Geology and Ground-Water Resources of the Missouri River Valley in Northeastern Montana

By FRANK A. SWENSON

With a section on

The Quality of the Ground Water

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GEOLOGY AND GROUND-WATER RESOURCES OF THE MISSOURI RIVER VALLEY IN NORTHEASTERN MONTANA

By Frank A. Swenson

ABSTRACT

The Missouri River valley in northeastern Montana includes a part of the Montana division of the Missouri–Souris irrigation project. The area covered is 5 to 15 miles wide along the Missouri River between Nashua, Mont., and the Montana–North Dakota State line. About 157,000 acres of land within this area has been proposed for irrigation under the Missouri Basin development plan.

The climate of the area is semiarid and characterized by abundant sunshine, low relative humidity, light rainfall, moderate wind movement, wide diurnal range in temperature, and pronounced seasonal extremes of temperature. Average annual precipitation at three United States Weather Bureau stations within the area ranges from 12.42 to 13.16 inches.

Much of the area covered by this report lies within the Fort Peck Indian Reservation. The towns are on the north bank of the Missouri River and are served by the Great Northern Railway and by good highways. Most people are engaged in raising grain or livestock and in services related to these occupations. Large reserves of lignitic coal are present at the eastern end of the area, but the only mining is for local needs.

The present physiographic development is closely related to drainage changes imposed on the area by at least two and possibly three advances of Pleistocene glaciers. A suggested history of pre-Pleistocene and Pleistocene physiography and drainage is outlined.

In the eastern part of the area the unconsolidated surface materials are underlain by Paleocene rocks, which in turn are underlain by beds of Late Cretaceous age; in the western part of the area, the surface materials are directly underlain by shale and sandstone of Late Cretaceous age. Bedrock exposures are numerous south of the river and north of the river east of Brockton, but west of Brockton the bedrock north of the river is mantled in most places by deposits of Pleistocene age.

The principal bedrock aquifers are in the Judith River formation, the Fox Hills sandstone, and the Hell Creek formation, all of Late Cretaceous age, and in the Fort Union formation of Paleocene (Tertiary) age. The Judith River formation is reached by wells more than 800 feet deep in the area from Wolf Point westward. East of Wolf Point the water-bearing sandstone appears to pinch out; no successful wells obtain water from the Judith River formation in that part of the area. The Fox Hills sandstone, Hell Creek, and Fort Union formations supply water to wells; flowing wells are obtained in topographically favorable locations from each of these aquifers.

Most domestic water supplies are obtained from alluvial deposits, but in some localities the alluvial materials have a low permeability and yield only a little water. Supplies for municipal and railroad use are obtained from beds of gravel or coarse sand in the deeper parts of the alluvial fill of bedrock valleys.

Water from bedrock aquifers in the Missouri River pumping units is highly mineralized and soft; the content of dissolved solids in nine samples ranged from 1,000 to 4,130 parts

per million, and the hardness ranged from 25 to 186 parts per million. Sodium chloride salinity characterizes the water in the Judith River formation; sodium bicarbonate alkalinity is prominent in water from the Hell Creek and Fort Union formations. Boron concentrations exceed 5 parts per million in water from the Judith River formation.

Water in the alluvium in places is highly mineralized and hard; the dissolved-solids content of 11 samples ranged from 829 to 2,780 parts per million, and hardness ranged from 220 to 995 parts per million. Boron concentrations are low.

Because of high mineral content and high percent sodium, all deep wells and most shallow wells from which samples were obtained yield supplies that are unsuitable for irrigation.

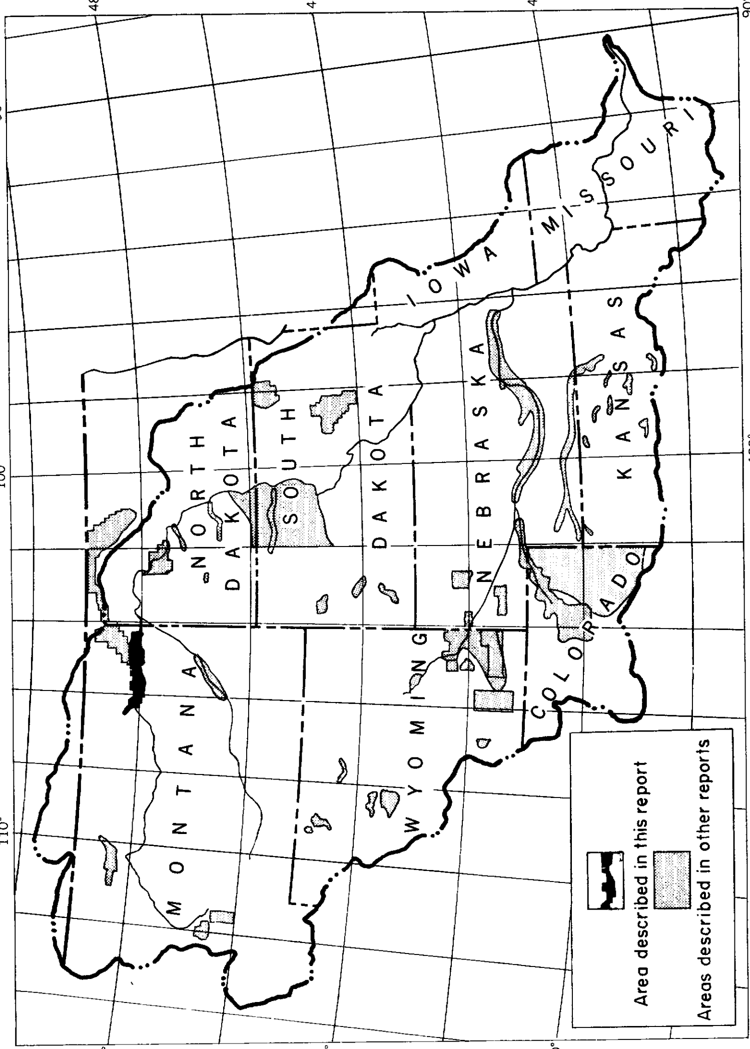
INTRODUCTION

LOCATION AND EXTENT OF THE AREA

The area described by this report extends along the north and east sides of the Milk River from Nashua to the confluence of the Milk and Missouri Rivers, thence eastward along both sides of the Missouri River to the Montana-North Dakota State line. (See fig. 1.) This area is 110 miles long and 5 to 15 miles wide. By far the largest part of the area lies in Roosevelt County, but smaller parts lie in Valley, McCone, and Richland Counties. About 157,000 acres of land in this belt is to be irrigated, according to the 1944 plans of the Bureau of Reclamation. Approximately 36,000 acres on the south side of the Missouri River is to be furnished water pumped directly from the river. About 100,000 acres north of the Missouri River is to be furnished water, either by pumping or by gravity, from the main Missouri River canal which is designed to carry water from a diversion dam, to be constructed on the main stream near Nashua, to the proposed Medicine Lake Reservoir. The remainder of the land to be irrigated lies near the eastern end of the area and will be supplied water from the Medicine Lake Reservoir. Some lands near the mouth of the Milk River and between Frazer and Wolf Point are under irrigation at the present time. In a few places irrigation developments made in the past are now abandoned.

SCOPE OF INVESTIGATION

The investigation upon which this report is based is one of several ground-water studies being made by the United States Geological Survey in connection with plans of the Interior Department for development of the Missouri River Basin. These studies will result eventually in both qualitative and quantitative evaluations of the recharge, discharge, and storage of ground water in areas to be irrigated under the development program.



—Map of the Missouri River Basin showing areas in which ground-water studies have been made under the program for the development of the Missouri River Basin.

In the course of this investigation an inventory was made of all wells in the area to determine the depth of wells, the depth to ground water below the land surface, the quantity of water available, the quality of water obtained from the various aquifers, and the direction of ground-water movement in unconsolidated deposits. Measurements were made of the water levels in observation wells, which were selected to give a general rather than a local picture of ground-water conditions. The outcrop areas of the bedrock formations, the glacial deposits, and more recent stream deposits within the area were mapped on aerial photos, and the data were transferred to the base map by means of a vertical projector.

GENERALIZED DESCRIPTION OF THE AREA

The part of Montana described in this report is typical of the semiarid plains in which wheat production is of primary importance. The altitude of the area ranges from about 1,880 feet above sea level near the Montana-North Dakota State line to more than 2,600 feet on the high buttes south of the Missouri River at the mouth of the Milk River. The land south of the Missouri River is rough and broken. The land north of the river consists of rolling glaciated plains, which are somewhat rougher east of Brockton than west of that town. Flat, poorly drained flood plains border the Missouri River and many of the larger tributary streams. Most of the cultivated land is used to grow spring wheat; but large areas, especially on the Fort Peck Indian Reservation, are used for grazing. The towns in the area are on the north side of the river and are along the Great Northern Railway and U. S. Highway 2.

PREVIOUS INVESTIGATIONS

The first recorded scientific observations in this area were those made by Lewis and Clark during their expedition in 1805 and 1806. In their diary of the expedition, Lewis and Clark described the area and noted the presence of coal beds, the lush growth of grass in major tributary valleys, the presence of boulders (since identified as glacial erratics), and many other features (Thwaites, 1904).

The first geologists to work in the area were Meek and Hayden (1861), who applied the name "Fort Union group" to the rocks now considered to be the Fort Union formation. Meek (1876) revisited the region and studied in more detail the beds exposed at Fort Union, on the Montana-North Dakota boundary, and presented a measured section in his published report. Smith (1908) mapped the geology of the Fort Peck Indian Reservation in connection with his investigation of the lignite resources of the area. Beekly (1912) extended Smith's geologic mapping eastward in investigating the Culbertson lignite field. Thom and Woodring mapped the northern part of McCone County as part of an investigation of the lignite coal resources (Collier and Knechtel, 1939). Geologic investigations of a more general nature were made by Collier (1918) and by Collier and Thom (1918).

Todd (1914) outlined an interpretation of the changes in drainage of the region caused by the advance of Pleistocene glaciers, and Bauer (1915) carried the history of the river back into Tertiary time. These men differed somewhat in their interpretations, and Todd (1923) later prepared a more lengthy paper dealing with the history of the drainage of this area.

Alden (1932) reported the results of a comprehensive physiographic and glacial study of the area; he included a summary of all previous work with the results of his own study, which began in the area in 1911. Alden's paper proved to be of great help in the field study and preparation of this report.

In 1946 a party led by Garland Gott, of the Geologic Division, U. S. Geological Survey, began a study of the geology of the Medicine Lake area. A report on the work has not yet been published, but members of the party have communicated orally with the writer and have kindly lent manuscript maps to him for use in his study.

DIVISION OF WORK

The geologic fieldwork upon which this report is based was done by the writer during the summer of 1947. The well inventory was made during the summer of 1947 and was field checked in the fall of 1949 by a party under the supervision of R. C. Vorhis who compiled the table of well records (table 9). The work was done under the general direction of A. N. Sayre, chief of the Ground Water Branch of the Geological Survey, and under the immediate supervision of G. H. Taylor, regional engineer in charge of ground-water studies under the Missouri River Basin program. After the field studies were completed, measurements of the water level in observation wells were continued until 1949 by personnel of the Bureau of Reclamation.

Water-quality studies were under the general direction of S. K. Love, chief of the Quality of Water Branch of the Geological

Survey, and under the immediate supervision of P. C. Benedict, district engineer in charge of quality-of-water studies in the Missouri River Basin. The chemical analyses of 21 water samples collected in the area were made by J. G. Connor, L. L. Thatcher, W. M. Barr, and B. C. Dwyer.

ACKNOWLEDGMENTS

The writer is indebted to many persons who contributed information and assistance in the field and in the preparation and review of this report. The Engineering Division, Office of the Great Northern Railway, furnished logs of wells drilled in the area by the company. H. W. Mutch, engineer in charge of the Wolf Point office of the Bureau of Reclamation, made data available to the writer, assigned men to the periodic measurement of observation wells, and was helpful in many other ways. Residents of the area cooperated wholeheartedly in the field investigation.

WELL-NUMBERING SYSTEM

In this report, all wells are numbered according to their location within the land subdivisions of the General Land Office survey of the area. (See fig. 2.) The well number is composed of the township number, the range number, the section number, and lowercase letters which indicate the subdivision of the section in which the well is located. The first letter denotes the quarter section and the second the quarter-quarter section or 40-acre tract. The letters are assigned in a counterclockwise direction beginning in the northeast quarter of the section or quarter-quarter section. Where two or more wells are located within a 40-acre tract, the wells are numbered serially according to the order in which they were inventoried.

CLIMATE

The area described by this report has a semiarid continental climate marked by abundant sunshine, low relative humidity, light rainfall confined largely to the warmer half of the year, little snowfall normally, moderate wind movement, wide diurnal range in temperature, and pronounced seasonal extremes of temperature.

Stations of the United States Weather Bureau are located at Poplar, Culbertson, and Frazer. The station at Poplar was established during 1882, but complete records are lacking for several of the years prior to 1925. The record at Culbertson began in

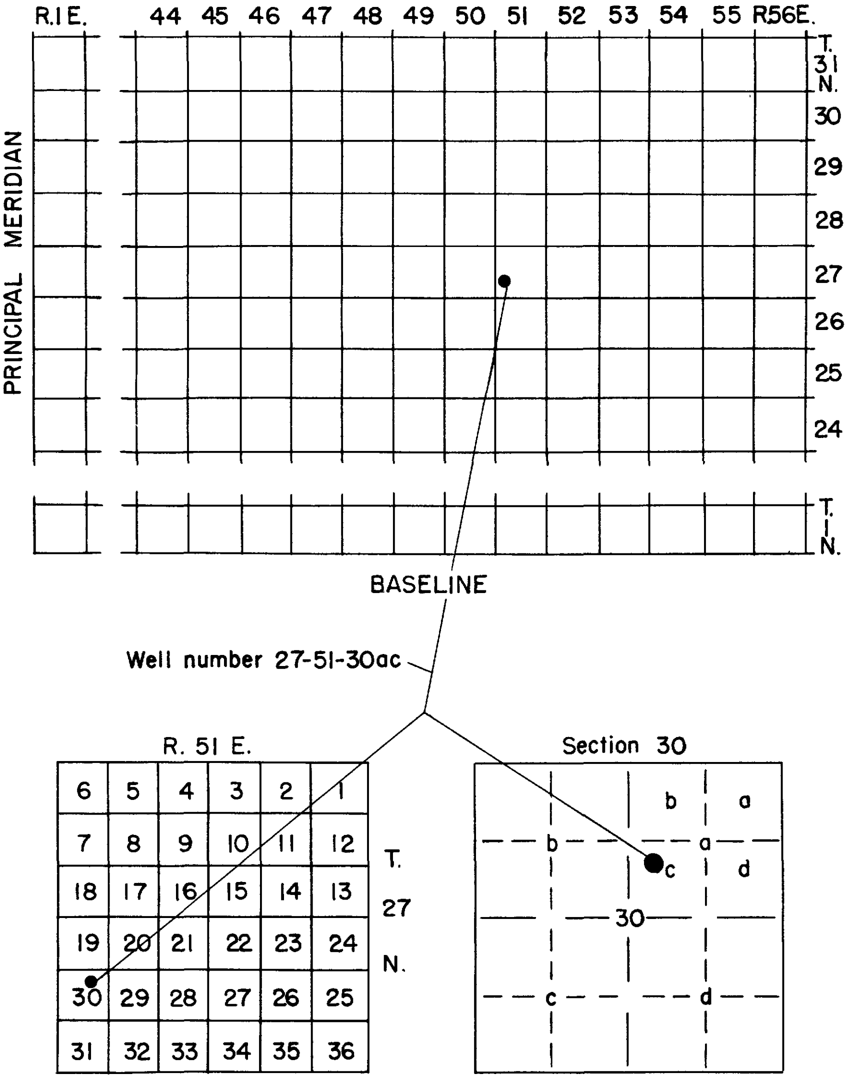


Figure 2. —Sketch showing well-numbering system.

1900 but is complete only since 1918. The station at Frazer was established in 1923, and complete records are available since 1924.

PRECIPITATION

The precipitation recorded at the Poplar, Culbertson, and Frazer stations is shown in tables 1, 2, and 3. Although the

Table 1.—*Precipitation, in inches, at Poplar, Mont.*

[From records of U. S. Weather Bureau]

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1882	[1]0.25	[1]0.27	[1]0.69	[1]0.66	3.68	0.74	0.60	0.36	0.78	2.98	0.48	0.48	11.97
1883	[1]1.92	[1].33	.74	.62	.68	[1].85	.16	1.44	[1].22	[1]1.20	.09	[1].08	8.33
1884	[1].10	.41	[1].08	.91	.78	1.67	3.40	.68	.64	.46	.43	.22	9.78
1885	.81	.64	.02	.77	.77	4.51	3.05	.42	.15	.09	.29	.41	11.93
1886	.40	.38	.20	.86	1.35	.80	.94	.51	.21	.40	.69	.67	7.41
1887	.49	.58	.14	.31	1.04	4.19	2.10	3.72	.90	1.37	.39	.28	15.51
1888	.48	.60	.41	.78	.77	4.94	2.19	1.40	.61	.88	.11	.23	13.40
1889	1.58	.15	.43	.07	2.82	.28	.50	.08	1.19	.02	5.43	.77	13.32
1890	.79	.10	.34	.36	1.77	3.79	.73	.04	1.81	1.25	.13	.09	11.20
1891	.47	.45	.44	.92	1.55	5.03	1.49	.82	.35	2.01	.94	.10	14.57
1892	.10	.60	1.40	2.32	1.12	1.30	3.09	.20	.20	[2]Tr.	1.15	1.82	13.30
1893	1.21	.70	.10	2.00	4.60	.70	3.35	.40	.80	1.87	[1]1.02	[1].92	16.67
1894	.52	.18	2.17	1.63	2.16	3.91	Tr.	.53	.70	1.44	.35	.40	13.99
1895	[1].62	[1].64	[1].28	[1]1.03	.69	2.30	1.01	.39	.28	[1].25	[1]1.62	.40	9.51
1896	1.49	.66	[1]1.85	2.41	3.70	3.79	1.22	.55	.15	.40	1.65	Tr.	17.87
1897	1.85	.60	1.60	.71	.47	[1]1.85	2.87	.58	.05	.11	1.10	[1].16	11.95
1898	Tr.	.60	2.91	1.72	.85	2.78	1.34	.09	2.45	1.22	.59	.60	15.15
1899	1.20	2.05	.63	.77	3.25	2.83	1.24	.35	Tr.	.73	.15	.40	13.60
1900	.00	.30	2.86	1.27	1.54	[1].58	.46	3.13	2.52	.91	.90	[1].34	14.81
1901	1.05	.50	Tr.	.38	.20	3.70	1.23	.68	2.69	.50	1.00	.60	12.53
1902	Tr.	1.58	.56	.50	3.12	2.81	1.18	[1].85	.39	.79	.65	1.06	13.49
1903	Tr.	.20	Tr.	.31	2.65	2.33	2.62	3.58	.64	.20	.35	.35	13.23
1904	1.05	.16	4.15	.80	.55	2.19	1.40	.70	.00	.75	.00	1.00	12.75
1905	.60	[1].30	.70	.00	1.57	3.73	1.99	.95	1.67	Tr.	.35	Tr.	11.86
1906	.40	Tr.	.40	3.10	4.94	8.12	.75	2.04	2.08	.25	1.27	2.00	25.35
1907	1.30	.40	1.50	.93	1.98	4.71	1.14	.42	Tr.	Tr.	Tr.	.12	12.50
1908	Tr.	.80	1.64	2.03	2.79	2.47	1.70	1.04	1.28	1.76	.20	.01	15.72
1909	.82	.93	Tr.	.22	2.20	3.84	2.08	.95	.22	.15	.60	.21	12.22
1910	.27	.32	1.95	1.24	1.25	1.50	.74	1.67	.38	Tr.	.40	Tr.	9.72
1911	.40	.35	.10	.68	2.37	1.75	1.35	1.74	3.99	1.18	.35	.10	14.36
1912	.02	Tr.	.56	.34	4.56	1.83	4.37	2.96	.25	Tr.	.62	Tr.	15.51
1913	.20	Tr.	.33	Tr.	1.37	2.42	1.31	2.14	.60	1.62	.22	Tr.	11.06

1914	.49	.26	.49	.14	.47	8.62	1.71	2.68	.90	.99	.17	.24	17.16
1915	.36	.21	.06	.15	2.28	1.80	3.02	.29	1.32	.41	.87	.65	11.42
1916	1.12	.44	.27	.25	1.20	4.70	3.87	.06	1.74	.96	.18	.61	15.40
1917	.28	.15	.10	1.26	.81	1.54	.35	.57	.25	.25	.00	.78	6.34
1918	.37	.10	.04	1.79	.37	1.23	2.33	3.21	.32	.58	1.88	.76	12.98
1919	.12	.41	.46	.29	2.17	.39	1.86	.41	.82	.74	.36	.10	8.13
1920	.75	.21	.35	.61	1.55	1.97	.17	1.63	1.54	1.12	.12	.05	10.07
1921	.24	.15	.68	1.46	1.26	7.32	2.22	.55	1.61	.01	.09	.09	15.68
1922	.19	.25	.33	1.00	2.60	4.21	1.58	1.58	1.19	.07	.17	.14	13.31
1923	.40	.12	.04	.63	1.85	4.69	3.21	[1]1.16	[1]2.54	.51	1.66	[1].08	16.89
1924	[1].19	[1].57	[1].69	[1].95	[1].89	[1]3.79	[1]1.56	[1]1.50	.01	.82	.11	.46	11.54
1925	.13	Tr.	.33	.72	.85	4.05	.96	.12	3.71	.80	.07	.26	12.00
1926	.16	Tr.	.21	.04	1.24	2.02	.51	1.46	1.95	.20	.65	.35	8.79
1927	.20	.06	.32	.35	5.28	2.02	1.56	1.83	2.50	1.28	.96	.46	16.82
1928	.05	.12	.12	.24	.28	5.04	4.72	.31	.23	.09	.00	.11	11.31
1929	.49	.16	.63	.56	2.36	2.42	.04	.13	1.04	.77	.16	.59	9.35
1930	.13	.62	Tr.	1.85	1.44	2.48	1.05	.75	1.60	1.31	.39	.19	11.81
1931	.06	.18	.26	.11	.21	1.39	2.01	.98	1.08	.10	.04	.37	6.79
1932	.27	.09	.90	2.23	.75	4.04	1.40	4.36	.34	1.04	.47	.02	15.91
1933	.08	.16	.47	1.30	2.63	1.52	2.09	2.91	.36	1.12	.50	.71	13.85
1934	.05	.10	.34	.06	.42	3.05	.95	.27	.67	.13	.10	.23	6.37
1935	.40	Tr.	.15	.42	1.59	2.64	6.87	.26	.17	.11	.44	.34	13.39
1936	.41	.45	.25	.19	1.50	.53	1.12	1.81	.71	.49	.11	.30	7.87
1937	.19	.09	.28	.48	Tr.	.85	3.52	.48	1.29	1.56	.08	.16	8.98
1938	.54	.32	1.49	.51	1.66	3.92	3.29	.95	1.10	1.82	.63	.15	16.38
1939	.19	.12	.27	.69	2.05	6.56	1.28	.96	.39	.51	Tr.	.71	13.73
1940	.07	.50	.49	1.64	1.24	3.88	2.73	.23	.41	.46	.98	.15	12.78
1941	.19	.14	.50	.96	1.99	4.32	1.54	1.49	1.65	.38	.78	.09	14.03
1942	.16	.45	.42	1.65	2.31	3.79	.65	1.29	.84	.64	.24	.53	12.97
1943	.78	.12	.74	1.11	.95	6.69	1.70	2.41	.10	1.12	.28	.12	16.12
1944	.04	.30	.95	1.22	1.54	5.37	.53	1.55	1.22	.00	.80	Tr.	13.52
1945	.26	.26	1.13	.59	.14	3.94	1.84	1.14	1.04	.58	.69	.30	11.91
1946	.02	.18	.17	.23	1.40	3.91	8.86	.17	2.33	1.25	.22	.20	18.94
1947	.60	.21	.22	.83	1.31	2.96	1.34	5.84	.91	.35	.81	.29	15.67
1948	.37	.35	.22	1.13	2.39	1.69	4.50	1.26	.10	.13	.70	.65	13.49
1949	.30	.23	.15	.08	1.46	2.12	1.00	.49	.06	.52	.05	.39	6.85

Table 1.—*Precipitation, in inches, at Poplar, Mont.*—Continued

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
Average 1882-1949........	0.46	0.35	0.64	0.86	1.70	3.08	1.91	1.22	0.97	0.69	0.58	0.38	12.84
Minimum....	.00	Tr.	Tr.	.00	Tr.	.28	Tr.	.04	.00	.00	.00	Tr.	6.34
Maximum....	[1]1.92	2.05	4.15	3.10	5.28	8.62	8.86	5.84	3.99	2.98	5.43	2.00	25.35

[1] Interpolated from adjacent stations.
[2] Tr. indicates trace.

Table 2.—*Precipitation, in inches, near Culbertson, Mont.*

[From records of U. S. Weather Bureau]

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1900	...	...	...	...	...	...	...	...	...	...	...	0.20	...
1901	0.39	0.18	0.12	0.30	0.16	3.55	1.66	0.37	1.96	0.07	0.19	.29	9.24
1902	[1]Tr.	1.08	.82	.44	3.01	3.91	2.04	.82	Tr.	.62	.53	.33	13.60
1903	.23	.17	.05	.13	4.04	2.46	2.74	3.49	1.21	.12	.12	.43	15.19
1904	.34	.27	1.79	.45	1.40	1.81	2.87	.64	.08	.19	Tr.	.39	10.23
1905	.23	.47	.26	Tr.	1.21	2.66	1.99	.90	2.11	...	.24	.07	...
1906	.71	.05	.04	2.20	3.50	.60	.45	1.99	2.93	.28	1.21	.47	14.43
1907	.67	.12	.37	...	...	...	1.48	2.02	.15	...	...	...	...
1908	...	...	...	...	...	...	2.60	.46	1.35	1.33	.05	Tr.	...
1909	.80	Tr.	.10	.02	2.70	2.86	3.83	...	...	...	...	...	...
1910	.40	.70	...	.13	1.40	1.94	...	...	...	...	.23	.05	...
1911	1.10	1.00	Tr.	.72	3.88	1.48	.95	.99	4.41	1.10	.60	.50	16.73
1912	.30	.35	.60	1.58	4.00	1.38	4.49	3.55	.35	.50	.20	.55	17.85
1913	.70	.10	1.10	.09	2.35	2.82	1.87	2.80	.50	1.45	.18	Tr.	13.96
1914	.64	.24	.88	1.21	1.01	5.10	1.15	4.15	.50	...	...	...	...
1917	...	...	...	...	...	...	...	...	...	...	.02	.67	...
1918	.36	.06	.09	2.33	1.11	1.05	1.55	2.11	.27	.59	1.20	.52	11.24
1919	Tr.	.32	.48	1.00	2.10	.99	2.88	.99	.39	.78	.10	.20	10.23
1920	.49	.11	.60	1.09	1.76	1.29	1.08	.95	1.31	1.68	.05	.03	10.44
1921	.08	.08	.80	.94	1.34	2.82	1.72	.08	1.90	.13	.46	.16	10.51
1922	.11	.44	.40	.77	3.35	2.37	1.81	.82	1.78	.41	.28	.17	12.71
1923	.27	.13	.13	.75	1.21	4.52	1.61	.93	2.95	.79	1.33	.04	14.66
1924	.08	.30	.32	1.03	1.16	3.52	1.59	1.23	.53	1.56	.12	.32	11.76
1925	.06	.12	.62	.90	.67	3.84	.53	.19	3.17	1.14	.50	.21	11.95
1926	.20	.07	.14	.01	1.19	2.42	1.09	.55	1.41	.75	.55	.29	8.67
1927	.21	.03	.12	.90	3.77	1.47	1.62	1.97	3.04	1.76	.52	.35	15.76
1928	Tr.	.14	.05	.19	.47	4.11	6.14	.50	.84	.16	.03	.27	12.90
1929	.34	.12	.32	.88	3.31	1.44	.21	.88	.50	.59	.15	.56	9.30
1930	Tr.	.63	Tr.	2.05	1.64	2.85	1.66	1.56	1.41	.97	.55	.10	13.42
1931	Tr.	.20	.57	.06	.29	2.66	1.87	2.19	1.26	.76	.04	.34	10.24
1932	.05	.19	.29	1.63	.89	5.62	1.33	1.90	.23	.93	.46	Tr.	13.52
1933	.14	.09	.51	1.53	2.98	1.79	.92	1.14	.39	1.34	.37	.88	12.08

Table 2.—*Precipitation, in inches, near Culbertson, Mont.*—Continued

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1934	0.07	Tr.	0.21	0.31	0.51	1.94	0.53	0.10	0.60	0.00	0.03	0.35	4.65
1935	.33	Tr.	.16	.27	1.55	3.12	5.06	.85	.17	.18	.61	.30	12.60
1936	.47	.44	.56	.18	1.55	.81	1.33	1.88	.50	.59	.21	.33	8.85
1937	.25	.07	.33	.27	.18	.65	1.89	.76	2.48	1.44	.09	.15	8.56
1938	.58	.32	.96	.63	1.48	5.11	3.41	1.30	2.45	1.52	.57	.19	18.52
1939	.30	.09	.15	.79	1.92	5.30	.77	1.28	.38	.63	.00	.65	12.26
1940	Tr.	.54	.37	1.42	2.22	3.22	1.70	.92	.38	1.32	.71	.04	12.84
1941	.15	.05	.37	1.36	2.89	6.94	2.16	3.36	2.82	.22	.66	.07	21.05
1942	.12	.24	.39	1.31	3.22	2.89	.91	1.70	1.33	.84	.06	.47	13.48
1943	.87	.05	.53	1.11	1.87	5.55	1.71	1.93	.50	1.12	.41	.16	15.81
1944	.12	.23	.79	1.36	1.82	8.33	.23	2.00	1.38	Tr.	.69	.00	16.95
1945	.22	.30	1.05	1.18	.35	3.34	1.05	.11	1.36	.68	1.86	.45	11.95
1946	.14	.35	.15	.08	1.76	3.01	5.42	1.10	1.40	1.54	.27	.47	15.69
1947	.43	.11	.45	1.72	1.89	3.01	.75	3.59	.75	.53	.60	.12	13.95
1948	.36	.68	.23	1.30	1.67	2.57	3.44	1.01	.20	.09	1.17	.57	13.29
1949	.37	.27	.24	.02	.93	2.29	1.70	.64	.10	1.55	.01	.45	8.57
Average 1918–49	.22	.21	.38	.92	1.65	3.15	1.86	1.26	1.19	.83	.46	.29	12.42
Minimum	Tr.	Tr.	Tr.	Tr.	.16	.60	.21	.10	Tr.	.00	.00	.00	4.65
Maximum	1.10	1.08	1.79	2.33	4.04	8.33	5.42	4.15	4.41	1.76	1.86	.88	21.05

[1] Tr. indicates trace.

Table 3.—*Precipitation, in inches, at Frazer, Mont.*

[From records of U. S. Weather Bureau]

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1923	....	....	....	....	....	....	....	....	....	0.38	0.69	0.16	....
1924	0.12	0.80	0.86	0.72	1.11	5.21	0.72	1.46	0.29	2.48	.10	.68	14.55
1925	.26	.25	1.17	.94	.54	4.15	1.77	.54	3.30	.87	.07	.26	14.12
1926	1.03	.16	.15	.08	.80	2.53	1.51	1.68	2.01	.46	.91	.45	11.77
1927	.34	.25	.78	.69	6.69	1.87	3.21	1.47	2.32	1.47	1.19	.92	21.20
1928	.19	.52	.14	1.18	.43	2.06	2.10	.74	.07	.27	.00	.16	7.86
1929	.58	.09	.91	.40	1.39	2.45	.21	.13	.93	1.20	.75	.77	9.81
1930	.28	1.12	.02	1.67	1.24	3.37	1.96	.85	.81	1.02	.73	.19	13.26
1931	.17	.15	.64	.03	.38	2.27	1.91	1.42	1.44	.37	.05	.53	9.36
1932	.20	.35	1.19	2.41	.92	4.17	1.70	1.85	.41	1.11	.72	.01	15.04
1933	.18	.15	.33	1.07	2.09	2.33	1.67	2.64	.61	1.09	.59	.92	13.67
1934	.32	.14	.71	.11	.65	3.22	.31	.21	.89	.13	.03	.38	7.10
1935	.72	.15	.70	.46	1.95	1.74	4.42	.53	.23	.06	.43	.27	11.66
1936	.75	.74	.59	.30	1.69	.17	.79	1.37	.20	.39	.32	.59	7.90
1937	.41	.04	.38	.37	.06	2.17	.91	.17	.94	1.86	.07	.10	7.48
1938	.34	.39	2.18	.33	2.25	2.48	3.36	.92	1.90	1.26	.87	.47	16.75
1939	.52	.10	.25	.75	4.12	4.95	1.10	.81	.61	.64	[1]Tr.	1.13	14.98
1940	.27	.60	.84	3.82	1.36	5.05	2.40	.21	1.93	.46	.82	.08	17.84
1941	.31	.33	.50	1.51	.77	3.75	1.29	1.68	2.28	.43	1.27	.08	14.20
1942	.08	.52	.40	1.06	1.91	5.15	1.20	1.83	1.32	1.05	.57	.33	15.42
1943	1.25	.05	.42	.98	.74	5.23	1.00	1.85	.11	2.29	.36	.07	14.35
1944	.15	.34	1.54	1.18	3.02	7.25	.38	1.55	1.34	.07	1.02	.09	17.93
1945	.32	.51	2.01	1.34	.32	3.42	1.02	1.06	.74	.75	1.04	.72	13.25
1946	.33	.58	.33	.22	.89	3.52	3.30	.57	3.22	.97	.55	.55	15.03
1947	.89	.30	.69	1.42	.53	3.53	1.99	4.20	.89	.43	.60	.46	15.93
1948	.29	.75	.51	.88	1.86	2.14	3.06	1.77	.63	.03	.63	.95	13.50
1949	.55	.46	.25	Tr.	1.41	1.26	1.84	.84	.18	.90	.05	.50	8.24
Average 1924–49	.42	.38	.71	.92	1.50	3.29	1.73	1.24	1.14	.85	.53	.45	13.16
Minimum	.08	.04	.02	Tr.	.06	.17	.21	.13	.07	.03	.00	.01	7.10
Maximum	1.25	1.12	2.18	3.82	6.69	7.25	4.42	4.20	3.30	2.48	1.27	1.13	21.20

[1] Tr. indicates trace.

average precipitation at each of the three stations is about the same, wide deviations in the precipitation totals for a given month occur as a result of heavy local storms. The greatest difference in the amount of precipitation received in 1 month occurred in June 1906 when Culbertson received only 0.60 inch and Poplar, 32 miles to the west, received 8.12 inches. The great variability of monthly and annual precipitation in the area is illustrated by the precipitation record at Poplar. (See fig. 3.) The average

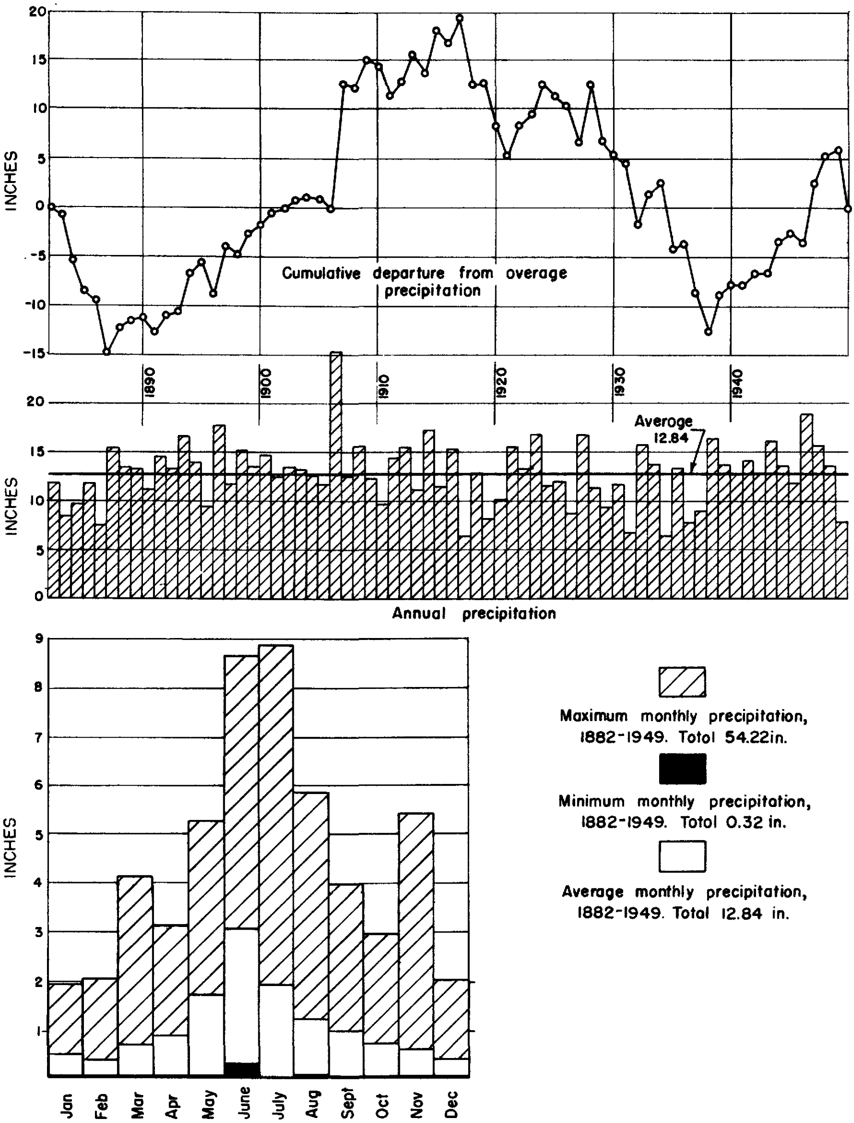


Figure 3. —Precipitation records at Poplar, Mont., 1882-1949. (From records of U. S. Weather Bureau.)

precipitation for April, the month of spring wheat planting, is 0.86 inch. During 60 percent of the years of record, however, precipitation during April was below average, and the average precipitation for this month during these years was only 0.41 inch. The average precipitation in April was 1.54 inches during the 40 percent of the years in which the precipitation during this month was above average. Thus, it may be seen that April is sometimes very dry and sometimes very wet. However, though the precipitation during April ranges from 0.00 to 3.10 inches, this range is not as great as the range during some of the other months of the year. Nevertheless, the precipitation during April, which comes early in the planting season, probably has a greater effect on crop growth.

To demonstrate the extreme variability of precipitation in the area, if all the months of maximum rainfall had occurred in the same year, a total of 54.22 inches of rain would have fallen; and if all the months of minimum rainfall had occurred in the same year, only 0.32 inch of rain would have fallen. So far as crop growth is concerned, the distribution of precipitation with respect to the growing season is far more important than the total amount of precipitation received during the year. It is possible for good crops to be grown during years of below-average precipitation if the moisture is received when needed. Conversely, a crop failure can occur during years of above-average precipitation if the moisture is received at times and in amounts disadvantageous to crop growth.

The cumulative departure from the average annual precipitation at Poplar, Mont., is shown graphically in figure 3. By use of records at nearby stations, interpolations have been made for months of no data to complete the precipitation record at Poplar from 1882 to 1949. Graphs showing the cumulative departure from normal precipitation are helpful in indicating dry and wet cycles; periods of above-normal precipitation are indicated by a rising trend, and periods of subnormal precipitation are indicated by a declining trend.

The record at Poplar indicates that in 1882 a dry cycle either was beginning or was in progress. This dry cycle ended in 1886, when the cumulative deficiency since 1882 amounted to nearly 15 inches of moisture. It is possible that if earlier records were available the dry cycle ending in 1886 would be shown to have been more severe than the one ending in 1937. The downward trend of the curve, which shows cumulative departures from average precipitation, is as steep in the period 1882–86 as at any time in the record.

