STATE OF WYOMING
THE GEOLOGICAL SURVEY OF WYOMING
S. H. KNIGHT, State Geologist

BULLETIN No. 30

# UNDERGROUND WATER RESOURCES
— OF —
# HORSE CREEK
— AND —
# BEAR CREEK VALLEYS,
## Southeastern Wyoming

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UNIVERSITY OF WYOMING
LARAMIE, WYOMING
MAY, 1940

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By W. LYLE DOCKERY

## INTRODUCTION

This report treats with the underground water resources of 1,355 square miles in Goshen, Laramie, and Platte Counties, Wyoming, and constitutes part of a program of investigation of the underground water resources of the state by the Geological Survey of Wyoming. The area comprises the drainage basin of Horse Creek and tributaries (Pl. I), excluding the part in T. 23 N., R. 62 W., northwest of the Fort Laramie Canal, and the western part of the Horse Creek drainage basin in the Laramie Range. There is also included the northern part of the Lodgepole drainage basin, which was not covered in a previous ground-water report on Lodgepole Valley (3).‡

Horse Creek rises in the Laramie Range and flows eastward and northeastward across the Great Plains to the North Platte River near Morrill, Nebraska. Its length, not including meanders, is about 125 miles, of which approximately 100 miles is in the area here described. Bear Creek, the principal tributary of Horse Creek, rises in the Great Plains, flows eastward and joins Horse Creek near Lagrange, Wyoming. Its approximate length is 55 miles.

During the last decade, because of the success of irrigation utilizing ground water in Lodgepole Valley to the south and in the North Platte Valley in Nebraska to the east, there has been considerable interest and speculation about applying the same methods locally. The residents usually have a fairly accurate knowledge of well yields and some knowledge of the general depth to water. They are entirely uninformed, however, as to the geologic factors which control the occurrence and quantities of underground water. Consequently, many thousands of dollars have been spent for drilling wells in localities which proved to be unproductive of large-yield wells. It was largely with the view of attempting to alleviate this condition that the present study was undertaken. Field investigation during the summer of 1939

* Thesis submitted to the Department of Geology and the Committee on Graduate Study at the University of Wyoming, in partial fulfillment of requirements for the degree of Master of Arts.

‡ Numbers in parentheses refer to the list of references on page 22. A number following a colon in parentheses gives the page in the reference cited.

consisted of study of the geology with reference to water-supply problems, geologic mapping, and collection of data on 288 wells.

The region has a semi-arid climate typical of the higher Great Plains. The only weather station in the area is at Lagrange, elevation 4,500 feet. Here the mean annual temperature is 46°; the average dates of latest and earliest frosts are May 22 and September 25 respectively; the average length of the growing season is 126 days. Mean annual precipitation is about 17 inches; on an average there are 78 days in the year with 0.01 inch or more precipitation. Altitude variation from 4,060 to 7,000 feet in the surrounding region undoubtedly causes considerable differences in temperature, and minor differences in precipitation from the Lagrange figures.

The early settlers were ranchers who had access to the free range. Land was plentiful, the country thinly populated, and titles were obtained only for land needed for home ranches. These were generally in favored places close to the principal streams. Deep wells were later drilled on the plains some distance from streams and water for domestic and stock use was pumped into tanks by windmills or engines.

With the exception of the part of Horse Creek Valley below Meriden and several other areas where irrigation is possible, the land is best adapted to grazing.

The only available water-supply bulletin, which covers the eastern part of the area, is that by Adams (1) published in 1902. This work is chiefly a resume of the general geology and surface waters.

The writer wishes to thank Dr. S. H. Knight, State Geologist of Wyoming, for making the work possible, the several faculty members of the Geology Department, University of Wyoming, for valuable suggestions, especially Dr. R. H. Beckwith, who revised and criticized the manuscript, and Dr. C. H. Falkenbach of the Frick Laboratory, American Museum of Natural History, for information on age relations of the White River group near the Laramie Range. Appreciation is also extended to the residents of the area, whose cooperation and kindness contributed to the success of the work.

## TOPOGRAPHY AND DRAINAGE

The northward-trending Laramie Range, with an average elevation of 8,000 feet, lies to the west of the area. In the extreme western part, late Paleozoic and Mesozoic rocks (Pl. II) dip steeply to the east along the east flank of the Laramie Range and form foothills several miles wide. The rocks are largely shales; the more resistant sandstones form hogbacks trending parallel to the mountain front.

A well-defined subsequent valley from two to five miles wide separates the foothills of the Laramie Range from the Great Plains and extends approximately 25 miles to the south. The valley floor is a gently rolling surface cut in the late Mesozoic and Tertiary sediments. Because of numerous streams which flow eastward across the valley and the absence of an integrated drainage system, it has not previously been named. The name Federal Valley is suggested from Federal post office near the center of the valley seven miles south of Horse Creek post office. As here designated, Federal Valley extends from Granite Canyon post office on the Union Pacific Railroad 25 miles south of Horse Creek post office to the drainage divide between Horse Creek and Chugwater Creek five miles north of Horse Creek post office.

Federal Valley is bounded on the east by a westward-facing escarpment about 500 feet high cut across nearly horizontal Tertiary sediments. From the crest of the escarpment the gently undulating Great Plains slope eastward from an elevation of about 7,000 feet to 5,200 feet near the Nebraska line and are incised by the valleys of Horse Creek and Bear Creek. The east and northeast parts of the area have undergone more dissection; stream valleys broaden and isolated remnants of the higher plains surface form tops of buttes.

The North and South Forks of Horse Creek join at Horse Creek post office. In the first five miles downstream from here the valley narrows to a steep-walled trench up to 200 feet deep. In the next 40 miles the walls recede in a number of places and the valley widens to a mile or two. From Horse Creek post office to Meriden the north wall is more persistent and bolder than the south. Below Meriden the valley trends northeast and widens.

Bear Creek rises on the Great Plains in the western part of the area, is perennial for two and one-half miles, intermittent and ephemeral for 15 miles, and perennial for the remaining 37 miles to its junction with Horse Creek near Lagrange. There is a definite relation between the flow of Bear Creek and the shape of the valley. The upper perennial stretch is in a shallow canyon incised into the surface of the Great Plains; the 15-mile intermittent and ephemeral part is in a broad shallow valley; the lower 37-mile perennial part is in a narrow, steep-sided canyon, which terminates a few miles above the junction with Horse Creek.

Below the junction the valley of Horse Creek is part of Goshen Hole, a large depression excavated to a depth of nearly 1,000 feet below the Great Plains surface. It is bounded on the east, west and south by conspicuous escarpments and opens to the northeast into the North Platte Valley. Horse Creek enters Goshen Hole through a gap three or four miles wide in the south escarpment rim. Bear Mountain flanks the gap on the west and Sixty-six Mountain on the east.

## STRATIGRAPHY

### UPPER CRETACEOUS

**Colorado group.**—The Colorado group, exposed in the vicinity of Horse Creek post office, includes the Thermopolis, Mowry, Frontier and Niobrara formations. As they are thin and could not be shown individually on the map (Pl. II), they are shown as a unit. The Colorado group is about 950 feet thick and consists of dark carbonaceous shales, massive and slabby sandstones, and a few thin beds of limestone. Detailed sections of this and the two overlying Cretaceous units were measured by Loeffler (5). The sandstones and limestones carry small amounts of water.

**Pierre shale.**—The Pierre shale, which overlies the Colorado group conformably, consists of 4,000 feet of brown shales, sandy shales, and slabby sandstones. It dips eastward at about 50° and, despite its thickness, is of limited outcrop in the area under discussion. The formation carries little water and much of it is high in mineral matter. Water from the Harold C. Jones well (no. 2),* which produces from the Pierre, showed a standard calcium carbonate hardness of 720 parts per million and also Glauber's salt and Epsom salt. The water has approximately three and one-half times the hardness of that used for domestic purposes in Laramie.

**Fox Hills sandstone.**—The Fox Hills sandstone, a gray massive moderately hard sandstone containing numerous tan and dark-gray shale beds, overlies the Pierre conformably, has a thickness of 375 feet, and dips eastward at about 30°. It crops out only in the extreme western part of the area. The Fox Hills sandstone is known to yield water of better quality than that of the Pierre, but it is hard.

**Lance formation.**—The Lance formation, the youngest Cretaceous unit exposed, crops out only in lower Horse Creek Valley and in Goshen Hole. The formation consists of a succession of tan to yellow sandstones and shales. Lenticular oyster beds containing **Ostrea glabra**, a two-foot layer of impure lignitic coal, **Triceratops** remains, and cannonball concretions as large as two feet in diameter occur about five miles west of the Nebraska boundary. Schlaikjer (8: 51) says the Lance formation of Goshen Hole consists of a lower succession of continental beds 100 to 200 feet thick, brackish-water beds 80 to 125 feet thick, and an upper succession of continental beds 60 to 100 feet thick. The relation of the Lance to the underlying formations is not definitely known. The Lance formation is an aquifer, but the quality of the water varies from bed to bed; waters from some horizons are highly mineralized.

## TERTIARY

**General statement.**—The Tertiary rocks are represented by the Chadron and Brule formations, of Oligocene age, and the Arikaree formation of late Oligocene or Miocene age. Because of lateral variations in lithology, gradational contacts, and poor exposures, the formations cannot be differentiated in many places.

* Well locations are shown on Plates II and III and locations by section, township, and range are given on pages 23 to 32.

The three were consequently mapped together as a single unit, the White River group.

**Chadron formation.**—The Chadron formation in the western part of the area near Horse Creek post office is a light-brown to drab locally cross-bedded poorly cemented arkosic conglomerate composed chiefly of material derived from the gigantic core of the Laramie Range. The thickness here is from 20 to 100 feet. To the east the Chadron is covered by younger rocks. It reappears around the edge of Goshen Hole, where it consists of lenses up to 60 feet thick of gray, greenish-gray, dark-red, and olive sandstones and sandy shales between the Lance formation and the Brule.

In the Goshen Hole region the Chadron contains an abundance of water of good quality.

**Brule formation.**—The Brule formation is typically a light-gray or light-tan massive moderately soft stratified andesitic and dacitic volcanic ash, which forms the lower slopes of the escarpments surrounding Goshen Hole and the escarpment near Horse Creek post office. It has an average thickness of about 200 feet and is more uniform in lithology than the other Tertiary formations. In many localities only a part of the formation is exposed and it is not always possible to tell which part is represented. At some places the Brule is entirely homogeneous; at others it contains lenticular hard layers or local sandy lenses. Near the Laramie Range the upper part interfingers with conglomerates similar in lithology to those of the overlying Arikaree formation.

The upper part of the Brule is cut by bed joints and at least one set of vertical joints. Recently weathered material consists of angular blocks up to a foot across that are bounded by joint surfaces. In addition there are fissures up to 12 inches wide that penetrate the upper part to depths of at least 30 feet. In some cases, they are filled by material from the overlying Arikaree, but in most, by material of the same lithology as the wall rock. The Brule is normally impervious. Local conglomerate lenses yield small amounts of water. Wells in strongly jointed and fissured areas yield large amounts of water. Water from the Brule is of good quality.

