Geology and Ground-Water Resources of Goshen County Wyoming

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1377

Prepared in cooperation with the State Engineer of Wyoming

Geology and Ground-Water Resources of Goshen County Wyoming

By J. R. RAPP, F. N. VISHER, *and* R. T. LITTLETON

With a section on

CHEMICAL QUALITY OF THE GROUND WATER

By W. H. DURUM

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UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1957

UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price $1.75 (paper cover)

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GEOLOGY AND GROUND-WATER RESOURCES OF GOSHEN COUNTY, WYOMING

By J. R. Rapp, F. N. Visher, and R. T. Littleton

ABSTRACT

Goshen County, which has an area of 2,186 square miles, lies in southeastern Wyoming. The purpose of this study was to evaluate the ground-water resources of the county by determining the character, thickness, and extent of the water-bearing materials; the source, occurrence, movement, quantity, and quality of the ground water; and the possibility of developing additional ground water.

The rocks exposed in the area are sedimentary and range in age from Precambrian to Recent. A map that shows the areas of outcrop and a generalized section that summarizes the age, thickness, physical character, and water supply of these formations are included in the report. Owing to the great depths at which they lie beneath most of the county, the formations older than the Lance formation of Late Cretaceous age are not discussed in detail.

The Lance formation, of Late Cretaceous age, which consists mainly of beds of fine-grained sandstone and shale, has a maximum thickness of about 1,400 feet. It yields water, which usually is under artesian pressure, to a large number of domestic and stock wells in the south-central part of the county.

Tertiary rocks in the area include the Chadron and Brule formations of Oligocene age, the Arikaree formation of Miocene age, and channel deposits of Pliocene age. The Chadron formation is made up of two distinct units: a lower unit of highly variegated fluviatile deposits that has been found only in the report area; and an upper unit that is typical of the formation as it occurs in adjacent areas. The lower unit, which ranges in thickness from a knife edge to about 95 feet, is not known to yield water to wells, but its coarse-grained channel deposits probably would yield small quantities of water to wells. The upper unit, which ranges in thickness from a knife edge to about 150 feet, yields sufficient quantities of water for domestic and stock uses from channel deposits of sandstone under artesian pressure. The Brule formation, which is mainly a siltstone, ranges in thickness from a knife edge to about 450 feet and yields water to domestic and stock wells from fractures and from lenses of sandstone. The Arikaree formation ranges in thickness from a knife edge to about 1,000 feet, and yields water to several domestic and stock wells in the northwestern part of the area. The Pliocene channel deposits, which probably do not exceed 25 feet in thickness, are not a source of water for wells in Goshen County.

The upland deposits, which are mainly of Pleistocene age, generally are dry and do not serve as aquifers; however, test drilling revealed several deep, buried channels occupied by deposits which probably would yield moderate quantities of water to wells if a sufficient saturated thickness were penetrated. The deposits of the third terrace, which are of Pleistocene age, range in thickness from a knife edge to about 210 feet and yield water to a large number of irrigation wells in the area. The flood-plain deposits, which are of Pleistocene and Recent age, range in thickness from a knife edge to about 200 feet. Those in

the valley of the North Platte River yield abundant water to many large supply wells. The flood-plain deposits along the valley of Rawhide Creek consist mainly of fine-grained materials and yield large supplies of water to wells only in the lower stretches of the creek valley near its confluence with the valley of the North Platte River. The deposits along the valleys of Horse and Bear Creeks generally are relatively thin and fine grained. In the vicinity of Lagrange, however, the deposits, which are about 45 feet thick, yield moderate supplies of water to several irrigation wells. Other Recent deposits in the area—dune sand, loesslike deposits, and slope wash—generally are fine grained and relatively thin and, hence, are not important sources of ground water.

The unconsolidated sand and gravel of the flood-plain and terrace deposits are the principal aquifers in the area. In some places they are in contact and form a single aquifer; in others they are separated and form distinct aquifers. However, generally they constitute a single aquifer and are so discussed. In most places in the flood-plain deposits of the North Platte River wells yielding 1,000 to 3,000 gpm (gallons per minute) could be developed. Wells having yields of 500 to 1,500 gpm probably could be developed in most of the terrace deposits. In the valley fill along Horse and Bear Creeks near Lagrange, wells having yields of 500 to 1,000 gpm could be developed. However, in the valley fill along Rawhide Creek and along Horse and Bear Creeks, in the deposits of the third terrace, and in the flood-plain deposits along the North Platte River at places where the saturated thickness is less than 50 feet, the installation of large-capacity wells should be preceded by test drilling to determine the characteristics of the water-bearing materials. In favorable areas, wells with possible yields of 500 to 1,000 gpm could be developed in the Arikaree formation.

The specific capacity of wells in the unconsolidated sand and gravel of the flood-plain and terrace deposits of the North Platte River valley ranges from 21 to 250 gpm per foot of drawdown and averages 120 gpm per foot of drawdown. The wide range in specific capacity is due, in part, to the differences in the characteristics of the aquifers and, in part, to differences in the construction and development of the wells. Two irrigation wells in the valley fill along Horse and Bear Creeks in the vicinity of Lagrange have specific capacities of 16.6 and 40 gpm per foot of drawdown, respectively. In the same vicinity an irrigation well that produces water both from the alluvium and from fractures in the Brule formation has a specific capacity of 25 gpm per foot of drawdown. Wells in the bedrock formation generally could be expected to have much lower specific capacities than those in the unconsolidated sand and gravel deposits. A well that produces water from the Arikaree formation has a specific capacity of 12 gpm per foot of drawdown, and two wells that are in the Lance formation have specific capacities of 0.2 and 1.5 gpm per foot of drawdown.

The unconsolidated sand and gravel deposits of the valley fill of the North Platte River are highly permeable and transmit water readily to wells. Pumping tests indicate that the coefficients of permeability range from 1,500 to 8,700 gpd (gallons per day) per square foot for the flood-plain deposits of the North Platte River, and from 2,300 to 5,900 gpd per square foot for the deposits of the third terrace. The storage coefficient was determined to be 0.235 for the flood-plain deposits and 0.216 for the deposits of the third terrace.

The depth to water in the alluvium along the streams generally is less than 50 feet, and in the terrace deposits it generally is less than 80 feet. In the bottom land along the major streams, and in much of the irrigated land south of the North Platte River, the water table is so near the surface that the capillary fringe extends to the root zone of the vegetation or to the land surface. In these areas much ground water is discharged by evapotranspiration. The depths to water in the upland areas generally are between 200 and 300 feet.

Recharge to the ground-water reservoir in the nonirrigated part of Goshen County is mainly by seepage from precipitation. The average annual precipitation in the area is about 14 inches, of which possibly not more than 5 percent percolates to the ground-water reservoir. In the irrigated area along the valleys of Horse and Bear Creeks it is estimated that half of the water diverted for irrigation is recharged to the ground-water reservoir. In the North Platte project area recharge to the water table in the area is from seepage from canals and irrigated land, from precipitation, and from underflow entering the area. It is estimated that about 202,000 acre-feet of water is recharged to the water table each year from the canals and irrigated fields, and about 6,000 acre-feet is recharged by underflow into the area through the alluvial fill. Recharge from precipitation and by underflow into the area through the bedrock formations totals about 97,000 acre-feet annually for the 4 years studied (water years 1947–48 to 1950–51), but no attempt was made to determine the portion contributed by each process.

Most of the recoverable ground water in the area is stored in the unconsolidated sand and gravel deposits of the valley fill. Practically all the ground water available for irrigation, industrial, and municipal supplies occurs in these deposits. The approximate quantity of ground water in storage in the valley fill of the North Platte River was computed, by multiplying the volume of saturated material by the average storage coefficient, to be 1,700,000 acre-feet. It was computed that about 21,000 acre-feet of water is in storage in the uppermost foot of the saturated material.

Sufficient data were not available to approximate the total amount of discharge from Goshen County; however, it was determined that in the 4 years of study an average of about 305,000 acre-feet of ground water was discharged annually from the North Platte River project area. About 217,000 acre-feet was discharged by streams and drains, about 59,000 acre-feet by evaportranspiration (including about 3,000 acre-feet of the water pumped from wells), and about 29,000 acre-feet as underflow through the valley fill.

Water in unconsolidated materials carries moderately low amounts of dissolved solids, principally calcium bicarbonate, and is characterized by hardness exceeding 200 ppm (parts per million), a substantial part of which is noncarbonate, by a low percentage of sodium, and locally, by excessive iron. The quantities of the individual constituents are influenced to some extent by irrigation practices. Water in the bedrock formations is characterized by low hardness and a high percentage of sodium. Water from the deeper Lance formation contains fluoride in concentrations that exceed the desirable upper limits for drinking water used by children. Wells in the valley fill near the Interstate canal in general yield water having a slightly lower mineral content than wells adjacent to the North Platte River.

Local problems in water quality occur where drainage from irrigated tracts is retarded by underlying materials of low permeability and where concentration of the shallow water by evaporation and transpiration occurs.

Spot sampling of surface water showed that the Cherry Creek drain carries about 2.3 tons of dissolved solids per acre-foot of runoff before the start of irrigation, but the mineral content fluctuates widely in response to surface inflow during the irrigation season.

INTRODUCTION

PURPOSE AND SCOPE OF THE INVESTIGATION

A program of ground-water investigation was begun in Wyoming in November 1940 by the U. S. Geological Survey in cooperation with the Wyoming State Planning and Water Conservation Board. As part of this program a study of Goshen County was begun in 1943 by J. B. Graham. The purpose was to evaluate the ground-water resources of the county by determining the character, thickness, and extent of the water-bearing materials; the source, occurrence, movement, quantity, and quality of the ground water; and the possibility of developing additional ground water. The study was discontinued early in 1944 and later, in 1948, was renewed as part of the cooperative program with the Wyoming State Engineer. A detailed study was made of the North Platte River irrigation project in Goshen County during 1949–51, as a part of the program of the Department of the Interior for development of the Missouri River basin. The data collected during that study are included in an open-file report [1] and most of the data are incorporated in this report. The field work and collection of data for this report were done by R. T. Littleton, F. N. Visher, H. M. Babcock, and J. R. Rapp under the general supervision of A. N. Sayre, chief of the Ground Water Branch of the Geological Survey. The investigation was completed and the report was compiled under the direct supervision of H. M. Babcock, district engineer for Wyoming.

The quality-of-water studies were made under the general supervision of S. K. Love, chief of the Quality of Water Branch of the Geological Survey, and P. C. Benedict, regional engineer in charge of the quality-of-water studies in the Missouri River basin.

The quantitative analyses of water-bearing materials were made by A. I. Johnson in the hydrologic laboratory of the Geological Survey at Lincoln, Nebr.

LOCATION AND EXTENT OF THE AREA

Goshen County lies in the southeastern part of Wyoming (fig. 1). It is bounded on the east by the Wyoming-Nebraska State line, and on the north, west, and south by Niobrara, Platte, and Laramie Counties, respectively. Goshen County is rectangular in shape and measures about 72 miles in a northerly direction and about 30½ miles in an easterly direction. The county has an area of 2,186 square miles, which covers 48 complete townships and parts of 12 others.

METHODS OF INVESTIGATION

A network of 65 observation wells was established in March 1949 to observe water-level fluctuations in the area; included were 27 wells in which periodic water-level measurements had been made previously.

[1] Visher, F. N., Rapp, J. R., and Babcock, H. M., 1954, Geology and ground-water resources of the North Platte irrigation project area in Goshen County, Wyo., with a section on the chemical quality of the ground water by W. H. Durum: U. S. Geol. Survey open-file report.

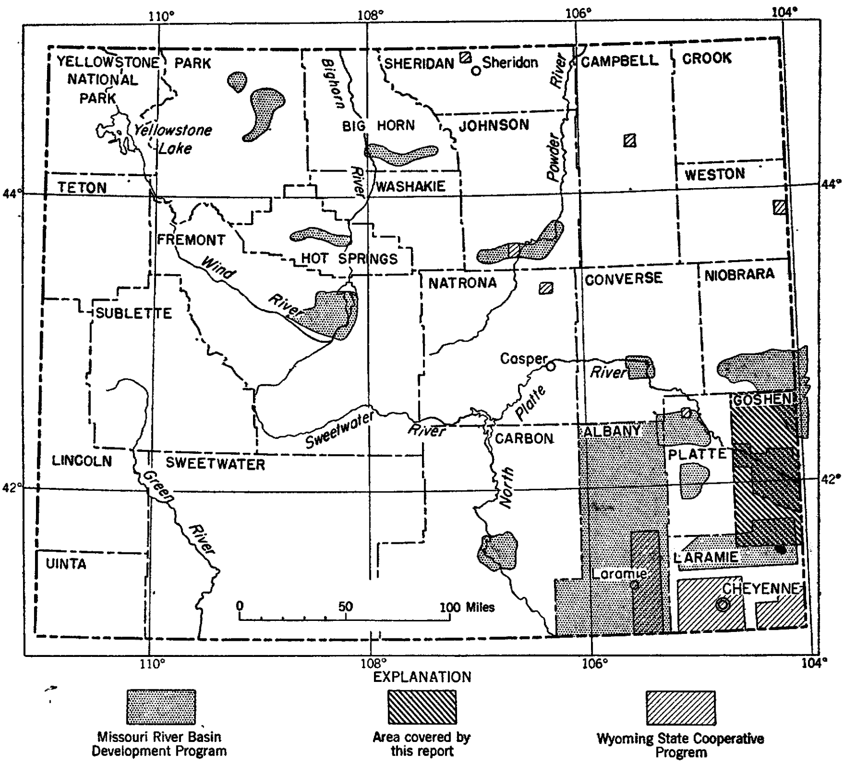

FIGURE 1.—Index map of Wyoming showing area covered by this report and other areas in which ground-water investigations have been made.

Measurements were made monthly from March 1949 through November 1951.

Records of 938 wells and springs in the area were obtained. Available information regarding the character and thickness of the water-bearing formations and the discharge of the wells was obtained from well drillers and well owners. An attempt was made to include all wells of large discharge. The depth to water below a fixed measuring point, generally the top of the well casing or the top of the pump base, in 812 wells was measured using a steel tape. The yield of 27 wells of large discharge was measured with a Hoff current meter. Small discharges were measured by timing with a stopwatch the filling of a calibrated container. These measurements, as well as other information about the wells, are given in table 7. Reported data are listed for most of the wells that could not be measured. In addition to the wells inventoried, records of shotholes made during seismic surveys by oil companies were studied but are not included in this report. Instrumental levels were run to many of the wells and to the test holes. Chemical analyses were made of

126 water samples collected from wells, springs, drains, canals, and streams in the area.

The hydrologic properties of the unconsolidated sand and gravel deposits were determined in the field by F. N. Visher, who made pumping tests of six wells. The physical and hydrologic properties of 21 samples of the bedrock formations were determined in the laboratory by A. I. Johnson at Lincoln, Nebr.

A study of the geology of the area was made by J. R. Rapp. Test drilling at 44 sites, a total of 5,152 feet, was supervised by Rapp and Visher, and the test holes were logged by Rapp.

The geologic and hydrologic field data were recorded on aerial photographs and were later transferred to a base map adapted from the Wyoming State Highway planning map. The wells shown on plate 4 were located within the sections by use of an odometer and by inspection of the aerial photographs; their locations are believed to be accurate within 0.1 mile.

WELL-NUMBERING SYSTEM

The wells are numbered according to their location within the Bureau of Land Management's system of land subdivision. All wells are in the sixth principal meridian and baseline system. The well number shows the location of the well by township, range, section, and position within the section. A graphical illustration of the well-numbering system is shown in figure 2. The first numeral of a well number indicates the township, the second the range, and the third the section in which the well is located. The lowercase letters following the section number indicate the position of the well within the section. The first letter denotes the quarter section and the second the quarter-quarter section (40-acre tract). The subdivisions of the sections are lettered a, b, c, and d in a counterclockwise direction, beginning in the northeast quarter. Where more than one well is in a 40-acre tract, consecutive numbers beginning with 1 are added to the well number.

This numbering system was used also to designate test holes, locations where rock samples were collected for laboratory tests, and locations where surface-water samples were collected for chemical analysis.

PREVIOUS INVESTIGATIONS

Several investigations of the geology and water resources of the general area have been made previously. The reports on these studies proved very useful in the preparation of this report, and many references are made to them.

The geology and water resources of much of the county were described by Adams (1902) in a report on the Patrick and Goshen Hole quadrangles. A report by Smith (1903) on the Hartville quadrangle describes a small section of the extreme western part of the county. Darton (1903) studied and mapped the geology of the Scotts Bluff quadrangle, Nebraska, which borders a part of Goshen County on the east. A soil survey was made by Veatch and McClure (1921) of

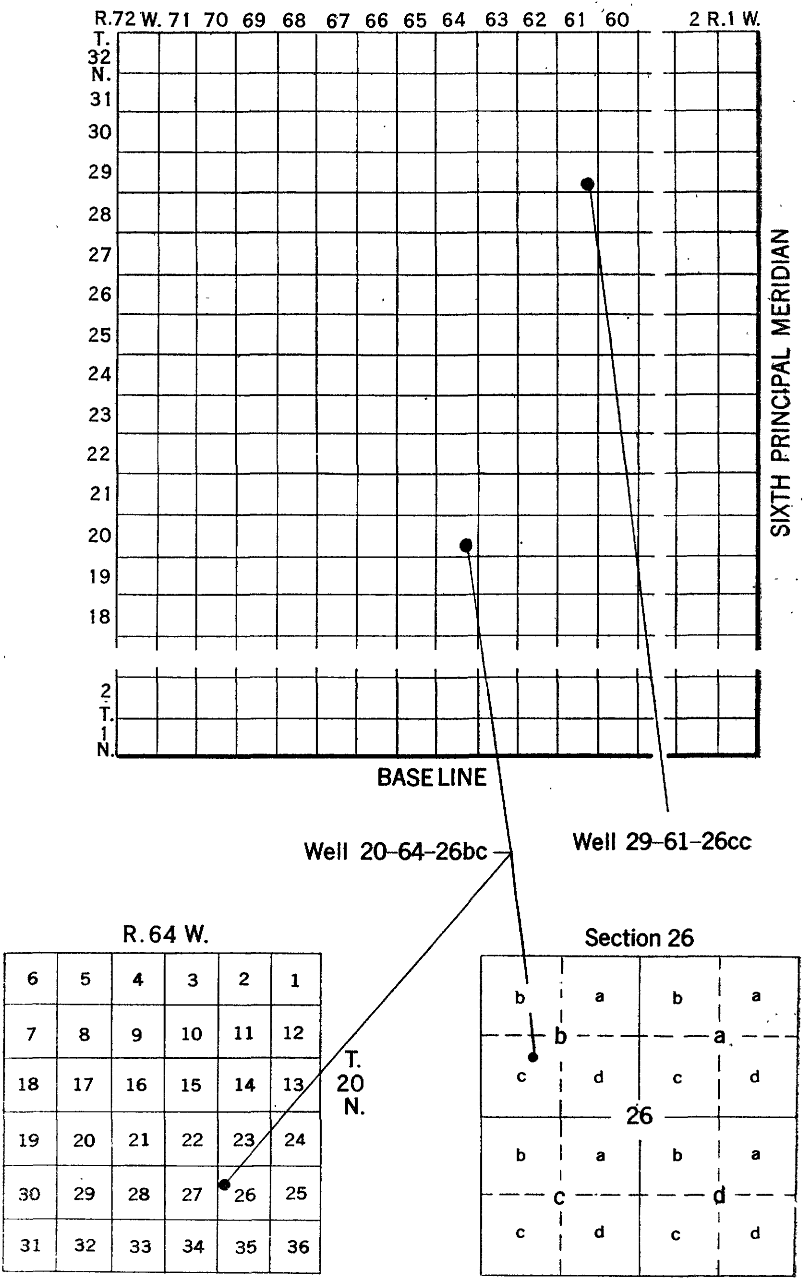

FIGURE 2.—Sketch showing well-numbering system.

the Fort Laramie area, Wyoming and Nebraska, which includes part of the North Platte River valley and part of Goshen Hole proper. Schlaikjer (1935a, b, and c) described the geology of the Goshen Hole area, which includes the part of the county south from the North Platte River to about the south boundary of T. 20 N. Wenzel, Cady, and Waite (1946) studied the geology and ground-water resources of Scotts Bluff County, Nebr., which borders part of the county on the east. Denson and Botinelly (1949) described the geology of the Hartville uplift, which includes the northwest corner of Goshen County.

During the course of this investigation the following three special studies were made in parts of the county. Babcock and Rapp (1952) described the geology and ground-water resources along Horse and Bear Creeks, which covers an area in the southern part of the county. Visher and Babcock (1953) made a ground-water study in an area several miles southwest of the town of Torrington. Visher, Rapp, and Babcock [2] described the geology and ground-water resources of the part of the county that lies approximately between the Interstate and Fort Laramie canals. Many of the data compiled during these studies are incorporated in this report.

ACKNOWLEDGMENTS

The writers wish to express their appreciation to all those who aided in this study. Well drillers in the area supplied logs for many of the wells, and oil companies made available their records of logs of test holes drilled during seismic surveys. The residents of the area supplied information about their wells and gave permission for the measurement of their wells, and for the drilling of test holes on their land. Information regarding public-supply wells was given by city and town officials of Torrington, Lingle, and Yoder. L. C. Bishop, State engineer of Wyoming, and Frank Murphy, chief hydrographer of Wyoming, gave helpful assistance and suggestions, and permitted access to records of wells and streamflow in the area. The management of the Goshen County Irrigation District gave helpful assistance and suggestions and permitted access to records of irrigation in the area. Personnel of the U. S. Bureau of Reclamation assisted by determining the altitude of the land surface at test-hole sites.

GEOGRAPHY

HISTORY

The history of Goshen County is closely associated with the different stages in the settling of the West. The North Platte River valley afforded an easy route for the early explorers and trappers, the cov-

[2] Op. cit.

ered wagons of the emigrants moving to the West, the cattlemen, and later the homesteaders.

The following summary of the history of Goshen County is based upon historical accounts of Wyoming, information obtained from the U. S. Park Service at the Fort Laramie National Monument, records of the U. S. Bureau of Reclamation, and records of the U. S. Bureau of the Census.

The earliest known inhabitants of the area were prehistoric hunters whose flint dart points of the Folsom and Yuma types have been found in the valley of the North Platte River. At present there is no general agreement as to the age of these people, but they may have occupied the area 8,000 to 10,000 years ago. They were followed some time later by another hunting, nonagricultural people, whose implements have been found. Next came proto-Pawnee people of the Upper Republican culture, who tilled the soil, made pottery, and built semi-subterranean houses. After these came the sedentary tribes of the true Pawnee Indians, who established farming villages of mud huts in the valleys and hunted on the adjacent plains. These Indians were living peacefully in the area when the white man first explored the Platte River valley. About 1760, Indians of the Sioux, or Dacotah, tribes, who then farmed and hunted in the forests south and west of Lake Superior, were defeated by the Chippewa Indians. The Sioux Indians, unable to defend themselves from the encroachment of the Chippewas, who had obtained guns from the French traders, gradually moved westward into the plains and assumed the culture of the Plains Indians. The Brule and Ogallala bands of the Dacotahs, with their allies, drove the established tribes of the Pawnee out of the North Platte River valley.

Not long after the Louisiana Purchase, Americans began to exploit the fur resources of the Rocky Mountains and the Great Plains. In 1812, Robert Stuart, traveling eastward from Astoria at the mouth of the Columbia River, reached the junction of the Laramie and Platte Rivers and gave what is apparently the first written description of the region. Ten years later the Rocky Mountain Fur Co. began operations in the area. Early in the summer of 1834, a trading station was established near the junction of the Laramie and Platte Rivers and called Fort William in honor of Capt. William L. Sublette. The fort soon became known as Fort Laramie after the Laramie River on which it was located. In 1849 the fort was taken over by the United States Government and a military unit was established to protect the emigrants who were traveling westward.

The history of the Oregon Trail as a wagon route began in 1830 when a party of trappers under the leadership of William L. Sublette set out for the Wind River in what is now Wyoming. In all there were 14 mule-drawn wagons, each loaded with 1,800 pounds of merchandise. The wagons returned to St. Louis by way of the North Platte River valley loaded with pelts. In 1832 Captain Bonneville led a wagon train to Oregon.

In 1841 the first organized band of about 80 homeseekers passed through the area bound for California and the Oregon country. This was the first of many wagon trains that went westward through the area along the Oregon Trail. In 1843 the first large group passed through the area—it consisted of 260 men, 130 women, and 610 children in 200 wagons. In 1845, about 3,000 people traveled west through the area. For the next quarter of a century annual caravans and scores of independent companies took tens of thousands of emigrants westward to build new states in the Rocky Mountain country and on the Pacific coast. In 1848, from early spring until late summer, the Oregon Trail was lined with so many trains that they were scarcely out of sight of one another. The year 1849 probably was the most important year in the history of the Oregon Trail, because of the discovery of gold in California. Between May and October, it is reported that 30,000 to 100,000 people passed through Wyoming; they were the "forty-niners." The Oregon Trail remained the great thoroughfare of the covered wagon to the West until the construction of the Union Pacific Railroad in the late 1860's, although wagons continued to follow the trail until late in the 1880's.

Led by Brigham Young, the first band of Mormons, which consisted of 149 people and 72 wagons, passed through the area in May 1847 on their way to settle in Salt Lake Valley. This began a large-scale migration of the Mormons into the Utah territory. Many of the later Mormon emigrants made the entire trip on foot, pushing and pulling handcarts containing their supplies and cooking utensils.

The rapid growth of American settlements in California, Oregon, and Utah led to the establishment in 1850 of mail service between Independence, Mo., and Salt Lake City, Utah. During most of the 1850's Fort Laramie was the division point for the mail stages. Stages from each end of the line were scheduled to meet at the fort on the 15th of each month. However, regular mail schedules were difficult to maintain and the mail service was very slow and irregular. Not until the Pony Express was established in April 1860 was there a fast and reliable mail service in the West. The Pony Express could not compete with the Overland Telegraph, however, and was abandoned upon completion of the telegraph line in October 1861.

Following in the footsteps of the trappers, traders, and emigrants to the West came the permanent settlers. These hardy pioneers used their homestead rights to file on lands adjacent to the streams, and cooperatively with their own labor, teams, and equipment, built canals to bring water to their lands. The oldest adjudicated water right in

Goshen County is from Rawhide Creek, with a priority of 1881. This was followed by the construction of the North Platte canal in 1883, the Torrington canal in 1886, and the Lucerne canal in 1892. Large-scale irrigation began with the construction of the Whalen Falls Carey Act project in the early 1900's, followed by the building of the Interstate and Fort Laramie canals by the Reclamation Service in 1910.

After the completion of the large canals considerable additional land was brought under irrigation. This resulted in an increase in farm population, which in turn led to an increase in the population of the nearby towns. In recent years there has been a marked increase of the population in and adjacent to the larger towns in the valley of the North Platte River, especially Torrington, and a decrease in the population of the smaller towns. According to the 1950 census the population of Goshen County was 12,634, the Torrington area having a population of 6,201, or almost half the total.

SURFACE FEATURES—LAND FORMS

Goshen County lies in the northwestern part of the High Plains section of the Great Plains physiographic province. The major part of the High Plains section, or the area that lies south of the 41st parallel, is a tableland constructed on fluviatile Tertiary deposits (Pliocene), which are frequently referred to as the "Tertiary mantle" (Fenneman, 1931). The rest, or northern part, of the High Plains section owes its relatively flat surface features to extensive erosion (mainly of Miocene deposits) to a uniform slope, which was accomplished mainly by stream action. Regionally, this surface consists of broad, nearly flat or gently rolling tabular uplands between streams, with isolated buttes and outlying ridges. In Goshen County the original High Plains surface has been deeply eroded as the result of uplift, and the tablelands and lower buttes and ridges are incompletely eroded features of the North Platte River valley, which has been cut about 1,000 feet into the plains. The surface features of Goshen County can be separated into three main topographic units: the upland areas, a section of the Hartville Hills, and the western part of the Goshen Hole lowland.

UPLAND AREAS

The upland areas comprise about the north third of the county, part of the western margin, and the southwest corner of the county. In the northern part of the county, in the area east of the Hartville Hills, the Tertiary deposits have been dissected into moderate relief by the drainage systems of Rawhide and Sheep Creeks. The upland area along the west boundary and in the southwestern part of the county is a divide area and consists of a more or less gently rolling tableland. As this area mainly is underlain by permeable materials, there is little or no surface runoff from it; consequently, the old tableland surface has only been moderately eroded by stream action. Although the surface is remaining more or less intact, the margins of the uplands are slowly retreating, owing to the erosion of the bordering escarpment faces by ground water which issues as springs and seeps.

HARTVILLE HILLS

In the northwestern part of Goshen County the relatively gentle topography of the upland area is broken by the Hartville Hills. This range of hills is comparatively rugged, owing to recurrent erosion of the old, resistant Precambrian and Paleozoic rocks of which it is made. Though the range has a mountainous appearance, the overall relief is only moderate. The most striking difference in altitude is in the Haystack Range on the east side of Whalen Canyon, where the rise from the bottom of the canyon to the summit of the range, in a distance of 1 mile, is nearly 1,000 feet. In many places along the east side of the range there are many resistant knobs, of no great altitude, that project through the Tertiary rocks.

GOSHEN HOLE LOWLAND

In the central, western, and southern parts of the county the upland area is terminated abruptly by a line of escarpments and topographic breaks which give way to the western part of an extensive erosional lowland, known as the Goshen Hole lowland. The Goshen Hole lowland, which in most places is clearly defined by escarpments, is a great wedge-shaped widening of the valley of the North Platte River. (See fig. 3.) The lowland is about 45 miles wide on the west in the vicinity of Fort Laramie, Wyo., and narrows to about 2 miles on the east in the vicinity of Lisco, Nebr.; it is about 100 miles long. Several erosional outliers break the continuity of the lowland and, owing to their sharp rise from the floor of the lowland, are prominent surface features when viewed from the valley. The main outliers are Wildcat Ridge in Nebraska, which includes the well-known, historic salient, Scotts Bluff; and Sixty-six and Bear Creek Mountains in Goshen County, Wyo. In Goshen County the lowland consists mainly of two more or less distinct topographic units—the valley of the North Platte River on the north, and Goshen Hole proper on the south.

VALLEY OF THE NORTH PLATTE RIVER

The valley of the North Platte River consists of an inner valley and a series of bordering pediments. The inner valley consists of a flood plain and from one to three alluvial terraces that border the flood plain. The terraces grade into a series of sweeping pediments which extend away from the river to the upland. The terraces and pediments

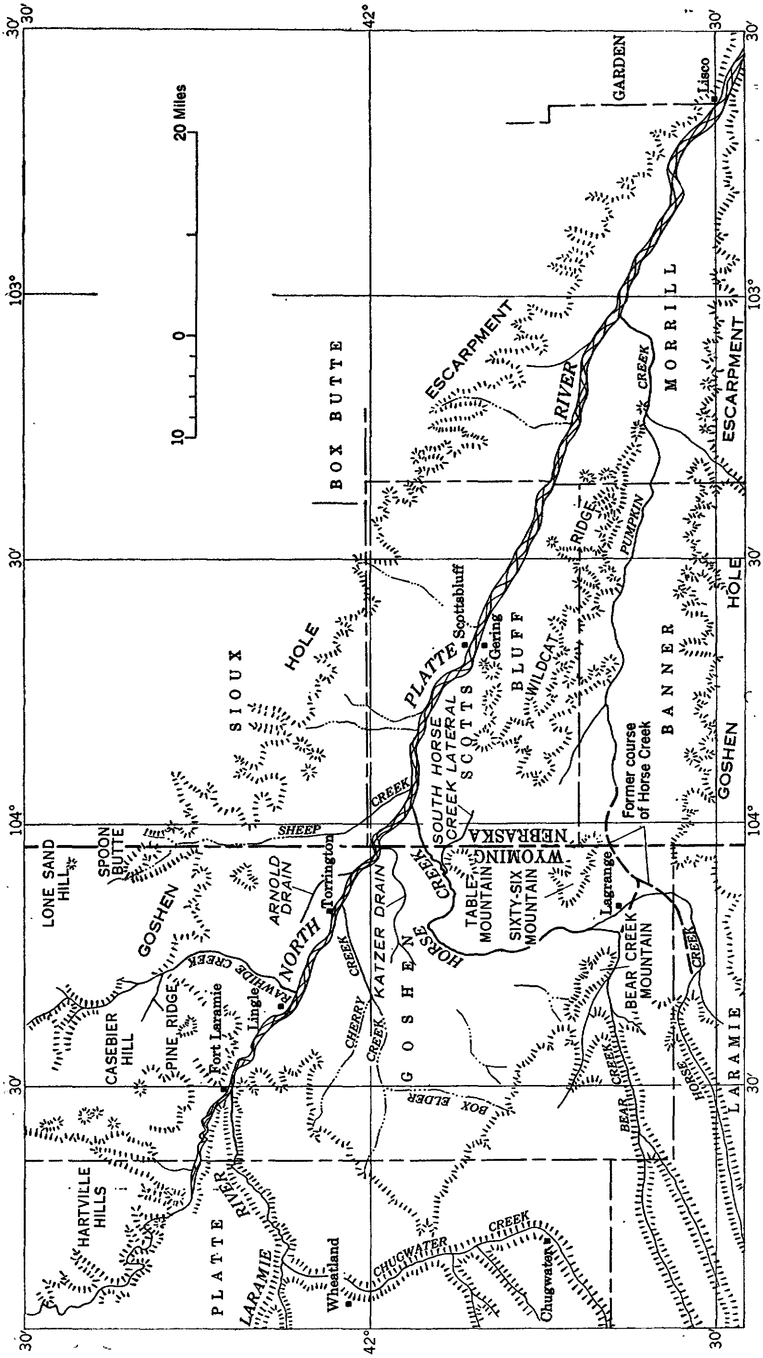

FIGURE 3.—Regional map showing the Goshen Hole lowland.

on the north side of the valley are best preserved because, for the most part, they are underlain by gravel deposits, which, being pervious, resist erosion. On the south side of the valley, where little or no gravel was deposited, the older surfaces largely have been destroyed by erosion, which formed younger pediments graded to the lower levels of the river.

In the upland areas north of the river there are several remnants of surfaces that were formed when the river and its tributaries were at considerably higher levels than at present. Many of these remnants are underlain by gravel deposits which are older, truncated, channel deposits or which were derived mainly from channel deposits.

The highest gravel deposits above the river occur on top of Spoon Butte at an altitude of about 5,000 feet. They are about 900 feet above the present level of the North Platte River and probably correlate with the eighth terrace as described by Cady (Wenzel, Cady, and Waite, 1946, p. 28–48). The next highest gravel deposits above the river occur on top of Pine Ridge and Casebier Hill where they overlie deposits of conglomerate. These gravel deposits were so intensively eroded that their origin could not be determined. However, because they occur at an altitude of about 800 feet above the present level of the river, they are correlated with the seventh terrace as described by Cady. About 650 feet above the North Platte River in the vicinity of Pine Ridge and on top of a hill in the southwestern part of T. 26 N., R. 60 W. are the next gravel deposits. The surface formed by these deposits is a pediment that probably correlates with the sixth terrace as described by Cady. The tops of the highest hills in the northern part of T. 25 N., R. 61 W., and in the southwestern part of T. 26 N., R. 61 W., and the relatively level area in the east-central part of T. 26 N., R. 63 W., are pediment remnants that lie between about 500 feet and about 380 feet above the present level of the river. This pediment is the second pediment above the third terrace level of the river, as described by Visher (Babcock and Visher, 1951, p. 9). The deposits underlying this surface probably are equivalent to those that underlie the fifth terrace as described by Cady. In part they are truncated channel deposits that probably would correlate with the Broadwater formation of Shultz and Stout (1948). The relatively extensive lowland in the central part of T. 26 N., Rs. 60 and 61 W., is a pediment remnant that lies between about 380 feet and about 280 feet above the present level of the river. It is the first pediment above the third terrace as described by Visher and probably is equivalent to the fourth terrace as described by Cady. In the eastern part of T. 25 N., R. 61 W., there is a pediment surface that slopes southward and merges with the third terrace. This surface slopes from about 450 to about 200 feet above the level of the river and probably includes parts of both the first and second pediments above the third terrace.

Remnants of the third terrace, the highest and oldest of the three surfaces mapped as terraces rather than as pediments, occur at many places along the inner valley of the North Platte River (see pl. 1). The most extensive remnant is on the north side of the river and extends eastward from about Rawhide Creek into Nebraska. It reaches a maximum width of about 4 miles. The riverward edge of this terrace generally is about 120 feet above the river, and the terrace surface slopes gently upward away from the river. The upslope boundary of the terrace generally is indistinct; it merges into alluvial fans and pediment slopes that extend upward to the remnants of the older pediments or to the upland itself. Erosion has lowered the original surface of the terrace, as is evidenced by the gravel hills that stand above the general terrace level in the southern part of T. 25 N., R. 61 W. Dune sand covers most of the third terrace between the Arnold drain and the Nebraska-Wyoming State line. On the south side of the river, only narrow remnants of the third terrace are present.

Remnants of the second terrace occur at many places on both sides of the river; however, the second terrace is best preserved between the Interstate canal and U. S. Highway 26 as a narrow strip half a mile wide that extends eastward from the center of R. 63 W. to the center of R. 64 W. The riverward edge of this terrace generally is 30 to 50 feet above the river. The surface of the terrace has been altered by the deposition of colluvium and alluvial fans, which slope upward away from the river at a gradient of about 70 feet to the mile. On the north side of the river the terrace surface generally is terminated on the landward side by a steep escarpment, but on the south side of the river the terrace surface in many places is continuous with an extensive pediment that slopes upward away from the river.

The first terrace borders the flood plain of the North Platte River and is from ½ to nearly 2 miles wide. This terrace has an irregular surface of very low relief as it is 10 to 20 feet above the river and is cut by a myriad of former channels of the river. Before the flow of the river was controlled by upstream dams, the first terrace is reported to have been inundated during very high floods.

Before the construction of the upstream dams, the flood plain, which is 5 to 10 feet above the river, normally was inundated during heavy spring runoff. The flow of the river now is fairly well confined to its present braided channel, which contains many bars and islands.

GOSHEN HOLE PROPER

Goshen Hole proper is separated from the inner valley of the North Platte River by a maturely dissected ridge of the Brule formation, which in places is several hundred feet above the flood plain of the river. (See pl. 1.) It is bounded on the northwest, the west, and the southwest by an escarpment that is several hundred feet high. (See plate 5.) On the south the escarpment is discontinuous; Bear Creek Mountain and Sixty-six Mountain are erosional outliers of the once continuous upland. The east boundary of Goshen Hole proper, which is poorly defined, is approximately the west side of Table Mountain. Goshen Hole proper can be defined better as including the lowland area drained by Cherry Creek and the area drained by Horse Creek between its confluence with Bear Creek and the south Horse Creek lateral division.

Topographically Goshen Hole proper is a low plain and a series of sweeping pediments that in most places slope up to the rimming escarpment. In many places the plain and lower slopes of the pediments are mantled with slope-wash material, which is pockmarked with windblown depressions, some of which are more than 40 feet deep. The upper parts of some of the pediments are cut by gullies which open onto the middle or lower slopes. The rolling topography of the part of Goshen Hole proper underlain by the Lance formation reflects to some extent the unconformable surface between the Lance and Chadron formations.

PHYSIOGRAPHIC HISTORY OF THE GOSHEN HOLE LOWLAND

VALLEY OF THE NORTH PLATTE RIVER

The dissection of the area by the North Platte River began during Pliocene time and has continued to the present time. Before the North Platte River began to downcut, it had shifted back and forth across the Tertiary alluvial plain. As it began downcutting, the river became established in essentially its present course. By the end of Pliocene time the river had cut down through about 700 feet of sediments to a height of perhaps 500 feet above its present level. In earliest Pleistocene time the channel, or valley, of the river was refilled to a level of about 650 feet above the present stream—the materials that were deposited at this time probably are equivalent to the Broadwater formation of Schultz and Stout (1948) in western Nebraska. Subsequently, for a long period the river downcut, until it was about 200 feet above its present level. During this period of downcutting the valley of the river was cut below the contact of the Brule and Airkaree formations. Characteristically, springs flow down escarpment faces from along this contact; the underlying softer Brule formation is eroded, undermining the Airkaree formation and thereby causing the escarpments to retreat. In this manner the valley was widened rapidly as the escarpments retreated and left a pediment surface. This surface is the second pediment above the third terrace. When the pediment intersected the Brule-Arikaree contact the rate of retreat of the escarpment decreased greatly, and the amount of material that was transported down the pediment slope from the retreating escarpment decreased. Later, minor valleys were cut into the relatively smooth pediment surface, and the sides of these valleys in turn were widened to form a new pediment—the first pediment above the third terrace. Parts of the older pediment were protected by gravel deposits and preserved as isolated remnants in the present topography.

Later in Pleistocene time there was a period of rapid downcutting, which lowered the river to about 200 feet below its present level. Before this period of downcutting, Rawhide Creek was a Yazoo-type tributary—that is, it paralleled the North Platte River through the eastern part of the county; thus, when the main stream cut down, the tributary cut a deep valley parallel to it. These valleys were afterwards refilled to about 180 feet above the present level of the river. The remnants of this valley fill are the deposits of the third terrace. (See pl. 1.)

After the valley was filled with the deposits of the third terrace the North Platte River became mainly a degrading stream. It cut into the deposits of the third terrace and reworked some of the older alluvial deposits as each successive terrace level was formed. Either in latest Pleistocene or early Recent time, the river cut down to about 30 feet above its present level and formed a flood plain that was from ½ to 2½ miles wide. There followed a period of reduced flow in the river during which this flood plain was largely covered with a thin veneer of colluvium and alluvial-fan material. The remnants of this surface constitute the second terrace. After this, the river again increased in erosive power and cut down to within 20 feet of its present level and formed a new flood plain that was almost as wide as the previous one, and removed most of the second terrace. This flood plain constitutes the first terrace. The river then cut to its present level.

GOSHEN HOLE PROPER

The formation of Goshen Hole proper was generally similar to, but in some respects different from, the formation of the valley of the North Platte River. As the river valley was cut below the Oligocene-Miocene (Brule-Arikaree) contact, several tributary streams whose courses were through the area now occupied by Goshen Hole proper also cut down below the contact. Goshen Hole began to form with the retreat of the escarpments along the contact. At this time Chugwater Creek was working headward toward the south from the Laramie River and intercepted the headwaters of the eastward-flowing streams that entered Goshen Hole. A tributary working southward from the North Platte River through Goshen Hole intercepted and diverted Bear Creek and then Horse Creek into Goshen Hole. Before this piracy their course extended along what is now the valley of Pumpkin Creek in Nebraska. The erosional processes of the expanding Goshen Hole were dependent mainly upon the local climate; whereas the erosion in the valley of the North Platte River was dependent upon the amount of runoff in the headwaters as well as upon the local climate. During the wetter periods large amounts of material were eroded from the escarpments and older pediments, and these were carried by the streams from Goshen Hole to the North Platte River. However, during drier periods such as the present, there was a decrease in erosion and essentially no external drainage from much of Goshen Hole. The small amounts of material eroded during these drier periods were deposited as alluvial fans in Goshen Hole, but these largely were removed by wind. Gradually these erosional processes exhumed some of the pre-Tertiary topography and produced a very irregular landscape within parts of Goshen Hole.

DRAINAGE

Goshen County is drained mainly by the North Platte River and its tributaries. The only other drainage system in the county is that of the Niobrara River, which drains the extreme northeastern part of the county. The rest of the area north of the North Platte River is drained by Sheep Creek in the east, Rawhide Creek in the center and northwest, and many small dry washes in the west. The area south of the river is drained by Horse Creek and its tributaries in the south and east, the Katzer drain in the east, the Cherry Creek drain and several small intermittent streams in the center, and several dry washes and the Laramie River in the west.

The North Platte River is a perennial stream throughout its course in Goshen County. The flow of the river is controlled by several upstream dams which release water according to downstream irrigation demands. Before the construction of the dams, the river had rather pronounced seasonal stages of high and low flow. Sheep Creek is an intermittent stream along the part of its course that lies in Goshen County. Rawhide Creek is a perennial stream throughout its course in the county. Horse Creek and its principal tributary, Bear Creek, are perennial streams throughout their courses in the county. Cherry Creek, which drains the northern part of Goshen Hole, was an ephemeral stream throughout its course before irrigation began, and flowed only during periods of heavy precipitation. Because of surface- and ground-water runoff from irrigation, the lower part of Cherry Creek (or the part of the creek lying east of the Fort Laramie canal) has become a perennial stream. This part of the creek is now called the Cherry Creek drain; it has entrenched itself as much as 35 feet below the bottom of its valley since irrigation was started. The Laramie River, which rises in the mountains to the west, is a perennial stream and in the county is second in size only to the main North Platte River. During the winter its flow is diverted into the Fort Laramie canal for use in generating power at the Lingle power station.

CLIMATE

The climate of the area is similar to that of other parts of the northern High Plains. It is characterized by low precipitation, a high rate of evaporation, and a wide range in temperature. The annual precipitation during the 30-year period of record and the normal monthly precipitation (computed through 1950) for the station at Torrington, Wyo., are shown graphically in figure 4. The normal precipitation

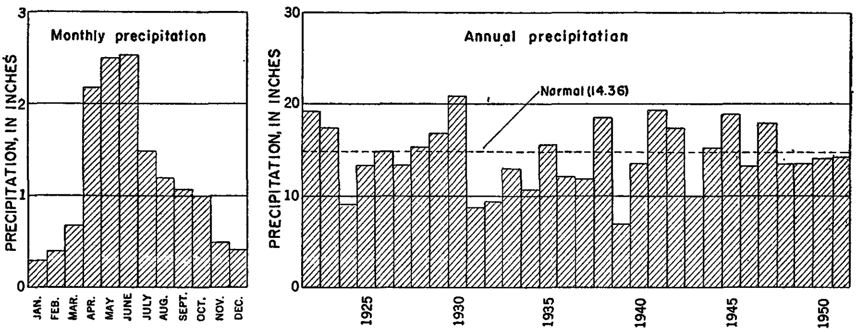

FIGURE 4.—Precipitation at Torrington, Wyo., 1922–51.

is 14.36 inches; the highest recorded annual precipitation was 20.91 inches and the lowest was 7.11 inches. About 51 percent of the annual precipitation occurs during April, May, and June; only about 11 percent occurs during November, December, January, and February, when it generally is in the form of light, dry snow. The summer rains, which are usually sporadic and unevenly distributed, occur largely as thunderstorms. Occasionally these storms are accompanied by strong winds and hail, which cause considerable damage to crops.

The mean annual temperature is 47.5° F., and the length of the growing season generally is about 150 days. There is a wide range between the maximum summer and the minimum winter temperature, and also between maximum daytime and minimum nighttime temperature.

AGRICULTURE

The present agricultural economy of the county has been developed largely through irrigation, dry farming, and stock raising. The lower lands, that is, those having access to surface-water supplies, generally are intensively utilized. Usually the supply of surface water is sufficient for irrigation, but shortages occur during periods of peak demand because of inadequate distribution facilities and also during periods of very low runoff in the drainage basin of the North Platte River. To overcome the shortages, some farmers have installed irrigation wells that are pumped for a supplementary water supply. The lands without surface-water supplies generally are used for dry farming and for raising cattle. However, some of the land outside the irrigation projects is irrigated with water from wells. The chief crops raised in the county are sugar beets, potatoes, beans, hay, and grain. Most of the livestock are beef cattle, although some dairy cattle, sheep, and hogs are raised.

The main industries in Goshen County are directly related to the processing of agricultural products; the largest industry is a sugar plant at Torrington, which extracts sugar from locally grown sugar beets.

TRANSPORTATION

Goshen County is served by lines of two railroads. The Casper branch of the Chicago, Burlington & Quincy Railroad follows the north bank of the North Platte River across the county. A branch of the Union Pacific Railroad for which Torrington is the terminal station serves the southern part of the county and joins the main line of the railroad to the south. The county is traversed by two main highways—U. S. 26 in an easterly direction, and U. S. 85 in a northerly direction. There are several black-top surfaced State and county roads, and other county roads that are graveled and maintained throughout the year.

GEOLOGY

SUMMARY OF STRATIGRAPHY

Goshen County is underlain by a considerable thickness of sedimentary rocks ranging in age from Cambrian to Recent that lie on crystalline rocks of pre-Cambrian age. The age, thickness, physical character, and water supply of these formations are summarized below. The areas of outcrop of the formations exposed in the county are shown on plate 1.

The pre-Tertiary formations exposed in the county are pre-Cambrian, Cambrian(?), Devonian, Mississippian, Pennsylvanian, and Late Cretaceous in age. All the pre-Tertiary rocks except the Lance formation of Late Cretaceous age lie at great depths beneath most of the county. These depths are considered excessive for the economic development of the formations as sources of ground water; therefore, these formations will not be discussed further. (For detailed descriptions of these rocks the reader is referred to the publications cited on page 94.