In 1887 this area entered a wet cycle which continued until 1916. Although the 29-year period included several years of near- or below-average precipitation, it ended with a cumulative excess of about 34 inches. During the very wet year of 1906, when almost twice the average amount of precipitation was received, the cumulative excess was increased 12.51 inches; but during the following 10-year period the increase amounted to only 6.67 inches.

In 1917 this area entered a dry cycle which continued, with some short-period exceptions, for 20 years; by 1937 the cumulative departure from average in this period amounted to a deficiency of about 31 inches (fig. 3). Since 1937, precipitation has been above average, except for 1940 and 1945 when precipitation dropped only slightly below average and 1949 when only 6.85 inches was received. This would indicate that this area is now in a wet cycle, but reliable predictions as to future trends cannot be made. It is interesting to note that maximum departures from average at the ends of both dry cycles and the one wet cycle have been between 14 and 20 inches. The rapid rise, as the latest wet cycle started, is in marked contrast with the slower, more gradual rise at the start of the wet cycle beginning in 1887. Graphs showing cumulative departures from average precipitation at Culbertson and Frazer show a marked similarity to the graph showing cumulative departure at Poplar; because of this similarity, the graphs for Culbertson and Frazer are not reproduced.

WIND

The prevailing wind at Poplar is from the west during all months of the year except April and May, when it is from the east. The winds do not have as uniform a direction at Culbertson and Frazer as at Poplar, possibly because of local factors. At the station near Culbertson they are from the northwest during the months of January, February, May, June, August, and September and from the west during the remainder of the year. At Frazer the winds are from the west from October to February, inclusive; from the northwest during March, May, August, and September; from the east during April and June; and from the west during July. The nearest Weather Bureau station recording wind velocities is at Williston, N. Dak., 43 miles east of Culbertson, where the average annual wind velocity is 9.1 miles per hour. The wind is frequently of sufficient velocity to cause soil movement and, during the winter, deep snow drifts. In many places where light sandy soils have been cultivated, soil blown from the field is piled up in low ridges along the fence line. In places where the original fences have been buried by the silt and fine sand, new fences have been installed above the old ones. Much of this blowing of soil occurred during the drought period between 1928 and 1938, but dust storms are still not uncommon during dry windy spring and fall months.

The practices of stripcropping and permitting the grain stubble to remain in the field later in the spring have helped to remedy the situation to some extent.

Chinooks occur occasionally during the late winter and early spring months and cause a sudden and sharp rise in temperature, which is conducive to rapid melting of snow and ice and resultant runoff. At times they result in the rapid breakup of ice on the Missouri River and the formation of ice jams which flood the low-lands, although the construction of the Fort Peck dam has greatly lessened the possibility of major floods on the main river. Hot winds, which are destructive to growing crops, occur occasionally during the summer months, but tornadoes are rare in Montana.

TEMPERATURE

The average annual temperature ranges from 40.0° F at Culbertson to 40.5° F at Poplar, where the recorded extremes of temperature are 110° F and -63° F. The coldest month is January, when the average temperature is 7° F; and the warmest month is July, when the average temperature is 70.7° F. The average temperature is below freezing from November to March, inclusive. The average period between frosts ranges from 117 days at Culbertson to 123 days at Poplar; but during the period of record, frosts have occurred in every month of the year except July.

GEOGRAPHY

CULTURE

The Fort Peck Indian Reservation lies north of the Missouri River and extends 80 miles eastward from Porcupine Creek at Nashua to Big Muddy Creek, 4 miles west of Culbertson. About 3,100 Assiniboine and Sioux Indians live on the reservation and control a total of 1,270,000 acres of land, part of which lies within the area studied. Fort Peck is an open reservation, where both Indians and non-Indians live. Much of the Indian land is leased to non-Indians for cultivation, and the rent from these lands is a major source of income for the Indians. Lands near the mouth of the Milk River, along the Missouri River between Frazer and Wolf Point, and along the Poplar River have been placed under irrigation by the Bureau of Indian Affairs. However, the irrigation project along the Poplar River has been abandoned. Except for the above-mentioned irrigated and cultivated lands, most of the bottom land on the reservation is brushy wasteland.

The towns within the report area are north of the Missouri River on the edge of the flood plain. Wolf Point, population about 2,000, is the county seat of Roosevelt County and the largest town in northeastern Montana. It is the location of an Indian subagency and has a large Indian population. It also is an important supply point for outlying ranches and a very important shipping point for wheat and cattle. Poplar, population about 1,500, is the second largest town in the area. It is the headquarters of the Bureau of Indian Affairs and has a large Indian population. Other important towns are Nashua, population about 1,000; Culbertson, population about 600; Bainville, population about 400; and Brockton and Frazer, population about 300 to 350 each. The towns all have grain elevators and ship grain.

AGRICULTURE AND INDUSTRY

Most people within the area raise grain or livestock or perform services related to these occupations. Wheat is the principal crop, and cattle, horses, and sheep are raised. Most of the wheat land in the area is stripcropped; summer fallowing is practiced extensively. These practices are not followed as much in the area between Culbertson and Bainville as elsewhere, as this area lies in a part of the valley that is not subject to such high winds.

Sugar beets, alfalfa, native hay, and small grains are raised on irrigated lands near the mouth of the Milk River and between Frazer and Wolf Point. Large waterlogged areas are used only for pasture or the growing of wild bluejoint hay. Poorly drained bottom lands along some of the larger tributary streams also are used for wild-hay production.

The principal occupation south of the Missouri River is the raising of beef cattle. Much of the rough land is suitable only for pasture, and several large cattle ranches are in this area. Wild hay is produced on the bottom lands for winter feed of breeding stock. All surplus animals are shipped to market in the fall, because supplies of winter feed are insufficient in most years for the number of animals that graze the summer range. Some subirrigated alfalfa is grown on bottom-land farms south of the river, but the fields are not extensive.

Large reserves of lignite coal are present in the area east of Brockton, but the coal production is not large because the coal deteriorates rapidly under open storage or distant shipment, although several mines operate in the fall and winter months to supply local needs. The coal seams are 12 to 14 feet thick in places and fairly clean. The beds overlying the coal are soft sand and clay; generally coal is left in the mine roof to provide support to the overlying beds. A thick coal bed is exposed in a new highway cut, 6 miles east of Brockton. This coal bed, like many others in the area, has been cut by a stream whose channel was later filled with sand. The seam of coal is mined about half a mile east of the exposure.

TRANSPORTATION

That part of the area lying north of the Missouri River has excellent rail service from the main line of the Great Northern Railway. A branch line of this railroad leads northwestward from Bainville to Opheim, which is about 50 miles north of Nashua. Another branch of the Great Northern crosses the Missouri River near Snowden to connect with the Sidney-Glendive branch of the Northern Pacific Railway at Sidney, on the lower Yellowstone River.

U. S. Highway 2 traverses the area from Bainville to Nashua. State Highway 16 crosses the Missouri River at Culbertson and leads north to Plentywood and south to Sidney. State Highway 13 crosses the Missouri River near Wolf Point and leads north to Scobey and south to Circle. All these highways are paved.

In general, roads south of the Missouri River are poor, and except in dry weather it is extremely difficult to get to several of the units proposed for irrigation. The only bridges crossing the river are at Wolf Point, Culbertson, and Snowden. The Snowden bridge is a one-track railway bridge which has been converted to dual use by laying planks over the railroad ties for use of cars and trucks. Vehicle and passenger ferries operate during the summer months at Poplar and Oswego. During the winter months much of the produce from the south side of the river is hauled across the ice to the railroad. Since the construction of the Fort Peck Dam, ice on the river does not form as rapidly in the fall; and operation of the reservoir gates causes fluctuations in the water level with a consequent breaking of the ice bridge. Thus the ranchers are sometimes forced to use the longer routes to get their produce to market.

HISTORY OF THE AREA

The history of this part of northeastern Montana is an interesting story of exploration and settlement, but it is discussed only briefly here.

The first white men in the region were wandering trappers, who passed through enroute to trapping grounds in the mountains to the west and along the upper tributaries of the Missouri River. These early trappers were probably associated with the Hudson Bay Company and other Canadian companies. They left little record of their wanderings.

The first well-authenticated records are those made by the Lewis and Clark Expedition, which crossed the region in 1805 on its way to the northwest and in 1806 divided and returned by separate routes to meet at the mouth of the Yellowstone River at the southeastern corner of the area. Through the many descriptive entries made in the journals of these explorers, it is possible to identify many of the more prominent landmarks along their route. Excellent descriptions were made of the badlands that border the area south of the Missouri River. The wide marshy bottoms of Big Muddy Creek and of the Poplar and Milk Rivers also were explored and described.

After the Lewis and Clark Expedition, interest in the area increased greatly and it was visited each year by an increasing number of trappers and prospectors. In order to give protection to these travelers the Federal Government built in 1826 the first Fort Union on the north bank of the Missouri River near the present site of Frazer. This fort was used for only 2 years, and in 1828 the much better known Fort Union was established on the north bank of the Missouri River near the present Montana-North Dakota State line. This was a military fort, but it was perhaps more important as an outfitting point for the many trappers and Indian traders who operated along the Yellowstone and upper Missouri Rivers. The chief intercourse with the outside world was by steamboat as Indian depredations made overland travel precarious. Steamboat traffic was important until the railroads were built into the area. The Missouri River is still considered to be a navigable stream as far west as Fort Peck; this accounts for the absence of bridges except for those so constructed as to permit the passage of large boats. Fort Poplar was constructed in 1861 and Fort Peck in 1867; Fort Peck Indian Reservation was established in 1877.

After the construction of the Northern Pacific Railway in 1882 and the Great Northern Railway in 1888, stock raising became the leading occupation. The N-Bar-N ranch, south of the Missouri River, opposite Frazer, became one of the largest in this section of the country; it is reported that in 1886 its herds were so large that 15 chuck wagons, each accompanied by 12 riders or more, were required to care for them. Several severe winters, following dry summers of little grass growth, caused tremendous livestock losses; however, the cattle business continued to grow in spite of these setbacks.

The so-called dry-land movement began about 1906 when the public lands were opened for settlement. Jim Hill, the illustrious "Empire Builder," was extremely active in agitating for this movement in order to provide goods and revenue for the Great Northern Railway. After homesteading was finally authorized, a great publicity campaign to interest possible homesteaders was opened by the railroad. The largest number of homeseekers arrived during 1908 and 1909. In 1913, after each Indian had been allotted 320 acres of grazing land, 40 acres of irrigable land, and 20 acres of timber land, the remaining lands on the reservation were opened for settlement. Most of the land allotted to the Indians was near the larger streams, such as the Missouri and Poplar Rivers and Big Muddy and Porcupine Creeks. Settlement on the reservation reached its height during the years 1914 and 1915.

The people attracted to the free lands in this part of Montana were a cosmopolitan group representing various trades and professions. Many of the homeseekers were without previous farm experience in a semiarid climate, and in their choice of sites they gave no special attention to the character of the land or to its adaptability to agriculture. During years of drought many settlers who had assumed too heavy financial obligations became discouraged and left the area, and the population decreased about 20 percent between 1930 and 1940.

PHYSIOGRAPHY

PRE-PLEISTOCENE AND PLEISTOCENE TOPOGRAPHY AND DRAINAGE

Alden (1932) discusses at some length the physiographic history of the region, and much of the following is based on his work.

In late Miocene and early Pliocene time this region had low relief, and streams draining from the Rocky Mountains spread a layer of clay, sand, and gravel over much of the report area. These stream deposits, known as the Flaxville gravel, cap gently rolling upland plains in northern Roosevelt County and adjoining parts of Sheridan, Daniels, and Valley Counties. Small remnants of gravel-capped plains north of Glendive, on the lower Yellowstone River, have been correlated with the Flaxville gravel areas to the north. Correlation of the levels of the various remnants of the Flaxville gravel indicates that the principal stream of the area was flowing at an altitude of about 2,700 or 2,800 feet above sea level, about 700 to 800 feet higher than the present Missouri River at Wolf Point. There is reason to believe that the principal stream at that time flowed northeastward across eastern Roosevelt County and southeastern Sheridan County and across Canada to Hudson Bay. The available evidence indicates that this stream left the present course of the Missouri River near Poplar, passed south of Homestead, and entered North Dakota just west of Grenora. (See fig. 4.)

A period of erosion followed the deposition of the Flaxville gravel, and broad plains developed about 500 feet below the Flaxville surface. The upland remnants capped by Flaxville gravel stood out as flat-topped buttes surrounded by badlands. Springs issuing from the base of the Flaxville gravel probably were instrumental in headward erosion of these uplands; the location of these springs was probably controlled by the slight irregularities of the bedrock surface on which the Flaxville gravel was deposited. In this way the pre-Flaxville drainage was possibly a controlling factor in the location of the smaller streams that destroyed the Flaxville plain.

In Pleistocene time the first continental ice sheet advanced over the region from the Keewatin center of glaciation near Hudson Bay. The stage of this first glaciation of the Pleistocene in northeastern Montana has not been determined because the criteria used for differentiating the various drift sheets in the humid Middle West cannot be used in this semiarid region. The oldest recognizable glacial drift mantles the uplands east of Brockton and much of the area south of the Missouri River and extends to a line about 10 miles north of Circle, the principal town in McCone County. The presence of the glacial drift on flat to gently rolling plains within a few miles of the Missouri River and at altitudes between 2,000 and 2,300 feet seems to mark this as the approximate level of the ancestral Missouri River at the time of the first ice invasion. The short, steep gullies that form the badlands along the south side of the Missouri River are encroaching on these plains remnants. The glacial drift is a dense gray calcareous clay containing scattered pebbles and boulders of quartzite, limestone, and granitic rocks, and its maximum thickness is 30 to 50 feet. Although no detailed pebble counts were made, there appears to be a somewhat greater proportion of quartzite pebbles, probably derived from the Flaxville gravel, in the till south of the Missouri River than in the younger tills to the north. The pebbles, even where exposed on the surface, do not seem to be weathered, but the undersides of many of the surface erratics have a calcareous coating presumably deposited by upward-moving ground water.

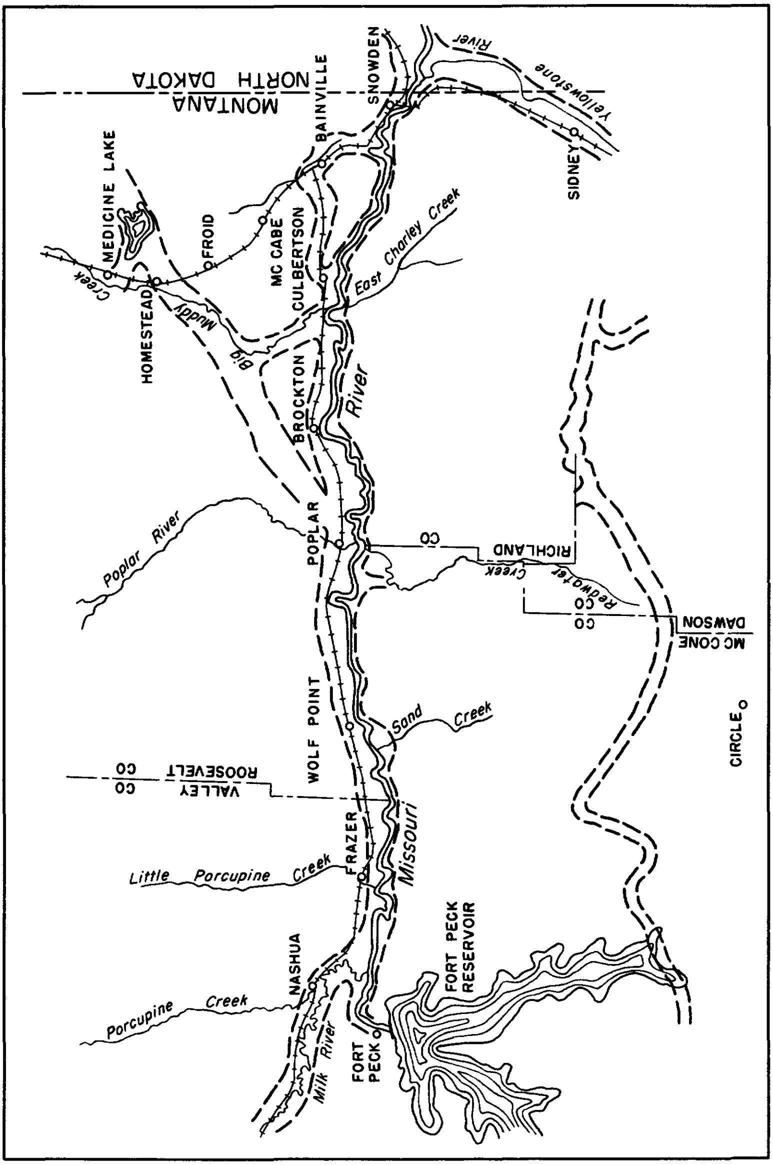


Figure 4. —Map showing major drainage channels of Pleistocene to Recent age (in part after Parker, 1936).

Alden considered the glacial deposits south of the Missouri River, and also those within 15 to 30 miles north of the river, to be of Iowan or Illinoian age; but it is the opinion of the writer that the older glacial deposits may be of Kansan age. This opinion is based on the fact that the glacial deposits south of the river have been eroded extensively in spite of the semiarid climate of this region. None of the constructional features of glaciation, such as moraines, kames, or kettles, are present in this area, whereas the area covered by the Illinoian drift in the Middle West maintains a constructional type of topography and numerous broad areas have imperfect drainage. It seems likely that constructional topography would be preserved longer in a semiarid climate than in a humid climate; because it is not, a Kansan age is suggested for the older drift lying south of the Missouri River. Other criteria used for dating the glacial-drift sheets in the Middle West, such as weathering of the drift, formation of gumbotil, and stratigraphic correlation with known sections, do not appear to be applicable in this region. Careful research on means of dating and differentiating the various glacial drifts in this area is needed before the pre-Pleistocene and Pleistocene geomorphic history and drainage can be worked out in detail.

At the time the Kansan(?) ice sheet attained its maximum extent, the ancestral Missouri River became an ice-marginal stream. The approximate course of this river has been mapped by Alden (1932) and Parker (1936). (See fig. 4.) This diversion channel is not now occupied by any major streams, but it is a prominent topographic feature in many places. Parker reports that the channel is better developed toward the east, where it has a continuous belt of alluvial filling that traverses a series of low divides, not only between major creeks but also over the divide between the present Missouri and Yellowstone Rivers. This diversion channel does not seem to have been used for any long period of time; it probably consisted mainly of a series of interconnected lakes formed by northward-draining streams blocked by the ice mass. The ice sheet was relatively weak and did not advance across the Missouri-Yellowstone divide. Parker (1936, p. 137) concluded from his study that "the ice sheet was perhaps only a few hundred feet thick and not heavily loaded with detritus." The writer is in complete agreement with this interpretation.

After the recession of the ice sheet, the ancestral Missouri River is believed to have reverted to a part of its former course. It is not definitely known whether the relatively new course followed by the river between Virgelle (approximately 180 miles west of Nashua) and Fort Peck was imposed on the river by the first ice sheet. It is possible that the river reverted to its former course between the first ice advance and a later one. It is relatively certain, however, that the river did reoccupy its former course across most of the report area. This course, however, diverged from the present channel near Poplar and trended northeastward. (Medicine Lake occupies a depression on the surface of the material filling the now buried valley.) During the period between this first glaciation and the time of diversion from that course, the river incised deeply in the soft bedrock.

Contract test drilling by the U. S. Geological Survey in the spring of 1947 showed that this valley was cut to an altitude of 1,744 feet above sea level north of Culbertson and between the towns of Froid and Medicine Lake. A cross section of this valley, based on the test drilling, is shown in figure 18. If the gradient of the river just before the advance of the ice sheet is assumed to have been comparable to the present gradient of the Missouri River, then the river had cut to a depth of about 1,860 feet above sea level at Wolf Point. If this is correct, then the bedrock surface is about 115 feet below the present river surface. The city well at Wolf Point, located near the north valley wall about 25 feet above river level, was drilled through coarse sand and gravel between 90 and 100 feet below the land surface. This also gives some indication of the depth to which the river had cut, although it is possible that the well is not located at the deepest part of the valley. These conclusions, which were reached by the author during the course of his field work, were substantiated later by the drilling of a test hole at Wolf Point. This test hole revealed shale bedrock at a depth of 115 feet. (See log of well 27-47-22ba, Roosevelt County, table 8.)

After the cutting of the deepest channel northeastward across Roosevelt County, probably in Illinoian time, another ice sheet advanced from the Keewatin center of glaciation. This ice sheet had a very important effect on the drainage of the area because it diverted the ancestral Missouri River from its course toward Hudson Bay to its present course to the Gulf of Mexico. The time of this diversion has not been determined precisely; however, Warren (1952) concluded from his studies of vertebrate fossils and from physiographic data collected near the mouth of the White River in South Dakota that the diversion occurred in Illinoian time.

Alden (1932) described a series of disconnected remnants of terminal moraine 5 to 35 miles south of the Max (Altamont) moraine, and these remnants are believed by the writer to mark the farthest advance of the ice sheet that caused the diversion. Alden projects this line of terminal moraine across the ancestral Missouri channel near Froid. The test holes drilled between Froid and Medicine Lake indicate that the ice mass placed about 180 feet of fill in the valley. (See fig. 18.) The fill raised the bottom of the valley to an altitude of about 1,920 feet above present sea level. This must be somewhat higher than the stream divides, which had to be breached for establishment of the new course of the Missouri River.

The ice mass advanced from the northeast and backed up the water in the ancestral Missouri into the lower course of the ancestral East Charley Creek (also known as Hardscrabble Creek) until it finally topped the divide between the ancestral Missouri and Yellowstone Rivers west of the present town of Bainville. Considerable melt water was discharged over this divide; by the time the ice sheet retreated, the new course had been cut lower than the surface of the fill placed in the deep valley near Homestead. It is quite apparent that the river flowed through the valley that connects Culbertson with Bainville, and it is likely that at that time the river flowed in its present course between Poplar and Culbertson, although data available at present do not preclude the possibility that the stream flowed northeast from Poplar and turned down the Big Muddy Valley.

The ancestral Missouri reached approximately its present grade when another widespread but weak ice mass advanced from the north and northeast. The broad sag that marked the buried course of the river toward Hudson Bay channeled this weak ice sheet toward the southwest. The ice spilled over the divide lying to the southeast of this channel in only one place. A narrow tongue of ice moved over the broad, low divide separating the drainage basins of Sheep and Shotgun Creeks near McCabe. This ice tongue entered the Culbertson-Bainville valley, which still was a narrow and somewhat tortuous gorge, and forced the stream into its present course between Culbertson and Snowden. The recency of this diversion is very apparent in the field. The present course of the river is almost straight, and the flood plain is narrow. Steep badland slopes border the flood plain in this reach. The divide between the Culbertson-Bainville valley and the Missouri River gorge to the south lies close to the present river. Water falling in places north of this divide must flow about 25 miles to reach the same position in the river that water falling a few hundred feet away to the south of the divide can reach by flowing about 2 miles.

West of Brockton this recent ice sheet advanced approximately to the present Missouri River. In two places it advanced slightly beyond the present river and caused short-lived diversions. South of Wolf Point the ice advanced up onto a low series of hills south of the river, and the ancestral Missouri was forced to flow across the divide east of Sand Creek. This channel is about 4 miles long and is marked by undrained depressions. The ice sheet also advanced across the present valley south of Chelsea and caused the diversion of lower Redwater Creek. A broad, poorly drained depression now marks the sag over the former valley of this creek; this depression lies north of the creek's right-angle turn 5 miles south of the Missouri River.

Abundant evidence indicates the recency and weakness of this latest ice invasion. No prominent terminal or recessional moraines were formed by this ice sheet. The ground moraine formed by it is thin and reflects, to a considerable extent, the topography over which the ice advanced. Only in the section between Brockton and Poplar is there a fairly thick deposit of glacial drift formed by this ice sheet. This greater thickness resulted from the channeling action of the broad sag that marked the northeast-trending ancestral Missouri River valley. The effectiveness of this channeling of the ice is indicated also by a remarkably straight series of narrow valleys trending N. 60° E. for more than 30 miles from sec. 1, T. 27 N., R. 51 E., to where they cross State Highway 16 about a mile north of Froid. Streams now occupy some of these valleys; other valleys are undrained depressions. In several places shallow notches over the tops or sides of hills mark the continuation of this alinement. It appears to the writer that this alinement is the result of horizontal shear zones developed between the moving ice to the northwest and ice lodged against the highlands to the southeast. This shear zone, being a zone of weakness in the ice mass, was followed by a stream which, flowing on the surface of the stagnant ice mass, was not influenced by the topography beneath the ice. A large valley was formed in the ice, and the rock debris in the ice was transported away by the running water. As the ice melted, less material remained to be deposited as ground moraine beneath this valley, and the topographic trough resulted. Slope wash or lacustrine deposits have mantled the water-sorted material that must have accumulated in parts of the river valley formed on the ice sheet.

Ground moraine deposited by this ice sheet is characterized everywhere by the presence of low ridges. The material that forms these ridges is more gravelly than the adjacent ground moraine. (See following analysis.)

Analysis of percent of grain sizes in samples from a gravelly ridge and ground moraine between ridges

[Analysis by U. S. Geol. Survey Hydrologic Laboratory, Lincoln, Nebr.]

Sample	Grain sizes (in percent)		
	Gravel	Sand	Silt and clay
Gravelly ridge	15.5	23.0	61.5
Ground moraine between ridges	.4	25.8	73.8

Most of the ridges are fairly straight, and some can be followed for several miles. More than half these ridges have a northeast-southwest bearing, and the other prominent set is almost normal to them. Close to the southeast edge of the ice sheet, the pattern of the low gravelly ridges is more jumbled and less regular than farther to the west. The gravelly ridges are best developed between Oswego and Nashua. Here the two main sets of low ridges meet almost at right angles in a distinct waffle pattern, and the depressions between the ridges are undrained. The pattern is very prominent in unbroken rangelands where the grass growth is not as heavy on the gravelly soils as elsewhere, and it can be traced across cultivated fields where crops are thin and poor on the gravelly soil. The maximum height of ridges within the area studied is about 10 feet, but ridges 10 to 15 miles north of Brockton are 15 to 20 feet high. The ridges stand out with a lighter color in aerial photographs. (See fig. 5.)

These low gravelly ridges very likely represent fillings of crevasses that resulted from a system of joints developed in the fracture zone of the ice mass while it was still in motion. When the ice sheet stagnated, probably because the main ice mass was no longer able to move southward over the divide between Hudson Bay and the Gulf of Mexico, it thinned mainly by surface melting. Streams flowing across the surface of the ice sheet deposited their loads into the existing crevasses; as melting continued, these deposits were lowered onto the land underlying the ice. The finer grained materials remained in suspension longer and escaped with the water as it found its way beneath the melting ice sheet. According to Flint (1947, p. 17), stagnation of an ice sheet occurs when the rigid upper zone (zone of fracture) of a glacier extends down to the subglacier floor. This zone is believed to extend down to depths of 100 to 200 feet, and thus we have a rough measure of ice thickness at the time the materials were accumulating in the crevasses. It is apparent that the ice mass was in a stagnant condition over a wide area; otherwise, the ridges would have been disturbed by further movement of the ice sheet.

Although, in general, the present topography differs little from the topography of the time of the melting of the last ice sheet, several relatively minor changes have occurred. West of Culbertson, the Missouri River has meandered back and forth across its flood plain but has accomplished little downcutting. Between Culbertson and Snowden, the Missouri River has excavated its new course, which, although widened somewhat, is still a gorge when compared to upstream and downstream reaches of the valley. South of the river small streams have continued to erode the older glacial drift and soft bedrock strata, thereby extending the badlands somewhat and building fans where the streams debouch onto

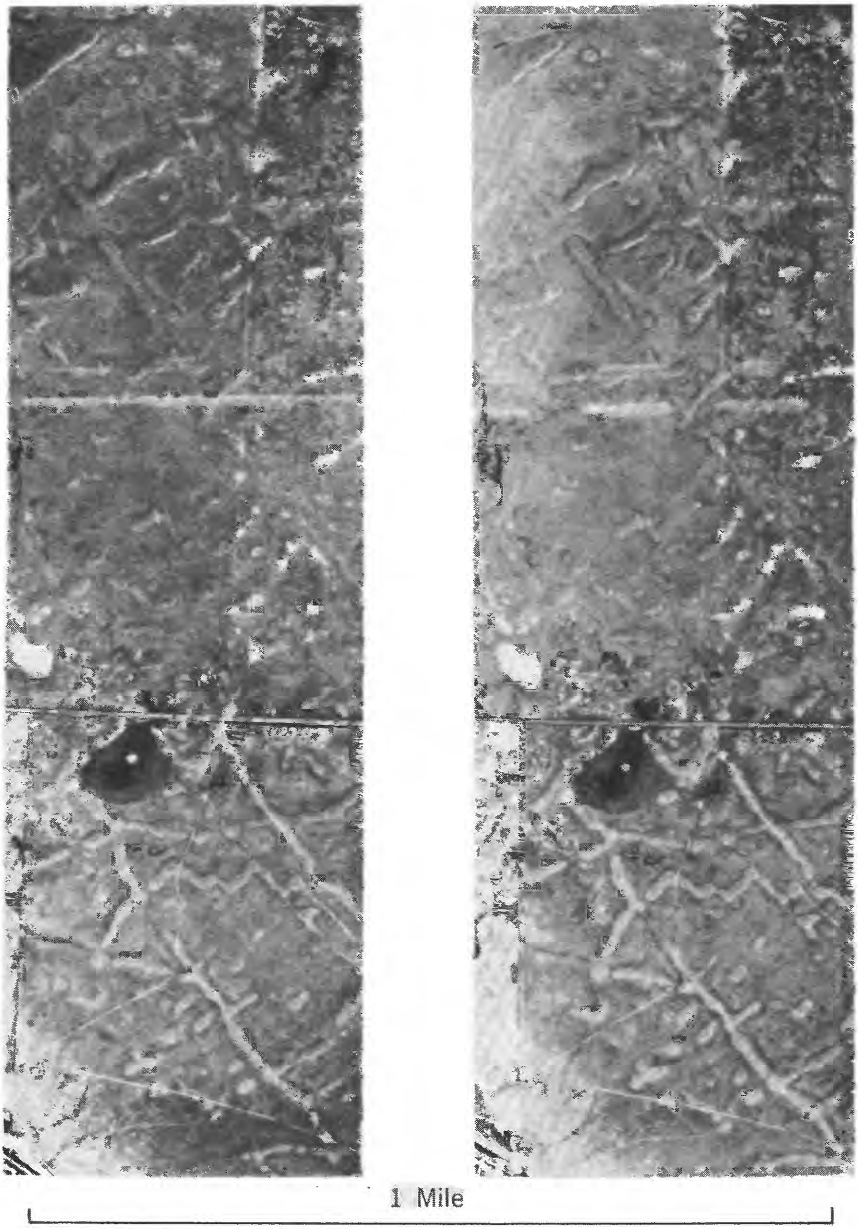


Figure 5. —Aerial photograph showing waffle pattern of gravelly ridges in the ground moraine.

the valley flat. North of the Missouri River the larger streams have removed much of the material deposited in their valleys by the last ice sheet; and, although complete drainage has not been achieved, the interstream areas have been narrowed.

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PRESENT TOPOGRAPHY AND DRAINAGE

The Missouri River, in traversing the report area, meanders across a flood plain, which ranges in width from about 1 mile to a little more than 4 miles. The alluvial bottoms are widest in the reach west of Brockton because in this part of the area the valley is older and the underlying bedrock is the weak Bearpaw shale. The narrowest and youngest part of the flood plain is in the 15-mile reach of the river downstream from Culbertson. The flood plain has many meander scars: the older have been filled with silt and organic material and are now broad, shallow sags; the younger contain standing water all year. Much of the lower land on the flood plain is brushy or covered with trees, predominantly cottonwood and willow. In most places farm crops are grown on the higher parts of the flood plain. Spring wheat is grown on nonirrigated farms throughout the area, and alfalfa is grown by subirrigation in a few places. However, wild hay is the most important crop grown in the valley south of the Missouri River and west of Wolf Point.

The flood plain of the Missouri River is bordered on the south by rough badland topography that ranges in width from about 1 to 20 miles. These badlands are developed on soft, almost flat-lying strata of Late Cretaceous and Paleocene age. The gently rolling land between the major coulees is cultivated, but the badlands are encroaching on these interstream areas in many places. Redwater Creek is the largest tributary entering the Missouri River from the south. Other streams are small; and few, if any, have perennial flows in excessively dry years. The flow in all tributaries from the south is flashy, and large discharges occur after heavy rains. Tributary streams heading in sandstone strata have built sandy alluvial fans where they discharge onto the flat flood plain. These deposits have obstructed the lower courses of the streams in some places, and the water spreads widely across the flood plain. This factor is important in the raising of wild hay on the bottom lands south of the river, especially west of Wolf Point.

The flood plain west of Brockton is bordered on the north by more gradually rising land. In places fairly extensive and gently rolling lands border the flood plain, and three of these, locally named the Poplar, Kintyre, and Chelsea benches, have been recommended by the Bureau of Reclamation for irrigation. All the lands bordering the bottoms are mantled by drift deposited by the latest ice sheet. In places the characteristic gravelly ridges are present at levels only slightly above the bottom lands, and it is obvious that the topography over which this ice sheet advanced was only slightly different from the present topography. These recently glaciated areas contrast markedly with the rough

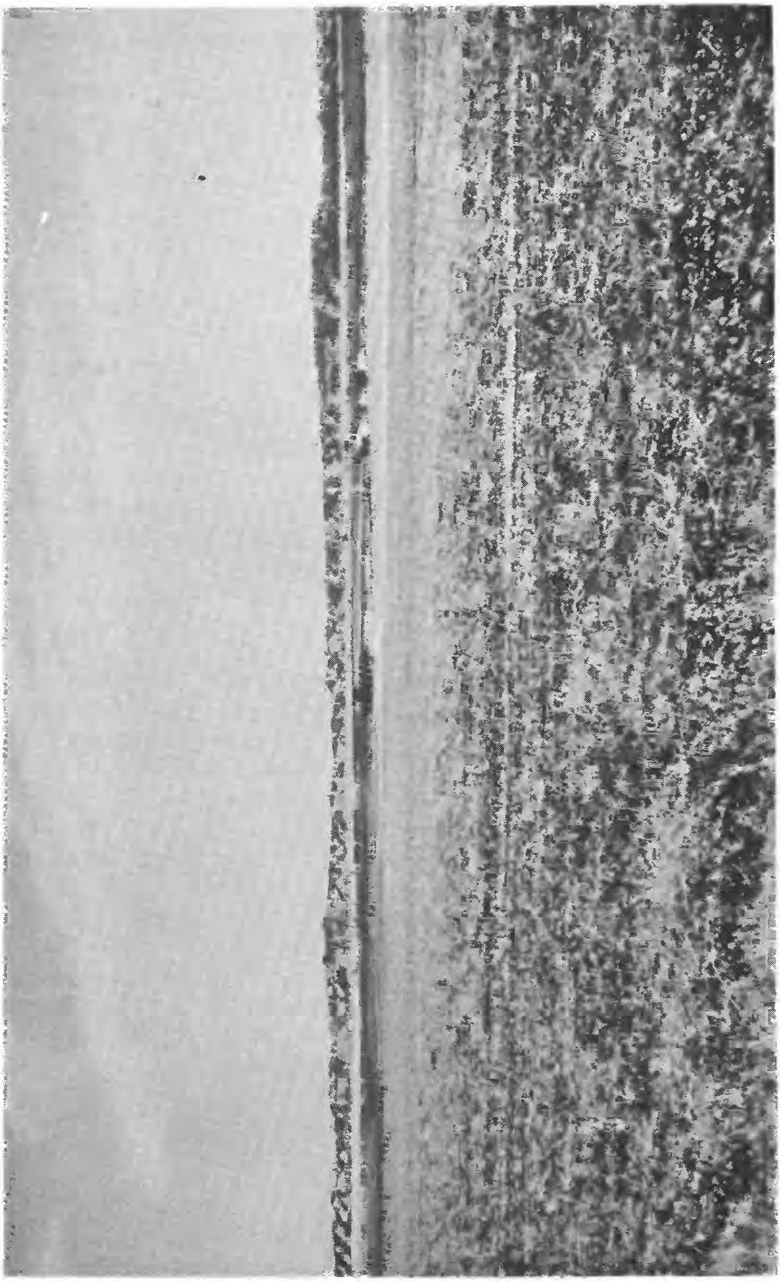

Figure 6. —View 6 miles east of Poplar, Mont., showing contrast between topographic development of the latest ground moraine (in foreground) and rough highland covered by an earlier(Kansan?) ice sheet (in distant background).

topography developed south of the Missouri River beyond the edge of this latest ice sheet. (See fig. 6.)

Streams tributary to the Missouri River from the north are larger and more numerous than those from the south. In most places the streams have cut fairly deep valleys across the rolling lands that border the river bottoms. Several of the larger streams have developed narrow alluvial plains that grade into the alluvial plain of the Missouri River. Drainage is poor in most of these narrow bottom lands because the streams are flowing on alluvium derived mainly from the Bearpaw shale, and the land is used principally for pasture or for production of native bluejoint hay. Poplar River and Little Porcupine Creek are the only streams that maintain a channel across the Missouri River bottom lands. Water from all other tributaries spreads out on the bottom lands and fills depressions where it either evaporates, is transpired by plant growth, or infiltrates to the ground-water reservoir. Materials carried by these streams are fine grained, and the low fans that are formed where the streams debouch onto the flood plain of the Missouri River have very low permeabilities. Some of these low fans now have concentrations of salts at the surface even before any irrigation water has been applied. It seems doubtful that these lands, in their present condition, should be considered for irrigation.

The Missouri River flood plain between Brockton and Culbertson is bordered on the north by steep rolling uplands. Bedrock is exposed in mnay of the coulee walls, and the topography strongly resembles that of the land south of the river. Because the latest ice sheet did not spread over this part of the report area, the rolling uplands are mantled by the older glacial drift. The valley in which Big Muddy Creek flows is broad and bordered by steep hills, and the low-gradient creek meandering across the valley floor appears dwarfed by the large size of the valley. Backwater from the Missouri River extends about 2 miles up the stream. A small unused dam a short distance upstream from the highway crossing is in need of repair. Much of the valley bottom is marshy and used only for pasture and the production of wild marsh and bluejoint hay.

East of Culbertson, the land bordering the narrow flood plain of the Missouri River has been carved into badlands, which are too steep for cultivation and so are used only for grazing. Bedrock is exposed continuously in the valley walls. The streams are short and steep, and after heavy rains they carry considerable water. Sandy colluvial fans have been formed where the coulees debouch onto the flood plain.

A broad, gently sloping valley extends from Culbertson to Bainville and then south to the Missouri River near Snowden. The hills bordering this valley on the north are fairly steep, and bedrock is exposed in some places in the coulees. The slope of the south valley wall is long and gentle and contrasts markedly with the steep badlands on the other side of the divide to the south. The valley contains some of the best croplands to be found in this area. The western part of this valley is mantled by colluvial material deposited by coulees draining from the highlands to the north, but a narrow belt of alluvium extends along the creek that drains the main valley. Toward the east this alluvial belt is somewhat more extensive, and much hay is raised by subirrigation. Very sandy outwash terraces lie east of Lanark and extend up the valley of Shotgun Creek. These terraces almost surround a large marshy depression which marks the termination of the tongue of ice that advanced down Shotgun Creek valley and dislodged the Missouri River.

North and east of Bainville much of the valleyfloor is alluvium, although colluvial slopes border the valley.

GENERAL GEOLOGY

Bedrock formations exposed within the area considered in this report consist of thick shale and sandstone deposits of Late Cretaceous and Paleocene age. The best and most extensive bedrock exposures are south of the river, where they have been cut into rather intricate badlands. Bedrock exposures are numerous north of the river east of Brockton, but west of this point the bedrock is almost everywhere covered by drift deposited by the latest ice sheet.