**Arikaree formation.**—The Arikaree formation overlies the Brule. In some places there is a disconformity between them; at others there is no evidence of an erosional break. The Arikaree has three textural phases. These are, from west to east, (1) coarse conglomerate (Fig. 1), (2) coarse evenly-bedded thin sandstones grading laterally into beds with large-scale cross-bedding, (Fig. 2), and (3) massive fine-grained gray salt-and-pepper sandstones with numerous resistant lenticular layers. The first phase is best developed in the area near Horse Creek post office, the second is well exposed in Bear Creek Canyon in T. 19 N., R. 63 W., and the third, which is eroded into pillars and spires, forms the summit of Bear Mountain west of Lagrange and is present farther east. These phases show only the general gradational aspects of the formation. In addition vertical variations are found. The Arikaree forms the surface of the Great Plains and the upper sheer edges of the escarpments. Its thickness is variable, with an average of about 275 feet. Because of its high topographic position the formation yields little water, which is, however, of excellent quality.

**Age relations.**—The White River group along the east side of the Laramie Range is not thoroughly understood. Because of the disconformity separating the Arikaree and the Brule, and limited faunal evidence, the age of the Arikaree was placed as Miocene. Recent detailed studies of the Tertiary sediments of Wyoming have shown that striking changes in lithology are not necessarily indicative of age difference. The disconformity separating the stream-deposited Arikaree and the subjacent Brule has no value as an indicator of a time break, for one would normally expect a disconformity beneath a stream-laid deposit of the magnitude of the Arikaree formation irrespective of previous subaerial erosion.

A study of the Tertiary deposits in southeastern Wyoming near the Laramie Range shows that the processes controlling the deposition of the White River group were complex and involved working and reworking of sediments by streams flowing from or across the mountains west of the region. Thus it is apparent that a fauna of a certain age found in a given lithologic type does not necessarily mean that the type is everywhere of the same age.

The most complete collection of vertebrate remains from the White River group of southeastern Wyoming was made by the Frick Laboratory, American Museum of Natural History, during

FIG. 1.—Conglomeratic phase of the Arikaree near Underwood, sec. 31, T. 19 N., R. 69 W.

the summer of 1939. Dr. C. H. Falkenbach, who directed the field work, expressed himself* as believing the White River group of southeastern Wyoming to be at least 90 per cent Oligocene in age.

The complex lithology, gradational contacts, intertonguing of sediments and scarcity of vertebrate remains lead the writer to believe that the terms Chadron, Brule, and Arikaree as applied to the Tertiary formations flanking the east side of the Laramie Range will never have more than general significance.

## QUATERNARY

**Alluvium.**—The floors of Horse Creek and Bear Creek Valleys, except in canyons, are covered by alluvium and gravel. The thickness and character of the alluvium are variable. It was derived largely from the Tertiary rocks within the area, although it is probable that the Laramie Range has contributed to the silt and gravel along Horse Creek.

Adjacent to the stream channels the alluvium, from a few to 30 feet thick, contains water in considerable quantities. Water is released freely and is suitable for domestic and irrigation purposes.

## STRUCTURE

The pre-Cambrian crystalline rocks in the core of the Laramie Range are flanked on the east by late Paleozoic and Mesozoic sediments dipping steeply to the east. These are unconformably overlain by almost horizontal Tertiary sediments of the White

* Oral communication, June, 1939.

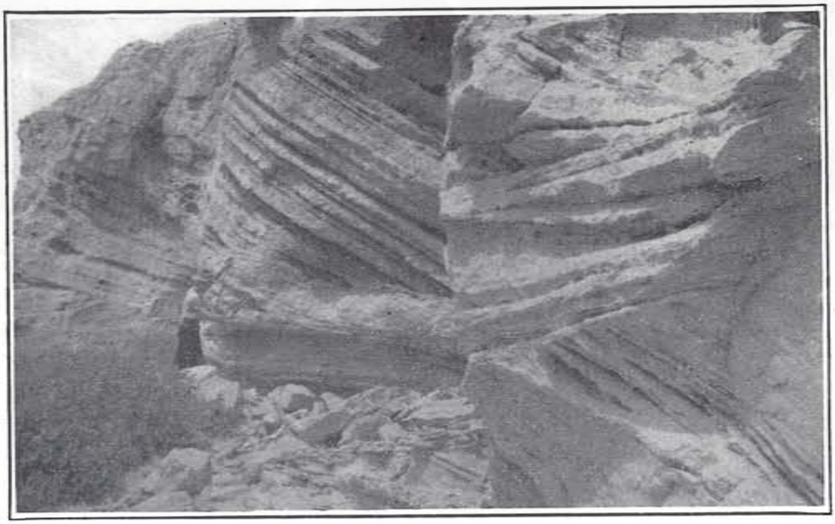

FIG. 2.—Cross-bedded sandstone phase of the Arikaree in Bear Creek Valley, sec. 4, T. 19 N., R. 63 W.

River group. In places the Tertiary sediments extend up against the mountains and completely cover the Paleozoic and Mesozoic rocks. The older rocks, because of the overlapping Tertiary, are of small surface areal extent.

The White River group in the westward-facing escarpment near Horse Creek post office dips eastward at an angle less than that of the Great Plains. In the eastern part of the area, in Goshen Hole, the Tertiary rocks have been removed by erosion, exposing the late Cretaceous Lance formation. The Lance is poorly exposed because of deep weathering and residual material from the Tertiary; little is known about the structure except that the prevailing dips are low.

The erosion surface upon which the Tertiary sediments were deposited was one of marked relief, 315 feet at an exposure one mile northeast of Farthing, which is near the Laramie Range about 10 miles north of Horse Creek post office. It is probable that farther east of the mountains the surface has less relief.

## PRECIPITATION

### DISTRIBUTION

The only precipitation data available within the area are those for Lagrange given below.

There is a range from a minimum of 11.37 inches in 1911 to a maximum of 25.05 inches in 1912. It is of interest to note that the minimum and maximum occurred in successive years. The mean of the annual precipitations for the 18 scattered years of complete yearly records is 17.65 inches, which is comparable to the mean annual of other stations in neighboring sections of the Great Plains province. For nine years the precipitation was above the mean annual and for nine it was below. During three years there was more than 20 inches of precipitation; during five there was less than 15 inches.

Approximately 71% of the annual precipitation occurs between April and September inclusive. May, with a mean monthly precipitation of 2.51 inches is the wettest month; January, with 0.49 inch, is the driest. On the other hand, during May, 1930, there was only 0.20 inch, and during January, 1921, there were 1.58 inches. The largest precipitation recorded in a single month was 6.84 inches during May, 1917, and there are two instances of more than 5.00 inches in August.

### DISPOSAL

Precipitation is disposed of through evaporation, transpiration, run-off, and percolation, which vary from place to place and with the seasons.

As 71% of the precipitation occurs from April to September inclusive, when the optimum conditions for evaporation prevail, a greater percentage of the precipitation evaporates than would be the case if the period of maximum precipitation were in winter. Growing plants take water from the soil and discharge it to the atmosphere through their leaves as transpiration, which varies in amount with different plants and with the same plant under different environmental conditions. Transpiration reaches a maximum during the growing season. The amount of water lost by evaporation and transpiration is difficult to estimate.

## Precipitation for Lagrange, Goshen County, Wyoming

Elevation 4,720 feet

(From records of the U. S. Weather Bureau)

| Year | Jan. | Feb. | Mar. | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1902 | .... | .... | .... | .... | 1.20 | 2.78 | 3.46 | 0.50 | 3.40 | 0.20 | .... | 1.43 | .... |
| 1910 | .... | .... | .... | .... | 1.65 | 0.60 | 1.52 | 1.00 | 3.28 | 0.82 | 0.18 | 0.79 | .... |
| 1911 | 0.77 | 0.16 | 0.03 | 1.38 | 1.06 | 1.63 | 0.96 | 1.08 | 0.86 | 2.64 | 0.30 | 0.50 | 11.37 |
| 1912 | 1 07 | 0.97 | 1.62 | 2.02 | 2.40 | 2.02 | 2.56 | 5.31 | 4.30 | 1.75 | 0.52 | 0.51 | 25.05 |
| 1913 | 0.41 | 0.75 | 0.49 | 0.86 | 2.99 | 1.94 | 3.73 | 2.73 | 1.38 | 0.53 | 0.22 | 2.59 | 18.62 |
| 1914 | 0.08 | 0.40 | 0.41 | 3.66 | 0.96 | 3.10 | 1.49 | 1.00 | 0.42 | 1.83 | 0.20 | 0.30 | 13.85 |
| 1915 | 0.49 | 0.69 | 1.18 | 3.99 | 2.62 | 3.47 | 1.35 | 1.96 | 4.10 | 3.01 | 0.27 | 0.53 | 23.66 |
| 1916 | 0.19 | 0.31 | 0.30 | 0.85 | 2.96 | 0.25 | 2.54 | 2.35 | 0.45 | 1.28 | 0.57 | 0.33 | 12.38 |
| 1917 | 0.22 | 0.10 | 0.53 | 1.37 | 6.84 | 4.15 | 1.09 | 0.89 | 0.47 | 0.38 | 0.37 | 0.43 | 16.84 |
| 1918 | 0.71 | 0.35 | 0.44 | 2.72 | 2.68 | 3.39 | 1.92 | 1.23 | 3.90 | 1.07 | 0.40 | 1.08 | 19.89 |
| 1919 | 0.04 | 0.75 | 1.72 | 1.48 | 0.21 | 1.01 | 1.69 | 0.08 | 1.10 | 1.33 | .... | 0.60 | .... |
| 1920 | 0.24 | .... | 0.77 | 4.75 | 2.46 | .... | .... | .... | .... | 0.02 | 0.64 | 0.50 | .... |
| 1921 | 1.58 | 0.32 | 0.26 | 1.74 | 2.17 | 1.24 | 0.92 | 1.01 | 0.90 | 0.81 | 0.56 | 1.62 | 13.13 |
| 1922 | 0.72 | 0.74 | 0.49 | 2.42 | 3.58 | 1.77 | 1.89 | 1.33 | 0.22 | 0.47 | 2.68 | 1.16 | 17.47 |
| 1923 | 0.25 | 1.37 | 0.70 | 1.95 | 2.80 | 4.60 | 0.86 | 1.22 | 1.26 | 3.04 | 0.73 | 0.81 | 19.59 |
| 1924 | 0.41 | 0.60 | 1.39 | 1.46 | 2.24 | 0.93 | 0.38 | 0.34 | 3.90 | 2.59 | 0.44 | 1.12 | 15.80 |
| 1925 | 0.13 | 0.68 | 0.86 | 1.51 | 1.97 | 2.86 | 1.35 | 1.63 | 0.89 | 2.62 | 0.83 | 2.18 | 17.51 |
| 1926 | 0.92 | 0.68 | 0.45 | 1.89 | 2.62 | 4.44 | 1.45 | 0.82 | 0.87 | 2.61 | 1.22 | 0.60 | 18.57 |
| 1927 | 0.30 | 0.44 | 2.90 | 5.45 | 2.21 | 2.71 | 1.65 | 4.11 | 0.88 | 1.36 | 0.46 | 0.46 | 22 93 |
| 1928 | 0.44 | 1.00 | 0.75 | .... | .... | 3.63 | 2.39 | 0.69 | 0.38 | .... | .... | .... | .... |
| 1929 | .... | .... | .... | .... | .... | 1.31 | 0.84 | 1.00 | .... | .... | .... | .... | .... |
| 1930 | 0.85 | 0.31 | 0.20 | 1.30 | 4.68 | 0.59 | 0.88 | 5.22 | 1.70 | 3.12 | 0.50 | 0.05 | 19.40 |
| 1931 | .... | .... | .... | .... | .... | .... | 0.69 | 0.77 | 0.50 | 1.66 | 0.25 | .... | .... |
| 1932 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 0.65 | .... |
| 1933 | 0.02 | 0.09 | 1.40 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 1936 | .... | .... | .... | .... | .... | .... | .... | .... | 0.58 | 0.47 | 0.88 | 1.11 | .... |
| 1937 | 0.48 | T | 0.94 | 1.04 | 1.62 | 2.50 | 2.66 | 0.16 | 0.88 | 1.11 | 0.71 | 1.15 | 13.25 |
| 1938 | 0.30 | 0.19 | 0.93 | 2.81 | 5.00 | 1.06 | 1.77 | 1.00 | 3.56 | 0.15 | 1.09 | 0.61 | 18.47 |
| 1939 | 0.70 | 1.07 | 0.95 | 0.48 | 0.78 | 1.41 | 2.07 | 1.13 | 0.60 | .... | .... | .... | .... |
| Mean | 0.49 | 0.57 | 0.86 | 2.15 | 2.51 | 2.22 | 1.68 | 1.54 | 1.63 | 1.45 | 0.64 | 0.88 | 17.65 |