Generalized section of the geologic formations in Goshen County

System	Series	Subdivision	Thickness (feet)	Physical characteristics	Water supply
Quaternary	Recent	Dune sand	0– 30±	Fine windblown sand.	Sand dunes serve as infiltration areas for recharge from precipitation.
		Valley fill: Flood-plain deposits (including deposits of the first terrace) and possibly younger part of deposit of second terrace.	0– 200+	Sand and gravel that contain lenses and beds of fine sand, silt, and clay; large chunks of siltstone; lenses of siltstone pebbles; and cobbles and boulders.	Yield water to many domestic, stock, irrigation, municipal, and industrial wells.
	Pleistocene	Valley fill: Deposits of the third terrace (include small remnants of deposits of the second terrace)	0– 210+	Sand and gravel that contain lenses and beds of fine sand, silt, and clay, and lenses of siltstone pebbles.	Yield water to many domestic, stock, and irrigation wells.
		Upland deposits	0– 225	Sand and gravel that contain lenses and beds of fine sand, silt, and clay, and lenses of siltstone pebbles. Includes some channel deposits that may be of Pliocene age.	Some of these deposits would yield enough water for irrigation if a sufficient saturated thickness were penetrated.
Tertiary	Pliocene	Channel deposits	0– 25±	Sand and gravel, poorly to moderately cemented; contains cobbles and boulders.	Not a source of water for wells in Goshen County.
	Miocene	Arikaree formation	0–1,000±	Loose to moderately cemented very fine to fine grained tan to gray sand and silt that contain many layers and concretions of hard, tough sandstone. The basal unit consists of coarse channel conglomerate.	Yield water to many domestic and stock wells and to a few irrigation wells.
	Oligocene	Brule formation	0– 450	Moderately hard, brittle argillaceous siltstone that contains channel deposits of sand and sandstone, localized beds of limestone, moderately thick beds of clay, and a few beds of volcanic ash.	Yield moderate quantities of water to irrigation wells where large fractures are present; otherwise, yield only small quantities to domestic and stock wells and springs.
		Chadron formation	0– 245±	Mainly consists of green, red, or buff bentonitic loosely to moderately cemented clay and silt that contains channel deposits of sandstone and conglomerate. Contains a lower unit that consists of variegated fluviatile deposits.	Yield water under artesian pressure from coarse-grained channel deposits to many domestic and stock wells.

Generalized section of the geologic formations in Goshen County—Continued

System	Series	Subdivision	Thickness (feet)	Physical characteristics	Water supply
Cretaceous	Upper Cretaceous	Lance formation	0–1,400±	Upper unit consists of a variegated sequence of beds of sandstone and shale that contain a few thin beds of coal; a few thin beds of impure limestone, which contain oyster shells; and chert pebbles, cobbles, and boulders that are mostly brown. Lower unit consists of a thick sequence of beds of carbonaceous shale, gray siltstone, and dark- to light-gray sandstone that contains thin beds of coal that are more numerous in the lower 300 feet of the unit.	Yield small quantities of water to a large number of domestic and stock wells and springs in the Goshen Hole lowland and to the municipal and railroad wells at Yoder. The water is produced from sandstone beds and generally is under artesian pressure.
		Fox Hills sandstone	0–190	Gray medium-grained sandstone that contains pyrite. Becomes finer grained in lower part and is very limy and has green spots in basal unit.	Ground-water possibilities not known owing to its considerable depth, but locally it might yield small to moderate quantities of water to wells.
		Pierre shale	0–5,520	Predominantly dark-gray shale that contains thin to moderately thick beds of sandstone.	
		Niobrara formation	0–345	Speckled calcareous black shale that contains a 20-foot bed of nearly pure chalk near the middle. At base is 25-foot bed of dense light-buff limestone (Timpas limestone).	
		Benton shale	0–1,400±	Mainly dark-gray to black shale; contains beds of limestone and sandstone.	
	Lower Cretaceous	Cloverly formation	0–160	Upper and lower sandstone units separated by a thick sequence of beds of dark-gray to black shale; the sandstone is clean to shaly.	
Jurassic		Morrison formation	0–220	Dull, variegated claystone, fine-grained fresh-water limestone, and lenticular sandstone.	
		Sundance formation	0–120	Glauconitic green shale and shaly sandstone.	
			0–220	Red to yellowish-tan and buff sandstone; contains shale in upper and lower part.	
			0–140	Tan to white fine- to coarse-grained massive to crossbedded sandstone.	
Triassic		Chugwater formation	0–400±	Red siltstone containing small amounts of red shale, fine-grained red silty sandstone, and thin seams of gypsum or anhydrite.	

Permian (?)		Gypsum and red-shale sequence	0– 310	Red shale, gypsum, or anhydrite; soft silty shale; gray dolomite; gray to pink coarsely crystalline crinkled limestone; and layers of pink and gray chert.	Generally deeply buried. Ground-water possibilities not known.
Permian (?)		Minnekahta limestone	0– 40	Purple to blue slabby, thin-bedded limestone and yellow to pink slabby, silty limestone.	
Permian (?)		Opeche shale	0– 80	Bright-red silty shale and yellow to red sandstone; contains geodes and thin lenses of purple, red, and gray chert.	
Permian (?)		Hartville formation	0– 250±	Sandstone, limestone, shale, dolomite, and breccia. At the top are 50 to 90 feet of soft white to yellow porous sandstone which probably correlates with the "Converse sand." Below this unit is a cherty dolomitic red sandstone, thin beds of dolomite, and breccia composed of angular blocks of sandstone and dolomite.	
Carboniferous: Pennsylvanian		Hartville formation	0– 975±	Limestone, dolomite, sandstone, shale, quartzite, siltstone, and chert.	
Carboniferous: Mississippian		Guernsey formation	0– 135±	Hard gray moderately cherty coarsely bedded limestone.	
Devonian		Guernsey formation	0– 65±	Thin-bedded slabby very fine grained hard, brittle silty purple to gray dolomite interbedded with hard dolomitic purple shale and siltstone. About 4 feet of pink arkose occurs at the base.	
Cambrian (?)		Quartzite	0– 10±	Hard coarse-grained reddish-brown quartzite that is conglomeratic in part.	
Pre-Cambrian		Igneous and metamorphic rocks		Complex sequence of gneiss, schist, phyllite, quartzite, and limestone, which were intruded by coarse-grained granite, ultrabasic rocks, and pegmatite dikes.	

GEOLOGIC HISTORY

PALEOZOIC AND MESOZOIC ERAS

Very few rocks of Paleozoic and Mesozoic age are exposed in Goshen County, but the geologic section underlying the county is complete so far as the regional sequence of formations is concerned. Deep oil tests in the county and outcrops of the rocks in nearby areas furnish data on the unexposed rocks for the following brief discussion of the geologic history of the county.

The basal sedimentary rock in the county is Cambrian (?) quartzite (Denson and Botinelly, 1949), which was laid down as sand on the beaches or near the shore of the Cambrian sea. During the rest of early Paleozoic time, until deposition again occurred in Devonian time, the area was a land surface, or if any sediments were laid down they subsequently were eroded away. During Devonian and Mississippian time the sea invaded the area and thick deposits of limestone were laid down to form the Guernsey formation. Later during Mississippian, Pennsylvanian, and Permian (?) time the sea became shallower, probably because of gradual uplift of the land, and beds of sand, sandy and pure limestone, and marine clay were laid down to form most of the Hartville formation. As emergence of the land continued, shoreline conditions prevailed and the sand at the top of the Hartville formation was deposited. Total emergence of the land during the first part of Permian time is indicated by the continental deposits of mud, silt, and sand that compose the Opeche shale. Then the sea again temporarily invaded the area and pure and muddy limestone were laid down to form the Minnekahta limestone. Later in Permian time the land again completely emerged to form wide mud flats. At this time the climate was arid and the mud, silt, and gypsum of the so-called gypsum and red-shale sequence were laid down.

In early Mesozoic time, during the Triassic period, local shallow basins and extensive mud flats predominated under prevailingly arid conditions and the gypsum and gypsiferous red clay, silt, and sand of the Chugwater formation were laid down. Chugwater deposition ended with regional uplift which resulted in general planation that continued into Jurassic time. Then a submergence of the land took place and, under shoreline conditions, sands and clays were deposited during Sundance time. Shoreline conditions gave way to continental conditions and, under a prevailingly humid climate, fresh-water clays and sands were laid down during Morrison time. At the beginning of Cretaceous time there was some uplift, after which nearshore deposits were laid down to form the Cloverly formation. Then the sea advanced and, during the remainder of Early and most of Late Cretaceous time, several thousand feet of marine clay and sand were deposited. These deposits comprise the Benton shale, the Niobrara formation, and the Pierre shale. The sea then began to retreat and in the latter part of Fox Hills time a considerable thickness of sand was laid down on the great series of marine clay and sand. After the retreat of the Cretaceous sea the area was occupied by extensive bodies of brackish water and then fresh water in which were deposited the sand, clay, and carbonaceous material of the Lance formation. During about the middle of Lance time the Cannonball sea advanced into North and South Dakota. A brackish-water estuary or inlet extended into Goshen County, Wyo., and brackish-water deposits were laid down; this was the last invasion of the area by a sea. Subsequently, continental deposition was resumed, and the Cretaceous period ended with extensive mountain making.

CENOZOIC ERA

TERTIARY PERIOD

During Paleocene and Eocene time, or during the time between the close of the Mesozoic era and the beginning of Oligocene deposition, the area was uplifted and then, being topographically high, was eroded by streams. The extent of this erosion is not known, but a large regional basin was formed. This basin probably had a relatively rugged topography that consisted of moderately high hills and stream channels that were several hundred feet deep. Oligocene time began with erosion that later gave way to alluviation by a system of streams that crossed the area generally from west to east. These stream deposits, which constitute the lower unit of the Chadron formation, in part were probably derived locally from the Lance formation; however, the main source of the materials is not known. As materials continued to be deposited, the streams began to meander, as evidenced by the sinuous channel sandstone in the upper unit of the Chadron formation. At this time the clay, silt, and the occasional limy beds that later consolidated to form the claystone, siltstone, and limestone of the upper unit were deposited as stream and lake deposits. The deposition of the Brule formation during the remainder of Oligocene time occurred under conditions that generally were similar to those that prevailed during the latter part of Chadron deposition, no definite break occurring in the deposition of the two formations. However, the larger grain size of the materials that compose the Brule formation indicates that some renewed activity, either uplift or volcanism or both, took place to the west of the area. The character of the sediments comprising the Brule formation indicate that the sediments were deposited in a large basin that contained small fresh-water lakes and mud flats and meandering streams.

At the beginning of Miocene time, uplift in the Laramie Range to the west rejuvenated the eastward-flowing streams to such an extent that they deposited very coarse materials in their channels. These coarse materials make up the basal unit of the Arikaree formation. Subsequently, the fine sand of the Arikaree formation in the region was deposited by widely meandering streams, aided to a minor extent by wind. During much of Pliocene time the area seemingly was topographically high, and relatively little deposition is known to have taken place. During the latter part of Pliocene time, however, the streams aggraded their channels for a time; but for the most part they were degrading. Possibly during early or middle Pliocene time, the central part of the county was upwarped in the form of an arch, and some faulting took place in the area at this time as well as later during the Quaternary period. In late Pliocene time the North Platte River is thought to have flowed in essentially its present course. At the end of Pliocene time, considerable uplift of the mountains to the west took place.

QUATERNARY PERIOD

During early and middle Pleistocene time, the uplift of the mountains to the west and the increase in precipitation rejuvenated the streams. During this time the North Platte River and its principal tributaries in the area were mainly degrading streams; therefore, little or no deposition took place. Then the climate became drier and the streams began to alluviate. At this time the flood plain of the North Platte River, which followed essentially its present course, was about 200 feet higher than the present level of the river. The lower course of Rawhide Creek was approximately parallel to and north of that of the river. In the latter part of Pleistocene time there was renewed downcutting by the streams—the North Platte River cut a channel about 200 feet below its present level, and Rawhide Creek deepened its channel accordingly. Subsequently the two streams alluviated and refilled their valleys to about 180 feet above the present level of the river. Remnants of this valley fill are the third-terrace deposits. During the subsequent formation of the lower terraces and the present flood plains, the streams reworked the valley fill to unknown depths. This reworking is indicated by the greater permeability of these deposits.

The river later cut down to about 30 feet above its present level and formed a flood plain that was from ½ to 2½ miles wide. During this time the flow of the river was reduced and materials that were derived from the valley sides were deposited as colluvium on the flood plain, the remnants of which are the second terrace. The erosive power of the river again was increased and the river lowered its flood plain to within 20 feet above its present level. This level is well preserved and constitutes the first terrace. Since then the river has cut to the level of its present flood plain. While in the process of forming the second and first terraces and the flood plain, the river reworked the underlying valley fill to unknown depths.

AERIAL VIEW OF GOSHEN HOLE PROPER

View is west of Lingle looking southward and shows the western Goshen Hole escarpment. In this area the escarpment is capped by channel conglomerate of the basal unit of the Arikaree formation. In the middle background the escarpment disappears westward and reappears as the indistinct dark line along the horizon. In the left foreground can be seen a stretch of the Fort Laramie canal.

VIEW OF A LARGE FISSURE IN THE BRULE FORMATION

The fissure was revealed when a truck tire broke through the cap of covering material. This hole has since been filled, but other holes have appeared in the area, revealing the presence of other fissures.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

CRETACEOUS SYSTEM

LANCE FORMATION

Character.—In Goshen County the Lance formation of Late Cretaceous age consists of two distinct units: a lower unit that consists predominantly of dark materials, and an upper unit that consists of a sequence of light, variegated beds. The color distinction between the two units probably is due mainly to weathering of the upper unit but partly to the greater abundance of carbonaceous material in the lower unit. Thin beds of coal occur in both units of the formation but they are more numerous in the lower unit.

The lower unit consists of a thick sequence of beds of carbonaceous shale, gray siltstone, and dark- to light-gray sandstone, and thin beds of coal throughout the sequence. This unit does not crop out in the report area, but it was penetrated in drilling wells and test holes.

The upper unit consists of a colorful sequence of beds of sandstone and soft shale. The extreme upper part of the unit consists mainly of platy clay that is red, blue, green, brown, and brownish yellow, with no restriction of color to individual beds. Contained in this clay zone are a few thin dark-gray beds of carbonaceous soft shale, and lenses of dark- to very-light-gray loosely to well-cemented sandstone, some of which contain moderately hard yellowish-brown sandstone concretions. These lenses of sandstone are somewhat similar to the channel deposits of sandstone in the upper unit of the overlying Chadron formation, but they are lacking in the many very small flakes of biotite that are contained in the Chadron. Below the predominantly shaly unit is a relatively thick sequence of beds that is mostly sandstone and partly soft shale. The beds of sandstone range from yellow to white, are very fine to fine grained, and for the most part are loosely cemented. These beds contain very hard dark-brown sandstone and ironstone concretions, which are as much as 2 feet in diameter and weather into typical concave-convex fragments. The beds of shale mainly are yellowish brown, but a few are carbonaceous and therefore are dark gray.

The unit contains a few thin beds of coal, a few thin beds of impure limestone that contain oyster shells, and brown pebbles, cobbles, and boulders of chert. Schlaikjer (1935a, p. 31–68) subdivided this upper unit into three parts: a lower continental deposit 100–200 feet thick that contains ceratopsian and other reptilian remains; a middle brackish-water deposit 80–125 feet thick; and an upper continental deposit 60–100 feet thick, that contains in its upper portion a new and very advanced form of *Triceratops*.

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Samples of sandstone from three beds in the upper unit of the Lance formation were collected for mechanical analysis. The particle-size distribution, by percentage of total weight of the sample, is given below.

Sample no.	Particle size in millimeters						
	Clay less than 0.004	Silt 0.004–0.0625	Sand				
			Very fine 0.0625–0.125	Fine 0.125–0.25	Medium 0.25–0.5	Coarse 0.5–1.0	Very coarse 1.0–2.0
21-61-32ba	11.0	33.4	54.8	0.8			
22-61-10bc	15.0	61.4	22.4	.2	0.2	0.4	0.4
23-61-34cd	14.0	13.2	36.0	36.2	.4		.2

Extent and thickness.—The Lance formation is exposed in the south-central part of the county. Its areas of outcrop are irregular because, after deposition, it was deformed and uplifted and then subjected to erosion. Streams cut deeply into the Lance formation and subsequently filled their channels with sediments; hence, in many places the younger Chadron formation either overlaps the Lance formation or occurs as outliers within it.

The thickness of the Lance formation ranges from a knife edge to about 1,400 feet. The greatest thickness found in the county was in an oil test in sec. 32, T. 22 N., R. 63 W., where about 1,400 feet was penetrated. In this well about 300 feet of the upper unit of the formation is present; the remaining 1,100 feet represents the lower unit.

Water supply.—The Lance formation supplies water to a large number of domestic and stock wells in the south-central part of the county. Also, it supplies water to both the municipal and the railroad wells at the town of Yoder. The most productive of these wells is reported to yield about 100 gpm. Possibly larger quantities of water could be developed from the formation, but it is doubtful that these would be adequate for irrigation or large industrial needs. Water is yielded from sandstone beds in the formation and generally is under artesian pressure, which in places is sufficient to bring the water to the land surface.

TERTIARY SYSTEM

Tertiary sedimentary rocks in the area include the Chadron and Brule formations of Oligocene age and the Arikaree formation of Miocene age. The ages of the formations were determined by vertebrate remains, and by lithology and stratigraphic position.

OLIGOCENE SERIES

CHADRON FORMATION

In Goshen County only the upper part of the Chadron formation is typical of the formation as it occurs in adjacent areas. The lower part of the formation consists of a series of variegated fluviatile deposits which, in the main, are strikingly different from the upper part of the formation. Schlaikjer (1935b, p. 69–97) proposed the use of the term Yoder formation for these beds; however, later studies by J. R. Hough (oral communication, 1951) and by P. O. McGrew (oral communication, 1951) indicated that the Yoder formation should be considered as part of the Chadron formation. However, owing to the differences between this lower unit and the rest of the formation, it is discussed separately.

Lower unit.—The lower unit is of fluviatile origin and consists of a series of lenses and beds of deposits that range in grain size from clay through coarse to very coarse gravel; the coarsest materials represent channel deposits. The overall color is red; the beds of clay and silt are brick red, dark red, green to blue green, and buff; and the beds of sandstone and conglomerate are brick red, maroon, purple, and green. Two samples of the most permeable deposits were collected near the town of Yoder for mechanical analysis. The grain-size distribution, by weight, is given below.

Sample no.	Particle size in millimeters								
	Clay less than 0.004	Silt 0.004–0.0625	Sand					Gravel	
			Very fine 0.0625–0.125	Fine 0.125–0.25	Medium 0.25–0.5	Coarse 0.5–1.0	Very coarse 1.0–2.0	Very fine 2.0–4.0	Fine 4.0–8.0
23–62–29dc1	5.0	2.8	2.1	4.6	9.1	15.2	43.7	16.8	0.7
23–62–29dc2	6.3	8.9	11.8	24.2	32.2	15.6	1.0		

The channel deposits in the western part of the county contain coarse to very coarse gravel; in the eastern part of the county the deposits are mainly fine- to medium-grained sand. Sample 23–62–29dc2 is thought to be typical of most of the finer grained channel deposits.

Except for the extreme upper part, the unit is quite distinctive because of its overall red color. It crops out in several places in the area, but the areas of outcrop are not very extensive. The largest of these is in the vicinity of the town of Yoder; a good section of the unit is exposed in a cut of the Fort Laramie canal about a mile northwest of Yoder. For the most part, the material is loosely consolidated and is easily eroded. The extent of the unit is imperfectly known because of the irregular occurrence of its areas of outcrop, but it is known to underlie the area south of the North Platte River from Yoder eastward to about the Wyoming-Nebraska State line. In test hole 24–62–26da, 95 feet of the unit was penetrated—this probably represents about its maximum thickness in the county.

Water in sufficient quantities for domestic and stock use very likely could be developed from the coarse-grained channel deposits of the unit. However, to locate these channel deposits by drilling probably would be difficult, owing to the irregular distribution of the unit and the sinuous courses of the channel deposits. Some wells in the county probably produce water from the lower unit, but logs of wells that might be producing from the unit are not sufficiently detailed to show accurately the source of the water supply.

Upper unit.—The upper unit consists mainly of green, brown, red, or buff bentonitic loosely to moderately cemented clay and silt. The upper unit is sandy in places, and coarse-grained channel deposits occur at different horizons but are concentrated near the top. In addition, the upper unit contains a few lenticular beds of limestone and volcanic ash.

Although the upper unit consists predominantly of clay, the uppermost part of it consists mainly of silt with an admixture of clay and sand—in places the top is marked by the top of channel-sandstone deposits. The percentage distribution of grain sizes, by weight, for seven samples of the uppermost part of the unit is given below.

Sample no.	Particle size in millimeters								
			Sand					Gravel	
	Clay less than 0.004	Silt 0.004–0.0625	Very fine 0.0625–0.125	Fine 0.125–0.25	Medium 0.25–0.5	Coarse 0.5–1.0	Very coarse 1.0–2.0	Very fine 2.0–4.0	Fine 4.0–8.0
23-62-1bb1	22.0	73.8	3.8	0.2		0.2			
23-62-1bb2	19.3	69.9	10.2	.4	0.2				
23-62-1bb3	21.2	62.0	11.2	3.6	1.8	.2			
24-62-12ca4	27.1	50.9	17.4	4.4	.2				
24-62-12ca5	28.4	70.0	1.4	.2					
24-62-12ca6	36.2	60.8	2.4	.6					
24-62-26bc	22.1	73.9	3.4	.6					
24-62-26cb1	5.0	10.2	9.2	33.8	28.8	12.2	0.8		
24-62-26cb2	3.5		5.2	15.0	33.9	34.3	8.0	0.1	

The three samples collected at 23-62-1bb are of clayey silt from the transitional zone (which in a few places contains minor channel deposits of sandstone) in the uppermost part of the Chadron formation; they are listed in descending order. The transitional zone is overlain by the Brule formation and is underlain by the typical clay of the Chadron formation. Samples 24-62-12ca4, 12ca5, and 12ca6 were collected respectively, from immediately below the contact of the Brule and Chadron formations, from 3½ feet below the contact, and from 6½ feet below the contact. At this locality, the uppermost channel sandstone is about 20 feet beneath the top of the formation. In places, the upper part of the unit consists of channel deposits of loosely to well-cemented sand and gravel. In the western part of Goshen Hole proper, these deposits contain a considerable amount of gravel, some of which is very coarse, but eastward they grade into fine- to coarse-grained sandstone. The two samples that were collected from a channel sandstone at 24–62–26cb consist mainly of fine to coarse sand. The sample collected at 24–62–26bc consists predominantly of silt but is considered to represent the Chadron formation because it was taken from below a channel sandstone, the top of which marks the top of the Chadron formation.

In places the upper unit is gray, owing to concentrations of volcanic ash. Lenses of relatively pure volcanic ash probably occur in the unit but, owing to the gentle relief on the formation and to the cover of eolian and slope-wash materials, none are exposed on the surface. Several limestone beds, which are very near the base of the unit, crop out in secs. 25, 26, and 34, T. 23 N., R. 63 W. The limestone is light pink and granular, and contains disseminated grains of calcite, quartz, and basic minerals and thin lenses of clay pebbles (1 to 2 millimeters in diameter).

Because it is soft and fine grained, the upper unit typically weathers to a gently undulating topography characterized by small, well-rounded hills. In places the resistant channel deposits of sandstone form mesalike prominences. The unit is exposed throughout much of the central part of Goshen Hole proper and in the valley of the North Platte River; it underlies younger formations in many other parts of the county. The upper unit ranges in thickness from a knife edge to about 100 feet in most of its area of outcrop, but its is as much as 150 feet thick in the eastern and southeastern parts of Goshen Hole proper.

The upper unit yields small quantities of water to many domestic and stock wells in the central part of the county. The water is produced from sandstone channel deposits and generally is under artesian pressure, which in some wells is sufficient to cause the water to flow at the surface. The channel-sandstone deposits generally are narrow, sinuous, and widely separated; therefore, they are difficult to locate by drilling.

BRULE FORMATION

Character.—The Brule formation, of Oligocene age, consists of buff, moderately hard, brittle argillaceous siltstone that is sandy at the top and in places at the base. It contains moderately thick channel deposits of sand and sandstone, localized beds of limestone, moderately thick beds of clay, and a few beds of volcanic ash. In places it lies unconformably on the Chadron formation; elsewhere the contact is conformable. In most places the Brule is overlain unconformably by the Arikaree formation.

The lower part of the Brule formation is sandy in places. In the area south of Torrington, channel deposits of sand and sandstone as much as 20 feet thick occur about 20 feet above the base of the formation. Laterally the channel deposits grade into sandy siltstone, which grades into the massive siltstone of the formation. Above this zone is a thick section that is predominantly siltstone and which constitutes about four-fifths of the formation. A few beds of pure volcanic ash occur in this part of the formation, but the volcanic ash mainly is admixed with reworked siltstone. Many of these reworked zones are channel deposits that grade laterally into the characteristic siltstone of the formation. The formation also contains thin lenticular beds of cherty limestone; several of these beds crop out along the ridge south of the town of Torrington and on Table Mountain. In places the limestone beds contain silicified gastropod shells and streaks of chalcedony and agate.

The upper part of the Brule formation consists of a moderately well consolidated admixture of silt and very fine grained sand, which is intermediate between that of typical deposits of the Brule and of the Arikaree. This part of the formation is fairly persistent and occurs as a relatively uniform deposit on Sixty-six and Bear Creek Mountains and on most of the escarpment surrounding Goshen Hole. On the escarpment about 7 miles southwest of Lingle, where the Brule formation is overlain by the basal conglomerate of the Arikaree formation, the upper part of the Brule consists of typical silt and sand interbedded with lenses of conglomerate, and the contact with the Arikaree is indistinct and difficult to establish.

Barite crystals occur throughout much of the Brule formation. The crystals occur as fill in cavities, in columnar or spheroidal clusters in which most of the crystals are very small, or they occur as fill in fractures in which the individual crystals may be as much as half an inch across. Calcium carbonate also occurs as cavity or fracture fill throughout most of the formation; it occurs in both its amorphous and crystalline (calcite) forms. These deposits probably are of secondary origin, but the calcium carbonate probably was deposited in disseminated form with the other materials of the formation during deposition, and later was concentrated in the voids.

Mechanical analyses of six samples of the Brule formation indicate that it is composed mainly of silt and varying amounts of clay and sand. The percentage of silt in the samples ranged from 53.8 to 77.6, and averaged about 70. The weight percentage by grain size of the samples is given below.

Sample no.	Particle size in millimeters						
	Clay less than 0.004	Silt 0.004–0.0625	Sand				
			Very fine 0.0625–0.125	Fine 0.125–0.25	Medium 0.25–0.5	Coarse 0.5–1.0	Very coarse 1.0–2.0
19–62–1bb1	14.1	74.1	10.0	1.4	0.2	0.2	
19–62–1bb2	15.6	76.4	7.6	.2	.2		
24–62–12ca1	19.5	70.7	7.2	2.4	.2		
24–62–12ca2	23.4	66.2	7.6	2.6	.2		
24–62–12ca3	23.8	53.8	17.2	5.0	.2		
24–62–15dc	19.4	77.6	2.4	.2	.2		0.2

Samples 19–62–1bb1 and 1bb2 were collected on the steep south slope of Bear Creek Mountain, about 100 feet below the top of the formation. Three samples collected at 24–62–12ca represent the lower part of the formation; the first sample was taken about 32 feet above the contact of the Brule and Chadron formations; the second, about 14 feet above the contact; and the third, immediately above the contact. Three other samples were collected at this location from below the contact; the results of the analyses of those three samples are included in the discussion of the upper unit of the Chadron formation. Sample 24–62–15dc was taken about 300 feet above the contact of the Brule and Chadron formations.

The Brule formation is cut by many fractures, fractured zones, fissures, and faults—these are especially in evidence on weathered surfaces. Many of these fractures, the result of weathering, are small and superficial and are filled with clastic materials, calcium carbonate (calcite), or barium sulfate (barite). There are also zones of fractures that are quite different from the fractures caused by weathering. The zones are made up of loosely assembled blocks or chunks of siltstone, which may be spaced as much as half an inch apart, and have a shattered appearance. One of these zones was found beneath a cover of detritus in sec. 20, T. 24 N., R. 61 W., and another was exposed in sec. 1, T. 23 N., R. 61 W., where a bulldozer had removed the overlying loose material. The fissures, which range in width from about 1 inch to about 2½ feet, probably extend the entire thickness of the formation. They probably resulted from warping, either regional or local, or both. Other than on badland surfaces the fissures are difficult to detect, as they are covered by eolian and fluviatile deposits, but parts of their surface traces can be determined on aerial photographs. The fractured zones and fissures constitute lines of weakness which generally show up on aerial photographs. The surface expression of a fissure is shown in plate 6.

Faults also cut the Brule formation, but they do not seem to be as numerous as the fractures and fissures. Only a few faults were detected, owing to the homogeneity of the formation and to the cover of loose materials, but undoubtedly there are many more. The most conspicuous fault is the Whalen fault, which has an estimated 700 feet of vertical displacement of beds with the upthrow on the west.

Extent and thickness.—The Brule formation crops out in much of the central and southern parts of Goshen County. It makes up the bases and lower slopes of escarpments that surround the Goshen Hole lowland, and its area of outcrop has the appearance of a broken ring that is somewhat elongated northwestward into the inner valley of the North Platte River. Several erosional outliers occur; south of Torrington is one that is 13 miles long in an easterly direction. In Goshen County the Brule formation ranges in thickness from a knife edge to about 450 feet.

Water supply.—Generally, the Brule formation, which consists mainly of an argillaceous siltstone that is relatively impermeable, does not yield water abundantly to wells. However, most wells in the formation produce small quantities of water for domestic and stock purposes from fractures. Lenses of sandstone in the formation also are thought to yield small quantities of water to wells.

In the southern part of the county near Lagrange, fissures and fractured zones yield relatively large quantities of water to irrigation wells. Yields of as much as 870 gpm are obtained from wells that tap both fractures and fissures in the Brule formation and sand and gravel in the overlying alluvium. Logs of successful irrigation wells in this area show a moderate thickness of saturated alluvium above the Brule formation. Water percolates downward through overlying permeable materials into interconnecting fractures and fissures, through which the water is transmitted to the wells.

In places in Goshen County additional supplies of water for irrigation probably could be developed from fractured zones and fissures in the Brule formation. The stream valleys, such as that of Horse Creek in the vicinity of Lagrange, are the most likely areas for further development, because they contain great thicknesses of saturated, coarse-grained materials that overlie the Brule formation. However, test drilling would be required to determine the location of the fractured zones.

MIOCENE SERIES

Generally, the deposits of Miocene age in Goshen County constitute a fairly homogeneous, mappable unit. Detailed geologic and paleontologic work in western Nebraska, however, has demonstrated that the Miocene deposits, at least in Nebraska, can be divided into smaller, mappable units. The following tabulation of Miocene deposits in adjacent areas in western Nebraska was abstracted from table 1 in the report by Lugn (1939, p. 1245–1276)—

Unconformity
Hemingford group 250–400 feet
(1) Sheep Creek formation 140–300 feet
Unconformity
(2) Marsland formation (old "Upper Harrison") 125–200 feet
Unconformity
Arikaree group 700–800 feet
(1) Harrison formation 200 feet
(2) Monroe Creek formation 375 feet
(3) Gering formation 100–200 feet
Unconformity

In places in Goshen County lateral equivalents of some of these formations were recognized or have been reported, but the scope of this report did not warrant the necessary detailed study needed to subdivide accurately the sandstones of Miocene age. Of the above-mentioned formations all those of the Arikaree group of Lugn (1939) and the Marsland formation of the Hemingford group of Lugn (1939) probably are present in Goshen County. The complexities of the problem of subdividing the Miocene deposits is evidenced by the conflicts in the data presented by Schlaikjer (1935c, p. 111–120) and Lugn (1939, p. 1251–54, p. 1268–69) and by others. As these deposits are fairly homogeneous and seemingly have similar water-bearing properties, they are herein grouped under Arikaree formation.

ARIKAREE FORMATION

Character.—In Goshen County the Arikaree formation consists mainly of loosely to moderately cemented very fine to fine grained tan to gray sand and silt that contain layers and concretions of hard, tough fine to very fine grained brown to gray sandstone; it contains also a few beds of white to gray volcanic ash, thick basal channel deposits of conglomerate, zones of loosely to moderately consolidated fine to very fine grained sand that are either markedly to slightly crossbedded or thinly laminated, and beds of white to light-gray volcanic ash. In places, the lithology of the lower part of the formation is quite different from that of the overlying part, and, for this reason, the two divisions of the formation are discussed separately as the basal unit and the upper unit. On plate 1, however, these units are not identified but are shown together as the Arikaree formation.

In Goshen County, the basal unit for the most part is a conglomerate that was laid down as channel deposits. These deposits consist of lenses of medium- to coarse-grained loosely to well-cemented sandstone that are interbedded with lenses of loosely to well-cemented conglomerate, which range in grain size from very fine gravel through large boulders. The conglomerate consists of pebbles of quartzite, granite, basic rocks, sandstone, chert, and limestone; red quartzite fragments (pebbles through large boulders) transported from the

Hartville Hills are conspicuous by their number, color, and size. This basal unit crops out mainly on the escarpment in the area west of Lingle, where the escarpment forms an approximate semicircle that extends on both sides of the valley of the North Platte River. The beds composing the channel deposits are unequally resistant to erosion and, therefore, form escarpments with prominent ledges. The channel deposits grade laterally into alluvial-fan deposits characterized by lenticular beds of sandstone that exhibit small-scale crossbedding. The alluvial fans grade into loosely to moderately cemented sandstone which may be massive or heavily crossbedded, or may show a nearly horizontal, finely laminar bedding. The lower unit generally is conspicuously unconformable with the underlying Brule formation and in different places is overlain either unconformably or conformably by the upper unit.

The upper unit consists mainly of fine-grained soft to moderately hard generally massive sandstone. A sample of the sandstone was collected at 19–62–1bb3 and the weight percentage by grain size was determined to be clay 4.0; silt, 28.4; very fine sand, 62.0; fine sand, 5.2; medium sand, 0.2; and coarse sand, 0.2. In general, there is very little horizontal bedding and only local small-scale crossbedding; therefore, the massiveness of the upper unit generally is broken only by concretionary layers, pipes, and nodules of well-cemented sandstone and by a few lenticular beds of volcanic ash. The concretions probably were formed by the cementing of sand by calcium carbonate that was deposited by percolating ground water. This phenomenon is discussed more fully by Cady (Wenzel, Cady, and Waite, 1946, p. 73–75). The beds of volcanic ash generally are thickest and most numerous nearer the top of the formation.

In Goshen County the Arikaree formation is cut by several faults and by many fractures. These were probably caused by post-Miocene stresses along faults which were active during the Laramide orogeny, and by regional post-Miocene upwarping of the area. On the west side of the Whalen fault the top of the Brule formation lies in fault contact with beds on the east side that were estimated by Schlaikjer (1935c, p. 121) to be 700 feet higher in the section. There also are several other faults and many fractures and fissures in the north-central part of the county. (See pl. 1.) Many of these fractures and fissures are open, but some are filled, as indicated by the occurrence of clastic dikes in the area. The dikes are resistant, and where erosion has been active they are prominent features. These dikes also are associated with faults in the area.

Extent and thickness.—The Arikaree formation crops out in the upland areas in Goshen County. It is relatively resistant to erosion and generally constitutes the upper part of the Goshen Hole escarpment. In many places erosional outliers are entirely of the Arikaree formation or are capped by it. In the county, it ranges in thickness from a knife edge to about 1,000 feet.

Water supply.—The Arikaree formation yields water to many domestic and stock wells in the county, and to three irrigation wells in the northern part of the county. Owing to the relatively low permeability of the material, a considerable saturated thickness of the formation normally must be penetrated in order to develop a well of large discharge. A well in Niobrara County, Wyo., about 6 miles north of the Goshen County line, reportedly yields 1,000 gpm with a drawdown of 14 feet, or a specific capacity of about 71 gpm for each foot of drawdown. This is a high specific capacity for wells in the Arikaree formation, and indicates that the water probably is coming from fractures. As there appear to be many fractures in the Arikaree in Goshen County, large yields should be available where the fractures can be located by test drilling.

PLIOCENE SERIES

In Goshen County the Pliocene deposits present a complex system of channel deposits that have been isolated, truncated, and obscured, or completely destroyed, by subsequent erosion. A more detailed study of the Pliocene deposits would be needed to define them accurately. Underlying the conglomeratic cap rock on Pine Ridge is a deposit of sandy siltstone about 60 feet thick that may be of Pliocene age. The coarse channel deposits that occur on several high isolated hills very likely are of Pliocene age, but the age of some of the lower channel deposits which are in the valley of the North Platte River, is very questionable. As they are quite similar to that of the Quaternary deposits of sand and gravel, these lower channel deposits are included with the upland sand and gravel in this report. Only the coarse channel deposits that occur on Pine Ridge, Casebier Hill, and Spoon Butte, and those that occur as isolated remnants on the upland area about 2 miles southeast of Casebier Hill are considered to be Pliocene.

CHANNEL DEPOSITS

The Pliocene channel deposits consist mainly of coarse sand and gravel which in places contain cobbles and medium-sized boulders. The deposits that form the cap rock on Pine Ridge and Casebier Hill are cemented by calcium carbonate into a moderately hard conglomerate that contains boulders ranging from small to medium. Pebbles of volcanic materials (probably rhyolite) were found on both Pine Ridge and Spoon Butte, and a fragment of stream-rounded red scoria was collected in the loose gravel on top of Pine Ridge. The deposits that occur on top of Spoon Butte consist of unconsolidated sand and gravel in which were found fragments of bones and horse teeth.

The Pliocene channel deposits in Goshen County as herein described probably do not exceed 25 feet in thickness. They are topographically high and are well drained; therefore, they are not a source of water for wells in Goshen County.

QUATERNARY SYSTEM

In the report area the Quaternary deposits include upland deposits, valley fill, dune sand, loesslike deposits, and slope wash. The areal distribution of the loesslike deposits and the slope wash was not mapped because these deposits generally occur only as a thin veneer, although they are present over much of the area. The loesslike deposits of eolian material range in size from silt to medium-grained sand, which indicates that their source is local. The slope wash occurs mainly as a mantle of detritus and rill wash on slopes below escarpments and hills and in bordering lowlands where stream erosion is at a minimum. The slope wash in the area is derived mainly from the Brule and Chadron formations and, therefore, consists mainly of fine-grained materials. Locally, the slope wash is as much as 54 feet thick in the area about 4 miles southwest of Torrington (section *C–C'*, pl. 1). Neither the loesslike deposits nor the slope wash are an important source of ground water.

PLEISTOCENE SERIES

UPLAND DEPOSITS

The upland deposits, of Pliocene(?) and Pleistocene age, include the deposits of sand and gravel that underlie the upland slopes which border the valley of the North Platte River. The lower boundary of these slopes is indistinct in many places, but it is about 200 feet above the present level of the river. Channel deposits of unconsolidated sand and gravel that probably are of Pliocene age are included with the Quaternary deposits because of their similarity to the younger deposits. The upland deposits consists of remnants of terrace deposits, pediment deposits, and the residuum from conglomerates—especially of the basal channel conglomerate of the Arikaree formation.

In the area about half a mile north of the town of Lingle the upland deposits form a conspicuous ridge. The origin of this deposit of sand and gravel is debatable, but probably is due to multiple conditions that include deposition by streams, accumulation of detritus, and disintegration of nearby rock. If the original pediment slope from the base of Pine Ridge, which lies about 5 miles to the northwest, is projected outward from the ridge, this deposit can be correlated with the gravels that underlie remnants of the pediment. However, because the deposit lies in the valley of the North Platte River within the limits of the level of the third terrace, it includes some river deposits. These upland deposits are topographically high and are largely drained and thus do not serve as an aquifer.

Test drilling in the valley of the North Platte River revealed several channel deposits of sand and gravel, the tops of which are about 200–450 feet above the level of the North Platte River. The extent of these channels is shown by bedrock contours (pl. 2), and their thickness is shown by cross sections (pl. 1). These thick channel deposits would yield adequate supplies of water to wells for irrigation if a sufficient saturated thickness were penetrated. The saturated thickness of these materials is shown on plate 3.

Many other upland deposits of sand and gravel are present in the county. These are mainly in the form of a thin veneer or occur in patches; usually they are topographically high and, therefore, well drained. They serve mainly as infiltration areas for recharge of underlying beds from precipitation.

PLEISTOCENE AND RECENT SERIES

VALLEY FILL

The valley fill of Pleistocene and Recent age occurs along the inner valley of the North Platte River and its tributaries. The fill consists mainly of highly permeable sand and gravel, and its deposition and distribution are described on pages 16–17. As shown by the contours of the bedrock surface (pl. 3) and by the cross sections (pl. 2), deep gravel-filled channels underlie the axial part of the stream valleys and the broad third terrace north of the river. The valley fill consists of the following depositional units: Those of the third terrace, the second terrace, the first terrace, and the flood plain (the latter two being mapped together).

Deposits of the third terrace.—For the purposes of this report only the third-terrace deposits that underlie the relatively flat area approximately between the Torrington canal on the south and the Interstate canal on the north and between Rawhide Creek on the west and the State line on the east are of sufficient extent and thickness to warrant describing in detail. The underlying deposits of sand and gravel occur as fill in channels that were cut by Rawhide Creek; therefore, owing to the irregular pattern of these channels, the thickness of the deposits ranges from a knife edge to about 210 feet.

The permeable third-terrace deposits constitute an important aquifer in that they yield water to many wells, a large number of which are used for irrigation, and they are recharged freely from surface water (canals and laterals, intermittent streams, and irrigated lands) and from precipitation. Generally, the saturated thickness of the material is sufficient for the development of large supplies of water, but in some places there is little or no saturated material because of the presence of buried ridges of bedrock which separate former channels of Rawhide Creek. (See pl. 3.) The most notable of these ridges is the one that underlies the area about 1½ miles north of Torrington.

Deposits of the second terrace.—The second terrace is a comparatively minor feature along the valley of the North Platte River, in that it is poorly preserved and occurs in narrow isolated patches. The largest remnant of this terrace occurs as a narrow strip between U. S. Highway 26 and the Interstate canal from about the center of R. 63 W. to about the center of R. 64 W. In test hole 25–63–3bb a thickness of 210 feet of deposits was penetrated beneath the second terrace before bedrock was struck. No attempt has been made to develop wells of large discharge in these second-terrace deposits, but wells of moderate to large yield probably could be developed in places. The second-terrace deposits are recharged freely from irrigation water and from precipitation.

Flood-plain deposits.—The flood plain as described and mapped in this report includes both the present flood plain and the next previous flood plain or first terrace, as the boundary between the two is indistinct and poorly defined and because the first terrace is reported to have been inundated by the North Platte River during periods of extremely high floods. The deposits that underlie the flood plain of the valley of the North Platte River consist mainly of sand and gravel that contain lenses and beds of fine sand, silt, and clay, large chunks of siltstone, lenses of siltstone pebbles, and cobbles and boulders. The greatest thickness of flood-plain deposits found along the North Platte River valley was 197 feet in test hole 24–61–15bd. The maximum thickness of these deposits beneath the flood plain of Rawhide Creek was reported to be 160 feet in a shot hole in sec. 15, T. 26 N., R. 62 W. The maximum thickness along Horse and Bear Creeks was about 45 feet in the vicinity of Lagrange. The flood-plain deposits of Rawhide Creek valley consist mainly of fine- to medium-grained sand that contains silt and gravel. These materials for the most part are fine grained, as they were derived mainly from local outcrops of the Arikaree and Brule formations. The deposits that underlie the valleys of Horse and Bear Creeks consist mainly of fine- to medium-grained sand admixed with silt, clay, and some gravel. However, in the vicinity of Lagrange, the deposits contain much sand and gravel.

Along the Laramie River and the North Platte River in the western part of the county, the flood-plain deposits are quite narrow. East of the town of Lingle, the flood plain widens to as much as 3 miles. The flood-plain deposits along Rawhide Creek are about 1 to 2 miles wide. These deposits are about 5½ miles wide along Horse and Bear Creeks in the vicinity of Lagrange. They also occur along Horse Creek north of Lagrange but, because they are relatively thin and narrow, they were not mapped.

Many wells in the area obtain water from the flood-plain deposits. These deposits are by far the most productive aquifer in the county, and yield water to many domestic and stock wells and to most of the irrigation, municipal, and industrial wells. Wells that yield more than 3,000 gpm have been developed in this aquifer in the valley of the North Platte River.

Dune sand.—Dune sand covers a considerable part of the area in much the same manner as the loesslike deposits that were previously described, and in many places the two deposits are admixed. Only the more extensive areas of dune sand are shown on plate 1. The largest deposit of dune sand is in the area north and east of Torrington, where the sand deposits extend from the level of the flood plain to above the level of the third terrace of the North Platte River. Another large deposit of dune sand occurs in the northeastern part of the county, where a thick deposit composes Lone Sand Hill and covers much of the adjacent area.

The dune sand generally lies above the water table and is not known to yield water to wells. It does, however, serve as an excellent medium for infiltration of water from precipitation and from streams and canals, and for recharge of underlying materials.

GROUND WATER

PRINCIPLES OF OCCURRENCE

The fundamental principles governing the occurrence and movement of ground water has been set forth in detail by Meinzer (1923a) and many others. Only a brief discussion of the subject will be made here.

Ground water in Goshen County is derived chiefly from the infiltration of irrigation water and from precipitation that falls as rain or snow. A part of this water runs off directly into streams, a part evaporates, a part is consumed by vegetation, and a part percolates through pore spaces in the soil and underlying rocks to the water table where it enters the zone of saturation. Some of the water in the zone of saturation eventually returns to the surface through seeps and springs or is discharged by wells and evapotranspiration. Most of the water, however, percolates directly and invisibly into surface streams.

The porous rocks below the water table generally are saturated. Those that are sufficiently permeable to do so, yield water to wells. In the more permeable rocks, such as the deposits of unconsolidated sand and gravel, the individual pores are interconnected and are large enough so that the water moves freely through them under the force of gravity, but in less permeable rocks, such as the siltstone and clay of some of the bedrock formations, the pores are so small that water moves through them slowly.

PHYSICAL AND HYDROLOGIC PROPERTIES OF WATER-BEARING MATERIALS

The quantity of water that a rock formation will yield to wells and the ability of the formation to transmit water depend upon the physical and hydrologic properties of the materials that constitute the formation. Detailed geologic descriptions of materials that are discovered in drilling, such as those included in the logs at the end of this report, are useful in determining the hydrologic properties of the rock formations, but more accurate quantitative estimates require a more comprehensive analysis of the materials by means of laboratory or field tests.

Twenty-one samples of the bedrock formations were analyzed in the hydrologic laboratory to determine their physical and hydrologic properties. These studies included particle-size analyses and determinations of apparent specific gravity, porosity, moisture equivalent, specific yield, and coefficient of permeability. Particle-size analyses were made for all 21 of the samples collected, but other physical values were determined only for 15 of them. The results of the laboratory studies for these 15 samples are summarized in table 1, and the 21 particle-size analyses are given on pages 28–33.

Pumping tests were made at four wells that tap the flood-plain deposits and at two wells that tap the third-terrace deposits. From these tests determinations of transmissibility, permeability, and storage coefficients were made. Pumping tests were made whenever possible because they allow an analysis of the water-bearing materials under natural conditions.

TABLE 1.—*Physical and hydrologic properties of the bedrock formations*

[Geologic source: Kl, Lance formation; Ta, Arikaree formation; Tb, Brule formation; Tc, Chadron formation. Type of material: Sls, siltstone; Ss, sandstone. Coefficient of permeability: N, negligible value]

Sample no.	Geologic source	Type of material	Porosity (percent by volume)	Specific retention (percent by volume)	Specific yield (percent by volume)	Coefficient of permeability (gpd/ft² at 60° F)
19-62- 1bb1	Tb	Sls	-----	-----	-----	0.1
- 1bb2	Tb	Sls	41.7	36.7	5.0	.2
- 1bb3	Ta	Ss	43.3	10.8	32.5	69
21-61-32ba	Kl	Ss	37.5	21.2	16.3	6
22-61-10bc	Kl	Sls	7.4	-----	-----	N
23-61-34cd	Kl	Ss	8.8	-----	-----	-----
23-62- 1bb1	Tc	Sls	45.5	43.2	2.3	N
- 1bb2	Tc	Sls	46.6	44.8	1.8	N
- 1bb3	Tc	Sls	41.8	-----	-----	-----
-29dc1	Tc	Ss	10.6	8.1	2.5	N
-29dc2	Tc	Ss	15.8	11.5	4.3	335
24-62-15dc	Tb	Sls	38.5	37.1	1.4	N
-26bc	Tc	Sls	44.5	-----	-----	-----
-26cb1	Tc	Ss	15.3	11.9	3.2	N
-26cb2	Tc	Ss	11.4	10.0	1.4	-----

LABORATORY DETERMINATIONS

Grain size.—A particle-size analysis, or mechanical analysis, of granular material consists of separating into groups the grains of different sizes and determining the percentage, by weight, of the total sample each size group constitutes. Grain sizes larger than 0.0625 millimeter were determined by wet-sieve analysis and sizes smaller than 0.0625 millimeter were determined by the hydrometer method of wet analysis. The results of the particle-size analyses of the materials are given on pages 28–33.

Porosity.—The porosity of a rock aggregate is its property of containing interstices without regard to size, shape, or arrangement of openings. Porosity is expressed quantitatively as the percentage of the total volume of a rock that is occupied by interstices. In a rock that is saturated with water, the porosity is the percentage of the total volume of rock that is occupied by water. The porosity of a rock indicates only the amount of water the rock can hold, not the amount it can yield to wells. Some rocks, such as clay and silt, may have a high porosity but will yield very little water to wells.

The porosity of some of the samples studied was determined as a step in the calculation of the specific yield. The porosities of the samples given in table 1 ranged from 7.4 to 46.6 percent by volume. In general the larger porosities occur in the finer grained rocks, so long as they are unconsolidated or only partially consolidated.