In general, the bedrock strata in this area are weak and readily eroded. Large concretions present in some of the sandy beds are more resistant to erosion, and in places they cap pillarsor form small waterfalls in the coulees. Such harder lenses are rare in the Bearpaw shale, which erodes into rounded hills unless capped by more resistant beds. Rock strata have a very gentle regional dip toward the east-southeast; mainly for this reason the youngest beds are exposed at the extreme eastern end of the area. This regional dip ranges from about 20 to 40 feet per mile, but somewhat steeper dips characterize the eastern flanks of gentle, northwest-trending anticlinal structures that cross the area near Poplar and Wolf Point. According to Dobbin and Erdmann (1946) and others,[1,2] the possible closure of these structures cannot be

[1]Emmons, C. L., 1919, U. S. Dept. Interior, Geol. Survey press release, Nov. 2, 1919.
[2]Thom, W. T., Jr., and Woodring, W. P., 1921. Possible oil in northeastern Montana: U. S. Dept. Interior press memo., May 6, 1921.

determined by surface mapping because of the absence of significant bedrock exposures north of the river. A test hole (27–51–35db) has been drilled to a depth of 3,085 feet on the Poplar structure, and indications of oil were reported. The log of this hole is included among the logs of wells and test holes at the end of this report.

Sedimentary rocks exposed within the area described in this report can be separated readily into four formations: Bearpaw shale, Fox Hills sandstone, Hell Creek formation, and Fort Union formation. The upper part of the marine Bearpaw shale is exposed in an almost continuous belt along the south wall of the Missouri River valley from Fort Peck to near Brockton. The Bearpaw shale also is exposed in a few places north of the river between Nashua and Wolf Point. Overlying the Bearpaw shale is the Fox Hills sandstone, which is chiefly marine and which is overlain unconformably by the nonmarine Hell Creek formation. East of Brockton the Fort Union formation is either at the surface or mantled by unconsolidated materials of Pleistocene and Recent age. The Judith River formation, which underlies the Bearpaw shale, is not exposed in the area but is important as an aquifer.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

UPPER CRETACEOUS SERIES

JUDITH RIVER FORMATION

The Judith River formation is an important source of ground water and, where exposed west of the area, consists largely of soft sandstone beds alternating with friable shale and numerous seams of coal. The sedimentary rocks for the most part represent fresh-water deposits, but intercalated with them are some brackish-water deposits. In the report area the Judith River formation is tapped by several wells ranging in depth from 700 to 1,100 feet.

On the eastern edge of Frazer, the Bureau of Indian Affairs has a well (27–44–34ac) which is reported to be 1,090 feet deep and which had a flow of about 25 gallons per minute (gpm) in 1947. This well entered the Judith River formation at a depth of 760 feet where a small flow of water was obtained; with deeper drilling the flow increased, and it is reported that the well had a flow of about 45 gpm under a pressure of 45 pounds per square inch when drilling was completed in 1933.

Another well (26–44–14aa1) that obtains water from the Judith River formation is located on the N-Bar-N ranch, about 4 miles southeast of the well at Frazer. This well was drilled in 1919 to a reported depth of 936 feet and obtained its first flow at a depth of 840 feet, or approximately 80 feet deeper than the well at Frazer. The well reportedly supplied 64 gpm under a pressure of 46 pounds per square inch when completed. The first water yielded was reported to be saltier than that at greater depths. The well now has a flow of only about 1½ gpm, mainly because the casing has collapsed. A sample of water from each well has been analyzed. (See table 4.) The considerable difference in the quality of the water from the two wells, as shown by the analyses, indicates that each well obtains water from separate sand beds in the Judith River formation.

Two wells in Wolf Point obtain water from the Judith River formation. One well (27–47–22bb), owned by the city and used for filling the swimming pool, is reported to be 1,100 feet deep. It was drilled as an oil test in 1926, but little other information is available. The well now has a flow of about 80 gpm. The other well (27–47–15bd), drilled in 1935 for the Sherman Hotel, is said to be between 965 and 985 feet deep. It is reported to flow 24 gpm and supplies all water required for a 105-room hotel. Samples from both these wells were analyzed. (See table 4.)

An oil test hole (27–51–35db) southeast of Poplar was drilled through the Judith River formation between 851 and 1,295 feet. (See table 8.) The formation was reported to consist of sandy shale that did not yield water, and thus it appears that this aquifer grades into shale between Wolf Point and Poplar.

BEARPAW SHALE

The Bearpaw shale is exposed in an almost continuous belt south of the Missouri River from Fort Peck to just beyond Sand Creek opposite Wolf Point. The outcrop belt extends at least several miles up each of the main tributary valleys. The Bearpaw shale occurs below river level in the narrow syncline that forms the southwestern closure of the Wolf Point anticline. A very small exposure of the formation is found in sec. 35, T. 27 N., R. 47 E., on the crest of that anticline. Between this point and R. 50 E., the Bearpaw shale is again below river level in the broad shallow syncline that lies between the Poplar and Wolf Point anticlines. The Bearpaw shale rises above river level on the western flank of the Poplar structure (R. 50 E.), and it is almost continuously exposed as far as the eastern edge of R. 52 E., where it passes below river level again. Scattered exposures of the Bearpaw shale occur north of the Missouri River in hills bordering the lower Milk River and flanking the alluvial bottom lands of the Missouri River as far east as Poplar. These exposures are discontinuous, and in most places the overlying formations have been eroded away; because of this, the shale has weathered to gentle slopes. Glacial drift was deposited over these gentle slopes by the last ice sheet that invaded the area. The best exposures are found along the lower valley of Wolf Creek and other large creeks whose valleys have been reexcavated since glaciation.

The Bearpaw is a dark-gray marine shale that is somewhat sandy in the upper part; the transition between the Bearpaw and the overlying Fox Hills sandstone is gradational. Small calcareous concretions are numerous in the shale in some localities. A few very fossiliferous zones contain well-preserved *Baculites* and pelecypods. The Bearpaw shale is reported to be about 1,000 feet thick in this area and is approximately equivalent to the upper part of the Pierre shale. The shale is tight, except in its upper part or in places where it has been deeply weathered, and it generally will not yield water to a well. Any water that might be obtained from permeable zones in the shale probably would be too highly mineralized for domestic or stock use.

FOX HILLS SANDSTONE

The Fox Hills sandstone crops out in a belt along the Missouri River from about the middle of R. 42 E. to the eastern edge of R. 52 E., where it passes below river level. Only the upper part of the formation is exposed in the synclinal structure lying between State Highway 13 and the mouth of Nickwall Creek. The belt of exposure extends several miles south of the river in the larger tributary valleys of the Missouri River near the western end of the area. The Fox Hills formation is exposed in only a few places north of the Missouri River. In the only complete section north of the river, located along the lower course of Wolf Creek, 46 feet 5 inches of strata can be referred to this formation. Another section, located in sec. 4, T. 26 N., R. 52 E., was found upon measurement to show 34 feet 2 inches of the Fox Hills sandstone. These two sections are somewhat thinner than sections south of Oswego, which range from 63 to about 80 feet in thickness. The two thinner sections were located close to the axis of anticlinal structures and may indicate that folding had begun in Late Cretaceous time. This factor may have considerable economic importance in determining the accumulation of oil and gas in these structures, and additional detailed studies are needed to check this possibility.[3]

[3] Since this report was written large oil accumulations have been found north of the river in both the Poplar and Wolf Point structures.

Section of Hell Creek formation, Fox Hills sandstone, and Bearpaw shale exposed in sec. 7, T. 27 N., R. 47 E.

	Feet	Inches
Gravelly glacial drift	24±	
Hell Creek formation:		
Sandstone, brown, shaly, weak; upper part covered by slumped drift	10+	
Sandstone, gray, shaly	2	9
Sandstone, massive, brown, crossbedded; cliff-forming	8	6
Sandstone, rich-brown, soft with thin shale partings	1	0
Sandstone, massive, rich-brown, soft	12	8
Fox Hills sandstone:		
Sandstone, buff to gray, fine-grained, with many thin partings of gray-green shale	1	8
Sandstone, buff to gray, fine-grained, soft, crossbedded	2	4
Sandstone, shaly, buff to gray	10	2
Sandstone, platy, thin-bedded, light-gray	1	4
Shale, sandy, soft, mealy, gray; upper part, lighter colored	30	4
Sandstone, gray, muddy; contains worm borings		4
Shale, brown		2
Shale, sandy, rusty		3
Bearpaw shale:		
Shale, dark-gray to black	30+	

Section of Hell Creek formation, Fox Hills sandstone, and Bearpaw shale exposed in sec. 4, T. 26 N., R. 52 E.

	Feet	Inches
Glacial drift, dark-gray, pebbly	5	3
Hell Creek formation:		
Sandstone, gray-brown, medium-grained; some crossbedded, some massive	6	0
Sandstone, rusty-colored		8
Clay shale, gray-brown		4
Carbonaceous lens		2
Shale, gray to brown		5
Sandstone, crossbedded, gray to rusty, medium-grained		10
Carbonaceous bed		5
Fox Hills sandstone:		
Sandstone, gray, massive, fine-grained	11	6
Shale, sandy	2	5
Sand, gray, with gypsum seams		6
Shale, sandy, brown		11
Shale, brown to gray, fissile; limonite lenses	8	3
Limonite concretions, layer of		8
Shale, brown, fissile		4
Shale, gray, fissile		6
Shale, gray sandy		9
Sandstone, carbonaceous, lensy	2	10
Shale, brown to gray, fissile	5	6
Bearpaw shale:		
Shale, dark-gray to black	50+	

In places the Fox Hills sandstone is an aquifer favorable for development of domestic water supplies, but because it underlies a thicker and more permeable formation, which is well known as a fairly prolific aquifer, its importance is reduced correspondingly. No wells within this area are definitely known to obtain water from only this formation. Several wells have been drilled through the Hell Creek and Fox Hills formations into the underlying Bearpaw shale; however, a large proportion of the water undoubtedly comes from the Hell Creek formation.

HELL CREEK FORMATION

The Hell Creek formation is exposed south of the Missouri River where it caps the badlands from R. 52 E. opposite Brockton to about R. 44 E. Westward the belt of outcrop swings south of the report area. Small exposures of the formation are present north of the Missouri, just west of Brockton, and along the lower valley of Wolf Creek.

No complete sections were available for measurement. In general, the Hell Creek formation consists of massive brown to gray sandstone with interbedded clay shale. Dinosaur remains occur in many places. One feature of the formation is the abundance of concretions, which appear to be of several distinct types. One type consists of limonite-cemented balls of sandstone as much as 2 or 3 inches in diameter. Often two or three such balls are grown together to form little doll-like figures. Another type, not as abundant, consists of fairly pure limonite. In weathering, this type of concretion develops an outer shell that eventually cracks off the rich-brown center, which has a satin lustre. The surface of many of these centers is marked on all sides with indentations resembling petrified raindrop impressions; these indentations probably mark the parts of the shell that were the last to become detached from the center. Large calcareous and limonitic concretions cap badland buttes in places or cause waterfalls in the coulees. Locally the cementing appears to be bedded and can be traced for several hundred feet.

The Hell Creek formation unconformably overlies the Fox Hills sandstone. The formation is probably 130 to 150 feet thick in this area; but because of its slight dip, the scarcity of horizon markers and the difficulty of determining contacts with adjacent formations, no very reliable measurement could be made.

Because most wells penetrate an unknown thickness of both the Hell Creek and Fox Hills formations, separating them for discussion of their water-yielding ability is difficult; however, because the Hell Creek formation is believed to be the thicker formation in this locality and because it contains more permeable sandstone, it may be assumed to be the more prolific aquifer.

PALEOCENE SERIES

FORT UNION FORMATION

The Fort Union formation underlies all the area east of Brockton. Almost continuous exposures occur along the south wall of the Missouri River valley, but exposures are discontinuous north of the river except in the reach extending some 15 miles below Culbertson. In some parts of Montana this formation can be subdivided readily into 4 or 5 members, but this is not possible with any degree of accuracy in the area described in this report.

The Fort Union formation is a thick sequence of soft sandstone interbedded with shale and a number of workable seams of lignite coal. The complete formation is not present, and no attempt was made to determine its thickness in this area. In the Richey-Lambert coalfield, about 30 miles south of the Missouri River, an incomplete thickness of about 1,230 feet of the Fort Union formation is reported by Parker (1936, p. 129). Fossil plant remains are abundant, but their stratigraphic range is so great that they are not useful for precise determination of the age of the strata. Because the type section of this formation is located at the southeastern end of the report area, stratigraphic correlation was made on the basis of lithology.

In general, adequate domestic water supplies can be obtained from the Fort Union formation by means of wells drilled 100 to 150 feet deep. Flowing wells can be obtained at greater depths on the Missouri River bottoms and in tributary valleys, and the local practice is to continue drilling until an adequate flow is obtained. The flowing wells are generally used for watering stock. The flow is not regulated, excess water being permitted to spill over the tank and to flow to the nearest coulee, where it rapidly sinks into the ground, evaporates, or is used by plants. Flows range from a few quarts to about 10 gpm. The water obtained from the flowing wells is considerably mineralized but is readily used by stock. No accurate logs of these deeper wells are available, and it is possible that some of the wells draw water not only from the Fort Union formation but also from the underlying Hell Creek and Fox Hills formations. Samples were obtained from three of these wells. (See table 4.)

PLEISTOCENE SERIES

OLDER GLACIAL DRIFT (KANSAN? STAGE)

Glacial drift, believed to be of Kansan age, is located on gently rolling lands south of the badlands that form the south valley wall of the Missouri River at altitudes above 2,000 feet. Till deposits of this same age cap the rolling highlands between Brockton and the Montana-North Dakota boundary. The maximum thickness of this glacial drift is between 30 and 50 feet, but in most places it is considerably thinner. It appears to have been deposited over a gently rolling topography having a maximum relief of about 300 feet. The drift is present only on the higher lands, except where it has slumped or been reworked by streams; thus, it is not directly involved in the areas proposed for irrigation. Toward the west the drift is composed to a great extent of reworked Bearpaw shale and has a low permeability. Most of the pebbles and coarser materials included in the drift are well-rounded quartzite probably derived from the Flaxville gravel, but some are crystalline rocks. Meager supplies of water can be obtained from the drift in most places by means of large-diameter wells. Toward the east the drift is composed to a greater extent of sand and clay derived from the Fort Union formation and thus has a somewhat higher permeability. In most places adequate domestic supplies can be obtained from large-diameter wells; for stock supplies it is probably advisable to drill wells into the underlying bedrock formations.

TERRACE DEPOSITS (ILLINOIAN? STAGE)

Downstream from the confluence of Big Muddy Creek and the Missouri River, in the lower course of East Charley Creek, and at both the upper and lower ends of the Culbertson-Bainville valley, there are several terrace remnants standing 30 to 40 feet above the alluvial bottom lands. These terraces are underlain by stream-laid deposits of sand and gravel believed to represent outwash from the Illinoian glacier, which shifted the drainage from Hudson Bay to the Gulf of Mexico. No similar deposits have been recognized upstream from Brockton.

These deposits are, with some question, assigned an Illinoian age because they definitely are outwash that stands considerably higher above the main stream than deposits known to be of Wisconsin age. The gravelly nature of these terrace deposits contrasts markedly with the uniform sandy composition of the Wisconsin outwash. The terrace remnants are of local importance as a source of gravel for roads and rough concrete work. Because the deposits are not extensive and receive only a small amount of ground-water recharge, they have little value as a source of ground water.

YOUNGER GLACIAL DRIFT (LATE WISCONSIN? STAGE)

The younger glacial drift covers all the area on the north side of the Missouri River west of Brockton. This drift has a maximum thickness of more than 60 feet between Brockton and Poplar, where it is fairly sandy and sufficiently permeable in most places to furnish adequate water supplies for domestic and limited stock needs. The drift west of Poplar is of low permeability, thin (except locally north of Chelsea and west of Frazer), and composed to a great extent of reworked Bearpaw shale; in most places only meager water supplies are obtainable. The gravelly ridges which characterize the drift surface are neither extensive nor thick enough to have any importance as ground-water reservoirs.

Moderate to large water supplies may be obtained from coarse gravel beds in the deepest part of the buried valley where this late Wisconsin(?) drift overlies the deeply cut valley of the ancestral Missouri River. Mantled with glacial drift with little topographic expression, this buried valley extends northeastward from Poplar to and beyond Medicine Lake. Test drilling is needed to determine the exact course and cross-sectional area of the buried channel and the permeability of the fill; this information may be an important factor bearing on the feasibility of the proposed Medicine Lake reservoir.

GLACIAL OUTWASH DEPOSITS

The most extensive deposits of glacial outwash are near Shotgun Creek in the Culbertson-Bainville valley. These deposits are very sandy, gently rolling benches that stand about 20 feet above both the present alluvial bottom of Shotgun Creek and the marshy depression located principally in sec. 35, T. 28 N., R. 57 E. In wet years this outwash plain is good cropland, but in dry periods the crops are parched because the surficial soil has a low moisture-retaining capacity. In some places sandy soil has been blown considerably in the past, and fence posts are buried in ridges built up along fence lines. Although the outwash deposits are not extensive or thick, they yield moderately large supplies of water suitable for domestic and stock use to wells equipped with properly selected screens.

GLACIOLACUSTRINE DEPOSITS

Deposits of glaciolacustrine origin are not extensive but are present in several places within the area. The depression in sec. 35, T. 28 N., R. 57 E., is floored with silt and fine sand which accumulated after the melting of the ice mass that was present in the depression while the surrounding outwash was accumulating. These deposits contain much carbonaceous material derived from plants that grew on the marshy bottom. North of Bainville a series of depressions, now used as reservoirs for irrigation water diverted from Shotgun Creek, contain similar glaciolacustrine deposits.

Lying south of the Missouri River opposite Chelsea is a depression about 3 miles long and about half a mile wide, which contains lacustrine deposits. This depression marks an area of settlement and compaction over the former valley of Redwater Creek. Water fills this depression during wet years, and in all but the driest years the depression is marshy. Fine silt having a high percentage of carbonaceous matter fills the bottom of this depression.

The glaciolacustrine deposits are not extensive or thick and, because they are composed of fine-grained materials, they have low permeabilities. In some places these deposits appear to form perched bodies of water, and this partly accounts for their present marshy condition. Inasmuch as the deposits rest on relatively impermeable strata, the depressions in which they occur would at first seem well adapted to serve as reservoirs for storage of surface water; however, the depressions are shallow and water stored in them would have a comparatively large surface exposed to evaporation; hence, their importance for this use is nullified.

RECENT SERIES

COLLUVIAL DEPOSITS

Colluvial deposits are present locally throughout the area. As they differ in composition from place to place, it is somewhat difficult to describe them in a general way. East of Culbertson they are heterogeneous aggregates of rock detritus which include materials derived from the Fort Union formation and from the glacial drift. The deposits are in part residual and in part transported, and some slopes are well mantled by them. In other places the colluvial material has been deposited as fans where intermittent streams still debouch onto the alluvial plains.

An almost continuous belt of colluvium has been built up by the coalescence of colluvial fans bordering the badlands along the Missouri River. The composition of each fan reflects the bedrock geology of the basin drained by the stream that built the fan. The longer streams south of the Missouri originate in exposures of the Fox Hills sandstone, or the Hell Creek or Fort Union formations, and have built fans that are sandier and more permeable than the fans formed by streams flowing their entire courses on the Bearpaw shale. The colluvial fans formed of materials derived from the Bearpaw shale have very low gradients and appear as low terraces where the Missouri River has cut against them.

The formation of a fan results from the decreased carrying capacity of a stream when its steep gradient is reduced on reaching the almost flat alluvial bottom lands of the Missouri River. The coarse materials are deposited first and accumulated as low fans bordering the highlands, whereas the finer-grained materials are carried across the fans and spread widely over the bottom lands. Few of the tributary streams are able to maintain a definite channel across the alluvial bottom lands and into the Missouri River. The colluvium is an important source of the material that fills the abandoned meandering channels of the river.

The colluvial deposits that are formed by streams heading in areas of sandy bedrock are relatively permeable and probably can yield supplies of water adequate for domestic use. Recharge is obtained from effluent seepage of streams and also from seepage from adjacent bedrock. Locally the colluvium may be as much as 50 feet thick, but in most places it is much thinner. The colluvial deposits formed by streams that flow only on the Bearpaw shale have very low permeabilities, and conditions are not generally favorable for development of ground water from these deposits, except where sandy lenses may yield a small supply of water to wells. Irrigation has been proposed for some of the low fans composed of reworked Bearpaw shale, but these lands in their present condition should not be irrigated because drainage is extremely poor and salts leached from the shales would soon concentrate in the upper part of the soil zone and ruin the land for further cultivation. The lands of the N-Bar-N and Farmers Creek pumping units are largely of this type. Fair stands of native bluejoint grass are now grown on these units for pasture and hay, and the present vegetation is able to utilize all the water obtained from precipitation and from flood discharge from the streams. It is not likely that these lands can receive application of additional water without serious damage. Careful consideration should be given to the soil scientists' reports on the characteristics of the soils in the area before any construction work is begun to bring in water for irrigation purposes.

ALLUVIAL DEPOSITS

Much of the land now irrigated, or proposed for irrigation under the present plan, is underlain by alluvium. The main exceptions are the colluvial fans, the outwash deposits near Bainville, and the late glacial drift that underlies the benches west of Frazer, north of Chelsea, and east of Poplar. The alluvial deposits throughout the area consist of fine-grained sediments of relatively low permeability. The materials of these deposits consist of a mixture of silt, fine sand, and clay. In some locations the alluvium is mantled by a thin layer of fine silt and clay derived from erosion of the Bearpaw shale. This material is similar to that described as colluvium, but it was not possible to map thin layers of this material where it forms a broad mantle over the alluvium. In general, the alluvial deposits have greater permeabilities than the colluvial fans. This is due, possibly, to the winnowing action of the Missouri River, which, in its meandering, has removed some of the finer grained materials. A good example of the contrast in permeabilities is found just south of Oswego, where the low fan of Oswego Creek shows heavy concentrations of soluble salts at the surface without extensive irrigation and the alluvial plain lying some 10 to 15 feet lower is not waterlogged even though it is irrigated. Some of the deposits beneath the alluvial bottom lands are so fine grained that waterlogging probably will take place unless great care is taken in the application of water and adequate drains are provided. Considerable land now under irrigation near the mouth of the Milk River and between Frazer and Wolf Point is threatened by waterlogging. The possibility of lowering the high water table in these areas should be studied with a view to reclaiming this land. Such detailed drainage studies will be a necessity on all lands within the area now proposed for irrigation.

Adequate supplies of water for domestic and stock use generally may be obtained from wells drilled into the alluvium. Where the alluvium is sandy, adequate supplies can be obtained in some areas by means of driven wells. The valley fill in the reach of the river above Poplar is 115 to 130 feet thick in the deepest part of the buried valley, and in places the layers of permeable sand and gravel within it supply large quantities of water to wells. A layer of sand and gravel at a depth of 41 to 53 feet is able to supply about 150 gpm to an 18-inch diameter municipal well (27–47–15cb1) at Wolf Point. The same layer is tapped by the Great Northern Railway well (27–47–15ab), which was pumped at 180 gpm, with a drawdown of about 10 feet, when constructed in 1939. A deeper well, sunk by the railway company (27–47–15ac), was drilled through the upper water-bearing zone and into a gravel layer between 82 and 91 feet; this lower gravel layer here supplies 200 gpm, with a drawdown of 26 feet, to a well 12 inches in diameter. The lower gravel is at a depth between 90 and 101 feet in the two municipal wells at Wolf Point and supplies most of the water yielded to these wells. The municipal wells, about 200 feet apart, are capable of supplying a total of about 500 gpm, with 14 feet of drawdown, if water is taken from both the upper and the lower gravel layers.

A city well (27–50–12ab1), drilled at Poplar in 1945, penetrates coarse sand and gravel at depths of 76 to 83 feet and 94 to 99 feet.

Losses of drilling fluid in the upper of these gravel zones at the time of drilling indicated a potential yield of 200 to 320 gpm, but the potential yield of the lower gravel was reported to be only 20 gpm.

A great Northern Railway well (28–55–28cd) at Blair, near the mouth of Big Muddy Creek, was drilled into a very permeable gravel at a depth of 120 to 134 feet. When the well was completed in 1936, it was pumped at a rate of 200 gpm with 3 feet of drawdown. The railway drilled other wells at Nashua, Frazer, Brockton, and Snowden but failed to find any deep water-bearing gravel; hence, it is possible that the lower gravel is located in only the deepest part of the buried valley, and the upper gravel may be lenticular. Considerable test drilling will be required before the thickness and lateral extent of these gravel layers can be determined.

QUALITY OF THE GROUND WATER

By Walton H. Durum

The chemical character of the ground waters and their general suitability for agricultural or domestic uses are discussed in this section. The differences in the results of analyses of waters from different formations, as well as the differences in the results of analyses of water from the same formation in different localities, are considered. This discussion is based on the results of analyses of 21 water samples collected in Valley, McCone, Roosevelt, and Richland Counties in October 1947. Nine of the samples are from wells 100 to 1,140 feet deep, which tap bedrock formations (Judith River, Hell Creek, and Fort Union formations) and are mostly flowing wells; eleven were obtained from wells 14 to 270 feet deep, which were drilled in the alluvium. (See fig. 7.) One sample was collected from the Missouri River 7 miles south of Nashua.

In view of the small number of samples from wells in bedrock, the chemical character of water in the deeper aquifers can be indicated only in a general way. This information, however, will be useful as reference data if future ground-water studies are made in the area.

CHEMISTRY OF GROUND WATER

Ground waters are solutions of bicarbonates, sulfates, and chlorides of the alkaline earths and the alkalies. Often present in ground waters, but usually in much smaller quantities, are

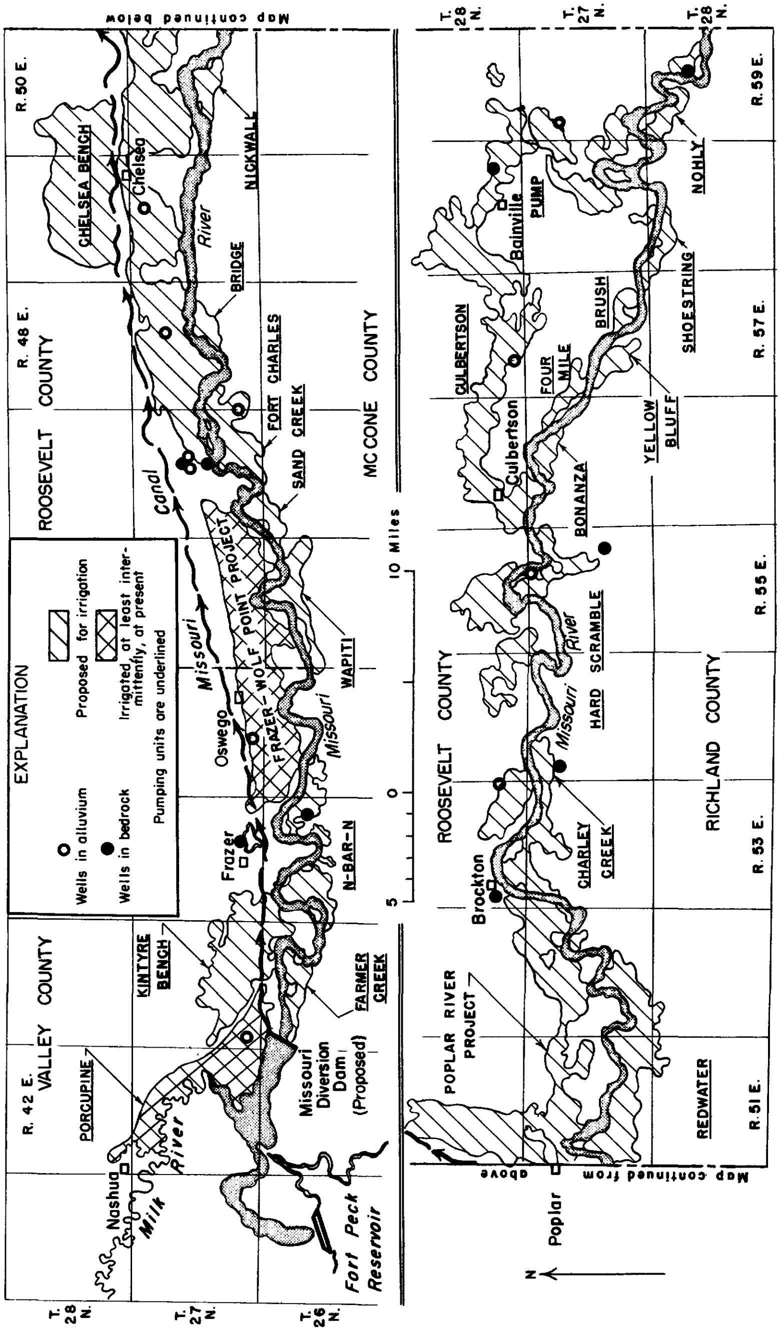

Figure 7. —Map showing ground-water sampling points.

silica, iron, manganese, fluoride, nitrate, phosphate, boron, heavy metals, hydrogen sulfide, carbon dioxide, and other constituents. Several factors determine the concentration and character of mineral constituents in a natural water. The most important of these factors are the source of the water, the mineral composition of the rocks through which the water has passed, and the length of time the water was in contact with the rock materials.

Water entering the soil first takes up soluble constituents from the soil, which always contains decaying organic matter, or humus, and disintegrated rock particles. The water, after dissolving carbon dioxide from the air as well as from the organic matter in the soil, acts vigorously on rock particles, breaking them up and forming new compounds of calcium, magnesium, and sodium, as well as silica complexes. Where soils are permeable, soluble materials are carried downward and flushed away. In less permeable soils, the soluble minerals from decomposed rock may remain in the soil. This is especially true where the water table is shallow and the capillary fringe above the water table may extend to the land surface. Water is evaporated from the land surface and replaced by salt-laden water, which moves upward from the water table. Thus a continuous process of evaporation of water and deposition of salts may occur where the counteracting agents, drainage and precipitation, are inadequate. These salts may be composed largely of sulfates of sodium, calcium, and magnesium, with smaller amounts of bicarbonate. The principal source of the sulfate may be the shales; however, bedrock in northeastern Montana also contains sulfide in the form of pyrites, which are oxidized to iron oxides and sulfuric acid on exposure to the air. The sulfuric acid then unites with calcium, with sodium, and with magnesium to form sulfates, which may replace part of the bicarbonate of the water. Where appreciable quantities of soluble compounds of calcium and magnesium are formed from decomposition of rocks, the shallow water is hard. This is especially true in water from the alluvium in the Missouri River pumping units where the hardness as $CaCO_3$ ranged from 220 to 995 parts per million (ppm) in the samples that were collected.

One of the distinguishing features of deep-well water in the area is that carbonate is commonly present. This constituent is reported separately from bicarbonate and appears only in certain of those analyses in table 4 in which the pH of the water exceeds 8.2 (upper limit of bicarbonate).

As water percolates through soil and rocks, various chemical and physical reactions may take place. The particles of which clay, sandstone, and soil are composed may enter into chemical exchange with ground-water solutions, giving off some constituents and taking on others. In this reaction, called ion exchange, ground

Table 4.—*Mineral constituents, in parts per million, and related physical*

Well or surface location	Date of collection	Depth of well (feet)	Temperature (°F)	pH	Specific conductance (micromhos at 25°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
Judith River formation											
26-44-14aa1...	Oct. 6	936	59	8.6	4,310	15	0.05	13	3.3	956	12
27-44-34ac.....	8	1,090	63	7.8	5,960	13	.51	16	5.1	1,420	18
27-47-15bd.....	10	985	63	8.3	7,080	13	.05	24	5.2	1,500	1.6
27-47-22bb.....	10	1,100	65	7.8	6,510	13	.13	15	36	1,330	19
Hell Creek formation											
28-53-30ad8...	Oct. 14	100	50	7.6	1,570	8.0	0.68	34	20	331	9.2
Hell Creek and Fort Union formations, undifferentiated											
27-54-7ba2....	Oct. 5	684	61	8.5	1,950	16	0.10	6.8	2.0	463	5.2
Fort Union formation											
26-59-10ca....	Oct. 12	795	51	8.7	3,070	12	0.05	9.7	4.4	784	81
27-55-23dd....	13	563	....	8.7	2,770	10	.05	9.8	4.6	727	18
28-58-26cd3...	13	1,140	49	8.3	2,920	7.0	.02	7.0	12	743	9.6
Alluvium											
27-43-31bb....	Oct. 9	30	49	7.6	1,900	16	0.30	161	61	193	16
27-45-33cd....	9	21	46	7.3	2,670	12	2.10	14	45	588	18
27-47-15ac....	10	93	48	7.9	1,740	16	2.80	106	36	220	8.0
27-47-15cb2...	15	100.4	51	8.3	1,890	25	1.50	74	33	359	2.4
27-47-25dd1...	10	20	47	7.7	1,820	16	.10	174	56	240	3.2
27-48-10cb1...	10	35.6	46	7.6	1,500	14	2.30	100	40	197	11
27-49-3ca......	14	60.0	47	7.8	1,470	11	.34	58	25	255	10
28-55-33da.....	13	15.3	45	7.1	3,230	12	3.60	229	103	467	14
27-59-7dd......	13	....	51	8.4	2,200	26	4.00	73	35	440	4.8
28-53-25db....	14	90	47	7.8	3,750	14	3.40	105	111	697	22
28-57-32db1...	13	18.9	46	8.1	1,240	21	.10	158	59	13	10
Surface water											
Missouri River (7 miles south of Nashua.....	Oct. 9	....	......	8.1	738	11	0.20	66	24	57	2.0

measurements of water samples from Missouri River pumping units, 1947

Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$		Percent sodium
								Total	Noncarbonate	
Judith River formation										
50	869	40	900	1.6	1.0	4.65	2,430	46	0	97
0	772	1,820	458	1.8	.5	5.02	4,130	61	0	97
24	482	5.8	2,050	1.0	1.0	5.07	3,870	81	0	98
18	544	1.9	1,850	1.0	1.0	5.16	3,550	186	0	93
Hell Creek formation										
0	882	157	6.0	1.0	2.5	0.58	1,000	167	0	80
Hell Creek and Fort Union formations, undifferentiated										
59	884	5.8	116	4.8	0.2	0.97	1,120	25	0	97
Fort Union formation										
72	1,950	9.1	52	3.0	0.4	0.00	2,000	42	0	92
131	1,580	16	44	3.2	.0	.38	1,760	43	0	96
128	1,720	6.8	52	1.4	2.5	.19	1,830	67	0	95
Alluvium										
0	441	672	25	0.5	6.0	0.25	1,370	653	291	38
0	524	1,010	26	.8	2.2	.50	1,970	220	0	84
0	412	529	11	.2	2.5	.14	1,130	412	74	53
0	532	572	18	.8	4.0	.06	1,350	320	0	71
0	688	503	29	.3	100	.06	1,470	664	100	44
0	662	288	6.0	.8	4.0	.27	987	414	0	50
0	534	345	12	.0	1.8	.25	987	248	0	68
0	1,190	971	26	.0	6.2	.16	2,410	995	19	50
0	731	645	5.3	.6	2.0	.18	1,600	326	0	74
0	1,130	1,270	8.0	.6	.5	.36	2,780	718	0	67
0	351	293	57	.1	6.0	.16	829	637	349	4
Surface water										
12	156	222	10	0.8	0.8	0.00	464	263	115	32

water is softened by contact with rock materials that give up sodium in exchange for calcium and magnesium in the water. This softening effect is particularly evident in the water from deep wells; several of the waters that were sampled had hardnesses of less than 70 ppm even though they were highly mineralized.

CHEMICAL QUALITY OF THE GROUND WATER

GEOCHEMICAL EXPRESSION

Analytical results, expressed both in parts per million and in equivalents per million, for water samples from 9 wells in bedrock (Judith River, Hell Creek, and Fort Union formations) and from 11 wells in the alluvium are given in tables 4 and 5. The wells sampled are listed by well-location number under the name of the geologic source. The results of an analysis of one sample of water from the Missouri River are also given. Typical analyses of waters from different sources are shown diagrammatically in figures 8 and 9.

It is often difficult to ascertain the geologic source of water from deep wells because well logs containing essential data generally are not available and because the subsurface formations may not be clearly identified. Where doubt exists as to the probable source, it may be practicable to identify the source on the basis of the chemical character of the water. However, this method has some limitations. Several water-bearing beds may be encountered in the drilling of the deeper wells, and ordinarily no attempt is made to case off completely the water from all but one aquifer; consequently, the water in many deep wells is a mixture of water from several aquifers. An additional factor is that corrosion of the well casing, which occurs frequently in deep wells that tap saline water, also may allow mixing within the casing of water from several strata.

Palmer (1911), Hill (1942), and others have classified waters on the basis of percentage composition of constituent ions. However, instead of expressing this composition as a unit weight of constituent in a unit weight of a solution (such as parts per million), they used the term reacting value to denote a relationship to combining weight. For example, in table 5 the equivalent combining weights for parts per million of anions listed for well 26—44—14aa1 are sulfate, 0.83; chloride, fluoride, and nitrate together, 25.48; and bicarbonate and carbonate, 15.91. These values amount to 2, 60, and 38 percent, respectively, assuming that the sum of the anion percentages equals 100. The anion reacting values for the individual well waters are plotted on the trilinear

Table 5.—*Mineral constituents, in equivalents per million, and reacting values of water samples from the Missouri River pumping units*

Well or surface location	Equivalents per million					
	Na, K	Ca	Mg	SO_4	Cl, F, NO_3	HCO_3, CO_3
Judith River formation						
26-44-14aa1	41.88	0.65	0.27	0.83	25.48	15.91
27-44-34ac	62.34	.80	.42	37.89	13.02	12.65
27-47-15bd	65.27	1.20	.43	.12	57.89	8.70
27-47-22bb	58.10	.75	2.96	.04	52.25	9.52
Hell Creek formation						
28-53-30ad8	14.65	1.70	1.64	3.27	0.26	14.46
Hell Creek and Fort Union formations, undifferentiated						
27-54-7ba2	20.27	0.34	0.16	0.12	3.52	16.45
Fort Union formation						
26-59-10cb	36.16	0.48	0.36	0.19	1.64	34.36
27-55-23dd	32.07	.49	.38	.33	1.41	30.26
28-58-26cd3	32.55	.35	.99	.14	1.58	32.46
Alluvium						
27-43-31bb	8.80	8.03	5.02	13.99	0.84	7.23
27-45-33cd	26.03	.70	3.70	21.03	.81	8.59
27-47-15ac	9.77	5.29	2.96	11.01	.36	6.75
27-47-15cb2	15.67	3.69	2.71	11.91	.62	8.72
27-47-25dd1	10.52	8.68	4.61	10.47	2.45	11.28
27-48-10cb1	8.84	4.99	3.29	6.00	.27	10.85
27-49-3ca	11.35	2.89	2.06	7.18	.37	8.75
28-55-33da	20.66	11.43	8.47	20.22	.83	19.51
27-59-7dd	19.25	3.64	2.88	13.43	.21	11.98
28-53-25db	30.86	5.24	9.13	26.44	.27	18.52
28-57-32db1	.83	7.88	4.85	6.10	1.71	5.75
Surface Water						
Missouri River (7 miles south of Nashua	2.52	3.29	1.97	4.62	0.33	2.96

diagram in figure 10 in which the apexes of the triangle equal 100 percent of the anions. The plotting emphasizes differences in the chemical character of the water; the low-sulfate, high-chloride percentages place waters from the Judith River formation in the lower right; the low sulfate, high bicarbonate of waters from the Fort Union formation in the lower left; and the low chloride, high sulfate-bicarbonate of the alluvium, generally at the left center of the triangle.

The amount of data available for plotting is far less than optimum; however, the typical analyses for the various sources suffice to indicate general groupings for the several sources.

