate	138
Chloride	175
Total dissolved solids	786

a/ Calculated.

Phillips, Alvord, and Billingsley[6] report that from March, 1912, until

6/ Phillips, Hiram, Alvord, J. W., and Billingsley, J. W., Op. cit., p. 216.

December, 1912, inclusive, the chloride varied from 132 to 249, the sulphate from 80 to 175, the calcium from 60 to 94, and the magnesium from 28 to 37 parts per million. C. E. Bretz[7] reports that from July, 1927,

7/ Bretz, C. E., Annual Report Oklahoma City Water Department, pp. 17, 38, and 59, 1931.

until June, 1930, the hardness of the Oklahoma City water supply varied from 175 to 309 parts per million, and the magnesium varied from 21 to 114 parts per million.

Ground-water supply

Red Beds. - From oil well data and deep tests for water in the vicinity, it is concluded that a well would strike salt water at 400 to 600 feet and would not obtain an adequate supply above that depth. The logs of eleven deep oil tests in Canadian County were collected and studied but no encouraging evidence could be found as any water reported below 400 feet, except in the extreme eastern part of the county, was salty. The log of the deep water test at Fort Reno was studied and correlated with the logs of wells at Oklahoma City producing good water from the Garber sandstone and it was concluded that the sands that produce good water at Oklahoma City are too impervious to serve as water bearers at Fort Reno and that the little water that they do carry is heavily charged with salt. The log of a 1,140-foot water test, No. 5, drilled on the Concho Indian Reservation, was studied and a conference was held with the driller of this well. The information obtained substantiated the reports on the Fort Reno test. Two deep test wells were drilled for water in 1912 by the city of El Reno but very little information could be obtained in regard to them. The fact that they were abandoned would indicate that nothing encouraging was found. Schwennesen[8] reports that one

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[8] Schwennesen, A. T., unpublished notes, 1914.

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of these tests, No. 55, was drilled to a depth of 3,300 feet, that it passed through red shale to a depth of 1,095 feet, and that from 1,095 feet to the bottom it passed through alternating strata of red shale and sandstone that contained salt water. The strata just below 1,095 feet probably belong to the [illegible] sandstone, which produces good water at Oklahoma City.

Data were obtained on twelve shallow wells near the reformatory site that obtain meager supplies either from the "Red Beds" or from shallow creek alluvium overlying the "Red Beds." Practically all of these wells are weak, even for windmill use, and especially weak in times of drought. Field tests were made by the writer of water from four of these wells, with results as shown below:

Field tests of water from shallow wells in the "Red Beds"

Well No.	Appearance when collected	Appearance when tested	Parts per million		
			Chloride (Cl)	Sulphate (SO_4)	Hardness
61	Clear	Clear, no precipitate	520	2,000	2,000
70	Clear	Clear, no precipitate	300	1,000	1,350
71	Muddy	One-fourth inch of mud in bottom of bottle	210	25	600
72	Clear	Clear, no precipitate	680	1,000	1,800

The above tests suggest that any water found in the "Red Beds" at a shallow depth would be too highly mineralized for satisfactory use, even if an adequate supply could be developed.

In 1893 a well 1,370 feet deep was drilled at Fort Reno, Canadian County, for the purpose of obtaining a supply of water for the post. The well, however, failed to yield enough good water for the purpose intended and was abandoned. A small amount of salt water was encountered at about 400 feet and fresh water at 441 feet. The following log of this well is given by Gould.[9]

9/ Gould, C. N., Geology and water resources of Oklahoma: U. S. Geol. Survey Water-Supply Paper 148, p. 106, 1905.

Log of well at Fort Reno

Formation	Thickness Feet	Depth Feet	
Soil and clay	20	20	
White sandstone	4	24	
Red shale	146	170	
Gypsum	2	172	
Sandstone	7	179	
Clay, keel	76	255	
Sandstone	3	258	
Red stone	67	325	
Clay, keel	6	331	
Red shale	110	441	
Water course	3	444	
Sandstone	20	464	
Red shale	200	664	
Sandstone	23	687	
Red shale	17	704	
Sandstone	9	713	
Red shale	29	742	
Sandstone	47	789	
Red shale	53	842	
Hard sandstone	13	855	
Sandstone	24	879	
Red shale	30	909	
Sandstone	6	915	
Clay, keel	20	935	
Red shale	43	978	
Sandstone	9	987	
Red shale	217	1,204	
Clay, keel	80	1,284	
Sandstone	10	1,294	
Red shale	26	1,320	
Sandstone	16	1,336	
Red clay	34	1,370	Total Depth