Moisture equivalent, specific retention, and specific yield.—The moisture equivalent of a water-bearing material is the ratio of (1) the weight of water that the material, after saturation, will retain against a centrifugal force that is 1,000 times the force of gravity to (2) the weight of the dry material. The moisture equivalent by volume is computed by multiplying the moisture equivalent by weight by the apparent specific gravity of the material. The specific retention—that is, the quantity of water that a material will retain against the pull of gravity if it is drained after having been saturated—is expressed as the ratio of the retained water to the total volume of material. It is determined by adjusting the moisture equivalent by volume by a correction factor that was calculated by Piper (1933, p. 481–487). Because the moisture equivalent is significant only as a means of determining the specific retention, only the specific retention is listed in table 1.

The specific yield of a water-bearing material is defined as the ratio of the volume of water that a saturated aquifer will yield by gravity to its own volume, and is numerically equal to the porosity minus the specific retention. The specific yield of the samples ranged from 1.4 to 32.5 percent. A fine-grained saturated material will yield its water slowly; the rate of draining is somewhat proportional to the permeability of the material. Owing to their fine-grained texture, the bedrock formations yield water slowly, and the values for specific yield that were calculated in the laboratory probably would not be reached in field tests under natural conditions until several months had passed.

Permeability.—The permeability of a formation generally is expressed as the coefficient of permeability, which as used in the Geological Survey is the Meinzer unit (meinzer)—the number of gallons of water a day, at 60°F, that is conducted laterally through each mile of the water-bearing bed under investigation (measured at right angles to the direction of flow), for each foot of saturated thickness of the bed, and for each foot per mile of hydraulic gradient. The field coefficient of permeability is the same unit, except that it is measured at the prevailing field temperature of the ground water rather than at 60°F. The coefficient of transmissibility may be expressed as the number of gallons of water a day, at the prevailing temperature, transmitted through each mile strip extending the saturated thickness of the aquifer under a hydraulic gradient of 1 foot to the mile; hence, it is the product of the average field coefficient of permeability and the saturated thickness of the aquifer.

The coefficient of permeability of 11 samples of the bedrock formations was determined with a constant-head permeameter. Laboratory methods employed in determining permeability have been described by V. C. Fishel (Wenzel, 1942, p. 59–68). Five of the samples transmitted no water during the time of the tests and the permeability is recorded as negligible. The coefficients of permeability determined by the laboratory tests for the bedrock formations generally were very low, ranging from a negligible amount to 6 gpd (gallons per day) per square foot in 9 of the samples. The other 2 had permeabilities of 69 and 335 gpd per square foot, respectively (table 1).

PUMPING-TEST DETERMINATIONS OF TRANSMISSIBILITY, PERMEABILITY, AND STORAGE COEFFICIENTS

Six pumping tests were made to determine the coefficients of transmissibility and storage[3] of the unconsolidated deposits of sand and

[3] The coefficient of storage of an aquifer is the volume of water it releases from or takes into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface.

A simple way of visualizing this concept is to imagine an artesian aquifer which is elastic and is uniform in thickness, and which is assumed, for convenience, to be horizontal. If the head of water in that aquifer is decreased there will be released from storage some finite volume of water that is proportional to the change in head. Because the aquifer is horizontal, the full observed head change is evidently effective perpendicular to the aquifer surface. Imagine further a representative prism extending vertically from the top to the bottom of this aquifer, and extending laterally so that its cross-sectional area is coextensive with the aquifer-surface area over which the head change occurs. The volume of water released from storage in that prism, divided by the product of the prism's cross-sectional area and the change in head, results in a dimensionless number which is the coefficient of storage. If this example were revised slightly, it could be used to demonstrate the same concept of coefficient of storage for a horizontal water-table aquifer or for a situation in which the head of water in the aquifer is increased.

gravel composing the valley fill. The field coefficients of permeability were determined by dividing the coefficient of transmissibility by the saturated thickness of the material. The results of these tests, which were obtained by means of the Theis method (Theis, 1935, p. 519–524) are shown in table 2.

TABLE 2.—*Results of pumping tests on wells*

	Well no.					
	24-61-2cb	24-61-5cbl	24-61-10cd	24-61-15ccl	25-61-33ab	25-63-12bd
Aquifer	Third-terrace deposits	Flood-plain deposits	Flood-plain deposits	Flood-plain deposits	Third-terrace deposits	Flood-plain deposits
Date of test	Aug. 1951	Oct.-Nov. 1951	Sept. 1951	Oct. 1951	Oct. 1951	Sept. 1951
Duration of test (hours)	12	25	9	37	24	3
Pump discharge (gallons per minute)	1,040	1,060	900	3,400	1,210	1,590
Drawdown at pumped well (feet)	9.1	6.1	7.6	18.3	9.3	9.8
Specific capacity of pumped well (gallons per minute per foot of drawdown)	114	174	119	186	130	162
Saturated thickness of aquifer (feet)	57	160	170	190	135	65
Coefficient of transmissibility (gallons per day per foot)	335,000	614,000	250,000	1,650,000	310,000	270,000
Average field coefficient of permeability (gallons per day per square foot)	5,900	3,800	1,500	8,700	2,300	4,200
Theoretical radius of influence of pumped well at end of test (feet)	------------	900	------------	1,800	660	------------
Storage coefficient of aquifer	------------	0.235	------------	0.235	0.216	------------

During each of three of the tests, a test well was pumped at a constant rate for at least 24 hours and periodic measurements were made of the drawdown in three observation wells at different distances from the test well. The transmissibility and storage coefficients were computed for each of these tests. Because the pumped wells penetrated the aquifer only partially, the drawdown in the observation well nearest the pumped well in each of the tests was somewhat greater than it would have been if the pumped well had fully penetrated the aquifer. Also, in each of the tests the drawdown in the observation well farthest from the pumped well was small, and the effects of the errors caused by extraneous influences were larger than in the nearer observation wells. Therefore, although there is substantial agreement between the results computed for the three observation wells in each test, only the result computed for the middle observation well is listed in the table for each of the three tests. Because insufficient data were collected during the other three tests, it was not possible to compute the value of the coefficient of storage, and only the value of transmissibility is listed.

The field coefficient of permeability computed for the flood-plain deposits ranged from 1,500 to 8,700 gpd per square foot; and that computed for the third-terrace deposits ranged from 2,300 to 5,900 gpd per square foot. The storage coefficient computed for the flood-plain deposits was 0.235 (two tests) and that computed for the third-terrace deposits was 0.216.

INTERFERENCE BETWEEN WELLS

In areas where wells of large discharge are closely spaced, the cones of depression around the wells may overlap sufficiently (interfere) to cause a substantial increase of the pumping lift. The amount of interference depends upon the distance between wells, the rate and duration of pumping of the wells, and the hydrologic properties of the aquifer.

As soon as a pump begins discharging water from a well under water-table conditions, the water table in the vicinity of the well is lowered, and a hydraulic gradient toward the well is established. The water table assumes a form comparable to that of an inverted cone, with the well at the apex of the cone. At the beginning, most of the water that is pumped from the well is obtained by dewatering materials close to the well. As pumping is continued, the material near the well is gradually dewatered; a hydraulic gradient is established that allows approximately the amount of water that is being pumped to be transmitted to the well; and the water is derived from ever increasing distances from the well. Thus, the cone of depression continues to expand, and the water table within the cone continues to decline gradually. The development of the cone may be altered if water is added to the formations by natural or artificial recharge, or if the expanding cone reaches less permeable rocks which form barriers to the movement of water. After the pumping of a well is stopped, water continued to percolate toward the well for a time because the hydraulic gradient is still in that direction; the water gradually fills the well and the adjacent material that was dewatered by pumping. As the material near the well is being refilled, the hydraulic gradient decreases, and the recovery of the water level in the well becomes progressively slower. A general equalization of water levels eventually takes place over the affected area, and the water table tends to assume its original form, although it may remain temporarily or permanently lower than before water was withdrawn, depending on recharge.

The drawdown in the vicinity of a discharging well decreases with an increase in distance from the well, and increases with an increase in the rate and duration of pumping. For example, test well 24–61–5cb, which was pumped at a rate of 1,060 gpm, after 25 hours produced drawdowns of 0.83 foot at 159 feet, 0.50 foot at 300 feet, and 0.33 foot at 500 feet. After the 25-hour period of pumping the computed radius of influence of the cone of depression was about 900 feet.

SPECIFIC CAPACITY OF WELLS

The specific capacity of a well, or yield per unit of drawdown, is expressed as the number of gallons per minute that a well yields for each foot of drawdown of the water level in the well. Under water-table conditions, this relation is approximately constant only when the drawdown is but a small fraction of the saturated thickness of the aquifer. The drawdown depends also upon the differences in the construction and development of wells. However, a comparison of specific capacities is useful in estimating the permeability of aquifers and the relative efficiency of wells. The discharge and drawdown of many of the wells are given in table 7.

The highest specific capacities in Goshen County are in wells in the unconsolidated sand and gravel deposits. Data for 35 wells of large discharge in the sand and gravel deposits of the valley fill of the North Platte River indicate that the specific capacities for these wells range from 21 to 250 gpm per foot of drawdown and average about 120 gpm per foot of drawdown. The wide range in specific capacities is due largely to the differences in the composition of the aquifer but partly to differences in construction and development of the wells. Two irrigation wells in the alluvium in the vicinity of Lagrange have specific capacities of 16.6 and 40 gpm per foot of drawdown, respectively. In the same vicinity an irrigation well that produces water from the alluvium and from fractures in the Brule formation has a specific capacity of 25 gpm per foot of drawdown.

Wells in the bedrock formations generally could be expected to have much lower specific capacities than the wells in the unconsolidated materials. Well 29–63–14dc, which is in the Arikaree formation, has a specific capacity of about 12 gpm per foot of drawdown. Well 29–63–6bd., which produces from both the Arikaree formation and the alluvium, has a specific capacity of about 17 gpm per foot of drawdown. The specific capacity of two wells in the Lance formation, 23–62–34cd and 25–63–25bd, is 1.5 and 0.20 gpm per foot of drawdown, respectively.

THE WATER TABLE

The water table is defined as the upper surface of the zone of saturation except where that surface is formed by an impermeable body (Meinzer, 1923b, p. 22). Where the aquifer is overlain by a bed that is impermeable or that is of low permeability the aquifer is artesian and a piezometric surface exists. The piezometric surface is an imaginary surface that everywhere coincides with the static level of the water in the aquifer; therefore, it is the surface to which the water from a given aquifer will rise under its full head. If the piezometric surface is above the land surface, water will flow from wells that tap the aquifer. In Goshen County both water-table and artesian conditions exist, but, as they are not coincident, only measurements of water-table wells were used in compiling the water-table contour map (pl. 1) and the depth-to-water map (pl. 4). For this reason no contours are shown in the central and east-central parts of the county, where most of the wells have tapped water under artesian pressure.

SHAPE AND SLOPE OF THE WATER TABLE

The water table in general is not level or uniform but is a warped, sloping surface. Irregularities in the amount and direction of slope are caused by differences in thickness or permeability of the aquifer and by unequal additions or withdrawals of water. Ground water moves in the general direction of the slope of the water table, and the rate of movement, assuming a uniform cross section, is proportional to the slope (hydraulic gradient) and the permeability of the water-bearing material. The configuration of the water table is shown by contours, which are lines along which all points have the same altitude. The direction of ground-water movement is at a right angle to the contour lines. The central part of the water-table contour map (pl. 1) is based on water-level measurements made during the spring of 1951. The water-level measurements used in constructing the contours in the upland areas were made during the period 1943–51. As there was no appreciable change in the water levels in the upland areas during this period, it was not necessary to adjust these measurements to conform with the water-level measurements made during the spring of 1951.

In the North Platte River valley and adjoining upland areas the water table in the valley fill, the upland deposits, and the Brule and Arikaree formations is continuous. The water table generally slopes toward the river and its principal tributaries in a downstream direction.

In the area that is underlain by the Lance and Chadron formations, a water table generally exists in the weathered zone or overlying slope-wash material. In the irrigated part of the area that is underlain by these formations, usually part of the weathered zone and overlying slope wash is saturated and the water table conforms closely to the topography of the land surface. The water-table contour lines were not extended into this area, as there were too few water-table wells for adequate control.

Inasmuch as the slope of the water table is dependent on the permeability and thickness of the water-bearing materials and on the amount of water being transmitted, the slope is considerably different in the various formations. Although a large amount of water is transmitted through the unconsolidated material of the valley fill and upland deposits, the deposits are so permeable that the water table is nearly flat, the average gradient being only about 15 feet to the mile. The slope of the water table in the less permeable Brule and Arikaree formations is much greater and generally ranges from about 45 feet to about 140 feet to the mile. However, the water table along the escarpments may slope as much as 400 feet to the mile. The slope of the water table in the Brule formation is affected largely by the extent to which the formation is fractured. In places where there has been little fracturing the slope of the water table is very steep, whereas in the more highly fractured areas the gradient is less. The slope of the water table in the Arikaree formation is about the same as that in the Brule formation.

DEPTH TO WATER

The depth to the water table in the area generally is determined largely by the configuration of the land surface. In general, the depth to water is greatest where the land surface is high and least where the land surface is low.

The depth to water in the area is shown on plate 4. The lines indicate areas where the depth to water is less than 50 feet, 50 to 100 feet, 100 to 200 feet, 200 to 300 feet, and more than 300 feet. In the bottom land along the major streams and in much of the irrigated area south of the North Platte River the water table is so shallow that the capillary fringe extends to the surface or to the root zone of the vegetation. Areas of high evapotranspiration, in which the depth to water generally is less than 10 feet, also are shown on plate 4. The depth to water in the flood-plain deposits generally is less than 50 feet, and in the third-terrace deposits it generally is less than 80 feet. The greater depths to water occur in the upland areas. In the vicinity of Pine Ridge and in the northern part of the county, in the divide area between the drainages of Rawhide Creek and a tributary of the Niobrara River, the depth to water exceeds 300 feet.

FLUCTUATIONS OF THE WATER TABLE

The water table is not a stationary surface but fluctuates up or down as water is added to or withdrawn from the underground reservoir. The stage of the water table indicates the quantity of water in storage in the ground-water reservoir in much the same manner as the water level in a surface reservoir indicates the amount of water in storage in the reservoir. Thus, water-level fluctuations indicate the changes in storage that result from recharge to or discharge from the ground-water reservoir during a given period. In much of the area the water table fluctuates noticeably in response to rather large changes in the rates of recharge or discharge. In the upland area, however, the recharge-discharge relationship is more or less in balance and the water table fluctuates within a very narrow range. (See hydrograph of well 29–61–26cb in fig. 5.) In Goshen County, recharge is contributed mainly by precipitation and irrigation seepage, and the discharge is

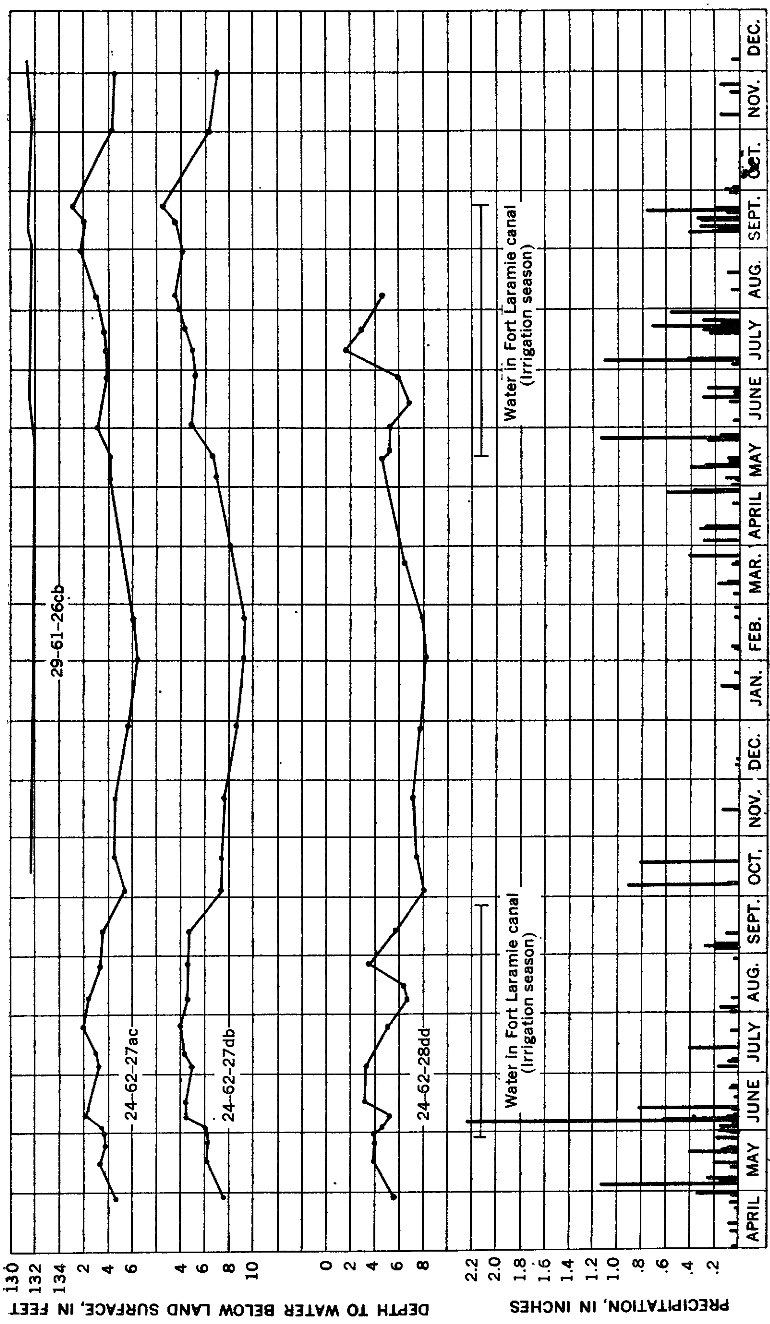

FIGURE 5.—Graph showing fluctuations of water levels in three wells adjacent to irrigated areas underlain by relatively impermeable bedrock, and fluctuations in well 29–61–26cb in the Arikaree formation.

due to the withdrawal of water by natural drainage, by evapotranspiration, and by pumping from wells. The graphs of the three wells adjacent to irrigated areas show water-level fluctuations caused by recharge, precipitation, and irrigation, and discharge by evapotranspiration.

In order to observe the fluctuations of the water table in the area, 65 wells were selected for periodic measurement of the water level. These measurements have been published in annual water-level reports (U. S. Geol. Survey, 1946–50, 1954–56).

Fluctuations caused by irrigation.—In the irrigated areas that are underlain by valley fill, fluctuations of the water table are caused principally by seepage from canals and laterals and from irrigated fields. In general, the water table rises during the irrigation season and falls during the rest of the year.

The hydrograph of the average depth to water in 12 wells in the valley of the North Platte River (fig. 6) shows that, in the part of the

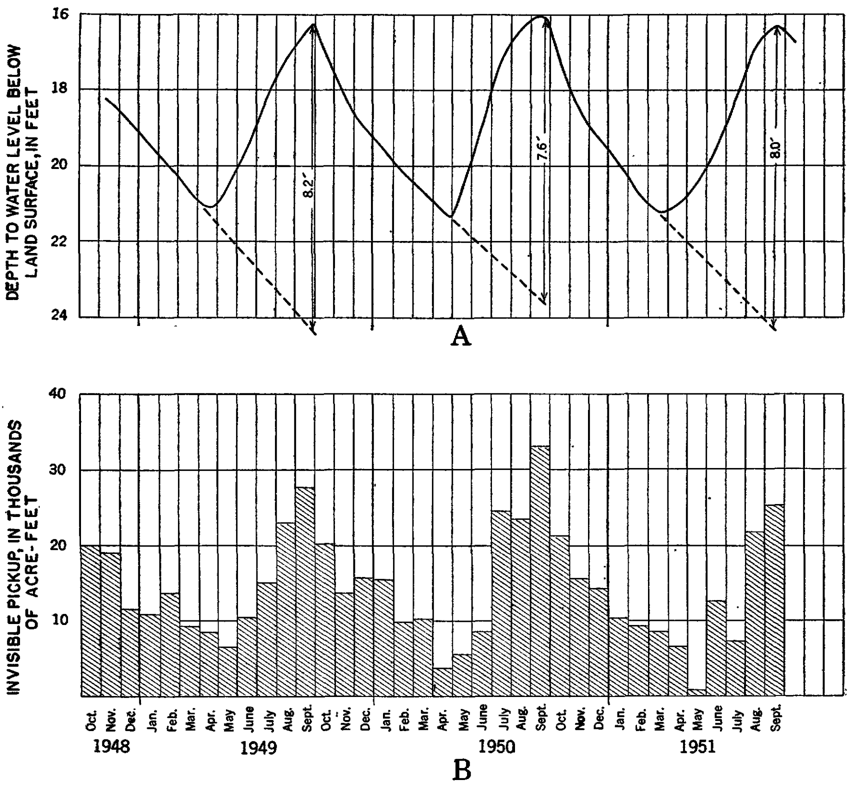

FIGURE 6.—Hydrographs showing (*A*) the average water level in 12 wells in the valley fill, and (*B*) the invisible pickup in the North Platte River between Whalen Dam and the Wyoming-Nebraska State line.

irrigated area underlain by the valley fill, the decline of the water table is checked as soon as irrigation water is applied to the land. After a few weeks the recharge from irrigation is sufficient to overbalance the natural discharge and cause the water table to rise. The water table usually begins to rise in April or May and continues to rise until about the end of September, when irrigation is discontinued or greatly reduced. The water table then declines from the seasonal high in September until irrigation begins again in April or May of the next year. The water table rises about 5 feet during the irrigation season and declines approximately the same amount during the subsequent nonirrigation season. Most of the rise is caused by seepage from canals and irrigated fields, although possibly a small amount may be due to precipitation during April, May, and June.

The rise of water levels does not reflect the entire magnitude of the seepage losses, because discharge from the ground-water reservoir continues throughout the period of rising water level; the rise indicates only the extent to which the recharge exceeds the discharge. If the downward trend of the hydrograph during the winter is projected until the time when the water levels actually reached the seasonal high, the gross average rise of water level that would have occurred if the winter net rate of discharge had continued through the summer was 8.2, 7.6, and 8.0 feet for 1949, 1950, and 1951, respectively, or an average of 7.9 feet for the 3 years of record (fig. 6). Because of greater loss from evaporation and transpiration and because the hydraulic gradient is steeper, the discharge from the ground-water reservoir increases during the summer. Consequently, projected declines shown in figure 6 probably should be slightly steeper and the gross average rise in water levels probably would be slightly higher than the indicated 7.9 feet.

In the areas underlain by the relatively impermeable bedrock formations, the fluctuations caused by seepage from the canals and laterals are as much as 25 feet in some places. The greatest fluctuations occur near canals that are normally high above the water table. Owing to the low permeability of the bedrock formations, the rise of the water table in places is great enough to bring the water table in contact with the bottom of the canal.

The fluctuations caused by seepage from irrigation water that is applied to the land are relatively small compared to fluctuations caused by seepage from canals. During an application of irrigation water the water table may rise as much as 4 feet, but this rise is usually followed by a decline that is due to transpiration by plants; the decline continues until the beginning of the next application of irrigation water. Fluctuations caused by the application of irrigation water in areas underlain by relatively impermeable bedrock formations are shown by hydrographs of wells 25–62-27acl, 24–62–27db, and 24–

62–28dd in figure 5. These hydrographs are more fully described in the following discussion of fluctuations caused by evapotranspiration.

Fluctuations caused by precipitation.—In the irrigated area underlain by alluvium and terrace sand and gravel, the amount of recharge to the water table from precipitation is so small in comparison to the recharge from irrigation that it has no appreciable effect on the water table. In the areas underlain by the relatively impermeable bedrock formations, the water table may rise 1 to 3 feet, or even more in places, owing to recharge from precipitation in the spring before the beginning of irrigation. This is shown by the hydrograph of wells in figure 5.

Fluctuations caused by evapotranspiration.—In areas where the capillary fringe extends to the land surface or into the root zone of the vegetation, ground water is discharged by evapotranspiration. In the area of high evapotranspiration along the North Platte River, discharge of ground water by evapotranspiration causes very little seasonal lowering of the water table. Although the rate of discharge of ground water is large during the growing season, much of the water discharged by evapotranspiration is rapidly replaced by ground water that moves in through the highly permeable sand and gravel.

In the areas of shallow water table that are underlain by impermeable bedrock evapotranspiration greatly affects the level of the water table during the growing season. The hydrographs in figure 5 show how the water table is affected by transpiration of plants. Hydrographs of wells 24–62–27acl and 24–62–27db, at the edge of a sugar-beet field, show the rise of the water level that was caused by the application of water to the field and the decline of the water level that was caused by evaporation and by transpiration by the beets. The beet field is in a poorly drained area where the slope wash is underlain by the Chadron formation. As a result of precipitation, water levels begin to rise in the late winter and continue to rise until June. By June, the rate of discharge of ground water by evapotranspiration is sufficient to overbalance the recharge due to precipitation and the water level begins to decline. This decline continues until the beet fields are irrigated, usually at the beginning of July, when the water levels begin to rise again. By the end of July 1949 the discharge of water by evapotranspiration was sufficient to overbalance the recharge from irrigation and precipitation, and the water level began to decline. By this time, the sugar beets had become quite large and were consuming a large amount of water. In the growing season of 1950, which was unusually cold and consequently was poor for crop production, the water level continued to rise during the entire irrigation season, and only minor declines were caused by evapotranspiration. After the end of the irrigation season, the water level declined owing to evapotranspiration.

The hydrograph of well 24–62–28dd, which is adjacent to an alfalfa field, shows a rise of the water table due to precipitation in the spring. The water table begins to decline as soon as the plants start growing later in the spring and continues to decline during most of the time that irrigation water is applied to the land. When the alfalfa is cut, the transpiration rate is greatly reduced and the water level rises rapidly as the result of the next irrigation that follows the cutting. As the alfalfa grows again, the transpiration rate increases and eventually overbalances the recharge from irrigation and thus again causes a decline of the water level. The hydrograph shows the effects of two cuttings of alfalfa during the 1949 irrigation season. The third cutting was in the fall after the irrigation season and had little effect on the water table.

Fluctuations caused by drainage.—In the areas underlain by the more permeable materials, the chief cause of decline of the water table is the discharge of ground water into streams and drains; the water level falls until the rate of discharge declines to the rate of recharge. This is illustrated in figure 6, which includes a hydrograph of the average water level in 12 wells in the valley fill. The water table declines steadily between September and April, during which time little or no recharge from irrigation takes place. In figure 6, the columns at the bottom of the graph show the invisible pickup of the North Platte River—the amount of water draining from the valley fill—in the stretch between the gaging stations at Whalen Dam and the Wyoming-Nebraska State line.

In most areas underlain by the relatively impermeable bedrock formations the decline of the water table due to drainage is small.

RECHARGE

Recharge is the term used to denote the addition of water to the ground-water reservoir, and it may be accomplished in several ways. Once the water becomes a part of the ground-water body it moves in the direction of the slope of the water table, later to be discharged at some point down gradient.

In nature a ground-water reservoir as a hydraulic system is in balance; over a long period of years the recharge is equal to the discharge and the water table is more or less fixed in position within seasonal limits. Discharge by wells is a new discharge superimposed on the previous system. Before a new equilibrium can be established, water levels must fall throughout the aquifer to an extent sufficient to increase the natural recharge or decrease the natural discharge or both, by an amount equal to the amount being discharged by the wells. Until this new equilibrium is established, water must be withdrawn from storage in the aquifer, and, conversely, the new equilibrium cannot be established until the amount of water that is withdrawn from storage by wells is sufficient to depress the water table enough to change the recharge or natural discharge, or both, by the proper amount. These are the fundamental laws upon which must be based all investigations to determine the potential perennial yield or so-called safe yield of aquifers.

For the purpose of discussing recharge, Goshen County is separated into two areas: the nonirrigated area and the irrigated area.

NONIRRIGATED AREA

In the nonirrigated area seepage from precipitation that occurs as rain or snow is the principal source of recharge. Under favorable conditions of soil moisture a part of the precipitation seeps down through the soil and is added to the ground-water reservoir. The average annual precipitation in the area is about 14 inches, of which possibly not more than 5 percent percolates to the ground-water reservoir. Most of the water that is recharged moves toward the North Platte River or its tributaries.

IRRIGATED AREA

In the part of the irrigated area that is underlain by the permeable sand and gravel of the valley fill, recharge by seepage from precipitation is small in comparison to the amount of recharge from irrigation water, as is demonstrated by the large fluctuation of the water table caused by the application of irrigation water. However, in the irrigated areas underlain by fine-grained slope-wash material, the water table is near the surface and consequently the small amount of precipitation that percolates to the ground-water reservoir causes an appreciable rise of the water table.

In the valleys of Horse and Bear Creeks the ground-water reservoir is recharged mainly by seepage from irrigation and to a minor extent by seepage from precipitation. It is estimated that about half of the water diverted for irrigation in the valley of Horse and Bear Creeks is recharged to the ground-water reservoir. The remainder of the irrigated land lies in the North Platte project area, which consists of that part of the valley of the North Platte River that lies between the Interstate and Fort Laramie canals. In this area sufficient information was obtainable to make quantitative estimates of the recharge to the reservoir.

NORTH PLATTE PROJECT AREA

In the North Platte project area, the recharge to the ground-water reservoir is derived from seepage from irrigation canals and irrigated lands, from subsurface inflow, and from precipitation. No attempt was made to estimate the amount of recharge by seepage from precipitation, but it is small in comparison to recharge from other sources.

SEEPAGE FROM IRRIGATION CANALS AND IRRIGATED LANDS

About 202,000 acre-feet of water is estimated to be recharged to the ground-water reservoir each year by seepage from canals and from canal water used to irrigate land. This estimate is made on the assumption that practically all the water lost from the canals and lateral systems is recharged to the ground-water reservoir. The evapotranspiration losses along the canals and lateral systems were considered to be negligible.

For the purpose of this study the irrigated area was divided into the following three parts, according to the source of irrigation-water supply: The area supplied by the Interstate canal, the area supplied by small diversions from the North Platte River, and the area supplied by the Fort Laramie canal.

Interstate canal.—The Interstate canal starts at Whalen Dam and carries water from the North Platte River to the irrigated lands on the north side of the river. Some water is delivered to the Lingle Water Users Association and to the Hill Lateral District; however, most of the water goes to the Pathfinder Irrigation District. The distribution system consists mostly of canals and ditches excavated in the valley fill.

The amount of seepage from the 50.8-mile stretch of the Interstate canal that lies within Goshen County was determined by the U. S. Bureau of Reclamation (1949) to be about 13 percent of the water that is diverted from the North Platte River. The average annual diversion from the river for the 4-year period 1948–51, inclusive, was 542,000 acre-feet, and the average annual seepage from the canal thus is estimated to have been about 70,000 acre-feet. No attempt was made to distinguish between seepage from the laterals and that from irrigated fields as factors in recharge to the ground-water reservoir. However, about half the diverted water is estimated to have recharged the ground-water reservoir. The average annual diversion from the canal into the lateral system is about 66,000 acre-feet; therefore, the annual recharge to the ground-water reservoir from that source is estimated to be about 33,000 acre-feet. Thus the total recharge derived directly and indirectly from the Interstate canal is estimated to be 103,000 acre-feet per year.

Small diversions.—Many small canals divert water from the North Platte River between Whalen Dam and the Wyoming-Nebraska State line. These canals from west to east are as follows: Burbank, Lucerne, Grattan, Rock Ranch, Torrington, North Platte, Narrows, Pratt-Ferris, French, and Mitchell-Gering. These canals and their lateral distribution systems are cut in the valley fill.

Records are kept only of the amount of water that is diverted from the river by the canals, and the estimates of seepage losses from these canals—about one-third of the water that is diverted from the river—is a composite of estimates made by the men who are responsible for the operation of each of these canals. In addition, an estimated one-fourth of the water applied to the irrigated fields seeps to the water table. Therefore, about half the total amount of water diverted into the small canals is recharged to the water table. As the average amount of water diverted into these small canals is about 58,000 acre-feet per year, the resulting recharge is estimated to be about 29,000 acre-feet per year.

Fort Laramie canal.—Water is diverted from the North Platte River into the Fort Laramie canal at Whalen Dam to supply the Goshen Irrigation District in Wyoming, a power-generating station south of Lingle, Wyo., and the Gering and Fort Laramie Irrigation District in Nebraska. According to records kept by the Goshen Irrigation District, the average annual loss of water from the canal and lateral system for the period 1948–51 was 64,000 acre-feet. This loss includes a large amount of water that was delivered to the farmers but not charged to them, and it is therefore considerably in excess of the amount of water lost by seepage.

In the Goshen Irrigation District most of the irrigated land is underlain by relatively impermeable bedrock covered by a mantle of fine-grained slope wash. Consequently, the irrigated land is poorly drained and the water table is maintained near the surface. Owing to these conditions, smaller quantities of irrigation water are required than in the rest of the area. Most of the irrigation water that percolates to the water table is subsequently used by plants, and, consequently, net recharge to the ground water reservoir is negligible.

The small part of the Goshen Irrigation District that is underlain by permeable sand and gravel is well drained; consequently, water seeping from the irrigated land moves away from the area of application. No estimate was made of the amount of water transmitted; however, this may be compensated for by an excess in the total given for the overall recharge to the water table from losses from the canal and lateral system.

The seepage loss from the Fort Laramie canal from water delivered to the Lingle power station is assumed, for administrative purposes, to be 6 percent of the water discharged through the power station. The average discharge through the powerplant for the years 1948–51 was 105,370 acre-feet a year and the average annual loss, on the assumed basis, was about 6,000 acre-feet per year. Thus the total recharge derived directly and indirectly from the Fort Laramie canal is estimated to be 70,000 acre-feet per year.

SUBSURFACE INFLOW

About 6,000 acre-feet of ground water per year moves through the valley fill of the valleys of the North Platte River and the Laramie River in a downvalley direction and enters the project area. (In the vicinity of the section chosen for estimation, on the line between Rs. 64 and 65 W., the valley fill consists mostly of flood-plain deposits.) Ground water moves into the project area also through the valley fill of Rawhide Creek and of Horse and Bear Creeks; however, this amount is small owing to the low transmissibility of the alluvium in these valleys. The total recharge to the area by subsurface inflow through the valley fill is small in comparison to recharge from other sources.

An estimate of the amount of ground water that enters the area through the valley fill of the North Platte and Laramie Rivers was made by the application of Darcy's law—

$$Q=PIA$$

in which Q=quantity of water passing a valley cross section, in gallons per day;
P=field coefficient or permeability (as defined on page 44);
I=hydraulic gradient of the water table, in feet per mile;
and A=cross-sectional area of the saturated part of the alluvium, in mile-feet.

The average field coefficient of permeability of the flood-plain deposits was determined from four pumping tests to be about 4,500 gpd per mile-foot for each foot per mile of gradient at the prevailing water temperature, and was used in computing the underflow for both valleys. The cross-sectional area of the saturated part of the flood-plain deposits of the North Platte River valley at the line between Rs. 64 and 65 W. is about 75 mile-feet, and the downvalley gradient of the water table is about 10 feet per mile; thus about 3,500 to 4,000 acre-feet of water enters the area each year through the flood-plain deposits of the North Platte River valley. The cross-sectional area of the saturated part of the flood-plain deposits of the Laramie River valley also is about 75 mile-feet, and the downvalley gradient of the water table is about 6 feet per mile; thus about 2,000 to 2,500 acre-feet of water enters the area each year through the flood-plain deposits of the Laramie River valley.

A large but unknown amount of ground water enters the North Platte project area by subsurface inflow through the bedrock formations. The amount of this recharge was not determined because of the variability in the permeability and thickness of these formations and because of the difficulty in determining these factors. However, it is lumped with recharge from precipitation, and all the errors of the analysis, in the storage equation for the North Platte project area on page 65.

DISCHARGE

Ground water is discharged from the area by flow into streams and drains, evapotranspiration, underflow, and pumping from wells. The rate at which it is discharged varies with many factors, such as the depth to the water table, the nature of the vegetative cover, and the season of the year. Local differences in conditions cause more ground water to be discharged from some parts of the area than from others. Large quantities of water are withdrawn by plants from the zone of saturation of the bottom land along the North Platte River and at other places where the water table is close to the land surface. Only very small quantities, if any, are withdrawn by plants where the water table is far below the land surface, but in such areas the vegetation indirectly effects ground-water recharge and discharge by consuming water from precipitation before it can become ground-water recharge. The discharge of ground water by streams and springs is, of course, limited to areas where the topography is such that the land surface intersects the water table.

STREAMS AND DRAINS

The contour map of the water table (pl. 1) shows that the general direction of movement of ground water in the area is toward the North Platte River. Much of the ground water is discharged directly into the river; however, some of it is intercepted by tributaries and drains, which carry the water to the river. Most of the ground water discharged by the streams and drains in the area is return flow from irrigation—that is, water that has been added to the zone of saturation by seepage from irrigation canals and irrigated fields. However, much of the ground water that is derived from infiltration of precipitation on the upland areas percolates to the stream valleys and is discharged into streams or into drains.

Horse and Sheep Creeks, which are fed by ground water in the area, discharge into the North Platte River in Nebraska. The flow of Horse Creek, which for the water year 1949–50 amounted to 49,860 acre-feet, was derived almost entirely from ground-water discharge and runoff from irrigation and precipitation. Essentially all the flow was derived from ground-water runoff that was contributed to the stream south of the North Platte project area.

Prior to irrigation no perennial streams flowed into the North Platte River between Torrington and the Wyoming-Nebraska State line; at present three perennial drains (the Cherry Creek, Katzer, and Arnold drains) contribute to the flow of the river. The total annual discharge of these drains is about 40,000 acre-feet, more than half of which is

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ground-water runoff; the remainder is largely derived from surface irrigation runoff.

An analysis was made of the flow of the North Platte River between the gaging station 2¼ miles downstream from Whalen Dam (Whalen station) and the gaging station ¼ mile upstream from the Wyoming-Nebraska State line (State line station) to determine the gain in flow in this section. Between the stations all diversions from the river and essentialy all inflow to the river from tributaries are measured. Diversions are made into the Burbank, Lucerne, Grattan, Rock Ranch, Torrington, North Platte, Narrows, Pratt-Ferris, French, and Mitchell-Gering canals, and inflow is from the Laramie River, Sand Point Draw, Sand Draw, Rawhide Creek, Cherry Creek drain, Arnold drain, North Platte waste, and Katzer drain, and from the Lingle powerplant. The total pickup was computed by subtracting from the discharge at the Whalen station the diversions below this station and then subtracting the resulting figure from the amount of flow at the State line. The invisible pickup was obtained by subtracting the aggregate quantity of water discharged by tributaries into the river from the total gain. The results of the computations, based on monthly discharges from October 1947 through September 1951, are shown graphically by block diagrams in figure 7.

In figure 7 the total height above the baseline of the left side of each block represents the measured discharge of the river at the Whalen station, and the total height above the baseline of the right side of each block represents the measured discharge at the State-line station. Thus, the direction of slope of the line across the top of the block shows whether a net gain or loss of flow occurred during that month, and the difference in height of the sides of the block indicates the magnitude of the gain or loss.

If diversions for irrigation were made during the month, the left side of the block has been divided into two parts; the upper part represents the magnitude of the diversions and the lower part represents the quantity of water that would pass the State-line station if no other gain or loss occurred. For some months when the diversions exceed the flow at Whalen Dam, such as September 1949, the lower part is negative and is, therefore, plotted below the base line.

The right-hand side is divided into three parts. The upper part represents the magnitude of the measured visible pickup (discharge of the tributaries) in the section, the lower part represents the flow that should pass the State-line station if no gain or loss takes place in the section, and the middle part represents, therefore, the invisible gain. A diagonal line is drawn to separate the visible gain from the invisible gain. Thus, two or three triangles are formed at the top of each block, depending on whether water was diverted; the area of each triangle is proportional to the magnitude of the gain or

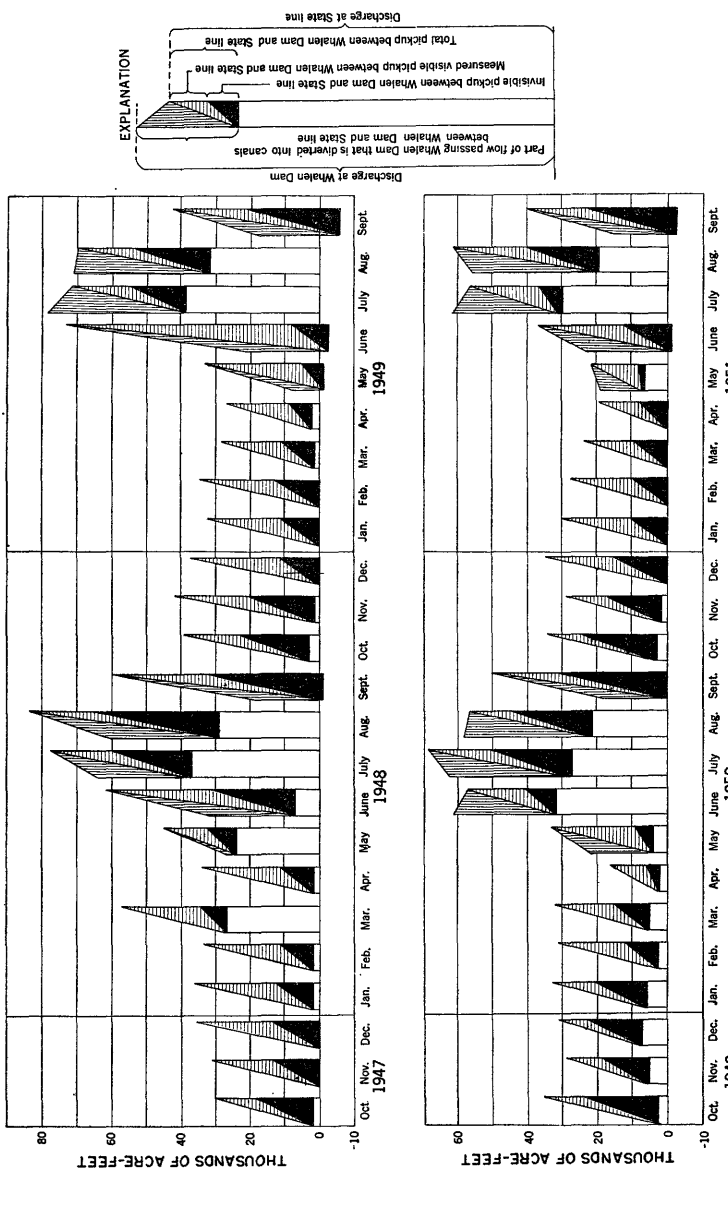

FIGURE 7.—Analysis of the water regimen of the North Platte River between Whalen Dam and the Wyoming-Nebraska State line.

loss in discharge that it represents. The area of the upper triangle is proportional to the volume of water diverted for irrigation, the area of the middle triangle is proportional to the volume of water discharge by the tributaries into the river (visible pickup), and the area of the lower triangle is proportional to the volume of water gained in the segment (invisible pickup).

The diagrams in figure 7 indicate the general regimen of the North Platte River between Whalen Dam and the State line. They show that during most of the year practically all the flow at the State line is derived from invisible pickup and tributary inflow below Whalen Dam. Occasionally during June, July, or August, the diversions exceed the gain and the flow of the river in the stretch is reduced.

For some months, notably those in the summer of 1949, the bottoms of the diagrams lie below the baseline, which indicates that the volume of water diverted was greater than the volume that passed Whalen Dam. During May, June, and September, 1949, more water was diverted above the State line than passed the Whalen station. Obviously, for this to happen, water had to be added to the river or the river would, of course, have been dry above the State line. The flow of the river was maintained by visible and invisible gain. The invisible pickup, which in many months is greater than the visible pickup, constitutes a large proportion of the total gain of the river.

The amount of invisible pickup in the North Platte River depends largely upon the gradient of the water table toward the river; this gradient varies with the fluctuations of the water table in the valley of the river. As shown in figure 6, the amount of invisible pickup in the river varies almost in direct proportion to the average position of the water level in the observation wells in the area. Minor variations are caused by the effects of evapotranspiration.

An analysis was made to determine the amount of the visible ground-water gain of the river that was contributed by tributary discharge. The water discharged by the tributaries consists of surface flow that enters the area, direct runoff from precipitation and irrigation within the area, and ground-water runoff within the area. By selecting periods when the first two of these increments are negligible, the third one can be estimated. The ground-water gain is approximately equivalent to the low or base flow of the streams.

The Laramie River is the only one of the four principal tributaries of the North Platte River in the area that transmits an appreciable amount of water into the area as surface flow. Usually the flow in the Laramie River is many times the amount of ground-water gain by the Laramie River within the area; however, a fairly accurate estimate of the amount of ground-water gain in the river can be made. During many months of the nonirrigation season all the surface flow of the Laramie River is diverted into the Fort Laramie canal for use in generating power. At these times all the flow of the Laramie River at its junction with the North Platte River near Fort Laramie is derived from ground-water pickup in the stretch below the diversion. An estimate of the average annual ground-water gain was made by averaging the monthly discharge during these periods for the water years 1947–48 through 1950–51 and multiplying by 12. The average annual ground-water pickup of the Laramie River in the area was calculated to be about 7,000 acre-feet.

The base flow of the other three principal tributaries in the area—Rawhide Creek, Cherry Creek drain, and Katzer drain—is largely ground-water pickup. During the irrigation season, however, a large amount of direct runoff from irrigation and precipitation is included. The base flow of these streams was estimated by averaging the flow during the months of November and April for the water years 1947–48 through 1950–51. This average is thought to be representative of the base flow throughout the year, as it is computed from base-flow periods after and before the irrigation season. On this basis the annual ground-water gain within the area by these three tributaries is about 31,000 acre-feet. The flow of Rawhide Creek is perennial, but as the flow is small it is though to have a negligible effect on the above determinations.

The average annual invisible gain in the North Platte River for the 4-year period of study was about 179,000 acre-feet. This, added to the 7,000 acre-feet of pickup in the Laramie River and the 31,000 acre-feet of pickup in the three other tributaries, gives a total annual ground-water runoff of about 217,000 acre-feet.

EVAPOTRANSPIRATION

Water may be taken into the roots of plants directly from the zone of saturation or from the capillary fringe above it, and then discharged from the plants by the process known as transpiration, or it may be brought to the land surface by capillary action and discharged directly from the soil by evaporation. The depths from which plants will lift ground water varies greatly with different types of plants and with different soils and conditions of water supply.

Most of the discharge of ground water by transpiration is thought to occur where the depth to water is less than 20 feet. The areas of high evapotranspiration are shown on plate 4. Grasses are the principal users of ground water in most of these areas; however, on the flood plain of the North Platte River the chief users are cottonwood and willow trees.

No data were obtained during this investigation on the rate at which ground water is evaporated and transpired in the report area.

In Scotts Bluff County, Nebr., which adjoins the report area on the east, the quantity of ground water evaporated and transpired from the zone of saturation in shallow-water areas was estimated to be 18 inches a year. (See Wenzel, Cady, and Waite, 1946, p. 118.) Tomlinson (1951, p. 11) estimated that, in addition to the precipitation during the growing season, 14.4 inches of water will be used by grasses in the area. The amount used by the cottonwood and willow trees along the streams is assumed to be considerably greater than 14.4 inches. Consequently, the average value of 18 inches is thought to be more representative.

Where the water table is close enough to the land surface to cause the discharge of ground water by evaporation, a residue of water-soluble minerals generally is left at the surface. The depth from which water may be brought to the land surface by capillarity depends upon the texture of the material above the water table—the finer grained the material, the greater the distance the water will rise. Very little water is believed to be brought to the land surface where the depth to water is more than 10 feet. The amount of water evaporated directly from the soil surface depends upon the depth to the water table and the type of soil and on the extent of the vegetative cover. Under natural conditions the growth of grass is so dense in the areas of shallow water table that practically no evaporation occurs directly from the soil surface. When the land in these areas is farmed and left without vegetation during part of the year, the opportunity for evaporation from the land surface is great, and a gradual buildup of salts at the land surface takes place. If farming is continued on such land, the crops are gradually restricted to the more salt-tolerant varieties, and eventually even these will not germinate.

The water table beneath 43,600 acres in the county, of which 37,500 acres of land is in the North Platte project area, lies sufficiently close to the land surface so that evapotranspiration takes place. (See pl. 4.) Assuming that an average of 18 inches of water is transpired and evaporated each year from the zone of saturation, the annual evapotranspiration loss from the ground-water reservoir in the county is about 65,000 acre-feet, of which about 56,000 acre-feet is from the North Platte project area. To this quantity must be added the part of the water pumped from wells that is evaporated and transpired.

WELLS

In the county about 8,700 acre-feet of ground water is pumped annually for irrigation, industrial, stock, domestic, and municipal uses; these uses are listed in what is believed to be the order of quantity pumped. Of the 8,700 acre-feet of water, 7,400 acre-feet was pumped in the North Platte project area. The quantity of water pumped for each of the different uses is given on pages 69–70. About 4,000 acre-feet of the water pumped from wells in the county is consumed and the remainder returns to the water table or enters the river. Of the 4,000 acre-feet of pumped water that annually is consumptively used in the county, about 3,000 acre-feet is consumed in the North Platte Irrigation Project area.