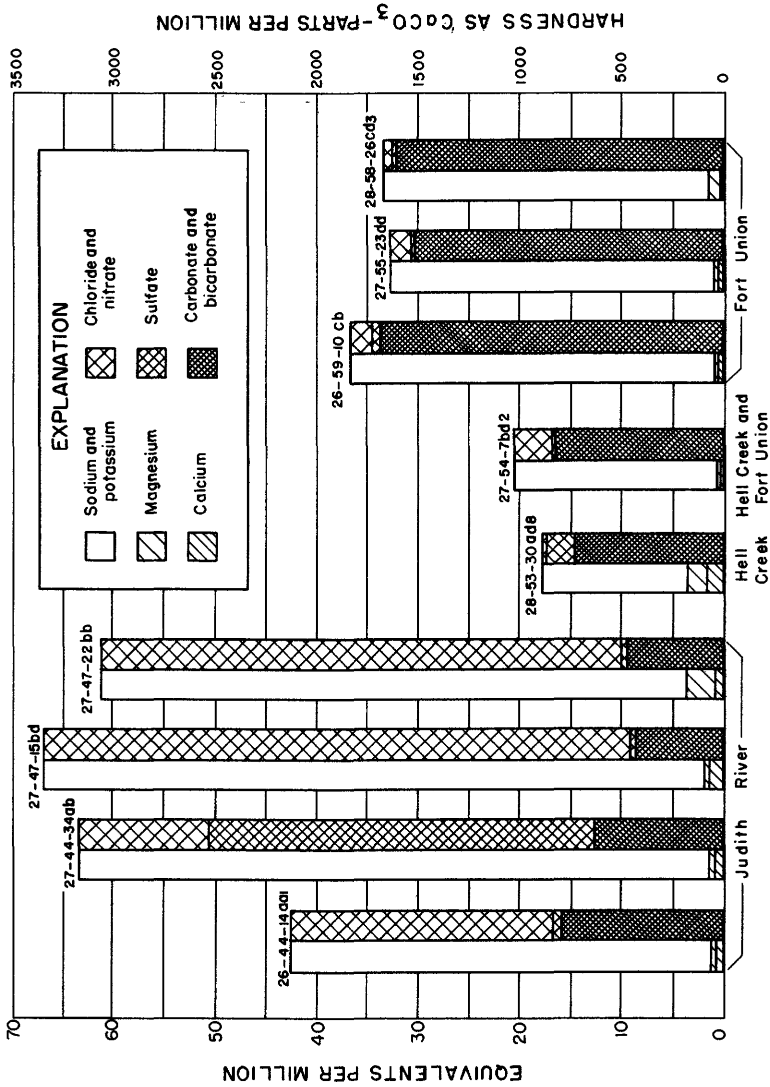

Figure 8. —Principal mineral constituents in ground waters from the Judith River, Hell Creek, and Fort Union formations.

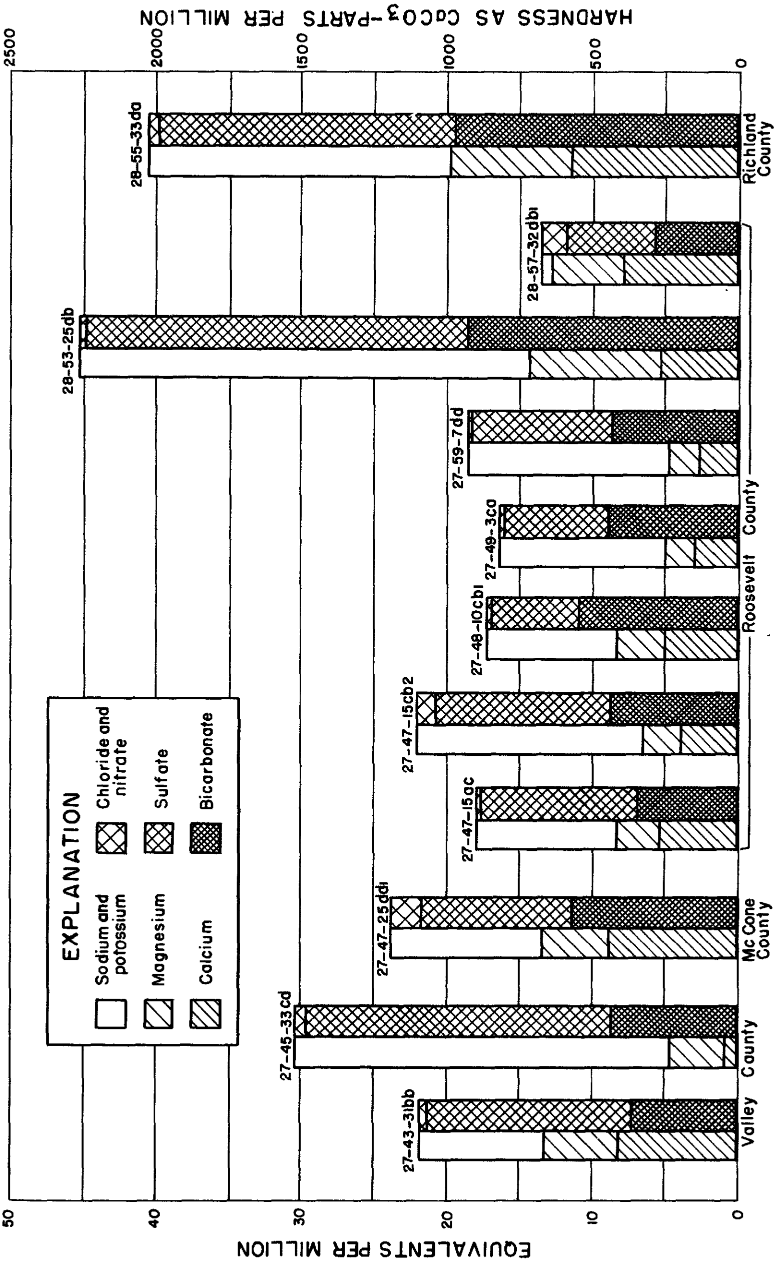

Figure 9. —Principal mineral constituents in ground water from the alluvium.

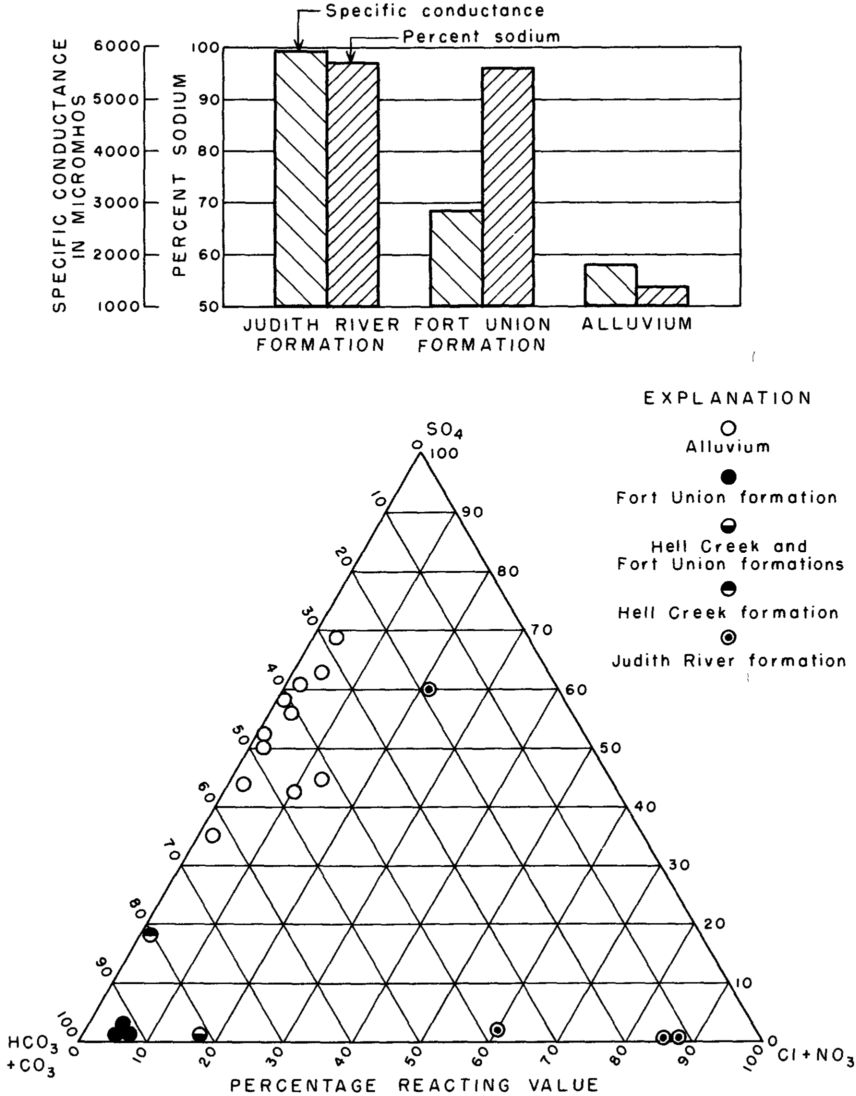

Figure 10. —Diagrams showing percentage reacting values and comparison of specific conductance and percent sodium of water.

CHEMICAL CHARACTER IN RELATION TO SOURCE

Water in the Judith River, Hell Creek, and Fort Union formations generally has a higher dissolved-solids content and is softer than water from alluvial deposits. (See table 6.) Hardness in water from the bedrock formations ranged from 25 to 186 ppm, whereas hardness in water from the alluvium exceeded 200 ppm in all samples. (See fig. 11.)

Table 6.—*Range of several mineral constituents in ground water of the alluvium and the Fort Union, Hell Creek, and Judith River formations*

[Parts per million]

Constituent	Alluvium		Fort Union, Hell Creek formations		Judith River formation	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Sodium + potassium....	719	23	865	340	1,500	968
Bicarbonate.............	1,190	351	1,950	882	869	482
Carbonate..............	0	0	131	0	50	0
Chloride..................	57	5.3	116	6.0	2,050	458
Fluoride..................	.8	.0	4.8	1.0	1.8	1.0
Boron......................	.50	.06	.97	.00	5.16	4.65
Dissolved solids.........	2,780	829	2,000	1,000	4,130	2,430
Total hardness..........	995	220	167	25	186	46
Noncarbonate hardness..............	349	0	0	0	0	0
Percent sodium.........	84	4	97	80	98	93

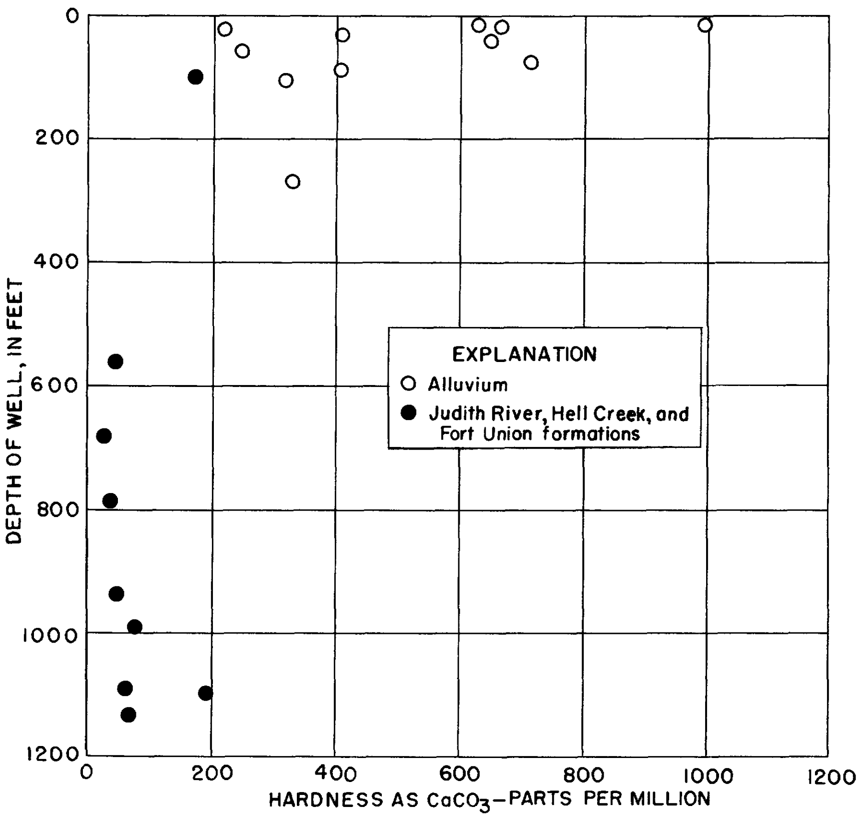

Figure 11.—Relation of depth of well to hardness of ground water in several geologic formations.

In general, the percent sodium increases with depth of well. (See fig. 12.) This relationship has particular significance where use of ground water for irrigation is contemplated. Water in which sodium exceeds 50 percent may be injurious to certain types of soils and crops, particularly when surface or subsurface drainage is inadequate.

The percent sodium in the analyses of samples of water from bedrock aquifers ranged from 80 to 98. The percent sodium in analyses of water from shallow aquifers ranged from 4 to 84, and most had a percent sodium in excess of 50.

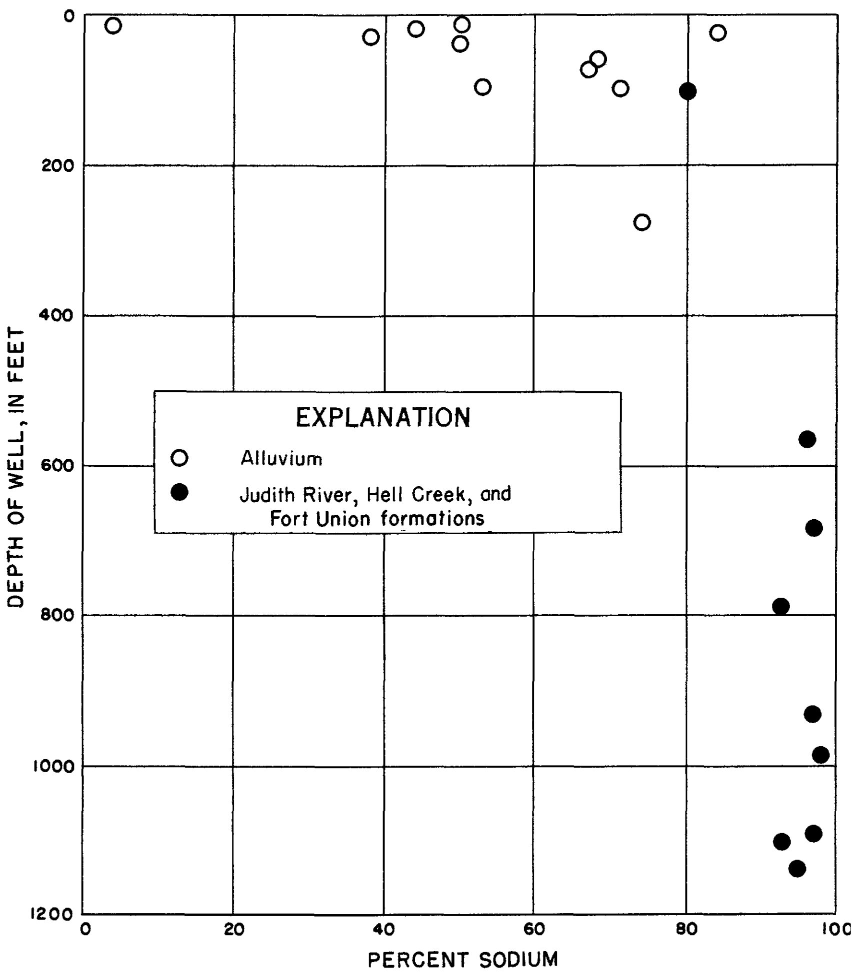

Figure 12.—Relation of depth of well to percent sodium in ground water in several geologic formations.

Owing to the greater frequency of occurrence of carbonate, the pH of most of the samples of deep-well water was greater than the pH of samples from the alluvium. The iron content in water from bedrock aquifers is also generally lower than in water from the alluvium.

Judith River formation.—In addition to previously shown properties of reaction, water from the Judith River formation differs from other bedrock waters by having higher concentrations of dissolved solids, chloride, and boron. Each of the four samples analyzed had about 5 ppm of boron. The presence of several parts per million of boron may be an aid to identification of water that is believed to originate from this formation. All the samples of water from the Judith River formation had a low content of calcium and magnesium, and the concentration of bicarbonate and carbonate was lower than that found in water from other bedrock aquifers.

Although 3 of the 4 samples of water from the Judith River formation contained little sulfate; the fourth sample, from well 27–44–34ac, 1,090 feet deep, contained 1,820 ppm of sulfate. All the factors that may have contributed to the alteration of the chemical composition of this water in its underground movement are not known. According to drilling records, however, the first flow from the Judith River formation was found at 760 feet. It is reported that waters from water-bearing beds near the top of the formation are more highly mineralized than waters from deeper water-bearing beds in the same formation, and it is possible that concentrations of sulfate, which may have been obtained from shale, may be greater in the upper horizons.

The mineral content of the water from well 26–44–14aa1, 936 feet deep, is less than that of the sample from well 27–44–34ac. The dissolved solids (2,430 ppm) are composed largely of sodium chloride. This well is believed to tap a deeper aquifer in the formation.

Hell Creek formation.—The Hell Creek formation is represented by a single sample (well 28–53–30ad8), and consequently the chemical character of water from this stratigraphic unit can be indicated only in a general way. This water differs from waters from the Judith River formation by having a lower content of dissolved solids, sodium, chloride, and boron. The dissolved solids are composed principally of sodium bicarbonate.

Hell Creek and Fort Union formations, undifferentiated.—The chemical quality of one ground-water sample (from well 27–54–7ba2) may be described as intermediate between that of water from the Hell Creek and that from the Fort Union formation. The dissolved solids (1,120 ppm) in this sample are composed largely of sodium bicarbonate, and the content of calcium and magnesium is negligible; thus, the water has the lowest hardness of all samples analyzed (25 ppm). A fluoride content of 4.8 ppm is the highest obtained in the waters analyzed.

Fort Union formation.—Water from the Fort Union formation can be readily distinguished from that of the Judith River formation by its uniformly lower content of dissolved solids, which are composed principally of sodium bicarbonate. Three wells, drilled to depths of 795, 563, and 1,140 feet in this formation, supply water in which carbonate exceeds 70 ppm and the hardness value is less than 70 ppm. (See table 4.) Well 28–58–26cd3 was drilled originally to 140 feet and drew water from the Hell Creek formation. However, it is thought that the lower part of the well collapsed and that the flow from this formation is blocked.

In the Fort Union formation, water low in sulfate has an unusually high content of bicarbonate. Riffenberg (1925, p. 47) has suggested that the relation of sulfate to bicarbonate in waters from the Fort Union and Lance formations may be due, either directly or indirectly, to the reducing action of the lignite, carbonaceous shale, or natural gas contained in these formations. In this reaction, the amount of bicarbonate that is produced is equivalent to the amount of sulfate that is reduced. Some water samples that were collected in the Missouri River pumping units were reported to contain hydrogen sulfide, which is an end product in this reaction.

A distinct softening action has taken place in most water obtained from bedrock formations. (See fig. 11.) Renick (1924) concluded from a microscopic examination of rock materials from formations in east-central Montana that the natural softening of waters in the Fort Union formation is effected by minerals that have ion-exchange properties. Renick pointed out that the exchange of calcium and magnesium in the water for the sodium in the ion-exchange silicate is rapid and that the replacement may be complete after the water has percolated through only a few feet of rock material that contains "natural zeolites." The exchange may also be aided by such minerals as kaolinite, feldspar, and mica, which are present in these rocks.

In view of high fluoride concentrations, 3.0 and 3.2 ppm in two water samples from the Fort Union formation, it appears that water from the deeper water-bearing sands in this formation may be expected to have a higher fluoride content than waters sampled from other stratigraphic units. Boron concentrations are negligible compared to those found in water of the Judith River formation. Percent sodium in water of the Fort Union formation is considerably higher than in water from the alluvium.

Alluvium.— Ground water in the alluvium, as represented by 11 samples, generally is highly mineralized and hard; the dissolved-solids content ranged from 829 to 2, 780 ppm, and the hardness ranged from 220 to 995 ppm. (See fig. 13 and table 4.) The dissolved-solids content of 8 of the samples exceeded 1, 000 ppm. In contrast to most water in deep horizons, carbonate is absent; and boron and percent sodium are lower.

Sulfate and bicarbonate are the important constituents of ground water in the alluvium, and chloride is relatively insignificant. (See fig. 13.) In the higher concentrations of dissolved solids, the quantities of sulfate and, to a lesser extent, bicarbonate are directly proportional to the total quantity of dissolved solids. In general, any increase in dissolved solids above 1, 000 ppm is due to the addition of sodium and sulfate. (See graphic representation of analysis of sample 28–53–25db in fig. 9.)

The similar chemical character of the water in wells 27–47–15ac and 27–47–15cb2, which are 93 and 100. 4 feet deep, respectively,

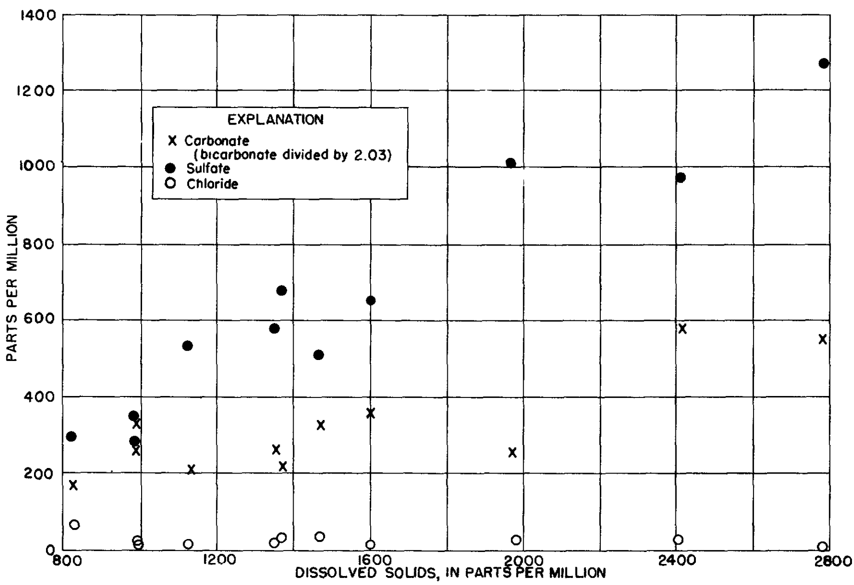

Figure 13. —Relation of carbonate, sulfate, and chloride to dissolved solids in ground water from the alluvium.

and are located at Wolf Point, suggests that both wells tap the same sand. The most significant difference in the analyses of the two samples is the cation relationship. Apparently a more complete exchange of calcium for sodium has occurred in the water in well 27–47–15cb2; consequently, this water is softer.

QUALITY OF WATER IN RELATION TO DRAINAGE

The high concentration of dissolved solids in some of the samples of shallow ground water is probably the result of evaporation. This is an important consideration, inasmuch as some lowland areas are reported to be waterlogged and other areas are likely to become waterlogged as a result of irrigation. Use of Missouri River water (see table 4) for irrigation may possibly result in an improvement in the quality of the ground water in areas that are well drained. However, the quality of the ground water in bottom-land areas can be improved only if the water table is permanently lowered and measures are taken to insure free movement of ground water out of the area. Initially, the flushing action of irrigation water that percolates to the water table will carry down salts deposited in the soils; this will likely result in increased concentrations of dissolved solids in the shallow ground water.

QUALITY OF WATER IN RELATION TO USE

DOMESTIC

When compared with usual standards, the chemical data shown in table 4 are indicative of water of poor quality. However, in areas where water supplies of a low mineral content are difficult to obtain, the residents often become accustomed to drinking water of relatively high mineral content (1,500 to 2,000 ppm of dissolved solids). It follows that the presentation of any standards, ratings, or limits for defining the general domestic utility of the water is useful for comparison only.

The United States Public Health Service (1946) has published drinking-water standards that limit the amount of mineral substances in water to be used in interstate commerce. Some of the suggested limits are as follows:

Constituent	*Maximum ppm*	
Iron and manganese together........	0.3	
Magnesium	125	
Sulfate	250	
Fluoride.................................	1.5	
Chloride.................................	250	
Dissolved solids	500	(1,000 permitted)

Water from the Judith River formation is highly mineralized and seldom used for drinking; but, like supplies from other bedrock aquifers, the water is soft and widely used for livestock, and for public and domestic purposes other than drinking.

Abundant supplies of water for domestic use are pumped from wells in the alluvium. The water from well 27–47–15ac, owned by the Great Northern Railway, is combined with water from a second shallow well, and the mixed water is softened with soda ash and lime.

Well 27–47–15cb2 (100.4 feet deep) is the older of two wells that supply water to the city of Wolf Point. Although the dissolved-solids content of this water is high (1,350 ppm), sodium bicarbonate is prominent, the content of magnesium low, and the water satisfactory for drinking.

Water from well 27–47–25dd1 (20 feet deep), which is in the Fort Charles unit, has a high content of nitrate (100 ppm). In view of the shallowness of this well and the low nitrate content of other waters, it is presumed that this high content of nitrate is caused by contamination from surface seepage.

The water having the lowest dissolved-solids content (829 ppm) was obtained from well 28–57–32db1 (18.9 feet deep); however, the water has a hardness of 637 ppm. The percent sodium (4 percent) in this water was the lowest obtained in the samples analyzed.

IRRIGATION

There is no present plan for utilizing ground water for irrigation in the report area; however, the supplies can be evaluated for supplementary irrigation use by standards suggested by Wilcox (1948). Wilcox states that under conditions described as "average" for crop growth in a given area, water is generally of questionable quality for irrigation if the percent sodium exceeds 60 and if the specific conductance (electrical measurement of the total ionizable salts) exceeds 2,000 micromhos. Scofield (1936) has discussed a

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third criterion, the concentration of boron, as a limiting factor in water for irrigation. Although a wide range in tolerance to boron exists among farm crops, Magistad and Christiansen (1944) suggest a boron limit of about 1 ppm in water for irrigation of boron-sensitive crops. More tolerant crops, such as alfalfa, withstand somewhat higher concentrations of boron.

No water supplies from bedrock and only a few from the alluvium, are satisfactory for irrigation. (See table 4 and representative analyses in fig. 10.) The dissolved-solids content and percent sodium of most water, particularly that from bedrock, are too high. Water in the Judith River formation is also excessively high in boron.

FLUCTUATIONS OF WATER LEVEL IN WELLS

Periodic measurements were made of the water levels in 16 observation wells in the area described in this report. (See table 7.) Although the period of measurement was not long enough to enable the writer to make many significant conclusions, some interesting characteristics of water-table fluctuations were indicated.

The hydrographs of two wells in unconsolidated surface deposits in irrigated areas (fig. 14) are characterized by a marked rise during the spring and summer and a marked decline during the remainder of the year. The rise in water level begins in April, probably as a result of recharge from snow melt, but it increases greatly with the beginning of irrigation in May. The marked rising trend indicates that the local areas near these wells are in imminent danger of waterlogging unless the amount of recharge is lessened or drainage facilities are provided. During 4 months in 1949 the water table was less than 5 feet below the land surface at well 27—45—33dc, and it is probable that the capillary fringe extended to the land surface. Under such conditions ground water is evaporated directly from the ground surface, and salts are deposited in the soil mantle. When the salt concentrations are great enough, the land becomes unproductive unless drainage facilities are provided and the salts can be flushed out.

The hydrographs of six wells in unconsolidated surface deposits in nonirrigated areas (figs. 15 and 16) probably represent the characteristic fluctuations of the water level in many wells in the area of study. The water-level fluctuations in these wells were remarkably similar. All these wells had low water levels when first measured in the summer of 1946; this was the result of the below-normal precipitation in the last half of 1945 and first half of 1946. In the latter half of 1946 the precipitation was far above normal, and the water level

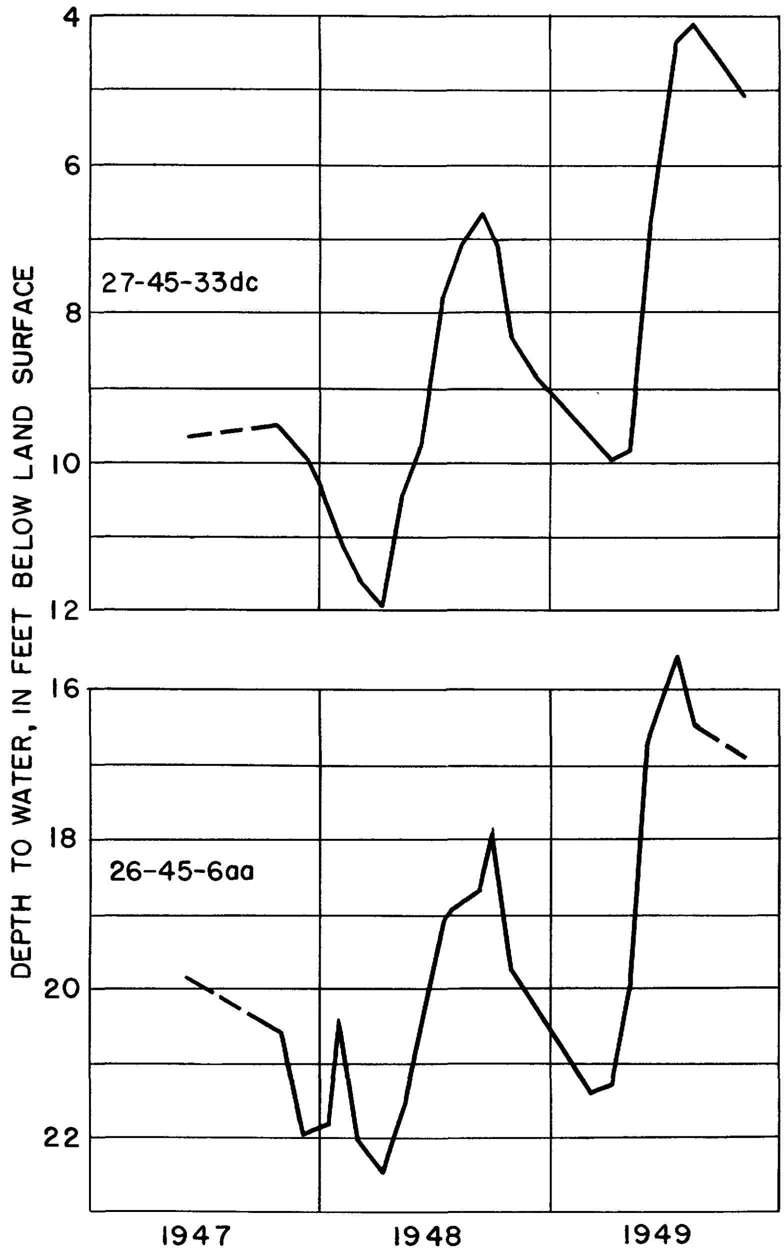

Figure 14. —Hydrographs of wells in unconsolidated surface deposits in irrigated areas, Valley County.

in these wells responded readily to this increase in precipitation. The rapidity of this response is an indication of the relative permeability of the material through which recharge to the

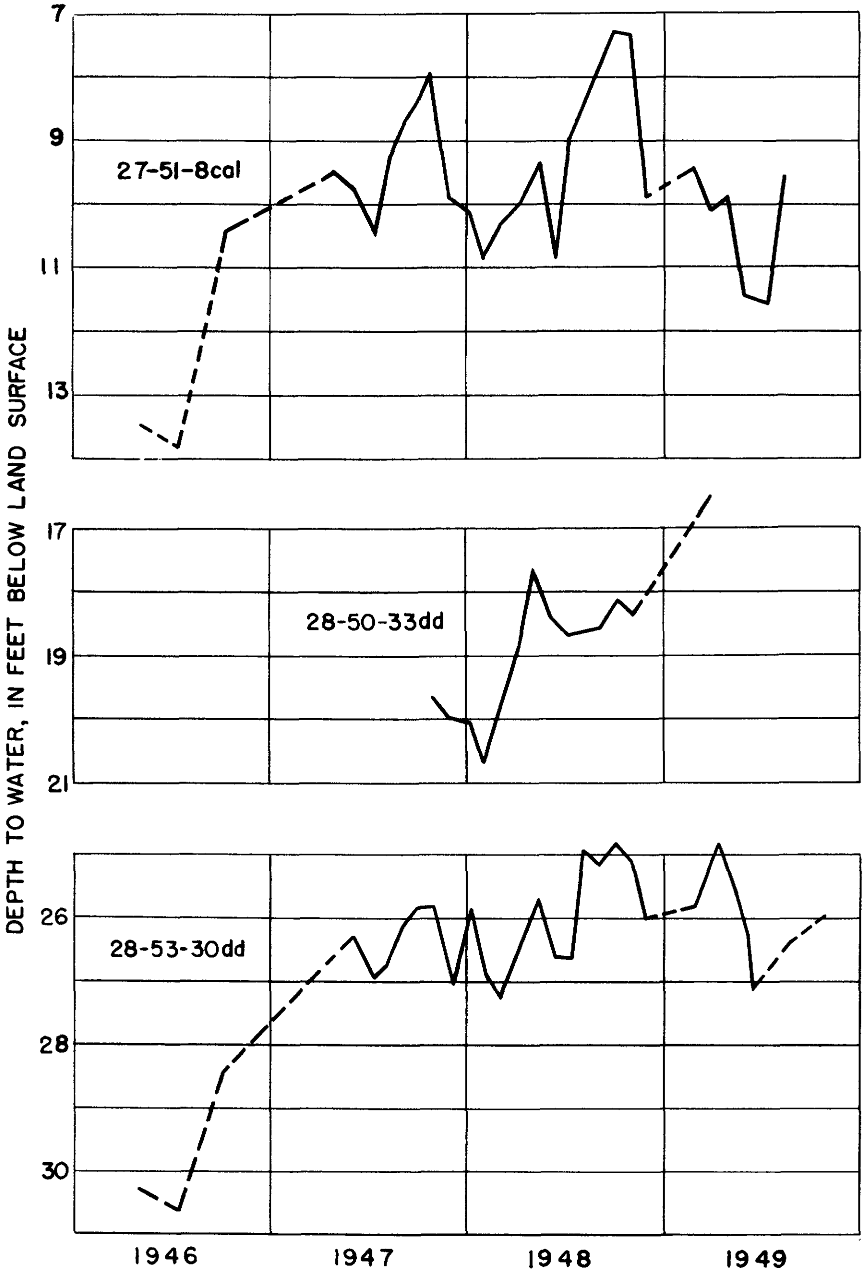

Figure 15.—Hydrographs of wells in unconsolidated surface deposits in nonirrigated areas, Roosevelt County.

ground-water reservoir must move. The contrast between the hydrographs of wells in irrigated and nonirrigated areas is marked. The hydrographs of wells in the former area indicate a more

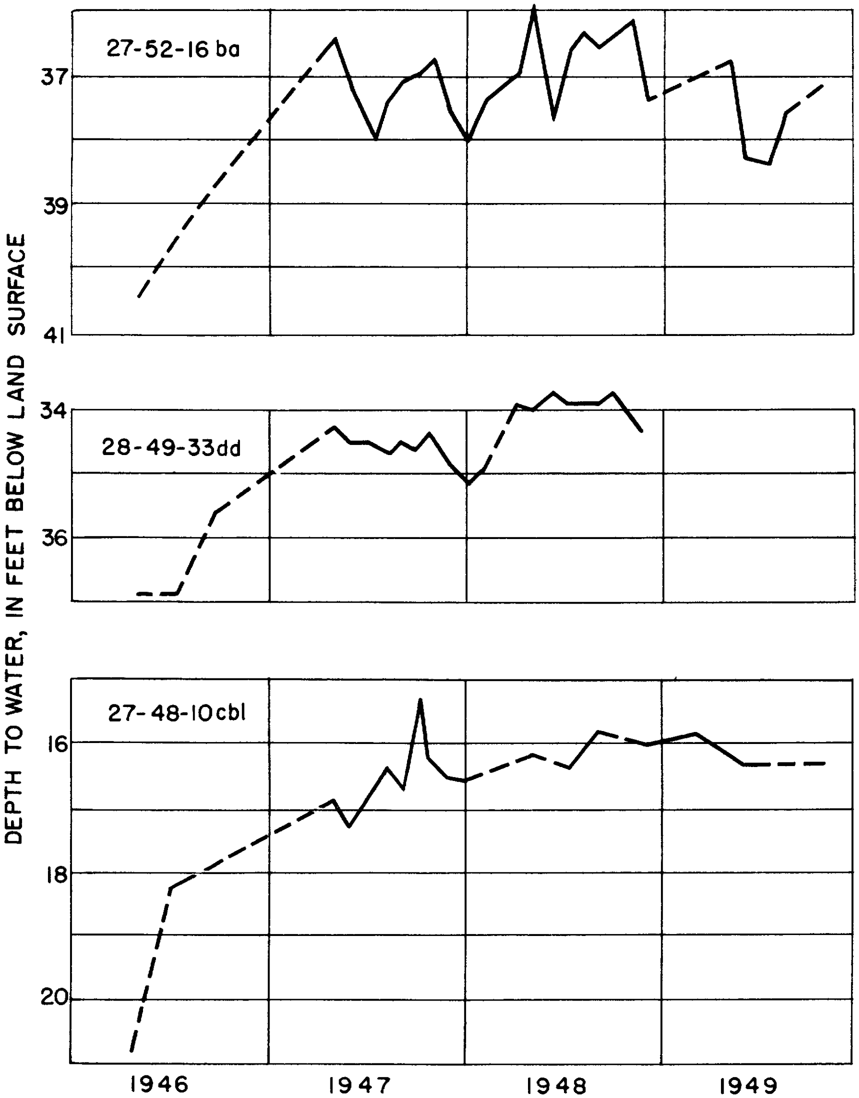

Figure 16. —Hydrographs of wells in unconsolidated surface deposits in nonirrigated areas, Roosevelt County.

uniform period of principal recharge during the irrigation season; the minor water-level fluctuations that are shown by wells in the nonirrigated areas are not apparent in the hydrographs of wells in the irrigated areas.

Hydrographs of wells ending in bedrock (fig. 17) do not show as marked water-level fluctuations as do those of wells in the

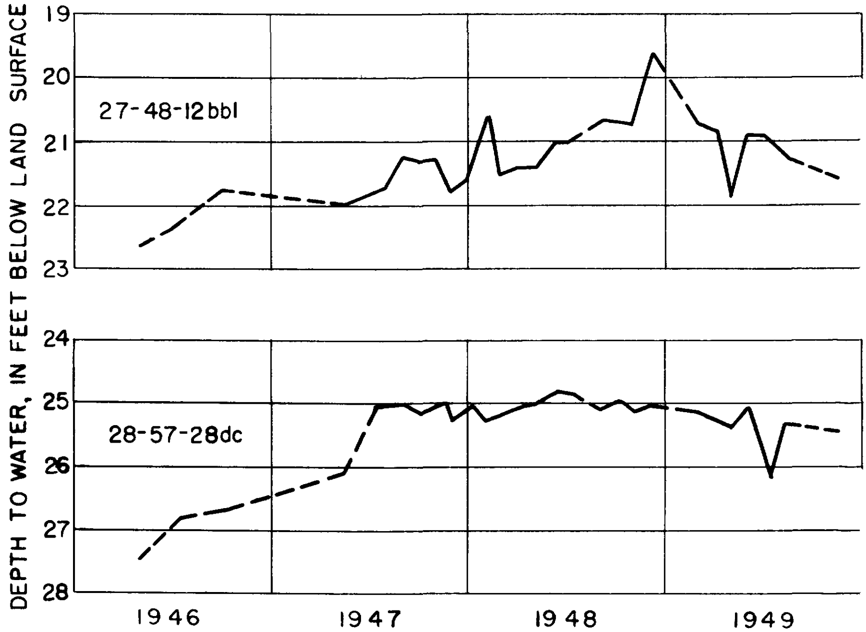

Figure 17. —Hydrographs of wells ending in bedrock, Roosevelt County.

unconsolidated surface deposits. The water level in wells tapping bedrock aquifers respond somewhat more slowly to the alternating dry and wet periods. Although water levels in the wells in non-irrigated areas reached their peaks in May or June of 1947, as a result of increased recharge from the above-normal precipitation in late 1946 and early 1947, the water levels in wells tapping bed-rock did not reach their peaks until the late summer and early fall of 1947. Some of the minor fluctuations of the water level in these wells may be partly due to changes in barometric pressure, inasmuch as the water in the bedrock aquifers is under artesian conditions.