Part of the water that falls in the area is carried away by Horse Creek. Comparison of precipitation records and stream discharge at Horse Creek gaging station shows that as small a part of the precipitation as 1.7% leaves the area as run-off. This figure is probably unreliable, as the gaging station is located below Hawk Springs reservoir, from which water is diverted for irrigation. Part of the diverted water undoubtedly returns to the stream below the station.

The amount of water that penetrates to the water table is controlled by a number of factors, such as relief, porosity and permeability of rocks and soil, plant cover, and water table gradient. Theis (9: 564-568) has made estimates of the amount of ground-water recharge from precipitation in the southern High Plains of New Mexico, Texas, Oklahoma, Kansas, and Colorado. The studies deal principally with an area of 35,000 square miles in the Llano Estacado, western Texas, of which Theis says:

"The main ground-water body in the southern High Plains lies in the Ogallala formation, of Pliocene and perhaps Miocene age. . . . The formation is variable laterally, but consists of four types of sediments, namely: Gravel found in old stream courses throughout the section, but most prominent near the base in the pre-Ogallala valleys; unbedded and unconsolidated fine sand and silt, which make up the bulk of the formation; cemented zones of calcareous fine sand and silt, differing from the last only in cementation, and forming caliche zones; and finally at the top of the formation a limestone several feet thick. . . . Overlying this limestone in most of the area is a deposit of fine sand or silt, reaching a thickness of over 100 feet, which has been correlated with the Pleistocene loess in Kansas and is probably of the same age throughout the area. The water-bearing Ogallala deposits rest generally on impervious shales ranging in age from Permian to Cretaceous. The surface of these pre-Ogallala beds slopes east and east-southeast about ten feet to the mile.

"The High Plains are in most places surrounded by scarps a few hundred feet high reaching down to pre-Ogallala rocks. The water-body in the Ogallala is thus raised above and isolated from the ground water in contiguous areas. The surface of the Plains, and particularly the Llano Estacado, is largely unscored by erosion. It slopes also east and east-southeast about ten feet to the mile. The surface is smooth and flat except for a few sand dunes and for numerous sinks in the surface—'dry lakes' or 'buffalo wallows'—from a foot or two to over a hundred feet deep and from a few feet to several miles in diameter.

"Nearly all the precipitation on this area, especially on the Llano Estacado, is either discharged by transpiration and evaporation within a short distance of where it fell or seeps to and recharges the ground-water body. Only close to the few narrow-valleyed streams does any water run off. A good part collects as ephemeral ponds in the depressions, where it usually, but not in all localities, remains through months of drouth. To penetrate to the ground water, the precipitation must pass through the tight loess cover and through the dense but jointed limestone capping the Ogallala. In a few areas sand dunes cover the surface, and in these places recharge is more favored. The average yearly precipitation ranges from 14 inches in the southwestern part of the area to 22 inches in the northeastern. It occurs preponderantly as summer showers and hence at the most inopportune time for rainfall penetration.

"The water table in the central part of the High Plains lies about halfway between the surface of the ground and the base of the Ogallala. Like the ground surface and the floor of the water body, it slopes east or east-southeast about ten feet to the mile.

"Natural discharge of the ground water occurs to a small extent in a few water-table lakes in depressions in the High Plains, but largely it must occur as seeps and springs at the eastern escarpment of the Plains. However, there are very few springs of any size and little evidence in the character of the vegetation of a great amount of seepage."

Quantitative estimates of ground-water recharge were made in the Llano Estacado by (1) measuring the flow across a certain cross-section, and dividing this by the tributary area, and (2) by measuring water table fluctuations. Theis estimates the annual ground-water recharge from precipitation as one-eighth to two-thirds inch, which is about 3½% of the 14-inch mean annual precipitation.

Topography, general structure, prevailing sandy nature of rocks and soil, precipitation, and position of water table in the Horse Creek drainage basin are similar to the features described in the Llano Estacado. The limestone of the Ogallala and overlying mantle of loess found in the southern High Plains do not have complements in the Horse Creek area; ephemeral ponds are also absent. The Horse Creek area contains a number of small springs, and the slope of the catchment area is higher, about 25 feet to the mile; the effect of this steeper gradient may be offset, however, by the permeable nature of the exposed formations.

Assuming a recharge rate of 3½% of the mean annual precipitation, there would be an annual ground-water recharge of about 45,000 acre feet in the Horse Creek area; if the recharge were 5% there would be approximately 65,000 acre-feet. It is probable that ground-water recharge in the Horse Creek drainage basin is near these estimates.

## SURFACE WATER

### CREEKS

Horse Creek is supplied in part by tributaries rising in the Laramie Range and in part by tributaries rising in the Great Plains. It is perennial throughout its length. A dam below the junction with Bear Creek diverts water into Hawk Springs reservoir, which has a capacity of 19,400 acre-feet. Water from the reservoir is used for irrigation in the vicinity of Hawk Springs.

Bear Creek heads near the western escarpment of the Great Plains, is fed by small springs along its upper part, and has perennial, intermittent, and ephemeral parts above its junction with the tributary in sec. 9, T. 19 N., R. 66 W. Below the junction it is perennial, and receives water from numerous springs along the canyon walls. Water is diverted for local irrigation along the perennial parts.

Fox Creek is the only relatively large stream rising in the area which is perennial throughout its length. This is caused by the large springs near its head and smaller springs lower down. Only a small amount of the water is used for irrigation, and consequently the creek contributes a proportionately large flow to Bear Creek.

## SPRINGS

The springs along upper Horse Creek Valley are small. In most cases they are near the tops of the escarpments far back from the stream, and the water evaporates or is absorbed near the springs. In some instances ranchers have constructed small reservoirs or tanks for livestock use near the springs. The springs along Horse Creek between Meriden and Hawk Springs are larger; springs are of small importance below Hawk Springs.

Hawk Springs, now covered by the waters of Hawk Springs reservoir, was located three and one-half miles north of Lagrange. Adams (1 : 27-28) wrote concerning it in 1902:

> "Hawk Springs, at the west end of 66 Mountain, is perhaps the largest so-called spring in the Goshen Hole country. . . . The ground is seepy, and the water rises in a number of places. . . . The source of the water cannot be definitely determined . . . (but) it appears that a considerable quantity of ground water passes laterally from the creek (Horse Creek) into gravels and sands, and it is not improbable that Hawk Springs is the point of issuance of this water, which follows a natural channel now obscured by surficial material."

Contact springs (7: 51) along Bear Creek and Fox Creek occur at the contact between the Brule and Arikaree formations. The Arikaree sandstone and conglomerate is more permeable than the underlying Brule ash and clay, and, in the absence of fissuring in the upper part of the Brule, water issues from the ground at the contact. These springs are small and only moisten the clay at the contact. At a distance this contact appears as a line of vegetation along the faces of the escarpments.

The larger springs along Fox Creek and Bear Creek occur within the Arikaree formation, generally at the contact of thin-bedded and underlying massive sandstone. The spring (no. 89) at the Ira P. Trotter ranch is one of these. (Fig. 3)

The spring (no. 162) at the C. C. Donahue ranch on Little Horse Creek four miles southwest of Meriden is estimated by Mr. Donahue to have a flow of ¾ second-foot. The flow of the spring (no. 258) at the Jelmer Johnson ranch on Horse Creek six miles south of Lagrange is of about the same magnitude.

## RECORDS OF STREAM DISCHARGE

At the time of writing, records are available on the discharge of Horse Creek for the years 1929 to 1936 inclusive (10). A gaging station was located six miles southeast of Yoder, Wyo., in sec. 13, T. 22 N., R. 62 W., and was in operation from May, 1928, until September, 1932. This station measured the discharge of a drainage area of 1,320 square miles. Discharge data from this station for the years 1929 to 1931 inclusive, follow:

### HORSE CREEK NEAR YODER, WYOMING

Discharge in acre-feet

| Month | 1929 | 1930 | 1931 |
|---|---|---|---|
| January | 984 | 2,820 | 2,670 |
| February | 833 | 4,220 | 1,090 |
| March | 2,520 | 2,370 | 3,580 |
| April | 6,430 | 228 | 1,830 |
| May | 7,070 | 836 | 437 |
| June | 6,600 | 281 | 54 |
| July | 234 | 15 | 12 |
| August | 25 | 3,310 | 29 |
| September | 1,900 | 2,950 | 22 |
| October | 258 | 3,010 | 312 |
| November | 3,230 | 2,730 | 655 |
| December | 3,390 | 2,840 | 246 |
| Total | 33,474 | 25,610 | 10,937 |

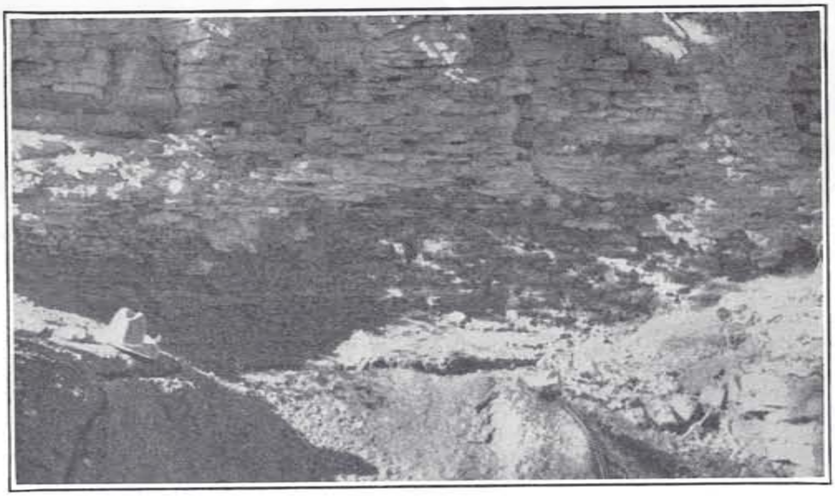

FIG. 3.—Spring (no. 89) issuing from the contact between a massive sandstone and the overlying thin-bedded fractured sandstone in the Arikaree. Sec. 17, T. 19 N., R. 65 W.