Tertiary sands. — It is believed that an adequate supply of water of good quality can be developed from the Tertiary sands capping the hills on the north side of the North Canadian River valley. A small amount of water has already been developed from this source for the Concho Indian Reservation by the use of Caddo Spring and two dug wells above the spring. The area controlled by the reservation is believed to furnish enough recharge to supply its needs. A supply for the Darlington Masonic Home was developed from a spring near the center of the west section line of sec. 13, T. 13 N., R. 8 W., but as the home has been abandoned very little water is now used. The town of Okarche has taken steps to get a water supply from one or more gravel-walled wells near Concho. It is understood that the town has water rights on the W. ½ of the SW.¼, sec. 1, T. 13 N., R. 8 W. This development will not interfere with the proposed wells for the reformatory but will give valuable information as to the water-bearing properties of the Tertiary sands.

~~Estimated recharge to the sands~~

The area underlain by the sands has a poor sandy soil that does not produce large crops and where it is not cultivated it is covered with a heavy growth of jack oaks. Only a small part of the water that falls on the area runs off. Many small basins were observed that had no surface outlets but evidently drained into the sand. A considerable part of the rainfall doubtless sinks to the water table, and a part of this ground water can be recovered through wells. Assuming that the reformatory will require 100 gallons a minute continuously throughout the year, the total yearly supply required is about 52,000,000 gallons, which is equal to about 3 inches, or 10 per cent of the rainfall, on one square mile. It is, however, believed that if this supply is to be obtained from this source, the Prison Bureau should obtain control of the well rights on three sections, or about 1,920 acres in the sand area.

~~Two possible methods of recovery of the water~~

~~Recovery from springs.~~ -- The small valleys at the edge of the sand area that extends through the sands into the underlying "Red Beds" generally contain seepage springs. The line of contact on each side of the valleys is generally marked by seepage springs and by willow and poplar trees. Several of the largest of these springs have been developed for domestic supplies; for example, Caddo Spring, supplying the Concho Reservation; Darlington Springs, supplying the Darlington Masonic Home, and others used for farm supplies. The usual method of development is to sink a brick-lined cistern into the sand at the spring to serve as a collecting basin and to let the water flow by gravity through a pipe from the cistern. Many of the smaller seepage springs dry up during the summer because the water is all consumed by the trees. Several of these springs might be developed but it is doubtful if the entire supply needed for the reformatory could be developed from springs.

~~Recovery from wells.~~ - There are quite a few farm wells that draw water from these sands for domestic and stock use but so far as known none of these extend to the bottom of the sands because they obtain xx abundant supplies not far below the water table. Most of the wells are dug wells and could not be sunk deeper after the "quicksand" was struck. Sand points are often driven in the bottom of the dug wells. These wells yield as much water as can be pumped by the windmills. The two wells belonging to the

Indian Reservation do not have sand points and are only dug to the "quicksand" but they deliver 10 to 15 gallons a minute. Well Nos. 1 and 2 are on hilltops and reach saturated sand at 22 feet. It is estimated that the total thickness of sand in the vicinity of these wells is about 80 feet, making about 60 feet of saturated sand that could be developed by a properly drilled well.

The results of field tests of the water from two wells and two springs in the Tertiary sands, given below, show that this is the best water available in this territory.

Number, or name	Appearance when collected and when tested	Parts per million		
		Chloride (Cl)	Sulphate (SO_4)	Hardness
1	Clear	2	25	90
4	Clear	2	20	60
Caddo Spring	Clear	4	25	195
Darlington Spring	Clear	2	15	95

River alluvium. - An adequate supply of somewhat mineralized water can probably be developed from the river alluvium. The present supply for Fort Reno is drawn from three wells in the alluvium. The city of El Reno draws its supply and the supply for the Rock Island Railroad from six wells in the alluvium. Many other towns and some industrial plants draw their supplies from the alluvium. Fort Reno pumps about 85,000 gallons a day from their three wells (No. 59). The only trouble reported is that the screens soon become corroded and clogged and consequently the yield of the wells is diminished. There has been no noted drop in the water level.