WELL LOGS

Relatively few drillers' logs are available for wells within or near the report area. (See table 8.) Although they show the general character of the materials penetrated, several of the logs are apparently incomplete or inaccurate and the different formations in the area cannot be definitely correlated from them.

WELL INVENTORY

During the course of the investigation, an inventory was made of all wells within the report area, and all information available regarding them was collected. (See table 9.) The locations of the 1,019 wells are shown on plate 1.

SUMMARY AND CONCLUSIONS

The climate of the area described in this report is semiarid. During years of favorable rainfall fair to good yields of small grains can be grown without irrigation, but in other years either poor yields or complete crop failures result except where the crops are irrigated. Continued profits from the raising of livestock are dependent largely on the growing of winter feed and on the growth of grass for summer pasturage on the rangelands. That the population decreased 20 percent between 1930 and 1940 and that it has continued to decline is evidence that farming under such unstable conditions is commonly unprofitable.

Much of the land now irrigated or proposed for irrigation is underlain by alluvium. The alluvial deposits throughout the area consist of fine-grained sediments of low permeability. Some of the alluvium in the bottom lands is so fine grained that waterlogging probably will occur in these areas unless the amount of irrigation water is controlled and adequate drains are constructed. Because the alluvium has a low permeability to a considerable depth, the construction of a drainage system that will adequately discharge the excess ground water will be impossible in many places. The rising trend of the water level in wells in the irrigated lands near Frazer is evidence of the need for drainage facilities.

Glacial drift, the surface of which is characterized by gravelly ridges, underlies other lands proposed for irrigation. The glacial drift contains a large proportion of fine-grained material and generally has a very low permeability. Where the gravelly ridges are closely spaced, the land must be leveled considerably before irrigation can be started. The conditions that cause the swampiness of the undrained depressions will be aggravated seriously by irrigation seepage unless leveling is done in these areas also. Although the gravelly materials in the ridges would be spread over the land surface, it is doubtful that this would materially aid the natural disposal of excess irrigation water. The tightness of the glacial drift into which the drainage ditches must be cut will limit their effectiveness.

Adequate supplies of water for domestic and stock use can be obtained in most parts of the report area. In places where the glacial drift rests directly on the Bearpaw shale, ground-water supplies must be developed from the drift unless deep and expensive wells are drilled.

Large supplies of ground water for municipal and industrial use must be obtained from the alluvium that fills the bedrock valley in which the Missouri River flows. Water-bearing deposits of sand and gravel in the alluvium have been penetrated in drilling municipal and industrial wells at Wolf Point, Poplar, and Blair at depths ranging from 76 to 134 feet. At Wolf Point and Poplar water is obtained from two separate gravel deposits. To determine the thickness and lateral extent of these gravel layers would require considerable test drilling.

The chemical character of most of the ground water considered in this report is the result of many natural phenomena. From the time such water entered the soil as rain or snow melt to the time it was analyzed, changes in composition occurred. These changes were due to solution of such compounds as sulfates and carbonates of calcium, magnesium, and sodium; redeposition and exchange of part of the constituents; and oxidation. Much of the shallow ground water in the alluvium has been concentrated by evaporation and transpiration.

The ground water analyzed in this investigation can be divided into two general groups: water from the bedrock and water from the alluvium. Water from wells 100 to 1,140 feet deep that penetrate the Judith River, Hell Creek, and Fort Union formations is highly mineralized and is generally soft. Water from the Judith River formation differs from the other water obtained from bedrock by having high sodium chloride salinity; water in the Hell Creek and Fort Union formations is excessively alkaline, calcium and bicarbonate being the principal constituents. Boron concentrations of about 5 ppm are characteristic of water from the Judith River formation. Some of the water from this formation is considered unpalatable but satisfactory for other domestic uses and the watering of stock.

Shallow wells in the alluvium provide most of the domestic water supply. This water is highly mineralized and hard and generally has an iron content in excess of 1 ppm. With the exception of samples from a few wells favorably located in the alluvium, most ground water analyzed was not acceptable for irrigation use, because of its high content of dissolved solids and percent sodium.

The analytical results of limited sampling of Missouri River water indicate that mixing of surface flows with the ground water in the alluvium probably would improve, in time, the chemical quality of the shallow ground water. To effect this improvement, however, adequate drainage must be provided to allow flushing of soluble salts from the soil.

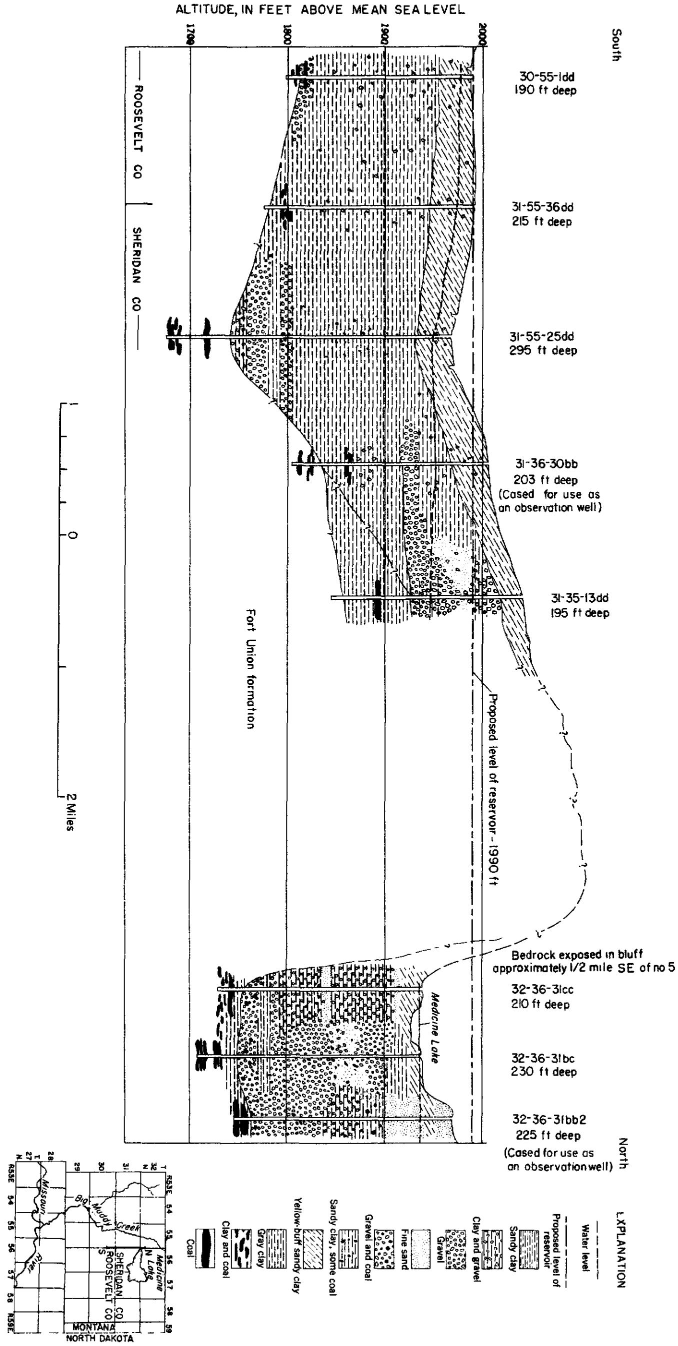

Figure 18. —Cross section through test holes in Roosevelt and Sheridan Counties, Mont.

Table 7.—*Water levels in observation wells*

[In feet below land-surface datum]

Date	Water level	Date	Water level	Date	Water level
Valley County, 26-45-1cb					
May 27, 1947	23.35	Feb. 3, 1948	23.39	May 7, 1948	23.31
Oct. 30	23.48	Mar. 3	24.54	June 7	23.90
Dec. 2	22.90	Apr. 6	23.85	Nov. 1, 1949	20.88
Jan. 5, 1948	23.40				
Valley County, 26-45-6aa					
June 4, 1947	19.95	June 7, 1948	20.29	Mar. 3, 1949	21.44
Oct. 30	20.64	July 6	19.10	Apr. 4	21.39
Dec. 2	22.00	Aug. 3	18.85	May 2	20.26
Jan. 5, 1948	21.85	Sept. 8	18.65	June 1	16.76
Feb. 3	20.35	Oct. 4	17.87	July 12	15.50
Mar. 1	22.14	Nov. 1	19.73	Aug. 17	16.50
Apr. 6	22.50	Dec. 2	20.08	Nov. 4	16.93
May 7	21.60				
Valley County, 27-43-23cb					
May 2, 1946	24.09	Dec. 2, 1947	25.50	Nov. 7, 1948	24.01
July 9	24.13	Jan. 5, 1948	24.10	Dec. 2	24.46
Oct. 8	24.29	Feb. 3	24.38	Mar. 3, 1949	26.13
May 2, 1947	24.02	Mar. 1	24.18	Apr. 5	24.63
June 3	24.04	Apr. 6	24.91	May 2	25.00
July 1	23.75	May 7	24.30	June 1	27.10
Aug. 4	23.83	June 7	24.28	July 12	24.60
Sept. 4	23.86	July 6	24.31	Aug. 17	25.00
Oct. 6	23.92	Oct. 4	24.43	Nov. 14	24.63
30	23.84				
Valley County, 27-45-33dc					
May 28, 1947	9.69	May 7, 1948	10.42	Dec. 2, 1948	8.87
Oct. 24	9.50	June 7	9.85	Apr. 5, 1949	9.99
Dec. 2	9.90	July 6	7.79	May 2	9.90
Jan. 5, 1948	10.55	Aug. 3	7.10	June 1	6.62
Feb. 3	11.25	Sept. 8	6.62	July 12	4.40
Mar. 1	11.65	Oct. 4	7.11	Aug. 17	4.12
Apr. 6	11.95	Nov. 1	8.40	Nov. 2	5.11
Roosevelt County, 27-48-10cb1					
Apr. 27, 1946	[1]20.82	Oct. 7, 1947	15.34	Dec. 6, 1948	16.02
July 9	18.23	27	16.19	Mar. 3, 1949	15.83
May 1, 1947	16.90	Dec. 3	16.50	Apr. 7	16.03
June 2	17.15	Jan. 7, 1948	16.53	May 4	16.18
July 12	16.92	May 7	16.14	June 3	16.35
Aug. 11	16.50	July 8	16.39	Nov. 16	16.32
Sept. 4	16.95	Sept. 8	15.80		
Roosevelt County, 27-48-12bb1					
Apr. 27, 1946	22.65	Dec. 4, 1947	21.80	Nov. 3, 1948	20.74
July 9	22.35	Jan. 7, 1948	21.60	Dec. 6	19.60
Oct. 8	21.75	Feb. 4	20.65	Mar. 3, 1949	20.72
May 1, 1947	22.00	Mar. 3	21.53	Apr. 7	20.83
June 2	21.99	Apr. 9	21.41	May 4	21.90
July 12	21.83	May 7	21.41	June 3	20.90
Aug. 11	21.70	June 15	21.02	July 12	20.95
Sept. 4	21.26	July 8	21.01	Aug. 17	21.23
Oct. 7	21.29	Sept. 8	20.65	Nov. 16	21.60
27	21.30	Oct. 4	20.68		

Table 7.—*Water levels in observation wells*—Continued

Roosevelt County, 27-49-7bb

Date	Water level	Date	Water level	Date	Water level
Oct. 27, 1947	7.45	July 8, 1948	7.20	Apr. 7, 1949	7.35
Jan. 7, 1948	7.38	Sept. 7	7.95	May 4	6.86
Feb. 4	7.20	Oct. 4	7.85	June 3	6.86
Mar. 3	7.87	Nov. 3	7.63	July 12	7.16
Apr. 9	7.20	Dec. 6	7.61	Aug. 17	7.72
May 7	6.58	Mar. 3, 1949	7.73	Nov. 28	8.35
June 15	6.50				

Roosevelt County, 27-51-8ca1

Date	Water level	Date	Water level	Date	Water level
Apr. 26, 1946	13.44	Oct. 27, 1947	7.92	Oct. 4, 1948	7.20
July 9	13.80	Dec. 4	9.90	Nov. 3	7.26
Oct. 8	10.38	Jan. 7, 1948	10.15	Dec. 3	9.87
May 1, 1947	9.42	Feb. 4	10.80	Mar. 4, 1949	9.40
June 2	9.68	Mar. 3	10.29	Apr. 6	10.05
July 12	10.42	Apr. 9	9.98	May 5	9.88
Aug. 11	9.15	May 11	9.36	June 2	11.43
Sept. 5	8.61	June 14	10.85	July 13	11.59
Oct. 7	8.24	July 8	8.97	Aug. 15	9.57

Roosevelt County, 27-52-8ac

Date	Water level	Date	Water level	Date	Water level
Apr. 29, 1946	66.70	Oct. 26, 1947	66.63	Nov. 2, 1948	66.69
July 10	66.64	Jan. 7, 1948	66.65	Dec. 3	66.82
Oct. 7	66.51	Feb. 4	64.07	Mar. 4, 1949	66.82
May 1, 1947	66.76	Mar. 3	66.77	Apr. 6	66.47
29	67.21	Apr. 9	66.80	May 5	66.86
June 2	66.74	May 11	66.65	June 2	66.88
July 12	66.74	June 14	67.00	July 13	66.90
Aug. 4	66.69	July 8	66.70	Aug. 15	67.15
Sept. 5	66.57	Sept. 7	66.76	Oct. 25	67.29
Oct. 7	66.55	Oct. 4	66.78		

Roosevelt County, 27-52-9bb

Date	Water level	Date	Water level	Date	Water level
Apr. 29, 1946	Dry	Dec. 5, 1947	67.00	Oct. 4, 1948	65.87
July 10	Dry	Jan. 7, 1948	65.35	Nov. 2	65.60
Oct. 8	Dry	Feb. 4	63.75	Dec. 3	67.82
May 1, 1947	65.77	Mar. 3	Dry	Mar. 4, 1949	66.63
June 3	65.82	Apr. 9	65.36	Apr. 6	65.05
July 12	66.70	May 11	65.59	May 5	66.39
Aug. 4	65.90	June 14	65.63	June 2	67.71
Sept. 5	65.23	July 8	66.85	July 13	68.00
Oct. 7	64.91	Aug. 4	65.78	Aug. 15	66.85
27	65.99	Sept. 7	65.85	Oct. 28	65.26

Roosevelt County, 27-52-16ba

Date	Water level	Date	Water level	Date	Water level
Apr. 26, 1946	40.51	Dec. 4, 1947	37.50	Oct. 4, 1948	36.35
July 16	39.35	Jan. 7, 1948	37.95	Nov. 2	36.12
May 1, 1947	36.36	Feb. 4	37.32	Dec. 3	37.34
June 2	37.12	Apr. 9	36.88	May 5, 1949	36.71
July 12	37.92	May 11	35.88	June 2	38.23
Aug. 4	37.38	June 14	37.63	July 13	38.38
Sept. 5	37.03	July 8	36.57	Aug. 15	37.53
Oct. 7	36.84	Aug. 4	36.27	Oct. 26	37.10
26	36.69	Sept. 2	36.52		

Roosevelt County, 28-49-33dd

Date	Water level	Date	Water level	Date	Water level
Apr. 27, 1946	36.86	Sept. 4, 1947	34.46	May 7, 1948	33.95
July 9	36.87	Oct. 7	34.56	June 14	37.72
Oct. 8	35.53	27	34.36	July 8	33.85
May 1, 1947	34.22	Dec. 5	34.80	Sept. 8	33.83
June 2	34.45	Jan. 7, 1948	35.15	Oct. 4	33.75
July 12	34.46	Feb. 4	34.95	Nov. 19	34.59
Aug. 11	34.61	Apr. 9	33.90		

Table 7.—*Water levels in observation wells*—Continued

Date	Water level	Date	Water level	Date	Water level
Roosevelt County, 28-49-34dc					
Apr. 27, 1946	28.16	Nov. 23, 1947	16.41	Nov. 3, 1948	17.91
July 9	28.59	Dec. 4	16.50	Dec. 1	17.90
Oct. 8	28.88	Jan. 7, 1948	17.00	6	18.04
May 1, 1947	14.70	Feb. 4	17.16	Mar. 3, 1949	18.50
June 2	14.91	Mar. 3	17.26	Apr. 7	18.55
July 12	14.86	Apr. 9	17.55	May 4	18.62
Sept. 2	15.31	May 7	17.72	June 3	18.60
4	15.00	June 14	17.72	July 12	18.75
Oct. 7	15.78	July 8	17.74	Aug. 17	19.21
22	15.93	Sept. 8	17.60	Nov. 28	19.82
27	16.06	Oct. 4	17.78		
Roosevelt County, 28-50-33dd					
Oct. 27, 1947	19.65	Apr. 9, 1948	18.79	Sept. 8, 1948	18.60
Dec. 5	20.00	May 7	17.66	Oct. 4	18.15
Jan. 7, 1948	20.07	June 14	18.45	Nov. 3	18.40
Feb. 4	20.70	July 8	18.71	Apr. 7, 1949	16.50
Mar. 3	19.78				
Roosevelt County, 28-53-30dd					
Apr. 26, 1946	30.24	Dec. 4, 1947	27.00	Oct. 5, 1948	24.73
July 10	30.61	Jan. 7, 1948	25.85	Nov. 2	25.05
Oct. 7	28.38	Feb. 4	26.88	Dec. 3	26.02
May 1, 1947	26.49	Mar. 4	27.25	Mar. 3, 1949	25.80
June 2	26.24	Apr. 8	26.47	Apr. 6	24.80
July 11	26.93	May 11	25.70	May 5	25.46
Aug. 4	26.67	June 14	26.60	June 2	26.35
Sept. 5	26.09	July 7	26.61	July 13	27.15
Oct. 7	25.81	Aug. 4	24.90	Aug. 15	26.44
26	25.80	Sept. 7	25.13	Oct. 28	25.95
Roosevelt County, 28-57-28dc					
Apr. 25, 1946	27.52	Jan. 7, 1948	25.05	Nov. 2, 1948	25.15
July 10	26.82	Feb. 5	25.26	Dec. 3	25.05
Oct. 7	26.70	Mar. 4	25.20	Mar. 4, 1949	25.15
May 24, 1947	26.09	Apr. 8	25.10	Apr. 6	25.31
July 14	25.07	May 11	25.01	May 5	25.40
Sept. 5	25.02	June 14	24.82	June 2	25.16
Oct. 7	25.18	July 7	24.84	July 13	26.22
25	25.10	Sept. 7	25.10	Aug. 15	25.40
Nov. 24	25.02	Oct. 5	24.96	Nov. 16	25.52
Dec. 4	25.30				

[1] Pump had been operating.

Table 8.—*Logs of wells and test holes*

	Thickness (feet)	Depth (feet)
Richland County, 27-51-35db		
[Pioneer Oil and Gas Co. test hole. Garlough, geologist of oil company that drilled hole, interprets Judith River formation to be from 1,040 to 1,420 feet and the Claggett formation to be from 1,420 to 2,190 feet. The writer considers the Judith River formation to be from 851 to 1,295 feet, the Claggett formation to be from 1,295 to 2,191 feet, the Eagle formation to be from 2,191 to 2,590 feet, and the Colorado shale to be from 2,590 to bottom of hole at 3,085 feet]		
Surface drift	30	30
Shale, gumbo, Bearpaw shale	501	531
Sand rock	4	535
Shale, gumbo	316	851
Shale, sandy, hard lenses	189	1,040
Shale, soft gray	250	1,290
Shale, sandy, show of oil	5	1,295
Shale, soft, gray	85	1,380
Shale, hard, gray	40	1,420
Shale, medium-hard	144	1,564
Shale, soft, very sticky, gray	38	1,602
Shale, medium-hard, gray, very little lime	99	1,701
Very hard, about half lime	6	1,707
Shale, gray, with 1-to 7-inch shell, very hard	89	1,796
Shale, gray	64	1,860
Shale, gray, with 1-to 11-inch shell, very hard	117	1,977
Shale, hard, gray	54	2,031
Shale, very hard	109	2,140
Shale, hard, gray	51	2,191
Lime rock, very hard	2	2,193
Shale, hard, dark, some fossils	262	2,455
Lime rock, very hard	2	2,457
Shale, hard, dark, some fossils	103	2,560
Shale, dark, some lime	8	2,568
Shale, hard, dark	11	2,579
Shale, hard, slightly lighter	11	2,590
Shale, hard, dark, showing oil saturation	215	2,805
Shale, softer, with some sand	65	2,870
Sand or sandy shale, showing oil	20	2,890
Shale, medium-dark	191	3,081
Sand-gas and show of oil, small flow of warm water, first water struck	3	3,084
Shale, dark, diamond bit lost, casing trouble	1	3,085
Roosevelt County, 26-59-3dd		
[Great Northern Railway. Log from Engineer's office of the Great Northern Railway. Site abandoned because water supply was inadequate]		
Clay, yellow	30	30
Mud, soft	6	36
Clay, yellow	14	50
Sandstone	10	60
Clay, gray	15	75
Clay, hard, sandy	5	80
Shale, gray, sandstone lenses	20	100
Shale, gray, layers of quicksand	30	130
Shale, blue, layers of quicksand	25	155
Lignite	5	160
Shale, hard	20	180
Coal	3	183
Shale, hard, gray	12	195
Coal	2	197
Shale, hard, gray	+88	+285

Table 8.—*Logs of wells and test holes*—Continued

	Thickness (feet)	Depth (feet)
Roosevelt County, 27-47-15ab		
[Great Northern Railway. Log from Engineer's office of Great Northern Railway. Well casing is 10 inches in diameter, and screen is set from 42 to 52 feet. Well pumped 180 gallons a minute with 10 feet of drawdown on test]		
Gumbo soil	22	22
Gravel and clay	1	23
Sand	19	42
Sand and gravel	10	52
Clay	5	57
Roosevelt County, 27-47-15ac		
[Great Northern Railway. Log from Engineer's office of Great Northern Railway. Well casing is 12 inches in diameter, and 12 feet of screen is set on bottom. Well pumped 200 gallons a minute with 26 feet of drawdown on test]		
Sand and clay	30	30
Sand and silt	20	50
River silt	31	81
Sand and silt	1	82
Gravel	9	91
Shale	....	....
Roosevelt County, 27-47-15cb1		
[City of Wolf Point. Log from Kelly Concrete Well Co. Pumped 500 gallons a minute with 14 feet drawdown. Well has screen between 40 and 63.5 feet and between 90 and 100.4 feet; well diameter is 18 inches]		
Clay, hard	4	4
Sand, fine	2	6
Clay gumbo, hard	20	26
Sand, fine	4	30
Quicksand	11	41
Sand and gravel	5	46
Gravel, coarse	5	51
Sand, fine	2	53
Clay, blue, and gravel	3	56
Quicksand	9	65
Clay, blue	4	69
Quicksand	8	77
Sand and clay	7	84
Sand, fine	6	90
Sand, coarse, and gravel	10.4	100.4
Shale	....	....
Roosevelt County, 27-47-22ba		
[City of Wolf Point—test hole 1]		
Soil	3	3
Clay	21	24
Clay and some quicksand	10	34
Quicksand and some clay	9	43
Quicksand, dirty, and some gravel	12	55
Quicksand and clay	14	69
Clay	4	73
Quicksand, gravel, and clay	8	81
Quicksand	26	107
Quicksand, gravel, and coal	8	115
Shale bedrock	13	128

Table 8.—*Logs of wells and test holes*—Continued

Roosevelt County, 27-50-12ab

[City of Poplar. Log of 6-inch diameter test hole from city engineer of Poplar. Production well drilled at this location pumped 650 gallons a minute with 11 feet drawdown]

	Thickness (feet)	Depth (feet)
Topsoil	1	1
Gravel, hard, and boulders	2	3
Clay, yellow, and small boulders	24	27
Sand, fine, yellow	1	28
Clay, sandy, yellow, and small boulders	17	45
Clay, blue, sandy, some small boulders	31	76
Gravel, coarse, and coarse sand	7	83
Gravel and sand, very rough	5	88
Clay, soft, blue	6	94
Boulders and fine sand, coarse and rough	5	99
Clay, very hard, blue	6	105

Roosevelt County, 28-53-29cb

[Great Northern Railway. Log from Engineer's office of Great Northern Railway. Hole was drilled to 400 feet but caved back to 260 feet]

	Thickness (feet)	Depth (feet)
Clay, sand, and gravel	10	10
Clay, yellow, and sand	42	52
Sand, fine, and gravel	3	55
Sand, fine, with binder	20	75
Clay, gray	26	101
Sandrock, fine	34	135
Shale, lenses of sandrock	75	210
Shale, gray	190	400

Roosevelt County, 28-55-cd

[Great Northern Railway. Log from Engineer's office of Great Northern Railway. Casing is 10 inches in diameter, and screen is 12 feet long. Well pumped 200 gallons a minute with 3 feet drawdown on test]

	Thickness (feet)	Depth (feet)
Clay, gray	78	78
Quicksand	42	120
Sand and gravel	3	123
Gravel	11	134

Roosevelt County, 30-55-1dd

[U. S. Geological Survey]

	Thickness (feet)	Depth (feet)
Soil	2	2
Clay, sandy, brown, with some gravel and cobbles	29	31
Clay, sandy, gray, with some gravel	15	46
Clay, gray, with some gravel	54	100
Clay, sandy, gray, with some gravel and coal fragments	20	120
Clay, gray, with some gravel	44	164
Gravel and boulders	6	170
Coal	3	173
Gravel and boulders	2	175
Clay, gray, with coal fragments	6	181
Shale, brownish-gray, with coal fragments	4	185
Shale, sandy, light-gray	5	190

Table 8.—*Logs of wells and test holes*—Continued

	Thickness (feet)	Depth (feet)
Sheridan County, 31-55-13dd		
[U. S. Geological Survey]		
Soil	2	2
Clay, sandy, yellow, with scattered pebbles	20	22
Gravel, coarse	14	36
Clay, sandy, yellow	11	47
Gravel	7	54
Clay and fine sand	11	65
Gravel	6	71
Gravel and clay	3	74
Gravel	9	83
Gravel with lenses of yellow clay	30	113
Clay, blue	3	116
Clay, sandy, blue	23	139
Clay, blue, and coal	6	145
Coal	5	150
Clay, gray	20	170
Clay, gray, with some sand and gravel	12	182
Clay, gray	8	190
Shale, brown	5	195
Sheridan County, 31-55-24aa		
[U. S. Geological Survey]		
Soil	2	2
Clay, sandy, yellow	4	6
Clay, sandy, yellow, with scattered pebbles and cobbles	13	19
Gravel, very coarse	18	37
Gravel, medium, and fine sand	8	45
Clay	6	51
Gravel and fine sand	35	86
Clay, sandy, yellow	8	94
Gravel, coarse	1	95
Sheridan County, 31-55-25dd		
[U. S. Geological Survey]		
Soil	1.5	1.5
Clay, yellow, with scattered cobbles	6.5	8
Clay, brown, with gravel stringers	8	16
Clay, yellow, with scattered pebbles	21	37
Clay, gray	30	67
Clay, fine sandy, gray	17	84
Clay, fine sandy, gray, with scattered coal fragments	46	130
Clay, gray	37	167
Gravel with coal fragments	9	176
Clay, very sandy, gray	12	188
Gravel	2	190
Clay, sandy, gray	2	192
Gravel	19	211
Clay, sandy, gray, with scattered pebbles and coal fragments	15	226
Clay, brown	2	228
Clay, sandy, gray	24	252
Coal	4	256
Clay, gray, with coal fragments	8	264
Clay, gray	6	270
Clay, gray, with coal stringers	11	281
Coal and gray clay	13	294
Clay, gray	1	295

Table 8.—*Logs of wells and test holes*—Continued

Sheridan County, 31-55-36dd

[U. S. Geological Survey]

	Thickness (feet)	Depth (feet)
Soil	1.5	1.5
Gypsum	2.5	4
Sand, fine, with clay stringers and scattered cobbles	5	9
Clay, sandy, with scattered pebbles	35	44
Clay, blue, with stringers of brown clay and scattered cobbles	23	67
Clay, blue, with stringers of brown clay and scattered pebbles	43	110
Clay, blue, interbedded with gravel and fine sand	30	140
Clay, blue, interbedded with gravel and fine sand; scattered coal fragments	10	150
Clay, blue, interbedded with gravel; scattered coal fragments	5	155
Gravel and blue clay interbedded; scattered coal fragments	5	160
Clay, blue and brown, interbedded with gravel	7	167
Clay, blue and brown, interbedded with gravel; scattered coal fragments	19	186
Clay, with coal fragments	11	197
Clay, brown and gray; scattered coal fragments	3	200
Clay, brown and gray; scattered pebbles and coal fragments	9	209
Clay, gray, interbedded with brown sandy clay; scattered cobbles	5	214
Sandstone, hard	1	215

Sheridan County, 31-56-28cc

[U. S. Geological Survey]

	Thickness (feet)	Depth (feet)
Soil	2	2
Rocks and gypsum; some gravel	5	7
Clay, brown, with sand stringers and coal fragments	43	50
Clay, brown, with some gravel and coal fragments	9	59
Sand, fine, with clay layers and coal fragments	12	71
Clay, sandy, gray, with gravel stringers	4	75
Clay, sandy, gray, with coal fragments	5	80
Clay, gray	6	86
Coal with clay partings	5	91
Clay, sandy, brown, with some gravel and coal fragments	5	96
Clay, gray	79	175
Clay, sandy, gray, with some gravel and coal fragments	14	189
Gravel and boulders	3	192
Clay, gray, with some gravel and coal fragments	59	251
Gravel and boulders, with some coal fragments	8	259
Clay, gray, with gravel stringers	19	278
Shale, light-gray	9	287
Coal with clay partings	3	290
Shale, gray, with coal and clay stringers	12	302
Shale, gray, with coal stringers	18	320
Shale, gray	7	327
Coal, with partings of gray and brown shale	6	333
Clay, light-gray	7	340
Clay, light-gray, with coal stringers	5.5	345.5
Rock	.5	346
Clay, light-gray and brown, with some gravel and coal fragments	13	359
Clay, light-gray, interbedded with gray clay and coal	8	367
Shale, carbonaceous	4	371
Clay, light-gray	11	382
Clay, light-gray, interbedded with gray clay and coal	13	395
Clay, light-gray, interbedded with brown and gray clay and coal	12	407
Clay, sandy, light-gray	3	410

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Table 6.—*Logs of wells and test holes*—Continued

	Thickness (feet)	Depth (feet)
Sheridan County, 31-56-30bb		
[U. S. Geological Survey]		
Soil	2	2
Clay, sandy, yellow, with scattered cobbles and pebbles	13	15
Clay, sandy, yellow, with scattered pebbles	20	35
Clay, bluish-gray, with scattered pebbles	41	76
Gravel with coal fragments	7	83
Clay, gray	14	97
Clay, gray, with coal fragments	4	101
Clay, gray	23	124
Clay, sandy, gray, with scattered pebbles	18	142
Clay and coal fragments	5	147
Clay, light-gray	9	156
Clay, light-gray, with scattered pebbles	14	170
Clay, light-gray	11	181
Coal, with clay partings	4	185
Clay, brownish-gray	6	191
Coal	3	194
Shale	1	195
Sand, clayey, gray, crossbedded	8	203
Sheridan County, 32-56-31bb		
[U. S. Geological Survey]		
Soil, sandy	2	2
Sand, fine	15	17
Clay, yellow, with scattered pebbles	10	27
Sand, fine, silty, with scattered coal fragments	6	33
Sand, very fine, with scattered coal fragments	11	44
Sand, fine	24	68
Clay, sandy, gray	7	75
Clay, gray, and fine sand; scattered coal fragments	18	93
Clay, gray, with scattered pebbles	11	104
Clay, gray, with scattered coal fragments	30	134
Gravel	22	156
Gravel and coal fragments	4	160
Gravel	5	165
Gravel, fine, and coal fragments	33	198
Gravel and coal fragments	9	207
Coal	8	215
Clay, gray	3	218
Coal	7	225
Sheridan County, 32-56-31bc		
[U. S. Geological Survey]		
Soil	1	1
Clay, brown, with scattered pebbles	13	14
Clay, blue	19	33
Clay, blue, with stringers of sand and gravel	4	37
Gravel, fine, with clay stringers	3	40
Gravel	15	55
Gravel and sand	10	65
Sand, fine, with scattered pebbles and coal fragments	5	70
Sand, fine, with coal fragments	5	75
Sand, fine, with scattered pebbles and coal fragments	15	90
Sand, with scattered pebbles and coal fragments	10	100
Gravel, coarse, with coal fragments	20	120
Gravel and sand, with clay stringers and coal fragments	20	140
Gravel, coarse, with coal fragments	16	156
Clay, gray, with gravel stringers and coal fragments	14	170
Gravel and coal fragments	10	180

Table 8.—*Logs of wells and test holes*—Continued

	Thickness (feet)	Depth (feet)
Sheridan County, 32-56-31bc—Continued		
Gravel, coarse, with boulders and coal fragments	9.5	189.5
Shale, brown	2.5	192
Clay, gray and light-gray	13	205
Coal, with partings of gray clay	9	214
Clay, gray, with coal stringers	6	220
Coal, interbedded with brown sandy clay	9	229
Clay, sandy, brown	1	230

Sheridan County, 42-56-31cc

[U. S. Geological Survey]

Soil	4	4
Clay, yellow	6	10
Clay, sandy, yellow, with scattered pebbles	14	24
Sand, fine	6	30
Sand, fine, with clay stringers and coal fragments	24	54
Clay, sandy, gray and brown, with scattered pebbles and coal fragments	12	66
Clay, gray, with scattered pebbles	6	72
Clay, gray, with sand stringers	8	80
Clay, gray, with scattered pebbles	14	94
Sand, fine	6	100
Sand, fine, with stringers of gray sandy clay	15	115
Clay, sandy, gray, with stringers of fine sand	5	120
Clay, gray, with scattered pebbles	7	127
Clay, sandy, gray, with stringers of fine sand, and scattered pebbles and coal fragments	11	138
Clay, sandy, gray, with scattered pebbles and coal fragments	13	151
Gravel and boulders	2	153
Clay, sandy, gray	3	156
Clay, sandy, gray, with stringers of gravel	5	161
Gravel and boulders, with stringers of gray sandy clay and coal fragments	9	170
Boulders and gravel	14	184
Limestone, gray, hard	2	186
Limestone, gray, hard, interbedded with gray clay	4	190
Clay, gray, interbedded with thin limestone layers	4	194
Coal	4	198
Coal, with partings of gray sandy clay	12	210

Valley County, 27-44-28dd1

[Great Northern Railway. Log from Engineer's office of Great Northern Railway. Test hole abandoned]

Clay and sand	5	5
Gravel	21	26
Clay, blue	69	95

Valley County, 27-44-28dd2

[Great Northern Railway. Log from Engineer's office of Great Northern Railway. Test hole abandoned]

Clay and sand	10	10
Gravel	19	29
Clay, blue	18	47
Shale	53	100

Table 8.—*Logs of wells and test holes*—Continued

	Thickness (feet)	Depth (feet)
Valley County, 27-44-28dd3		
[Great Northern Railway. Log from Engineer's office of Great Northern Railway. Test hole abandoned]		
Clay, sandy	6	6
Gravel	17	23
Clay, blue	20	43
Shale	47	100
Valley County, 28-42-31dd		
[Great Northern Railway. Log from Engineer's office of Great Northern Railway. Water used for stock yards at Nashua]		
Silt and clay	33	33
Clay, some gravel	8	41
Sand, fine, and gravel	2	43
Clay, blue	80	123

RECORD OF WELLS

Table 9.—*Record*

Well number: See explanation of well-numbering system in text. Type of well: B, bored; Dn, in feet below land surface; measured depths are shown in feet and tenths below measuring bearing material: Cl, clay; G, gravel; K, undifferentiated Cretaceous sediments; Kb, Bearpaw Quaternary deposits; S, sand; Sh, shale; Ss, sandstone; X, log of well available. Method of pitcher pump; Pl, plunger; Z, removed or destroyed since well was first inventoried. Type of water: C, cooling; D, domestic; I, industrial; N, none; O, observation; PS, public supply; pump; L, land surface; Tca, top of casing; Tco, top of cover; Tcu, top of curb; Tp, top of below measuring point; Reported depths are given in feet; measured depths are given in feet,

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
		McCone County				
26-43- 8cb	Nickels Bros	Dr	800	5	P	Kjr
9bd	Terry and Rathert	Du, Dn	7.5	1¼	P	....
9ca	........do	Du, Dn	12.0	1¼	P	....
10ba	........do	Du, Dn	20	1¼	P	....
10bb	........do	Du, Dn	20	1¼	P	....
10cc	........do	Du, Dn	30	1¼	P	....
24aa	U. S. Geol. Survey	Dn	27.0	1¼	P	X
24dd	....	Du, Dr	....	4	P	....
26-44- 5cc	U. S. Geol. Survey	Dn	19.5	¾	P	S, X
5dd	........do	Dn	19.2	¾	P	S, X
7aa	........do	Dn	19.5	1¼	P	S, X
7ad1	........do	Dn	19.4	¾	P	S, X
7ad2	........do	Du	18.5	¾	P	S, X
7da1	Roy Huber	Du, Dn	20	....	P	....
7da2	........do	Dn	....	1¼	P	....
7dd	U. S. Geol. Survey	Dn	18.8	¾	P	S, X
8aa	........do	Dn	19.2	¾	P	S, X
8ab	........do	Dn	26.7	¾	P	S, X
8ac1	........do	Dn	19.5	¾	P	S, X
8ac2	King Walton	Du, Dn	26	1½	P	....
8ba1	U. S. Geol. Survey	Dn	19.5	¾	P	S, X
8ba2	L. McNabb	....	....	1½	P	....
8cb	........do	Dn	....	1¼	P	....
8dd	John Walton	Du, Dn	14	1¼	P	....
9bc	U. S. Geol. Survey	Dn	23.0	1¼	P	S, X
9cb	........do	Dn	19.3	¾	P	S, X
9cc	........do	Dn	20.0	¾	P	S, X
11ad1	........do	Dn	17.5	1¼	P	S, X
11ad2	........do	Dn	27.0	....	N	X
11bb	........do	Dn	23.5	1¼	P	S, X
11cd	........do	Dn	20.0	1¼	P	S, X
12bc	Rathert and Schreiber	....	....	....	....	....
12cc	U. S. Geol. Survey	Dn	28.0	1¼	P	S, X
13aa	........do	Dn	24.0	1¼	P	S, X
13ba	........do	Dn	30.0	....	N	X
13bb	........do	Dn	....	¾	P	S, X
13ca	........do	Dn	24.5	¾	P	S, X
13da	........do	Dn	23.5	¾	P	S, X
13dd	........do	Dn	24.0	1¼	P	S, X
14aa1	Rathert and Schreiber	Dr	936	6, 3½	P	Kjr
14aa2	........do	Dn	35	1¼	P	S
14cc	U. S. Geol. Survey	Dn	21.0	1¼	P	S, X
14da1	........do	Dn	30.0	¾	P	S, X
14da2	........do	Dn	28.0	¾	P	S, X
16bc	........do	Dn	19.2	¾	P	S, X

of wells

driven; Dr, drilled; Du, dug; J, jetted; S, spring. Depth of well: Reported depths are shown point. Type of casing: C, concrete; N, none; P, pipe; T, tile; W, wood. Character of water-shale; Khc, Hell Creek formation; Kjr, Judith River formation; L, lignite; Q, undifferentiated lift: C, centrifugal; Cy, cylinder; F, natural flow (gallons per minute); J, jet; N, none; P, power; D, diesel; E, electric; G, gasoline; H, hand-operated; T, turbine; W, wind. Use of RR, railroad; S, stock. Measuring point: Bp, base of pump; Hca, hole in casing; Hp, hole in pipe. Altitude above mean sea level: Altitudes obtained by spirit level. Depth to water level tenths, and hundredths.