The other gaging station on Horse Creek is located in sec. 25, T. 23 N., R. 58 W., three miles northeast of Lyman, Neb., and measures the discharge of a drainage area of 1,860 square miles. Discharge data for the years 1932 to 1936 inclusive, follow:

HORSE CREEK NEAR LYMAN, NEBRASKA

Discharge in acre-feet

| Month | 1932 | 1933 | 1934 | 1935 | 1936 |
|---|---|---|---|---|---|
| January | 1,680 | 1,540 | 1,410 | 581 | 670 |
| February | 3,850 | 989 | 1,080 | 563 | 450 |
| March | 1,910 | 1,860 | 1,200 | 458 | 793 |
| April | 1,510 | 2,090 | 1,090 | 1,440 | 845 |
| May | 3,280 | 10,500 | 516 | 2,190 | 949 |
| June | 10,200 | 7,740 | 1,110 | 10,080 | 5,950 |
| July | 6,640 | 5,950 | 1,000 | 2,680 | 1,680 |
| August | 7,750 | 8,240 | 1,030 | 2,070 | 2,380 |
| September | 8,510 | 14,300 | 768 | 2,480 | 1,880 |
| October | 5,210 | 5,480 | 781 | 1,790 | 1,860 |
| November | 2,160 | 1,830 | 631 | 1,360 | 1,120 |
| December | 1,320 | 1,550 | 732 | 930 | 841 |
| Total | 54,020 | 62,069 | 11,348 | 26,622 | 19,418 |

Diversion of water for irrigation at Hawk Springs reservoir, 11 miles above the Yoder gaging station, influenced the records of the Yoder station. Gagings were abnormally low during some summer months when almost all the flow of Horse Creek was diverted into Hawk Springs reservoir. It is probable that return flow from irrigated areas added to the run-off during the fall months.

Records of the Lyman gaging station are more reliable than those of the Yoder station. Part of the water diverted at Hawk Springs reservoir re-enters Horse Creek as return flow above the Lyman station. The gagings at this station, however, undoubtedly include some water from outside the Horse Creek drainage area, as some of the land irrigated by the Fort Laramie canal, which diverts water from the North Platte River, provides a return flow into the lower part of Horse Creek.

## UNDERGROUND WATER

### SOURCE

The underground water of the region is derived from two sources. Horse Creek contributes a relatively small but stable volume of water from the Laramie Range. Influent seepage from the stream is of importance in the valley near Horse Creek post office, and farther down where water is diverted for local irrigation.

The major source of underground water is, however, precipitation that falls on the area. Part of the precipitation seeps into the ground and percolates downward. Absorption is small in areas of dense clay and is proportionately high in outcrops of conglomerate and sandstone. For the entire area, an estimated ground-water recharge of 5% of the precipitation has been mentioned previously in this paper.

## RELATION TO SURFACE FEATURES

Underground water is controlled to a large extent by surface features. Absorption is less on steep slopes than on gentle slopes, other factors being equal. Leakage from water-bearing beds occurs at springs in some places along escarpment faces and valley walls, especially along Fox Creek and Bear Creek. Sharp and narrow crests, which tend to produce well delineated drainage divides, are absent, but the long, narrow valleys form natural lines of drainage. Underground water normally moves toward them in much the same direction as surface water.

## OCCURRENCE

**Colorado group, Pierre shale, and Fox Hills sandstone.**—These rocks, which consist of shales, sandstones, and a few thin beds of limestone, are exposed in the extreme western part of the area near Horse Creek post office (Pl. II), where they form foothills against the Laramie Range and are exposed in the floors of Federal Valley and upper Horse Creek Valley. They have a total thickness of about 5,300 feet and dip eastward at 30° to 60°; the dip decreases eastward from the Laramie Range.

There are no wells that produce from the Colorado group. The sandstones and limestones of the Colorado group are probably aquifers, but are at too great a depth under most of the area to be important sources of water. Wells drilled in the Pierre shale have had varying degrees of success, depending upon whether or not a sandstone aquifer was reached. In some places it is possible to locate wells so that they will produce from sandstones in the Pierre shale; at other places it is covered by alluvium or White River sediments and consequently the position of the sandstone beds cannot be determined from surface observation. Ground-water conditions in the Fox Hills sandstone are normally more favorable for well production than in the Pierre.

Tests on water from the Pierre show the presence of Epsom salt and Glauber's salt, and a standard $CaCO_3$ hardness of 720 parts per million, which is three and one-half times the hardness of that used for domestic purposes in Laramie. The Fox Hills yields water of better quality than the Pierre, but it is hard. Water from these formations is used for domestic purposes, but it leaves much to be desired. These rocks do not contain underground water in quantities sufficient for irrigation.

**Lance formation.**—The Lance formation, a succession of sandstones and sandy shales, is exposed in lower Horse Creek Valley and in Goshen Hole (Pl. III). It is the youngest Cretaceous unit exposed. The structure and stratigraphy of the Lance are not completely understood, but the prevailing dips are low and the average thickness is about 400 feet. It is doubtful that the entire succession is present at any one locality. Conditions for water production from shallow wells are in general more favorable than in the older Cretaceous rocks near Horse Creek post office. The quality of the water, which is not as good as that from the Tertiary formations, varies at different stratigraphic levels in the Lance. Water from some horizons is highly mineralized. There is abundant ground-water for domestic use, but it is doubtful that wells in the Lance would provide enough water for irrigation.

**Chadron formation.**—There is no record of wells drilled in the Chadron formation in the western part of the area. In the eastern part, around the edge of Goshen Hole, the Chadron occurs as lenses of sandstones and sandy shales up to 60 feet thick between the Lance and Brule. Wherever the Chadron extends below the water table, it carries water in quantities ample for domestic use. The water is of better quality than that of the underlying Cretaceous rocks.

**Brule formation.**—The average thickness of the Brule is about 200 feet. For the most part, it is a claystone composed largely of dacitic and andesitic volcanic ash, and is too impervious to permit free transmission of water. At some exposures, the Brule is cut by bed joints and at least one set of vertical joints; in addition, fissures up to 12 inches wide and 30 feet deep are present. In some instances, the fissures are filled with conglomerate and sandstone from the overlying Arikaree formation, but usually the filling is the same type of material as the wall rock.

It is believed that surface water percolates downward and enters the interconnecting joints, which function as narrow channels and transmit water to the wider fissures. The fissures are large enough to retain a considerable quantity of water and to concentrate the water supplied by the tributary joint system. A well which penetrates a fissure yields water; one that does not is dry or gives a small yield.

This hypothesis would explain the erratic success of wells drilled in the Brule, for often large-yield wells are located near dry holes. As the fissures are only a few inches wide, it seems improbable that large-yield wells produce only water stored in fissures. If such were the case, water in a fissure would behave as though stored in a tank, for the drainage area of the fissure walls is relatively small. On the other hand, if the fissure were connected by a tributary system of joints, the total drainage area of the joint walls would be much larger. The cone of influence of a well producing from the fissure would also be much larger.

The joints and fissures in the Brule are secondary, rather than original interstices, but their origin is not yet understood. The fissures are covered and their extent and size cannot be determined from surface observation and, consequently, the success of wells in the Brule cannot be anticipated in advance. Water from the Brule is of good quality, and is suitable for domestic use.

**Brule-Arikaree contact.**—Water percolating downward through the Arikaree may be held in the basal gravels or sandstones of the formation. Such a condition prevails where the upper part of the Brule is free from joints and fissures. Wells drilled in the Arikaree to the Arikaree-Brule contact usually yield enough water for domestic use, although the supply is commonly smaller than that obtained from fissures in the Brule. Some wells have failed to produce water in either the basal Arikaree or in the upper Brule. Such failures cannot be predicted.

**Arikaree formation.**—The Arikaree formation has an average thickness of about 275 feet, and forms the surface of the Great Plains. It is conglomeratic in the western part of the area (Fig. I). The conglomerate lenses pinch out eastward and are replaced by sands. In the eastern part of the area the conglomerates are represented by thin lenses of gravel. Here the formation is composed, for the most part, of soft permeable sandstones. It appears that both the conglomerate and sandstone facies are highly permeable, for on the Great Plains wells producing from the Arikaree formation are about 150 feet deep. This shows that the zone of saturation occurs normally in the lower part of the formation.

Local indurated layers in the Arikaree, such as those exposed at Bear Mountain and in adjacent areas, may impede or prevent downward percolation of ground water and produce perched water tables of small area. Perched water tables also occur where thin-bedded sandstones overlie more massive sandstones.

A few wells drilled in the Arikaree have encountered water under hydrostatic pressure, which caused the water to rise several feet in the wells; this condition, however, is not general. Because of the formation's high topographic position, it does not yield large amounts of water. The water is of good quality and occurs in quantities ample for domestic use, but insufficient for well irrigation.

**Alluvium.**—The streams, especially in the eastern part of the area, are aggrading, but have not yet developed wide flood plains. Deposits of alluvium along the streams, for the most part, are derived from rocks in the area; those of Horse Creek Valley are derived in part from the granites of the Laramie Range. The thickness of the alluvium ranges from a few feet to 30 feet. Twelve to 15 feet is the average thickness along the principal streams.

The alluvium is an important source of underground water in lower Horse Creek Valley near Lagrange. Here Horse Creek is in places an influent stream, i. e., contributes water to the zone of saturation. Water also enters the alluvium by seepage from the adjacent uplands. Large amounts of gravel are present in the alluvium, so that rapid withdrawal of a large volume of water is possible. The two successful irrigation wells (nos. 251, 252) in the area produce largely from gravel beds in the alluvium.

Many residents secure water for domestic use from the alluvium. Well irrigation from the alluvium is most feasible near Lagrange. It is probable that irrigation wells might produce successfully from the stream alluvium elsewhere, provided the volume of gravel is large enough.

## DEPTH TO WATER TABLE

The water table lies at depths ranging from a few feet to more than 200 feet beneath the surface. Plate I, compiled from well data, shows depth to the water table classified as under 50 feet, 50 to 100 feet, 100 to 200 feet, more than 200 feet, and unclassified. Areas designated as unclassified are those for which well data are lacking. In most instances, however, an approximate figure for depth to the water table can be obtained by reference to a near-by area for which the depth is known.