SUBSURFACE OUTFLOW

A considerable quantity of ground water moves through the valley fill across the Wyoming-Nebraska State line. Most of the outflow occurs in the valley of the North Platte River; very little is thought to leave the county through the valley fill of Horse and Sheep Creeks. An estimate of the amount of ground water leaving the area through the valley fill of the North Platte River was made by the application of Darcy's law. The average coefficient of permeability of the flood-plain deposits is taken as 4,500 gpd per mile-foot per foot per mile of gradient, the cross-sectional area of the saturated part of these deposits is 217 mile-feet, and the downvalley gradient of the water table is about 6 feet per mile; thus, between 6,500 and 7,000 acre-feet of water leaves the area each year through the flood-plain deposits. The coefficient of permeability of the third-terrace deposits is assumed to be 2,300 gpd. This permeability of the terrace sand and gravel is based on pumping tests that were made on two widely spaced wells—well 25–61–33ab in the area and well 24–57–34badl in the nearby Dutch Flats area (Babcock and Visher, 1951, p. 15–17). In each test the coefficient of permeability obtained was 2,300 gpd. The coefficient of permeability obtained from a pumping test on well 24–61–2cb is not considered to be representative of the coefficient of permeability of the third-terrace deposits because the well discharges water from a local highly permeable channel deposit. The cross-sectional area of the saturated part of the third-terrace deposits at the east edge of the area is 425 mile-feet, and the downvalley gradient of the water table is 20 feet per mile; thus, about 22,000 acre-feet of water leaves the area annually through this material. Some water leaves the area by underflow through the bedrock, but the amount is believed to be small in comparison to the amount that leaves the area through the unconsolidated materials.

STORAGE EQUATION FOR NORTH PLATTE PROJECT AREA

The amount of water that is recharged to the ground-water reservoir during a year is equal to the amount of water that is discharged, plus or minus the change in storage during the year. Sufficient data were not available for approximating the total amount of discharge from Goshen County; however, it was possible to make an approximation of the total amount of discharge from the North Platte project area. About 217,000 acre-feet of ground water is estimated to have been discharged from the North Platte project area by streams and drains during the period 1948–51; about 59,000 acre-feet of ground water was discharged by evapotranspiration (including 3,000 of the 7,400 acre-feet pumped from wells); and about 29,000 acre-feet of ground water was discharged by underflow. Therefore, a total of about 305,000 acre-feet was discharged from the ground-water reservoir in the North Platte project area each year.

About 202,000 acre-feet of the water that enters the North Platte project area in canals is estimated to have been recharged to the water table each year from the canals and irrigated fields, and about 6,000 acre-feet was recharged from underflow into the area through the alluvium. No estimate was made of the amount of recharge from precipitation in the area or from underflow into the project area through the bedrock formations. Records of the water level show that essentially no annual change in storage occurs; therefore, the amount of recharge from these sources should be approximately equal to the difference between the recharge, from irrigation and underflow through the alluvium, and the total discharge. This amounts to 97,000 acre-feet. No attempt was made to determine the amounts contributed by each of the factors. The figure includes also any errors involved in estimating the other items of the analysis.

QUANTITY OF WATER IN STORAGE

Most of the recoverable ground water in the county is in the unconsolidated sand and gravel deposits of the valley fill, and the Arikaree formation. The approximate amount of ground water in storage was calculated for only the unconsolidated deposits of the valley fill of the North Platte River. The extent of these deposits and their saturated thickness are shown on plate 3. The quantity of ground water in storage in these deposits was determined roughly by multiplying the volume of saturated material (7,400,000 acre-feet) by the average specific yield, 0.23, determined in three pumping tests. The volume of saturated material was determined from the saturated-thickness map of the area and represents an average saturated thickness of about 81 feet beneath about 91,000 acres. The volume of water in storage computed from these figures is about 1,700,000 acre-feet. From the present position of the water table an estimate of the quantity of ground water represented by a foot of rise or decline of the water table was computed to be 21,000 acre-feet.

RECOVERY OF GROUND WATER

SPRINGS AND SEEPS

There are many small springs and seeps in the county, but only a few are shown on plate 4. These springs and seeps supply small quantities of water, which are used primarily for watering livestock. All the springs observed in the area are gravity springs; that is, the water does not issue under artesian pressure but discharges by gravity along outcrops of the water table. There are two types of gravity springs in the area: depression springs, where water flows to the surface from permeable material because the land surface extends below the water table; and contact springs, whose waters flow to the surface from permeable material over the outcrop of material of relatively low permeability, which retards the downward percolation of the ground water. Depression springs generally are found in the alluvium along the stream valleys and in the lowland areas. Contact springs occur mainly along the contact between the Brule and Arikaree formations on the faces of the escarpments that surround the Goshen Hole lowland.

WELLS

Types of wells.—Most of the wells in the area are drilled wells cased with steel casing that ranges in sizes from about 2 to 24 inches in diameter. Practically all the irrigation, public-supply, and industrial wells in the area are drilled. A few dug wells, generally ranging from 3 to 5 feet in diameter, have been constructed for domestic and stock use. Most of the dug wells are cribbed with concrete, brick, rock, or wood. A few small-diameter driven wells have been installed for domestic and stock use at places where the water table is near the surface.

Drilling methods.—Most of the drilled wells in the area were put down by either the cable-tool, standard hydraulic-rotary, or the reverse-rotary method. Both small- and large-diameter wells and test holes were drilled by the cable-tool method. The standard hydraulic-rotary method was used for drilling small-diameter wells and test holes, and the reverse-rotary method was used for drilling large-diameter wells.

The cable-tool method of drilling (sometimes referred to as the percussion or churn-drill method) is done by means of a string of solid drilling tools with a cutting bit on the bottom, operated in the drill hole on the end of a cable that is lifted and dropped regularly to produce a cutting or drilling action at the bottom of the hole. The material is removed from the bottom of the hole by means of a bailer or sand bucket. Usually a casing is forced into the hole as the drilling proceeds, and the drill, and bailer or sand bucket, are lowered and withdrawn through the casing.

Many of the small-diameter wells in the area have been drilled by the standard hydraulic-rotary method. Holes ranging from about 4 to about 8 inches in diameter have been drilled by this method. Drilling is done by rotating the drilling tools which are at the bottom of a string of drilling pipe. During the process of drilling, water is pumped downward through the revolving drill stem and bit into the bottom of the hole and up the hole to the land surface into a sump pit where the water is taken by the pump and recirculated. Materials drilled from the bottom of the hole are carried to the surface by the water. Mud, clay, or some manufactured product generally is used to increase the viscosity and material-lifting capacity of the water and also to seal the hole and prevent caving and the loss of drilling water by seepage into permeable materials.

The standard hydraulic-rotary method of water-well drilling generally is limited to holes of small diameter, owing to the difficulty of providing enough water in the drill hole to maintain sufficient velocity to carry the drill cuttings to the land surface. This disadvantage has been overcome in the reverse-rotary method of drilling by reversing the direction of flow of the circulating water; hence, the name "reverse rotary." By this method the water is pumped up the hollow drill stem and discharged into the settling pit where the drill cuttings remain. The water runs back to the drill hole by gravity. Enough water is provided to keep the drill hole full at all times, so that the hydrostatic pressure will prevent caving. A slowly revolving bit at the lower end of the drill stem cuts or scrapes the material loose from the bottom of the hole. Generally, a hole about 48 inches in diameter is drilled, a perforated casing of smaller size is placed in the hole, and the annular space around the casing is packed with sorted gravel.

Methods of lift.—Many of the domestic and stock wells in the area are equipped with lift or force pumps in which the cylinders are placed below the water table. These pumps generally are operated by windmills or by electric motor. The domestic wells, where electric power is available, are usually equipped with pumps that force water into pressure systems. In parts of the area where the depth to water is not great, generally less than 15 feet, many wells are equipped with hand-operated pitcher pumps.

Most of the large municipal, industrial, and irrigation wells are equipped with turbine pumps operated by electric motors or diesel engines. Where the water is within suction lift, some of the large wells are equipped with horizontal centrifugal pumps.

UTILIZATION OF GROUND WATER

During the course of the investigation information about 938 wells in the county was obtained. All known irrigation, public-supply, and industrial wells were visited, and all available data concerning them were compiled. No attempt was made to inventory all the domestic and stock wells, but data pertaining to some of them were collected in areas where information was needed. Pertinent data on the wells that were inventoried during the investigation are given in table 7, and the location of the wells is shown on plate 4.

DOMESTIC AND STOCK SUPPLIES

Most of the rural residents and the residents of some of the smaller towns in the area obtain their domestic and stock-water supplies from wells of small diameter equipped with cylinder pumps operated by windmill, by hand, or by small electric motors. Most of the domestic wells located where electric power is available are equipped with electrically powered pumps that pump water into pressure systems. In the valleys of the North Platte River and its tributaries, where the water table is shallow many of the domestic and stock supplies are derived from shallow driven wells. The driven wells were not inventoried because very little information about them was available.

About 600 acre-feet of water is estimated to be used annually in the county for domestic and stock supplies.

The ground water in the area varies greatly in chemical character, but generally is satisfactory for most domestic and stock uses.

PUBLIC SUPPLIES

Three municipalities (Torrington, Lingle, and Yoder) in the county have public water systems that obtain water from wells. The average daily consumption of these municipalities aggregates about 800,000 gallons. The remaining municipalities in the area do not have public water systems, and water is supplied by privately owned wells.

Torrington (population 3,247) is supplied by four drilled wells within the city limits. The wells range in depth from 60 to 90 feet. The wells obtain water from the flood-plain deposits of the North Platte River valley and are reported to yield from 450 to 1,000 gpm. The wells are equipped with electrically powered turbine or centrifugal pumps that pump water directly into the city mains and force water into a 50,000-gallon steel tank, which maintains an average operating pressure of about 45 pounds to the square inch in the city distribution system. The annual consumption of water in 1951 was about 270,000,000 gallons, which is equivalent to an average rate of consumption of about 740,000 gpd or 510 gpm. The results of the analyses of water from wells 24–61–10bc, 24–61–10bd, and 24–61–10cb1 (see table 3) indicate that the water is hard; the water is not treated.

Lingle (population 403) is supplied by three drilled wells within the city limits. The wells are about 50 feet deep and obtain water from the flood-plain deposits of the North Platte River valley. The wells are equipped with electrically powered turbine or centrifugal pumps which pump water directly into the city mains and force water into a 55,000-gallon steel tank, which maintains an average operating pressure of about 45 pounds per square inch in the city distribution system. The annual consumption of water in 1951 was about 10,000,000 gallons, which is equivalent to an average rate of consumption of about 27,000 gpd or 19 gpm. The analysis of water from well 25–62–18db3 indicates that the water is hard; the water is not treated.

Yoder (population 128) is supplied by two drilled wells within the city limits. The wells are 80 and 101 feet deep and obtain water from sandstone in the Lance formation. They are reported to yield less than 100 gpm with a drawdown of about 70 feet. The wells are equipped with electrically powered turbine pumps which pump water directly into the city mains and force water into a 40,000-gallon tank. No information on the rate of consumption of water is available, but the annual consumption is estimated to be about 3,000,000 gallons; this is equivalent to an average daily rate of consumption of about 8,000 gpd or 6 gpm.

INDUSTRIAL SUPPLIES

Ground water is used by several industries in the area. A sugar refinery at Torrington obtains water from three wells for use in washing beets and refining sugar. These wells, which are drilled into the flood-plain deposits, supply a total of about 6,000 gpm to the factory during the operating season, for a total of about 2,400 acre-feet per year. The Union Pacific Railroad Co. pumps water from wells at Torrington, Yoder, and Lagrange. The Chicago, Burlington & Quincy Railroad Co. owns and operates wells at Torrington and Fort Laramie.

IRRIGATION SUPPLIES

History of development.—Seventy-three irrigation wells in the county were inventoried during the study. Sixty-one of these wells are in the North Platte project area. These wells are shown on plate 4 and pertinent data are given in table 7. All the irrigation wells in the county at the end of 1951 are thought to have been included in the inventory. About three-quarters of the irrigation wells have been drilled in recent years (since 1946). The remaining quarter were drilled before 1946; the earliest recorded date is 1930.

Quantity of water pumped.—Forty-five of the seventy-three irrigation wells in the county were pumped during 1951. These wells pumped a total of about 4,800 acre-feet of water, of which about 3,700 acre-feet was pumped within the North Platte project area. The amount of water pumped was determined by assuming that the average amount of water pumped per well was equivalent to the average amount pumped from wells for which measurements were made—that is, from wells that are equipped with electrically powered pumps. The quantity of water pumped for irrigation by electrically powered pumps in the area during 1951 was calculated from records of power consumption supplied by the power companies and from measurements of the rate of power input and the rate of well discharge that were made during the investigation. The rate of power input to the motors was determined by clocking the electric watt-hour meters with a stopwatch, and the total duration of pumping during the year was determined by dividing the total amount of power consumed during the year by the rate of power input. Measurements of the rate of discharge were made with a Hoff current meter, which was inserted into the discharge pipe of each pumping plant and moved about in a prescribed horizontal, vertical, and circular pattern while being timed with a stopwatch in order to obtain an integrated average velocity of the discharging water. The rate of discharge was then computed by applying the empirically derived formula (Rohwer, 1942, p. 3–40)—

$$D=(419A-5)V$$

in which D=the discharge of the pump, in gallons per minute;
A=the cross-sectional area of the discharge pipe, in square feet;
and V=the average integrated velocity of the discharging water, in feet per second.

Power required for pumping water.—The cost of pumping water from a well depends upon the cost of drilling the well and installing the pump, the cost of the fuel or power, and the cost of maintenance and operation. The only cost that could be determined with any reasonable degree of accuracy was the cost of the electric power for the few electrically powered units in the area. This is given in kilowatt-hours rather than in dollars and cents because a complicated sliding scale is used in charging for the use of electric power. The average amount of electric power required to pump an acre-foot of water was computed to be 1.90 kilowatt-hours per foot of lift. The average overall efficiency of the electrically powered units was calculated to be 54 percent.

POSSIBILITIES OF DEVELOPING ADDITIONAL LARGE SUPPLIES OF WATER

Additional large supplies of water can be developed from several aquifers in Goshen County. In most places in the flood-plain deposits of the North Platte River, wells yielding 1,000 to 3,000 gpm could be developed. In many places in the third-terrace deposits, wells yielding 500 to 1,500 gpm probably could be developed. In places in the flood-plain deposits along Horse and Bear Creeks in the vicinity of Lagrange, wells having yields of 500 to 1,000 gpm could be developed. In favorable areas, wells with possible yields of 500 to 1,000 gpm could be developed in the Arikaree formation.

In general the amount of water that can be pumped depends upon the saturated thickness of the aquifer. The performance of existing wells indicates that wells having a capacity of 1,000 gpm or more probably can be developed at almost any place in the flood-plain deposits of the North Platte River where the saturated thickness exceeds 50 feet. However, in the flood-plain deposits along Rawhide Creek and along Horse and Bear Creeks, in the third-terrace deposits, and in the flood-plain deposits along the North Platte River where the saturated thickness is shown to be less than 50 feet, the installation of large-capacity wells should be preceded by test drilling in order to determine the permeability and the saturated thickness of the material.

The amount of water that can be withdrawn from the ground-water reservoir without causing excessive permanent lowering of the water table depends upon the capacity of, and the amount of recharge to, the ground-water reservoir. If water is pumped from the ground-water reservoir at a greater average rate than the average rate of recharge, the water level declines and the supply eventually is depleted. If the recharge during the nonpumping period replaces the pumped water, the discharge can exceed the average rate of recharge for short periods of time without causing serious lowering of the water level. In this way the aquifer could be used as a storage reservoir, to which water could be added or from which water could be withdrawn. To develop the maximum amount of ground water from the valley fill, water must be pumped in excess of the rate of recharge during the growing season.

For the four water years 1947–48 through 1950–51 an average of about 217,000 acre-feet of ground water left the North Platte project area annually as surface flow—this represents the amount of rejected or excess ground water. In addition to this amount, about 29,000 acre-feet of ground water is estimated to leave the area as underflow through the valley fill, and about 59,000 acre-feet is discharged by evapotranspiration, including about 3,000 acre-feet of the water discharged by wells. The withdrawal and consumptive use of a large additional quantity of ground water in the area would cause a decline in the amount of ground-water pickup by the streams. However, ground water used by industry for cooling or in some other nonconsumptive way would have no net effect on the flow of the North Platte River. If sufficient ground water were withdrawn to cause a decline of the water table, additional water would be salvaged from the present loss by evapotranspiration and would be available for irrigation and other uses. Of course, some of the water pumped for irrigation would return to the ground-water reservoir as recharge. Thus, the amount consumptively used, and not balanced by a decrease in evapotranspiration, would represent a potential decrease in the pickup of the river.

If an extensive program of ground-water development is undertaken in the area in the future, records should be kept of the amount of water that is pumped and of the changes in water level, and water samples should be collected periodically from selected wells for chemical analysis.

CHEMICAL QUALITY OF THE GROUND WATER

By W. H. Durum

Closely allied to problems of quantity of ground water are those relating to the quality of ground water. An insufficient supply or the overdevelopment of ground water in an area is sometimes associated with undesirable chemical characteristics of that water—excessive amounts of dissolved solids, chloride, iron, or manganese, or other substandard characteristics such as excessive hardness or corrosiveness. These problems are related to the geologic and hydrologic factors in an area.

Perhaps equally important is the fact that land-use practices involving reuse of water, such as large-scale irrigation, tend to modify the quality of water through concentration of the shallow water by evaporation and transpiration, which may involve deposition and re-solution of salts in the soil or at the ground surface. Ultimately this process may adversely affect the water user downstream, as the irrigation waste water that reaches the stream either through drains or by underground movement contains more dissolved solids than the water that was applied to the land originally.

Chemical analyses were made of water samples collected in Goshen County in order to determine the general usability of the ground water and the possibility of future changes in quality. The geologic formations exposed in the area have long yielded water for domestic and stock purposes; therefore, it could be assumed that the supplies from these aquifers generally are potable. However, accurate data relating to the degree and type of hardness, the quantities of iron, fluoride, and nitrate, and the percentage of sodium are needed for more careful appraisal of the ground-water resource. Furthermore, current data on water quality will need to be collected in the future to show what effect irrigation in the area has on the chemical character of the ground water. The writer (in Visher and Babcock, 1953) has shown that, in some parts of Goshen County, waterlogging causes local deterioration of the chemical quality of the ground water in shallow aquifers.

COLLECTION OF DATA

During the investigation, samples of ground water were collected from all the principal water-bearing sources in the county. Chemical analyses of the water samples from the 52 wells and 6 seeps or springs sampled are given in table 3; figure 8 shows location of sampling

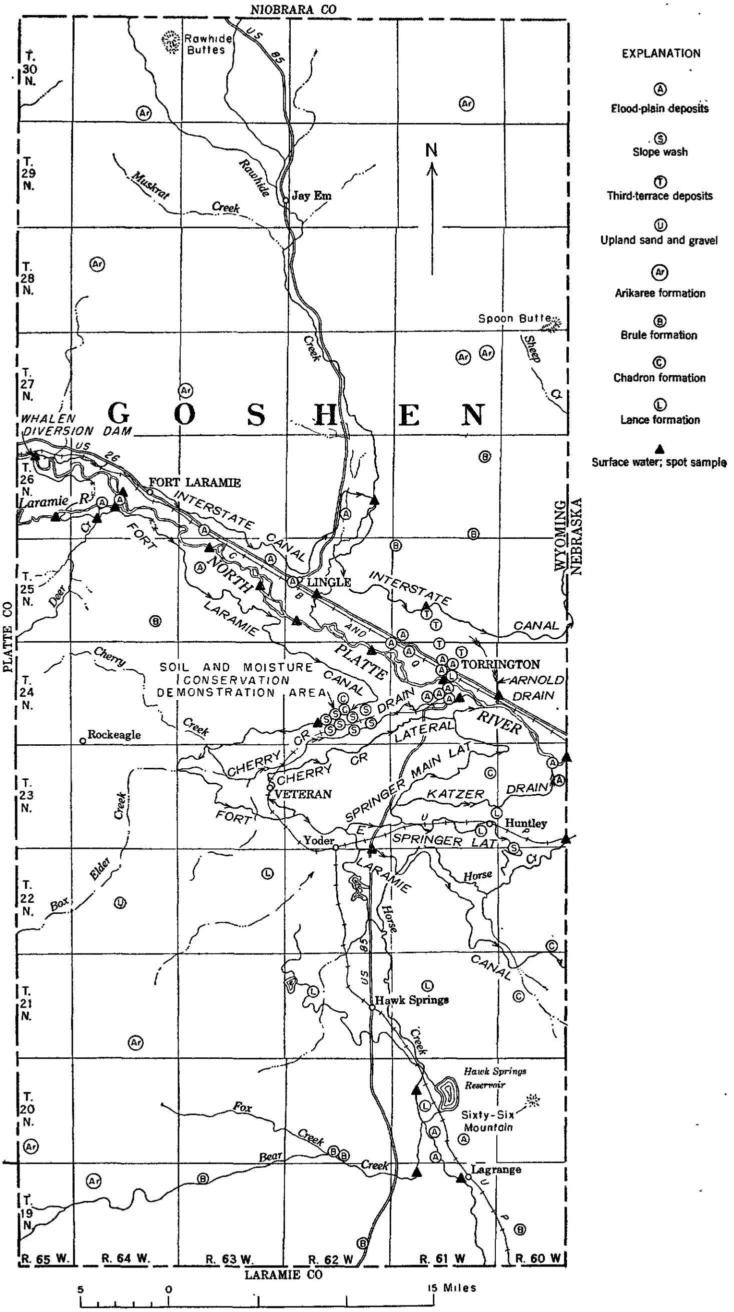

FIGURE 8.—Index map of Goshen County, Wyo., showing location of quality-of-water sampling points.

points. These samples were collected during the period August to November 1951. Most of the samples were obtained from wells in the valley fill, which is the most important aquifer in the area. Three wells were resampled during pumping tests to determine whether any significant changes in the quality of the water occurred during the pumping period.

Earlier analyses of 16 ground-water samples, principally from shallow augered holes, and 1 surface-water sample collected in the Soil and Moisture Conservation Demonstration Area (Visher and Babcock, 1953) have been used in this report to supplement the data collected during the present study. These analyses are given in table 4. Information pertaining to the ground-water supplies that were sampled is summarized below.

Data on ground-water supplies sampled for chemical analysis

Source	Number of supplies	Range in depth (feet)	Use of water
Lance formation	5	85–470	Public, domestic, and stock.
Chadron formation	5	50–124	Domestic and stock.
Brule formation	9	33–160	Do.
Arikaree formation	9	90–300	Do.
Upland sand and gravel	1	40	Irrigation.
Third-terrace deposits	4	96–120	Principally irrigation.
Flood-plain deposits	22	[1] 26–210	Public, industrial, irrigation, domestic, and stock.
Slope wash [2]	9	0–8	None.

[1] Deepest well taps Chadron formation also.
[2] Principally augered test holes.

A qualitative study also was made of the mineralization of the water in streams that are tributary to the North Platte River and of the effects of surface inflow on the quality of the water in the North Platte River between Whalen Dam and the Nebraska State line. Samples representing the quality of water before, at the peak of, and after the irrigation season were collected in March, August, and October, 1951, respectively, from the Laramie River, Deer Creek, the Cherry Creek drain, Rawhide Creek, Horse Creek, and the North Platte River. The Interstate canal and the Fort Laramie canal were sampled only once during the investigation. However, Geological Survey records for continuous periods of sampling during 1951 of the North Platte River below Guernsey Reservoir supplement these data that were obtained during the peak of the irrigation season. Chemical analyses of the samples are given in table 5, and the location of the sampling points is shown in figure 8. Some of these analyses consist of only a few individual determinations.

Although the suitability of water for all uses cannot be measured by a single criterion, it is now generally accepted that water supplies serving public, domestic, and general industrial purposes should be

TABLE 3.—*Chemical analyses and other related measurements of ground water, Goshen County, Wyo.*

[Analyses in parts per million except as indicated]

Well no.	Depth (feet)	Date of collection	Temperature (° F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25° C.)	pH
Lance formation																						
20-61-17dd	Spring	Oct. 24, 1949	56	53	0.02	50	11	60	18	332	0	39	10	0.4	2.3	0.20	416	171	0	40	608	7.7
21-61-17ad	85	Nov 6, 1951	54	11	.97	3.5	1.3	310	6.3	601	37	96	37	2.4	8.8	.77	833	14	0	97	1,320	8.8
21-62-17ab	117	do	54	17	.03	9.5	3.3	429	7.0	413	22	405	113	.5	39	.21	1,250	37	0	95	1,940	8.6
22-63-12cb	157	Nov. 19, 1951	------	11	.26	6	1.7	273	5.4	434	18	185	34	.3	19	.18	790	22	0	95	1,230	8.6
23-61-25aa	Seep	Oct. 30, 1951	52	38	------	49	19	292	12	513	0	363	41	.9	12	.57	1,080	200	0	75	1,610	8.0
-36bb	275	Nov. 7, 1951	50	11	.01	1.7	.5	237	2.6	576	28	1.0	9.5	1.6	1.2	.36	592	6	0	98	951	8.7
24-61-10db	470	Oct. 22, 1951	59	11	.04	1.8	1.0	275	1.6	660	35	1.0	7.5	2.4	.3	.39	664	8	0	98	1,080	8.7
Chadron formation																						
21-60-17cc	124	Oct. 30, 1951	53	10	0.02	1.8	0.6	198	3.8	456	33	13	9.0	1.4	1.1	0.43	518	7	0	97	824	8.9
22-60-33dd	85	do	57	12	.06	2.5	.9	206	4.4	469	20	26	23	1.6	.7	.42	539	9	0	97	876	8.6
23-61-12dc	50	Nov. 23, 1951	50	11	.61	4.0	2.2	262	7.1	460	15	102	68	1.6	.7	.37	713	19	0	95	1,160	8.6
24-62-22ca	------	Aug. 15, 1950	------	16	------	8.5	1.2	202	7.7	297	0	65	114	1.1	.3	.30	580	26	0	92	920	7.8
-22cd	83	do	------	50	------	16	4.9	324	11	353	0	298	99	.6	14	.20	996	60	0	91	1,460	7.8
Brule formation																						
19-60-20cd	90	Nov 14, 1951	53	50	0.29	32	7.3	33	5.8	180	4	15	4.0	0.8	16	0.03	262	110	0	38	363	8.3
19-62-26db	42	Nov. 7, 1951	52	48	.03	19	4.7	126	7.2	299	16	43	28	.4	7.0	.24	474	67	0	78	693	8.5
19-63-5cd	Spring	Sept 30, 1949	59	58	.02	42	7.5	17	9.6	195	0	12	4.0	------	6.8	.30	250	136	0	20	333	7.2
20-62-33ac	33	Oct. 18, 1949	52	64	.02	51	18	122	9.6	556	0	20	4.2	.6	5.6	.20	584	202	0	55	813	7.8
-34cb	Spring	Sept. 30, 1949	49	62	.02	22	6.5	149	10	475	0	23	9.4	------	5.2	.30	560	82	0	77	760	8.1
25-61-6cb	100	Nov 26, 1951	55	64	.10	38	7.5	67	11	188	0	25	25	------	97	------	428	126	0	51	588	7.6
25-64-25cc	120	Nov 6, 1951	54	59	1.1	46	10	32	7.4	208	0	29	9.0	.4	29	.05	332	157	0	29	452	8.2
26-61-12bd	120	Oct. 23, 1951	------	------	.01	------	------	98	------	206	9	------	------	------	------	------	420	------	------	------	597	8.4
-35dd	160	Nov. 26, 1951	53	58	.06	8.0	2.7	139	11	307	0	36	18	.7	48	.21	483	31	0	87	677	8.0

Arikaree formation

19-64-8cd	Spring	Oct. 25, 1949	52	54	0.02	57	8.7	7.5	5.6	223	0	0.1	2.0	0.6	1.7	0.20	286	178	0	8	362	7.6
20-65-34da	----	Nov. 7, 1951	----	48	.26	43	11	11	3.8	182	8	1.0	5.5	.8	11	.17	252	154	0	13	340	8.4
21-64-34ab	204	do	55	46	.03	52	7.2	9.7	2.2	193	6	1.0	3.5	.4	6.5	.04	238	159	0	11	340	8.3
27-61-10da	261	Oct. 23, 1951	----	----	.14	----	----	17	----	159	0	----	----	----	----	----	288	----	----	----	403	8.1
-12bb	274	do	----	----	.12	----	----	14	----	183	0	34	20	.4	----	----	324	----	----	14	452	8.2
27-63-19bd	300	Nov. 21, 1951	54	56	.09	25	1.6	37	16	164	4	16	6.0	.4	9.6	.04	260	69	0	47	339	8.4
28-64-17ba	90	do	53	52	.04	84	2.6	41	7.1	232	9	73	22	.6	9.6	.07	430	220	15	28	598	8.4
30-61-27dd	148	Oct. 23, 1951	----	45	.19	66	16	11	6.5	221	0	25	21	.3	24	.04	354	232	51	9	506	7.7
30-64-34da	----	Nov. 20, 1951	52	51	.09	97	14	7.8	6.1	297	18	17	13	.8	19	.03	397	301	28	5	574	8.5

Upland sand and gravel

22-64-21aa	40	Aug. 29, 1951	52	----	0.02	----	----	39	----	330	0	----	----	----	----	----	486	----	----	----	728	7.3

Third-terrace deposits

24-61-2cb	112	Aug. 23, 1951	57	26	0.02	102	22	40	11	310	0	155	13	0.2	14	0.06	540	343	89	20	808	7.3
-4aa	120	Aug. 16, 1951	58	34	.02	99	19	42	16	279	0	160	13	.2	25	.06	554	327	98	21	806	7.5
25-61-28bc	120	do	58	35	.02	78	9.6	43	9.7	189	0	160	13	.2	4.5	.07	450	234	79	28	647	7.5
-33ab:																						
(after 40 min.)	96	Oct. 24, 1951	----	----	.04	----	----	41	----	239	7	----	----	----	----	----	512	----	----	----	735	8.2
(after 9 hr.)	96	do	----	----	.03	----	----	----	----	----	----	159	----	----	----	----	542	305	----	----	762	----
(after 24 hr.)	96	Oct. 25, 1951	57	43	.03	98	15	43	12	264	0	159	12	.2	14	.15	544	306	90	23	752	8.0
(after 30 hr.)	96	do	----	----	.06	----	----	----	----	----	----	158	----	----	----	----	530	294	----	----	748	----

Slope wash

22-60-6aa	Seep	Oct. 30, 1951	42	36	----	134	35	415	29	287	6	975	112	0.9	7.1	0.59	1,890	479	234	64	2,610	8.3

TABLE 3.—*Chemical analyses and other related measurements of ground water, Goshen County, Wyo.*—Continued

Well no.	Depth (feet)	Date of collection	Temperature (° F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25° C.)	pH
Flood-plain deposits																						
20-61-26cb [1]	210	Aug. 21, 1951	54	44	0.04	56	13	29	6.2	260	0	31	8.5	0.3	3.9	0.11	324	191	0	24	436	7.5
-28bb	35	Sept. 28, 1949	55	51	.02	75	12	23	6.4	320	0	29	9.2	.2	2.8	.10	390	237	0	17	533	7.7
-33cd	46.5	Aug. 31, 1951	51		.02			46		375	0						438				661	7.3
23-60-10bb	50	Aug. 21, 1951	56	21	.02	74	20	92		279	0	199	19	.4	2.0	.13	578	266	37	43	865	7.7
-15ba	50	do	56		.04			125		375	0						674				1,010	7.4
24-61-5cb1	93	Aug. 15, 1951	57	42	.04	69	16	59	12	240	0	155	13	.3	8.9	.09	504	239	42	34	720	7.4
(after 20 min.)	93	Oct. 31, 1951	58	48	.04	76	20	63	13	252	16	160	15	.8	10	.10	553	272	39	32	779	8.6
(after 12 hr.)	93	do			.10							156					576	276			795	
(after 24 hr.)	93	Nov. 1, 1951			.01							163					558	270			775	
-6bb	36	Aug. 27, 1951	57	35	.02	76	17	48	9.2	231	0	155	13	.3	9.1	.09	496	258	69	28	706	7.4
-10bc	63	Sept. 7, 1951	58	35	.03	93	17	43	9.4	264	0	154	12	.2	19	.09	528	302	86	23	751	7.4
-10bd	60	do	58	37	.06	97	18	45	8.9	282	0	153	12	.4	19	.08	536	314	83	23	777	7.3
-10cb1	90	Aug. 16, 1951	56	36	.02	86	21	53	12	286	0	158	13	.3	16	.10	550	302	67	27	794	7.4
-15cc1:																						
(after 1 min.)	85	Oct. 9, 1951	57	20	1.0	86	18	51	4.8	308	0	133	17	.4	.6	.07	490	287	34	27	754	7.9
(after 7 hr.)	85	do			2.6							121					546				847	
(after 23 hr.)	85	Oct. 10, 1951			3.5							127					542				842	
(after 31 hr.)	85	do			2.3							129					536				839	
(after 41 hr.)	85	Oct. 11, 1951			5.3			58				132						335		27		
24-61-15cc2:																						
(at start)	86	Nov. 26, 1951	52		1.4	77	15	61	4.5	262	0	158					494	252	37	34	742	7.5
-21ab	50	Sept. 7, 1951	52	25	.05	86	17	108	4.6	326	0	226	18	.3	6.5	.13	658	284	17	45	974	7.4
-22ba	26	do	56		.37			83		106	0						452				675	7.3
25-61-31db	95	Aug. 17, 1951	57	44	.02	51	9.7	68	9.3	214	0	125	11	.3	4.1	.08	430	167	0	45	630	7.6
25-62-18db3	51	Sept. 7, 1951	59	46	.03	74	28	56	19	291	0	172	14	1.0	7.7	.11	570	300	61	27	814	7.4
25-63-8dc2	68.5	Aug. 27, 1951	58		.04			75		278	0						662				935	7.5
-12bd	81	Sept. 4, 1951	59		.55			59		228	0						550				742	7.3
26-62-27db		Nov. 4, 1951	55	52		24	4.9	103	13	184	6	143	12	.3	1.5	.10	468	80	0	70	649	8.3
26-63-32da	80	Aug 27, 1951	59	30	.03	71	15	37	4.2	188	0	150	12	.3	2.0	.05	430	240	86	25	616	7.5
26-64-22cc	62	Aug 20, 1951	56	27	.03	88	23	53	6.7	286	0	170	16	.2	11	.09	540	314	79	26	805	7.4
-28bb	28.8	Sept. 7, 1951		26	.02	76	14	44	4.2	202	0	162	13	.3	2.4	.07	446	249	83	27	660	7.4

[1] Taps alluvium and Brule formation.

TABLE 4.—*Chemical analyses of water in the Soil and Moisture Cons ervation Demonstration area near Torrington, Goshen County, Wyo.*

[Analyses in parts per million except as indicated]

Location and source	Depth (feet)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25° C)	pH
24-62-26ab, Slope wash over Brule formation	Seep	Aug. 15, 1950	46	------	56	11	107	16	306	155	13	0.7	1.1	0.20	562	186	0	53	779	7.7
Do	Seep	Oct. 22, 1950	41	0.02	55	12	84	9.4	258	140	13	.4	1.5	.10	486	186	0	48	693	7.6
24-62-25cc, Slope wash over sand and gravel (augered hole)	8	Aug. 15, 1950	49	------	89	30	114	24	447	198	12	.5	23	.20	774	344	0	40	1,070	7.8
Do	6.5	Oct. 23, 1950	54	------	93	34	127	27	501	208	13	.6	18	.30	826	370	0	41	1,150	7.4
24-62-27ac, Slope wash over Brule formation	Seep	Aug. 15, 1950	36	------	52	18	56	9.4	206	145	11	.5	.9	.10	464	202	33	36	605	7.2
Do	Seep	Oct. 22, 1950	36	.02	58	19	68	9.5	241	148	18	.4	1.2	.20	510	222	24	39	685	7.2
24-62-35bc, Slope wash over sand and gravel	Seep	Aug. 15, 1950	48	------	56	12	614	16	738	705	129	.9	19	.70	1,960	188	0	86	2,700	7.8
Do	Seep	Oct. 23, 1950	45	------	60	13	616	17	715	765	114	.7	24	.50	2,010	202	0	86	2,800	7.7
24-62-27cb, Slope wash over Brule formation (augered hole)	6	Aug. 15, 1950	48	------	146	54	68	38	521	308	12	.8	.4	.20	964	587	160	19	1,250	7.3
Do	7	Oct. 24, 1950	45	------	101	34	48	26	380	175	13	.5	3.0	.10	666	393	81	20	899	7.4
24-62-28dd, Slope wash over Chadron formation (augered hole)	5	Aug. 15, 1950	48	------	209	85	76	66	646	455	55	.4	1.2	.30	1,310	872	342	15	1,720	7.2
Do	6	Oct. 23, 1950	53	------	174	48	69	56	653	258	20	.6	.9	.20	1,000	632	113	18	1,370	7.2
24-62-28da, Slope wash over Brule formation (augered hole)	4	Aug. 14, 1950	45	------	150	65	61	68	785	180	16	1.3	4.4	.20	980	640	0	15	1,390	7.5
Do	7	Oct. 24, 1950	53	------	188	68	62	52	743	250	34	1.1	.4	.20	1,070	750	141	14	1,480	7.5
24-62-33ab, Slope wash over Chadron formation (augered hole)	2	Aug. 14, 1950	36	------	128	18	516	23	708	885	60	.7	1.4	.20	2,020	394	0	73	2,660	7.4
Do	2	Oct. 23, 1950	37	------	194	34	614	27	1,220	810	90	.6	1.0	.10	2,410	622	0	67	3,170	7.4
Fort Laramie canal, bridge at lower end of area	------	Aug. 14, 1950	12	.02	54	16	34	4.4	148	130	9.0	.4	.7	.10	354	199	78	27	508	7.6

TABLE 5.—*Chemical analyses and other related measurements of surface water, Goshen County, Wyo.*

[Analytical results in parts per million except as indicated]

Source	Date of collection	Temperature (° F)	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Parts per million	Dissolved solids: Tons per acre-foot	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25° C)	pH
Laramie River, 26-64-28a	Mar. 27, 1951	48	28	0.01	79	19		49	262	0	138	14	0.5	1.0	0.32	480	0.65	274	59	28	702	7.8
Do	Aug. 14, 1951	69									152					486	.66				742	
Do	Oct. 29, 1951	48									149					500	.68	284			740	
Laramie River, 26-65-25c	Mar. 27, 1951	47	22	.01	86	24	51	4.2	284	0	167	16	.3	2.0	.10	540	.73	313	80	26	780	7.5
Do	Aug. 14, 1951	68									149					508	.69				744	
Do	Oct. 29, 1951			.02							164					576	.78	330			839	
Arnold drain, 24-61-24a	Mar. 27, 1951	52	37	.01	68	9.8		38	187	0	116	11	.4	2.4	.08	400	.54	210	57	28	572	7.9
Do	Aug. 14, 1951	73	29	.01	68	13		48	202	0	139	11	.5	2.0	.07	424	.58	224	58	32	628	7.7
Do	Oct. 29, 1951	54		.02							144					474	.64	246			667	
Cherry Creek drain, 24-61-23b	Mar. 27, 1951	53	35	.01	41	12		537	577	10	668	82	1.2	20	.49	1,690	2.30	152	0	88	2,480	8.3
Do	Aug. 16, 1951	63	25	.01	52	14		175	302	0	263	28	.6	7.1	.17	726	.99	188	0	67	1,080	7.8
Do	Oct. 29, 1951	52		.02							500					1,400	1.90	170			2,020	
Deer Creek, 26-64-29d	Mar. 27, 1951	47	45	.01	56	13		26	275	0	13	5.5	.7	1.5	.05	300	.41	194	0	22	464	7.6
Do	Aug. 14, 1951	65									10					326	.44				506	
Do	Oct. 29, 1951	44									10					356	.48	218			483	
Rawhide Creek, 25-62-20a	Mar. 27, 1951	49	33	.01	45	8.6		95	266	0	110	13	.6	2.8	.13	448	.61	148	0	58	670	8.1
Do	Aug. 15, 1951	72	37	.01	50	11		105	255	0	160	13	.6	2.2	.13	526	.72	169	0	57	770	7.7
Do	Oct. 29, 1951	55		.02							162					570	.78	164			824	
Rawhide Creek, 26-62-25b	Mar. 27, 1951	43	24	.02	42	8.8		56	262	0	31	10	.5	1.3	.07	314	.43	141	0	46	492	7.7
Do	Aug. 15, 1951	64	21	.01	28	8.3		106	310	0	53	16	.5	.6	.13	396	.54	104	0	69	621	8.1
Do	Oct. 29, 1951	44		.02							58					474	.64	137			713	
Interstate canal, 25-61-28b	Aug. 15, 1951	70									130					338	.46				527	
Fort Laramie canal, 22-62-1b	Aug. 16, 1951	70									129					352	.48				529	
North Platte River, 23-60-3d	Mar. 27, 1951	51	23	.01	73	20		86	269	0	192	19	.5	5.5	.13	552	.75	266	45	41	838	7.9
Do	Aug. 14, 1951	72	14	.01	63	18		55	202	0	155	13	.4	3.3	.09	424	.58	230	64	34	657	7.7
Do	Oct. 29, 1951	52		.02							221					620	.84	310			919	
North Platte River, 24-61-15c	Mar. 27, 1951	53	23	.01	76	21		73	264	0	181	17	.5	4.5	.13	544	.74	276	60	36	805	7.9
Do	Aug. 14, 1951	71									150					408	.55				627	
Do	Oct. 29, 1951	52		.02							221					594	.81	290			861	
North Platte River, 24-62-1c	Mar. 27, 1951	51	24	.01	48	21		71	174	0	183	17	.5	4.1	.13	472	.64	207	64	43	698	7.9
Do	Aug. 14, 1951	70									147					394	.54				608	
Do	Oct. 29, 1951	51		.02							232					594	.81	292			867	
North Platte River, 25-62-30d	Mar. 27, 1951		23	.02	78	25		62	251	0	189	18	.5	3.3	.11	546	.74	296	90	31	796	7.9
Do	Aug. 14, 1951	71									143					384	.52				596	
Do	Oct. 29, 1951	54		.02							218					552	.75	276			818	

North Platte River, 25-63-4c	Mar. 27, 1951	48	19	.01	71	17		53	207	0	164	14	.3	.6	.13	450	.61	246	76	32	676	7.5
Do	Aug. 14, 1951	70									139					378	.51				588	
Do	Oct. 29, 1951	47		.02							228					602	.82	304			864	
North Platte River, 25-63-14d	Mar. 27, 1951	51	20	.02	59	18		61	168	0	181	16	.3	6.1	.10	466	.63	222	84	37	675	7.7
Do	Aug. 14, 1951	70									141					380	.52				590	
Do	Oct. 29, 1951	49		.02							228					576	.78	303			852	
North Platte River, 26-64-22c	Mar. 27, 1951	48	20	.02	76	17		55	206	0	178	14	.5	1.3	.20	466	.63	258	89	31	699	7.6
Do	Aug. 14, 1951	67									137					366	.50				561	
Do	Oct. 29, 1951			.02							188					516	.70	277			749	
North Platte River, 26-65-11b	Mar. 27, 1951	48	10	.01	82	30	84	5.6	207	0	297	25	.2	1.1	.21	654	.89	326	156	35	950	7.4
Do	Aug. 14, 1951	69	7.0	.01	52	16	35	3.4	154	0	132	11	.2	2.3	.09	336	.46	194	68	28	530	7.4
Do	Oct. 29, 1951	41									319					734	1.00	354			1,040	
Horse Creek, 23-60-34c	do	54									320					1,040	1.41	172			1,500	
Horse Creek at Lagrange	Sept. 28, 1949		40	.02	22	18	38	21	236	0	33	7.0		1.5	.20	298	.41	129	0	35	438	7.3
Horse Creek north of Lagrange	do	52	46	.02	60	14	57	7.2	365	0	30	10	.6	2.2	.20	436	.59	207	0	36	619	7.8
Bear Creek 2.5 miles west of Lagrange	do		45	.02	46	11	43	5.6	302	0	9.0	7.4	.4	1.2	.30	344	.47	161	0	36	481	7.8

clear, pleasant tasting, preferably of moderately low temperature, neither corrosive nor scale forming, free from minerals producing undersirable physiological effects, and free from disease-producing organisms. Water for irrigation has special requirements, principally in the amount of dissolved solids, boron, and the percentage of sodium. The discussion of water quality in this report pertains only to the chemical quality of the water and does not relate to the sanitary quality of the individual supplies, except that a high nitrate and chloride content might be an indication of pollution.

Certain criteria have been developed for use in the evaluation of water with respect to its general suitability as an irrigation supply. These criteria are discussed more fully on pages 92–93.

PRINCIPAL CONSTITUENTS

Water percolating through soil and rocks exerts a solvent action upon the materials through which is passes. This solvent action is greatly increased by the presence of carbon dioxide, which is formed by organic processes and which is absorbed from the atmosphere and from the soil, as well as by organic acids formed in the soil. The amount and the character of the dissolved mineral matter in a water depend on the chemical and physical composition of the rocks through which the water passes, the duration of the contact, and other factors such as temperature and pressure.

The tables of analyses show results for dissolved solids, silica, iron, calcium, magnesium, sodium, potassium, bicarbonate, carbonate, sulfate, chloride, fluoride, nitrate, specific conductance, boron, hardness, and percentage of sodium (percent sodium as used by Scofield, 1938, p. 4–5). The chemical constituents are reported in parts per million, 1 ppm being equivalent to 1 milligram of a given constituent in 1 liter (1 kilogram) of water, or 8.34 pounds of constituent per million gallons of water. Perhaps of principal interest to water users in Goshen County are the results for dissolved solids, iron, fluoride, nitrate, hardness, and percent sodium. Each is defined and its importance is described briefly in the following discussion. For more detailed discussion of these and other substances, results for which appear in the tables of analyses, the reader is referred to the introductory section of any water-supply paper published annually by the Geological Survey, entitled "Quality of surface waters of the United States."

The term dissolved solids refers to the amount of dissolved mineral matter that remains after the water has been evaporated. Some organic material as well as some water of crystallization may be included in the residue. For this report, dissolved solids exceeding 1,000 ppm are reported in most analyses as the sum of the determined constituents; this method of reporting is more accurate for higher concentrations if the principal constituents including silica have been determined. Water having less than 500 ppm of dissolved solids is satisfactory for domestic and many industrial uses; water containing more than 1,000 ppm may cause physiological disturbances except to those accustomed to the use of water of such high mineral content.

Iron in alkaline water is generally in the form of ferrous bicarbonate; the iron is derived from rocks or from the pipes through which corrosive water flows. Water containing more than a few tenths of a part per million of iron is objectionable owing to its taste and to its ability to stain, which results from the oxidation of the iron. Iron is sometimes a problem in water from both the shallow and the deep sources in this area. Most of the analyses, however, indicate that iron in the water should not be much of a problem.

Fluoride in water supplies is related to both the mottling of tooth enamel and the incidence of dental caries (tooth decay) in the permanent teeth of children (Dean, 1943). A fluoride concentration of about 1.0 to 1.5 ppm in the water supplies greatly lessens the incidence of dental caries in the permanent teeth of children who use the water. Mottling of tooth enamel is caused by the use of water in which the fluoride concentration is greater than about 1.5 ppm; the severity of mottling increases with the fluoride content of the water.

Water from most of the shallow sources in this area contains less than 1.0 ppm of fluoride, but some water from the Chadron and Lance formations contains more than 2.0 ppm.

Nitrate may be produced by oxidation of nitrogenous material. The presence of large amounts of this ion generally is interpreted to be an indication of pollution; however, it may be an indication of the action of harmless bacteria in the soil mantle through which the water percolates, or of past fertilization of fields in the recharge area. Recent studies (Maxcy, 1950, p. 265) show that a high concentration of nitrate in drinking water may be a contributing factor in the development of cyanosis in infants (blue baby). Two wells in the Brule formation yielded water having nitrate (as NO_3) in excess of 45 ppm, which is considered by many authorities to be the tolerable upper limit for supplies used in the feeding of infants.

Hardness is due principally to the salts of calcium and magnesium in solution. Because calcium carbonate, calcium sulfate, and, to a lesser extent, magnesium carbonate are present in the principal aquifers in the area, ground water derived from these aquifers contains varying amounts of calcium and magnesium, and therefore is fairly hard. The quantity of other hardness-forming constituents, such as iron, aluminum, zinc, barium, and strontium, in water in this area is not sufficient to have any appreciable effect upon total hardness. The hardness equivalent to the bicarbonate in a water is called carbonate (temporary) hardness; the remainder, noncarbonate (permanent) hardness.

Excessive hardness is recognized by the large quantity of soap required to produce lather and by the formation of an insoluble curd in all washing processes in which soap is used. Excessive hardness in water supplies is particularly objectionable in many industrial operations.

CHEMICAL CHARACTER IN RELATION TO SOURCE

Water in unconsolidated deposits in this area differs in chemical character from water in the bedrock. In addition to having some noncarbonate hardness, the water in the unconsolidated deposits is harder and has a lower percentage of sodium. The differences between the waters from the two sources increase progressively with the greater age of the bedrock formation. For example, water in the Lance formation generally is more highly mineralized, lower in silica content, and softer than water in the younger bedrock and in the valley fill.

In the following sections, descriptions are included for only those deposits that constitute aquifers of some importance at present. Thus, analyses were not made for samples of water from the Pliocene Channel deposits, Pleistocene upland deposits, or deposits of the second terrace or the dune sand.