Method of lift and type of power	Use of water	Measuring point			Depth to water level below measuring point	Date of measurement
		Description	Height above land surface (feet)	Altitude above mean sea level (feet)		
			McCone County			
F(40)	S	......	......	......	......	......
Cy, G	S	Tco	0.5	......	7.2	11-22-49
N	N	Tca	2.7	......	7.80	11-22-49
Cy, G	S	......	......	......	......	......
Cy, H	D	......	......	......	......	......
Cy, G	S	......	......	......	......	......
N	N	Tca	2.5	......	24.32	9-22-49
Cy	N	Tco	1.1	......	19.20	11-22-49
N	N	Tca	1.5	2,017.6	14.09	10-28-49
N	N	Tca	4.9	2,020.9	16.85	10-28-49
N	N	Tca	4.9	2,018.9	14.69	10-28-49
N	N	Tca	1.6	2,019.1	12.83	10-28-49
N	N	Tca	2.5	2,019.0	13.24	10-28-49
Cy, H	N	......	......	2,016.4	......	......
P, H	D	......	......	2,016.0	......	......
N	N	Tca	2.2	2,017.6	11.89	10-28-49
N	N	Tca	1.8	2,016.1	11.87	10-28-49
N	N	Tca	1.3	2,019.7	18.23	10-28-49
N	N	Tca	1.8	2,017.9	14.91	10-28-49
Cy, G	S	......	......	......	......	......
N	N	Tca	1.5	2,021.0	17.97	10-28-49
Cy	N	......	......	......	......	......
P, H	S	......	......	2,013.6	......	......
Cy, G	D, S	......	......	2,014.5	......	......
N	N	Tca	2.4	2,016.4	15.80	10-28-49
N	N	Tca	1.7	2,014.9	13.86	10-28-49
N	N	Tca	1.0	2,013.8	11.46	10-28-49
N	N	Tca	2.2	2,006.8	9.96	10-28-49
......	......	......	......	......	......	......
N	N	Tca	2.8	......	13.27	11- 9-49
N	N	Tca	2.5	2,014.3	13.62	10-28-49
......	......	......	......	......	......	......
N	N	Tca	2.8	2,015.8	18.39	10-28-49
N	N	Tca	3.5	2,016.7	......	......
......	......	......	......	......	......	......
N	N	Tca	2.2	2,017.4	19.32	10-28-49
N	N	Tca	2.0	2,017.0	19.85	10-28-49
N	N	Tca	.4	2,013.6	16.87	10-28-49
N	N	Tca	2.5	2,014.7	18.17	10-28-49
F(1.5)	S	......	......	2,023.0	......	1947
Cy, H	D	......	......	2,018	......	......
N	N	Tca	......	......	......	......
N	N	Tca	2.1	2,017.1	18.93	10-28-49
N	N	Tca	1.4	2,017.4	19.01	10-28-49
N	N	Tca	1.8	2,014.2	11.63	10-28-49

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
		McCone	County—Continued			
26-44-16ca	U. S. Geol. Survey	Dn	18.3	¾	P	S, X
16cc1	do	Dn	27.0	1¼	P	S, X
16cc2	do	Dn	19.2	¾	P	S, X
17aa1	do	Dn	21.0	1¼	P	S, X
17aa2	do	Dn	18.6	¾	P	S, X
17aa3	do	Dn	20.0	¾	P	S, X
17ab	do	Dn	19.3	¾	P	S, X
17bd	A. R. Mielke	Du, Dn	20	....	P	S
17cb	Mrs. J. M. Walton	Dn	19	1½	P	S
17cc	U. S. Geol. Survey	Dn	17.0	1¼	P	S, X
17cd	do	Dn	18.9	¾	P	S, X
17db	do	Dn	20.2	¾	P	S, X
17dc1	W. A. Twitchell	Dn	18	1¼	P	....
17dc2	U. S. Geol. Survey	Dn	19.8	¾	P	S, X
18aa	do	Dn	22.0	1¼	P	S, X
18ad1	do	Dn	18.9	¾	P	S, X
18ad2	do	Dn	18.8	¾	P	S, X
18cd	do	Dn	32.0	¾	P	S, X
18da	do	Dn	20.8	¾	P	S, X
18dc	George Bartch	Dn	30	1¼	P	S, X
19aa	U. S. Geol. Survey	Dn	18.5	¾	P	S, X
19ab	George Bartch	Dn	30	1¼	P	S
19bd	School	Dn	29.0	....	N	Kb
20aa	U. S. Geol. Survey	Dn	19.4	¾	P	S, X
20ad1	W. A. Twitchell	Du	20	1½	P	....
20ad2	do	Dn	19.3	¾	P	S, X
20ad3	U. S. Geol. Survey	Dn,	19.5	¾	P	S, X
20ba	Oscar Gribble	Du, Dn	12	1¼	P	....
20da	U. S. Geol. Survey	Dn	20.0	....	N	Kb, X
21aa	do	Dn	20.5	1¼	P	S, X
21ab	do	Dn	26.0	¾	P	S, X
23aa	do	Dn	30.0	1¼	P	S, X
26-45-17bc	L. Blevins	Dn	25	1¼	P	....
17cb	do	Dr	17.9	5	P	Q
17cd	do	B	26.5	18	W	....
18aa	U. S. Geol. Survey	Dn	21.0	1¼	P	X
18ac1	Rathert and Schreiber	Du	14.5	6	P	....
18ac2	do	Du, Dn	22	1¼	P	....
18ac3	do	Dn	....	1¼	P	....
18ad	U. S. Geol. Survey	Dn	24.0	1¼	P	X
26-46-1da1	Elmer Pipal	....	29	1¼	P	....
1da2	do	Dn	24	....	P	....
9cc	J. E. Terry	Dr	96.2	8	P	Q
10ba	Ray and Roy Kusker	Dn	30	1¼	P	Q
10bb	Arthur Turner	Dn	30	1¼	P	Q
10ca	Rupert Durham	Dr	79.2	4	P	....
12bb	Frank Kusker	Dn	26	1¼	P	....
13aa	Kusker School	Dr	79.5	4	P	....
14aa1	Myra Kusker	B	20	8	P	....
14aa2	do	Du	10.5	48	W	....

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
McCone County—Continued						
N	N	Tca	2.7	2,013.4	11.69	10-28-49
N	N	Tca	1.8	2,013.8	12.16	10-28-49
N	N	Tca	1.8	2,013.8	12.20	10-28-49
N	N	Tca	2.2	2,016.4	13.89	10-28-49
N	N	Tca	2.3	2,017.1	14.50	10-28-49
N	N	Tca	1.0	2,013.1	11.34	10-28-49
N	N	Tca	1.7	2,017.7	15.48	10-28-49
Cy, H	S	...	...	2,013	...	...
Cy, W	D, S	...	...	2,015.9	...	...
N	N	Tca	.4	2,015.9	11.22	10-28-49
N	N	Tca	2.1	2,016.3	12.78	10-28-49
N	N	Tca	.8	2,015.2	12.34	10-28-49
Cy, H	S	...	...	2,013	14	...
N	N	Tca	1.2	2,015.1	12.00	10-28-49
N	N	Tca	2.0	2,017.5	12.56	10-28-49
N	N	Tca	2.1	2,017.1	11.91	10-28-49
N	N	Tca	2.2	2,016.2	11.70	10-28-49
N	N	Tca	2.4	2,023.1	16.03	10-28-49
N	N	Tca	2.3	2,017.5	12.98	10-28-49
Cy, H	D, S	...	...	2,018	...	...
N	N	Tca	2.5	2,018.7	15.18	10-28-49
Cy, G	S	...	...	2,018	...	...
...	...	...	...	2,027	Dry	8-30-49
N	N	Tca	1.6	2,014.2	11.34	10-28-49
Cy, G	S	Tco	2.0	2,018.0	16.78	8-13-49
N	N	Tca	1.7	2,013.5	11.48	10-28-49
N	N	Tca	1.0	2,015.3	12.53	10-28-49
Cy, G	S	...	...	2,014.1	...	...
...	...	L	...	2,015.6	Dry	10-13-49
N	N	Tca	2.7	2,021.7	18.88	10-28-49
N	N	Tca	2.0	2,023.7	21.61	10-28-49
N	N	Tca	3.1	2,025.1	26.69	10-28-49
Cy, G, H	S	...	...	...	20	...
N	N	Tca	1.4	...	17.70	11-22-49
N	N	Tcu	.3	...	22.45	11-22-49
N	N	Tca	1.6	2,007.0	11.75	10-26-49
N	N	Tcu	.5	2,006.4	10.09	9-29-49
Cy, W, G	S	...	...	2,005.9	...	...
N	N	...	...	...	...	...
N	N	Tca	11.5	...	12.72	10-26-49
Cy, H	D	L	...	...	21	...
Cy, G	D, S	L	...	...	16	...
Cy, W, H	D, S	Tco	1.2	...	54.61	11- 8-49
Cy, W, H	S	L	...	...	25	...
Cy, G, H	S	L	...	...	24	...
Cy, W, H	D, S	Tca	.5	...	33.50	11- 8-49
Cy, W, H	S	L	...	...	18	11- 9-49
Cy, H	N	Tca	.2	...	40.68	4-30-47
					42.22	11- 8-49
Cy, H	S	L	...	...	16	...
...	...	...	...	2,039.2	5.71	11- 9-49

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
McCone County—Continued						
26-46-14ba1	Ray and Roy Kusker........	R	....	1	W	....
14ba2	........do........................	Dr	1,100	....	....	....
14cb	........do........................	....	....	....	....	K
18cb	B. S. Wilson	Du	47	36	W	....
26-47- 6cb	Joseph Pipal.................	B	52	6	P	....
9aa	George Meister	Dr	72.5	6	P	....
10ba	T. S. Simerson..............	Dr	78	6	P	Ss
10bc	........do........................	B	45.5	8	P	....
27-47-23dd	....	Dn	....	1¼	P	....
24ca	....	Dn	....	1¼	P	....
24cc	....	Dn	....	1¼	P	....
25ad	Elizabeth Randall...........	Dn	....	1¼	P	....
25ba	Robert Balder...............	Dn	....	1¼	P	....
25dd1	H. J. Hansen	Dn	20	1¼	P	Q
25dd2	........do........................	Dn	20	1¼	P	....
26dc	J. Sellrude....................	Dn	31	1¼	P	....
27ac	Joseph Maier.................	Dn	23	....	....	....
27db	William Maier...............	Dn	....	1¼	P	....
34ca	F. Reed........................	Dn	17.4	1¼	P	....
34db	Peter Berg....................	Dn	31	2	P	....
34dc	E. J. Byxbe...................	Dn	20	1¼	P	....
35ab	J. Sellrude....................	Dn	32	1¼	P	....
35ba	........do........................	Dn	21	1¼	P	....
35db	Ralph Howe	Dn	32	1¼	P	....
36ad	M. Purdy......................	Dn	29	1¼	P	....
27-48-14dd	Floyd DeWitt.................	Dn	30	1¼	P	....
15ca	George Barber...............	Dn	25	1¼	P	....
19db1	E. A. Kolden..................	Dn	40	1¼	P	....
19db2	........do........................	Dn	37	1¼	P	....
20cc	L. Applegreen	Dn	35	1¼	P	....
22bb	J. B. Sweitzer................	Dn	35	1¼	P	....
22bc	........do........................	Dn	25	1¼	P	....
23cd	George Hartig................	Dn	35	1¼	P	....
27ad	L. Applegreen	Dr	120	6	P	....
27ba	R. C. Scoville...............	Du	14.1	36	W	....
28aa	....	Du	27.6	36	C	....
28bd	Harry Night Club............	Dr	115.0	6	P	....
30bc	Henry Urban..................	Dn	25	1¼	P	....
30cc	School.........................	Du, Dn	20	1½	P	....
30db	Andrew Wigesmana.........	Dn	28	1¼	P	....
31ac	John Balder...................	Dr	92.6	6	P	....
31bc	Chris Pederson..............	Dn	....	1¼	P	....
32ba	L. Applegreen...............	Du	26.2	12	C	....
27-50-20db	Charles Nelson..............	Dr	38.5	6	P	....
22ac	John Rome....................	Dn	28	1¼	P	....
22bc	John Hentzy..................	Dr	55	6	P	....
23cd	Daniel Brink..................	Dr	63.8	5	P	Q, G
25dc	R. G. Miller...................	Dr	58	4	P	G
26ba	T. Rounds.....................	Du, Dn	....	1¼	P	....
27ab1	C. L. Smith...................	Dr	75	5	P	....

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
McCone County—Continued						
Cy, W, H	S	L	...	...	30	...
...	...	L	...	...	Dry	1924
F(?)	...	...	...	...	...	...
Cy, H	D, S	L	...	...	46	...
Cy, W, H	D, S	...	...	...	22	...
Cy, H	D, S	Tco	1.0	...	61.15	11- 9-49
N	N	L	...	...	59	...
N	N	Tco	.3	...	Dry	11- 9-49
Cy, H	...	...	...	...	...	...
Cy, H	S	...	...	...	...	...
Cy, H	N	...	...	...	...	...
Cy, H	N	Tca	2.2	...	9.00	5-29-47
Cy, W, H	D, S	...	...	...	...	...
Cy, W	D, S	L	...	...	10	...
Cy, H	S	...	...	...	...	...
Cy, W	D, S	L	...	...	27	...
P, H	D, S	...	...	...	17	...
P, H	D, S	...	...	...	...	...
Cy, W	D, S	L	...	...	9.40	11- 9-49
Cy, G	...	L	...	...	9	...
P, H	D, S	L	...	...	11	...
Cy, G	S	L	...	...	28	...
N	N	Tca	.6	1,983.7	10.07	4-29-47
Cy, G	D, S	L	...	...	28	...
Cy, H	D, S	L	...	...	22	...
Cy, G, H	D, S	L	...	...	18	...
Cy, H	D, S	L	...	...	20	...
Cy, G, H	S	...	...	...	14	...
P, H	D	L	...	...	14	...
Cy, G, H	D, S	L	...	...	15	...
Cy, W	S	L	...	...	14	...
Cy, E	D, S	L	...	...	14	...
Cy, H	D, S	L	...	...	30	...
Cy, W	...	...	...	...	...	...
Cy, H	D, S	Tco	2.0	...	13.77	5- 7-47
					13.6	11-11-49
					13.53	11-29-49
...	...	L	...	...	25.4	4-27-49
					24.54	11-11-49
J, H	D	L	...	...	70	...
Cy, W, G	D, S	...	...	...	20	...
Cy, H	D	L	...	...	14	...
Cy, H, G	D, S	L	...	...	14	...
Cy, W. H	D, S	Tca	.5	...	61.22	11-10-49
Cy, W	N	...	...	...	...	...
Cy, H	S	Tca	2.0	...	21.20	11-10-49
Cy, H	N	Tca	1.1	...	12.55	11-11-49
Cy, H, G	D, S	L	...	...	16	11-14-49
Cy, E	...	Tca	1.0	...	15.21	11-11-49
Cy, H	D, S	Tca	2.5	...	16.32	11-14-49
Cy, E	D, S	L	...	...	21	...
Cy, H	D, S	Tco	.2	...	13.47	11-14-49
Cy, E	S	L	...	...	14	...

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
			McCone County—Continued			
27-50-27ab2	C. L. Smith.................	Dr	16	$1\frac{1}{4}$	P	....
27ba	T. Rounds...................	Dr	26.7	6	P	....
35ba	....	Dr	36.7	6	P	....
			Richland County			
26-51-13aa1	Henry Hines.................	Du	21.2	29	W	....
13aa2	.......do.......................	Du	9.1	$1\frac{1}{4}$	P	....
26-52- 5ba	....	Dr	50.4	6, $1\frac{1}{4}$	P	....
5ca	Harry Hagen.................	Dr	62	6, $1\frac{1}{4}$	P	....
26-57- 1bb	Norman Atwood.............	Dr	104	4	P	....
1dd	G. S. Martin................	Dr	440	2	P	....
26-58- 1da	Clarence Herriot............	Dr	200	4	P	....
2cb	James Bawden...............	Dr	680	4	P	....
6cc	Raymond Trudell...........	Dr	410	4	P	....
26-59- 6bc	Karsten Borg................	B	33.2	30	P	....
6dd	Ingolf Jacobson.............	Dn	22	8	P	....
8ac	Bruce Burgess...............	Du	30	48	W	....
8ca	.......do.......................	Dr	234	4	P	....
9ca	Ben Doyle, Jr................	Dn	30	$1\frac{1}{4}$	P	....
17aa	James Berry..................	Du	24.2	48	W	....
22ad	E. Anderson..................	Dr	850	....	....	....
27-51-19ad	....	Du	11.1	48	W	....
25dd	J. Wilkeson..................	Dr	95	$4\frac{1}{2}$	P	....
26dd	Frank Colgan................	Dr	35.7	6	P	....
27bc	Jacob Pischke................	Dr	60	$4\frac{1}{2}$, $1\frac{1}{4}$	P	....
27cb	Joseph Marottek............	Du	28.1	30	W	Q
28ca	....	Dr	17.1	$4\frac{1}{2}$	P	....
28db1	Anton Gluba.................	Dr	47.3	8, $1\frac{1}{4}$	P	Q
28db2	.......do.......................	B	20.4	24	W	....
28db3	.......do.......................	B	25.9	12	W	....
29ab	G. H. Colgan................	Dr	74	$4\frac{1}{2}$	P	....
29bb	Henry Etzel..................	Dr	60.0	$5\frac{1}{2}$	P	G
29bc	....	Du	26.1	30	W	....
29bd	Frank Colgan................	Dr	30.2	4	P	....
30ac	A. E. Johnson...............	Du, Dn	27.7	48, $1\frac{1}{4}$	P	....
30ad1	C. B. Travis.................	Du, Dr	24.9	48, $1\frac{1}{4}$	P	....
30ad2	.......do.......................	B	26.7	8	P	Q
32ba	G. H. Colgan................	Dr	100+	5	P	....
35dd	....	Dr	55.3	$4\frac{1}{2}$	P	....
27-52-28ab1	Evam Hines..................	Dn	16.9	$1\frac{1}{4}$	P	Q
28ab2	.......do.......................	Dn	27	$1\frac{1}{4}$	P	Q
28ab3	.......do.......................	Dn	27	$1\frac{1}{4}$	P	Q
28ba	Roy Paulston................	Dn	17.3	$1\frac{1}{4}$	P	Q
31ca	Charles Cooper.............	Dr	59.8	$4\frac{1}{2}$	P	....

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
McCone County—Continued						
P, H	D	......	......	......	10	......
Cy, N	N	Tco	0.2	......	15.0	11-11-49
N	N	Tca	1.0	......	29.14	11-14-49
Richland County						
C, E	S	Tco	2.6	......	11.25	11- 2-49
Cy, E	S	Tco	.6	......	7.42	11- 3-49
Cy	N	Tca	.8	......	46.78	11- 3-49
Cy, W, G	D, S	L	......	......	30-40	......
Cy, W	D, S	L	......	......	39	......
F	D, S	......	......	......	......	......
Cy, E	S	......	......	......	......	......
F(3)	D, S	......	......	......	......	......
F(2)	D, S	L	......	......	......	......
Cy, W	D, S	Tca	.4	......	23.12	11-17-49
Cy, G	D, S	L	......	......	19	......
Z	......	Tcu	.6	......	9.8	7- 2-47
Cy, G	D, S	L	......	......	60	......
Cy, H	S	L	......	......	16	......
Cy, W, H	S	Tco	.4	......	16.36	11-17-49
F(1.5)	S	......	......	......	......	......
N	N	Tco	.2	......	10.47	11- 1-49
Cy, W	D, S	L	......	......	30	......
N	N	Tca	.3	......	19.19	11- 2-49
Cy, G	S	Tca	.5	......	23.52	11- 2-49
Cy, G	S	Tco	1.5	1,960.2	24.26	5- 9-47
					26.31	11- 2-49
N	N	......	......	......	Dry	11- 2-49
Cy, H, G	S	Tco	1.2	......	25.79	5- 9-47
					24.63	11- 1-49
Cy, H	N	Tco	2.0	......	16.05	5- 9-47
					13.46	11- 2-49
N	N	Tcu	1.4	......	18.05	5- 9-47
					16.32	11- 2-49
Cy, H	D, S	L	......	......	20	......
Cy, W	D, S	Tca	1.4	......	17.83	11- 1-49
N	N	Tco	.2	1,962.8	22.15	5- 9-47
					21.13	11- 1-49
Cy, H	N	Tca	.3	......	17.85	11- 1-49
Cy, E	D, S	Tco	1.6	1,957.5	17.84	5- 9-47
					15.75	11- 1-49
Cy, E	D, S, I	Tca	.7	1,955.7	15.24	5- 8-47
					14.48	11- 1-49
Cy, H	D, S	Tca	2.7	1,959.9	19.34	5- 8-47
					16.88	11- 1-49
N	N	Tca	.3	1,992.3	51.34	5- 9-47
					50.23	11- 1-49
Cy, G	D, S	Tca	1.2	......	38.48	11- 2-49
Cy, W, G	S	Tco	1.1	......	12.39	11- 4-49
Cy, H	D, S	L	......	......	14	......
Cy, H	D	L	......	......	14	
Cy, W, G	S	Tca	.4	......	13.94	11- 4-49
Cy, H	N	Tca	.7	......	35.93	11- 3-49

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
			Richland County—Continued			
27-52-32ad	R. H. Renz	Dr	100	3, 2	P	...
32cc	Lincoln School, district 17	Dr	42.2	6	P	...
27-53- 1cc	Harry Foss	B	30.9	18	W	...
1cd	Elmer Foss	B	35.2	24	W	...
3ba	Oscar Labidee	Dr	103	4	P	...
4aa	Paul Patch	Dr	102	4	P	...
4bb1	Ramon Ruffatto	Dn	63.9	6	P	S
4bb2	do	Dr	57.6	6	P	...
4bb3	do	Dr	79	4	P	...
7aa	Peter Bertino	Du	33.7	60	N	...
9dd1	William Ralston	Du	...	48	W	...
9dd2	do	B	31.0	24	P	G
10bc1	P. P. Ruffatto	Du	17.1	48	W	Q
10bc2	do	Dr	100	...	...	...
10cc	William Ralston	Du	14.4	48	W	S
12ab	Elmer Foss	Dr	71.3	4	P	...
27-54- 7ba1	do	Dr	38.4	4	P	...
7ba2	do	Dr	684	4	P	Khc
7bb	Harry Foss	Du	28.2	48	N	...
7bd	Elmer Foss	Dr	92	4	P	Khc
8bd	do	Dr	98	6	P	Khc
8cc1	...	Du	15.2	24	C	...
8cc2	Elmer Foss	Du	15.3	36	N	...
9bb	...	Dr	45.3	4	P	...
9bc	...	Du	17.1	48	N	...
12cc	Donald Birch	Dr	129	4	P	...
27-55- 3db1	...	Dn	...	1¼	P	...
3db2	...	Dn	...	6	P	...
9ad	Clara Johnson	Dr	84	5	P	...
10bb1	N. Anderson	Dr	119	5	P	...
10bb2	do	Du	21.1	...	N	...
10bc	Peter Johnson	B	20.5	24	W	...
11aa	Benjamin Antonson	Dr	33	5	P	...
12bb	George Baker	Du	12.3	24	W	...
12bc	M. Antonson	Dr	48	5	P	...
12bd	...	...	500	2½	P	...
15ac	C. S. Gould	Dr	550	2	P	...
15bb	Peter Johnson	Dr	63	4	P	...
15dc	...	B	27.6	18	W	...
17bb	Peter Johnson	Dr	25.0	4	P	...
21ba1	O. Madsen	Du	8	36	W	...
21ba2	do	Du	8	24	P	...
23bb1	Stanley Patch	Du	17.0	48	W	...
23bb2	do	Dr	25	4	P	...
23dd	C. S. Gould	Dr	563	3¼	P	...

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
Richland County—Continued						
Cy, H, W	S	L	...	...	40	...
Cy, H	N	Tca	6.0	...	45.38	11- 4-49
N	N	Tca	1.2	...	17.82	11- 9-49
Cy, H	D, S	Tca	.7	...	27.45	7- 3-47
					26.87	11- 9-49
Cy, G	S	Tca	.2	...	36.78	11- 7-49
Cy, W, G	D, S	Tca	.2	...	36.92	11- 7-49
Cy, W, H	D	Tca	1.6	...	34.4	11- 8-49
Cy, W, G	S	Tca	.3	1,929.6	16.92	7- 7-47
					17.38	11- 8-49
J, E	D	L	...	...	30	...
Cy, H	S	Tco	.5	...	25.8	7- 7-47
					24.83	11- 9-49
Cy, H	D, S	Tca	.8	...	8.14	7- 7-47
N	N	Tco	3.6	...	20.0	11- 9-49
Cy, W	S	Tco	2.0	...	11.37	6-23-47
					14.32	11- 8-49
Cy, G	...	L	...	...	46	...
N	N	Tcu	.8	...	9.69	7- 7-47
					11.35	11- 9-49
N	N	Tca	1.3	...	46.42	11- 9-49
N	N	Tca	1.2	...	15.13	11- 9-49
F (8)	S	...	...	1,942	...	...
N	N	Tco	.3	...	23.53	11- 9-49
Cy, G	D, S	L	...	...	60	...
Cy, H	S	L	...	...	58	...
N	N	...	...	...	Dry	11-10-49
N	N	Tco	.8	...	12.49	11-10-49
Cy, G	D, S	Tca	1.1	...	20.48	11-10-49
N	N	...	...	...	Dry	11-10-49
Cy, W	D, S	L	...	...	25	...
Cy	N .	...	...	...	...	...
Cy, H	...	...	...	...	...	...
Cy, G	D, S	L	...	...	16	...
Cy, W	S	L	...	...	35	...
N	N	Tca	.1	...	14.73	11-14-49
Cy, W	S	Tco	1.2	...	13.79	7- 7-49
					14.38	11-14-49
Cy, H, W	S	Tca	1.0	...	15.13	11-15-49
N	...	...	...	...	10.25	6-19-47
					Dry	11-15-49
Cy, W	D, S	L	...	...	10	...
F(1.5)	S	...	...	...	...	...
F(0.5)	...	...	...	...	...	...
Cy, H	N	L	...	...	40	...
Cy, G	S	...	...		4.12	7-10-47
					4.16	11-15-49
Cy, H	N	Tca	1.1	...	7.13	7- 3-47
					7.35	11-10-49
Cy, H	D, S	L	...	...	5	...
Cy, H	D, S	L	...	...	5	...
Cy, W	D, S	Tco	.7	...	12.64	6-25-47
					12.32	11-14-49
Cy, H	D	L	...	...	12	...
F(4)	S	...	...	1,942	...	11-15-49

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
	Richland County—Continued					
27-55-26bb1	S. Antonson	B	33.3	24	W	....
26bb2	......do	Dr	....	....	....	....
26ca1	Peter Johnson	Du	10.3	48	....	....
26ca2	......do	Dr	695	4	P	....
26ca3	......do	Du	6.1	48	W	....
27-56- 6cc1	K. R. Hill	Dr	580	3	P	....
6cc2	......do	Dr	50	5	P	....
10cc	C. G. Carlisle	Dr	130	4	P	....
15bb	J. Lawson	B	65	24	W	....
22bb	....	Du	46.5	36	W	....
22dc1	Dethman Bros	Dr	200	4	P	....
22dc2	......do	Dr	74	4	P	....
22dd	......do	Dr	90	4	P	....
27-57-19dc	....	Dr	145	3	P	....
29ad	D. R. Aldworth	Dr	100	4	P	....
32bc1	......do	Dr	850	1½	P	....
32bc2	......do	Dr	125	4	P	....
36cd	W. R. Martin	Dr	133	4	P	....
28-53-29dc	Elof Larson	Dn	20	1¼	P	....
32ad1	William Fisher	Dn	20	1¼	P	Q
32ad2	......do	Dn	20	1¼	P	Q
32bc	M. Ziolkowski	Dn	16	1¼	P	Q
32da	Ludwig Rud	Du	18.1	48	W	Q
33cd1	Mrs. Clara Smith	Dr	38.4	4	P	Q
33cd2	......do	Dr	85.3	6	P	....
28-55-33da	C. A. Birch	Dn	15.3	1¼	P	....
	Roosevelt County					
26-46- 1ba1	Anderson Bilyeu	Dn	18	1¼	P	Q
1ba2	......do	Dn	24	1¼	P	Q
2aa	Elizabeth Youngman	Dn	27	1¼	P	Q
2ab	W. Cantrell	Dn	23	1¼	P	Q
2bb	Shirley Bridges	Dr	50.9	4	P	....
5db	J. E. Wetsit	Dn	40	1¼	P	Q
5dd	......do	Dn	20	1¼	P	Q
6ca	S. Nichols	Dr	65	6	P	....
26-58- 5ab	Carl Harmon	B	26.4	18	W	....
26-59- 3ac	Clayton	Dr	50.2	6	P	....
10bd	Mary Wilson	Dr	64	6	P	....
10ca	......do	Dr	795	3	P	....
10dd	......do	Dr	64	4	P	....
11bc	......do	Dr	800	6	P	....
11db	Wilson family	Dr	800	5	P	....
15ad	......do	Dr	817	3	P	....
15bd	Mary Wilson	Dr	813	3	P	....
27-46- 6bb	C. Neilson	Du	15	48	W	G
7bb	....	Dn	60	6	P	....
11dd1	Obert Nyland	B	94.5	24	W	G, Sh
11dd2	......do	B	16.7	24	W	G

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
			Richland County—Continued			
N	N	Tco	1.7	....	23.45	11-15-49
Cy, H	D, S	L	....	....	40	....
H	D, S	Tco	1.1	....	8.02	7- 8-47
					8.48	11-15-49
F(0.75)	N	....	....	....	....	....
N	N	Tco	2.0	....	3.24	7- 8-47
					2.00	11-15-49
F(3)	....	....	....	....	....	....
Cy, H	....	L	....	....	14	....
Cy, W	S	L	....	....	70	....
Cy, G	S	L	....	....	35	....
N, W	N	Tco	.2	....	43.88	6-18-47
					44.38	11-16-49
Cy, G	S	L	....	....	80	....
Cy, G	S	L	....	....	35	....
Cy, W	S	L	....	....	50	....
Cy, W	S	L	....	....	50	....
Cy, W	S	L	....	....	40	....
F(1.5)	S	....	....	....	....	....
Cy, W	S	L	....	....	60	....
Cy, W	S	L	....	....	20	....
Cy, G	D, S	L	....	....	13	....
Cy, E	D	L	....	....	15	....
Cy, H	S	L	....	....	15	....
Cy, H	D, S	L	....	....	12	....
Cy, H	D, S	Tco	1.0	1,930.2	17.36	7- 7-47
					16.37	11- 4-49
Cy, G	S	Tca	1.8	....	17.32	11- 8-49
Cy, H	D	Tca	.8	....	32.54	11- 8-49
Cy, H	S	Tca	.6	....	11.32	11-14-49
			Roosevelt County			
Cy, H	S	....	....	....	11	....
P, H	D	....	....	....	12	....
Cy, G	D, S	....	....	....	17	....
Cy, G	D, S	....	....	....	16	....
N	S	Tca	0.6		18.53	10-26-49
Cy, G	D	....	....	....	....	....
Cy, W	S	....	....	....	8	....
Cy, W	....	....	....	....	....	....
N	N	Tcu	.0	....	26.0	11-21-49
Cy, H	N	Tca	....	....	32.59	11- 2-49
Cy, G	S	L	....	....	23	....
F(1)	S	....	....	....	....	11- 2-49
Cy, W	D, S	L	....	....	23	....
F(1)	S	....	....	....	....	11- 2-49
F(2.5)	S	....	....	....	....	7-24-47
F(3)	S	....	....	....	....	7-24-47
F(3)	S	....	....	....	....	11- 2-49
Cy, G	D, S	Tco	1.5	....	12.0	10-28-49
Cy, H	....	....	....	....	....	....
N	N	Tco	.0	....	52.59	11-18-49
Cy, W	S	Tco	.8	....	5.3	6-10-47
					7.38	11-29-48

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Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
Roosevelt County—Continued						
27-46-11dd3	Obert Nyland	B	34	....	......	G
11dd4	........do	B	78	18	W	G
13bb	Mrs. Hadle Nyland	B	89	24	W	G
14aa	Obert Nyland	Dr	118	6	P	Sh
20cd	Arnold Wiebe	Dr	105	4	P	....
24bb	F. Rathert	B	69	18	W	G
24cb	....	Dn	....	1¼	P	....
25ad	Harvey Hamilton, Sr.	Dr	50	6	P	....
25ba	Thomas Ryan	Dr	35	6	P	G, S
26bc	....	Dr	55	4	P	....
26cd	Elsie Brugurer	Dr	22	1¼	P	....
27ad	Wesson Murdock	Dr	60	6	P	Q
27cb	George Denny	Dr	80	6	P	Q
28ba	Melvin Fischer	....	....	2½	P	G
28bb	........do	Du	5	36	P	G
28da1	Joshua Wetsit	B	38.1	18	P	....
28da2	........do	B, Dn	50	1¼	P	....
30dd	....	Du, Dn		1¼	P	....
31ba	Bernard Standing	D	58	1¼	P	....
31bb	W. Wetsit	Dn	48	6	P	....
31cb	J. Fighter	Dr	90	6	P	....
32bc	....	Dn	....	1¼	P	....
33aa	Joseph Day	Dn	25.2	1¼	P	....
33ba	........do	Dn	25	1¼	P	....
33ca	........do	Dr	59	5½	P	....
34ca	........do	Dr	48.6	4	P	....
35aa	Charles Clancy	Dr	35	6	P	....
36aa	John Cloud	Dr	59	6	P	....
36ac1	Nelson Chasing Hawk	B	21.6	18	P	....
36ac2	Joseph Robinson	B	20.1	18	P	Q
27-47- 3bc1	Robert Berry	Dr	160	6	P	....
3bc2	........do	Dr	100	6	P	....
3bc3	........do	B	80	24	N	....
3cd	Percy Peterson	B	33.1	30	W	G
4da	Robert Berry	Du, Dn	....	1¼	N	....
9dd1	James Rada	B	60	18	W	....
9dd2	Albert Henze	B	49.2	30	W	....
10bd	Percy Peterson	Dr	140	6	P	....
11cc1	D. Mueller	Dn	10	1¼	P	....
11cc2	Murray Long	B	17	14	C	....
12cc1	Frank Carter	Dr	85	4	P	....
12cc2	D. Blacktail	Dr	70	6	P	....
13ab1	Phillip Courchene	Dr	112	6	P	....
13ab2	David Courchene	Dn	34	1¼	P	....
13ba1	Dean Olson	Dn	35	1¼	P	....
13ba2	........do	Du, Dn	40	1¼	P	....
13ba3	........do	Dn	15	1¼	P	....
13ba4	........do	Dr	84.6	4	P	....
13bb	Bernar Iwen	Dr	36	1¼	P	....
13cb	....	Du	14.2	36	W	....

of wells—Continued

Method of lift and type of power	Use of water	Measuring point			Depth to water level below measuring point	Date of measurement
		Description	Height above land surface (feet)	Altitude above mean sea level (feet)		
			Roosevelt County—Continued			
Cy, W	...	L	...	...	9	...
Cy, H	D	L	...	...	60	...
Cy, W	D, S	L	...	...	81	...
Cy, W	S	L	...	...	80	...
Cy, W	D, S	L	...	...	70	...
Cy, W	D, S	L	...	...	63	...
Cy, G	D, S	...	...	...	...	...
Cy, H	D, S	L	...		15	...
Cy, G	D, S	L	...	...	25	...
...	...	...	...	...	...	...
Cy, H	D	...	...	...	...	...
Cy, H	D	L	...	...	20	...
Cy, H	D, S	...	...	...	...	...
F(?)	D, S	...	...	...	...	...
F(0.5)	D, S	...	...	...	...	10-28-49
Cy, W	D, S	Tca	1.2	...	23.78	10-26-49
Cy, H	N	...	...	...	...	...
Cy, H	...	...	...	...	...	...
Cy, H	D, S	L	...	...	10	...
Cy, H	S	...	...	...	...	...
Cy, H	S	...	...	...	...	...
Cy, H	N	...	...	...	...	...
...	...	Tca	.5	...	17.40 15.56 15.46	5- 7-47 11-18-49 11-29-49
Cy, H	D, S	L	.0	...	14.80	11-29-49
Cy, W	D, S	Tca	.5	1,989.8	19.25 18.68	5- 7-47 11-29-49
N	N	Tca	.6	...	16.05 16.08	10-27-49 11-29-49
Cy, H	D, S	L	...	...	20	...
Cy, H	D	L	...	...	16	...
Cy, H	D, S	Tca	1.0	...	13.05	10-25-49
Cy, H	D, S	Hca	1.1	...	10.82	10-25-49
J, E	D, S	L	...	...	40	...
Cy, G	S	L	...	...	40	...
N	N	L	.0	...	59.10	11-30-49
Cy, W, H	D, S	Tco	1.7	...	32.31	11-30-49
Cy, H	S	L	...	...	7	...
Cy, G, H	D, S	Tco	1.3	...	55.41	11-30-49
Cy, W, H	D, S	Tco	.8	...	46.68	11-30-49
Cy, H	S	L	...	...	75	...
Cy, E	D	L	...	...	6	...
C, E	D, S	Tco	.2	...	7.11	11-18-49
Cy, H	D	Tca	1.0	...	27.72	11-17-49
Cy, H	D	Tca	.2	...	25.28	11-18-49
N	N	L	...	...	18	...
Cy, E	D, S	L	...	...	14	11-17-49
J, E	D	L	...	...	20	...
Cy, E	I, S	L	...	...	20	...
Cy	S	L	...	...	8	...
Cy, W, E	S	L	...	...	23.20	...
J, E	D, S	L	...	...	18	...
Cy, H	N	L	...	...	13	...

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Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
	Roosevelt County—Continued					
27-47-13da1	H. V. Johnson	Du	19.1	36	P	....
13da2	........do	Dn	20	1¼	P	....
14aa	C. Track	Dn	....	1¼	P	....
14bb	T. Jensen	Du	12	36	W	....
14cb1	Stampede Grounds	Dn	27	1¼	P	....
14cb2	........do	Dn	18	1¼	P	....
14cb3	........do	Dn	22	1¼	P	....
14cb4	........do	Dn	22	1¼	P	....
14cc	Amos Shrader	Dn	19	1¼	P	....
14da	A. F. Smith	Dn	19	1¼	P	....
15ab	Great Northern Ry	Dr	57	12	P	G, Q
15ac	........do	Dr	93	12	P	G
15bd	Sherman Hotel	Dr	985	4	P	Kjr
15cb1	City of Wolf Point	Dr	97	16	P	....
15cb2	........do	Dr	100.4	18	P	....
17ac1	Kermit Smith	Dn	25	1¼	P	....
17ac2	........do	Dr	52	6	P	....
17ac3	Henry Arndt	Dn	35	1¼	P	....
17bd1	Charles Hall	Dn	35	1¼	P	....
17bd2	........do	Dn	25	1¼	P	....
17dd	Jonn Akers	Dr	57	6	P	....
19ad1	J. R. Wilson	Dr	38.4	6	P	....
19ad2	Richard Streichen	Dn	....	1¼	P	....
19ad3	........do	Dn	....	1¼	P	....
19bb	Henry Headdress	Dr	27.2	6	P	....
19dc	George Peterchek	Du, Dn	....	1¼	P	....
20ac	Clifford Squires	Dn	16	1¼	P	....
20bc	Robert Dumont	Dr	50.2	4	P	....
20dc	Wilfred Smith	B, Dn	25	1¼	P	....
20dd1	Charles Mundtz	B, Dr	26.5	6	P	....
20dd2	........do	Dn	25	1¼	P	....
22bb	City of Wolf Point	Dr	1,100	6	P	Kjr
23bb	Paul Keen	Dn	14	1¼	P	....
30bd	Mrs. T. Firstsound	Dr	54	6	P	....
30db	Claude Bearskin	Dr	66	1¼	P	....
27-48- 2ba	....	Du	2.4	48	W	....
3dc	William Hormek	Dr	40	6	P	....
5cc1	George Blunt	Dr	36.2	6	P	....
5cc2	K. B. Ault	B	36.4	24	W	G
6da	Padgett	Dr	....	6	P	....
9ad	S. C. Lun	Dn	27	1¼	P	....
9dc	David LaRocque	Dr	59	6	P	....
10cb1	Joseph Camrud	Dr	35.6	6	P	....
10cb2	........do	Dr	56	5	P	....
10cb3	........do	Dr	38	6	P	....
10db1	Guy Madison	Dn	30	1¼	P	....
10db2	........do	Dn	25	1¼	P	....
11ad	James Pedigo	Dr	87	6	P	....
12ac	W. L. Smith	Dn	12	1¼	P	S
12bb1	Harry Johnston	Dr	175	6	P	....