The shape of the water table normally conforms to that of the ground surface, but has less relief. The water table is nearer the surface in the valleys. Fluctuations of the water table are due to the different modes of occurrence of underground water just discussed, and because of the varying factor of water disposal through evaporation, transpiration, percolation, and run-off. Fluctuations could not be noted within the short time alloted to this study, and the residents have little knowledge of variation in water table levels. Mr. Hugh Stemler states that from observation of his irrigation wells (nos. 251, 252) in the alluvium of lower Horse Creek Valley, the water table is normally three feet lower in October than in May, provided precipitation is normal.

## ARTESIAN CONDITIONS

The only flowing well in the area (no. 225) is in lower Horse Creek Valley about seven miles west of the Nebraska line. According to Mr. A. Jones, the owner, the well was drilled for oil and abandoned at a depth of about 5,000 feet. The flow is small, and the water is heavily mineralized. Water reaches the surface through a pipe two inches in diameter, and is used for watering livestock and for pasture irrigation. No log was available, and the horizon from which the water comes is not known.

The geology and topography are such that it is not anticipated that flowing artesian wells will be encountered in the Tertiary rocks. Deep wells sunk into the underlying Cretaceous rocks might flow, but it is probable that water from such wells would be unfit for domestic use.

## RECHARGE FROM STREAM AND IRRIGATION WATER

Horse Creek and Bear Creek are influent in some places and effluent in others. A stream or stretch of a stream is influent with respect to ground water if it contributes water to the zone of saturation. A stream or stretch of a stream is effluent with respect to ground water if it receives water from the zone of saturation (*7*: 56). The gradient of Bear Creek is greater than that of Horse Creek, and influent stretches along Bear Creek, other things being equal, are shorter and less numerous. The principal influent stretch of Horse Creek is near Lagrange, and it is here that the optimum conditions for irrigation from ground water in the area prevail.

Ground-water recharge from irrigation occurs in two ways: (1) through seepage from canals, and (2) from percolation after use. Mr. C. C. Donahue, water commissioner, states that in the sandy soil of Goshen Hole as much as 65% of irrigation water is lost in transit through percolation and evaporation. No figures on fluctuations of the water table in irrigated areas of this district are available, but there is evidence that the water table is nearer the surface now than before irrigation. In some areas irrigated by the Fort Laramie canal, which diverts water from the North Platte River, this rise in water table is as much as 25 feet.

## IRRIGATION SUPPLIES

Successful well irrigation depends largely upon the factors: (1) the water table must be at a relatively shallow depth; (2) there must be a sufficient quantity of water available for irrigation; and (3) the area to be irrigated must be near the well.

At the present time, Mr. Hugh Stemler of Lagrange is the only farmer in the area using well irrigation. His pump, powered by a small farm tractor, lifts water simultaneously from two adjacent wells (nos. 251, 252). Well no. 251 is 33 feet deep and four feet in diameter; well no. 252 is 68 feet deep and two feet in diameter. The pump has a capacity of 1,200 gallons per minute, or approximately 2.7 second feet.

The Quaternary alluvium and gravel here is about 30 feet thick. Both wells obtain the larger part of the water from the alluvium, and the remainder from the underlying White River group. The water level normally fluctuates from six feet below the surface in May to nine feet below the surface in October.

During the 1939 growing season the pumping plant irrigated 160 acres, on which the following crops were grown: beets, 17 acres; beans, 107 acres; barley, 22 acres; corn, 10 acres; and millet, 4 acres. The plant was in operation 96 days. Operating cost, exclusive of depreciation, was $186.56.

In drilling wells for irrigation, residents are cautioned against (1) drilling wells in localities other than those covered by Quaternary alluvium (Pls. II and III), and (2) drilling deep wells from which water cannot be raised to the surface economically, even if it is encountered in quantities ample for irrigation.

## MUNICIPAL SUPPLIES

Hawk Springs and Lagrange are the only villages in the area. Neither has a municipal water-supply system. There are about 12 wells in Hawk Springs, all of which produce from the Lance formation. The wells are about 75 feet deep, and none of them yield water in large quantities; the volume, however, is ample for domestic use. There are about 50 wells in Lagrange. These are shallower than those at Hawk Springs and produce from the White River group and the Quaternary alluvium at a depth of about 35 feet. Water level in the wells is approximately 25 feet below the surface. The supply is more abundant here than at Hawk Springs.

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# WELL DATA

## DATA FOR WELLS SHOWN ON PLATE II

(Numbers 1-131 inclusive)

| No. | LOCATION | OWNER | Method of lift | Elev. | Depth | Diam. | Water level | Aquifer | Topog. | Use | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | C—35-17-70 | J. C. Monday | Wind | 6550 | 17 | Dug | 9 | Qal. | Valley | Gen. | Dry in 1934 |
| 2 | SW—25-17-70 | Harold C. Jones | Hand | 6505 | 62 | 6″ | 17 | Kp | do | do | Water is very hard |
| 3 | NW—25-17-70 | John Innes | do | 6460 | 16 | Dug | .... | Qal | do | do | |
| 4 | SE—30-17-69 | Chas. F. Smith | Wind | 6425 | 25 | do | 15 | Twr | do | do | |
| 5 | SE—28-17-69 | W. S. Dereemer | do | 6450 | 117 | 6″ | 57 | do | do | do | |
| 6 | E½—27-17-69 | Nick Contos | Hand | 6370 | 30 | Dug | 22 | Qal | do | do | |
| 7 | W½—13-17-70 | John Whitaker | Wind | 6560 | 35 | 6″ | .... | Kp | do | do | |
| 8 | NW—8-17-69 | Nimmo Livestock Co. | do | 7050 | 110 | do | .... | Twr | Hillside | Stock | Not in use |
| 9 | SW—4-17-69 | do | do | 7060 | 120 | do | .... | do | Draw | do | Never pumps dry |
| 10 | C—3-17-69 | do | .... | 6875 | 110 | do | .... | do | do | .... | Not in use |
| 11 | E½—21-18-69 | C. W. Hirsig II | Wind | 6510 | 126 | do | 108 | do | do | Stock | |
| 12 | NW—17-18-69 | do | do | .... | ? | do | 60 | do | do | do | |
| 13 | 6-18-69 | R. J. Welty | do | 6820 | 200 | do | .... | do | Plains | do | Pumps dry |
| 14 | 6-18-69 | do | do | 6840 | 287 | do | .... | do | do | .... | Dry |
| 15 | NE—10-18-69 | C. W. Hirsig II | do | 6510 | 440 | do | 12 | do | Valley | Gen. | Tried for flowing well |
| 16 | E½-21-17-68 | Dugald Whitaker | do | 6220 | 30 | do | .... | Qal | do | do | |
| 17 | NE—13-17-68 | Nimmo Livestock Co. | do | 6120 | 117 | do | 60 | Twr | Hillside | Stock | Never pumps dry |
| 18 | SE—21-18-68 | do | do | .... | 52 | do | .... | do | Valley | do | |
| 19 | NE—12-19-68 | Carl Long | do | 6035 | 143 | do | .... | do | Plains | Gen. | Pumps dry |
| 20 | S½—6-19-67 | Claud Long | do | 6035 | 180 | do | .... | do | do | do | |
| 21 | SW—5-19-67 | do | do | 6015 | 175 | do | .... | do | do | do | |
| 22 | E½—4-19-67 | Chas. Cline | do | 5860 | 220 | do | .... | do | do | do | Very good water |
| 23 | N½—10-19-67 | H. W. Gard | do | 5820 | 150 | do | .... | do | do | Stock | |
| 24 | SE—35-20-67 | Harry Ewart | do | 5710 | 159 | do | 145 | do | Draw | Gen. | |
| 25 | SW—36-20-67 | G. H. Tate | do | 5700 | 116 | do | .... | do | do | do | Gravel bed produces water |
| 26 | SW—1-19-67 | Margaret Hanson | do | 5760 | 201 | do | 125 | do | Plains | do | First water at 93 feet |
| 27 | NE—11-19-67 | Henry Hanson | do | 5760 | 160 | do | 130 | do | do | do | |
| 28 | SW—12-19-67 | H. W. Gard | do | 5740 | 154 | do | 135 | do | do | do | Can be pumped dry |
| 29 | SE—11-19-67 | do | do | 5820 | 162 | do | .... | do | do | Stock | do |
| 30 | E½—15-19-67 | Frank A. Bliss | do | 5875 | 180 | do | | do | do | Gen. | Pumps dry |

# DATA FOR WELLS SHOWN ON PLATE II—Continued

| No. | LOCATION | OWNER | Method of lift | Elev. | Depth | Diam. | Water level | Aquifer | Topog. | Use | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 | C—14-19-67 | W. F. Young | Hand | 5730 | 22 | Dug | 20 | Twr | Plains | Gen. | Pumps dry |
| 32 | C—14-19-67 | do | Wind | 5730 | 65 | 6″ | .... | do | do | do | Gravel bed produces water |
| 33 | E½—24-19-67 | do | do | 5700 | 38 | do | 36 | do | do | Stock | do |
| 34 | E½—25-19-67 | Percy Laycock | Motor | 5700 | 12 | do | .... | Qal | Valley | Gen. | ........ |
| 35 | NW—5-18-67 | F. L. DuVall | Wind | 5880 | 75 | do | .... | Twr. | Plains | do | Never pumps dry |
| 36 | NE—4-18-67 | H. A. DuVall | do | 5950 | 40 | do | .... | do | do | do | Can be pumped dry |
| 37 | SE—5-18-67 | Ralph Rogers | do | 5860 | 65 | do | .... | do | do | do | Never pumps dry |
| 38 | 10-18-67 | Alton Bell | do | 5940 | 100 | do | 80 | do | do | do | do |
| 39 | SE—16-18-67 | Mrs. Eargle | do | 6000 | 185 | do | .... | do | do | do | ........ |
| 40 | NE—19-18-67 | Dave Stalker | do | 6000 | 180 | do | .... | do | do | do | Has been pumped dry |
| 41 | NE—27-18-67 | Alex Nimmo | Hand | 5940 | 65 | do | .... | do | Valley | do | ........ |
| 42 | NW—29-18-67 | Nimmo Livestock Co. | Wind | 6025 | 250 | do | 150 | do | Plains | Stock | ........ |
| 43 | C—1-17 67 | J. M. Carey | do | 5950 | 157 | do | 97 | do | Hillside | Gen. | ........ |
| 44 | N½—10-17-67 | do | do | 5950 | 30 | Dug | 27 | Qal | Valley | do | ........ |
| 45 | SW—28-17-67 | O. S. Shelton | do | 6430 | 235 | 6″ | 205 | Twr | Plains | do | Gravel bed produces water |
| 46 | S½—26-17-67 | Keith Holmes | do | 6300 | 175 | do | 150 | do | do | Stock | ........ |
| 47 | S½—32-17-67 | O. S. Shelton | do | 6475 | 240 | do | 233 | do | do | Gen. | Gravel bed produces water |
| 48 | SE—2-16-67 | Keith Holmes | do | 6320 | 160 | do | 140 | do | do | do | ........ |
| 49 | NE—12-16-67 | C. S. Vanderpool | do | 6280 | 200 | do | 163 | do | do | do | ........ |
| 50 | SW—6-16-66 | Floyd Holmes | do | 6270 | 200 | do | 180 | do | do | do | ........ |
| 51 | N½—8-16-66 | C. S. Vanderpool | do | 6210 | 178 | do | 157 | do | do | Stock | ........ |
| 52 | SW—2-16-66 | John Bevan | do | 6150 | 250 | do | .... | do | do | Gen. | ........ |
| 53 | NW—4-16-66 | Barney Faber | do | 6190 | 200 | do | 184 | do | do | do | "Sand pumped" every 5 years |
| 54 | S½—32-17-66 | A. Peters | do | 6180 | 156 | do | 144 | do | do | Stock | ........ |
| 55 | C—34-17-66 | do | do | 6140 | 215 | do | 200 | do | do | Gen. | ........ |
| 56 | C—14-17-66 | Geo. Persse | do | 5825 | 50 | do | 37 | do | do | do | ........ |
| 57 | SE—4-17-66 | J. M. Carey | Motor | 5740 | 60 | do | 30 | do | Hillside | Stock | ........ |
| 58 | NW—4-17-66 | Mrs. W. P. Owens | Wind | 5860 | 208 | do | 180 | do | Plains | Gen. | ........ |