Chadron and Lance formations.—The chemical character of water from the Chadron and Lance formations is similar, but it is unlike that of water in the younger rocks. (See table 3.) In addition to a higher content of dissolved solids, the water in the Chadron and Lance formations generally has undergone nearly complete natural softening. In the Chadron formation this softening is thought to occur mainly in the bentonitic silt and clay of the upper unit. The water from both formations is principally of the sodium bicarbonate type and generally has a pH greater than 8.3. The average for silica in samples from wells is about 11 ppm, which is much lower than the average for silica in the water from unconsolidated materials. The large amount of bicarbonate and small amount of sulfate in some samples of water from the Lance formation are probably due to natural reduction of sulfate—perhaps as a result of the presence of thin beds of dark carbonaceous shale and coal. The reduction of sulfate and a resultant equivalent increase in bicarbonate is nearly complete in water from the deep sources in the Lance formation. The percent sodium was generally above 95. The concentration of fluoride in two samples exceeded 2.0 ppm.

Brule formation.—This discussion of the quality of the water from the Brule formation is based on the analyses of nine samples (table 3) and on data obtained in earlier investigations in Wyoming (Babcock and Rapp, 1952, p. 18–19). The concentration of dissolved solids is moderate, ranging from 250 to 584 ppm. The hardness is variable, although it is generally less than that in the sand and gravel of the valley fill.

Differences in the observed quality of water from shallow sources in the Brule formation probably are due to a large extent to internal factors. One of these factors is the low permeability of the fine-grained materials that compose the formation; the slow movement of water through much of this aquifer allows alteration of the dissolved chemical constituents of the water that percolates from the overlying materials. The percent sodium is generally higher, but the total mineral content is approximately the same as in water from overlying sources. On the other hand, fractures in the Brule formation allow water from other sources to move rapidly through the formation without significant change in chemical composition during the movement. Thus, water from the Brule may differ substantially in composition, depending on whether it moves slowly or quickly through the formation.

The results of the analysis of water from well 26–61–35dd (table 3) indicate that in water from deep sources in the Brule formation sodium has almost completely replaced calcium and magnesium. The samples of water from the Brule formation contained above-normal quantities of nitrate, which likely was derived from surface sources.

Arikaree formation.—Because of its topographic position away from the irrigated areas and its upgradient position with respect to water movement in the area, the Arikaree formation would be expected to yield water that is lower in dissolved solids than that in the river valleys. Seven of the eight samples from this source contained less than 400 ppm of dissolved solids, but the water for the most part is hard.

Deposits of the third terrace.—The samples from the deposits of the third terrace were obtained from wells between Torrington and the Interstate canal. The water from the several sources was nearly uniform in quality and was of the calcium bicarbonate or calcium sulfate type (table 3). The concentration of dissolved solids (450 to 554 ppm) and the hardness (234 to 343 ppm) are comparable to those for water from the flood-plain deposits. Because the terrace deposits receive recharge from canal seepage and other surface water in addition to precipitation, the quality of water in shallow beds adjacent to canals probably is similar to that of the irrigation water. However, the chemical quality of the water becomes increasingly modified at greater distances from the infiltration area.

Flood-plain deposits.—Most of the samples obtained from the flood-plain deposits were from wells in the valley of the North Platte River. The water obtained from this source probably is a mixture of the water that moves through the valleys of the North Platte

River, the Laramie River, and Rawhide Creek as well as that seeping from canals and irrigated fields. Precipitation is an additional factor that tends to dilute the water; seasonally, precipitation plus the addition of irrigation water, tends to modify the composition of the shallow water.

Like water in the terrace deposits, water from the flood-plain deposits is moderately low in mineral content and generally is hard. (See table 3.) The observed range in dissolved-solids content was from 324 to 674 ppm. Locally the hardness is less than 200 ppm, but generally it exceeds 250 ppm. Excessive iron has been a problem, particularly in the water from wells that supply the sugar refinery at Torrington. During the pumping test of well 24–61–15ccl, iron increased from 1.0 ppm at the beginning of the test to 5.3 ppm at the end of 41 hours of continuous pumping. One explanation that has been offered for the increase in iron during normal pumping is that seepage from warehouses storing sugar beets carries iron in solution to the zone of saturation. This appears unlikely, however, because the wells are more than 80 feet deep and because the physical properties of the water and the mineral substances in solution are characteristic of the water from these deposits. Corrosion of the well casing by surface seepage, which permits the entry of shallow water, and finely divided sediments, including iron-bearing minerals, in suspension in the sample as a result of heavy pumping, are factors that are considered most significant.

Silica and noncarbonate hardness are generally more prominent in water from unconsolidated materials than in water from the deeper sources in bedrock.

Slope wash.—The chemical quality of the water in the slope wash in general is unsatisfactory where the slope wash overlies either the Chadron formation or the unfractured Brule formation. The poor quality of the water is due in part to the low permeability of the slope wash as well as to the inadequate drainage of the underlying bedrock. The results of analyses of water from seep 22–60–6aa (table 3) and from springs and augered holes in the Soil and Moisture Conservation Demonstration area (table 4) show that the water generally contains appreciable quantities of sulfate and is hard. The results of the analysis of water from augered test hole 24–62–25cc (table 4) show that water of better quality is obtained from the slope wash where it overlies sand and gravel. Water from the slope wash is of similarly better quality where the slope wash overlies fractured zones of the Brule formation.

TEMPERATURE

Collins (1925) reported that—

The temperature of ground water available for industrial supplies is generally from 2° to 3° F above the mean annual air temperature if the water is between

30 and 60 feet below the surface of the ground. An approximate average for the increase in temperature with depth is about 1° F for each 64 feet.

The mean air temperature for this area is 47.5°F; therefore shallow ground water would be expected to average about 50°F. For 24 samples of water from unconsolidated deposits at depths ranging from 26 to 210 feet the median temperature was 57°F. A pocket field thermometer with an accuracy of about ±0.5° F was used to measure the temperatures, which ranged from 51° to 59°F. The results obtained are somewhat higher than Collins' estimates which were necessarily generalized and did not take into account such factors as summertime application of irrigation water from surface sources to the land, which would tend to raise temperatures in proportion to the amount of recharge to the ground-water reservoir.

The median temperature for 13 samples from the bedrock formations (exclusive of one seep) was 53°F. The depth of the wells sampled ranged from 40 to 470 feet.

GENERAL RELATIONSHIP OF QUALITY OF GROUND AND SURFACE WATERS

The total mineral content or the concentration of a specific substance in water from unconsolidated materials in the North Platte River valley in general does not increase or decrease downstream from the head of the valley. However, water from the valley fill near the Interstate canal is slightly lower in mineral content than that from the valley fill near the North Platte River in the vicinity of Torrington.

ALKALINITY AND SULFATE

As bicarbonate and sulfate are the two principal anions in the waters from unconsolidated materials, the changes in concentration can be illustrated by plotting the two constituents on a sketch map showing the location of wells that were sampled in the vicinity of Torrington. The relationship of alkalinity (as carbonate plus bicarbonate) to sulfate in water from the unconsolidated deposits in the Torrington area, expressed in equivalents per million, is shown in figure 9. The concentration of sulfate is nearly uniform, whereas alkalinity increases, but not progressively, away from the Interstate canal. The increase in alkalinity indicates the limy character of the materials. This increase in concentration down gradient from the canal toward the river is not unexpected, inasmuch as canal water moving downslope and mixing with percolating water from irrigated tracts would tend to become more concentrated. It is rather surprising that sulfate shows so little variation, and it may be an indication that the shallow water is in equilibrium with its geologic environment so far as sulfate is concerned.

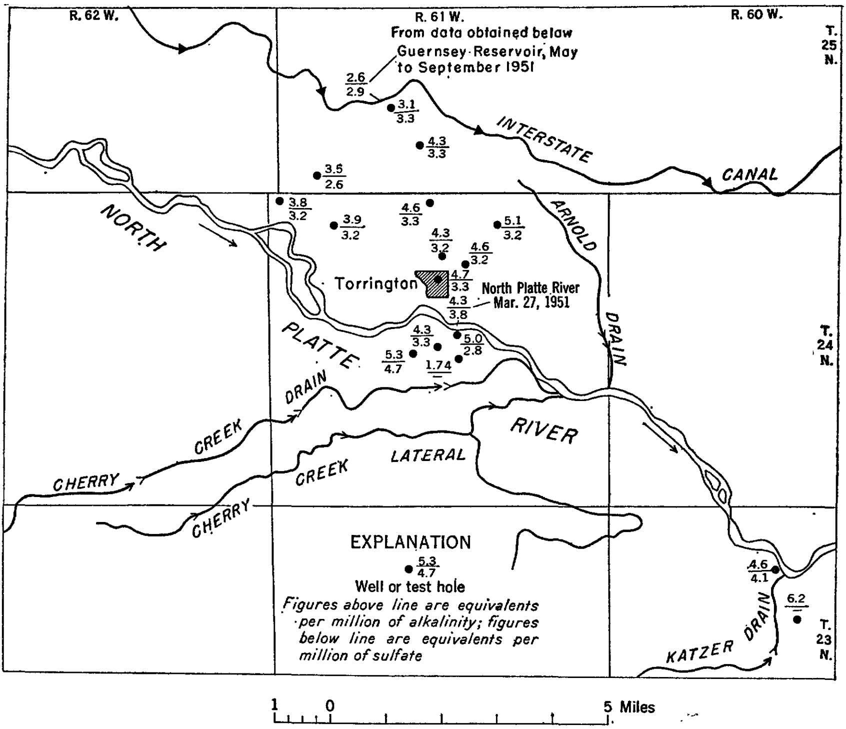

FIGURE 9.—Ratio of alkalinity to sulfate in water from unconsolidated deposits in the Torrington area.

RELEASES FROM GUERNSEY RESERVOIR

Further evidence of the chemical effect of applied irrigation water that is diverted from the North Platte River below Guernsey Reservoir is shown by data obtained by the U. S. Geological Survey from December 1950 to September 1951. (See table 6.) Samples were obtained at a sampling station below Guernsey Reservoir, and during the period May 3 to September 30 a total of 7 composite samples composed of 88 daily samples (57 percent of total days) were analyzed. The results of these analyses are given below.

Period of sampling	Bicarbonate and carbonate		Sulfate		Dissolved solids (ppm)
	(ppm)	(epm)	(ppm)	(epm)	
May 3–Sept. 30, 1951	160	2.6	141	2.9	369

The time-weighted average for bicarbonate and carbonate (alkalinity), 2.6 epm (equivalents per million) and for sulfate, 2.9 epm, are very nearly the same as results for the sample from well 25–61–28bc, immediately below the Interstate canal.

TABLE 6.—*Chemical analyses and other related measurements of the North Platte River below Guernsey Reservoir, December 1950 to September 1951*

[Analytical results in parts per million except as indicated]

Sample no.	Date of collection	Mean discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Residue on evaporation at 180° C	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25° C)	pH	Color (units)
M-3781	Dec. 7, 11, 1950	166	13	0.24	93	33	100	5.6	232	0	330	24	----	3.0	0.13	744	1.01	333	366	176	37	1,040	7.5	5
M-3732	Jan. 1-16, 1951	205	12	.01	102	37	103	5.5	251	0	370	33	0.2	3.3	.20	816	1.11	452	406	200	35	1,140	7.9	4
M-3777	Jan. 22-24	141	15	.06	66	59	114	5.8	272	0	398	28	.5	3.2	.14	840	1.14	320	406	183	37	1,190	8.1	6
M-3733	Feb. 1-28	173	15	.01	109	38	108	5.5	262	0	390	31	.2	3.2	.19	868	1.18	405	428	213	35	1,190	8.0	4
M-3778	Mar. 6-9	63.3	15	.14	71	57	103	5.8	252	0	375	27	.4	2.8	.13	778	1.06	133	412	205	35	1,140	8.0	5
M-3734	Mar. 25-31	16.0	13	.06	99	33	98	5.2	243	0	338	30	.4	3.0	.15	782	1.06	34	383	184	35	1,090	7.9	3
M-3735	Apr. 2-5	726	13	.04	100	34	102	5.3	242	0	353	30	.3	2.8	.14	796	1.08	1,560	391	193	36	1,120	7.8	3
M-3779	Apr. 23	1,050	13	.08	67	45	101	5.5	206	0	340	28	.4	2.0	.12	740	1.01	2,100	352	183	38	1,030	7.9	6
M-3736	Apr. 26-27	934	13	.04	81	29	91	4.5	194	0	300	26	.4	1.5	.15	680	.92	1,710	320	161	38	966	7.8	5
M-3780	Apr. 30	958	12	.18	64	33	80	5.0	186	0	270	23	----	5.2	.11	616	.84	1,590	296	143	37	872	7.8	8
M-4323	May 3-14	1,638	13	.20	54	16	40	3.6	149	0	145	10	.4	2.4	.04	374	.51	1,650	202	80	30	570	7.8	13
M-4380	June 4-22	2,768	13	.04	54	17	39	3.2	161	0	137	10	.2	1.0	.12	368	.50	2,750	204	72	29	559	7.5	3
M-4381	July 6-10	4,150	10	.02	56	18	42	3.5	167	0	152	11	.2	1.2	.11	388	.53	4,350	214	77	30	593	7.8	5
M-4382	Aug. 10-31	4,653	12	.02	51	18	36	3.2	156	0	131	10	.2	1.8	.11	352	.48	4,420	199	71	28	538	7.8	3
M-4383	Sept. 1-11	3,213	9.8	.02	53	16	37	3.3	158	0	134	11	.2	1.3	.09	344	.47	2,980	199	69	28	545	7.7	4
M-4882	Sept. 12-27	2,374	14	.04	57	18	42	3.5	169	0	151	12	.4	1.8	.10	394	.54	2,530	216	77	29	597	7.7	7
M-4384	Sept. 28-30	1,011	11	.02	64	21	49	3.8	185	0	171	14	.2	1.9	.08	430	.58	1,170	244	92	30	665	7.9	3

Releases from Guernsey Reservoir during the period May to September were considerably lower in dissolved solids than releases during the winter and early spring months of lower discharge; therefore, water of better quality was diverted to the Interstate canal during the irrigation season. The water was quite uniform in concentration during the season; concentrations of dissolved solids ranged from 344 ppm (0.47 ton per acre-foot) to 430 ppm (0.58 ton per acre-foot). These data support the observation that canal seepage tends to dilute shallow ground water in areas that are not waterlogged.

By the same reasoning, it might be expected that during the growing season, May to September, when releases from Guernsey Reservoir are larger than during the rest of the year, some movement of better quality water occurs from the North Platte River to shallow aquifers adjacent to the stream. Consequently, shallow wells drawing water from the flood-plain deposits might be expected to be lower in dissolved solids during this period. Such a situation probably would occur were it not for the fact that, during the irrigation season, ground-water levels in the irrigated areas are at their peak and movement of the water is in the direction of the North Platte River. Thus, dilution does not take place during the irrigation season, and, shallow ground water in the flood-plain deposits tends to be lower in dissolved solids away from the river than adjacent to it. On the other hand, if, during this period, pumping from wells near the North Platte River was so great as to lower water levels sufficiently to reverse the gradient and induce movement of water from the stream, then it is possible that some lowering in dissolved solids would be observed.

TRIBUTARY FLOW TO NORTH PLATTE RIVER

The results of analyses of surface waters that were sampled prior to, at the peak of, and immediately after the irrigation season are given in table 5. The highest mineralization, 1,690 ppm (2.30 tons per acre-foot), was for water in the Cherry Creek drain (March 27, 1951), and the lowest, 300 ppm (0.41 ton per acre-foot), was for Deer Creek (March 27, 1951). The general relation of sulfate to dissolved solids for the three sampling periods is shown in figure 10. The triangle pattern is formed by plotting sulfate in equivalents per million (epm) and dissolved solids in parts per million (ppm) as two sides of the triangle; the size and shape of the triangle represents the relation of the two variables at the time of the sampling. Little change in the sulfate–dissolved solids relation is shown for the Laramie River, whereas wide fluctuations are shown for the Cherry Creek drain.

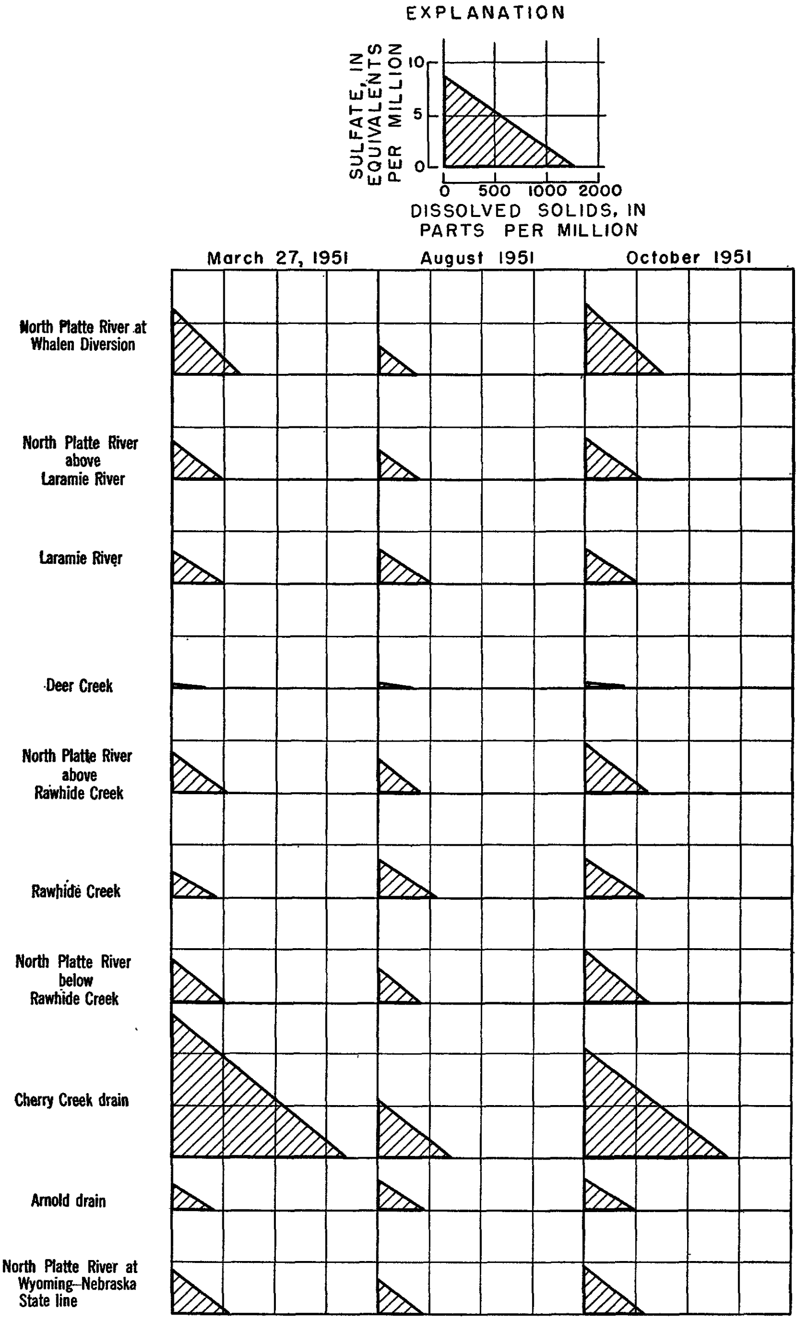

Figure 10.—Relation of sulfate to dissolved solids in spot samples of surface waters, 1951.

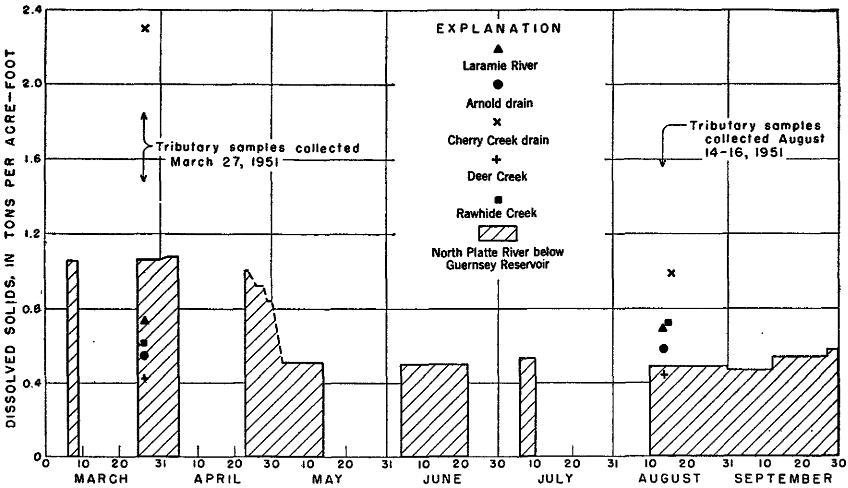

FIGURE 11.—Tonnages of dissolved solids in water during continuous periods of sampling, North Platte River below Guernsey Reservoir, and in spot samples of water from tributaries, March to September 1951.

Figure 11 shows the dissolved-solids load, in tons per acre-foot, that passed the sampling station below Guernsey Reservoir during continuous periods of sampling between March and September 1951. The effects of impounding are quite apparent in the uniformity of the load during much of the irrigation season, except during heavy runoff at the end of April and beginnnig of May. Except for the Cherry Creek drain, spot samples from tributaries that were collected on March 27 show dissolved-solids loads that are appreciably less than releases from Guernsey Reservoir, whereas resamples from the same tributaries in August generally show higher loads than composite samples for the North Platte River.

QUALITY OF GROUND WATER IN RELATION TO USE

The quality of the water from the valley fill and the Arikaree and Brule formations is generally satisfactory for most domestic needs. The mineral content of the water from unconsolidated deposits averages about 500 ppm, which is the amount that has been specified by the U. S. Public Health Service (1946) as a maximum for water used on common carriers in interstate traffic. In some places the ground water in the flood-plain deposits contains excessive amounts of iron; the water may require aeration or other suitable iron-removal treatment if it is to be satisfactory for domestic and industrial processes. Removal of the silica and other treatment may be necessary if the water is to be used in steam boilers.

Water from bedrock sources older than the Brule formation is generally potable, except that the water from the Lance formation may be slightly higher in mineral content than is desirable. However, the water from deeper sources in bedrock generally is relatively soft and, hence, is preferred for some domestic and industrial uses. The fluoride content of three of the seven samples from the Lance formation is greater than is desirable in drinking water for children. The amount of iron in solution in deeper aquifers is very small. According to the standards of Wilcox (1948), water from the unconsolidated deposits is satisfactory for irrigation. Water from deeper sources in the Brule, Chadron, and Lance formations locally is of questionable quality for irrigation because the percentage of sodium is high. (See fig. 12.) This is not a matter of significance, however, because these formations are not capable of yielding large amounts of water to wells for irrigation.

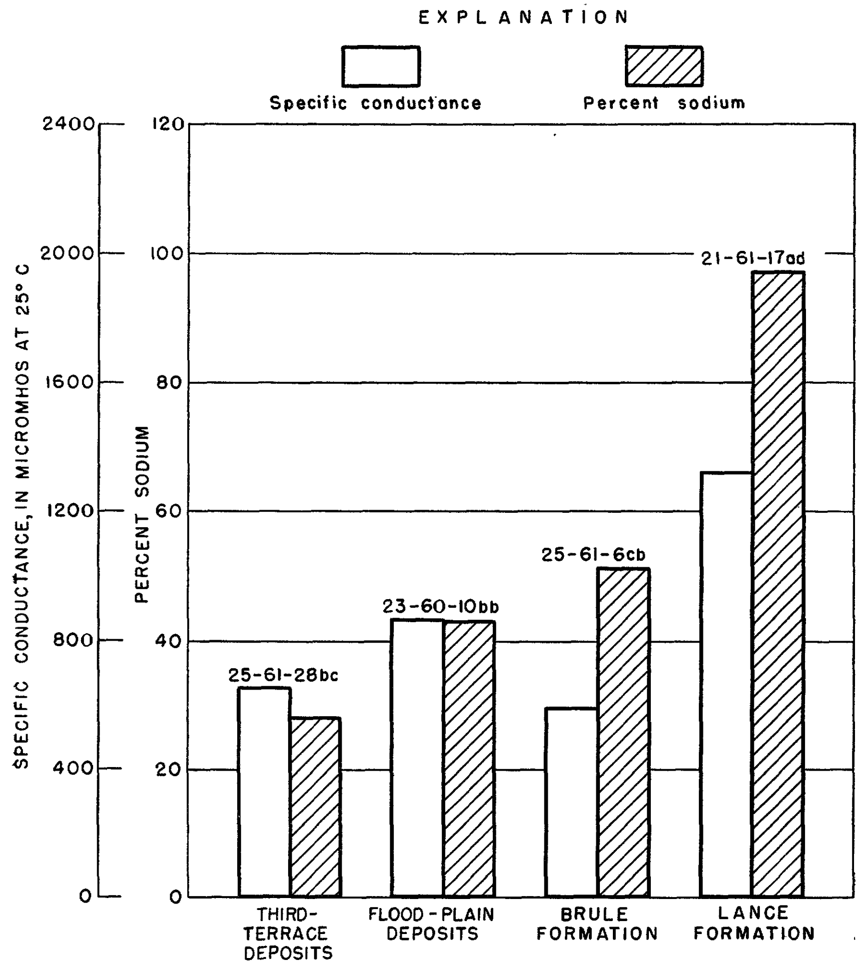

Figure 12.—Comparison of water for irrigation use (after Wilcox).

TEST-HOLE AND WELL LOGS

Logs of 104 test holes and wells in Goshen County, Wyo., including 44 test holes drilled for the U. S. Geological Survey are listed under the section "Basic Data." The locations of test holes and wells used in constructing the cross sections and the map of the bedrock topography are shown on plates 1 and 2.

The logs entitled "sample logs" are those for which the well cuttings were collected from test holes and studied by J. R. Rapp, geologist of the U. S. Geological Survey. The "drillers' logs" are written logs of wells that were obtained from drillers' records or from other sources, and their terminology is essentially unchanged; however, the geologic interpretations of the logs were made by Rapp. The test-hole and well logs are numbered according to the system used for numbering wells as previously described.

Altitudes given in feet and tenths were determined by spirit leveling; those given in even feet were interpolated using topographic maps or were determined by using an aneroid barometer.

RECORDS OF WELLS AND SPRINGS

Records of 938 wells and springs in Goshen County, which were obtained during the investigation, are listed in the section "Basic Data." The locations of these wells and springs are shown on plate 4. All information classed as reported was obtained from the well owner or driller.

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BASIC DATA

Logs of test holes and wells in Goshen County

[Sections are those given on plate 2]

	Thickness (feet)	Depth (feet)
SAMPLE LOGS		
20–61–20cc		
[Test hole 6, section F–F′. Altitude, 4,491.1 feet]		
Soil, brown	2	2
Flood-plain deposits:		
Silt and clay, tannish-gray	8	10
Silt, tannish-gray, contains siltstone fragments	8	18
Sand to medium gravel; appreciable number of pink feldspar and siltstone fragments	7	25
Brule formation:		
Siltstone, bentonitic, buff	5	30
20–61–22cc		
[Test hole 4, section F–F′. Altitude, 4,497.6 feet]		
Sand, very fine, brown	6	6
Flood-plain deposits:		
Sand to medium gravel, poorly sorted; contains abundant feldspar pebbles	4	10
Sand to fine gravel; contains abundant pink feldspar pebbles	16	26
Brule formation:		
Siltstone, sandy, buff	4	30
20–61–25bb		
[Test hole 1, section F–F′. Altitude, 4,495.2 feet]		
Sand, very fine, brown	9	9
Flood-plain deposits:		
Sand, tan, and medium gravel; consists mainly of pink feldspar pebbles	8	17
Brule formation:		
Siltstone, bentonitic, sandy, buff	3	20
20–61–26ab		
[Test hole 2, section F–F′. Altitude, 4,496.6 feet]		
Sand, very fine, subangular, brown	8	8
Flood-plain deposits:		
Sand and gravel; contains abundant pink feldspar pebbles	2	10
Sand and gravel; contains abundant pink feldspar and siltstone pebbles	8	18
Brule formation:		
Siltstone; buff at top grading into tan bentonitic siltstone	2	20
20–61–27aa		
[Test hole 3, section F–F′. Altitude, 4,501.5 feet]		
Sand, fine, brown	9	9
Flood-plain deposits:		
Sand to fine gravel; contains pink feldspar and buff siltstone pebbles	6	15
Sand to medium gravel; contains pink feldspar and buff siltstone pebbles	5	20
Sand to fine gravel; contains pink feldspar and buff siltstone pebbles	6	26
Brule formation:		
Siltstone, blocky; contains very little buff clay	4	30

SAMPLE LOGS

	Thickness (feet)	Depth (feet)
20-61-28bb [Test hole 5, section F-F'. Altitude, 4,492.1 feet]		
Sand, fine, brown	7	7
Flood-plain deposits:		
Sand, brown; and coarse gravel, mostly pink feldspar	3	10
Sand, brown; and medium gravel, mostly pink feldspar	5	15
Sand to fine gravel; contains abundant pink feldspar and buff siltstone pebbles	3	18
Brule formation:		
Siltstone, blocky, buff	12	30
23-60-3bb [Test hole 5, sectionA-A'. Altitude, 4,034.3 feet]		
Soil, dirty gray	3	3
Flood-plain deposits:		
Sand to coarse gravel	7	10
Sand to fine gravel	10	20
Sand to fine gravel; contains buff to gray clay	10	30
Sand and very fine gravel; contains buff to gray clay	10	40
Sand to fine gravel; contains buff to gray clay	20	60
Sand, very coarse; contains buff to gray clay and siltstone pebbles	20	80
Sand to very fine gravel; contains buff and orange clay and siltstone pebbles	10	90
Sand, very coarse; contains buff and orange clay and siltstone pebbles	10	100
Sand to very fine gravel; contains buff and orange clay and siltstone pebbles	20	120
Sand, coarse; contains very fine gravel	10	130
Sand to very fine gravel	20	150
Sand to coarse gravel; contains buff to green siltstone pebbles	21	171
Lance formation:		
Shale, soft, dark-gray; in places yellowish-brown to olive-drab and orange	9	180
24-60-10aa [Test hole 2, section A-A'. Altitude, 4,204.8 feet]		
Sand, very fine, brown	6	6
Third-terrace deposits:		
Sand to medium gravel; contains clay	4	10
Sand to very coarse gravel	10	20
Sand to coarse gravel	10	30
Sand to medium gravel	10	40
Sand to very fine gravel; contains beds of coarse sand	10	50
Sand to fine gravel; contains beds of coarse sand	16	66
Sand, coarse	5	71
Sand to fine gravel; contains clay lens	19	90
Sand to very fine gravel	10	100
Sand; contains very fine gravel and clay	10	110
Sand, very coarse	30	140
Sand; contains very fine gravel	10	150
Sand to very fine gravel	20	170
Sand, very coarse; contains clay lens	10	180
Sand to very fine gravel; contains siltstone pebbles	10	190
Sand to fine gravel; contains siltstone pebbles	8	198
Sand to coarse gravel; contains siltstone pebbles	14	212
Brule formation:		
Siltstone, sandy, buff	8	220
Siltstone, bentonitic, buff	10	230
24-60-34ca1 [Test hole 4, section A-A'. Altitude, 4,036.4 feet]		
Silt, sandy	4	4
Flood-plain deposits:		
Gravel, dark; contains sand	26	30
Sand and gravel; contains pink clay layers	10	40
Sand and gravel; contains white clay pebbles	10	50
Sand and gravel	20	70
Sand, and coarse gravel; contains pink clay layers	10	80
Sand, medium; contains gravel and yellow to red clay layers	10	90
Sand and gravel; contains grayish-brown clay layers	10	100
Sand, very coarse; contains gravel and yellow to gray clay layers	15	115
Chadron formation:		
Clay, sandy, red and green	5	120

SAMPLE LOGS

	Thickness (feet)	Depth (feet)
24-60-34ca2		
[Test hole 3, section A-A'. Altitude, 4,046.0 feet]		
Sand, fine, frosted, brown	6	6
Flood-plain deposits:		
Sand to medium gravel	4	10
Sand to very fine gravel	10	20
Sand to coarse gravel	10	30
Sand, coarse; contains fine tan gravel	10	40
Sand and very fine gravel	10	50
Sand to medium gravel; contains clay lenses	10	60
Sand to medium gravel; contains clay lenses and siltstone pebbles, buff at the base	4	64
Chadron formation:		
Clay, light-tan	6	70
Clay, light-tan, with yellowish-brown or green streaks	5	75
Clay, green; contains tan, light-brown, and green siltstone and clay pebbles	10	85
Clay, tan; contains tan, light-brown, and green siltstone and clay pebbles	29	114
Clay, green; contains red, green, tan, and light-brown clay pebbles. This 6-foot seqnence very likely is part of the lower unit)	6	120
24-61-2bc		
[Test hole 5, section B-B'. Altitude, 4,202.2 feet]		
Sand, very fine, brown; contains silt	9	9
Third-terrace deposits:		
Gravel, very fine, rounded, and sand	1	10
Gravel, fine, ronnded, and sand	10	20
Sand and fine to medium gravel	10	30
Sand, and very fine to fine gravel	10	40
Sand and gravel	10	50
Sand and gravel; contains boulders	10	60
Brule formation (weathered):		
Silt, light-tan	15	75
24-61-2cc		
[Test hole 7, section B-B'. Altitude, 4,205.5 feet]		
Sand, very fine, brown	9	9
Third-terrace deposits:		
Sand to coarse gravel	21	30
Sand to coarse gravel; contains boulders	67	97
Clay, light-tan	1	98
Sand to coarse gravel; contains boulders	2	100
Sand to medium gravel; contains clay layers	10	110
Sand to coarse gravel; contains boulders	20	130
Sand and medium gravel	11	141
Chadron formation(?):		
Clay, green	9	150
24-61-3ad		
[Test hole 6, section B-B'. Altitude, 4,204.4 feet]		
Silt, sandy	10	10
Third-terrace deposits:		
Sand, coarse, rounded	10	20
Sand and gravel	10	30
Sand and gravel; contains boulders	20	50
Sand and very fine to fine gravel	10	60
Sand and gravel	27	87
Brule formation (weathered):		
Silt, buff	13	100

SAMPLE LOGS

24-61-15bd
[Test hole 8, section B-B'. Altitude, 4,081.4 feet]

	Thickness (feet)	Depth (feet)
Soil, sandy	2	2
Flood-plain deposits:		
Sand and gravel; contains cobbles	8	10
Sand, very coarse	5	15
Sand; contains very fine gravel	5	20
Sand to fine gravel; contains bone fragments	5	25
Sand to very fine gravel; contains clay and bone fragments	6	31
Sand to fine gravel; contains clay, buff siltstone pebbles (some contain green spots), and wood fragments	9	40
Gravel, fine to medium; contains buff and green siltstone pebbles	10	50
Sand to very fine gravel; contains buff to green clay	10	60
Sand and gravel; contains boulders and clay	5	65
Sand to fine gravel	5	70
Gravel, very fine; contains buff to green clay	10	80
Sand and fine gravel; contains buff to green clay and siltstone and brick-red sandstone pebbles	10	90
Sand and fine gravel; contains buff to green clay and siltstone pebbles	20	110
Sand to medium gravel; contains buff to green clay and siltstone pebbles	15	125
Sand and very fine gravel; contains buff to green clay and siltstone pebbles	5	130
Sand to fine gravel; contains buff to green clay and siltstone pebbles	10	140
Sand to medium gravel; contains buff to green clay and siltstone pebbles	10	150
Sand and very fine gravel	10	160
Sand and very coarse gravel; contains boulders; many black rocks (limestone and basic)	25	185
Sand to medium gravel	5	190
Sand and very coarse gravel; contains boulders	7	197
Lance formation:		
Shale, dark-gray	8	205

24-61-21ad
[Test hole 9, section B-B'. Altitude, 4,083.8 feet]

	Thickness (feet)	Depth (feet)
Sand, very fine, brownish	6	6
Flood-plain deposits:		
Sand to fine gravel	4	10
Sand to very fine gravel	11	21
Sand and very fine gravel; contains buff to tan siltstone pebbles	.5	21.5
Sand and fine gravel; contains buff to tan siltstone pebbles	38.5	60
Sand and fine gravel; contains buff siltstone pebbles	10	70
Sand; contains buff to green pebbles of siltstone, clay, and soft sandstone, and very fine crystalline gravel	6	76
Chadron formation:		
Sandstone, soft, coarse; cemented with clay	14	90
Sandstone, soft, mostly coarse; contains buff and green siltstone and clay pebbles	5	95
Sandstone, soft, very coarse; contains very fine gravel; yellowish-brown surfaces. This sandstone marks the top of the lower unit	5	100
Sandstone, soft, very coarse; contains very fine gravel; yellowish-brown and green surfaces due to green clay pebbles	5	105
Sandstone, soft, very coarse; contains very fine mostly greenish-gray but some yellowish-brown gravel; drilling fluid was first colored by purple clay and silt	2	107
Sandstone, soft, very coarse, purple, green and brown	8	115
Sandstone, soft, mostly medium to coarse, purple, green and brown	10	125
Clay; contains a little sand and gravel; purple, green, yellowish brown, and pink	7	132
Lance formation:		
Shale, sandy, dark-gray; contains fragments of yellow shale and sandstone, and fragments of black carbonaceous material	3	135

SAMPLE LOGS

	Thickness (feet)	Depth (feet)
24-62-1bb [Test hole 9, section C-C′. Altitude, 4,115.0 feet]		
Soil	6	6
Flood-plain deposits:		
Sand to fine gravel	4	10
Sand to coarse gravel	10	20
Sand to medium gravel	10	30
Sand to coarse gravel; contains siltstone pebbles	10	40
Sand; contains fine to coarse gravel	10	50
Sand and gravel; contains boulders	10	60
Sand; contains very fine gravel	10	70
Sand and fine gravel; contains siltstone pebbles	10	80
Sand and gravel; contains brown clay lenses	40	120
Sand and fine gravel; contains green clay lenses	10	130
Sand and medium gravel; contains green sandstone pebbles	10	140
Sand and very fine gravel	10	150
Sand and fine gravel	10	160
Sand and gravel	8	168
Sand and gravel; contains boulders (abundance of black rock fragments and glass fragments)	7	175
Lance formation:		
Shale, soft; very dark-gray with few yellow spots	10	185
24-62-1cc [Test hole 10, section C-C′. Altitude, 4,117.9 feet]		
Soil, sandy, brown	4	4
Flood-plain deposits:		
Sand to very coarse gravel	36	40
Sand to coarse gravel	10	50
Sand and gravel; contains boulders	20	70
Sand and gravel; contains light-gray clay	10	80
Sand to coarse gravel	10	90
Sand and fine gravel; contains flesh-colored clay	10	100
Sand and gravel; contains boulder bed from 106-109 feet	10	110
Sand and gravel; contains boulder bed from 114-118 feet, and tan clay	10	120
Sand and gravel; contains much clay	10	130
Sand and gravel; contains boulder bed 133-137 feet	12	142
Sand to coarse gravel	4	146
Chadron formation (This sequence is part of the lower unit.):		
Clay, green, brown, and red; and dark-red to purplish-red sandstone	4	150
Sandstone, dark-red to purplish-red to 55 feet, and pink, yellowish-brown, and green clay	10	160
Lance formation:		
Clay, pink, yellowish-brown, and green	6	166
Sandstone, fine (no sample)	10	176
Clay, silty; green with yellowish-brown spots	4	180
Clay, sandy; green with yellowish-green spots	10	190
Clay, sandy; olive-drab with yellowish-brown, blue, and gray spots	5	195
Clay; olive-drab with yellowish-brown and gray spots; contains ferruginous sandstone that is dark brown with specks of yellowish brown and red to black	9.5	204.5
Rock, no sample but probably ferruginous sandstone, very hard	.5	205
24-62-23dd [Data from Visher and Babcock (1952, p. 101). Test hole 12, section C-C′. Altitude, 4,233 feet]		
Slope wash:		
Silt and sand	26	26
Brule formation:		
Siltstone; struck a 1-foot cavity at 34 feet and lost circulation	18	44
Chadron formation		
Clay	6	50
24-62-24cb [Data from Visher and Babcock (1952, p. 101). Test hole 11, section C-C′. Altitude, 4,270 feet]		
Slope wash:		
Silt and sand	54	54
Brule formation:		
Siltstone, broken and creviced; lost circulation at 55 feet	7	61

SAMPLE LOGS

24-62-26da

[Test hole 13, section C-C′. Altitude, 4,156.9 feet]

	Thickness (feet)	Depth (feet)
Soil	4	4
Slope wash:		
Silt, loose, tan	6	10
Silt, loose, buff	10	20
Silt, dirty tan, mottled appearance	10	30
Sand, coarse; contains buff clay	10	40
Chadron formation (Entirely represented by the lower unit):		
Sand to coarse gravel; contains soft brick-red sandstone pebbles, and buff, pink, and green clay	10	50
Clay, light-red, tan, and green	10	60
Clay, tan; brown to green with light-red and green spots	10	70
Clay, tan; mottled with brown, green, and light gray	10	80
Clay; red with green and light-gray spots	10	90
Sandstone, fine to very fine, soft, argillaceous; brick-red with light bluish-green (turquoise) spots	15	105
Clay, sandy; brick-red with light bluish-green spots	5	110
Sandstone, fine to very fine, soft, argillaceous, calcareous; brick-red with more bluish-green spots than above and some purple	5	115
Sandstone, coarse to very coarse, red to green; contains clay layers	5	120
Sandstone and conglomerate, fine probably interbedded, green to red; contains clay	10	130
Clay and gravel; some red, green, and yellow sand	5	135
Lance formation:		
Clay; mostly yellow with some green and pink	5	140
Clay; mostly yellow with some green, pink, and blue; contains ironstone fragments	10	150

25-60-34da

[Test hole 1, section A-A′. Altitude, 4,232.9 feet]

	Thickness (feet)	Depth (feet)
Silt, sandy, brown	7	7
Upland deposits:		
Sand to coarse gravel; contains tan to gray clay, siltstone and sandstone pebbles	23	30
Sand and fine gravel	10	40
Sand and very fine gravel	10	50
Siltstone, angular, sandy in part, buff to green (large chunks)	10	60
Siltstone, angular, sandy, gray to buff	20	80
Siltstone, blocky, soft, pink	8	88
Sand to very fine gravel; contains much clay and many siltstone pebbles	2	90
Sand to medium gravel; contains much clay and many siltstone pebbles	10	100
Sand; contains very fine gravel and siltstone pebbles	20	120
Sand to fine gravel, silty; contains buff siltstone pebbles	20	140
Sand to fine gravel, argillaceous, green; contains buff siltstone pebbles	10	150
Brule formation (weathered):		
Silt, argillaceous, buff	40	190

25-61-7dc

[Test hole 4, section C-C′. Altitude, 4,319.7 feet]

	Thickness (feet)	Depth (feet)
Sand, very fine, brown	8	8
Upland deposits:		
Sand and very fine to medium gravel	2	10
Sand; contains very fine light-brown gravel	10	20
Sand, fine; contains very fine gravel	14	34
Gravel, very fine	11	45
Sand, and gravel; contains buff siltstone pebbles	23	68
Silt, sandy, light-tan	12	80
Silt, sandy, pink	5	85
Silt, sandy, light-tan	10	95
Brule formation:		
Siltstone, tan with greenish hue; contains considerable clay	5	100
Siltstone, buff; contains very little clay	5	105

SAMPLE LOGS

	Thickness (feet)	Depth (feet)
25-61-12ac		
[Test hole 1, section B-B′. Altitude, 4,522.0 feet]		
Sand, very fine, subangular, brown	8	8
Upland deposits:		
Sand to medium gravel	6	14
Brule formation (weathered):		
Silt, buff	61	75
25-61-13bc		
[Test hole 2, section B-B′. Altitude, 4,474.7 feet]		
Sand, very fine	7	7
Upland deposits:		
Sand and very fine gravel	8	15
Clay, silty, light-gray	1	16
Sand to coarse gravel	14	30
Sand to fine gravel; contains light-gray clay lenses	20	50
Sand, light-tan; contains gravel and light-brown clay lens from 54-57 feet	10	60
Sand to fine gravel	9	69
Clay lens, sandy, light-gray	3	72
Sand to medium gravel	18	90
Sand and very fine gravel, clayey	20	110
Sand and fine gravel	10	120
Sand and gravel; contains boulders	10	130
Sand and fine gravel	20	150
Sand and very fine gravel	10	160
Sand and fine gravel	10	170
Sand; contains fine gravel	10	180
Sand and very fine gravel	18	198
Lime, white; contains black streaks	.5	198.5
Sand and fine gravel	10.5	209
Brule formation:		
Siltstone, sandy at top, buff	11	220
25-61-18cc		
[Test hole 5, section C-C′. Altitude, 4,253.6 feet]		
Sand, very fine, brown	8	8
Third-terrace deposits:		
Sand and gravel	2	10
Sand and gravel; contains boulders	37	47
Sand and gravel	3	50
Sand and very fine to fine gravel	10	60
Sand and fine to medium gravel	24	84
Brule formation (weathered):		
Siltstone, buff	16	100
25-61-23cd		
[Test hole 3, section B-B′. Altitude, 4,305.7 feet]		
Silt, and very fine sand	8	8
Upland deposits:		
Sand to medium gravel	12	20
Sand to fine gravel; contains clay	10	30
Sand to medium gravel; contains siltstone pebbles	20	50
Sand to fine gravel; contains siltstone pebbles	10	60
Silt, sandy, buff	15	75
Brule formation:		
Siltstone, buff; brown surfaces on fragments indicating fractured material	10	85

SAMPLE LOGS

	Thickness (feet)	Depth (feet)
25-61-28dc1 [Drilled for observation well. Altitude, 4,211.6 feet]		
Sand, very fine, brown	8	8
Third-terrace deposits:		
Sand to fine gravel, and light-gray clay	7	15
Sand and fine gravel	5	20
Sand to coarse gravel, poorly sorted	10	30
Sand and very fine gravel	10	40
Sand to coarse gravel	5	45
Sand and very fine gravel	15	60
Sand and fine gravel	10	70
Sand, very coarse	10	80
Sand and medium gravel; contains clay lens	10	90
Sand and fine gravel; contains clay lens	20	110
Sand, very coarse; contains very fine gravel and clay lens	10	120
Sand and gravel; contains boulders	10	130
Sand to fine gravel; contains clay	10	140
Gravel, very coarse, poorly sorted; contains siltstone pebbles	10	150
Sand and gravel; contains boulders and siltstone pebbles	10	160
Gravel, fine to medium; contains sand and siltstone pebbles	2	162
Brule formation:		
Siltstone, buff	8	170
25-61-28dc2 [Drilled for observation well. Altitude, 4,212.6 feet]		
Sand, very fine, brown	7	7
Third-terrace deposits:		
Sand and coarse gravel	3	10
Sand and very fine to fine gravel	10	20
Sand and fine to medium gravel	7	27
Clay layer, light-tan	1	28
Sand and fine to medium gravel	2	30
Sand and gravel; contains boulders and clay layer	10	40
Sand and fine to medium gravel	18	58
25-61-28dc3 [Drilled for observation well. Altitude, 4,211.6 feet]		
Sand, very fine, brown	7	7
Third-terrace deposits:		
Sand and gravel	3	10
Gravel, very fine, and sand	10	20
Gravel, very fine and fine, and sand; contains 1-foot clay lens, gray at 27 feet	16	36
Sand and very fine gravel	2	38
Sand and gravel; contains 0.5-foot clay lens at 39 feet	2	40
Sand and gravel	8	48
Sand and gravel; contains boulders	2	50
Sand and gravel	8	58
25-61-33ca [Altitude, 4,205.7 feet]		
Loam, sandy, brown	6	6
Third-terrace deposits:		
Sand and gravel	4	10
Gravel, fine to very fine; contains sand	10	20
Gravel, fine to very fine, and sand	30	50
Gravel and sand; contains layers of tan clay	10	60
Gravel and sand; contains boulders	10	70
Gravel and sand; contains boulders and buff clay pebbles	5	75
Brule formation:		
Siltstone, buff	35	110
Chadron formation(?):		
Clay, green	5	115

SAMPLE LOGS

	Thickness (feet)	Depth (feet)
25-61-33cd [Altitude, 4,209.0 feet]		
Sand, very fine, brown	8	8
Third-terrace deposits:		
Sand and gravel	32	40
Gravel, very fine, well-rounded, well-sorted; contains sand	10	50
Gravel, poorly sorted, subangular to angular; contains sand	10	60
Gravel, very fine to fine, well-sorted, rounded; contains sand	10	70
Sand and gravel, poorly-sorted	10	80
Brule formation:		
Siltstone, clean	10	90
25-61-34aa [Test hole 4, section B-B′. Altitude, 4,234.5 feet]		
Sand, very fine; contains silt	13	13
Third-terrace deposits:		
Gravel, fine, and sand	7	20
Sand; contains gravel	10	30
Gravel, fine, and sand	20	50
Gravel, fine; contains light-tan clay layers	10	60
Gravel, fine to medium, and sand; contains light-tan clay layers	10	70
Gravel, fine to medium; contains tan sandstone pebbles	10	80
Gravel, fine to medium; contains clay layer	10	90
Gravel, fine to medium	10	100
Sand; contains gravel	10	110
Sand; contains gravel; abundant yellow grains	10	120
Sand and gravel; contains clay layers	30	150
Sand and gravel	20	170
Sand and gravel; contains boulders	15	185
Chadron formation(?):		
Claystone, buff; contains green zones	10	195
25-62-25bb [Test hole 6, section C-C′. Altitude, 4,226.3 feet]		
Sand, very fine, brown	7	7
Third-terrace deposits:		
Sand and gravel	23	30
Sand and gravel; contains boulders	37	67
Clay streak, light-tan	1	68
Sand and gravel; contains boulders	2	70
Sand, coarse to very coarse	10	80
Gravel, very fine, and sand	4	84
Sand, and gravel, very fine	6	90
Sand, coarse; contains a little very fine brown gravel	5	95
Sand to medium gravel; contains thin clay layers	14	109
Sand, brownish, and gravel, very coarse	5	114
Sand and gravel	6	120
Sand and gravel; contains clay lenses	19	139
Brule formation:		
Silt, light-tan	11	150
Silt, light-tan; some green spots (very few)	5	155
Silt, light-tan	10	165
Siltstone, light-tan; contains barite crystals. (All the overlying material listed as Brule formation is weathered.)	5	170
Siltstone, light-tan; contains barite crystals and green spots	4	174
Siltstone, buff	1	175
Clay, brownish-gray containing green	5	180
25-62-26da [Test hole 7, section C-C′. Altitude, 4,203.5 feet]		
Silt, sandy, brown	6	6
Third-terrace deposits:		
Sand and very coarse gravel	4	10
Sand and fine gravel	10	20
Sand and gravel; contains boulders	10	30
Sand to medium gravel	10	40
Sand to fine gravel	10	50
Sand and gravel; contains clay and boulders	10	60
Sand to medium gravel; contains clay	10	70
Sand and gravel; contains clay and boulders	25	95
Brule formation (weathered):		
Silt, sandy, buff	10	105