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
Roosevelt County—Continued						
Cy, E, W, H	S	Tca	6.0	....	9.1	6-11-47
					10.09	11-18-49
P, H	D	L	....	....	16	....
Cy, H	N	....	....	....	....	....
Cy, E, H	D	L	....	....	8	....
Cy, H	D	L	....	....	15	....
P, H	D, S	L	....	....	16	....
Cy, G	D, S	L	....	....	16	....
N	N	L	....	....	16	....
Cy, E	D, S	L	....	....	15	....
Cy, E	D, S	L	....	....	12.90	....
C, E	RR	....	....	....	33.7	11-24-39
C, E	RR	L	....	....	20	....
F(24)	D	....	....	....	....	....
C, E	PS	....	....	....	....	....
C, E	D	L	....	....	57	....
Cy, E	S	L	....	....	15	....
J, E	D	L	....	....	20	....
Cy, E	D	....	....	....	18	....
J, E	D	....	....	....	....	....
Cy, G	S	L	....	....	16	....
J, E	D, S	L	....	....	12	....
Cy, H	D, S	Tca	1.0	....	17.80	11-17-49
Cy, H	N	....	....	....	....	....
Cy, G	S	....	....	....	....	....
Cy, H	D, S	Tca	1.0	....	11.75	11-18-49
Cy, H	D, S	....	....	....	....	....
Cy, H	D, S	....	....	....	....	....
Cy, H	D	Tca	.2	....	19.60	11-17-49
Cy, E	D, S	L	....	....	16	....
Cy, H	D	L	....	....	17.31	11-19-49
Cy, E	S	L	....	....	18	....
F(65)	D	....	....	....	....	....
Cy, H	D, S	L	....	....	11	....
Cy, H	D, S	Tco	.5	....	20.12	11-18-49
Cy, H	D, S	Tca	1.0	....	17.4	11-18-49
N	N	L	....	....	1.36	11-23-49
Cy, E	D, S	L	....	....	28	....
N	N	Tca	1.0	....	33.21	11-17-49
					32.17	11-23-49
N	....	L	....	....	31.50	11-22-49
Cy, H	S	Tca	.8	....	37.62	5-14-47
					37.86	11-17-49
Cy, H	D	L	....	....	24	....
Cy, W, G	D, S	Tca	1.0	....	20.95	11-15-49
Cy, W	O	Tca	.5	1,979.0	21.32	4-27-46
Cy, E	D, S	L	....	....	16	....
J, E	D	....	....	....	16	....
Cy, E	D, S	L	....	....	20	....
Cy, H	I	L	....	....	20	....
Cy, W, H	D, S	L	....	....	18	....
Cy, H	D	L	....	....	12	....
N	O	Tca	.2	1,982.2	22.85	4-27-46

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
			Roosevelt County—Continued			
27-48-12bb2	Harry Johnston...............	Dr	40	6	P	....
16db	F. Foster......................	Dn	29	1¼	P	....
17ba1	A. Sansaver..................	Dn	20	1¼	P	....
17ba2	........do.......................	Dn	30	1¼	P	....
17cd	John Clark....................	Dn	30	1¼	P	....
17dd	A. Sansaver..................	Dn	30	1¼	P	....
18dd	William Lindsay.............	Dn	25	1¼	P	....
20dc	Samuel Long.................	Dn	40	1¼	P	....
21cc	Guy Madison.................	Dr	60	6	P	....
28bb1	Roy Sansaver................	Dn	30	1¼	P	....
28bb2	........do.......................	Dn	30	1¼	P	....
28bb3	Ranch Night Club	Dr	30	6	P	....
27-49- 2bd1	A. K. Holen.................	Dr	55	4½	P	....
2bd2	........do.......................	Dr	55	4½	P	....
2db	........do.......................	Dr	50	6	P	....
3bd	James Growing Thunder..	Dr	....	3	P	....
3ca	U. S. Bureau of Indian Affairs......................	Dr	60.0	6	P	....
3db	........do.......................	Du	....	4	P	....
3dd	Wilfred Lambert............	Dr	56	5	P	....
5ab	Elvin Warrior................	Du, Dn	30	36	W	....
6dd	Willard Ruggles.............	Dr	56	4	P	....
7bb	....	Dr	43.4	4	P	....
9aa	Charley Iron Bear...........	Dr	55	5	P	....
9ba	David Johnson................	Du	30	1¼	P	....
9da	C. MacDonald...............	Dr	55	6	P	....
9db	David Johnson...............	B	60	3	P	....
10aa	Jack Pipe......................	Dn	30	1½	P	....
10cb	T. Manning	Dn	40	1¼	P	....
10da	Herman Red Elk...........	Du, Dn	20	1¼	P	....
11bc	....	Dn	....	1½	....	....
14bb1	John Enlow...................	Dr	21.6	1¼	P	....
14bb2	........do.......................	Dn	10	2	P	....
27-50- 1dc	Clemmins.....................	Dr	....	4½	P	....
1dd	Picnic Ground...............	Dr	....	5	P	....
2bb	Earl Heddrick................	Dr	65	4	P	G
2cb	R. Scott.......................	Dr	49	4½	P	S
2dc1	Virgil Lowe...................	Dr	....	5	P	G
2dc2	........do.......................	Dr	45	6	P	....
3aa	S. Savior......................	Dr	80	4½	P	....
3ad1	W. Longee....................	Dr	90	5	P	S
3ad2	Inez Thompson..............	Dr	57.0	4½	P	....
3db	Youngeman Estate..........	Dr	....	5	P	....
4ad	John Eagleman.............	Dr	47	3	P	....
4bb	Inez Thompson..............	B	27.3	12	P	....
5cd	....	Dr	21.1	6	P	....
7bb	A. A. Warner...............	Dr	32	6	P	....
8cc	Francis Eagle Bear.........	Dr	38	5	P	....
8cd	....	Dr	45.2	6	P	....
9bb	A. A. Warner...............	Dr	42.6	6	P	....

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
Roosevelt County—Continued						
Cy, W	S	Tca	0.2	....	21.32	11-17-49
Cy, H, W	D, S	Tco	.5	....	6.50	11-15-49
Cy, H	S	L	....	....	20	....
Cy, W, H	D	L	....	....	20	....
Cy, H	D, S	L	....	....	20	....
Cy, G	S	L	....	....	20	....
P, H	D	L	....	....	10	....
Cy, H	S	L	....	....	16	....
Cy, H	D	Tca	1.0	....	17.35	11-15-49
J, E	D	L	....	....	16	....
Cy, H	S	....	....	....	10	....
Cy, H	D	L	....	....	8	....
Cy, G	S	....	....	....	....	....
J, E	D	....	....	....	....	....
Cy, H	S	....	....	....	....	....
Cy, H	D, S	....	....	....	....	....
Cy, H	D, S	Tca	.9	1,976.8	18.28	9-17-47
N	N	....	....	....	....	....
Cy, H	D, S	L	....	....	20	....
Cy, G	D, S	L	....	....	8	....
J, E	D, S	Tca	.6	1,978.2	{ 5.1	5-12-47
					7.82	11-18-49
N	O	Tca	1.8	....	9.25	10-27-47
Cy, H	D, S	L	....	....	31	....
Cy	N	....	....	....	....	....
Cy, G	D, S	....	....	....	....	....
Cy, H	D, S	....	....	....	....	....
Cy, G	....	Tco	.7	1,965.6	{ 8.34	9-17-47
					10.75	11-17-49
Cy, G	....	L	....	....	22	....
N	N	Tca	1.9	....	11.81	11-18-49
N	N	....	....	....	....	....
P	N	Tca	.6	....	7.34	11-18-49
J, E	D	....	....	....	....	....
Cy, H	N	Tca	1.0	....	12.41	10-21-49
Cy, H	D	Tca	.5	....	15.14	10-21-49
Cy, H	D, S	L	....	....	14	....
Cy, H	D, S	L	....	....	19	....
Cy, W	D, S	Tca	.5	....	20.20	10-19-49
J, E	D, S	L	....	....	8	....
Z	N	Tca	.5	1,968.4	16.45	5-15-47
Cy, H	D, S	....	....	....	19	....
N	D	Tca	1.0	....	19.45	10-20-49
N	N	Tca	.5	....	15.53	10-20-49
Z	....	Tca	.3	1,965.2	13.3	5-15-47
N	N	Tca	1.0	1,966.7	{ 13.85	5-15-47
					14.92	11-28-49
Cy, H	N	Tp	2.5	....	{ 9.4	4-27-46
					9.93	11-28-49
N	N	Tca	.5	....	18.32	11-21-49
Cy, W	N	L	....	....	16	....
Cy, W	N	Tca	.3	....	18.02	11-28-49
Cy	N	Tca	.1	....	15.80	11-21-49

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
	Roosevelt County—Continued					
27-50-10ab	Wilbur Loveshim	Dr	50.6	6	P	......
10cd	A. A. Warner	Dr	35.0	6	P	......
11aa	......do	Dr	......	4	P	......
11ab	D. K. O'Connor	Dr	65	4	P	S
11bb1	John Werner	Dr	35.2	5	P	......
11bb2	......do	Dr	60	4	P	......
11da	Howard Fronbeau	Dr	56	5	P	......
11db	William Bokas	Dr	60	4	P	S
11dd	Thorwald Hagadon	Dr	25	1¼	P	S
12ab1	City of Poplar	Du, B	99	16	P	G
12ab2	U. S. Bureau of Indian Affairs	Dr	85	4½	P	S
12ac	R. E. Patch	Dr	100	5	P	......
12ad1	City of Poplar	Du	42	360	C	G, Q
12ad2	......do	Du	42	168	C	G, Q
12bb	U. S. Bureau of Indain Affairs	Dr	68	4	P	......
13bd	D. C. Hagadone	Dn	30	1¼	P	S
23dd	L. E. Schieffert	Dn, B	19	16, 1¼	P	S
24bc1	W. Hagadone	Dn	12	1¼	P	S
24bc2	......do	Dn	21	1¼	P	S
24bc3	......do	......	15	1¼	P	S
25bd1	L. E. Schieffert	B, Dn	20	36, 1¼	W, P	Q
25bd2	......do	Du	12.3	36	W	Q
27-51- 4bc	Victor Hanson	Dr	105	6	P	......
5cc	Vigga Danielson	Dr	112	5	P	Q
5db	......do	Dr	63.0	6	P	Q
7ad	D. Smith	Dr	78	......	......	S
7bd1	Dr. Swanson	Dr	80	6	P	......
7bd2	......do	Dr	74.9	4½	P	......
7bd3	......do	Dr	80	4½	P	......
7bd4	Ricker	Dr	65	4½	P	......
7bd5	D. Burshia	Dr	......	......	......	......
8ca1	L. Combs	Dn	33.0	1¼		Q
8ca2	......do	Dn	25	1¼	P	S
8ca3	Clarence Wilke	Dn	16	1¼	P	S
8ca4	......do	Dn	12	1¼	P	S
9ca	Fanny Smith	Dr	76	4½	P	S
9cc	William Ogle	Dr	95	4½	P	S
10bb	Melbourne Estate	Dr	62.8	4½	P	......
10da	Mercy Clischer	Dr	40.8	5	P	S
10db	Carl Walking Eagle	Dr	50	4½	P	......
11cc	Mrs. E. Gearhart	Dr	60	4½	P	S
11cd	John Whitehawk	Dr	80	4½	P	S
12ab	Thomas Buckles	Dr	48	4½	P	......
13cb	......do	Dr	78	6	P	S
14bd	Mrs. Mark Longee	Dn	40	1¼	P	S
15bb	Fred Walking Eagle	Dr	88	4½	P	......
16cd1	J. Demson	Dn	26	2	P	S
16cd2	......do	Dn	32	1¼	P	S
17dc1	Robert Atchison	Dn	......	......	......	S
17dc2	......do	Dn	26	1¼	P	S

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
Roosevelt County—Continued						
Cy, H	D	Tca	0.5	...	11.55	11-21-49
Cy, H	S	L	...	...	6	...
Cy, E	D, S	Tca	.5	...	15.10	10-19-49
Cy, H	D, S	Tca	.5	...	10.53	10-19-49
Cy, G	D, S	Tca	1.3	...	11.29	5-13-47
					16.35	10-20-49
Cy, H	N	...	...	...	...	...
Cy	D	L	...	...	10	...
Cy, H	D, S	Tca	2.5	...	11.35	10-20-49
Cy, G	D, S	L	...	...	10	...
C, E	PS	L	...	...	48	...
Cy, H	D	L	...	...	64	...
Cy, W	N	Tca	1.0	...	62.52	10-21-49
C, E	PS	Tca	1.0	...	15.5	10-21-49
...	...	L	...	...	13	...
N	N	Tca	1.0	...	12.95	10-19-49
Cy	D, S	L	...	...	12	...
Cy, G	D, S	L	...	...	12	...
C, G	I	Tca	.0	...	7.55	10-20-49
C, E	D	L	...	...	8	...
Cy, G	S	L	...	...	8	...
Cy, W, G	N	L	...	...	10	...
N	N	Tcu	.0	...	9.96	10-20-49
Cy, G	S	L	...	2,025	74	...
N	N	L	...	...	59	...
Cy, W	N	Tca	.3	2,009.3	62.61	5-15-47
					61.20	10-21-49
Cy, G	...	L	...	...	50	...
Cy, W	D, S	L	...	...	38	...
N	N	Tca	.3	...	37.95	10-21-49
Cy, E	D	L	...	...	40	...
Cy, H	D	...	...	...	...	...
Cy, H	N	Tco	.2	...	36.85	10-21-49
N	O	Tca	.2	1,950.0	13.64	4-26-46
J, E	D, S	L	...	...	12	...
P, H	D	L	...	...	13	...
Cy, E	S	L	...	...	12	...
Cy	D, S	Tca	1.0	...	21.09	10-24-49
Cy, H	D, S	L	...	...	21	...
N	N	Tca	.5	1,992.6	40.49	5-29-47
					41.44	11- 7-49
Cy, H	D, S	Tca	1.3	...	22.07	10-24-49
Cy, H	D, S	Tca	.8	...	20.38	10-24-49
Cy, E	D, S	L	...	...	18	...
Cy, W	D, S	L	...	...	30	...
Cy, H	D, S	Tca	1.3	...	16.20	10-25-49
Cy, H	D, S	Tca	1.0	...	22.59	10-26-49
Cy, H	D, S	L	...	...	14	...
Cy, H	D, S	Tca	.5	...	12.49	12-24-49
Cy, G	S	L	...	...	20	...
P, H	D	L	...	...	20	...
Cy, G	S	L	...	...	15	...
P, H	D	L	...	...	15	...

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
			Roosevelt County—Continued			
27-51-18bc1	H. H. Brown	Dr	73	4½	P	
18bc2	do	Du, Dn	35	24, 1¼	P	S
21bb	E. Smith	Dn	8.0	1¼	P	S
27-52- 1ba	David Johnson	Dr		4½	P	
1bc1	James Walking Eagle	Dr		4½	P	
1bc2	do	Dr				
2aa	Mrs. Medicine Crow	Dr	69.2	4	P	
2ac	D. R. Weinberger	Dr		4½	P	S
2ca	James Spotted Bird	Dr	15	4	P	
2da	D. R. Weinberger	Dr		5	P	
2dd	Grover Cleveland	Dr	67.0	4½	P	S
7cd	Robert Warclub	Dr	68.5	4½	P	
7da	George Nick	Dr		4½	P	
8ac		Dr	83.0	4½	P	
8da	Mrs. Mabel Shields	Dr	64.5	4½	P	
9ac	Lloyd Half-Red	Dr	80	4½	P	
9ad	Steven Bird	Dr	65	4½	P	
9bb		Dr	66.5	4½	P	
9dc	Earnest Longee	Dr	70.6	4½	P	
10bc	LeRoy Rattling-Thunder	Dr	100	4½	P	
10cc	J. H. Bow	Dr	95	4½	P	
10da	School	Dr	67.0	5	P	
10dc	Gilbert Walker	Dr	1.0	4½	P	
11ba	Julia Fast Horse	Dr	33.0	4	P	
11bc	George Washington	Dr		4½	P	
11bd	William Jones	Dr	100	4½	P	
11ca	Black Duck	Dr	63.5	4½	P	
15bb	Robert Warclub	Dr	88.5	4½	P	
16ad		Dr	16.0	4	P	
16ba	Leroy Rattling-Thunder	Dr	62.3	4½	P	
17bb	Joe Muskrat	Dr	125+	4½	P	
17cb	Thomas Buckles	Dr	28	4½	P	S
18ab	Leroy Rattling-Thunder	Dr		4½	P	
18ad	Joshua Spotted Dog	Dr	125+	4½	P	
18ca	Clarence Whiteshield	Dr	100	4½	P	
27-53- 3aa	Frank Mattelin	Dn	68			S
6ba	Bud Lien	Dr	80	6	P	SS
27-56- 1aa	A. C. Peterson	Du	11.8	48	W	
5ca		Du	18.9	36	W	
27-57- 1bc1	Albert Becker	B	13.5	18	P	Q
1bc2	do	B	10	36	P	Q
1bc3	do	Du	8.0	48	W	Q
2aa	do	Dr	110	4	P	
2cb		Du	28.0	36	W	
3db	J. O. Wilkerson	Dr	100	4	P	
4ab	F. McCann	Dn		1¼	P	S
10ba1	J. O. Wilkerson	Dr	110	4	P	
10ba2	do	B	50.6	12		
12bb	Harvey Parks	Du	29.7	48	W	

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
Roosevelt County—Continued						
Cy, W, G	D, S	....	....	....	....	....
Cy, H	S	Bp	0.3	....	12.54	10-24-49
Cy, H	N	Bp	.2	....	Dry	10-24-49
N	N	....	....	....	....	....
Cy, H	D, S	Tca	1.0	....	26.75	10-26-49
Cy, H	N	....	....	....	....	....
Cy, W	S	Tca	1.0	....	25.36	10-26-49
Cy, G	D, S	L	....	....	29	....
N	N	Tca	.4	....	Dry	10-26-49
N	N	Tca	-.2	....	34.67	10-26-49
Cy, H	D, S	Tca	1.0	1,954.8	33.3	5-23-47
					33.09	10-26-49
Cy, H	N	Tca	.2	....	Dry	10-25-49
....	....	Tco	.5	....	24.70	10-25-49
N	O	Tca	1.8	1,988.9	68.50	4-29-46
N	N	Tca	.7	....	45.82	10-25-49
Cy, W	D, S	L	....	....	45	....
Cy, H	N	Tca	1.5	....	48.50	10-25-49
N	O	Tca	.0	2,001.4	65.77	5- 1-47
Cy, H	D, S	Tca	.8	....	51.55	10-25-49
Cy, H	D, S	....	....	....	....	....
Cy, H	D, S	L	....	....	44	....
N	N	Tca	.8	....	57.09	10-25-49
N	N	L	....	....	Dry	....
N	N	Tca	.7	....	Dry	10-26-49
Cy, H	N	Tca	.0	1,964.0	40.34	5-23-47
					41.56	10-26-49
Cy, H	....	Tca	1.3	....	36.75	10-26-49
Cy	N	Tca	1.3	....	44.08	10-26-49
N	N	Tca	.4	1,990.3	70.48	5-29-47
					67.65	10-25-49
N	N	Tca	2.7	....	Dry	10-26-49
N	O	Tca	1.0	1,961.5	41.51	4-26-46
Cy, H	D, S	Tca	.4	....	66.38	10-25-49
N	S	L	....	....	14	....
N	N	....	....	....	....	....
Cy, H	D, S	Tca	.6	....	73.88	10-25-49
Cy, H	D, S	L	....	....	69	....
Cy, G	S	L	....	....	12	....
Cy, W	S	Tca	1.5	....	15.50	10-26-49
Cy, W	S	Tcu	2.0	....	2.65	6-24-47
					6.58	11-16-49
N	N	Tcu	.3	1,907.4	14.04	6-17-47
					15.39	11-16-49
N	N	Tco	1.6	....	8.49	11-16-49
Cy, G	S	Tco	1.5	....	5.15	11-16-49
N	N	Tco	1.0	....	4.67	11-15-49
Cy, W	D, S	L	....	....	10	....
Cy, W	N	Tco	.3	....	28.30	11-16-49
N	N	Tca	1.0	....	71.20	11-16-49
Cy	N	Hp	1.5	....	6.34	11-18-49
N	N	Tca	.6	....	4.30	11-16-49
N	N	Tcu	.0	....	50.30	11-17-49
N	N	Tcu	.4	....	28.8	6-24-47

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
			Roosevelt County—Continued			
27-57-13cb	William Harmon	B		14	W	
14aa1	Manford Higgins	B	80			
14aa2	do	B	46.4	48	W, P	L
18ab	E. B. McCann	Dr	147	6	P	L, Q, R
26db	W. Harmon	Dr	210	2	P	S
27-58- 1bd	Clark Lundquist	Dr	65	3	P	
1cd1	C. A. Torgerson	Du	13.6	30	P	
1cd2	do	Du	6.0			
2aa1	Clark Lundquist	Du	6.4	36	W	
2aa2	do	Dr	220	5	P	
3aa	Ed Brunner	Dr	157	4	P	
3ab1	do	Du	15.5	60	W	
3ab2	do	Du	6.3	60	P	L
5dd	H. Smestad	B		18	W	
6bb	do	Du	43.8	48	W	
6bc	C. E. Smith	B	23.2	20	W, C	Q
7bb1	do	Du	10.5	48	W, P	
7bb2	do	Du	9.9	36	C	
10bb	William Harmon	Dr	100+	4	P	
11cd		Dr	43.2	3	P	
12db	Clark Lundquist	Du	26.3	36	W	
13db	Walter Romo	Dr	200	4	P	
13dc	Paul Romo	Dr	228	4	P	
14cc	School	B	32.0	18	W	
15ba	William Harmon	Dr	253	3	P	
20dd	do	Dr	136.0	4	P	
21ab	do	Dr	160	2	P	
23aa		Dr		4	P	
23bb1	Carl Harmon	Dr	555	4	P	
23bb2	do	Dr		4	P	
24ac		Dr	100+	3	P	
25bb	D. E. Simard	Dr	730	3	P	
25cd	do	Dr	614	3	P	
27ac1	Carl Harmon	Dr	550	1¼	P	
27ac2	do	B	31.5	18	W	
27ba		Dr	37.4	3	P	
28ab	William Harmon	B	100+	12	W	
28cc	do	B	54.5	12	W	
32aa	Carl Harmon	B	45.5	12	W	
33da1	G. D. Simard	Dr	405	3	P	L
33da2	do	Du	20.2	72	W	S
34ba1	do	Dr	460	3	P	L, S
34ba2	do	Dr	250	4	P	L
27-59- 3ac	L. R. Gosner	Dr	140	4	P	
4aa1	R. W. Briske	Dr	170	4	P	

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
			Roosevelt County—Continued			
N	N	Tca	0.6	...	39.97	6-24-47
N	N	L	...	...	Dry	...
Cy, G	S	Tcu	.5	...	34.34	11-17-49
Cy, W	D, S	Tca	1.3	...	33.54	11- 9-49
G, W	S	L	...	...	20	...
J, E	D	L	...	...	14	...
Cy, H	D, S	Tca	1.0	...	11.4	6-30-47
					13.11	11-22-49
...	...	Tca	.5	...	2.74	6-30-47
					3.32	11-22-49
N	N	Tca	1.7	1,936.5	3.32	6-30-47
					6.43	11-22-49
Cy, W	S	Tca	1.2	1,950.7	38.69	11-22-49
Cy, G	S	Tca	1.5	...	19.65	11-23-49
N	N	Tcu	3.1	...	10.88	11-23-49
Cy, H	N	Tca	.0	...	5.56	6-26-47
					3.29	11-23-49
N	N	Tcu	.5	...	58.2	6-26-47
					52.60	11-21-49
Cy, G	D, S	Tco	.8	...	40.55	11-18-49
Cy, H	S	Tcu	1.0	1,999.0	22.32	11-15-49
N	S	Tco	1.5	1,960	3.0	6-24-47
					4.34	11-17-49
N	N	Tco	.1	...	7.34	6-24-47
					Dry	11-17-49
C, H	N	Tca	1.0	...	66.18	11-21-49
...	...	...	...	...	Dry	11-23-49
Cy, H	D, S	Tco	.3	...	25.12	11-23-49
Cy, G	D, S	L	...	...	80	...
Cy, W, H	D, S	L	...	...	101	...
N	N	Tco	.2	1,919.3	29.54	6-26-47
					29.48	11-25-49
Cy, W	S	Tca	.4	...	41.22	11-21-49
N	N	Tca	.4	...	Dry	11-22-49
Cy, E	D, S	L	...	...	35	...
Cy, W	D, S	Tca	1.5	...	65.57	6-26-47
F(2)	D, S	...	...	1,916.5	...	...
Cy, H	U	...	...	...	...	...
N, W	N	Tco	.2	1,952.5	67.82	6-27-47
					67.72	11- 3-49
F(3)	D, S	...	...	...	...	...
F(7)	S	...	...	...	...	...
F(0.5)	S	...	...	1,900.4	...	...
Z	...	Tco	.4	1,898.9	12.92	7-16-47
N	N	Tca	.2	1,917.5	27.57	11-23-49
N	N	Tco	1.0	...	67.29	11-21-49
N	N	Tcu	1.0	...	Dry	11-21-49
N	N	L	...	...	Dry	11-21-49
F(2)	...	L	...	1,905.7	...	11-22-49
Cy, W	N	Tco	1.0	1,902.6	16.24	6-27-47
					15.35	11-22-49
N	N	Tca	.8	...	.7	11-22-49
Cy, E	D	L	...	...	7	...
J, E	D, S	L	...	...	80	...
Cy, E	D, S	L	...	...	66	...

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
		Roosevelt County—Continued				
27-59- 4aa2	R. W. Briske	Dr	170	4	P	....
5aa	Oscar Nelson	Du	20	36	C	....
5ac	........do	Du	9.2	36	C	....
7dd	Randolph Crum	Dr	270	4, 3, 2	P	....
18ba	Oscar Romo	Dr	160	4	P	....
18cb	........do	Dr	360	4	P	....
29ca	Thomas Halverson	B	48.2	36	W	....
30ba	D. E. Simard	Dr	1,200	2½	P	....
35ba	Briske	B	64	18	W	....
28-48- 1da	U. S. Bureau of Indian Affairs	Dr	60.0	5	P	....
3ac1	N. Christianson	B	30	18	W	G
3ac2	........do	Dr	40	6	P	G
3da	L. A. Holum	Du	32	48	W	G
3dd1	........do	Dr	43.4	6	P	G
3dd2	........do	B	32	12	T	G
3dd3	........do	Dr	42	6	P	G, Q
8bb	Thomas Heidner	B	102+	18	....	....
17ba	Oscar Erickson	B	25.4	24	W	S
18ad1	........do	Dr	140	4	P	G
18ad2	........do	Dr	120	2	P	G
18ad3	........do	Dr	120	....	....	G
20aa	Chester Erickson	Dn	22	1¼	P	G
21cd	Nelson Heidner	Dr	65	5	P	G, S
21dd	A. J. Thomas	Du	34.8	24	W	....
25cb	M. T. Schwinden	B	62.7	18	W	G
30ad	Joe Fahey	B	54.4	24	P	X
31ab1	Alfred Stephanson	B	52.6	24	P	....
31ab2	........do	B	30	24	W	....
32bc1	A. J. Fredrickson	B	117	24	W	S
32bc2	........do	Dr	76	4	P	Sh
34ac	A. J. Thomas	B	43	18	W	G
36dd1	....	Du, Dn	....	1¼	W, P	....
36dd2	....	Du	2.7	60	C	....
28-49- 1da	Thomas Saby	Du	8.6	24	P	....
10dd	Roy White	Dr	....	5½	P	....
12bc	....	Dr	84.0	5	P	....
16ba1	James Reid	Du	11.2	24	P	G
16ba2	........do	Du	3.8	60	P	G
17aa1	Oscar Monson	Du	21.5	48	W	....
17aa2	........do	Dn	20	1¼	P	....
18bd	John Anderson	Du	12.7	24	W	G
23ad	B. W. Andresen	Dr	41	4	P	G, X
24bd	........do	Du	9	....	....	G
33dd	Eddie Bear	Dr	53.1	5	P	....
34bc	....	Dr	23.3	4½	P	....
34dc	....	Dr	49.2	4	P	....
36ca	M. Budak	Du	42	3	P	G
36cd	Kenneth Ault	Dr	24.4	6	P	....

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
Roosevelt County—Continued						
N	N	Tca	1.3	....	66.75	11- 3-49
Cy, H	D	Tca	.7	....	7.16	7-15-47
Cy, W	S	Tcu	.7	1,940.1	4.9	7-15-47
					5.40	11- 4-49
Cy, E	D, S	L	....	....	80	....
Cy, W	N	Tca	1.2	1,972.9	81.76	6-30-47
					83.92	11- 3-49
Cy, E	D, S	L	....	....	110	....
Cy, W, E	D, S	Tca	.5	....	29.78	6-27-47
					26.89	11-25-49
F(1)	S	....	....	....	....	....
Cy, E	D, S	L	....	....	25	....
N	N	Tca	1.0	....	29.07	11-22-49
Cy, G	D, S	L	....	....	25	....
Cy, H	S	L	....	....	20	....
Cy	N	L	....	....	29	....
J, E	D	L	....	....	25.35	11-22-49
Cy, W	I	L	....	....	28	....
Cy, H	S	....	....	....	....	....
Cy, W	D, S	L	....	....	99.66	11-21-49
Cy, W	S	Bp	.6	....	19.45	11-21-49
Cy, W	S	L	....	....	70	....
Cy, W	S	L	....	....	60	....
J, E	D	L	....	....	40	....
Cy, H	N	L	....	....	18	....
Cy, W	D, S	L	....	....	50	....
Cy, H	N	Tca	1.8	....	13.60	11-21-49
Cy, W	D, S	Tca	.5	....	52.25	11-23-49
Cy, W	D, S	Tca	.4	....	43.08	11-22-49
Cy	D, S	Tca	.4	....	45.15	11-22-49
....	S	L	....	....	20	....
Cy, G	S	L	....	....	65	....
Cy, W	N	L	....	....	40	....
Cy, H	D	L	....	....	18	....
Z	....	Tcu	.2	1,981.6	17.2	5-14-47
....	S	Tcu	1.0	....	1.92	5-14-47
					1.35	11-29-49
F(1)	D, S	Tca	2.4	....	....	11-18-49
Cy, H	....	....	....	....	....	....
Cy	N	Tca	.5	....	36.79	11- 9-49
N, W	....	Tca	.0	....	9.04	11-18-49
Cy, E	S	Tco	3.1	....	2.99	11-18-49
Cy, W	S	Tco	.1	....	16.80	11-18-49
P, H	D	....	....	....	....	....
Cy, H	D, S	Bp	.2	....	5.77	11-19-49
J, E, Cy, H	D, S	L	....	....	31	....
Cy, H	S	L	....	....	4	....
Cy	O	Tca	.2	....	37.06	4-27-46
N	N	Tca	2.0	....	21.14	5-14-47
					21.06	11- 9-49
N	O	Tca	.5	1,984.8	28.66	4-27-46
Cy, H	D, S	L	....	....	40	....
....	D, S	Tca	.8	....	16.91	11-19-49

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
		Roosevelt County—Continued				
28-50- 7ba1	....	Dr	76.0	3½	P	....
7ba2	....	Du	12.0	42	W	S, G
12ab	Stanley Nees........	Dr	52.5	5	P	....
17dc	Joseph Dolezilek........	Dr	48	5½	P	....
21aa	Thomas Reid........	Dr	....	....	....	....
21ac	........do........	Du	12	48	W	....
21ad	........do........	Du	12	48	W	....
26dc	G. McGowam........	Dr	90	4	P	....
27cb1	Frank Two........	Du	8.6	30	P	....
27cb2	........do........	Du	11.9	36	W	....
29dd	Charles Dolezilek........	Dr	90	5	P	G, Q
31bc	....	Dr	18.4	4	P	....
31da	Seth Red Thunder........	Dr	40	6	P	....
32ca	Joe Red Thunder........	Du, Dn	....	1¼	P	....
32da	Mrs. Julia Red Thunder...	Dr	60	6	P	....
33dd	George Thompson........	Dr	77.2	4½	....	....
34cc	....	Dr	46.6	4	P	....
35cd	....	Dr	....	4	P	....
36dd	James Yellow Owl........	Dr	45	4	P	G
28-51-19ab	W. H. Bridges........	Du	18	60	C	G
28-52-15dd	Luke Jelden........	Dr	108	6	P	....
19aa1	....	Du	87.8	36x48	W	....
19aa2	....	Dr	....	4½	P	....
23cd1	L. A. Storm........	Dr	137.8	5	P	....
23cd2	........do........	B	52.4	11	P	....
25ca	Frank Mattelin........	Dr	76.0	4	P	....
29cd1	....	Dn	....	1¼	P	....
29cd2	....	B	6.3	8	W	....
34dc1	Lucien Walking Eagle......	Dr	65	6	P	....
34dc2	........do........	Dr	93	5	P	....
28-53-19cd	George Boyd, Sr........	Dr	66	4½	P	S, G
20dc	Virgil War Club........	Dr	....	4½	P	....
22da	Ernest Bighorn........	Dr	36	4½	P	....
22dc1	Morris Bighorn........	Dr	80	6	P	....
22dc2	Ernest Bighorn........	....	36	....	....	....
22dd1	....	Dr	....	....	....	....
22dd2	Grant Smith........	Dr	14.5	4½	P	....
25aa	Frank Mattelin........	Du	2.5	....	C	L
25ca	........do........	Dr	76.0	5	P	....
25db	........do........	Dr	90	5	P	Q
26ad	A. Come Last........	Dn	....	1¼	P	....
26cc	Frank Mattelin........	Du, Dr	78.2	90, 4½	C, P	Q
27aa	Grant Smith........	Dr	....	6	P	....
27cb	........do........	Dr	24.0	4½	P	....
29bc1	John Necklace........	Dr	54.0	4½	P	....
29bc2	Florence Burshie........	Dr	82	4	P	S
29cb1	Great Northern Ry........	Dr	260	8	P	....
29cb2	School District 3........	Dr	88	6	P	....
30ad1	T. Johnson........	Dr	83	....	....	S
30ad2	School........	Dr	105	4	P	Q

of wells —Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
Roosevelt County—Continued						
Cy, H	D	Tca	0.8	...	49.72	11-18-49
N	N	Tco	2.0	...	11.69	11-18-49
Cy	N	Tca	.0	...	52.10	10-21-49
Cy, H	D	L	...	...	46	...
F(?)	...	L	...	...	...	11- 4-49
Cy, H	S	...	...	...	...	...
Cy, G	S	Tco	.5	...	8.16	11- 4-49
Cy, W	S	Tca	.3	...	6.50	10-21-49
...	...	Tca	3.5	...	4.11	11-18-49
N	N	Tcu	2.0	1,990.7	5.00	5-15-47
					8.63	11-18-49
Cy, W	D, S	L	...	...	86	...
...	...	Hp	5.6	...	13.36	4-27-46
Cy, G	D, S	L	...	...	18	...
Cy, H	D	...	...	...	...	...
Cy, H	D, S	...	...	...	...	...
N	O	Tca	.3	...	19.95	10-27-47
N	N	Tca	.5	1,974.1	21.4	5-15-47
					23.12	11-18-49
Cy	N	Tca	1.0	...	20.95	10-19-49
Cy, H	D, S	...	...	...	...	...
Cy, H	D, S	Tcu	.5	...	16.00	10-21-49
Cy, W, G	D, S	Tco	1.7	2,096.7	51.60	10-28-49
Cy	N	Tco	1.7	...	88.30	5-20-47
					88.35	10-28-49
N	N	...	...	...	...	...
N	N	Tca	1.0	...	Dry	10-28-49
N	N	Tca	.5	...	51.38	10-28-49
Cy, G, H	S	Tca	1.0	...	23.22	9-16-47
Cy	N	Tp	1.8	...	10.50	10-28-49
N	N	Tcu	.5	...	Dry	10-28-49
Cy, H	S	Tca	1.0	1,996.0	60.06	10-28-49
N	N	...	...	...	60	...
Cy, H	D, S	Tca	1.8	...	62.95	10-28-49
Cy, H	D, S	Tca	.3	...	34.68	10-28-49
Cy, W	S	Tca	.5	...	15.28	10-28-49
Cy, H	D, S	Tca	.2	1,980.2	29.34	10-31-49
Cy, W	D, S	L	...	1,960	28	...
Cy, H	D, S	Tca	.5	...	28.48	10-28-49
N	N	Tca	.5	...	Dry	10-28-49
F(?)	S	Tcu	2.7	...	...	10-31-49
Cy, G	S	Tca	1.0	...	23.22	9-16-47
Cy, G	D, S	L	...	...	30	...
F(1)	S	L	...	...	...	10-31-49
N	N	Tca	.3	1,937.6	18.68	9-16-47
					17.45	10-31-49
Cy, W	D, S	L	...	1,943	14	...
N	N	Tca	.0	...	6.04	10-31-49
N	N	Tca	1.0	...	Dry	10-27-49
Cy, E	D	Tca	1.0	...	31.60	10-28-49
...	RR	L	...	...	30.0	10-31-35
Cy	N	Tca	1.3	...	34.45	10-27-49
J, E	D	L	...	...	67	...
J, E	D	Tca	7.0	...	44.60	10-27-49

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
		Roosevelt County—Continued				
28-53-30ad3	School	Dr	110	6	P	Q
30ad4	Merlin Iverson	Dr	90	6	P	S, R
30ad5	James Elgie	Dr	71	5	P	S, R
30ad6	Lien	Dr	108	....	....	G
30ad7	S. Nieggard	Dr	96.0	5	P	....
30ad8	........do	Dr	100	3¼	P	Khc
30da1	E. C. Woeppel	Dr	65	....	P	S
30da2	Louis Nelson	Dr	56	5	P	G
30da3	Milo Strangling	Dr	62	7	P	Q, R
30da4	George Shanks	Dr	80	6	P	Q
30da5	H. W. Quitmeyer	Dr	93	6	P	S
30da6	H. Lien	Dr	64	4	P	G
30da7	Milo Strangling	B	42	12	T	....
30da8	Occident Elevator	Dr	52.0	4½	P	....
30da10	B. Johnson	Dr	79	4	P	S
30da11	Great Northern Ry	Dr	106	5	P	G
30da12	........do	Dr	96	5	P	G
30db	Harry Red Boy	Dn	75	5	P	....
30dd	....	Dr	34.2	4	P	....
31bb	Lien	Dr	65	4½	P	....
34ad	Maurice Bighorn	Dr	45.0	5	P	....
35dd	....	Dr	46.3	5	P	....
28-54-16db	Norman Hollow	Dr	135	6	P	....
21dc	Community Well	Dr	....	6	P	....
23ad	C. J. Munch	Dr	225	4	P	....
25bc	James Black Dog, Sr	Dr	15.0	6	P	....
25db	Leon Spotted Bull	Dr	16.0	5	P	....
26bc	Community Well	Dr	130	6	P	....
26bd	Crazy Bull	Dr	82.9	4½	P	....
26cb1	School	Dr	138	4½	P	....
26cb2	........do	Dr	138	4½	P	....
26cd1	Frank Longee	Dr	86	6	P	....
26cd2	........do	B	30	8	W	Q
26db1	Thomas Drum	Dr	100+	4½	P	....
26db2	Lyda Broken	Dr	187	4½	P	....
26dd	Hale	Dr	....	5	P	....
27ad	Presbyterian Church	Dr	155	6	P	C1(?)
27bc1	Elizabeth Four Bear	Dr	100	5	P	....
27bc2	........do	B	87	20	W	C1
27dc	Frank Perry	Dr	220	4	P	....
28cc	Reuben Counter	Dr	51.3	5	P	Q
29cd	Catherine Blunt	Du	11.6	26	C	....
31aa	K. Freeman	B	94.5	8	W	....
32ba	Mrs. L. Red Bear	B	36.4	8	W	....
33ad	Felix Necklace	Dr	80	....	P	S
33dd	Thomas Long Cloud	Du	16.6	30	W	S
35ca	Gilbert Bear	Du	....	48	W	....
35dd	Elmer Red Eagle	Dr	130	5	P	....
36bb	Francis Hale	Dr	43.5	6	P	....
28-55-22bb	H. J. Folvage	....	12	....	....	....