## DATA FOR WELLS SHOWN ON PLATE II—Continued

| No. | LOCATION | OWNER | Method of lift | Elev. | Depth | Diam. | Water level | Aquifer | Topog. | Use | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 59 | NW—5-17-66 | Harry Creathbaum | do | 5920 | 156 | do | 100 | do | do | do | |
| 60 | SW—32-18-66 | Mary Kirkbride | Wind | 5930 | 135 | 6" | 35 | Twr | Plains | Gen. | |
| 61 | SW—33-18-66 | Mrs. Mable Beaver | do | 5860 | 130 | do | 100 | do | do | Stock | |
| 62 | SE—34-18-66 | do | do | 5780 | 150 | do | 100 | do | do | Gen. | |
| 63 | NW—34-18-66 | do | do | 5840 | 130 | do | 100 | do | do | do | |
| 64 | NW—32-18-66 | Mary Kirkbride | do | 5975 | 224 | do | 175 | do | do | Stock | |
| 65 | C—29-18 66 | do | do | 5920 | 200 | do | 165 | do | do | do | |
| 66 | C—24-18-66 | Oscar Pence | do | 5600 | 90 | do | .... | do | do | do | |
| 67 | NW—22-18-66 | do | do | .... | 90 | do | .... | do | do | do | |
| 68 | NE—17-18-66 | Mary Kirkbride | do | .... | 60 | do | 10 | do | Valley | do | |
| 69 | C—8-18-66 | R. Trotter | do | 5590 | 64 | do | .... | do | Draw | do | |
| 70 | NW—7-18-66 | Nimmo Livestock Co. | do | .... | 120 | do | .... | do | Hillside | do | Never pumps dry |
| 71 | NW—11-18 66 | Oscar Pence | do | 5560 | 60 | do | 28 | do | Draw | Gen. | |
| 72 | C—3-18-66 | R. Trotter | Hand | 5550 | 12 | do | .... | Qal | Valley | do | |
| 73 | W½—5-18-66 | Henry Hanson | Wind | 6000 | 130 | do | 100 | Twr | Plains | do | |
| 74 | NE—23-19-66 | L. G. Harding | do | 5540 | 120 | do | .... | do | do | Stock | |
| 75 | C—12-19-66 | do | do | 5475 | 140 | do | .... | do | do | Gen. | |
| 76 | N½—11-19 66 | Earl Marsh | do | 5300 | 70 | do | 40 | do | Valley | do | |
| 77 | NW—3-19-66 | Peter Schultz | do | 5575 | 120 | do | 70 | do | Plains | Stock | |
| 78 | NW—4-19-66 | do | do | 5615 | 161 | do | 90 | do | do | Gen. | |
| 79 | SW—32-20-66 | Max Pensold | do | 5600 | 135 | do | 100 | do | Draw | do | First water at 100 feet |
| 80 | SE—31-20-66 | do | do | 5640 | 165 | do | 100 | do | Hillside | Stock | |
| 81 | S½—31-20-66 | do | do | 5640 | 173 | do | 100 | do | do | do | |
| 82 | NW—10-20-65 | Chas. Enix | do | 5370 | 160 | do | .... | do | Plains | Gen. | |
| 83 | N½—11-20-65 | Bill Wright | do | 5410 | 119 | do | 112 | do | do | do | |
| 84 | N½—12-20-65 | P. J. Peterson | do | 5380 | 139 | do | 102 | do | do | do | First water at 110 feet |
| 85 | S½—12-20-65 | A. M. Marvick | do | 5390 | 124 | do | 115 | do | do | do | |
| 86 | E½—36-20-65 | Jay Bowie | do | 5340 | 130 | do | .... | do | do | Stock | |
| 87 | NW—3-19-65 | W. J. Pence | do | 5350 | 145 | do | 120 | do | do | Gen. | |
| 88 | NE—9-19-65 | do | do | 5390 | 140 | do | 120 | do | do | do | |
| 89 | N½—17-19-65 | Ira P. Trotter | Springs | 5300 | .... | .... | .... | do | Valley | do | Contact spring |
| 90 | SE—13-19-65 | Ella Griffin | do | 5150 | .... | .... | .... | do | do | do | do |

## DATA FOR WELLS SHOWN ON PLATE II—Continued

| No. | LOCATION | OWNER | Method of lift | Elev. | Depth | Diam. | Water level | Aquifer | Topog. | Use | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 91 | N½—10-18-65 | H. H. Young | Wind | 5575 | 200 | 6" | .... | Twr | Plains | Gen. | |
| 92 | C—11-18-65 | Albert Werner | Wind | 5400 | 200 | 6" | 160 | do | do | Stock | |
| 93 | E½—7-18-65 | Sam Davis | do | 5775 | 257 | do | 222 | do | do | Gen. | |
| 94 | SE—7-18-65 | E. W. Harding | do | 5640 | 165 | do | .... | do | Valley | do | |
| 95 | S½—9-18-65 | Telsie G. Werner | do | 5460 | 180 | do | 100 | do | Draw | do | |
| 96 | NW—17-18-65 | E. W. Harding | do | 5600 | 150 | do | .... | do | Valley | do | |
| 97 | C—15-18-65 | Albert Werner | do | 5460 | 110 | do | 80 | do | Plains | do | |
| 98 | S½—20-18-65 | do | do | 5505 | 140 | do | 110 | do | do | Stock | |
| 99 | S½—35-18-65 | Alex Kirkbride | do | 5550 | 100 | do | 75 | do | Hillside | Gen. | |
| 100 | S½—35-18-65 | do | do | 5445 | 50 | do | 25 | do | Valley | Stock | |
| 101 | 11-17-65 | Warren Livestock Co. | do | 5640 | 200 | do | .... | do | Plains | do | |
| 102 | E½—27-17-65 | do | do | 5940 | 222 | do | 172 | do | do | do | |
| 103 | SE—12-16-65 | J. C. Berry | do | 5910 | 245 | do | 232 | do | do | Gen. | |
| 104 | SW—4-16-64 | D. M. Stevens | do | 5750 | 168 | do | 145 | do | do | do | |
| 105 | 35-17-64 | James Wilkinson | do | 5725 | 250 | do | .... | do | do | Stock | |
| 106 | 29-17-64 | do | do | 5825 | 250 | do | .... | do | do | do | |
| 107 | 19-17-64 | do | do | 5750 | 150 | do | .... | do | do | do | |
| 108 | 22-17-64 | do | do | 5650 | 260 | do | .... | do | do | do | |
| 109 | 23-17-64 | do | do | 5700 | 250 | do | .... | do | do | do | |
| 110 | 12-17-64 | do | do | 5500 | 140 | do | .... | do | do | do | |
| 111 | 36-18-64 | do | do | 5450 | 100 | do | .... | do | do | do | |
| 112 | N½—20-18-64 | Dan Kirkbride | do | 5400 | 138 | do | 108 | do | do | Gen. | |
| 113 | 18-18-64 | James Wilkinson | do | .... | 150 | do | .... | do | do | Stock | |
| 114 | C—12-18-64 | Wallace Powers | do | 5300 | 175 | do | 160 | do | do | Gen. | |
| 115 | NW—27-19-64 | Geo. Weaver | do | .... | 180 | do | 150 | do | do | Stock | |
| 116 | SW—24-19-64 | Oscar Yoder | do | 5340 | 180 | do | .... | do | do | do | |
| 117 | SW—12-19-64 | do | do | 5010 | 90 | do | 30 | do | Valley | Gen. | |
| 118 | SE—12-19-64 | William Brown | Motor | 4990 | 90 | 11" | 10 | do | do | do | First water at 10 feet |
| 119 | SW—8-19-64 | W. J. Bunn | Springs | 5100 | .... | .... | .... | do | do | do | Contact Spring |
| 120 | NW—4-19-64 | Frank Horton | Wind | 5340 | 165 | 6" | .... | do | Plains | Stock | |
| 121 | NE—4-19-64 | do | do | 5340 | 200 | do | .... | do | do | do | |

## DATA FOR WELLS SHOWN ON PLATE II—Continued

| No. | LOCATION | OWNER | Method of lift | Elev. | Depth | Diam. | Water level | Aquifer | Topog. | Use | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 122 | C—31-20-64 | do | do | 5360 | 170 | do | .... | do | do | do | |
| 123 | NW—32-20-64 | do | do | 5350 | 150 | do | .... | do | do | do | |
| 124 | E½—33-20 64 | Frank Horton | do | 5340 | 200 | do | 170 | do | do | Gen. | |
| 125 | S½—27 20-64 | C. D. Fulton | do | 5310 | 212 | do | 200 | do | do | do | |
| 126 | SW—26-20-64 | do | do | 5180 | 226 | do | .... | do | do | Stock | |
| 127 | SE—23-20-64 | Arthur Mathoit | Hand | 5080 | 80 | do | .... | do | Draw | Gen. | |
| 128 | S½—13-20-64 | R. D. Bunn | Wind | 4990 | 20 | Dug | 12 | Qal | Valley | do | |
| 129 | N½—7-20-64 | A. J. Eslinger | do | 5350 | 190 | 6" | 130 | Twr | Plains | Stock | First water at 140 feet |
| 130 | S½—6-20-64 | E. F. Samuelson | do | 5340 | 150 | do | 90 | do | do | Gen. | |
| 131 | NE—1-20-64 | R. E. Swanson | do | 5250 | 240 | do | .... | do | do | do | |