SAMPLE LOGS

	Thickness (feet)	Depth (feet)
25-62-35da [Test hole 8, section C-C'. Altitude, 4,118.4 feet]		
Silt, sandy, brown	6	6
Flood-plain deposits:		
Sand to fine gravel	4	10
Sand to coarse gravel	50	60
Sand and fine gravel; contains buff to gray siltstone pebbles	20	80
Sand and fine gravel; contains clay	10	90
Sand, very coarse; contains medium gravel, clay and siltstone pebbles	10	100
Sand and very coarse gravel; contains clay and siltstone pebbles	10	110
Sand to medium gravel; contains clay and siltstone pebbles	10	120
Sand to fine gravel; contains clay and siltstone pebbles	20	140
Sand to very coarse gravel; contains clay and siltstone pebbles	28	168
Chadron formation (Entirely represented by the lower unit):		
Sandstone (no sample obtained), and silt and sandy clay; buff with yellowish-brown and pink spots; contains sand, and gravel, very fine	5	173
Shale, soft; sandy in part; contains pink, reddish-purple, dark-red and brick-red clay lumps	2	175
25-63-3bb [Test hole 1, section D-D'. Altitude, 4.244.1 feet]		
Sand, very fine, subangular, frosted, brown	3	3
Flood-plain deposits:		
Clay, sandy, very light-tan	21	24
Sand, very coarse, and very fine gravel; contains siltstone pebbles	14	38
Sand to coarse gravel; contains siltstone pebbles and clay lenses at 45 feet and 49 feet	18	56
Sand and gravel; contains boulders	9	65
Sand, coarse, and very fine gravel	3	68
Sand and gravel; contains boulders	3	71
Sand and gravel	19	90
Sand and very fine to fine gravel	30	120
Sand and very fine to fine gravel; contains thin light-tan clay lenses	15	135
Sand; contains very fine gravel	5	140
Gravel, very fine to fine, and sand	16	156
Sand, very fine to very coarse; contains thin clay lenses	9	165
Sand to fine gravel; contains thin clay lenses	5	170
Sand to medium gravel; contains thin clay lenses	10	180
Sand to fine gravel; contains thin clay lenses	10	190
Sand and gravel	4	194
Sand and gravel; contains boulders and clay layers	6	200
Sand and medium gravel	6	206
Silt, mixed with sand and gravel	4	210
Brule formation:		
Siltstone, buff	15	225
25-63-4ad [Test hole 2, section D-D'. Altitude, 4,192.3 feet]		
Soil	4	4
Flood-plain deposits:		
Sand, very fine; contains clay; brown	5	9
Gravel, poorly-sorted	11	20
Sand and very fine gravel	10	30
Sand and fine gravel	10	40
Sand and very fine gravel; streak of charcoal at 46 feet	10	50
Sand and very fine gravel	20	70
Sand and very fine gravel; contains charcoal	10	80
Sand, brown; contains charcoal	10	90
Sand and fine gravel; clay lens at 99 feet	10	100
Sand and very fine gravel	20	120
Sand and gravel; contains brown boulders and clay	10	130
Sand and gravel; contains boulders	10	140
Sand and fine gravel; contains clay	20	160
Sand, very coarse; contains clay	10	170
Sand very fine gravel; contains clay and boulders (173-176)	6	176
Clay; contains sand and gravel; buff	4	180
Brule formation:		
Siltstone, bentonitic, buff containing green and white spots; contains clay	10	190

SAMPLE LOGS

	Thickness (feet)	Depth (feet)
25-63-9bb [Test hole 3, section D-D'. Altitude, 4,182.6 feet]		
Soil	4	4
Flood-plain deposits:		
Sand to medium gravel	6	10
Sand to fine gravel; contains siltstone pebbles	10	20
Sand to fine gravel	10	30
Sand to fine gravel; contains thin clay lenses	20	50
Sand, many black grains, and very fine gravel	10	60
Sand and very fine gravel; contains clay streaks	20	80
Sand and fine gravel; contains clay streaks	10	90
Sand very fine gravel; contains clay streaks	10	100
Sand and fine gravel; contains clay streaks	10	110
Sand to medium gravel; contains clay lenses and boulders	10	120
Sand and fine gravel; contains clay lenses	10	130
Sand and gravel; contains clay lenses and boulders	5	135
Sand and very fine gravel; contains clay lenses	7	142
Sand and fine gravel; contains siltstone and sandstone pebbles	8	150
Sand and very fine gravel; contains siltstone pebbles	10	160
Sand and gravel; contains siltstone pebbles, and boulders	5	165
Sand to fine gravel; contains siltstone pebbles	6	171
Chadron formation:		
Clay, light-gray	4	175
25-63-17dc [Test hole 4, section D-D'. Altitude, 4,245.4 feet]		
Sand, very fine; contains silt and fine sand; brown	8	8
Food-plain deposits:		
Sand, and gravel; contains a predominance of siltstone pebbles	3	11
Gravel; consists of siltstone and crystalline pebbles	9	20
Silt; contains clay, sand, and gravel; buff	10	30
Gravel, very fine, and silt, buff	9	39
Sand, medium-grained, brown	2	41
Brule formation:		
Siltstone, lower part sandy, buff	9	50
Siltstone, buff	10	60
Siltstone, buff; contains fine gravel (crystalline pebbles)	5	65
Clay; contains silt; green and tan	5	70
26-61-16dd [Test hole 1, section C-C'. Altitude, 4,399.6 feet]		
Soil	2	2
Upland deposits:		
Gravel; consists of crystalline siltstone and sandstone pebbles	14	16
Brule formation:		
Siltstone, buff	4	20
Siltstone, buff; contains a few green spots	10	30
Siltstone, buff	5	35
Siltstone, buff; contains a few green spots and clay	10	45
26-61-28bd [Test hole 2, section C-C'. Altitude, 4,393.0 feet]		
Sand, fine, subangular, frosted, brown	9	9
Upland deposits:		
Clay, sandy; contains a few lenses of very fine gravel	19	28
Sand, and very fine gravel; in places cemented by calcium carbonate	22	50
Sand and very coarse gravel	42	92
Silt, buff; contains some sand and gravel	13	105
Brule formation:		
Siltstone, buff; contains clay	15	120
26-61-32ad [Test hole 3, section C-C'. Altitude, 4,397.4 feet]		
Sand, subangular, frosted, brown; and light-tan silt	15	15
Brule formation:		
Siltstone, buff; contains green areas in which small barite and calcite crystals seem concentrated (minute crystals are disseminated throughout the material as are biotite and muscovite flakes)	10	25
Siltstone, buff has green spots; fragments contain brown to black faces indicating fracture surfaces	5	30
Siltstone, buff	40	70

SAMPLE LOGS

	Thickness (feet)	Depth (feet)
26-64-23bc		
[Altitude, 4,242.1 feet]		
Silt, sandy, brown	7	7
Flood-plain deposits:		
Sand and gravel; contains clay	3	10
Sand to fine gravel	10	20
Sand and gravel; contains boulders	10	30
Sand to medium gravel	10	40
Sand to very fine gravel	10	50
Sand and gravel; contains boulders	20	70
Sand and very fine gravel	50	120
Sand and gravel; contains boulders	10	130
Sand and very fine gravel	20	150
Sand and fine gravel; contains siltstone and sandstone fragments	10	160
Sand and gravel; contains siltstone and sandstone fragments and boulders	10	170
Boulder (could not penetrate)	0	170
26-64-27da		
[Altitude, 4,226.9 feet]		
Silt, sandy, brown	7	7
Flood-plain deposits:		
Sand to fine gravel	5	12
Arikaree formation:		
Sand, very fine, tannish-gray; contains silt	8	20
Sandstone, very fine, soft, tannish-gray; contains silt	20	40

DRILLERS' LOGS

	Thickness (feet)	Depth (feet)
19-61-4cd3		
Soil	6	6
Flood-plain deposits:		
Sand and gravel; contains 8-inch boulders	6	12
Sand, coarse, and gravel	18	30
Brule formation:		
Clay, buff	25	55
20-61-22dc		
[Altitude, 4,502.9 feet]		
Soil, and clay, sandy	12	12
Flood-plain deposits:		
Sand and gravel	33	45
Brule formation:		
Siltstone, buff (hole was refilled to 43.3 feet)	9	54
20-61-33dc		
Sand and clay	6	6
Flood-plain deposits:		
Gravel	2	8
Boulders	9	17
Sand and gravel	13	30
Sand, fine	11	41
Brule formation:		
Siltstone, broken	3	44
Siltstone	4	48
20-65-26ba		
[Altitude, 5,381.3 feet]		
Soil	10	10
Arikaree formation:		
Sandstone	10	20
Limy rock, layers	10	30
Sandstone	40	70
Limy rock, layers	10	80
Sandstone	35	115

DRILLERS' LOGS

	Thickness (feet)	Depth (feet)
21-60-6ac		
Chadron formation:		
Shale, red and blue	80	80
Rock	10	90
Sand, "salt and pepper"	14	104
21-62-32db		
Soil	10	10
Lance formation:		
Clay, black	40	50
Sand	10	60
21-64-3dc		
Silt, loose, clayey	40	40
Lance formation:		
Clay, variegated; contains layers of sandstone	128	168
Shale, black and blue; contains coal and layers of sand	82	250
22-60-6ab		
Soil	20	20
Lance formation:		
Clay, yellow	40	60
Clay, red	20	80
Clay, black	40	120
Sandstone, white	40	160
22-60-10bc		
Soil, sandy	40	40
Lance formation:		
Clay, red	50	90
Sand, white	30	120
Sandstone	1	121
Sand, white	19	140
Gumbo, black	20	160
22-60-21bb		
Soil and fine sand	40	40
Lance formation:		
Clay, yellow	60	100
Clay, white	40	140
Clay, black	95	235
Sandstone; contains water	40	275
22-64-6cd		
Topsoil	30	30
Brule formation:		
Clay, brown	10	40
Chadron formation:		
Shale	30	70
Clay	40	110
Sandstone, hard	3	113
Sandstone, soft, brown	17	130
Lance formation:		
Clay, yellow	10	140
Clay, brown	10	150
Clay, pink	10	160
Clay, gray	10	170
Rock	10	180
Clay, yellow	10	190
Clay, pink, and sand (water)	13	203

DRILLERS' LOGS

	Thickness (feet)	Depth (feet)
23-60-20bc		
Chadron formation:		
Soil and clay, light-color	30	30
Sandstone, red (The red sandstone probably represents deposits belonging to the lower unit of the Chadron formation)	30	60
23-60-30cd		
Soil	2	2
Chadron formation (The lower part of this clay probably belongs to the Lance formation):		
Clay, red, yellow, and blue (water)	36	38
Lance formation:		
Sandstone, yellow (reached water at 120 feet that rose to 80 feet)	100	138
23-61-11dc		
Chadron formation(?) (As this log is very general, it is difficult to differentiate the formations. The lower 6 feet of sand supplies water to the well, and very likely is part of the Lance formation):		
Clay, blue and red	58	58
Clay, hard, blue and red	12	70
Clay, blue and red	20	90
Sandstone	2	92
Clay, red	30	122
Sandstone	2	124
Lance formation:		
Sand, blue	6	130
23-61-24dc		
Soil	12	12
Lance formation:		
Clay, yellow; contains dark-yellow fragments	78	90
Shale, black; contains white sand layers	106	196
23-61-30dc		
Soil	10	10
Chadron formation:		
Clay	58	68
Lance formation:		
Rock, hard	2	70
Clay, yellow	15	85
Sand, yellow; contains water	5	90
Clay	20	110
Sand and clay, yellow	15	125
23-61-36bb		
Chadron and Lance formations:		
Clay, blue, green, red, and white (The upper part of this clay probably is part of the Chadron formation)	110	110
Shale, black; contains 18-inch bed of coal	5	115
Shale, black; contains thin streaks of sand	90	205
Sandstone, poorly cemented, white	70	275

DRILLERS' LOGS

	Thickness (feet)	Depth (feet)
23-62-34db		
Soil	15	15
Chadron formation (This material is part of the lower unit of the Chadron formation):		
Sand and gravel; dark on top, red on bottom	15	30
Lance formation:		
Shale, muddy, gray	20	50
Sand, rusty colored	35	85
Shale, gray	5	90
Clay, very muddy, yellow	10	100
Shale, blue	40	140
Sand	5	145
Shale, blue	15	160
Shale, brown	15	175
Sand, soft, gray	10	185
Shale, blue	10	195
Sand, soft, gray	25	220
Shale, brown	50	270
Limy shells	30	300
Shale, gray	30	330
Sand, soft, gray	10	340
Shale, blue	10	350
Sand, coarse, white	5	355
Shale, brown	15	370
Shale, blue	35	405
Shale, sandy, gray	15	420
Shale, blue	40	460
Sand, gray	10	470
Shale, blue	10	480
Sand, gray	10	490
Shale, blue	10	500
Shale, muddy, white	5	505
Shale, blue	10	515
Shale, brown	15	530
Sand, gray (water rising to within 10 feet of surface)	5	535
Shale, brown	5	540
Shale, gray	15	555
Shale, muddy, dark	10	565
Shale, brown	15	580
Shale, muddy, dark	20	600
24-60-4ad [Altitude, 4,225.2 feet]		
Third-terrace deposits:		
Sand and gravel	130	130
Brule formation:		
Bedrock	15	145
24-60-22ad [Altitude, 4,199.8 feet]		
Third-terrace deposits:		
Sand and gravel	100	100
Brule formation:		
Siltstone	6	106
24-61-3ac		
Soil	5	5
Third-terrace deposits:		
Sand and gravel. (Terrace deposits not completely penetrated.)	135	140
24-61-10bd		
Soil, sandy	4	4
Flood-plain deposits:		
Sand	15	19
Sand, fine	6	25
Sand, coarse, and gravel	6	31
Sand, fine	1	32
Sandstone	.5	32.5
Sand, coarse, and gravel	27.5	60

DRILLERS' LOGS

	Thickness (feet)	Depth (feet)
24-61-10db [Altitude, 4,097.9 feet]		
Flood-plain deposits:		
Sand and gravel	77	77
Gravel, fine to coarse; composed predominantly of quartz and pink orthoclase, with some basalt and sand	8	85
Gravel, fine to coarse; and buff, pink, and green, bentonitic, waxy clay	5	90
Clay, bentonitic, waxy, buff, pink, and green; and fine to coarse gravel	5	95
Clay, brown and gray, and gravel	5	100
Gravel, fine to coarse	15	115
Gravel, medium, clean	15	130
Gravel and sand; contains silt and gray, greenish-yellow, and pink clay	20	150
Sand and gravel	5	155
Sand; contains gravel, clay, and silt	5	160
Lance formation:		
Clay and silt, yellow to gray; contains a few fragments of gravel	5	165
Clay, gray; yellow limonite stain and carbonaceous shale; contains brown soft lignitic coal	5	170
Shale, gray, yellow; contains bentonite and coal	5	175
Shale, carbonaceous, gray to dark-gray; contains dense soft black coal, and gray and white bentonite	5	180
Coal, brittle, dense, black, and dark-gray shale, contains some bentonite	5	185
Shale, gray, interbedded with fine-grained sandstone; contains bentonite and coal	5	190
Sandstone, fine to medium-grained, poorly cemented, gray to white; consists mainly of angular grains of quartz	10	200
Sandstone, fine- to medium-grained, poorly cemented, bentonitic, gray	5	205
Sandstone, fine-grained to very fine grained, poorly cemented, gray to dull tan; composed mainly of angular grains of quartz	15	220
Shale, micaceous, laminated, gray to light-gray, and very fine silt	10	230
Sandstone, very fine-grained, compacted, gray and dull tan; consists of angular grains of quartz	15	245
Siltstone, gray, interbedded with gray shale and white bentonite	10	255
Shale, micaceous, silty, laminated, gray, interbedded with beds of white bentonite	10	265
Shale, micaceous (muscovite), dark-gray; contains some white bentonite	5	270
Shale, dark-gray, interbedded with gray siltstone; contains abundant oyster-shell fragments	10	280
Sandstone, fine-grained, poorly to well cemented, calcareous, soft to hard, gray; composed of angular grains of quartz	5	285
Shale, sandy, soft, gray; contains oyster shells	15	300
Sandstone, fine-grained, calcareous to weakly calcareous, poorly to well cemented, gray to light-gray	40	340
Sandstone, clayey, soft, calcareous, gray	15	355
Sandstone, very fine grained; approaches a siltstone; somewhat clayey; gray; composed mainly of angular grains of quartz, poorly cemented	15	370
Siltstone, soft, poorly cemented, gray; composed of angular grains of quartz, somewhat clayey	10	380
Shale, silty, weakly calcareous, gray	20	400
Shale, gray, interbedded with gray siltstone	10	410
Sandstone, soft, poorly cemented but tightly compacted, light-gray	10	420
Siltstone, gray, interbedded with thin, fine-grained, gray sandstone	5	425
Sandstone, fine-grained, poorly cemented, light-gray; composed of angular grains of quartz, sparsely interbedded with gray siltstone	45	470
24-61-15cc1		
Soil	5	5
Flood-plain deposits:		
Sand, coarse	50	55
Gravel; contains small pebbles	5	60
Sand, coarse	25	85
24-61-15cc5 [Altitude, 4,086.1 feet]		
Soil	4	4
Flood-plain deposits:		
Sand and gravel	196	200
Lance formation:		
Clay, sandy, and sandstone	30	230
Shale	67	297
Shale and sandstone (artesian water)	63	360
Sandstone	75	435

DRILLERS' LOGS

	Thickness (feet)	Depth (feet)
24-61-28cb		
Soil	30	30
Brule formation:		
Clay	10	40
Sandstone, blue	30	70
Shale, blue	20	90
(No record)	10	100
Clay	75	175
Lance formation(?):		
Shale, red	25	200
Shale, sandy	10	210
Sand (contains water)	10	220
Shale and clay	40	260
Shale, blue	15	275
24-63-7dc		
Brule formation:		
Clay and hard shale	145	145
Clay, red	5	150
Chadron formation:		
Clay, "sticky," blue	5	155
Clay, tan	15	170
Clay, soft, pink	10	180
Rock, hard; contains gravel	2	182
Lance formation:		
Clay, soft, yellow	18	200
Clay, sandy	15	215
Clay, soft	2	217
Sand, yellow	8	225
Clay, yellow	5	230
Clay, pink and yellow	10	240
Clay, hard, yellow	5	245
Shale	5	250
Rock, hard	3	253
Shale, soft	17	270
Rock	1	271
Sand	4	275
Clay, red and yellow	9	284
Shale, hard	3	287
Shale, blue	3	290
24-63-17dd		
Brule formation:		
Soil	10	10
Clay	10	20
Sandstone, gray	10	30
Sandstone, brown	10	40
Clay	60	100
Chadron formation(?):		
Clay, blue	10	110
Clay, brown	40	150
Sandstone, red	10	160
Lance formation(?):		
Shale	30	190
Rock	10	200
Clay and shale	90	290
Shale, sandy, blue	25	315
25-60-19bb [Altitude, 4,413 feet]		
Upland deposits:		
Sand	20	20
Gravel	60	80
Brule formation:		
Siltstone	340	420
Chadron formation:		
Clay, blue and white	5	425

DRILLERS' LOGS

	Thickness (feet)	Depth (feet)
25-61-19bc [Altitude, 4,228 feet]		
Soil	10	10
Third-terrace deposits:		
Gravel	60	70
Sand, fine	50	120
25-61-27cb [Altitude, 4,219.1 feet]		
Soil	8	8
Third-terrace deposits:		
Sand, coarse	8	16
Sand, fine; contains some clay	12	28
Sand and gravel	27	55
Sand, gravel, and boulders	5	60
Sand, fine	7	67
Sand, fine; contains fragments of siltstone	15	82
Brule formation:		
Siltstone	4	86
25-61-28bc [Altitude, 4,235 feet]		
Soil	6	6
Third-terrace deposits:		
Gravel, coarse	12	18
Sand, fine	16	34
Sand, coarse	5	39
Sand, fine	3	42
Sand, coarse	14	56
Boulders and sand	12	68
Gravel, and sand, coarse	27	95
Sand, coarse; contains clay and boulders	9	104
Sand, fine	4	108
Sand, coarse	12	120
25-61-28db [Altitude, 4,223.1 feet]		
Soil	14	14
Third-terrace deposits:		
Sand	12	26
Gravel (water at 46 feet)	38	64
Clay	2	66
Sand	40	106
25-61-29da [Altitude, 4,237.6 feet]		
Soil and "quick sand"	14	14
Third-terrace deposits:		
Sand and gravel	98	112
25-61-31db [Altitude, 4,150.2 feet]		
Soil	6	6
Flood-plain deposits:		
Sand and gravel	30	36
Sand	8	44
Sand; contains some gravel	9	53
Sand, fine; contains some gravel	17	70
Sand and boulders	4	74
Sand and medium to coarse gravel	11	85
Gravel, medium to coarse	9	94
Lance formation(?):		
Shale	1	95

DRILLERS' LOGS

	Thickness (feet)	Depth (feet)
25-61-33ab [Altitude, 4,210.8 feet]		
Soil	12	12
Third-terrace deposits:		
Sand	2	14
Sand, packed	8	22
Gravel	74	96
25-61-33bb [Altitude, 4,226.3 feet]		
Soil	4	4
Third-terrace deposits:		
Silt, sandy	46	50
Gravel	67	117
25-61-33db [Altitude, 4,207 feet]		
Soil	10	10
Third-terrace deposits:		
Sand and gravel	50	60
Clay	5	65
Sand and gravel, fragments of siltstone at bottom (this well is believed to have reached the Brule formation at 91 feet)	26	91
25-61-34bb [Altitude, 4,205.6 feet]		
Soil	8	8
Third-terrace deposits:		
Sand	4	12
Sand, hard	8	20
Gravel	31	51
Sand, coarse	36	87
25-61-34dc [Altitude, 4,202 feet]		
Third-terrace deposits:		
Sand and gravel	40	40
Brule formation:		
Siltstone	40	80
25-61-35cc [Altitude, 4,190.5 feet]		
Third-terrace deposits:		
Sand and gravel	85	85
Brule formation:		
Siltstone	1	86

DRILLERS' LOGS

	Thickness (feet)	Depth (feet)
25-62-10da		
[Altitude, 4,305.3 feet. Because this log is very generalized, the geologic interpretation is only approximate]		
Soil	15	15
Third-terrace deposits:		
Gravel	75	90
Brule formation(?):		
Clay	10	100
Sand	4	104
Clay and sand	33	137
Mud	10	147
Clay	3	150
Clay, sandy	50	200
Sandstone	5	205
Chadron formation(?):		
Clay and sandstone	40	245
Clay, sticky, blue	15	260
Clay, sticky, white	95	355
Lance formation(?):		
Clay, green, and gray shale	20	375
Sand, brown (contains water)	15	390
Sand and clay	20	410
25-62-15cd2		
[Altitude, 4,171.5 feet]		
Flood-plain deposits:		
Soil, sandy	35	35
Sand, white	1	36
Sand, fine	24	60
Clay	1	61
Sand, fine	39	100
Brule formation(?):		
Siltstone	3	103
25-62-16bc		
[Altitude, 4,188.4 feet]		
Soil	11	11
Flood-plain deposits:		
Gravel; contains fine sand at bottom	52	63
25-62-18ca		
[Altitude, 4,174.3 feet]		
Flood-plain deposits:		
Sand and gravel	17	17
Boulders	3	20
Sand, and medium gravel	17	37
Sand, and fine gravel	15	52
Sand, and hard gravel	6	58
Sand, and medium gravel	9	67
25-62-18db3		
Clay, sandy	6	6
Flood-plain deposits:		
Sand, coarse, and gravel	45	51
25-63-8dc1		
[Altitude, 4,204.0 feet]		
Flood-plain deposits:		
Sand and gravel	94	94
Chadron formation(?):		
Clay	33	127
Lance formation:		
Clay and sand	13	140

DRILLERS' LOGS

	Thickness (feet)	Depth (feet)
25-63-9db [Altitude, 4,195.4 feet]		
Soil	6	6
Flood-plain deposits:		
Sand	12	18
Sand, coarse, and gravel	46	64
25-63-11ad [Altitude, 4,198.3 feet]		
Soil	18	18
Flood-plain deposits:		
Gravel	51	69
Brule formation(?):		
Siltstone	3	72
25-63-12bd [Altitude, 4,208.5 feet]		
Soil	10	10
Flood-plain deposits:		
Sand and gravel	22	32
Clay	3	35
Gravel and boulders	46	81
25-63-15cc [Altitude, 4,212.1 feet]		
Flood-plain deposits:		
Sand	27	27
Gravel	27	54
Brule formation:		
Siltstone	33	87
25-63-17bd [Altitude, 4,225.9 feet]		
Flood-plain deposits:		
Sand and gravel	60	60
Brule formation:		
Siltstone	5.3	65.3
25-63-25bd [Altitude, 4,165 feet]		
Flood-plain deposits:		
Sand and gravel	20	20
Chadron formation:		
Clay	70	90
Lance formation:		
Clay, yellow	38	128
Sand, yellow and red	17	145
Clay, hard	2	147

DRILLERS' LOGS

	Thickness (feet)	Depth (feet)
26-62-11dd [Altitude, 4,272 feet]		
Soil	8	8
Flood-plain deposits:		
Sand, fine	24	32
Sand and gravel	29	61
Boulders	2	63
Brule formation:		
Siltstone	3	66
26-62-14ba [Altitude, 4,274 feet]		
Soil	12	12
Flood-plain deposits:		
Sand, fine	2	14
Clay	10	24
Sand and gravel	34	58
Brule formation:		
Siltstone	4	62
26-62-14bb [Altitude, 4,274.4 feet]		
Soil	12	12
Flood-plain deposits:		
Sand, fine	12	24
Sand and gravel	10	34
Brule formation:		
Siltstone	5	39
26-63-32da [Altitude, 4,204.6 feet]		
Soil	20	20
Flood-plain deposits:		
Sand and gravel	60	80
26-64-22cc [Altitude, 4,233.1 feet]		
Soil	8	8
Flood-plain deposits:		
Sand and boulders	22	30
Sand and gravel	25	55
Sand, coarse	7	62
26-64-23cb		
Sand, fine	10	10
Flood-plain deposits:		
Clay, blue, and rock	3	13
Gravel	47	60
28-62-23aa		
Arikaree formation:		
Sand and sandstone, light-gray to light-brown	5	5
Sandstone, light-brown and tan	10	15
Sandstone, light-gray	35	50
Sand and silt; contains ledges of fine-grained sandstone	20	70
Sandstone, light-brown and gray	30	100
Sand, very fine-grained, brown	50	150

TABLE 7.—*Records of wells and springs in Goshen County*

Well number: See text for description of well-numbering system.
Type of supply: B, bored well; Dn, driven well; Dr, drilled well; Du, dug well; Sp, spring.
Depth of well: Measured depths are given in feet and tenths below measuring point; reported depths are given in feet below land-surface datum.
Type of casing: C, concrete, brick or tile pipe; N, none; P, iron or steel pipe; R, rock.
Character of material: Cl, clay; G, gravel; S, sand; Sl, silt; Sls, siltstone; Ss, sandstone.
Geologic source: Kl, Lance formation; Q, flood-plain deposits; Qt, third-terrace deposits; Qu, upland deposits; Ta, Arikaree formation; Tb, Brule formation; Tc, Chadron formation.
Method of lift (first letter): C, cylinder; Cf, centrifugal; F, flows; J, jet; N, none; T, turbine; Type of power (Second and third letters): E, electric motor; G, gasoline or diesel engine; H, hand operated; N, none; W, windmill.
Use of water: D, domestic; I, irrigation; In, industrial or railroad; N, none; O, observation; P, public; S, stock.
Description of measuring point: Bpb, bottom of pump base; Edp, end of discharge pipe; Hpb, hole in pump base; Hph, hole in pump housing; Ls, land surface; Tc, top of casing; Tcu, top of curb; Tpb, top of pump base; Tpc, top of pipe clamp; Tph, top of pump housing; Twc, top of well cover.
Height of measuring point: Altitudes determined by spirit level are given in feet and tenths; altitudes determined by aneroid are given in feet.
Depth to water: Measured depths to water level are given in feet, tenths, and hundredths; reported depths are given in feet.
Remarks: Ca, sample collected for chemical analysis; D, discharge in gallons a minute (E, estimated; M, measured; R, reported); DD, drawdown in feet while discharging at the preceding rate; L, log of well given in table on well logs; T, temperature in degrees Fahrenheit.

Well no.	Owner or user	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed		Method of lift	Use of water	Measuring point			Distance to water level below measuring point (feet)	Date of measurement	Remarks
						Character of material	Geologic source			Description	Distance above (+) or below (−) land-surface (feet)	Height above mean sea level (feet)			
19-60- 8bb	Wm. A. Craton	Dr	105.0	4	P	Sls	Tb	N	N	Tc	+2.4	4,670.0	59.50	June 5, 1951	
-10ba	H. Nighswonger	Du	115	60	C	Sls	Tb	N	N	Tc	+.5		91.06	Nov. 5, 1948	
-15ac	A. D. Green	Dr	140	4	P	Sls	Tb	C, W	S	Tc	+.7		76.54	June 5, 1951	
-15cb	Fred W. Stull	Dr	96.5		P	Sls	Tb	C, W	N	Tpb	+.5	4,703.8	83.94	do	
-19ab	Fred Petsch	Dr	92.2	6	P	Sls	Tb	N	N	Tc	0	4,742.5	58.35	do	
-20cd	Frank J. Johnson	Dr	90	6	P	Sls	Tb	C, W	S	Tc	+.3		58.58	Nov. 14, 1951	T53, Ca.
-30dc	do	Dr	118.5	4	P	Sls	Tb	C, W	S	Tc	+.4	4,748	89.63	May 10, 1943	
19-61- 2cc1	D. Rodeman	Dr	50	6	P	S, G, Sls	Qf, Tb	C, W	S	Ls			13	Feb. 26, 1950	
- 2cc2	City of Lagrange	Dr	30.8	5	P	S, G	Qf	N	O	Tc	+.9	4,578.1	16.63	May 22, 1951	
- 3bb	Frank L. Graves	Dr	64	6	P	S, G	Qf	C, H, E	D, S	Hph	+2.4		40.01	Oct. 25, 1949	
- 4cd1	Hugh Stemler	Du, Dr	33	48	P	S, G	Qf	C, H	D, I, O	Tcu	+.7	4,558.1	7.40	May 22, 1951	D1, 200M.
- 4cd2	do	Du, Dr	65	48	C	S, G	Qf	T, G	I	Tcu	0	4,558.1	7	Sept. 29, 1949	
- 4cd3	do	Dr	55.0	18	P	S, G	Qf	T, E	I	Tpb	+.6		5.78	May 3, 1949	D900R, L.
- 4cd4	do	Dr	39	18	P	S, G	Qf	T, E	I	Ls			6	Feb. 6, 1950	D600R.
- 6bc	Virgil M. Jones	Dr	160		P	Sls	Tb	C, G	D	Ls			30	Oct. 18, 1949	D10R.
- 9db	E. W. Johnson	Dr	57.5		P	Sls	Tb	C, W	S	Tpc	+.3	4,583.3	20.44	June 16, 1943	
-10ac	do	Dr	70.5	5	P	S, G, Sls	Qf, Tb	C, W	S	Tc	+.7	4,575.9	11.97	do	
-11ab	G. Wendt	Dr	151	20	P	S, G, Sls	Qf, Tb	T, G	I	Hpb	+.3	4,586.3	19.26	June 21, 1943	D850E, DD34.
-19bc	State of Wyoming	Dr		5	P	Sls	Tb	N	N	Tc	+.8		65.78	Nov. 3, 1950	
-20ad	do	Dr		5	P	Sls	Tb	C, W	S	Tc	0		74.58	Nov. 13, 1951	

TABLE 7.—*Records of wells and springs in Goshen County*—Continued

Well no.	Owner or user	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below land-surface (feet)	Measuring point: Height above mean sea level (feet)	Distance to water level below measuring (feet)	Date of measurement	Remarks
19-61-27cb	Fred Petsch	Dr		4	P	Sls	Tb	C, W	S	Tc	+.4		57.31	Nov. 3, 1950	
-29ca	E. W. Johnson	Dr		6	P	Sls	Tb	C, W	S	Tc	+1.0		40.36	do	
-30cb	State of Wyoming	Dr		6	P	Sls	Tb	C, W	S	Tc	+.9		43.39	do	
-33bd	do	Dr		6	P	Sls	Tb	C, W	S	Tc	+.5		71.91	do	
19-62- 2ad	Edward Krohn	Dr	92			Sls	Tb	C, N	O	Bpb	+1.4	4,685.0	58.85	May 22, 1951	
- 2bc	Eldon L. Preston	Dr	60	6	P	Sls	Tb	J, E	D	Ls			30	Sept. 30, 1949	T55.
- 7bb	I. W. Christanson	Dr		6	P	Ss	Ta	C, H	S	Tc	+.6		49.49	Oct. 25, 1950	
-10da	C. W. Lovercheck	Dr	360	4	P	Ss	Kl	C, W	S	Tc	+1.5		221.02	Nov. 3, 1950	
-15da	do	Dr	415	6	P	Sls	Tb	N	N	Ls	0		66.77	Oct. 3, 1950	
-19aa	Andrew Oleson	Dr	159	4	P	Ss	Ta	C, N	N	Tc	+.3		60.69	May 4, 1943	
-26db	F. E. Jones	Dr	42	5	P	Sls	Tb	C, W	S, O	Tc	+.2		28.17	May 22, 1951	T52, Ca.
-30bb	R. H. Brown	Dr		5	P	Ss	Ta	C, W	N	Tc	+1.1		79.12	Oct. 25, 1950	
19-63- 3ab	R. W. Yates	Dr	160	6	P	Sls	Tb	C, W, H	D	Ls			80	Oct. 18, 1949	
- 3ac	do	Du		48	R	S, G	Qf	C, H	N	Tcu	+.3		11.30	do	T52.
- 5cd	Charles F. Swarm	Sp				Sls	Tb	F	S						T59, D10E, Ca.
- 6ad	E. K. Parsons	Dr	176	5	P	Sls	Tb	N	N	Tc	+.9	5,049	147.54	May 7, 1943	
- 8ba	Charles F. Swarm	Dr	100	5	P	Sls	Tb	C, W	D, S	Ls			60	Sept. 30, 1949	T59.
-13dd	E. K. Parsons	Dr		6	P	Ss	Ta	N	N	Tc	+1.1		43.67	Oct. 25, 1950	
-16ab	State of Wyoming	Dr	92	5	P	Ss	Ta	C, W	S	Ls			79	Oct. 26, 1950	D5E.
-17bc	Charles F. Swarm	Dr	119	4	P	Ss	Ta	C, W	S	Hpb	+.5		93.59	do	
-19dc	do	Dr		4	P	Ss	Ta	N	N	Tc	+1.3		189.46	do	
-23cd	Peter Haberkorn	Dr		5	P	Ss	Ta	C, W	S	Hph	+1.8		129.60	Oct. 27, 1950	
-28da	R. H. Brown	Dr	256	6	P	Ss	Ta	C, W	S	Tc	−4.9		190.99	Oct. 25, 1950	
-33bd	Dan Kirkbride	Dr	127	4	P	Sls	Tb	N	N	Tc	+.3		93.67	May 4, 1943	
-35db	Ray Sherard	Dr	175	5	P	Sls	Tb	C, W	S	Tc	+.1		160.02	Oct. 25, 1950	
19-64- 1bd	Wm. and J. W. Brown	Dr	98.5	5	P	Ss	Ta	C, N	N	Tc	+.3		68.44	May 7, 1943	
- 4bb	Frank Horton	Dr		6	P	Ss	Ta	C, W	S	Twc	+.1		156.54	Oct. 14, 1950	
- 5bc	Daniel Jensen	Dr		6	P	Ss	Ta	C, W	S	Tc	0		152.49	do	
- 8cd	do	Sp				Ss	Ta	F	D, S						T52, D15E, Ca.
-12ad	Earl K. Parsons	Dr	17	5	P	S, G	Qf	C, N	N	Tc	+.7	4,942	8.44	May 4, 1943	
-18ba	C. D. Griffin	Dr		6	P	Ss	Ta	C, H	D	Hph	+1.7		8.33	Oct. 25, 1949	
-24cc	Oscar Yoder	Dr		4	P	Ss	Ta	N	N	Ls	0		200.12	Oct. 26, 1950	
-28bd	F. R. Schuppan	Dr		5	P	Ss	Ta	N	N	Tc	+.7		178.68	Nov. 13, 1951	
-28dc	do	Dr	300	6	P	Ss	Ta	C, W	S	Ls			270	Oct. 26, 1950	
-29ca	C. D. Griffin	Dr	136.5	5	P	Ss	Ta	N	N	Tc	+.5		118.60	Nov. 13, 1951	
19-65- 3bc	E. J. Marsh	Dr		5	P	Ss	Ta	N	N	Tc	+2.1		119.54	Oct. 11, 1950	

20-60-15cb	James A. Card	Dr			P	Ss	Ta(?)	C, W	S	Tpc	+.4		183.87	June 5, 1951	
-18dd	E. J. Lowry	Dr	85	8	P	Ss	Ta(?)	C, W	S	Tc	+2.0		74.89	Oct. 18, 1951	
-19ca	Frank Sanders	Dr	65	6	P	Sls	Tb	C, W	S	Tc	+1.1		38.86	Oct. 18, 1951	
-20dc	O. L. Jones	Sp				Ss, Sls	Ta, Tb	F	D, S						T53, D3E.
-32bb	Lincoln Land Co.	Dr		6	P	Sls	Tb	C, W	S	Tc	+1.0		42.25	Nov. 14, 1951	
-34cb	C. A. Warner	Dr	60	6	P	Sls	Tb	C, W	D, S	Tc	+.6		54.36	do	
20-61- 1bb	R. B. Boynton	Dr	132.5			Ss	Tc	C, N	N	Bpb	+.4	4,454.9	45.62	Apr. 6, 1943	
- 3ca	D. L. Trout	Dr	14	6	P	Ss	Kl	C, H	D	Ls			7	Oct. 18, 1951	
-12dd	E. J. Lowry	Dr	165	4	P	Ss	Ta(?)	N	N	Ls			100	do	
-14cc	Daniel Phinney	Dr		5	P	S, G	Qf	C, W	S	Tc	0		8.11	Nov. 29, 1948	
-17dd	A. F. Chaha	Sp				Ss	Kl	F	S						T56, D10E, Ca.
-22dc	Curtis Templin	Dr	43.3	18	P	S, G	Qf	T, G	I	Tc	+.2	4,503.1	17.33	May 24, 1943	D450R, L.
-24cc	F. Sanders	Dr	43.6	6	P	Sls	Tb	C, W	S	Tc	+.9		7.99	Oct. 18, 1951	
-26cb	Eugene Hanson	Dr	210	20	P	S, G, Sls	Qf, Tb	T, G	I	Bpb	+.4	4,519.4	24.77	Sept. 25, 1949	T54, D870R, Ca.
-27dd	Curtis Templin	Dr	86	6	P	S, G, Sls	Qf, Tb	C, N	O	Tc	+.9	4,528.8	30.40	May 22, 1951	
-28bb	John Meyers	Dr	35	10	P	S, G	Qf	Cf, E	D	Tc	0		9.07	Sept. 28, 1949	T55, D400R, Ca.
-33cd	Oscar Sherard	Dr	46.5	18	P	S, G	Qf	T, G	I	Tc	0		8.11	Aug. 31, 1951	T51, D700M, DD36, CA.
-33dc	do	Dr	48	18	P	S, G	Qf	T, G	I	Hpb	+.5		8.43	Aug. 30, 1951	T51, D910M, DD22.7, L.
-34cb	Nels Sherard	Dr	24.4	24	P	S, G	Qf	T, G	I	Tc	+1.2		4.01	June 4, 1943	
20-62- 1bc	John F. Rockhold	Du	24.8	30	C	Ss	Kl	N	N	Tc	0		21.56	Nov. 29, 1948	
- 2ab	Earl Arnold	Du	31.3	36	C	Ss	Kl	N	N	Tcu	+1.0	4,464.1	24.58	Apr. 7, 1943	
- 6ab	Wm. Poage	Dr			P	Ss	Kl	C, H	N	Hph	+1.4		72.85	Nov. 13, 1948	
- 8aa	Earl Arnold	Dr	104	4	P	Ss	Kl	N	N	Tcu	+.4	4,556	50.70	Apr. 5, 1943	
-17ca	Lincoln Land Co.	Dr	276	6	P	Sls	Tb	N	N	Tc	+1.0	4,744	190.37	May 3, 1943	
-18ba	Wm. Poage	Sp				Ss, Sls	Ta, Tb	F	S						
-19ad	J. Matje	Dr		6	P	Sls	Tb	C, W	S	Tc	+1.1		149.86	Oct. 26, 1950	
-23ba	Walter S. Gomme	Du	96.0	40	C	Sls	Tb	C, W	S	Tc	+.3		42.84	Sept. 12, 1950	
-24db	Earl Arnold	Du, Dr	57.3	36	C	Sls	Tb	C, W	D, S	Tc	+1.0	4,544.3	53.44	Apr. 6, 1943	
-31bd	A. R. Kessler	Dr	53	4	P	Sls	Tb	C, N	N	Bpb	+.6	4,790	41.29	May 4, 1943	
-33ac	C. B. Kessler	Dr	33	6	P	Sls	Tb	C, E	D	Ls			20	Oct. 18, 1949	T52, D15E, Ca.
-34cb	Fred N. Stoll	Sp				Sls	Tb	F	S						T49, D10E, Ca.
20-63- 1dd	Wm. Poage	Dr	72	6	P	Ss	Kl?	C, W	S	Tc	+.9		57.03	Oct. 24, 1950	
- 3cc	Herbert Dowers	Dr	154	6	P	Ss	Ta	C, W	S	Tc	+.1		87.96	Oct. 16, 1950	
- 5bc	D. J. Swanson	Dr		6	P	Ss	Ta	C, W	S	Tc	+1.4		157.77	do	
- 9bb	do	Dr	134.5	6	P	Ss	Ta	C, W	S	Tc	+.6		112.80	do	
-13cc	Wm. Poage	Dr		6	P	Sls	Tb	C, W	S	Tc	0		37.17	Oct. 24, 1950	
-15bb	do	Sp				Ss, Sls	Ta, Tb	F	D, S						D5E.
-17bc	do	Dr	40	6	P	Ss	Ta	C, W	S	Tc	+1.5		24.00	Oct. 24, 1950	
-19cc	Earl Vandehei	Dr		6	P	Ss	Ta	C, W	S	Tc	+1.9		22.64	Oct. 26, 1950	
-27bc	J. Matje	Dr		5	P	Sls	Tb	C, W	S	Tc	+.2		73.54	Oct. 18, 1950	
-34da	Julia W. Yates	Dr	102	4	P	Sls	Tb	N	N	Tcu	+.8	4,982	65.61	May 3, 1943	
-35bb	J. Matje	Dr			P	Sls	Tb	C, H, W	D, S	Hph	−2.2		60.47	Oct. 26, 1949	
-35dc	A. R. Kessler	Dr	70	5	P	Sls	Tb	J, E	D, S	Ls			50	Sept. 30, 1949	T60.
20-64- 3cc	Buford R. Beaver	Dr	178.5	4	P	Ss	Ta	N	N	Tc	+1.0	5,267.2	134.60	July 9, 1951	
- 6bb	Homer Cotton	Dr		4	P	Ss	Ta	N	N	Tc	+1.1	5,326.5	102.23	Oct. 12, 1950	
-10ca	Buford R. Beaver	Dr		6	P	Sls	Tb(?)	C, W	S	Tc	+.6	5,268.1	191.11	Oct. 18, 1950	
-12ab	D. J. Swanson	Dr		5	P	Ss	Ta	C, W	S	Tc	+1.7		145.42	Oct. 16, 1950	
-18ac		Sp				Ss	Ta	F	S						
-19da	J. Matje	Sp				Ss	Ta	F	S						D100E.
-21cd	Daniel Jensen	Dr		5	P	Ss	Ta	C, W	S	Twc	+.8	5,348.2	175.52	Oct. 11, 1950	
-22db	do	Dr	165	6	P	Ss	Ta	C, W	S	Twc	+.4	5,154.1	100.51	do	

TABLE 7.—*Records of wells and springs in Goshen County*—Continued

Well no.	Owner or user	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below (−) land-surface (feet)	Measuring point: Height above mean sea level (feet)	Distance to water level below measuring point (feet)	Date of measurement	Remarks
20-64-26cc	Daniel Jensen	Dr	229	5	P	Sls	Tb	C, W	S	Hpb	+.2	5,284.3	194.58	Oct. 11, 1950	
-30cc	J. Matje	Dr	123.0	4	P	Ss	Ta	N	N	Tc	0	5,384.8	100.62	do	
20-65- 2ab	Chas. A. Campbell	Dr	169	6	P	Ss	Ta	C, N	O	Tc	+.4	5,367.5	116.81	May 22, 1951	
- 3bb	Arthur Eastwood	Dr		6	P	Ss	Ta	C, N	N	Tpb	+.5	5,393.7	112.91	Oct. 14, 1950	
-11aa	Mrs. F. Wright	Dr	128	5	P	Ss	Ta	C, N	N	Tc	0	5,365.5	116.61	Oct. 12, 1950	
-13cc	Lawrence M. Mathree	Dr	176	6	P	Ss	Ta	N	N	Tc	+1.5	5,421.7	151.16	May 7, 1943	
-15bb	Hi Land Farms Co.	Dr			P	Ss	Ta	N	N	Tc	0	5,423.7	119.45	July 5, 1951	
-15db	J. Matje	Dr		6	P	Ss	Ta	C, W	S	Tc	+.9		143.66	Oct. 12, 1950	
-25bc	Fox Creek Land and Livestock Co.	Dr			P	Ss	Ta	N	N	Tc	+1.4	5,374.4	81.79	July 5, 1951	
-26ba	J. Matje	Dr	115	6	P	Ss	Ta	C, W	S	Tc	+2.2	5,383.5	88.24	Oct. 12, 1950	L.
-27bc	do	Dr		6	P	Ss	Ta	C, W	S	Tc	+1.0	5,393.5	77.79	do	
-33dd		Dr	113.5	4	P	Ss	Ta	C, N	N	Tc	0		97.51	May 4, 1943	
-34da	J. Matje	Dr		5	P	Ss	Ta	C, W	S	Tc	+.8	5,415.8	105.93	Oct. 11, 1950	Ca.
21-60- 5bc	Geo. Ring	Dr	103	5	P	Ss	Tc(?)	F	D, S						D1.5R.
- 6ac	Hammond Investment Co.	Dr	104	6	P	Ss	Tc(?)	F	S						T55, D3M, L.
- 7ab	do	Dr	106.5	8	P	Ss	Tc(?)	F	S						D15E.
- 9ab	Earl R. Hubbs	Dr	87.0	3	P	Ss	Tc	C, N	N	Hpb	+.6	4,280	34.59	Apr. 6, 1943	
-17cc	Paul Harris	Dr	124	6	P	Ss	Tc	F	D, S						T53, D5R, Ca.
-17db	O. Miller	Dr	140	5	P	Ss	Tc(?)	F	D, S						D6R.
-18ac	D. R. Gillaspie	Dr	100	4	P	Ss	Tc(?)	F	N						D1M.
-21aa	J. F. Smith	Dr	141.5	3	P	Ss	Tc(?)	C, N	N	Tc	+.4	4,380	109.14	Apr. 6, 1943	
-33dc	V. H. and S. D. Mihan	Dr	79.5	5	P	Sls	Tb	N	N	Tc	+1.0	4,437	26.78	do	
21-61- 3cc	Wyo. Farm Loan Bank.	Dr	101.5	4	P	Ss	Kl	C, N	N	Tc	+.3	4,296.5	42.34	Apr. 3, 1943	
-14aa	Lloyd G. Culbertson	Dr	166	5	P	Ss	Tc(?)	N	N	Tc	+.4	4,337.3	78.39	do	
-17ad	H. W. Hill	Dr	85	5	P	Ss	Kl	C, W	D, S	Ls			50	Nov. 6, 1951	T54, Ca.
-23dd	Simon D. Mihan	Dr	157.5	5	P	Ss	Kl	C, N	N	Tc	+.4	4,407.3	94.27	Apr. 6, 1943	
-28aa	C. W. Jones	Dr	73			Ss	Kl	C, N	N	Bpb	+.5	4,352.7	27.83	do	
-29cc	Mamie M. Davis	Dr			P	S, G	Qf	C, H	N	Hph	+1.0		6.15	Nov. 29, 1948	
-31ba	C. Kaufman	Dr			P	Ss	Kl	C, W	S	Hph	+1.5		40.36	do	
-32ad	Mamie Marlatt	Dr	190	6	P	Ss	Kl	C, E	D	Ls			110	1949	