From July 1, 1929, to June 30, 1930, the city of El Reno pumped 329,000,000 gallons from six wells in the alluvium (Nos. 48-53). The capacity of each well according to tests made early this year are given in the well tables. The only trouble that the city has had has been due to corrosion and clogging of the well screens. The following table gives the pumpage at El Reno by years from July 1, 1926, to June 30, 1930, and by months from July 1, 1929, to June 30, 1930.

Year (July - June)	Pumpage (in gallons)
1926 - 1927	293,846,000
1927 - 1928	297,965,000
1928 - 1929	319,000,000
1929 - 1930	329,000,000

Month	Year	Pumpage (in gallons)
July	1929	35,875,000
August	"	41,700,000
September	"	29,695,000
October	"	26,195,000
November	"	25,565,000
December,	"	24,030,000
January,	1930	24,855,000
February,	"	21,355,000
March,	"	24,775,000
April,	"	26,930,000
May,	"	22,150,000
June,	"	25,700,000

In 1918, the Chicago, Rock Island & Pacific Railroad Co. drilled 37 test holes in the river bottom to determine the best place for a pumping station to supply the railroad, but as it was decided to buy water from the city of El Reno no supply was developed except one for the railroad station at Kerfoot. This extensive testing developed the fact that the thickness of water-bearing sand and gravel ranges from 0 to 45.5 feet, and also varies in character from very fine sand to fine gravel. In view of this variability, no well should be drilled in the alluvium without first drilling test holes to determine the amount and kind of water-bearing material that will be found.

The following analyses will give a general idea of the mineral composition of the water from the alluvium.

Analyses of water from wells in the valley alluvium along North Fork of Canadian River [a/]

No.	Silica, iron and alumina SiO_2, Fe_2O_3, Al_2O_3	Calcium Ca	Magnesium Mg	Sodium and Potassium Na + K	Bicarbonate HCO_3	Sulphate SO_4	Chlorine Cl	Hardness	Total solids	Date tested	Remarks
20	50	124	24	63	396	155	25	-	625	1918	Tested by C. R.I.& P. R.R.
21	71	122	26	84	422	203	30	-	742	1918	do.
34	16	68	57	109	443	189	60	-	716	1918	do.
37	22	157	70	150	453	479	95	-	1,196	1918	do.
39	32	112	55	88	396	286	53	-	822	1918	do.
40	5	60	21	34	274	64	16	-	334	1918	do.
42	5	97	44	155	465	175	141	-	847	1918	do.
43	10	135	85	186	570	237	263	-	1,194	1918	do.
44	10	116	72	180	372	310	250	-	1,120	1918	do.
48	24	81	36	161	234	177	232	-	825	1931	do.
49	26	76	41	140	319	175	160	-	777	1931	do.
51	74	103	39	132	327	174	181	-	868	1931	do.
52	17	95	50	117	353	180	155	-	792	1931	do.
48-53 (Average 1927)	14	88	38	121	307	180	142	-	740	Mar.19,1927	do.
59 (3 wells)	15	131	36	166	374	315	139	-	986	Dec.7,1929	International Filter Co.

a/ Analyses Nos. 20, 21, 34, 37, 39, 40, 42, 43, 44, 48, 49, 51, and 52 were taken from records furnished by the Chicago, Rock Island & Pacific Railroad Co.; Nos. 48-53, average, was furnished by the city manager of El Reno; and No. 59 was furnished by Mr. Lester, Chief Clerk at Fort Reno. The results reported in hypothetical combinations in grains per United States gallon, have been recalculated to parts per million and the ionic form

The above analyses show that the mineral composition varies from place to place. It probably varies also from time to time due to floods, etc.

This water has the characteristic of corroding the perforated pipes or screens used in the wells, with the effect that many of the wells decline rapidly in yield. Several perforated casings that have been removed from wells have been almost completely sealed by a coating from ¼ to 3/4-inch thick, which cements the sand and gravel on the outside of the casing, making a hard conglomerate. This cementing material appears to be in part calcium carbonate, and can be dissolved with hydrochloric acid. It is possible that these screens might be cleaned in place by treatment with hydrochloric acid. Special attention should be given to the types of screens and the methods of finishing wells that will be the most successful under these conditions. Fort Reno has one well that has not failed due to corrosion; it is a gravel-walled well with concrete casing and screen.

It will probably be necessary to chlorinate the water if the supply is derived from the river alluvium. The El Reno city supply is not at present chlorinated but the Chicago, Rock Island & Pacific Railroad Co. buys water from the city and chlorinates it. The supply for Fort Reno is chlorinated part of the time, especially during the summer.