## DATA FOR WELLS SHOWN ON PLATE III

(Numbers 132-288 inclusive)

| No. | LOCATION | OWNER | Method of lift | Elev. | Depth | Diam. | Water level | Aquifer | Topog. | Use | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 132 | NE—5-20-63 | R. E. Swanson | Wind | 5180 | 180 | 6" | .... | Twr | Plains | Stock | |
| 133 | SE—6 20-63 | do | do | 5220 | 180 | do | .... | do | do | do | |
| 134 | NW—28-20-63 | Geo. Hendrickson | do | 4960 | 135 | do | .... | do | do | do | |
| 135 | SW—27-20-63 | do | do | 4970 | 159 | do | 125 | do | do | Gen. | |
| 136 | SE—28-20-63 | do | do | 4970 | 135 | do | 125 | do | do | Stock | |
| 137 | N½—32-20-63 | Geo. Parsons | do | 4995 | 145 | do | 110 | do | do | Gen. | |
| 138 | N½—1-19-63 | Albert Kessler | do | 4845 | 75 | do | .... | do | Valley | do | |
| 139 | NE—3-19-63 | Julia W. Yates | do | 4900 | 167 | do | 87 | do | do | do | |
| 140 | NE—3 19-63 | do | do | 4885 | 15 | Dug | 10 | Qal | do | do | |
| 141 | N½—7-19-63 | Arthur Schiske | do | 4930 | 75 | 6" | 40 | Twr | Hillside | do | |
| 142 | NE—23-19-63 | Pete Haberkorn | do | 5100 | 204 | do | 200 | do | Plains | do | Small flow into well |
| 143 | SW—23-19-63 | do | do | 5060 | 170 | do | .. | do | Draw | Stock | Never pumps dry |

## DATA FOR WELLS SHOWN ON PLATE III—Continued

| No. | LOCATION | OWNER | Method of lift | Elev. | Depth | Diam. | Water level | Aquifer | Topog. | Use | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 144 | N½—26-19-63 | B. A. Hubbs | Wind | 5140 | 200 | 6″ | .... | Twr | Plains | Gen. | Pumps dry |
| 145 | C—25-19-63 | F. W. Booth | do | 5220 | 150 | do | 80 | do | do | do | Never pumps dry |
| 146 | S½—33-19-63 | Walter Hunnel | do | 5220 | 108 | do | .... | do | do | do | .......... |
| 147 | E½—1-18-63 | Union Pacific | do | 5125 | 40 | do | 35 | do | Hillside | do | Can be pumped dry |
| 148 | E½—4-18-63 | Harold Hunnel | do | 5230 | 214 | do | 180 | do | Plains | do | .......... |
| 149 | SW—4-18-63 | W. J. Hixenbaugh | do | 5245 | 140 | do | 122 | do | do | do | .......... |
| 150 | SE—5-18-63 | Alvin Krakow | do | 5250 | 150 | do | 120 | do | do | do | .......... |
| 151 | E½—10-18 63 | John Donahue | do | 5225 | 175 | do | 145 | do | do | do | Pumps dry |
| 152 | C—12-18-63 | Clint C. Donahue | .... | 5150 | 400 | do | .... | do | do | .... | Dry; not in use |
| 153 | C—12-18-63 | do | .... | 5150 | 200 | do | .... | do | do | .... | do |
| 154 | S½—10-18-63 | W. F. Hansen | Wind | 5165 | 80 | do | 68 | do | do | Gen. | Can be pumped dry |
| 155 | N½—14-18-63 | Clint Donahue | do | 5110 | 60 | do | 45 | do | do | Stock | .......... |
| 156 | N½—14-18-63 | do | do | 5100 | 100 | do | 80 | do | do | do | First water at 60 feet |
| 157 | C—15-18-63 | W. F. Hansen | do | 5170 | 75 | do | 63 | do | do | do | Can be pumped dry |
| 158 | NE—20-18-63 | John Donahue | do | 5330 | 175 | do | 145 | do | do | do | .......... |
| 159 | NE—22-18-63 | Clint C. Donahue | do | 5125 | 65 | do | 60 | do | do | do | Does not pump dry |
| 160 | NE—23-18-63 | do | do | 5080 | 50 | do | 30 | do | do | do | .......... |
| 161 | N½—30-18-63 | James Wilkinson | do | 5300 | 100 | do | .... | do | do | do | .......... |
| 162 | SW—25-18-63 | Clint C. Donahue | Spring | 5060 | .... | .... | .... | do | Valley | Gen. | ¾ sec. ft. flow |
| 163 | E½—33-18-63 | James Wilkinson | Wind | .... | 30 | 6″ | .... | Qal | do | Stock | .......... |
| 164 | 4 17 63 | do | do | 5400 | 75 | do | 45 | Twr | Plains | do | .......... |
| 165 | 4 17-63 | do | Hand | 5300 | 30 | do | 20 | do | Draw | Gen. | .......... |
| 166 | 9 17-63 | do | Wind | .... | 140 | do | .... | do | do | Stock | .......... |
| 167 | 18 17 63 | do | do | 5500 | 150 | do | .... | do | Plains | Gen. | .......... |
| 168 | SW—10-18-62 | Alex Shield | do | 4920 | 75 | do | .... | do | Valley | do | .......... |
| 169 | SW—9-18-62 | Dan Donahue | do | 4925 | 70 | do | .... | do | do | do | Never pumps dry |
| 170 | W½—9-18-62 | Meriden Store | do | 4970 | 80 | do | 45 | do | do | do | .......... |
| 171 | NW—11-18-62 | Maple Grove Co. | do | 4960 | 75 | do | .... | do | do | do | .......... |
| 172 | NE—11-18-62 | do | do | 4920 | 75 | do | .... | do | do | do | .......... |
| 173 | W½—8-18-62 | Claud Booth | do | 5060 | 247 | do | 120 | do | Draw | Stock | .......... |
| 174 | E½—7-18-62 | do | do | 5105 | 210 | do | 47 | do | do | Gen. | Fills from seep at 47 feet |
| 175 | E½—6-18-62 | John W. Brown | do | 4980 | 25 | Dug | 22 | Qal | Valley | do | .......... |

## DATA FOR WELLS SHOWN ON PLATE III—Continued

| No. | LOCATION | OWNER | Method of lift | Elev. | Depth | Diam. | Water level | Aquifer | Topog. | Use | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 176 | NE—30-19-62 | F. W. Booth | do | 5100 | 150 | 6" | .... | Twr | Plains | do | |
| 177 | SW—18-19-62 | Noah Gregory | do | 5100 | 256 | do | 90 | do | do | do | |
| 178 | N ½—18-19-62 | E. L. Gregory | do | 4975 | 80 | do | 60 | do | Draw | do | |
| 179 | S ½—7-19-62 | Herman Stellpflug | do | 5045 | 300 | do | .... | do | do | do | |
| 180 | S ½—1-19-62 | Lon Lovercheck | do | 4700 | 280 | do | .... | do | Valley | do | |
| 181 | W ½—6-19-61 | Bear Mt. Store | Hand | 4550 | 84 | do | .... | do | do | do | Pumps dry in 30 minutes |
| 182 | E ½—2-19-62 | O. M. Lovercheck | Wind | 4700 | 162 | do | 150 | do | Hillside | do | |
| 183 | N ½—5-19-62 | M. L. Graves | Motor | 4840 | 69 | do | .... | do | Valley | do | |
| 184 | W ½—33-20-62 | John G. Bunn | Wind | 4760 | 75 | do | .... | do | do | do | |
| 185 | E ½—33-20-62 | Chas. B. Kessler | do | 4725 | 35 | Dug | .... | do | do | do | |
| 186 | C—33-20-62 | do | Hand | 4725 | 35 | 6" | .... | do | do | do | |
| 187 | S ½—28-20-62 | Joe Matje | Wind | 4820 | 100 | do | .... | do | do | do | |
| 188 | SW—13-20-62 | F. M. Smith | do | 4600 | 60 | do | .... | do | Plains | do | |
| 189 | SE—13-20-62 | do | do | 4520 | 28 | do | .... | do | do | Stock | |
| 190 | E ½—12-20-62 | J. A. Test | do | 4560 | 127 | do | 100 | Kl | do | Gen. | Can be pumped dry |
| 191 | NW—12-20-62 | F. A. Rockhold | do | 4515 | 198 | do | 45 | do | do | do | |
| 192 | SW—1-20-62 | C. M. Rockhold | do | 4490 | 91 | do | 84 | do | do | do | Poor water |
| 193 | NW—1-20-62 | Elvin Shimic | do | 4440 | 40 | do | .... | do | do | do | |
| 194 | NE—2-20-62 | Joe Fisher | do | 4460 | 16 | do | 14 | do | do | do | Good water |
| 195 | C—35-21-62 | C. W. Culley | do | 4450 | 19 | do | 11 | do | do | do | |
| 196 | SE—26-21-62 | Chas. Hirsig | do | 4425 | 60 | do | 52 | do | do | do | |
| 197* | SW—13 21-62 | J. H. Swanson | Hand | 4390 | 72 | do | 50 | do | do | do | Can be pumped dry |
| 198 | NE—14-21-62 | E. W. Schwab | do | 4360 | 50 | do | 35 | do | do | do | |
| 199 | SE—11-21-62 | Harry Marlatt | Wind | 4400 | 32 | do | 20 | do | do | Stock | First water at 11 feet |
| 200 | SE—11-21-62 | do | Hand | 4400 | 132 | do | 124 | do | do | Gen. | Softer water than No. 199 |
| 201 | W ½—12-21-62 | G. Korb | Motor | 4360 | 23 | do | 16 | do | do | do | Does not pump dry |
| 202 | NE—11-21-62 | Guy Marlatt | Wind | 4380 | 55 | do | .... | do | do | do | |
| 203 | SW—1-21-62 | Earl Woodard | .... | 4325 | 14 | do | | do | do | .... | Not in use |

* This well is typical of the 12 wells in Hawk Springs, Wyoming. All the wells produce from small seeps. Some wells are slightly shallower and some are slightly deeper than no. 197, but in none of the wells is water very abundant.