21-62- 3aa	J. E. and L. Rudeen	Dr	102	4	P	Ss	Kl	N	N	Tc	+.5	4,432.5	28.83	Apr. 3, 1943	
- 5ba	C. A. VerStraten	Dr	83.5	3	P	Ss	Kl	C, N	N	Tc	0	4,405.9	54.58	do	
- 6cb	E. W. David	Dr	90	5	P	Ss	Kl	C, W	N	Hph	+2.0		28.83	Oct. 13, 1948	
-10cd	A. Wesch	Dr	73.2	5	P	Ss	Kl	J, E	D, S	Tc	−4.3		15.83	Oct. 12, 1951	
-12bb	M. Larson	Dr	12.3	4	P	Ss	Kl	N	N	Tc	+.3		8.65	Nov. 1, 1948	
-12dd	Wm. G. Vance	Dr	15.2	5	P	Ss	Kl	N	N	Tc	−4.0	4,336.4	5.38	Apr. 6, 1943	
-13cc	John Donahue	Dr	53	6	P	Ss	Kl	C, H	S	Tc	+.4		24.61	Sept. 14, 1950	
-14dd	Lloyd Blunt	Dr	30	6	P	Ss	Kl	C, H	D	Tc	+.6		7.80	do	T58
-17ab	H. H. Handley	Dr	117	5	P	Ss	Kl	J, E	D, S	Ls			30	Nov. 6, 1951	T54, Ca.
-17cd	Ira E. Brown	Dr	106.5	4	P	Ss	Kl	N	N	Twc	+.5	4,446.0	58.86	Apr. 5, 1943	
-21da	B. L. Howery	Dr	110.5	4	P	Ss	Kl	C, N	N	Tc	0	4,449.5	51.35	Apr. 7, 1943	
-23da	Waldon Smith	Dr	70	4	P	Ss	Kl	C, W	D, S	Tc	+1.4		19.07	Sept. 14, 1950	
-30cd	Leonard Hirsch	Dr	96.5	4	P	Ss	Kl	C, N	N	Tc	0	4,524.4	79.27	Apr. 5, 1943	
-32db	C. C. Sanford	Dr	60	4	P	Ss	Kl	C, W	S	Ls			18	Sept. 14, 1950	L.
-35ad	E. Shimic	Du	18.6	40		Ss	Kl	C, H	N	Twc	+1.0		9.53	Nov. 1, 1948	
21-63- 4aa	Lillian H. Free	Dr	52		P	Ss	Kl	C, N	N	Bpb	+.4	4,440.4	24.30	Apr. 3, 1943	
- 6bb	L. E. Fogelman	Dr		5	P	Ss	Kl	C, W	S	Tc	+1.0		15.64	Nov. 13, 1948	
-15aa	E. B. Woodford	Dr	122.5	4	P	Ss	Kl	C, N	N	Tc	+.5	4,486.0	77.51	July 3, 1943	
-19bc	Smith Bros.	Dr	210	5	P	Sls	Tb	C, W	S	Tc	+.9		184.82	Sept. 5, 1950	
-22dd	Clyde Hunter	Dr	61	4	P	Ss	Kl	C, N	N	Tc	+.6	4,532.6	45.45	Apr. 5, 1943	
-23bb	Wm. G. Knapp	Dr	19.3	3	P	Ss	Kl	N	N	Tc	+1.3		10.07	do	
-30cd	R. E. Swanson	Dr	194	5	P	Sls	Tb	C, N	N	Bpb	+1.0	5,244.6	178.72	July 3, 1951	
-35dc	Herbert Dowers	Dr	115	3	P	Ss	Kl	C, N	N	Tc	+.5	4,619	58.35	Apr. 5, 1943	
21-64- 2aa	T. and F. Kane	Dr	49.5	4	P	Ss	Kl	C, N	N	Bpb	0	4,556.3	23.24	Apr. 20, 1943	
- 3dc	Smith Bros.	Dr	250	6	P	Ss	Kl	N	N	Twc	+2.8		30.57	Aug. 27, 1950	L.
- 7cc	do	Dr	179.5	6	P	Sls	Tb	C, W	S	Ls			150	Jan. 6, 1950	
-13ab	Drummond Smith	Dr	145.5	4	P	Sls	Tb	N	N	Tc	+1.4	4,611.9	121.90	Apr. 30, 1943	
-17cc	Smith Bros.	Dr	170	4	P	Ss	Ta	C, W	S	Tc	+1.0	5,314.2	154.06	Sept. 5, 1950	D10E.
-21cc	F. Brain	Dr	220	6	P	Ss	Ta	C, W	D, S	Twc	+.3	5,334.6	172.83	Oct. 17, 1950	
-23cb	Smith Bros.	Dr	215		P	Sls	Tb	C, W	D, S	Tc	+.8	5,264.3	182.61	Sept. 5, 1950	
-26bb	Clifford J. Stafford	Dr	225	6	P	Sls	Tb	C, W	N	Bpb	+1.2	5,285.0	184.14	July 2, 1951	
-31dc	Homer Cotton	Dr	107	4	P	Ss	Ta	C, W	D, S	Tc	+.6	5,305.6	88.39	Oct. 16, 1950	
-32cb	Buford R. Beaver	Dr	142.5	5	P	Ss	Ta	C, N	N	Tc	0	5,304.4	100.53	May 7, 1943	
-34ab	G. H. Wilkins	Dr	204	6	P	Ss	Ta	C, W, G	S	Tc	+.6		179.89	Oct. 16, 1950	T55, Ca.
21-65- 1bc	H. D. Havely	Dr		5	P	Ss	Ta	C, W	S	Tc	+1.0	5,236.6	107.84	Oct. 17, 1950	
- 3ad	Mary H. Blanchard	Dr	135	6	P	Ss	Ta	N	N	Tc	+1.1	5,243.5	112.47	Apr. 30, 1943	
-10cd	O. B. Wilson	Dr		6	P	Ss	Ta	C, W	S	Hpb	+.2		108.64	Oct. 17, 1950	
-11ad	do	Dr	151.5	4	P	Ss	Ta	N	N	Tc	+1.6	5,290.6	125.06	June 29, 1951	
-15dc	Alba Pense	Dr	160	6	P	Ss	Ta	C, W	D, S	Tcu	+.2	5,348.6	123.10	Oct. 17, 1950	
-24bb	O. B. Wilson	Dr	180	4	P	Ss	Ta	C, W	S	Tc	+.6	5,329.0	122.43	do	
-24cd	Shapiro Estate	Dr	166.5	5	P	Ss	Ta	N	N	Tc	+1.5	5,344.2	126.99	do	
-26cc	Arthur Eastwood	Dr		5	P	Ss	Ta	N	N	Tc	+1.6	5,388.5	143.50	do	
-27cc	F. I. Hinshaw	Dr		4	P	Ss	Ta	N	N	Tc	+.7	5,410.4	135.20	June 29, 1951	
22-60- 5cb	J. Yocum	Dr	150	4	P	Ss	Kl	C, W	D, S	Hph	+1.3		81.36	Nov. 23, 1948	
- 6aa	H. Lippincoll	Sp				Cl	Tc [a]	F	S						Ca.
- 6ab	do	Dr	160	5	P	Ss	Kl	J, E	D, S	Ls			80		L.
- 9aa	J. C. Rincker	Du	20	48		Ss	Tc	C, H	D	Hph	+1.5		7.51	Sept. 28, 1950	
- 9cc	F. Glebe	Dr		6	P	Ss	Kl	J, E	D, S	Tc	−5.0		36.04	Nov. 23, 1948	
-10bc	J. C. Rincker	Dr	160	6	P	Ss	Kl	C, E	D	Ls			45	Sept. 28, 1950	L.
-19da	A. Stephenson	Dr	168	6	P	Ss	Kl	C, E	D, S	Twc	+1.0		10.85	Oct. 4, 1951	
-21bb	A. Johnson	Dr	275	6	P	Ss	Kl	C, W	S	Ls			150	Oct. 7, 1950	L.

See footnotes at end of table.

TABLE 7.—*Records of wells and springs in Goshen County*—Continued

Well no.	Owner or user	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below land-surface (feet)	Measuring point: Height above mean sea level (feet)	Distance to water level below measuring (feet)	Date of measurement	Remarks
22-60-27ba	W. S. Payne	Dr	160	5	P	Ss	Kl	C, W, E	D, S	Hpb	+2.0		80.95	Oct. 4, 1950	T56.
-27dd	C. Gibson	Dr	125	6	P	Ss	Kl	J, E	D, S	Ls			15	Oct. 11, 1951	
-31aa	T. Briggs	Dr	102.1	6	P	Ss	Tc(?)	F	D, S						D0.5M.
-32cc	Hammond Investment Co.	Dr	108	4	P	Ss	Tc(?)	F	N						T56, D3E.
-32dd	D. H. Shubert	Dr	76	4	P	Ss	Tc(?)	F	D, S						T57, D1R.
-33dd	F. C. Dahlgren	Dr	85	5	P	Ss	Tc	F	D, S						T57, D2M, Ca.
22-61- 5ba	John Vaska	B	30	6	P	Ss	Kl	C, H	D, S	Ls			26	Jan. 12, 1950	
-17ad	J. Matje	Dr	104.5	4	P	Ss	Kl	N	N	Tc	+1.0	4,280.0	54.00	Apr. 3, 1943	
-21ad	P. D. Hacker	Dr	71.9	4	P	Ss	Kl	N	N	Tcu	0		42.70	Oct. 18, 1951	
-23db	Hugh Bunnell	Dr	152	6	P	Ss	Tc(?)	C, E	D, S	Tc	0		59.88	Oct. 11, 1951	
-25cd	A. Ehrlich	Dr	19.6	4	P	Ss	Kl	C, H	D	Tc	+.2		9.34	do	
-28cc	G. C. Hacker	Dr	114.5	4	P	Ss	Kl	N	N	Tc	+.4	4,313.1	48.97	Apr. 3, 1943	
-32cc	Howard L. Hill	Dr	89			Ss	Kl	C, N	N	Bpb	0	4,347.0	51.72	do	
22-62- 5aa	F. B. and Guy Mason	Dr	144.0	4	P	Ss	Kl	N	N	Tc	+.2	4,264.2	21.77	Sept. 12, 1950	
- 7ad	Wm. Yeik	Dr		6	P	Ss	Kl	C, H	S	Tc	+.6		14.66	Sept. 13, 1950	
- 8cc	Clyde Yeik	Dr	92	6	P	Ss	Kl	C, W	S	Hpb	+1.0		24.06	do	
-11aa	L. E. Smith	Dr	77	5	P	Ss	Kl	N	N	Tc	0	4,264.4	38.05	Apr. 2, 1943	
-13bb	Samuel Garrett	Dr	148	5	P	Ss	Kl	N	O	Tc	+.6		43.06	May 22, 1951	
-20bb	C. C. Haddix	Dr	60	6	P	Ss	Kl	C, E	D, S	Bpb	+.4		3.98	Sept. 13, 1950	
-22bb	F. Splinter	Dr	126	7	P	Ss	Kl	C, E	D, S	Ls			30	Nov. 8, 1951	
-25aa	Frank Hughes	Dr	64	4	P	Ss	Kl	C, W	S	Ls			12	Oct. 12, 1951	
-31db	E. David	Dr	140	6	P	Ss	Kl	C, W	S	Tc	+1.2		34.18	Nov. 2, 1950	
-32aa	Pearl L. Janssen	Dr		4	P	Ss	Tc	N	N	Tc	+.7		4.25	do	
-35aa	John Garrelts	Dr	14	4	P	Ss	Kl	C, H	D	Tc	+.2		6.06	Nov. 1, 1948	T57.
22-63- 1ab	Bert W. Welch	Dr	63.5	4	P	Ss	Kl	C, W	S	Bpb	+.2	4,307.8	41.62	Mar. 23, 1943	
- 2ab	Clyde Yeik	Dr		4	P	Ss	Kl	N	N	Tcu	+1.0		46.43	Nov. 8, 1948	
- 4cb	Wm. L. Likins	Dr	67	4	P	Ss	Kl	C, E	D, S	Ls			30	Nov. 8, 1951	
-12ad	Loren E. Likins	Dr	72.2	4	P	Ss	Kl	N	N	Tc	0	4,324.3	38.05	Apr. 24, 1943	
-12cb	E. C. House	Dr	157	5	P	Ss	Kl	C, E	D	Ls			60	Nov. 19, 1951	Ca.
-15dc	Vernon Clemens	Dr	158.5	4	P	Ss	Kl	N	N	Tc	+.6	4,412.0	66.95	Mar. 24, 1943	
-17aa	Lincoln Land Co.	Dr	100	4	P	Ss	Kl	C, N	N	Bpb	0	4,440.8	76.63	do	
-24bb	Laura M. Small	Dr	52.8	4	P	Ss	Kl	N	N	Tc	+.2	4,343.0	23.70	do	
-25dd	Paul H. Arnold	Dr	153.5	4	P	Ss	Kl	N	N	Tc	+.6	4,440.0	77.32	Apr. 3, 1943	
-29aa	F. J. Martin	Dr	1,100	4	P	Ss	Kl	N	N	Tc	+2.3	4,442	22.89	Mar. 24, 1943	
-35dd	E. W. David	Dr	170	6	P	Ss	Kl	C, W	S	Tc	+.9		82.61	Nov. 2, 1950	

22-64- 1bc	A. M. Rhodes	Dr	80.5	4	P	Ss	Tc	C, N	N	Bpb	+.5	4,476.0	55.95	Mar. 22, 1943	
- 6cd	Breckner Bros.	Dr	203	6	P	Ss	Tc	C, W	S	Ls			80	Apr. 15, 1950	L.
- 9bc	Clyde Yeik	Dr	100	6	P	Ss	Kl	C, W	S	Tc	+.4		45.06	Sept. 6, 1950	
-13aa	Laura Hill	Dr	69	4	P	Ss	Tc	C, N	N	Tc	+.7	4,520	35.34	Mar. 23, 1943	
-13cd	do	Dr	71.1	4	P	Ss	Kl	N	N	Tc	+.8	4,501	55.44	do	
-14cc	H. A. Garrelts	Dr	78	6	P	Ss	Kl	J, E	D, S	Twc	+1.3		66.64	Sept. 6, 1950	
-21aa	do	Dr	40	18	P	S, G	Qu(?)	T, E	I	Ls			11	1950	T52, D275M, DD29, Ca.
-21ad	do	Dr	38	18	P	S, G	Qu(?)	T, E	I	Tc	+1.1		13.04	Sept. 6, 1950	D365E.
-22ad	Fed. Land Bank of Omaha.	Dr	67.4	4	P	Ss	Kl	N	N	Tc	+1.4	4,530	44.00	Apr. 30, 1943	
-26cc	G. M. Smith	Du		36	R	Ss	Kl	N	N	Tc	+1.0		33.43	Nov. 13, 1948	
22-65-14cc	Bernice Holden	Dr		4	P	Ss	Ta	C, G	S	Twc	+.6		94.52	Oct. 18, 1950	
-22cc	Mabel S. Fry	Dr		4	P	Ss	Ta	C, H	D	Tc	+.7		78.46	do	
23-60- 6ca	Goshen Irrigation Dist.	Dr		6	P	Ss	Tc	C, H	D	Hph	+1.7		56.79	Sept. 26, 1950	
- 7dd	Karl Sager	Dr	61	6	P	Ss	Kl(?)	C, H	D, S	Hph	+1.3	4,110.5	29.06	Apr. 3, 1951	
- 8cd	State of Wyoming	Dr	15.0	4	N	Ss	Tc	N	N	Ls	0	4,105.8	14.69	do	
- 9cc	do	Dr	88.0	4	N	Ss	Kl(?)	N	N	Ls	0	4,149.2	62.14	do	
- 9dd	do	Dr	11.1	4	N	Ss	Tc	N	N	Ls	0	4,044.1	8.18	Sept. 26, 1950	
-10aa	French Ditch Irrigating Co.	Dr	50	24	P	S, G	Qf	T, E	I, O	Tc	+.5	4,031.3	8.38	Apr. 17, 1951	D1, 370M, DD24.
-10bb	do	Dr	50	26	P	S, G	Qf	T, E	I	Tc	0		9.96	Sept. 27, 1950	T56, D1, 180M, DD10, Ca.
-15ba	do	Dr	50	24	P	S, G	Qf	T, E	I	Tc	+.6		21.12	Apr. 3, 1951	T56, D910M, DD11.8, Ca.
-15cc	John Heiser	Dr		6	P	Ss	Kl	T, E	D, S	Tc	−6.3		23.22	Sept. 28, 1950	
-16da	State of Wyoming	Dr	78.0	4	N	Ss	Tc(?)	N	N	Ls	0		30.52	Sept. 27, 1950	
-18cc	R. Carson	Dr	90	6	P	Ss	Kl	C, H	S	Tc	+.4		14.19	Sept. 25, 1950	
-19cd	P. Keenan	Dr	136	6	P	Ss	Kl	C, W	D, S	Hpb	+.7		5.14	do	
-20bc	M. Marks	Dr	60	6	P	Ss	Kl(?)	C, H	D, S	Ls			30	Sept. 28, 1950	L.
-21dd	Mrs. H. Moline	Dr		5	P	Ss	Kl	Cf, E	D, S	Tc	−4.8		5.07	Nov. 23, 1948	
-30cd	J. Cox	Dr	138	6	P	Ss	Kl	C, E	D, S	Ls			80	Sept. 29, 1950	L.
-33da	E. Baker	Dr	144	6	P	Ss	Kl	C, E	S	Hph	+1.7		33.46	Nov. 23, 1948	
23-61- 1cc	John Oyars	Dr		6	P	Ss	Tc	C, H	D	Hph	+2.1		9.81	Sept. 26, 1950	
- 8da	Alfred D. Eggers	Dr	202.0	5	P	Ss	Kl(?)	N	N	Tc	+1.2	4,255.1	22.19	Apr. 2, 1943	
-11dc	W. Lamma	Dr	130	6	P	Ss	Kl	C, E	D	Hph	+1.3		47.61	Sept. 26, 1950	L.
-12dc	E. Anderson	Dr	50	6	P	Ss	Tc	C, W, H	D	Bpb	+.3		7.18	Sept. 27, 1950	T50, Ca.
-14bb	H. Jones	Dr	140	6	P	Ss	Kl	C, E	D	Ls			40	Sept. 26, 1950	
-14dd	P. L. Rouse	Dr	250	6	P	Ss	Kl	C, E	D	Ls			30	do	
-17dd	Jonas Stolberg	Du		36	R	Ss	Tc	N	O	Twc	0		7.95	Apr. 17, 1951	
-23ad	W. Todd	Dr	120	4	P	Ss	Kl	C, H	D, O	Hph	+1.7		13.07	do	
-23bb	R. Dolezal	Dr	75	6	P	Ss	Kl(?)	C, W	D, S	Tc	+1.4		36.84	Nov. 19, 1948	
-24da	Hazel Brooks	Dr	100	6	P	Ss	Kl	C, H	N	Tc	0		42.21	Sept. 15, 1950	
-24dc	do	Dr	196	4	P	Ss	Kl	C, E	D						L.
-25aa		Sp				Ss	Kl	F	S						T52, Ca.
-26db	W. Riggs	Dr	100		P	Ss	Kl	C, E	D, S	Hph	+1.7		32.69	Nov. 19, 1948	
-27da	J. B. Fuller	Dr	254	6	P	Ss	Kl	C, W	D	Ls			100	Jan. 18, 1950	
-29dd	R. Ludwig	Dr	62	6	P	Ss	Kl(?)	C, E	D, S	Hph	+1.6		18.48	Nov. 19, 1948	
-30dc	Goshen Irrigation Dist.	Dr	125	6	P	Ss	Kl	C, E	D	Hph	+.8		44.56	Oct. 8, 1950	L.
-33cd	R. A. Jepson	Dr	57	4	P	Ss	Kl	C, H	D, O	Hph	+1.8		13.05	Apr. 17, 1951	

TABLE 7.—*Records of wells and springs in Goshen County*—Continued

Well no.	Owner or user	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below (−) land-surface (feet)	Measuring point: Height above mean sea level (feet)	Distance to water level below measuring point (feet)	Date of measurement	Remarks
23-61-36bb	Huntley School	Dr	275	6	P	Ss	Kl	C, E	D	Ls			115	Jan. 12, 1950	T50, D50R, L, Ca.
23-62- 1ad	C. S. Macy	Dr	84.4	7	P	Ss	Tc	N	N	Tc	+2.1	4,297.2	38.70	May 22, 1943	
- 5bb	Mrs. L. B. Ritter	Dr	90	6	P	Ss	Tc	J, E	D, S	Ls			20	Nov. 9, 1951	
- 7bc	H. Bayless	Dr	85	4	P	Ss	Tc	J, E	D, S	Ls			15	do	
- 8ad	B. E. Thompsen	Dr	150	5	P	Ss	Tc	C, W	D, S	Ls			50	do	
-10aa	Ermine L. Davis	Dr	198.0	3	P	Ss	Tc(?)	C, N	N	Tc	+1.2	4,286.1	124.68	Apr. 2, 1943	
-10cb	E. D. Eaton	Dr	134.1		P	Ss	Tc	C, N	O	Bpb	+1.1	4,246.9	77.34	Apr. 17, 1951	
-12ad	Chas. O. Walgreen	Dr	241	6	P	Ss	Tc	C, N	N	Bpb	+.3	4,330.5	191.42	Nov. 30, 1950	
-19bb	Oscar Guth	Dr	113.5	4	P	Ss	Tc(?)	N	N	Tc	+1.0	4,277.5	76.66	Apr. 2, 1943	
-20ad	Nona D. Agee	Dr	185.5	5	P	Ss	Kl(?)	N	N	Tc	+.7	4,305.4	115.52	Nov. 30, 1950	
-24dc	W. G. Krepps	Dr	170	4	P	Ss	Kl	C, W	S	Hph	+1.7		113.38	Oct. 9, 1950	
-34cd	Town of Yoder	Dr	101	18	P	Ss	Kl	T, E	P	Tc	−3.9		4.99	Sept. 13, 1950	D100E, DD67.
-34db	Union Pacific R. R.	Dr	600	15	P	Ss	Kl	C, G	In	Tc	−3.5		18.32	Nov. 1, 1948	L.
-34dc	Town of Yoder	Du	80	72	C	Ss	Kl	T, E	P	Twc	+1.2		16.26	Sept. 13, 1950	
-35dd	Silver Tip Refinery	Du	17.2	36	C	Ss	Tc	N	N	Twc	−6.7		2.52	Nov. 1, 1948	T54.
-36bb	Odessa Dearing	Dr		5	P	Ss	Tc(?)	J, E	D, S	Tc	−5.5		20.40	do	
23-63- 3cd	G. E. Ryan	B	80	6	P	Ss	Kl(?)	C, E	D, S	Tc	−6.8		11.68	Nov. 6, 1948	
- 4cc	H. Haas	Dr		4	P	Ss	Tc(?)	C, E	N	Tc	−5.6		25.42	do	
-10dd	William Pursley	Dr	78	6	P	Ss	Tc	J, E	D, S	Tc	−5.4		31.50	Oct. 10, 1950	
-13cb	Don Brandenburg	Dr	80	5	P	Ss	Tc	J, E	D	Ls			20	Nov. 9, 1951	
-19aa	M. L. Pattison	Dr	78.5	4	P	Ss	Tc	N	N	Tc	+2.3	4,301.0	26.95	Apr. 22, 1943	
-21dd	J. L. Rimmer	Dr	44	6	P	Ss	Tc	C, W, E	D, S	Ls			20	Nov. 9, 1951	
-22ab	T. H. Eaton	Dr	64	5	P	Ss	Tc(?)	C, W	D, S	Ls			22	do	
-25aa	F. Johnston	Dr	60	5	P	Ss	Tc(?)	C, W	D, S	Tc	0		13.22	Nov. 8, 1948	
-26aa	R. S. Rentz	Dr			P	Ss	Tc(?)	C, W	D, S	Tc	+.4		22.17	do	
-32ad	W. A. Clemmens	Dr	112	5	P	Ss	Tc(?)	C, W	N	Bpb	+.8		36.12	Mar. 23, 1943	
-33dd	M. David	Dr		4	P	Ss	Kl	N	N	Tc	0		46.55	Nov. 13, 1948	
23-64- 8cd	T and H Ranch Co.	Dr	14.5	6	P	Ss	Tc	C, W	S	Tc	+1.4		13.34	Sept. 6, 1950	
-13da	Ada M. Hall	Dr	49.2	4	P	Ss	Tc	C, N	N	Tc	+1.2	4,303.0	23.98	Mar. 22, 1943	
-16bc	State of Wyoming	Dr	65	6	P	Ss	Tc	C, W	S	Tc	+.4	4,290.4	10.94	Mar. 20, 1943	
-18ab	T and H Ranch Co.	Dr	52	6	P	Ss	Tc	C, W	D, S	Bpb	+1.0	4,310.6	14.53	Mar. 19, 1943	
-18cb	do	Dr	20.5	6	P	Ss	Tc	C, W	D, S	Tc	+.3	4,321.2	11.90	do	
-19da	C. F. Goertz	Du	26.5	48		Ss	Tc	C, W	S	Bpb	+.8	4,351.2	18.38	Mar. 20, 1943	
-21ac	T and T Ranch Co.	Dr		4	P	Ss	Tc	C, W	S	Tc	+.6		42.20	Sept. 6, 1950	

-25aa	Kenneth H. Yorges	Dr	33.2	3	P	Ss	Kl	N	N	Tc	0	4,347.2	31.55	Mar. 22, 1943	
-25cc	do	Dr	138.5	4	P	Ss	Kl	N	N	Tc	+.4	4,436.7	106.44	do	
-27ac	Merl Teeters	Dr	39.5	5	P	Ss	Tc	C, W	S	Tc	+.6	4,366.4	20.93	Mar. 20, 1943	
-30bd	John C. Teeters	Du		24	P	Ss	Tc	N	N	Tc	+2.3		8.13	Sept. 6, 1950	
-32cb	Merl Teeters	Dr			P	Ss	Kl(?)	C, W	S	Tc	+.5	4,472.8	45.99	do	
-34cd	do	Dr		3	P	Ss	Tc	N	O	Tc	0		6.03	May 22, 1951	
-36dc	State of Wyoming	Dr			P	Ss	Tc(?)	C, W	S	Hph	+1.4		73.83	Nov. 13, 1948	
23-65- 1ba	E. J. Clark	Dr	80	4	P	Sls	Tb(?)	C, E	D	Ls			65	Nov. 8, 1951	
- 2cc	T and H Ranch Co.	Dr	58.5	3	P	Sls	Tb	N	N	Tc	+1.8	4,462.9	45.03	Mar. 19, 1943	
- 3ba	G. S. Dawson	Dr	129.5	5	P	Sls	Tb	C, N	N	Bpb	+.5	4,552.4	67.04	do	
- 9da		Du	33.5	48	R	Sls	Tb(?)	N	N	Twc	+.3	4,473.3	31.85	do	
-14ab	T and H Ranch Co.	Du	24		P	Ss	Tc	N	N	Tc	-.5		19.26	Sept. 6, 1950	
-14cd	G. H. Baker	Dr	33.6	4	P	Ss	Tc	N	N	Tc	+1.4	4,377.5	28.31	Mar. 19, 1943	
-24cb	Carl Brown	Dr		6	P	Ss	Tc	N	N	Tc	+1.2		15.90	Sept. 6, 1950	
-35db	Merl Teeters	Dr		4	P	Ss	Tc	C, W	S	Tc	+1.0		68.83	do	
24-60- 3ad	G. Miller	Dr	140	6	P	S, G	Qt	C, W, H	D, S	Tpc	-5.5	4,204.2	56.19	Mar. 26, 1951	
- 3cd	L. Daiss	Dr	150	6	P	S, G	Qt	C, W, H	D, S	Hph	+1.8	4,204.2	43.90	Sept. 7, 1950	
- 4ad	M. C. Spurgin	Dr	145	5	P	Sls	Tb	C, G	D	Hph	+2.6	4,227.8	50.74	do	L.
- 6cc	E. D. Jones	Dr			P	S, G	Qt	C, W, H	S	Hph	+2.6	4,217.3	40.73	Mar. 26, 1951	
- 7cc	W. I. Middlesworth	Dr	52	5	P	S, G	Qt	C, W	S	Tc	+3.3		25.30	Sept. 6, 1950	
- 9bb	Besse B. Cory	Dr		6	P	S, G	Qt	C, H	S	Hph	+2.0	4,222.9	49.89	Mar. 26, 1951	
- 9cb	do	Dr	26	4	P	S, G	Qt	N	N	Tc	+1.0	4,193.3	19.84	Mar. 25, 1951	
-10aa	F. M. Vermeline	Dr	51.2	4	P	S, G	Qt	C, N	O	Tc	+.8	4,202.0	54.08	Apr. 17, 1951	
-17dc	W. I. Middlesworth	Dr	106	5	P	S	Qt	C, W	S	Ls			80	Sept. 6, 1950	
-19ba	Frank Graham	Du, Dr	32	18	P	S, G	Qf	Cf, G	I, O	Twc	0	4,071.2	14.22	Apr. 17, 1951	
-21db	W. I. Middlesworth	Dr			P	S, G	Qt	C, W	S	Hph	+1.8	4,204.8	61.79	Apr. 2, 1951	
-22ad	do	Dr	106	6	P	S, G	Qt	C, W	S	Tc	+.3	4,200.1	69.48	Sept. 1, 1950	L.
-22ca	do	Dr	76	5	P	S, G	Qt	J, E	D	Tc	-5.0	4,186.3	49.44	Apr. 2, 1951	
-27cd	Edgar Ginter	Dr	73	6	P	Ss	Tc	J, E	D, S, O	Tc	-5.0		16.48	Apr. 17, 1951	
-27dd	R. A. Bissell	Dr	24	14	P	S, G	Qt	Cf, E	D, S	Tcu	0	4,169.3	20.62	Apr. 2, 1951	
-28ca	L. Heinz	Dr	35	18	P	S, G	Qf	T, G	I	Hpb	+.7	4,061.6	18.57	do	
-31da	State of Wyoming	Dr	22.2	4	N	Ss	Tc	N	N	Ls	0	4,063.7	5.32	Apr. 3, 1951	
-32aa	Raymond Lively	Du, Dr	11.0	22	P	S, G	Qf	Cf, G	O	Tc	+.8		7.56	Apr. 17, 1951	
-34bb	R. Parsley	Du	11.9	24	P	Ss	Tc	C, H	D	Tc	0		4.75	Sept. 6, 1950	
-34dd	L. Heinz	Dr		8	P	S, G	Qf	J, E	D, S	Twc	-5.3	4,046.0	12.69	Nov. 20, 1948	
24-61-2bc	E. D. Jones	Dr	100	5	P	Sls	Tb	J, E	D, S	Tc	-6.0		37.03	Aug. 7, 1951	
-2cb	E. W. Gamble	Dr	112	24	P	S, G	Qt	T, E	I, O	Tc	0	4,207.5	75.69	Apr. 17, 1951	T57, D1, 040M, DD9.1, Ca.
- 2dc	John Urback	Dr	145	4	P	S, G	Qt	C, H	D, S	Tcu	+.5	4,202.2	65.60	Sept. 8, 1950	
- 3ac	Kenneth Gamble	Dr	140	24	P	S, G	Qt	T, G	I	Ls			72	Sept. 8, 1944	D1, 010R, L.
- 3cc	J. W. Madden	Dr	219.0	4	P	Sls	Tb	N	N	Tc	+.5	4,206.3	75.70	May 1, 1943	
- 4aa	A. Damrow	Dr	120	18	P	G	Qt	T, G	I	Hpb	+1.0	4,206.7	74.74	Mar. 28, 1951	T58, Ca.
- 5cb1	University of Wyoming.	Dr	93	18	P	S, G	Qf	T, G	I, O	Tpb	+1.0	4,125.4	25.32	Apr. 17, 1951	T57, D1, 220M, DD7, Ca.
- 5cb2	U. S. Geol. Survey	Dn	26.5	1	P	S, G	Qf	N	O	Tc	+2.6		24.87	Nov. 19, 1951	
- 5dd	Jesse J. Hawks	Dr	43	10	P	S, G	Qf	Cf, E	I	Ls			19	June 15, 1947	D712R.
- 6bb	W. B. Jones	Dr	36	20	P	S, G	Qf	Cf, E	I	Tc	-6.0	4,116.4	4.67	Mar. 28, 1951	T57, D900R, Ca.
- 6bc	Lloyd Deering	Dr	54.5	18	P	S, G	Qf	T, G	I	Hpb	0		10.33	Aug. 13, 1951	
- 6bd	W. Froehlich	Dr	36	20	P	S, G	Qf	Cf, N	N	Twc	0		10.92	Oct. 14, 1948	
- 9ba	Clyde Smith	Dr	56	18	P	S, G	Qf	N	N	Tc	+.3	4,115.5	17.36	Aug. 16, 1950	
-10aa	Mrs. V. Jones	Dr	100	4	P	G	Qt	C, E	D	Tc	-5.0	4,178.9	46.19	Sept. 8, 1950	

TABLE 7.—*Records of wells and springs in Goshen County*—Continued

Well no.	Owner or user	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below (−) land-surface (feet)	Measuring point: Height above mean sea level (feet)	Distance to water level below measuring point (feet)	Date of measurement	Remarks
24-61-10bc	City of Torrington	Dr	63	48	C	S, G	Qf	T, E	P	Ls			20	Jan. 6, 1950	T58, D750R, Ca.
-10bd	do	Dr	60	48	C	S, G	Qf	T, E, G	P	Ls			19	Jan. 5, 1950	T58, D1, 000R, DD11, L, Ca.
-10cb1	do	Dr	90	18	C	S, G	Qf	Cf, E	P	Ls			20	do	T56, D650R, DD9, Ca.
-10cb2	do	Dr	73	24	C	S, G	Qf	Cf, E	P	Ls			20		D450R.
-10cb3	do	Dr	80	8	P	S, G	Qf	N	N	Ls			20	Dec. 13, 1951	
-10cb4	do	Dr	80	8	P	S, G	Qf	N	N	Ls			20	do	
-10cc1	Chicago, Burlington and Quincy R. R.	Dr	61	10	P	S, G	Qf	N	N	Ls			17		
-10cc2	do	Dr	64	8	P	S, G	Qf	C, G	In	Ls			17		
-10cd	St. Joseph's Orphanage.	Du, Dr	37.0	74	C	S, G	Qf	T, E	I, O	Tc	+1.0	4, 099.1	21.93	Apr. 17, 1951	D800M, DD6.7.
-10db	Goshen Co. Memorial Hosp.	Dr	470	6	P	Ss	Kl	C, E, F	P						T59, D15M, L, Ca.
-13cb	John Fales	Dr	27	6	P	S, G	Qf	Cf, E	I, O	Tc	−6.0	4, 079.1	8.25	Mar. 28, 1951	
-14aa	Henry Miller	Dr	1, 080	6	P	Ss	Kl(?)	C, H, F	D, S	Tc	+.2				
-15ab	Preston Wyo, Farms Co.	Dr		18	P	S, G	Qf	T, G	I	Hpb	+.2		20.78	Apr. 2, 1951	D1, 400M, DD11.
-15ba	St. Joseph's Orphanage.	Dr	50	18	P	S, G	Qf	N	N	Tc	0		17.52	Aug. 21, 1951	
-15cc1	Holly Sugar Co.	Dr	85	20	P	S, G	Qf	T, E	In	Hpb	+2.4		13.77	Oct. 9, 1951	T57, D3, 400M, DD18.3, L, Ca.
-15cc2	do	Dr	86	20	P	S, G	Qf	T, E	In	Hpb	+2.2	4, 085.2	11.65	do	T52, D3, 100R, Ca.
-15cc3	do	Dr	87	20	P	S, G	Qf	T, E	In	Hpb	+2.4	4, 085.6	12.10	do	D3, 100R.
-15cc4	do	Dr	100	3	P	S, G	Qf	N	N	Tc	+2.4		11.05	do	
-15cc5	do	Dr	435	6	P	Ss	Kl	F	D						L.
-15cd	Yellowstone Potatoe Co.	Dr	38	18	P	S, G	Qf	Cf, E	In, O	Tc	0	4, 083.7	11.50	Apr. 17, 1951	
-20dd	Herb Helgenfeld	Dr		5	P	S, G	Qf	Cf, E	D	Tc	−5.5		10.84	Nov. 1, 1948	
-21ab	Lincoln Land Co.	Dr	50	4	P	S, G	Qf	C, E	S	Tc	−5.0	4, 085.6	5.43	Jan. 17, 1951	T52, Ca.
-22ba	John Hardesdy	Dr	26	10	P	S, G	Qf	J, E	S	Tc	−4.3		.75	Sept. 7, 1951	T56, Ca.
-22bb	Union Pacific R. R.	Dr		24	C	S, G	Qf	Cf, G	In	Tc	−3.8		7.68	Oct. 25, 1948	D300R.
-23ab	O. E. Jackson	Du, Dr	26.8	20	P	S, G	Qf	C, G	I	Twc	0		9.60	Aug. 13, 1951	

-23ac	do	Dr	30	18	P	S, G	Qf	T, E	I	Tc	+2.0		8.40	Nov. 2, 1948	D580M, DD7.2.
-23ad	do	Dr	35	20	P	S, G	Qf	Cf, G	S, I	Twc	0		9.33	do	D740M, DD8.2.
-23bb	R. C. Carroll	Du	28	40	C	S, G	Qf	T, G	I	Bpb	+.3	4,078	9.88	do	D700R.
-26dc	C. A. Quade	Dr		24	C	Sl, Cl	Tc	N	N	Tc	+.5	4,117	5.50	May 22, 1951	
-28cb	Clyde Smith	Dr	275	6	P	Ss	Kl	C, G	S	Tc	+.6		116.23	Oct. 9, 1950	L.
-31bb	E. Hunter	Dr	160	6	P	Ss	Kl	C, E	D, S	Ls			142	Nov. 9, 1951	
-32dd	Henry Holkenbrink	Dr	140	5	P	Ss	Tc	N	N	Tc	+1.0		137.88	Nov. 1, 1948	
-33cc	H. L. Holkenbrink	Dr	162.5	5	P	Ss	Tc	N	N	Tc	+.7	4,347.4	142.10	Apr. 2, 1943	
-35bb	P. Porter	Du	15			Sl, Cl	Tc	C, H	D, O	Bpb	+.2		5.95	Apr. 17, 1951	
-36aa	State of Wyoming	Dr	35.2	4	N	Sl, Cl	Tc	N	N	Ls	0		24.32	Sept. 27, 1950	
-36ab	do	Dr	36.2	4	N	Sl, Cl	Tc	N	N	Ls	0	4,145.3	28.40	May 22, 1951	
24-62- 1ab	J. C. Lynch	Dr			P	S, G	Qf	Cf, G	I	Tcu	0		8.85	Oct. 14, 1948	
- 1cb	Lincoln Land Co.	Dn		2	P	G	Qf	C, W	S	Ls			10	Oct. 2, 1950	
- 3cc	R. L. Kelley	Dr	70	6	P	Sl, Cl	Tc	C, H	D	Tc	+.4	4,192.0	36.38	Apr. 3, 1951	
- 3dc	Lincoln Land Co.	Dr		5	P	Ss	Tc	J, E	D, S	Tc	−6.5		30.21	Nov. 18, 1948	
- 4cc	James Franks	Dr	40.0	6	P	Sls	Tb(?)	C, H	D	Hph	+2.6	4,229.1	35.64	Apr. 3, 1951	
- 5bb1	H. Herman	Dr	30.5	4	P	Sl, Cl	Tc	N	N	Tc	0	4,225.2	18.91	Oct. 2, 1950	
- 5bb2	do	Dr	196	6	P	Ss	Kl	C, W	D	Hph	+1.6		80.19	do	
- 6ba	A. Harvey	Dr	83.6	6	P	Ss	Tc	C, W	S	Tc	+.6		77.70	Oct. 5, 1950	
- 6da	B. Power	Dr	25	6	P	Sl, Cl	Tc(?)	C, H	D	Tc	+.4		15.84	Oct. 2, 1950	
- 6dd	W. Bremer	Dr	64	6	P	Sls	Tb(?)	J, E	D, S	Tc	−5.0	4,282.2	44.83	Apr. 3, 1951	
- 8bc	Chris H. Bremer	Dr	139	4	P	Sls	Tb(?)	C, N	N	Bpb	+1.2	4,335.5	99.08	May 14, 1943	
-10ad	L. Wagner	Dr	39.4	6	P	Sl, Cl	Tc	C, E	D	Hph	+1.3	4,184.1	31.35	Apr. 3, 1951	
-10cd	O. Huckfelt	Dr	44.5	4	P	Sls	Tb	N	N	Tc	+1.7	4,257.3	34.91		
-11da	H. Smith	Dr	11.3	6	P	Sl, Cl	Tc	C, H	D, O	Tc	+.2	4,129.5	7.55	Apr. 17, 1951	
-13bc	P. Grant	Dr	90	4	P	Ss	Tc(?)	C, W	S	Tc	−5.0		11.14	Nov. 18, 1948	
-13cb	do	Dr		6	P	Ss	Kl(?)	C, E	D	Twc	0		115.35	Oct. 3, 1950	
-14ba	W. D. Lichty	Dr	160	6	P	Ss	Kl(?)	C, E	D	Ls			120	do	
-18ab	W. Bremer	Dr	70	4	P	Sls	Tb	C, W	S, O	Tc	+.7		52.37	Feb. 19, 1951	
-20bc	A. N. Clark	Dr	420	6	P	Ss	Kl	C, W	S	Twc	+1.0		94.17	Oct. 2, 1950	
-22ca	W. Bremer	Dr		6	P	Ss	Tc	C, W	N						Ca.
-22cd	do	Dr	83	4	P	Ss	Tc	C, W	S	Tc	+.5		27.59	May 25, 1949	Ca.
-23db	U. S. Geol. Survey	Dr	44.5	1¼	P	Sls	Tb	N	O	Tc	+2.5	4,258.2	39.39	Apr. 17, 1951	
-25bc	Charles Fritz	Dr	73.7	4	P	Ss	Tc	N	N	Tc	+.1	4,157.4	19.98	May 29, 1943	
-25cc	U. S. Geol. Survey	Dn	12.8	½	P			N	O	Tc	+1.2	4,152.7	12.12	Apr. 17, 1951	
-27ac1	do	Dr	30.6	1¼	P			N	O	Tc	+1.4	4,258.6	23.48	do	
-27ac2	do	Dn	12.7	½	P			N	O	Tc	+1.3	4,226.1	4.95	May 11, 1949	
-27bd	do	Dn	16.1	½	P			N	O	Tc	+.9	4,245.5	14.43	Apr. 17, 1951	
-27db	do	Dn	16.8	½	P			N	O	Tc	+2.2	4,216.5	7.06	Sept. 13, 1949	
-28dd	do	Dn	11.6	½	P			N	O	Tc	+2.4	4,217.3	8.16	do	
-32aa	do	Dn	11.8	½	P			N	O	Tc	+2.2	4,245.8	10.62	Apr. 17, 1951	
-34bc	do	Dn	19.3	½	P			N	O	Tc	+1.7	4,167.8	13.11	do	
24-63- 1dd	A. Brown	Dr	233.5	4	P	Ss	Kl	N	N	Tc	0		128.52	Oct. 5, 1950	
- 2bb	Amos Gillaspie	Dr	56.2	6	P	Sls	Tb	C, W	S	Hph	+2.3	4,358.3	45.45	Apr. 3, 1951	
- 2dd	W. Bremer	Dr	81.3	4	P	Ss	Tc	C, H	S	Tc	+.2	4,297.9	60.00	do	
- 7dc	Kenneth Pursley	Dr	290	4	P	Ss	Kl	C, W	D, S						L.
- 8cd	H. L. Holkenbrink	Dr	91.0	5	P	Sls	Tb	N	N	Tc	+.2		89.40	Aug. 28, 1950	
- 9ba	H. Pursley	Dr	140	6	P	Sls	Tb	C, W	D, S	Ls			78	Nov. 8, 1951	
-12cd	A. N. Clark	Dr	270	6	P	Ss	Kl(?)	C, W	D, S	Ls			100	Oct. 2, 1950	
-17dd	Paul Johnson	Dr	315	6	P	Ss	Kl	C, W	S	Tc	+.4		206.53	Nov. 2, 1950	L.
-18da	Kenneth Pursley	Dr		4	P	Ss	Tc(?)	C, G	S	Hpb	+1.3		19.89	Aug. 28, 1950	

TABLE 7.—*Records of wells and springs in Goshen County*—Continued

Well no.	Owner or user	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below (−) land-surface (feet)	Measuring point: Height above mean sea level (feet)	Distance to water level below measuring point (feet)	Date of measurement	Remarks
24-63-22ba	P. Johnson	Dr	88.5	6	P	Ss	Tc(?)	N	O	Bpb	+.6	4,337.1	39.52	Apr. 17, 1951	
-25dd	Frank Adams	Dr	144.5	4	P	Ss	Tc	C, N	N	Bpb	+1.3	4,310	54.57	May 14, 1943	
-28bc	Harry Cressan	Dr	31.5	6	P	Ss	Tc	C, N	N	Tc	+1.1	4,276.0	16.75	Mar. 16, 1943	
-31ba	Carl Spencer	Dr	50.2	6	P	Ss	Tc	C, N	N	Bpb	+.3	4,266.2	18.65	Mar. 17, 1943	
-35bc	Robert Curry	Dr	150	6	P	Ss	Kl	C, E	D, S	Ls			75	Nov. 9, 1951	
24-64-12cc	Harry G. Shepard	Dr	42.1	5	P	Ss	Tc	C, N	O	Tc	+.7	4,397.5	19.08	May 22, 1951	
-12dd	Edward Pursley	Dr	40	5	P	Ss	Tc	C, W	D	Tc	+.1		27.76	Aug. 28, 1950	
-17dd	Marie J. Krauss	Dr	192	6	P	Ss	Tc	C, N	N	Tc	+1.0		172.35	Mar. 17, 1943	
-22da	T and H Ranch Co.	Dr	33.5	4	P	Ss	Tc	N	N	Twc	+1.3	4,341.6	30.47	do.	
-27cb	Albert H. Kemper	Dr	60	4	P	Sls	Tb	C, W	D, S	Ls			45	Aug. 28, 1950	
-29ba	E. J. Clark	Dr	75.2	3	P	Ss	Tc	C, N	N	Bpb	+1.5	4,460.8	53.65	Mar. 17, 1943	
-34cc	E. W. Oaks	Dr	27.5	4	P	Ss	Tc	N	O	Tc	+.8	4,331.5	19.96	May 22, 1951	
24-65- 9aa		Dr			P	Ss	Ta	C, W, H	S	Hph	+1.8	4,899.2	81.89	May 25, 1951	
-15cd	G. Gamblin	Dr	204	5	P	Ss	Ta	C, W	S	Tc	+.6		190.89	May 29, 1951	
-24aa	do.	Dr			P	Sls	Tb	C, W	S	Hpb	+.9		42.38	do.	
25-60- 6ac	John Conway	Dr	100	4	P	Sls	Tb	N	N	Tc	+.6	4,492.6	55.17	June 6, 1950	
- 8dd	Clayton Lif	Dr	110	4	P	Sls	Tb	C, W, G	D, S	Tc	+.5	4,304.7	79.22	do.	T56, D7E.
-19bb	G. E. Nash	Dr	425	4	P	Sls	Tb	N	N	Tc	+3.6		172.66	June 4, 1950	L.
-28db	do.	Dr	310	8	P	Sls, Ss	Tb, Tc	C, W	S	Tc	+.3	4,336.5	162.28	June 6, 1950	D7E.
-29bb	do.	Dr	380	6	P	Ss	Tc	C, W	S	Tc	+.2	4,330.8	199.69	do.	D2E.
25-61- 2ba	W. A. Hovey	Dr	190			Sls	Tb	C, W	S	Tc	+.3		50.46	June 5, 1950	
- 2dc	do.	Dr	61		P	Sls	Tb	C, W	S	Ls			59	Nov. 26, 1951	
- 5da	J. C. Christenson	Dr	100	5	P	Sls	Tb	C, W	S	Tph	+2.7		80.24	do.	
- 6cb	do.	Dr	100	5	P	Sls	Tb	C, W, E	D, S	Ls			80	do.	T55, Ca.
- 7dc	Clarence Mullock	Dr	98.5	6	P	S, G	Qt	T, E	D	Ls			89		T55, D60R.
-16bb	State of Wyoming	Dr	81.1	6	P	Sls	Tb(?)	C, W	S	Tc	+2.8		52.54	Nov. 30, 1951	
-18cc	J. W. Jobe	Dr	105	4	P	S, G	Qt(?)	C, N	N	Tc	+.3	4,261.7	85.87	May 1, 1943	
-19ad	do.	Dr		4	P	S, G	Qt(?)	N	N	Tc	+.2	4,264.2	82.06	Mar. 28, 1951	
-19bc	C. A. Rife	Dr	120			S, G	Qt	N	N	Ls			70	1946	L.
-21cc	J. M. Keefer	Dr	197	4	P	S, G	Qt(?)	C, N	N	Tc	+.5	4,250.8	74.96	May 31, 1943	
-26dc	W. B. Coy	Dr		6	P	S, G	Qt	C, W	S	Bpb	−1.1		61.37	June 5, 1950	
-27cb	Charles Stricker	Dr	86	18	P	S, G	Qt	T, G	I	Tc	+.4	4,219.5	37.46	Mar. 28, 1951	D800R, DD28, L.
-28ad	H. Hobson	Dr	75	4	P	S, G	Qt	C, W, G	S	Bpb	+1.9		17.29	Aug. 25, 1950	
-28bc	Homer Hood	Dr	120	18	P	S, G	Qt	T, G	I	Hpb	+.5		59.59	Aug. 6, 1951	T58, D500M, DD 5.2, L, Ca.