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
Roosevelt County—Continued						
J, E	D	L	....	....	39	....
J, E	D, S	L	....	....	43	....
J, E	D	L	....	....	39	....
Cy, H	....	Tca	1.0	....	79.45'	10-27-49
J, E	....	L	....	....	60.00	10-27-49
J, E	D	L	....	....	75	....
N	....	Tca	.0	....	Dry	10-27-49
J, E	D	Tca	-5.0	....	16	10-27-49
J, E	D, I	Tca	2.0	....	37.20	10-27-49
Cy, W, E	D	Tco	.0	....	49.75	10-27-49
J, E	D	Tca	-7.0	....	40	10-27-49
Cy, H	D, S	Tco	.7	....	50	10-27-49
J, E	D	Tco	2.0	....	37	10-27-49
N	N	Tca	.9	....	Dry	10-27-49
J, E	D	L	.0	....	44	10-27-49
T, E	RR	Tco	.0	....	30	10-27-49
C, E	RR	Tco	-6.0	....	24	10-27-49
N	N	Tca	.7	....	57.05	10-28-49
N	O	Tca	.7	1,943.5	30.94	4-26-46
Cy, G	S	L	....	....	25	....
Cy, W	S	Tca	1.0	....	6.79	10-28-49
Cy, W	S	Tca	.7	1,933.3	19.68	6-13-47
Cy, G	D, S	Tca	1.2	2,115.2	69.24	11- 1-49
Cy, G	....	L	....	....	100	....
Cy, W	D, S	....	....	2,147	87	....
N	N	Tca	.5	....	Dry	11- 1-49
N	N	Tca	.5	....	Dry	11- 1-49
N	N	Tca	1.3	....	77.42	11- 1-49
N	N	Tca	.8	....	Dry	11- 1-49
Cy, H	D	L	....	....	54	....
N	N	....	....	....	....	....
Cy, H	....	Tca	1.0	....	24.85	11- 1-49
N	N	L	....	....	26	....
Cy, G	D, S	Tca	1.0	1,974.0	72.15	6-16-47
					75.15	11- 1-49
Cy, H	D, S	Tca	.5	....	56.50	11- 1-49
Cy, H	S	Tca	.5	....	31.00	11- 2-49
Cy, H	D	Tca	.8	....	56.80	11- 1-49
N	N	....	....	....	....	....
Cy, H	D	Tcu	.0	....	65.89	11- 1-49
Cy, H	....	Tca	1.0	....	58.12	11- 2-49
N	N	Tca	1.3	....	41.78	11- 2-49
					10.15	6-16-47
N	D	Tcu	1.8	1,981.6	10.09	11- 1-49
N	N	Tco	.0	....	62.98	11- 1-49
Cy, H	S	Tco	1.3	1,966.6	5.03	6-16-47
					18.38	11- 1-49
Cy, G	D, S	Tca	.3	....	17.65	11- 2-49
N	N	Tcu	2.0	....	15.66	11- 2-49
Z	....	Tcu	1.0	1,926.5	23.37	6-11-47
Cy, W	D, S	L	....	....	14	....
N	N	Tca	.5	1,923.1	20.5	6-16-47
					19.19	11- 2-49
Cy, H	D, S	....	....	....	8	....

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
			Roosevelt County—Continued			
28-55-23ad	C. J. Munch	Dr	205	4	P	L
24ba	F. McNughton	B	189+	15	W, P	...
24dd	........do	Dn	30.6	1¼	P	...
27ac	B. Olson	Dr	70	4	P	...
27ba	........do	B	73.5	18	W	...
28bb	Mrs. M. R. Mantel	Dr	18.0	4	P	...
28cd	Great Northern Ry	Du	134	10	C	...
29dc	C. D. Martel	Dr	60	4½	P	S
30dd	Medicine Bear	Dr	45.9	4½	P	...
31ad	Harvey Buck Elk	Dr	6.6	4½	P	...
32ac	Amos Lambert	Dr	85	4½	P	...
32ba	Dan High Eagle	Dr	33.8	4½	P	...
34aa1	J. W. Peerboom	B	20	6	W	...
34aa2	........do	B	...	...	...	G
34aa2	........do	...	6	...	...	...
35ad	........do	Dr	135	4	P	S, G, L
36aa1	........do	Du	26	48	W	G
36aa2	........do	...	6	...	...	...
36aa3	........do	...	6	...	...	...
36bd	........do	...	4	...	...	...
36cd	........do	Du	11.0	48	W	S
28-56- 1aa	Leonard Salvevold	B	90	24	W	L
1cb1	Eugene Larsen	B	80.5	15	W	S, L
1cb2	........do	Dr	2.0	3	P	Q
2aa	William Larsen	B	156	15	W	G, S, L
2ca1	Manual Larsen	B	138.4	15	W	...
2ca2	........do	B	155.5	15	W	...
2da	William Larsen	B	30	18	W	...
3aa	Gunder Martin	B	137	12	W	L, S
3bb	C. V. Thomsen	B	130	18	W	L
4ba	Barland Agency	B	158.6	24	W	...
4da	Triplett Estate	B	45.4	24	N	Cl, L
6ad	Paul Plaauld	Dr	180	6	P	...
7aa	Gerald Cobban	Dr	337.2	4½	P	...
10ca	Sidney Blair	...	...	...	...	L
11cb	I. Larsen	B	45	24	W	L
12ab1	Walter Nelsen	Dr	350	4	P	Q
12ab2	........do	B	170	...	...	Q
12ba	Holger Hofman	B	170	18	W	L
12cb	I. Larsen	B	203	18	...	L, S
12db1	Holger Hofman	B	33	24	W	L, S
12db2	........do	Du	33	24	W	...
14cb	Thorvald Svensen	Dr	...	5	P	...
15ca	William Larsen	B	...	12	W	...
16ad	School Section	B	...	20	W	G
20ca	John Dann	Dr	75	6	P	Q
20cb	Alvin Cooper	Du	8.2	30	P	L
21ac	Axel Waldhausen	B	66.4	12	W	...
21ca	...	Du	4.4	24	W	...
23db	F. G. Leonard	Du	14.0	...	...	...

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
Roosevelt County—Continued						
Cy, W	D, S	Tca	0.0	2,147.0	170	...
Cy, G	S	Tca	.0	...	121.65	11- 4-49
N	N	Tca	1.0	...	Dry	11- 2-49
Cy, W, E	S	...	...	...	...	...
N	N	Tcu	1.7	...	48.58	11- 3-49
N	N	Tca	.0	...	Dry	6-16-47
					Dry	11- 3-49
Cy, D	RR	Tcu	.1	1,922.7	17.8	6-17-47
Cy	D, S	Tca	1.0	...	20.8	6-17-47
					22.08	11- 2-49
N	N	Tca	1.0	...	15.85	6-16-47
					16.06	11- 3-49
N	N	Tca	1.0	...	Dry	11- 2-49
Cy, G	S	Tca	.5	...	13.30	11- 2-49
Cy, H	D, S	Tca	1.2	...	14.88	11- 2-49
Cy, H	N	L	...	...	15	...
N	N	L	...	...	14	...
F(?)	...	...	...	...	...	11- 3-49
Cy, G	...	L	...	...	29	...
Cy, G	D, S	Tcu	1.0	...	24.00	11- 2-49
F(?)	S	...	...	...	...	11- 2-49
F(?)	...	...	...	...	...	11- 2-49
F(?)	...	...	...	...	...	11- 2-49
Cy, G	S	Tcu	1.0	...	8.52	11- 3-49
Cy, E	S	Tco	1.0	...	68.00	11-15-49
Cy, H	N	L	...	...	80.50	11-14-49
...	...	...	...	...	Dry	11-14-49
Cy, E	S	L	...	...	140	...
Cy, N	N	Tco	.2	...	135.17	11- 7-49
N	N	Tco	.4	...	133.60	11- 7-49
Cy, G	S	Tcu	.0	...	11.65	11-14-49
Cy, W, G	S	Tcu	.5	...	124.02	11- 7-49
Cy, W	S	...	...	...	105	...
Cy, W	N	Tco	.3	...	133.85	11- 7-49
Cy, H	N	Tco	.0	...	45.40	11- 7-49
Cy, W	D, S	Tca	.7	...	54.50	11- 8-49
N	N	Tca	1.6	...	329.67	11- 7-49
F(?)	...	...	...	...	...	11- 7-49
Cy, W	S	Tcu	.0	...	18.09	11-14-49
N	N	Tca	2.0	...	231.39	11-14-49
Cy, G	S	Hp	.7	...	85.65	11-15-49
Cy, E, W	S	L	...	...	140	...
Cy, W, E	S	Tco	.7	...	89.07	11-14-49
Cy, G	S	Tcu	1.0	...	15.65	11-14-49
N	N	L	...	...	13	...
Cy, E	S	Tco	1.3	...	89.58	11- 9-49
Cy, W	N	Tco	1.0	...	53.50	11- 7-49
Cy, W	S	Tcu	.6	...	56.38	11- 7-49
Cy, G	S	Tca	2.0	...	67.40	11- 7-49
F(0.75)	S	Tco	2.0	...	...	11- 7-49
Cy, H	N	Tco	.0	2,005.1	29.55	7-28-47
					27.79	11- 7-49
...	...	Tcu	.5	...	2.65	11- 7-49
Cy, H	N	...	...	...	Dry	11- 9-49

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
			Roosevelt County—Continued			
28-56-24db	F. G. Leonard	Dr	130	5	P	Q
24dd	Mrs. Leonard	....	7.0	....	....	....
25bd	John Forsyth	Du	40	36	C	G, Q
26cb	C. R. Casterline	B	19.3	14	P	S
26db	....	Du	30.9	30	W	....
27ad	Mrs. Anna Mouthart	Du	20	48	W	....
27bd1	B. Bowers	Du	16.3	48	C	Cl, G
27bd2	......do	Du	15.2	48	W	Cl
27bd3	......do	B	13	30	P	Cl
27ca	C. R. Casterline	B	43.4	24	P	Q, S
28bd1	Russell Oelkers	B	2.0	12	W	....
28bd2	......do	Du	7.7	48	W	....
29ac	Ened Heinz	B	....	20	P	....
29bc1	Mrs. Moothart	Du	41.3	24	P	....
29bc2	......do	Dr	90	5	P	....
29bc3	L. Matson	B	50	36	W	Q
29cb	T. C. Moore	Du	49.5	30	W	....
29cd	Marius Bertelson	B	5.0	....	....	....
29db	Mrs. W. T. Hall	B	25	12	W	....
29dc	A. Cox	Du	....	6	P	S
29dd	Fred Treager	B	....	....	....	....
30cc	L. Matson	....	....	....	....	....
30dd	Cooper and Astle	Du	20.1	36	W	....
32aa	N. Nelson	B	....	24	W	....
32db1	Paul Brien	B	8.5	....	....	....
32db2	......do	B	....	18	W	....
33ab	R. McKinney	B	39.5	30	P	....
33ad	O. Melland	B	90	18	W	....
33cd	Mrs. B. Swindle	B	15.2	12	W	....
36cb1	H. O. Park	B	75	15	W	....
36cb2	......do	B	....	15	W	....
28-57- 4ab	Charles Young	B	176	18	W	L
4bd	......do	Du	14	40	C, W	L
4dc	William Fritz	B	95	18	W	G
5ac	Ivan Morrow	B	15.4	18	W	....
6dd	....	B	150	18	W	....
4ab	William Larsen	B	25.0	15	W	....
7cc	....	S	....	....	....	L
8bb	Ivan Morrow	B	146	18	W	....
8dd	William Ross	....	....	18	W	....
9cc1	W. M. Forbes	B	28.2	12	W	....
10bb	Charles Young	B	24.5	8	P	....
13da1	S. H. Mitchell	Du	2.7	48	W	....
13da2	......do	Du	1.0	....	....	....
13da3	......do	Du	10.2	48	W	....
16cd1	J. Swindle	Du	20	30	T	L
16cd2	......do	S	....	....	....	....
19cd	Mrs. J. Wicks	Du	24.8	48	W	....
20aa	Robert Gobbs	B	96	18	W	....
25ba	F. Traeger	Du	13.5	48	W	L, Cl

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
Roosevelt County—Continued						
J, E	S	L	...	...	60	...
Cy, W	N	...	...	...	Dry	11- 9-49
Cy, G	D, S	L	...	...	34	...
F(?)	S	...	...	...	...	...
N	N	Tcu	1.5	1,961.8	18.68	6-25-47
					18.23	11-10-49
Cy, W	D, S	Tco	.3	...	18.61	11- 9-49
Cy, H	D, S	Tco	.3	...	12.58	7-28-47
					14.33	11-10-49
Cy, H	S	Tco	1.0	...	14.53	11-10-49
Cy	S	Tco	.3	...	10.55	11-10-49
Cy, W	D, S	Tca	.0	...	37.72	11-10-49
N	...	...	...	...	Dry	...
N	S	Tco	1.3	...	6.64	11- 9-49
Cy, G	S	Tco	1.0	...	43.40	11- 7-49
Cy, E	C	Tco	1.5	...	36.36	11- 7-49
Cy, E	S	Tca	1.2	...	34.75	11- 7-49
Cy, E	S	Tco	.4	...	44.38	11- 7-49
Cy, W	N	Tco	.0	...	20.72	11- 7-49
Cy, H	N	...	...	...	Dry	...
Cy, H	D	Tco	.3	...	16.85	11-10-49
P, H	D	Tco	2.5	...	7.50	11-10-49
Cy, G	S	...	...	...	7	11-10-49
F(?)	S	...	...	...	...	...
Cy, H	D, S	Tco	.3	...	10.95	11- 3-49
Cy, G	S	Tcu	1.7	...	11.98	11- 9-49
N	...	...	...	...	Dry	11-10-49
Cy, H	...	Tcu	1.0	...	17.25	11-10-49
Cy, G	D, S	Tcu	2.0	...	39.02	11-10-49
Cy, W, G	N	Tco	.0	...	42.45	11-10-49
N	N	Tcu	.5	...	Dry	11-10-49
Cy, W	S	Tco	.5	...	62.54	11-10-49
Cy, H	D, S	...	...	...	...	...
Cy, G	S	Tco	.8	...	141.35	11-15-49
Cy, H	D, S	L	...	...	10	...
Cy, W	D, S	Tco	1.3	...	42.80	11-14-49
N	N	L	...	...	Dry	11-15-49
Cy, W	S	Tco	1.0	...	123.50	11-14-49
Cy, H	N	Tco	.2	...	25+	11-14-49
F(?)	...	...	...	...	...	...
Cy, W	D, S	Tco	1.0	...	89.30	11-14-49
Cy, W	N	Tco	1.0	...	44.08	11-15-49
N	N	Tcu	1.0	...	14.79	11-15-49
N	N	Tca	.0	...	23.81	11-14-49
F(?)	S	Tco	.0	...	1.70	11-18-49
F(?)	S	...	...	...	...	11-18-49
...	...	Tco	1.0	...	7.64	7-16-47
					7.91	11-22-49
P, H	D	L	...	...	17	...
F(?)	...	...	...	...	...	...
Cy, H	S	Tco	1.0	...	20.10	11- 9-49
Cy, G	S	L	...	...	56	...
Cy, H	N	Tco	.5	...	10.41	11-18-49

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
Roosevelt County—Continued						
28-57-25cb	F. Traeger	B	74.9	18	W	Cl
25cc1	do	B	82	18	C, W	
25cc2	do	B	24			
26ca1	William Alexander	B	100+	10	P	
26ca2	do	Dr	67	4½	P	
28cd	F. B. McCann	S				L
28dc	School	B	30.3	12	T	
29db	C. G. Hawkins	Dr	160	6	P	L, Q
30bb		B	70.8	12	W	
31ad1	D. S. Nelson	Du	20	48	W	S
31ad2	do	Du	22.6	36	W	
31cb1	A. C. Petersen	Du	30.8	48	W	Cl, L
31cb2	do	Du	15.0	48	W	Q
32db1	H. C. Bjorge	Du	18.9	48	Cy, W, E	S
32db2	do	Du	27.0	36	P	
32db3	do	Dr	150	5	P	S
33aa	A. Forsyth	B	70	24	P	
33ab	do	B	37.5	15	W	
33cb	F. B. McCann	Du	14	48	W	S
34dd	J. O. Wilkerson	Du	20	48	P	S
35ab	William Alexander	Du	1.5	24	W	
36ab	George Piercy	Du	1.8	42	W	Q
36dd	Hans Smestad	B	8.4	12	W	
28-58- 4ba	Mrs. Ada Dunn	Du	18	26	P	
4cc1	Charles Caldwell	Du		6	P	G
4cc2	do	Du	36	18	W	
5ad1	Edward Dahlstrom	B	33	18	W	
5ad2	do	B	15	24	W	
5dd	Charles Johnson	Du	35	36	P	
7bc1		Dr	.6	4	P	
7bc2	E. Eagen Estate	Du		24	W	
14dd	Ulrich Crusch	Dr	89.0	4	P	
15bb	O. Granley	Du	1.0			L
15bd	do	Du	1.8	30	P	
15ca	do	S				
17ca1	Sam Runningen Estate	Dr	43.2	4	P	
17ca2	do	Du	16.2	36	P	
18db		Du	11.2	36	W	
19dc	Carrie Hanson	B	30	24	W	Q
19dd	C. Grindland	Du	26.5	36	W	S
20da	Jerry Amsler	Du	9.1	36	W	
21cd	Mrs. Charley Evans	Du		36	W	
22cd	Albert Granley	Du	16	36	C	
22dc	do	Du	4.7	48	W	
24ca		S		1½	P	

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
			Roosevelt County—Continued			
N	N	Tco	1.8	...	13.58	11-18-49
Cy, E	D	L	...	...	15	...
Cy, G	S	Tco	.9	...	12.13	11-18-49
Cy, W	S	Tco	1.0	...	32.33	11-18-49
Cy, G	S	Tca	.8	...	28.52	11-18-49
F(?)	...	...	...	...	...	...
N	O	Tco	.2	...	27.72	4-25-46
Cy, W	S	L	...	...	50	...
Cy, H	N	Tco	.0	...	56.95	11- 9-49
Cy, W	S	L	...	...	19	...
Cy, H	S	Tco	.3	...	17.97	6-25-47
					19.64	11-16-49
Cy, W	D, S	Tcu	1.0	...	24.98	6-25-47
					25.08	11-16-49
Cy, W	S	Tcu	.5	...	11.26	6-25-47
					13.22	11-16-49
W	S	Tco	.5	1,976.4	19.18	11-16-49
Cy, E	D	Tca	.2	...	24.5	6-25-47
					26.66	11-16-49
Cy	S	Tca	1.3	...	51.50	11-21-49
Cy	S	Tco	.3	...	17.45	11-16-49
Cy, H	D	Tcu	1.0	...	16.87	11-16-49
Cy, W, E	D, S	Tco	.5	...	7.40	6-25-47
					10.50	11- 9-49
·Cy, H	D, S	L	...	...	8	...
F(0.07)	S	...	...	...	...	...
...	S	Tcu	1.0	...	1.68	11-14-49
Cy, H	N	...	...	...	Dry	11-18-49
Cy, H	D, S	L	...	...	15	...
...	...	L	...	...	30	...
Cy, W, H	S	L	...	...	30	...
Cy, H	D, S	L	...	...	30	...
Cy, H	S	L	...	...	9	...
P, H	D	L	...	...	30	...
N	N	L	...	...	Dry	...
F(0.75)	S	...	...	...	...	11-18-49
Cy, W, G	...	Tca	1.4	...	38.36	11-21-49
F(2)	S	...	...	...	...	11-22-49
F(0.25)	S	...	...	...	...	11-22-49
F(0.5)	S	...	...	...	...	11-22-49
N	N	Tca	.8	...	40.09	7-16-47
					39.93	11-21-49
Cy, H	N	Tco	.0	...	14.33	7-16-47
					14.18	11-22-49
Cy, W, H	N	Tco	.2	2,003.1	8.45	7-16-47
					8.46	11-22-49
Cy, G	D, S	Tca	.3	...	30.00	7-16-47
Cy, H	...	Tco	.5	...	24.05	7-16-47
					24.92	11-21-49
Cy, H	D, S	Tco	.0	...	5.31	7-16-47
					7.12	11-22-49
Cy, H	D, S	...	...	...	...	...
Cy, E	D, S	L	...	...	10	...
N	N	Tcu	1.7	1,980.0	3.62	7-16-47
					3.35	11-22-49
F(1.5)	S	...	...	...	...	...

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
Roosevelt County—Continued						
28-58-24dc	....	B	34.5	18	W	....
25db	Andrew Simonson	Dr	80	4	P	....
26cd1	John Simard..........	J	27	2½	P	....
26cd2	......do..........	Du	11.7	36	W	....
26cd3	......do..........	Dr	1,140	3	P	....
28bc	L. Robinson..........	B	47	18	T	....
29aa	......do..........	Du	5.9	48	W	....
29bb	C. Grindland..........	B	25.9	30	W	....
31bb1	George Piercy..........	Du	22.4	36	W, C	S
31bb2	......do..........	Du	29	48	P	Q
31bb3	......do..........	Du	30	48	P	Q
31db	......do..........	Dr	240	3	P	....
33aa	James Falcon..........	Du	27.3	36	W	....
34ba	James Vannatle..........	Du	11.1	36	W	....
34bb1	Town of Bainville..........	Dr	52.0	15	P	X
34bb2	......do..........	B	40	36	P	....
34bd1	M. A. Berwick..........	Dr	160	5	P	....
34bd2	......do..........	Du	45.1	24	P	....
35ca	Paul Panasuk..........	Du	14.1	48	W	....
28-59- 2cc	Perry LePage..........	B	46.6	18	W	....
3da	John Mehlon..........	Du	12.1	36	T	....
17ba1	A. Panasuk..........	B	24.2	18	W	....
17ba2	......do..........	Du	12	18	W	....
17ba3	......do..........	Du	7.4	48	W	....
17cc	....	Du	18.0	24	P	....
19cc	....	Du	....	48	W	....
26cd	Ira Calder..........	B	60	16	W	....
27cc1	Elmer Dye..........	Du	6.1	48	W	....
27cc2	......do..........	Du	20.5	36	N	....
28bb1	....	B	23.7	12	W	....
28bb2	....	Du, Dn	15.1	48, 1¼	C, P	....
29cc1	Charles Owen..........	Dr	300	....	P	....
29cc2	......do..........	B	....	18	W	....
29dd1	John Panasuk..........	Du	12.0	18	C	....
29dd2	......do..........	Du	8	36	W	....
30ac	Myrtle Allen..........	Dr	280	4	P	....
35ab	Alvin Briske..........	B	60	18	W	....
36bd	State Line Cafe..........	Dr	460	6	P	....
Valley County						
26-42- 1aa	....	Dn	....	1¼	P	....
2aa	Marion Johnston..........	Dn	15	1¼	P	S
26-43- 1cc	James Brown..........	Dn	20	1¼	P	S
3bd	Raymond Johnson..........	B	24	6	P	S
4aa	....	Dr	35.7	4	P	....
4ad1	William Adkins..........	Dn	....	1¼	P	....
4ad2	E. P. Brooks..........	Du	24	1¼	P	S
5ac	Andrew Thomson..........	Dn	22	1¼	P	....

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
Roosevelt County—Continued						
Cy, H	S	Tca	0.3	...	17.31	11-21-49
Cy, G	D, S	L	...	...	40	...
...	D	L	...	...	18	...
Cy, H	S	...	...	1,956.3	.8	7-16-47
					.7	11-22-49
F(0.75)	...	...	...	1,962.5	...	...
Cy, E	S	L	...	...	18	...
Cy, G	S	Tcu	1.7	1,981.9	4.46	7-16-47
					6.82	11-21-49
N	N	Tcu	1.0	...	Dry	1947
					Dry	11-21-49
Cy, W	D, S	Tco	.2	1,994.2	20.21	6-24-47
					20.46	11-22-49
Cy, W	D, S	Tco	.2	...	22.35	11-21-49
Cy, H	D, S	Tca	.2	...	20.04	11-21-49
Cy, H	S	Tca	1.2	...	124.66	11-21-49
Cy, H	N	Tco	.2	...	24.66	11-22-49
Cy, H	S	Tco	1.0	...	8.36	11-22-49
J, E	D	L	...	...	39	...
Cy, E	D	...	...	...	33	...
Cy, E	D, S	...	...	...	...	...
N	N	...	...	...	...	...
Cy, G	D, S	Tco	.7	...	8.3	6-30-47
					8.83	11-22-49
N	N	Tca	.9	...	11.92	11-18-49
P, H	D	Tca	2.7	...	13.61	11-18-49
Cy, H	D	Tco	.2	...	18.16	11-18-49
Cy, W	S	L	...	...	6	...
Cy, H	S	Tco	2.3	...	6.9	11-18-49
Cy, W, H	S	Tco	.8	...	16.26	11-18-49
F(1.25)	S	...	...	...	...	...
Cy, G	D, S	L	...	...	25	...
N	D	Tca	.8	...	4.51	11-18-49
Cy, H	S	Tco	.1	...	14.38	11-18-49
Cy, W, H	S	Tca	.2	...	17.31	11-18-49
N	N	Tca	...	...	Dry	11-18-49
Cy, G	S	L	...	...	130	...
Z	...	Tca	1.5	...	28.19	7-15-47
Cy, E	D	Tco	5.5	...	4.75	11-21-49
Cy, H	S	L	...	...	6	...
Cy, W	D, S	L	...	...	60	...
Cy, E	D, S	L	...	...	27	...
Cy, E	D	L	...	...	300	...
Valley County						
Cy	N	...	...	...	...	...
N	S	L	...	...	12	...
Cy, G, H	D, S	L	...	...	10	...
Cy, G	S	L	...	...	20	...
N	N	Tco	0.5	...	Dry	5- 2-49
Cy	N	...	...	...	...	...
Cy, G	D, S	L	...	...	15	...
Cy	D, S	...	...	...	...	...

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
			Valley County—Continued			
26-43- 5ca	Emily Wind Chief	Du	20	2	P	S
5db	B. Dykster	Dn	30.1	$1\frac{1}{4}$	P	...
6ac1	Leslie Fourstar	Dn	...	$1\frac{1}{4}$	P	S
6ac2	...do	Du	...	...	...	S
6bd	F. Sibley	Dn	18	$1\frac{1}{4}$	P	S
12dd	W. D. Henderson	Du	24	$1\frac{1}{4}$	P	S
26-44- 1aa	...	Du	54.3	16	W	...
1cd	Shirley Bridges	Dn	...	$1\frac{1}{4}$	P	...
1da	...	Dn	...	$1\frac{1}{4}$	P	...
1dc	Paul Hamilton	Dr	56	6	P	...
1dd	Allen Smoker	Dr	65	6	P	...
2da	Edward Archdale	Dr	60	5	P	...
7ba	C. Pederson	Dn	20	$1\frac{1}{4}$	P	S
9ac	Robert Westland	Du	12.7	$3\frac{1}{2}$	P	...
10bc	Paul Dassonville	Du	17.9	8	P	Q
12aa	Comes Last	Du, Dn	...	6	P	...
15bb	J. E. Tucker	Dn	18	$1\frac{1}{4}$	P	Q
15bc	Alfred Grandchamp	Dn	17	$1\frac{1}{4}$	P	Q
26-45- 1ab	Joseph Jackson	B	17.5	4	P	Q
1bb	Daniel Martin	Du	23.0	6	P	...
1cb	Steven Standing	Dr	50.4	5	P	...
1cc	William Smith	Dr	28	5	P	...
1cd	George Depew	Dn	18	$1\frac{1}{4}$	P	...
2ac	Mrs. N. G. Thunder	B	21.1	12	P	Q
2ad	Nellie White	Dr	52.9	4	P	Q
2bb	Wilbur Keiser	B	30	12	P	...
3aa	...do	Dr	47.8	5	P	...
3bc	John Sansaver	B	36	12	P	...
3cb	Harry Hamilton	B	36	12	P	...
4ac	Charles Smith	B	32	12	P	...
4bc	Calvin Archdale	B	14	12	P	...
4cb	Stonewall Jackson II	Dr	64	5	P	S
4cc	T. Jackson	Dr	28	5	P	S
4dc	Louis Winn	B	34	12	P	...
4dd	Beulah Archdale	Dr	61	4	P	...
5ab	F. Archdale	Dr	25.1	5	P	...
5ad	Thomas Flynn	Dr	68	6	P	...
5cb	Boyd	Dr	15.7	5	P	...
5dd	Wallace Fourstar	Dr	37	5	P	...
6aa	...	Dr	24.5	4	P	...
6bd	Dan Big Legging	B	...	10	P	...
7ac	...	B	...	12	P	...
7ad	Wesley Ackerman	Dr	63	5	P	...
8cc1	Scott Bros	J	1,030	3	P	Kjr
8cc2	...do	Dn	20	$1\frac{1}{4}$	P	...
9ac	Eugene Grandchamp	Dr	55	16	P	...
9db	Alice Kirn	Dr	110	...	...	...
11ac	W. E. Chaney	Dn	...	2	P	...
27-42- 8ab	...	Dn	21.9	$1\frac{1}{4}$	P	...
24ca	James Brown	Dr	90	4	P	...

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
Valley County—Continued						
Cy, G, H	D, S	L	...	...	18	...
P, H	D, S	Hp	1.2	...	17.39	11-15-49
Cy, H	D, S	L	...	...	12	...
Cy, H	N	L	...	...	14	...
Cy, H	D, S	L	...	...	12	...
Cy, G	D, S	L	...	...	15	...
N	N	Tca	.5	2,029.3	26.85	5-28-47
					23.97	11- 7-49
Cy, H	N	...	...	...	...	...
Cy, H	N	...	...	...	...	...
Cy, H	D, S	...	...	...	...	...
Cy, G	D, S	...	...	...	...	...
Cy, H	D	...	...	...	...	...
Cy, G	D, S	L	...	...	16	...
N	N	L	...	...	12	...
N	S	Tco	1.5	...	14.09	11- 7-49
Cy, H	S	...	...	...	...	...
Cy, H	D, S	L	...	...	12	...
P, H	D	L	...	...	13	...
Cy, G	D, S	Bp	.9	...	9.76	5-27-47
					5.38	11- 1-49
Cy, H	D	Tca	10.5	2,005.5	12.83	5-27-47
Cy, H	D, O, S	Tca	1.1	2,015.6	24.45	5-27-47
Cy, W	D, S	L	...	...	8	...
Cy, G	D, S	L	...	...	8	...
Cy, H	...	...	...	...	Dry	...
N	N	Tca	.2	...	21.80	11- 2-49
Cy, G	S	...	...	...	Dry	...
Cy, H	D, S	Tca	.7	...	14.15	11- 2-49
Cy, H	D, S	...	...	...	...	...
Cy, H	D, S	L	...	...	20	...
Cy, H	...	...	...	...	...	...
Cy, H	D	Tca	.2	...	6.3	5-28-47
					7.80	10- 9-47
Cy, H	D, S	...	...	...	...	...
Cy, G	...	L	...	...	21	...
Cy, G	D, S	L	...	...	22	...
Cy, G	N	...	...	...	...	...
Cy, H	D, S	Bp	.8	...	8.84	11- 3-49
Cy, H	D, S	...	...	...	...	...
N	N	Tco	.6	...	4.58	11- 3-49
Cy, H	D, S	...	...	...	...	...
N	O	Tca	.5	2,023.2	20.45	6- 4-47
Cy, H	D, S	Tca	.2	...	6.85	6- 9-47
Cy, H	D, S	...	...	...	...	...
Cy, H	D, S	...	...	...	...	...
F(3)	D, S	...	...	...	...	...
Cy, G	D, S	...	...	...	...	...
Cy, G	D, S	L	...	...	40	...
...	...	L	...	...	12	...
Cy, E	D, S	...	...	...	...	...
Cy, H	N	...	...	...	...	...
Cy, H	N	...	...	...	...	...

Table 9.—*Records*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
		Valley County—Continued				
27-42-24cc	Oran Barnes	B	39	24	W	S
25ab	Ray Porter	B	14.9	10	P	....
25ba	George Ivey	Du	20	48	N	....
25cd	Abner Todd	Dn	....	1¼	P	....
25dc	C. H. Brocksmith	B	12.9	10	P	....
26ad	........do	Dn	25	1¼	P	....
26ba	....	Dn	....	1¼	P	....
26dc	B. T. Barnes	Dn	25	1¼	P	Q
26dd	....	Dr	90	4	P	....
27ad	T. A. Doney	Dn	27	1¼	P	S
34aa	Edmund Scharf	Dn	30	1¼	P	S
34ac	Charles Hall	Dn	36	1¼	P	....
35aa	George Conners, Jr	Dr	11.4	3½	P	....
35dd	Marion Johnson	Dn	25	1¼	P	S
36ba	....	Dr	39.9	4	P	....
36cd	J. M. Sholtus	Dn	26	1¼	P	....
36da	....	Dn	25	1¼	P	S
27-43-22bd	Albert Rude	Dn	32	1¼	P	Q
23cb	....	B	27.9	20	W	....
23da1	Melvin Quiring	Dn	30	3	P	G
23da2	........do	B	22.9	5	P	G
25ad	William Adkins	Du	25	36	W	S
26bb	....	Du	14.9	18	P	....
28aa	....	Dr	89.1	4½	P	....
31bb	Hiram Peters	Dn	30	1¼	P	S
32bb	Emil Prohl	Dr	38.3	4	P	Q
32cb	Otis Myhre	Dn	26	1¼	P	Q
33cc	Andrew Fourstar	Dr	55.0	5	P	....
34ad	....	B	57.3	24	W	....
34ba	....	Dr	107.3	4	P	....
27-44-14dd	....	Du	....	48	W	....
26cb	....	B	51.4	8	W	....
27bc	Frank Meyers	Du	15.5	24	W	G
28cc	O. Sandwick	Du	23	48	W	G
28dc	Great Northern Ry	Du	24.6	120 x 480	W	G
28dd	William Brough	Du	16.9	30	W	....
31aa	William Hentges	Dr	104	3½	P	Q
32ca	........do	Du, Dn	21	1¼	P	Q
32dc	Walter Clark	B	20.3	24	P	G
33ac	Theo. Pour Eagle Boy	Du, Dn	74	6	P	Q
33ad	Howard Kjensrud	Dr	80	4	P	S
33bc	Victoria Bird	Dn	24	1¼	P	G
34ac	Tribal Council	Dr	1,090	5⅝	P	Kjr
35dd	T. A. Quiring	B	28	4	P	G
27-45-11bc	John Greenwood	Du	25.4	48	C	Cl
32dd	Enright Johnson	Dn, B	....	10	P	....
33cc	F. Buckles	Dr	73	6	P	....
33cd	Harry Follet	B	21	12	P	....
33dc	Eva Mae Smith	B	18.1	12	P	....
34cd	Edith Reddoor	B	18	12	P	....

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date of measurement
			Valley County—Continued			
Cy, E	D, S	L	...	...	19	...
N	N	Tco	0.3	2,047.7	3.40	6- 6-47
					7.77	11-16-49
N	N	L	...	...	19	...
Cy, H	D, S	...	...	...	...	...
N	N	Tco	.7	...	10.91	11-16-49
Cy, H	D, S	L	...	...	20	...
Cy	N	...	...	...	...	...
Cy, H	D, S	L	...	...	18	...
Cy, H	D	...	...	...	...	...
Cy, H	S	L	...	...	15	...
Cy, H	D, S	Tco	.1	2,030.9	21.13	6- 6-47
					20.19	11-16-49
Cy, G, H	D, S	...	...	...	Dry	11-16-49
N	N	...	...	...	Dry	11-16-49
Cy, G	I	L	...	...	15	...
N	N	Tca	.9	...	13.77	11-16-49
Cy, G	...	L	...	...	20	...
Cy, H	S	L	...	...	18	...
Cy, H	S	L	...	...	30	...
N	O	Tcu	.2	2,096.4	24.29	5- 2-46
Cy, G, H	...	L	...	...	22	...
N	N	Tca	.2	...	21.63	11-14-49
Cy, G, H	D, S	L	...	...	23	...
N	N	Tco	.0	...	14.70	11-14-49
Cy, W, G	D, S	Tca	.2	2,129.1	81.14	6- 6-47
Cy, H	D, S	L	...	...	20	...
Z	...	Tca	.8	...	24.72	6- 5-47
Cy, H	D, S	L	...	...	25	...
Cy	N	Bp	1.2	2,040.0	25.76	6- 5-47
N	N	...	...	...	Dry	11-14-49
N	N	...	...	...	Dry	11-10-49
Cy, H	D, S	Tco	.6	...	22.44	11- 8-49
N	N	Tcu	.1	...	30.42	6-10-47
					30.66	11- 8-49
Cy, H	S	Tco	.8	...	14.21	11- 9-49
Cy, W	...	L	...	...	17	11- 8-49
Pl, E	RR	Tco	2.9	...	15.88	11- 9-49
Cy, H	N	Tco	1.0	...	11.98	11- 9-49
Cy, W, G	D, S	L	...	...	92	...
Cy, H	N	...	...	...	18	...
Cy, H	D, S	Tco	.2	...	16.84	11- 9-49
Cy, H	D, S	L	...	...	50	...
Cy, W, H	D, S	Tco	1.0	2,065.0	38.02	6- 4-47
Cy, H	D, S	L	...	...	18	...
F(25)	D	...	...	...	...	1947
Cy, H	S	L	...	...	16	...
Cy, H	D, S	Tco	.8	...	24.32	11- 8-49
Cy, H	...	...	...	...	...	...
Cy, G	D, S	...	...	...	...	...
Cy, H	D	L	...	...	10	...
N	O	Tca	1.2	2,011.2	10.89	5-28-47
Cy, H	N	Tca	.2	2,010.7	12.41	5-28-47
					11.71	11- 2-49

Table 9.—*Record*

Well	Owner or tenant	Type	Depth (feet)	Diameter (inches)	Casing	Character of water-bearing material
		Valley County—Continued				
27-45-34dd	Jacob Bad Hawk............	Dr	63	4	P	....
35ba1	....	Dr	33.5	4	P	G
35ba2	....	Dr	27.8	2½	P	....
35cb	....	B	19.9	12	P	....
36bb	George Thompson.........	B	28	12	P	S
36dc	J. F. McGuire.............	B	20.8	16	T	Q
28-42-20aa	Ray Hassler.................	Dr	42	5	P	G
29ad	W. M. Lauckner..........	Dr	40	6	P	G
31bd	Michael Tihasta...........	Dr	52.9	8	P	S
31dd	Great Northern Ry........	Dr	116	6	P	S
32dd	E. House.....................	Dr	60	6	P	Q, G

of wells—Continued

Method of lift and type of power	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point	Date to measurement
Valley County—Continued						
Cy, H	N	....	....	....	....	....
Cy, W	D, S	Bp	0.4	....	31.45	11- 1-49
Cy	N	Tp	3.5	....	15.27	11- 1-49
N	N	Tca	.1	....	16.19	11- 2-49
Cy, H	D, S	....	....	....	....	....
J, E	D, S	Tcu	1.8	....	10.82	11- 1-49
Cy, E	D, S	L	....	....	26	....
J, E	D	L	....	....	30	....
Cy, E	D, S	Tco	.7	....	19.54	11-17-49
....	S	....	....	....	....	....
Cy, H	D, S	L	....	....	30	....

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