## DATA FOR WELLS SHOWN ON PLATE III—Continued

| No. | LOCATION | OWNER | Method of lift | Elev. | Depth | Diam. | Water level | Aquifer | Topog. | Use | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 204 | NW—1-21-62 | Bob Carlisle | Wind | 4315 | 60 | 6" | .... | Kl | Plains | Gen. | Pumps dry |
| 205 | NW—36-22-62 | W. A. James | do | 4280 | 150 | do | 15 | do | do | do | First water at 10 feet |
| 206 | NE—35-22-62 | John Garrelts | Motor | 4290 | 18 | do | 12 | do | do | do | Near creek |
| 207 | SW—26-22-62 | T. W. Bracken | Wind | 4295 | 208 | do | .... | do | do | do | ........ |
| 208 | NW—25-22-62 | Guy Capek | Motor | 4265 | 135 | do | .... | do | do | do | ........ |
| 209 | SW—23-22-62 | Alex Woods | Wind | 4260 | 255 | do | .... | do | do | do | ........ |
| 210 | SW—23-22-62 | do | Hand | 4260 | 90 | do | 30 | Twr (?) | do | do | ........ |
| 211 | SW—23-22-62 | do | .... | 4260 | 99 | do | 30 | do | do | .... | Not in use |
| 212 | NE—11-22-62 | Bryan Marlatt | Wind | 4245 | 200 | do | .... | Kl | do | Gen. | ........ |
| 213 | NE—2-22-62 | Kenneth Yorges | Hand | 4245 | 15 | do | .... | Qal | do | do | Pumps dry |
| 214 | N ½—1-22-62 | Henry Wunder | Wind | 4240 | 60 | do | 40 | Twr | do | do | Good water |
| 215 | NE—31-23-61 | Harry Miller | do | 4240 | 142 | do | 30 | Kl | do | do | Water mineralized |
| 216 | NW—32-23-61 | Mrs. L. H. Hughes | Motor | 4260 | 82 | do | .... | do | do | do | do |
| 217 | W ½—34-23-61 | James Coxbill | Hand | 4240 | 100 | do | 30 | do | do | do | First water at 50 feet |
| 218 | NW—5-22-61 | F. M. Hackleman | do | 4220 | 23 | do | .... | do | do | do | ........ |
| 219 | NW—5-22-61 | do | do | 4220 | 30 | do | .... | do | do | Stock | ........ |
| 220 | NE—6-22-61 | A. J. Soller | do | 4225 | 16 | do | 12 | Twr | do | Gen. | ........ |
| 221 | NW—6-22-61 | A. E. Springer | do | 4225 | 16 | do | .... | do | do | do | ........ |
| 222 | NW—6-22-61 | do | Wind | 4225 | 16 | do | .... | do | do | do | ........ |
| 223 | SW—5-22-61 | Joe Roushar | do | 4220 | 35 | do | .... | Kl (?) | do | do | Does not pump dry |
| 224 | SE—9-22-61 | A. Jones | Hand | 4240 | 26 | do | 16 | Qal | do | do | ........ |
| 225 | SE—9-22-61 | do | .... | 4260 | 5000 | 2" | .... | ? | do | Stock | Flowing; abandoned oil well |
| 226 | SW—18-22-61 | Edgar Hughes | Hand | 4280 | 18 | 6" | 8 | Kl | do | Gen. | ........ |
| 227 | SW—18-22-61 | do | Wind | 4280 | 18 | do | 8 | do | do | Stock | ........ |
| 228 | SW—15-22-61 | E. W. Talley | do | 4280 | 182 | do | 100 | do | do | Gen. | ........ |
| 229 | NE—23-22-61 | T. H. Englehart | Hand | 4200 | 52 | do | 40 | do | do | do | ........ |
| 230 | NW—23-22-61 | Hugh J. Bunnell | Wind | 4260 | 152 | do | 29 | do | do | do | ........ |
| 231 | SE—23-22-61 | M. Woolam | Hand | 4225 | 23 | do | 16 | Twr | Valley | do | ........ |
| 232 | W ½—19-22-61 | Edgar Hughes | Wind | 4300 | 18 | do | 8 | Kl | Plains | do | ........ |
| 233 | S ½—19 22-61 | John Frisknecht | do | 4300 | 97 | do | .... | do | do | do | Can be pumped dry |
| 234 | N ½—30-22-61 | Ralph W. Hickman | do | 4320 | 125 | do | 30 | do | do | do | First water at 90 feet |

## DATA FOR WELLS SHOWN ON PLATE III—Continued

| No. | LOCATION | OWNER | Method of lift | Elev. | Depth | Diam. | Water level | Aquifer | Topog. | Use | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 235 | NE—32-22-61 | Geo. C. Hacker | do | 4340 | 72 | do | 30 | do | do | do | |
| 236 | W ½—5-21-61 | C. A. Harshburger | do | 4395 | 98 | do | 65 | do | do | do | |
| 237 | SW—30-21-61 | Lincoln Land Co. | Hand | 4380 | 70 | do | .... | do | Valley | do | |
| 238 | C—32-21-61 | G. A. Davis | Wind | 4445 | 100 | do | .... | do | do | Stock | |
| 239 | C—32-21-61 | do | Motor | 4470 | 170 | do | .... | do | Plains | Gen. | |
| 240 | SW—32-21-61 | do | .... | 4420 | 18 | Dug | 8 | Qal | Valley | .... | Not in use |
| 241 | SW—31-21-61 | do | Wind | 4500 | 70 | 6′ | .... | Kl | Plains | Gen. | |
| 242 | SE—31-21-61 | Lincoln Land Co. | Hand | 4500 | 16 | Dug | 8 | Qal | Valley | do | |
| 243 | SE—17-20-61 | Lincoln Land Co. | Hand | 4445 | 12 | 6″ | 8 | Qal | Valley | Gen. | |
| 244 | SE—30-20-61 | W. A. Gross | Wind | 4510 | 16 | do | 7 | do | do | Stock | Waters 500 head stock |
| 245 | NE—32-20-61 | do | Hand | 4510 | 20 | do | 8 | do | do | Gen. | |
| 246 | NE—32-20-61 | do | Wind | 4510 | 20 | do | 8 | do | do | do | |
| 247 | SW—33-20-61 | Oscar Sherard | do | 4520 | 101 | 10″ | 8 | Twr | do | do | Tested 1.06 sec. ft. |
| 248 | NE—5-19-61 | Hugh Stemler | do | 4525 | 52 | 6′ | 20 | do | do | do | |
| 249 | NW—4-19-61 | do | Hand | 4530 | 15 | do | 7 | Qal | do | Stock | |
| 250 | SE—5-19-61 | do | Wind | 4545 | 68 | do | 20 | Twr | do | Gen. | |
| 251a | SW—4-19-61 | do | Motor | 4570 | 33 | 4′ | 9 | Qal | do | Irri. | Back graveled |
| 252a | SW—4-19-61 | do | do | 4570 | 68 | 2′ | 9 | do | do | do | Casing perforated |
| 253b | W ½—2-19-61 | C. F. Moody | Hand | 4575 | 35 | Dug | 23 | Twr | do | Gen. | |
| 254 | NE—8-19-61 | F. E. Jones | .... | 4580 | 70 | 6″ | 13 | do | do | .... | Not in use |
| 255 | NE—7-19-61 | do | Wind | 4620 | 300 | do | 50 | Twr (?) | do | Gen. | |
| 256 | C—9-19-61 | C. W. Hershey | do | 4620 | 60 | do | 10 | Twr | do | do | |
| 257 | N ½—18-19-61 | F. E. Jones | do | 4750 | 56 | do | 25 | do | do | Stock | |
| 258 | W ½—1-18-61 | Jelmer Johnson | Springs | 4680 | .... | .... | .... | do | do | .... | Fills small reservoir |
| 259 | SE—19-18-60 | John E. Latenser | Wind | 4920 | 160 | 6″ | 90 | do | Plains | Stock | |
| 260 | NW—19-18-60 | do | do | 4830 | 100 | do | 90 | do | do | Gen. | |
| 261 | NW—19-18-60 | do | do | 4830 | 205 | do | 100 | do | do | do | Small seep; pumps dry |
| 262 | NE—18-18-60 | J. H. Draper | do | 4820 | 40 | do | 36 | do | do | do | |

a These two wells have a combined output of 1200 gallons per minute. The alluvium and gravel is here about 30 feet in thickness.
b This well is typical of the 50-odd wells in Lagrange, Wyoming.

# DATA FOR WELLS SHOWN ON PLATE III—Continued

| No. | LOCATION | OWNER | Method of lift | Elev. | Depth | Diam. | Water level | Aquifer | Topog. | Use | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 263 | NE—6-18-60 | W. J. Clark | Wind | 4800 | 135 | 6" | 100 | Twr | Plains | Gen. | .... |
| 264 | SW—31-19-60 | Fred McClure | do | 4790 | 139 | do | 79 | do | do | do | .... |
| 265 | N ½—31-19-60 | J. P. Curran | do | 4760 | 150 | do | .... | do | do | do | Has been pumped dry |
| 266 | N ½—32-19-60 | Fred McClure | do | 4760 | 190 | do | .... | do | do | .... | Not in use |
| 267 | SW—6-19-60 | E. L. Chamberlain | do | 4700 | 307 | do | 170 | do | do | Gen. | First water at 300 feet |
| 268 | SE—6-19-60 | Frank Sanders | do | 4690 | 300 | do | .... | do | do | do | .... |
| 269 | SW—6-19-60 | E. L. Chamberlain | do | 4700 | 297 | do | 170 | do | do | Stock | .... |
| 270 | NE—6-19-60 | Mrs. Sadie Jane | do | 4620 | 300 | do | .... | do | do | Gen. | First water at 175 feet |
| 271 | SE—19-22-60 | J. A. Madden | Hand | 4200 | 87 | do | 35 | Twr (?) | do | do | .... |
| 272 | NE—19-22-60 | Alva Stephenson | Wind | 4190 | 167 | do | 80 | do | do | do | First water at 20 feet |
| 273 | SW—17-22-60 | do | do | 4175 | 115 | do | 20 | do | do | do | .... |
| 274 | SW—18-22-60 | Reclamation Serv. | Hand | 4130 | 20 | 18" | 6 | Qal | Valley | do | .... |
| 275 | E ½—16-22-60 | Orval Notman | Wind | 4160 | 160 | 6" | .... | Twr (?) | Plains | do | .... |
| 276 | W ½—15-22-60 | D. G. Greenwald | do | 4160 | 210 | do | 50 | Kl | do | do | .... |
| 277 | NW—15-22-60 | M. F. Phillits | do | 4110 | 160 | do | 60 | do | do | do | .... |
| 278 | N ½—15-22-60 | Henry Lehman | do | 4100 | 65 | do | 20 | Twr | do | do | .... |
| 279 | NW—17-22-60 | Don Rutten | do | 4180 | 180 | do | .... | Kl | do | do | Never pumps dry |
| 280 | SW—10-22-60 | A. J. Atkinson | do | 4120 | 120 | do | .... | Kl (?) | do | do | Pumps dry |
| 281 | SE—9-22-60 | Ferd Zimmerer | do | 4120 | 166 | do | 40 | do | do | do | First water at 60 feet |
| 282 | SW—8-22-60 | Jess Jones | Hand | 4110 | 30 | 1 ½" | .... | Kl | Valley | do | .... |
| 283 | NW—10-22-60 | J. C. Rincker | Wind | 4115 | 160 | 6" | .... | do | Plains | do | .... |
| 284 | NE—7-22-60 | C. D. Sill | do | 4120 | 80 | do | .... | do | do | do | .... |
| 285 | SW—5-22-60 | J. Yocum | do | 4160 | 150 | do | .... | do | do | do | .... |
| 286 | SE—5-22-60 | Joe Long | Motor | 4140 | 100 | do | .... | do | do | do | .... |
| 287 | SE—3-22-60 | C. H. Packer | Wind | 4090 | 200 | do | .... | do | do | do | Good water |
| 288 | NE—5-22-60 | Joe Long | Hand | 4130 | 112 | do | | Twr (?) | do | do | Has 72 feet of pipe |

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