-28cc	G. L. Hood	Dr	120	18	P	S, G	Qt	T, G	I	Edp	+6.0		56.97	Oct. 14, 1948	D920M, DD8.
-28db	M. W. Berry	Dr	106	24	P	S, G	Qt	T, E	I, O	Tc	0	4,223.1	47.65	Apr. 17, 1951	D1,290M, DD15, L.
-29da	C. A. Gamble	Dr	112	18	P	S, G	Qt	T, G	I	Hpb	0	4,237.6	62.75	Mar. 28, 1951	D860M, DD6.1, L.
-30ac	V. Funchouser	Dr		5	P	S, G	Qt	C, E	D, S	Hph	+2.2	4,245.3	69.77	Mar. 26, 1951	
-31db	R. E. McLeod	Dr	95	18	P	S, G	Qf	T, G	I	Tpb	+1.0	4,151.2	41.15	Mar. 28, 1951	T57, D1, 040M, DD8.8, L, Ca.
-32aa	Elmer Robbins	Dr	96	14	P	S, G	Qt	T, G	I	Hpb	0		52.08	Aug. 17, 1951	D1, 200R, DD16.
-33ab	Boyd Reid	Dr	96	18	P	S, G	Qt	T, E	I	Tc	0	4,210.8	35.73	Mar. 28, 1951	T57, D1, 200M, DD9.2, L, Ca.
-33bb	W. G. Sellers	Dr	117	18	P	S, G	Qt	T, G	I	Edp	+5.5	4,231.8	54.40	Oct. 14, 1948	D1,000R, DD8, L
-33cd	K. Webb	Dr	89	18	P	S, G	Qt	T, G	I	Hpb	+1.0	4,217.6	77.28	Mar. 28, 1951	D400R.
-33db	W. M. Schumarher	Dr	91	18	P	S, G	Qt	T, G	I	Ls			28	Aug. 30, 1948	D1,000R, DD47, L.
-33dc	do	Dr	72	18	P	S, G	Qt	T, G	I	Ls			60	July 16, 1946	D500R.
-34bb	D. and M. Miller	Dr	87	27	P	S, G	Qt	T, E	I	Tc	+.3	4,205.9	30.19	Mar. 29, 1951	D1,160M, DD14, L.
-34dc	E. Shaine	Dr	80	6	P	S, G, Sls	Qt, Tb	J, E	D	Ls			30	Sept. 8, 1950	L.
-35bb	A. D. Hacker	Dr	96		P	S, G	Qt	C, W	D, S	Tc	+.6	4,231.1	58.45	Mar. 28, 1951	
-35cc	J. E. Walla	Dr	86	24	P	S, G	Qt	T, G	I	Hpb	+.5	4,191.0	28.18	do	D1,200R, DD11, L.
25-62-4 cc	L. R. Brewer	Dr	39.0	5	P	S, G	Qf	C, H	D, O	Bpb	+1.4	4,227.5	24.58	Apr. 17, 1951	
-7 cb	E. Greenwald	Dr	70	4	P	Sls	Tb	J, E	D	Twc	+1.1	4,222	68.05	Mar. 29, 1951	
-8 ba	P. H. DuPertuis	Dr		6	P	Sls	Tb	C, W	S	Tc	+.5	4,283.4	72.86	Mar. 28, 1951	
-10ab	C. W. Yorges	Dr	45	6	P	Sls	Tb(?)	N	N	Tc	+.4	4,245.6	44.74	do	
-10cb	C. Caldwell	Dr	80	6	P	Ss	Tc(?)	J, E	D	Bpb	−5.9	4,199.1	11.98	July 26, 1950	
-10da	V. McElhaney	Dr	410	6	P	Ss	Kl	C, W	D	Ls		4,305.3	180	do	L.
-11bb	C. L. Beatty	Dr	87	3	P	Sls	Tb(?)	N	N	Tc	+1.2	4,268.4	65.11	Aug. 11, 1943	
-12dc	Lloyd McElhaney	Dr	300	4	P			N	N	Tc	0	4,317.7	79.89	May 31, 1943	
-14ab	A. B. Daniel	Dr	146.5	4	P	Ss	Tc	C, N	N	Tc	+.4	4,294.4	111.57	do	
-15bc	A. Dolberg	Du				S, G	Qf	C, W	D	Tcu	+.3		6.98	Oct. 13, 1948	T57.
-15cd1	C. Smith	Dr	65	4	P	S	Qf	N	O	Tc	−4.1	4,175.6	3.51	Apr. 17, 1951	
-15cd2	do	Dr	103	3	P	S	Qf	C, H	D, O	Tc	+.8	4,172.3	7.06	Nov. 19, 1951	L.
-16bc	O. Daiss	Dr	63	6	P	S, G	Qf	J, E	D	Tc	+.4	4,188.8	10.60	July 26, 1950	L.
-16cd	D. Daiss	Dr	61	6	P	S	Qf	J, E	D	Ls			34	do	
-17bd	Lingle Cemetery	Dr		4	P	Sls	Tb(?)	J, E	D	Tc	−5.9	4,223.6	55.17	Mar. 28, 1951	
-18ca	Sarah Miller	Dr	67	18	P	S, G	Qf	T, G	I	Tc	+1.2	4,175.5	25.40	do	D1,040M, DD7, L
-18cb	Alice F. Peterson	Dr		18	P	S, G	Qf	T, G	I	Hpb	+.7		19.55	Aug. 7, 1951	
-18da	J. A. Woods	Dr	44	18	P	S, G	Qf	T, G	I	Hpb	+1.5		21.39	July 18, 1950	D520R.
-18db1	Town of Lingle	Dr	50	6	P	S, G	Qf	Cf, E	P	Ls					
-18db2	do	Dr	50	6	P	S, G	Qf	Cf, E	P	Ls					
-18db3	do	Dr	51	18	P	S, G	Qf	T, E	P	Tc	+1.5		22.68	Jan. 10, 1950	T59, L, Ca.
-19aa	Lester C. Stroud	Dr	83	18	P	S, G	Qf	T, G	I, O	Tpb	+.6	4,172.9	26.02	Apr. 17, 1951	D1,000R, DD4.
-19dc	John Vandel	Dr	52	18	P	S, G	Qf	T, G	I	Edp	+3.5	4,156.9	15.94	Mar. 28, 1951	D1,000R, DD4.
-22cd	J. M. Patton	Dn	15	1½	P	S	Qf	N	N	Tc	−.5	4,163.7	12.34	do	
-24cc	B. F. Marshall	Dr	60	4	P	S, G	Qt	C, W	D, S	Tc	−4.0	4,226.9	49.64	do	
-24cd	J. G. Webb	Dr	70	6	P	S, G	Qt	J, E	D, S	Ls			34	July 27, 1950	
-25cc	Lingle Water Users Assoc.	Dr	110.5	4	P	S, G	Qf	C, N	N	Twc	+.5	4,201.1	58.13	May 1, 1943	
-27bd	M. Stephenson	Dr	32		P	S, G	Qf	C, G	S	Twc	+.3	4,153.6	19.98	Oct. 13, 1948	
-27dd	E. Lum	Dr		4	P	Sl, Cl	Tc	C, H	D, S	Twc	0		46.78	Oct. 21, 1945	
-31bd	Ted Phelps	Dr	102	4	P	Ss	Tc	C, H	D	Tc	0		22.00	July 19, 1950	

TABLE 7.—*Records of wells and springs in Goshen County*—Continued

Well no.	Owner or user	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below (−) land-surface (feet)	Measuring point: Height above mean sea level (feet)	Distance to water level below measuring point (feet)	Date of measurement	Remarks
25-62-32dd	W. Kaphe	Dr	50		P	S, G	Qf	J, E	D, S	Tc	−5.0	4,166.3	18.55	Nov. 18, 1948	
-34ca	D. H. Willer	Du	12	72	P	S, G	Qf	Cf, G	I	Tc	−5.0		3.77	Nov. 20, 1948	D550R.
-36ca	W. W. Weckwerth	Dn	10	1½	P	S, G	Qf	Cf, G	I, O	Tc	+1.4	4,118.0	9.14	Apr. 17, 1951	D73R.
25-63- 1dd	H. Oxley	Du		60	C	Sls	Tb	C, W	S	Twc	+.3	4,265.5	57.39	Mar. 29, 1951	
- 2cc	Afton Koenig	Dr	72	5	P	S, G	Qf	C, E	D, S	Tc	−5.4	4,203.7	52.86	do	
- 4ac	L. Oliver	Dr	62.5	18	P	S, G	Qf	N	N	Tc	0	4,200.1	25.79	do	
- 5cc	E. L. Parish	Dr	70	5	P	Sls	Tb	J, E	D	Tcu	0	4,218.0	25.56	Oct. 17, 1950	
- 7da	H. W. Markland	Dr	96	4	P	Sls	Tb	J, E	D	Tc	−8.9		29.19	July 20, 1950	
- 8dc1	C. J. Burns	Dr	140	6	P	Ss	Kl	J, E	D, S	Ls		4,204.0	18	1947	L.
- 8dc2	do	Dr	68.5	24	P	S, G	Qf	T, G	I	Tc	+.2	4,216.4	25.59	Apr. 4, 1951	T58, D1, 020M, DD24.7, Ca.
- 9cc	Emery Bright	Dr	61.0	24	P	S, G	Qf	T, G	I, O	Hpb	+.5	4,197.3	24.19	Apr. 17, 1951	D1, 300R, DD8.
- 9db	A. Sterkel	Dr	64	18	P	S, G	Qf	T, G	I	Hpb	+.4	4,195.8	26.03	Apr. 4, 1951	D1, 350R, DD12, L.
-11ad	H. S. Kirk	Dr	72	18	P	S, G	Qf	T, G	I	Hph	0	4,198.3	32.33	June 28, 1950	D800R, L.
-12bd	R. Peterson	Dr	81	18	P	S, G	Qf	T, G	I, O	Hpb	+1.8	4,210.3	45.34	Apr. 17, 1951	T59, D1, 590M, DD9.8, L, Ca.
-13bb	C. H. Hayes	Dr	60	10	P	S, G	Qf	T, G	I	Edp	+4.0	4,180.6	32.09	Mar. 29, 1951	D900R.
-13cd	R. N. Paules	Du		48		S, G	Qf	Cf, E	D	Tc	−7.2	4,158.8	10.73	do	
-15cc	W. H. Wagner	Dr	87	6	P	S, G	Qf	J, E	D	Tc	−6.0	4,206.1	34.12	Apr. 3, 1951	L.
-15db	John Walters	Dr	87	18	P	S, G	Qf	T, G	I	Tpb	+.5	4,176.7	17.45	do	D1, 000R, DD5.
-16bb	F. R. Pearson	Du, Dr	30.0	60	C	S, G	Qf	N	N	Tc	−.3	4,193.1	21.89	Apr. 4, 1951	
-17bd	Lincoln Land Co	Dr	65.3	24	P	S, G	Qf	T, G	I	Tc	+.3	4,226.2	19.47	do	D600M, L.
-17da	R. H. Lamphier	Dr	71.0	4	P	S, G	Qf	J, E	D	Tc	−7.2	4,207.9	20.71	July 20, 1950	
-20ad	J. Specknor	Dr	150	4	P	Ss	Kl(?)	J, E	D	Twc	−4.2		45.20	July 18, 1950	
-21ac	R. H. Lamphier	Dr	60	6	P	Sl, Cl	Tb	C, H	D	Tc	0	4,245.1	43.54	July 20, 1950	
-22aa	Greenwald Estate	Dr	60	18	P	S, G	Qf	T, G	I, O	Tpb	+.2	4,177.4	20.85	Apr. 17, 1951	D1, 200R, DD8.
-25bd	U. S. Bureau of Reclamation.	Dr	147	6	P	Ss	Kl	J, E	D	Tpc	−3.5	4,165	18.64	July 21, 1950	D6.6M, DD31, L.
-25ca	E. G. Phelps	Sp				Sls	Tb	F	N						D200E.
-25cc	O. Daiss	Dr		6	P	Sl, Cl	Tc(?)	C, W	N	Twc	+1.2	4,265.3	34.38	Apr. 3, 1951	
-25da	E. G. Phelps	Sp				Sls	Tb	F	N						D300E.
-25db	do	Sp				Sls	Tb	F	D, I						D500E.
-27ad	T. Daiss	Dr	22	4	P	Sls	Tb	C, H	D	Tc	0	4,247.9	20.31	July 20, 1950	
-32aa	W. M. Fairbanks	Dr	70	6	P	Sls	Tb	C, W, H	D	Tc	+.8	4,411.3	62.21	May 24, 1951	

-33aa	H. L. Holkenbrink	Dr	64.8	4	P	Sls	Tb	N	N	Tc	+.3	4,325.4	54.82	Apr. 8, 1943	
25-64- 2cc	C. H. Fleming	Dr	57.4	5	P	Ss	Ta	C, W	S	Tc	+2.2	4,366.5	37.62	May 1, 1951	
- 5da	Harold DeWitt	Dr	137	6	P	Ss	Ta	N	N	Tc	+1.6	4,423.6	97.44	Apr. 29, 1943	
- 9cb	Charles Motsick	Dr	179.5	6	P	Ss	Ta	N	N	Tc	+.6	4,521.4	138.34	May 2, 1951	
-10aa	Keith Duncan	Dr	55.3	5	P	Ss	Ta	C, W	S	Tc	+.5	4,384.6	49.76	May 1, 1951	
-10da	A. A. Darnall	Dr	86.1	5	P	Ss	Ta	C, W	S	Tc	+.5	4,428.5	68.70	do	
-14bc	T. F. Daiss	Dr	178.8	6	P	Ss	Tb	C, W	S	Tc	+.3	4,540.4	138.65	do	
-16cb	P. Pontarolo	Dr		6	P	Ss	Ta	C, W	D, S	Hph	+1.9	4,570.6	154.83	May 2, 1951	
-17ad	Wm. W. Duncan	Dr	185	5	P	Ss	Ta	C, N	N	Bpb	+.8	4,554.0	145.44	do	
-22ba	Angela Pontarolo	Dr	175	6	P	Ss	Ta(?)	C, W	D, S	Tc	+1.5	4,586.4	116.38	May 1, 1951	
-22cc	E. F. Stout	Dr	180		P	Ss	Ta(?)	C, W	S	Hph	+1.9	4,634.1	146.62	May 2, 1951	
-25cc	G. Duncan	Dr	120	5	P	Sls	Tb	C, W	D, S	Tc	+.7	4,723.8	105.68	Aug. 28, 1950	T54, Ca.
-29aa	L. F. Miller	Dr		3	P	Sls	Tb(?)	C, W	S	Hph	+2.0	4,745.2	219.17	May 2, 1951	
-32da	Allington Adams	Dr	199	5	P	Sls	Tb	C, N	N	Tc	+.5	4,724.1	134.22	May 1, 1951	
-34aa	J. C. Schaefer	Dr	152	3	P	Sls	Tb	C, W	S	Hph	+2.4	4,680.1	91.81	May 2, 1951	
25-65- 3dc	Henry Butler	Dr	48		P	Ss	Ta	C, H	D	Hph	+1.3	4,437.4	33.84	May 29, 1951	
-26bb	R. F. Harroun	Dr		6	P	Ss	Ta	C, E	D, S	Tc	+.3	4,819.5	222.28	do	
-35bc	C. A. Summers	Dr		6	P	Ss	Ta	C, N	N	Tc	0	4,889.3	224.83	May 25, 1951	
-35da	G. L. Solomon	Dr		5	P	Ss	Ta	C, N	N	Tc	+.8	4,919.8	275.89	do	
26-60- 4cc	G. W. Carpenter	Dr		5	P	Sls	Tb	C, W	S	Tc	+.3	4,433.0	52.42	June 8, 1950	D10E
- 5ca	Thomas Duncan	Dr		6	P	Sls	Tb	N	N	Tc	+.6	4,469.4	57.77	do	
- 6dc	Carpenter and Broadbent.	Dr	286	6	P	Sls	Tb	C, W	S	Tc	0	4,550.8	82.69	do	
-10dd	do	Dr	17.6	5	P	Sls	Tb	N	N	Tc	0	4,356.6	14.52	do	
-16bc	State of Wyoming	Dr	80.5	5	P	Sls	Tb	N	N	Tc	0	4,361.9	41.31	do	
-22bd	Carpenter and Broadbent.	Dr	51.4	5	P	Sls	Tb	N	N	Tc	+1.6	4,336.0	37.42	do	
-28bb	John Conway	Dr	100	6	P	Sls	Tb	N	N	Tc	+1.2	4,400.1	75.88	June 7, 1950	
-29dd	do	Dr	90	5	P	Sls	Tb	N	N	Tc	+.5	4,418.0	64.52	do	
-30da	do	Dr	64		P	Sls	Tb	C, W	S	Hph	+1.8	4,464.3	47.24	June 16, 1950	
- 2dd	Chestnut Valley Ranch Inc.	Dr		5	P	Sls	Tb	C, W	S	Hpb	+.4	4,500.1	53.05	June 18, 1950	
- 3bd	Jess Deahl	Dr	80	6	P	Sls	Tb	C, W	S	Twc	+.4		80.20	June 27, 1950	
- 4dd	do	Dr	79	8	P	Sls	Tb	C, W	S	Tc	+1.3	4,556.9	61.99	do	
- 5cb	do	Dr	90	6	P	Sls	Tb	C, W	S	Tpc	+1.4		65.46	do	
-10da	James Moore	Dr		6	P	Sls	Tb	N	N	Tc	+1.0	4,499.2	66.71	June 17, 1950	
-12bd	M. Beaty	Dr	120	6	P	Sls	Tb	C, W	D, S	Ls			100	Oct. 23, 1951	Ca.
-12dc	Louise Mantor	Dr	80	6	P	Sls	Tb	N	N	Tc	+1.3	4,448.9	55.12	June 7, 1950	
-14ad	State of Wyoming	Dr	85	5	P	Sls	Tb	C, H	D	Tc	0	4,443.2	55.94	June 8, 1950	
-14cc	Hattie Fitzgerald	Dr	80	5	P	Sls	Tb	N	N	Twc	0		36.82	June 9, 1950	
-15ca	Carl Hanson	Dr		6	P	Sls	Tb	C, W	S	Bpb	+2.4		64.38	do	
-16da	State of Wyoming	Dr		6	P	Sls	Tb	C, H	D, O	Tc	0	4,425.8	51.97	Apr. 17, 1951	
-17bc	J. G. Deahl	Dr		5	P	Sls	Tb	C, W	S	Ls			99	Nov. 30, 1951	
-21ad	Fred Milsap	Dr	60	6	P	Sls	Tb	C, W	D, S	Tc	−4.3	4,389.5	39.00	June 9, 1950	
-22db	Hattie Fitzgerald	Dr		5	P	Sls	Tb	C, W	S	Tc	−.3		55.02	do	
-24dc	John Conway	Dr	40.7	3	P	Sls	Tb	N	N	Tc	+.2	4,403.9	38.52	June 16, 1950	
-27db	Hattie Fitzgerald	Dr	75	4	P	S, G	Qt	N	N	Tc	0		28.03	June 9, 1950	
-29dd	Fred Milsap	Dr		6	P	Sls	Tb	C, W	S	Tc	+2.5	4,420.0	82.33	do	
-35dd	W. A. Hovey	Dr	160	6	P	Sls	Tb	C, G	D, S	Tc	+.5	4,389.7	50.42	June 5, 1950	T53, Ca.
26-62- 8ba	Malm Bros.	Dr	73	6	P	Sls	Tb	C, W	S	Tc	+.8	4,431.9	39.01	July 10, 1950	
-11dc	A. Damrow	Dr		18	P	S, G	Qf	T, G	I	Tc	0		14.74	Oct. 12, 1948	
-11dd	do	Dr	66	18	P	S, G	Qf	N	N	Tc	+.6		18.02	July 26, 1950	L.
-14ba	do	Dr	62	18	P	S, G	Qf	T, G	I	Tpb	0		16.57	Oct. 12, 1948	D200R, L.

TABLE 7.—*Records of wells and springs in Goshen County*—Continued

Well no.	Owner or user	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below (−) land-surface (feet)	Measuring point: Height above mean sea level (feet)	Distance to water level below measuring point (feet)	Date of measurement	Remarks
26-62-14bb	A. Damrow	Dr	39	18	P	S, G	Qf	T, G	I, O	Tc	+.2	4,274.6	12.52	Apr. 17, 1951	D350R, L.
-16ac	Malm Bros.	Dr	50	6	P	Sls	Tb	C, W	D, S	Ls		4,298.5	30	July 14, 1950	
-22aa	State of Wyoming	Dr	9	5	P	S, G	Qf	C, H	N	Tc	0	4,254.8	7.81	Oct. 12, 1948	
-22cc	Mrs. Hunter	Dr	26.0	5	P	Sl, Cl	Tb [a]	C, W	S	Tc	+1.0	4,262.2	16.11	do	T53.
-23cb	State of Wyoming	Dr	17.7	4	P	S, G	Qf	N	N	Tc	+.3		8.45	Oct. 27, 1948	
-26cc	C. C. France	Dr	63	6	P	S	Qf	J, E	D	Ls			15	July 26, 1950	
-27db	C. R. Marls	Dr		5	P	S, G	Qf	C, H	D, S	Tc	+.5	4,242.9	5.92	Oct. 27, 1948	T55, Ca.
-28bc	Ella Hunter	Dr		6	P	Sls	Tb	N	N	Tc	+2.5		42.93	Oct. 11, 1950	
-32bd	do	Dr	145	6	P	Sls	Tb(?)	C, W	S	Tc	+1.0	4,349.6	73.06	do	
-34ab	C. C. France	Dr		6	P	S, G	Qf	N	N	Tc	+.4	4,229.4	6.14	July 26, 1950	
-34dc	L. G. Flock	Dr	26	4	P	S, G	Qf	C, E	D, S	Tcu	0		10		T55.
26-63- 3ab	Jess Skinner	Sp				Ss	Ta	F	S						D3E.
- 3cd	do	Dr	388		P	Ss	Ta	C, W	S	Ls		4,833.6	360	July 18, 1950	
- 4cb	do	Dr			P	Ss	Ta	C, W	S	Tc	+.8	4,626.5	193.19	do	
- 9dc	H. Skinner	Dr	315	6	P	Ss	Ta	C, W	S				275		
-11ba	Bernard Davis	Dr	365	6	P	Ss	Ta	C, W	S				285	July 20, 1950	
-11cd	H. Skinner	Dr	293	5	P	Ss	Ta	C, W	D, S	Tc	+.4	4,771.5	269.29	July 18, 1950	
-12cc	Malm Bros.	Dr		5	P	Sls	Tb	C, W	S	Tc	+.5	4,740.0	229.23	July 14, 1950	
-15aa	J. C. Nichols	Dr		6	P	Sls	Tb	C, W	S	Tc	+.5	4,691.4	210.94	July 18, 1950	
-15dd	do	Sp				SS, Sls	Ta, Tb	F	S						D1E.
-26cb	do	Dr		8	P	Sls	Tb	C, W	S	Twc	+.9	4,349.9	49.25	July 21, 1950	
-31ca	E. Paules	Dr	30	24	P	S, G	Qf	C, G	I, O	Tc	−5.5		7.35	Apr. 17, 1951	
-32da	J. Spikner	Dr	80	18	P	S, G	Qf	T, G	I, O	Tc	+1.0	4,205.6	25.64	do	T59, D1, 020M, DD5.7, L, Ca.
-33bc	F. G. Melchert	Dr	82	4	P	S, G	Qf	Cf, E	D, S	Tc	−5.4	4,226.3	45.82	Mar. 29, 1951	
-33cd	J. C. Nichols	Dr	66.0	5	P	S, G	Qf	N	N	Tc	+.4	4,242.5	48.49	do	T60.
-34ba	J. C. and Mabel Nichols.	Dr	53	5	P	Sls	Tb	C, W, G	S	Tc	+.4	4,289.1	42.65	Oct. 9, 1948	
26-64- 2bc	Cletus Walker	Dr	100	4	P	Ss	Ta	C, W	D, S	Tc	+.2	4,398.4	78.19	July 25, 1950	
- 4ca	J. E. Scott	Dr		4	P	Ss	Ta?	C, W	S	Tc	+1.6	4,389.1	33.59	July 26, 1950	
- 8bb	do	Dr	100	6	P	Sls	Tb?	C, W	D	Tc	+.8	4,347.0	74.58	Oct. 1, 1948	T52.
- 8cd	W. H. McDonald	Du	45	24	P	S, G	Qf	T, G	I, O	Tc	−3.0		21.71	Apr. 17, 1951	D600R.
-15bb	H. C. Hanke	Dr	56	6	P	S, G	Qf(?)	C, W	D, S	Bpb	+.2	4,264.1	40.66	Nov. 9, 1948	
-15da	C. Jenkins	Dr	80		P	S, G	Qf	C, H	D, S	Twc	+.3	4,306.0	64.95	Oct. 7, 1948	T57.
-21db	B. L. Haynes	Dr		4	P	Ss	Ta?	C, W	D, S	Hph	+1.7	4,265.8	48.84	Jan. 19, 1951	

-22ad	Edward Copyak	Dr	32	5	P	S, G	Qf	Cf, E	D, O	Twc	+.8		13.90	Oct. 31, 1949	
-22cc	F. Bay	Dr	62.0	18	P	S, G	Qf	T, G	I	Hpb	0	4,233.1	17.68	Apr. 4, 1951	T56, D990M, DD 16, L, Ca.
-23ac	C. C. Paules	Dr	56	6	P	S, G	Qf	C, W, G	S	Ls			36	Oct. 16, 1950	
-23bc	Town of Ft. Laramic	Dr	75	24	P	S, G	Qf	T, E	I	Twc	−6.2		16.54	July 28, 1951	
-23bd	Roy Nearing	Dr	70	18	P	S, G	Qf	T, G	I	Hpb	0		7.36	Aug. 22, 1951	
-23cb	Chicago Burlington and Quincy R. R.	Dr	60		P	S, G	Qf	C, W	In	Ls			50	Oct. 2, 1951	L.
-24cb	T. W. Woodard	Dr		4	P	S, G	Qf	C, W	D, S	Tc	+.3	4,251.7	47.45	Mar. 29, 1951	T60.
-26bd	B. F. Marshall	Dr		4	P	S, G	Qf	C, H	D	Tc	+.2		8.04	Oct. 16, 1950	
-26dc	L. B. Chambers	Dr	40	6	P	S, G	Qf	C, H	D, O	Tc	+.8	4,249.7	24.54	Apr. 17, 1951	
-28bb	U. S. Park Service	Dr	28.8	18	P	S, G	Qf	J, E	O	Tc	+1.2	4,247.1	17.02	May 24, 1951	Ca.
-29ad	do	Du	43	36	R	S, G	Qf	C, H	O	Twc	+.8	4,249.6	19.26	do	
-30ac	Alice Flannery	Du	6			S, G	Qf	C, W	N	Bpb	+1.0		6.14	Oct. 8, 1948	
-34dd	C. H. Morrow	Dr	181.5	6	P	Ss	Ta	N	N	Tc	+.7	4,409	142.47	Apr. 29, 1943	
-35da	State of Wyoming	Dr	50	4	P	Ss	Tb(?)	C, W	S	Tpc	+1.4		29.80	Apr. 4, 1951	
-36ad	L. M. Fleming	Dr	29.0	6	P	S, G	Qf	J, E	D, S	Tc	−5.3	4,213.4	17.13	Oct. 17, 1950	
26-65- 3ac	A. A. Fisher	Dr	56.0		P	Ss	Ta(?)	C, W	S	Tc	+.2	4,314.4	49.71	Oct. 7, 1948	T52.
- 9aa	Charles Frederick	Du	25			S, G	Qf	C, W	D, S	Tcu	0		19.40	Oct. 1, 1948	T56.
-10ca	Frank Beal	Dr	14	24	P	S, G	Qf	N	N	Tc	+1.8		4.39	Oct. 17, 1950	
-11ba	U. S. Bureau of Reclamation.	Dr	26.8	6	P	S, G	Qf	Cf, E	D, O	Tc	−3.8	4,267.0	11.68	Apr. 17, 1951	
-14aa	V. A. Bombgartner	Dr		24	P	S, G	Qf	C, G	I	Twc	+1.0		16.68	Oct. 17, 1950	
-14ac	do	Dr	50	3	P	Sls	Tb	C, W	S	Tc	+.8	4,281.0	27.70	Apr. 4, 1951	
-22dc	do	Dr		5	P	Sls	Tb	C, W	S	Tc	+1.0	4,387.3	45.73	do	
-36ad	J. E. Bay	Dr	65	4	P	Ss	Ta	C, W	S	Tc	+1.0	4,304.1	39.76	Oct. 17, 1950	
27-60- 3db	A. C. Grosjean	Dr	269	6	P	Ss	Ta	C, W	D, S	Twc	+.2	4,814.4	225.83	Nov. 22, 1949	
- 4ba	Hans Northness	Dr		6	P	Ss	Ta	C, W	S	Twc	0	4,734.3	169.52	June 19, 1950	
- 5cb	Walter Berry	Dr	76	6	P	Ss	Ta	C, W	S	Twc	+.9	4,584.2	41.48	do	
- 7ca	C. C. Henderson	Dr	200	6	P	Ss	Ta	N	N	Tc	+.9		185.31	June 20, 1950	
- 9cc	Hans Northness	Dr		6	P	Ss	Ta	C, W	D, S	Tc	+1.4	4,528.9	65.81	June 19, 1950	
-15bb	do	Dr		6	P	Ss	Ta	C, W	S	Tc	+.5		131.27	do	
-20bc	do	Dr		6	P	Ss	Ta	C, W	S	Tc	0	4,702.3	212.05	do	
-31cc	Chestnut Valley Ranch, Inc.	Dr	119	6	P	Sls	Tb	C, W	S	Tc	+3.0	4,517.3	93.22	June 17, 1950	
27-61- 2dc	Morgan N. Norris	Dr	265	6	P	Ss	Ta	C, W	S	Hph	+2.0		233.90	June 20, 1950	
- 3ca	Elizabeth Nieman	Dr		4	P	Ss	Ta	C, N	N	Tc	+.3		239.38	June 28, 1950	
- 8aa	R. D. Kitchel	Dr	265		P	Ss	Ta	C, W	D, S	Twc	+1.0	4,785.3	225.54	do	
- 9ad	N. J. Simmons	Dr	265.0	6	P	Ss	Ta	C, W	S	Tc	+.9		232.64	do	
-10da	Lester Gunsaullus	Dr	261	4	P	Ss	Ta	C, W	D, S	Ls		4,812.0	255	June 18, 1950	Ca.
-12bb	C. C. Henderson	Dr	274	6	P	Ss	Ta	C, W	D, S	Tc	+.5		244.49	June 20, 1950	Ca.
-17bc	J. F. Simmons	Dr	167	6	P	Ss	Ta	C, W	S	Twc	+.4	4,672.4	129.60	June 28, 1950	
-19ad	Morgan Norris	Dr	185	6	P	Ss	Ta	N	N	Tc	−4.6	4,684.6	144.83	do	
-19bb	do	Dr	150	6	P	Ss	Ta	C, W	S	Bpb	+.4	4,619.7	106.51	do	
-22cb	W. VanKleeck	Dr	275	4	P	Ss	Ta	C, W	D, S	Tc	+1.5	4,835.8	252.66	Aug. 23, 1950	
-24bb	Lester Gunsaullus	Dr	123.5	6	P	Ss	Ta	C, W	S	Tpc	+1.9		119.80	June 18, 1950	
-25ba	Chestnut Valley Ranch Inc.	Dr	185	6	P	Ss	Ta	C, W	S	Tcu	+.5	4,685.6	151.07	June 17, 1950	
-26bb	Lester Gunsaullus	Dr	226	5	P	Sls	Tb(?)	C, W	S	Tc	0	4,776.8	202.37	do	
-26dc	Chestnut Valley Ranch Inc.	Dr		6	P	Sls	Tb(?)	N	N	Tc	+.2	4,703.7	149.75	June 18, 1950	

See footnote at end of table

TABLE 7.—*Records of wells and springs in Goshen County*—Continued

Well no.	Owner or user	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below (−) land-surface (feet)	Measuring point: Height above mean sea level (feet)	Distance to water level below measuring point (feet)	Date of measurement	Remarks
27-61-28ca	J. M. Ochsner	Dr	180	6	P	Sls	Tb(?)	C, W	D, S	Tc	+1.4	4,747.6	174.14	June 28, 1950	
-29da	Jess Deahl	Dr	220	6	P	Sls	Tb(?)	C, W	S	Tc	+.5	4,758.1	172.86	June 27, 1950	
-33cc	J. M. Ochsner	Dr	84	6	P	Sls	Tb	C, W	S	Tc	+1.5	4,662.2	82.04	June 28, 1950	
-34bb	do	Dr	140	8	P	Sls	Tb	C, W	S	Tc	+.4	4,656.3	84.38	Jan. 28, 1950	
-35cc	Chestnut Valley Ranch Inc.	Dr	209.0		N	Sls	Tb	N	N	Ls	0	4,634.1	139.26	June 18, 1950	
27-62-13db	R. L. Simmons	Dr	101	6	P	Ss	Ta	C, W	S	Hpb	+1.1	4,546.2	78.92	June 28, 1950	
-22bc	L. Newell	Dr	86	6	P	Sls	Tb	C, W, E	D	Tc	−3.4		9.69	Nov. 5, 1951	
-29ca	do	Dr	116	5	P	Sls	Tb	C, W	S	Tpc	+.5	4,454.2	32.18	June 30, 1950	
-32ca	Malm Bros.	Dr		5	P	Ss	Ta	N	N	Tc	0	4,478.0	26.11	July 10, 1950	
-33dd	do	Dr		6	P	Sls	Tb	C, W	S	Twc	+.4	4,331.4	30.57	do	
27-63- 4bc	R. Lively	Dr		4	P	Ss	Ta	C, W	S	Tc	+.1	4,656.1	61.42	Aug. 1, 1950	
- 6bc	Roy Nearing	Dr	270	6	P	Ss	Ta	C, W	D, S	Hpb	+1.1	4,846.6	254.10	July 25, 1950	
- 7cb	A. J. Schissler	Dr	196	6	P	Ss	Ta	C, W	S	Tc	+1.3	4,742.5	185.69	do	
- 9cb	C. P. Jones	Dr	262	6	P	Ss	Ta	C, W	D, S	Tc	0	4,711.3	214.52	July 19, 1950	
-10cc	R. J. Steidley	Dr	165		P	Ss	Ta	C, W	S	Tc	+.5	4,584.3	85.81	July 20, 1950	
-13dd	L. Newell	Dr		6	P	Ss	Ta	C, W	S	Tpc	+.2	4,516.0	58.17	July 14, 1950	
-16bc	State of Wyoming	Dr	186		P	Ss	Ta	C, W	S	Tc	+.4	4,630.5	121.00	July 20, 1950	
-19bd	E. Kamber	Dr	300	7	P	Ss	Ta	C, W	D, S	Tc	+.2	4,752.1	263.79	Aug. 1, 1950	T54, Ca.
-20bd	A. J. McWhworter	Dr	252	6	P	Ss	Ta	C, W	D, S	Tc	+.4	4,696.2	214.00	July 20, 1950	
-24ca1	L. Newell	Dr	180	5	P	Ss	Ta	C, W	S	Tc	+.4	4,580.4	131.95	June 30, 1950	
-24ca2	do	Sp				Ss	Ta	F	S						D5E.
-24cb	do	Dr		5	N	Ss	Ta	N	N	Ls	0	4,520.5	55.61	June 30, 1950	
-26db	do	Dr	192.0	5	P	Ss	Ta	N	N	Tc	+.6	4,631.1	171.90	Sept. 14, 1950	
-29cb	Dwight Walker	Dr	122	6	P	Ss	Ta	C, W	S	Tc	0	4,547.3	97.20	July 19, 1950	
-31ab	J. Alle	Du	92		P	Ss	Ta	C, W	D, S	Twc	0	4,488.8	65.00	do	
-33ba	Jess Skinner	Dr	150	5	P	Ss	Ta	C, W	S	Ls		4,574.3	82	do	
-35ca	Bernard Davis	Dr	275	6	P	Ss	Ta	C, W	S	Tc	0	4,702.0	238.80	July 10, 1950	
27-64- 2aa	C. Nearing	Dr	238	5	P	Ss	Ta	C, W	D, S	Ls		4,828.9	210	Sept. 19, 1949	
- 3ab	Martha Kappus	Dr	170	5	P	Ss	Ta	C, W	S	Twc	0	4,813.6	50.66	Aug. 3, 1950	
- 5ab	C. J. Fenn	Dr	130	6	P	Ss	Ta	C, W	S	Tc	+.4	4,701.2	90.27	do	
-12ba	Roy Nearing	Dr	260	5	P	Ss	Ta	C, W	S	Tc	+.1	4,838.4	252.06	July 25, 1950	
-18cc	A. E. Thomas	Dr	45	5	P	S, G, Ss	Qf, Ta	C, W, G	D, S	Tc	+.5	4,483.1	28.80	July 26, 1950	
-18da	J. E. Scott	Dr		6	P	Ss	Ta	C, W	S	Tc	+.2	4,535.7	53.99	do	
-20ad	do	Dr		6	P	Ss	Ta	C, W	S	Tc	+.1	4,691.3	176.06	do	

-22cd	do	Dr	200	4	P	Ss	Ta	C, W	S	Tc	+1.3	4,680.9	168.51	do	
-24ac	A. J. Schissler	Dr	200	6	P	Ss	Ta	C, W	S	Tc	+2.5	4,664.1	161.01	July 19, 1950	
-34ab	J. E. Scott	Dr		6	P	Sls	Tb(?)	C, W	S	Tc	+1.1	4,512.5	102.50	July 25, 1950	
27-65-36bd	State of Wyoming	Dr	33	4	P	Ss	Ta(?)	C, W	S	Tc	+.4	4,380.2	31.49	Oct. 8, 1948	
28-60- 3cc	T. C. Lewis	Dr	230	6	P	Ss	Ta	C, W	S	Tc	+.2		217.60	Nov. 19, 1949	
- 4bb	do	Dr		5	P	Ss	Ta	N	N	Tc	+4.4	4,818.2	186.27	do	
- 7bd	F. M. Baumgardner	Dr	150		P	Ss	Ta	N	N	Twc	0	4,716.5	85.61	Nov. 21, 1949	D45E.
- 8bb	do	Dr		6	P	Ss	Ta	C, W	S	Tc	+2.3		167.11	Nov. 22, 1949	
-15ba	T. C. Lewis	Dr		6	P	Ss	Ta	C, W	S	Tc	+.1	4,780.2	167.34	do	
-15cc	do	Dr		6	P	Ss	Ta	N	N	Tc	+.6	4,737.3	129.53	do	
-17aa	Lenora Backhaus	Dr		6	P	Ss	Ta	C, W	D, S	Tc	+1.9	4,800.6	182.16	do	
-18ab	F. M. Baumgardner	Dr	90		P	Ss	Ta	C, W	D, S	Tcu	-4.9	4,701.9	71.96	Nov. 21, 1949	
-20ab	do	Dr	125	6	P	Ss	Ta	C, N	N	Tc	+.4	4,701.7	102.25	June 22, 1950	
-21bc	Frank Lewis	Dr		6	P	Ss	Ta	C, W	S	Bpb	+.5		87.51	do	
-22ca	Keith Newman	Dr		6	P	Ss	Ta	C, W	S	Tc	+.2	4,700.0	100.71	Nov. 22, 1949	
-27bd	do	Dr		6	P	Ss	Ta	C, W	S	Tc	+.4	4,710.0	122.10	do	
-30cd	Russell Foote	Dr	57	6	P	Ss	Ta	C, W	S	Tc	0	4,618.8	30.96	June 22, 1950	
-32bd	A. C. Grosjean	Dr	23	6	P	Ss	Ta	C, W	S	Hpb	0	4,604.0	14.82	June 19, 1950	
-33cb	F. M. Baumgardner	Dr		6	P	Ss	Ta	C, W	S	Tc	0	4,662.6	83.37	do	
28-61- 1aa	Edwin Grapes	Dr	170	6	P	Ss	Ta	C, W	S	Tc	+.8		155.02	Nov. 20, 1949	
- 3ab	Wayne Childers	Dr	133	6	P	Ss	Ta	C, W	S	Tc	+1.3	4,754.0	111.43	June 22, 1950	
- 4cb	Continental Oil Co.	Dr		5	N	Ss	Ta	N	N	Ls	0	4,710	79.70	June 29, 1950	
-11db	H. A. Glandt	Dr	149	6	P	Ss	Ta	C, W	D, S	Tc	+.7		139.14	Nov. 21, 1949	
-12bb	do	Dr	192	6	P	Ss	Ta	C, W	S	Bpb	0	4,784.9	149.32	do	
-17da	Continental Oil Co.	Dr		5	N	Ss	Ta	N	N	Ls	0		54.82	June 29, 1950	
-20ab	do	Dr	173	5	N	Ss	Ta	N	N	Ls	0		67.85	do	
-20dd	do	Dr		6	N	Ss	Ta	N	N	Ls	0		158.70	do	
-23bb	Walter Berry	Dr	179	6	P	Ss	Ta	C, W	S	Tpc	-5.5	4,773.9	159.43	June 20, 1950	
-26bb	do	Dr	175	6	P	Ss	Ta	C, W	S	Bpb	+.2	4,766.5	165.09	June 18, 1950	
-29ad	Continental Oil Co.	Dr		5	N	Ss	Ta	N	N	Ls	0		91.72	June 29, 1950	
-32dd	N. J. Simmons	Dr	213	6	P	Ss	Ta	C, W	D, S	Twc	+.7	4,775.0	205.90	June 28, 1950	
-33da	J. D. Lovercheck and Son.	Dr		3	P	Ss	Ta	C, W	S	Tc	+.6	4,799.4	215.04	do	
-35ca	Walter Berry	Dr	190	6	P	Ss	Ta	C, W	S	Twc	0	4,766.7	183.74	June 22, 1950	
-36dc	State of Wyoming	Dr	197	6	P	Ss	Ta	C, W	S	Tc	+.5	4,770.4	183.29	June 18, 1950	
28-62- 1ab	B. J. Lenz	Dr	165	6	P	Ss	Ta	C, W	D, S	Tc	0	4,749.3	134.63	Aug. 23, 1950	
-13ac	C. Parsons	Dr	173	5	N	Ss	Ta	N	N	Ls	0		21.94	July 5, 1950	
-19ca	Patrick Bros	Dr		6	P	Ss	Ta	N	N	Tc	+3.2	4,458.7	19.65	Oct. 14, 1949	
-22cc	C. Parsons	Dr		5	N	Ss	Ta	N	N	Ls	0		8.45	July 5, 1950	
-22dd	do	Dr	252	5	N	Ss	Ta	N	N	Ls	0		27.36	do	
-23aa	do	Dr	150		N	Ss	Ta	N	N	Ls	0		13.32	do	L.
-24ba	do	Dr	172	5	N	Ss	Ta	N	N	Ls	0		48.36	do	
-28aa	B. F. Marshall Estate	Dr		5	N	Ss	Ta	N	N	Ls	0		7.66	do	
-29cd	Patrick Bros	Dr	55	6	P	S, G	Qf	N	N	Tc	-5.6	4,450.2	36.58	Oct. 14, 1949	
-33ad	B. F. Marshall Estate	Dr		5	N	S, G	Qf	N	N	Ls	0		9.70	July 5, 1950	
28-63- 1ad	L. Harris	Dr		6	P	Ss	Ta	C, W	S	Tc	+.8	4,558.1	40.03	Oct. 14, 1949	
- 5ad	A. Harris	Dr	170	6	P	Ss	Ta	C, W	S	Tc	+1.3	4,713.3	60.94	Sept. 17, 1949	
- 7ac	David M. Foote	Dr	108	6	P	Ss	Ta	C, W	S	Twc	+.4		81.65	Sept. 18, 1949	D50E.
- 8cc	do	Dr	200	6	P	Ss	Ta	C, W	S	Tc	+.5	4,806.8	138.47	do	
-11bb	J. A. Waggoner	Dr	122	6	P	Ss	Ta	N	N	Tc	+.2	4,604.1	47.71	Oct. 14, 1949	
-14dc	do	Dr	112	30	P	Ss	Ta	T, G	I	Tc	+.2	4,503.8	23.43	Aug. 27, 1951	D950M, DD78.
-15cc	Burley Borton	Dr		6	P	Ss	Ta	C, W	S	Tc	+.9	4,582.4	24.52	Aug. 18, 1950	

TABLE 7.—*Records of wells and springs in Goshen County*—Continued

Well no.	Owner or user	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below (−) land-surface (feet)	Measuring point: Height above mean sea level (feet)	Distance to water level below measuring point (feet)	Date of measurement	Remarks
28-63-18dc	David M. Foote	Dr		4	P	Ss	Ta	C, W	S	Hpb	+.7	4,712.8	51.94	Sept. 19, 1949	
-19bc	do	Dr	139.5	6	P	Ss	Ta	C, W	D, S	Tc	+.9	4,747.7	83.24	do	
-22ac	G. W. Kuskie	Dr		6	P	Ss	Ta	C, W	S	Tc	+.7	4,550.1	35.74	Aug. 18, 1950	
-26bb	Burley Borton	Dr		6	P	Ss	Ta	C, W	S	Tc	0	4,615.0	129.98	Aug. 1, 1950	
-28bc	K. C. Jones	Dr	100	5	P	Ss	Ta	C, W	S	Tc	+.8	4,615.8	59.64	do	
-30cd	Roy Nearing	Dr		6	P	Ss	Ta	C, W	S	Hpb	0	4,691.8	94.09	Sept. 19, 1949	
-32aa	James O'Brien	Dr		6	P	Ss	Ta	C, W	D, S	Tc	+.7	4,591.4	42.35	Aug. 1, 1950	
-32ca	do	Dr		4	P	Ss	Ta	C, W	S	Tc	+1.2	4,636.7	77.14	do	
28-64- 1da	David M. Foote	Dr		6	P	Ss	Ta	C, W	S	Twc	+.9	4,722.2	86.83	Sept. 18, 1949	
- 2bc	Frank Scott	Dr	30	6	P	Ss	Ta	N	N	Tc	+.7	4,750.4	24.91	Sept. 16, 1949	
-11aa	do	Dr	144	4	P	Ss	Ta	C, W	S	Tc	+.4	4,804.4	99.64	Sept. 20, 1949	
-13bb	do	Dr	81.0	6	P	Ss	Ta	C, W	S	Tcu	0	4,835.6	73.85	Aug. 14, 1950	
-15ad	Fred Blevens	Dr		6	P	Ss	Ta	C, W	S	Tc	+.3	4,779.4	92.95	Sept. 20, 1949	
-16aa	State of Wyoming	Dr		6	P	Ss	Ta	C, W	S	Tc	+1.1	4,730.6	53.24	Aug. 15, 1950	
-17ba	Lloyd Damrow	Dr	90		P	Ss	Ta	C, W	S	Hpb	+1.2	4,776.6	77.91	do	T53, Ca.
-17cc	Vera Hazelwood	Dr			P	Ss	Ta	C, W	S	Twc	+1.3	4,706.5	31.62	do	
-21ac	Jess Skinner	Dr	22	6	P	Ss	Ta	C, H	S	Tc	+.3	4,694.0	19.48	do	
-23bc	Fred Blevens	Dr		6	P	Ss	Ta	C, W	S	Tc	+.3	4,768.0	87.88	Sept. 20, 1949	
-24cc	Frank Scott	Dr	287	4	P	Ss	Ta	C, W	D, S	Tc	+.5	4,875.5	238.99	Sept. 19, 1949	
-28ac	Frank Kappus	Dr	90	6	P	Ss	Ta	C, W	S	Hpb	+.6	4,722.3	56.36	Aug. 15, 1950	
-32ab	David M. Foote	Dr	98	8	P	Ss	Ta	C, W	S	Tc	+.8	4,709.7	62.36	do	
-34aa	Roy Nearing	Dr	170	6	P	Ss	Ta	C, W	S, O	Tc	+.8	4,738.6	100.96	May 24, 1951	
28-65-12db	Martha Kimball	Dr		6	P	Ss	Ta	C, W	S	Tc	+1.8	4,785 2	19.40	Sept. 16, 1949	
-14dd	Vera Hazelwood	Dr	120	4	P	Ss	Ta	C, W	S	Tc	+1.5	4,835.2	100.90	Aug. 16, 1950	
29-60- 4cb	Earl Seegrist	Dr	132	6	P	Ss	Ta	C, W	D, S	Hpb	+1.0	4,744.6	92.14	Nov. 9, 1949	
- 5ad	Vern Torrance	Dr		6	P	Ss	Ta	C, W	D, S	Tc	+1.1		95.36	do	
- 6bb	A. J. Fisher	Dr	210	6	N	Ss	Ta	N	N	Ls	0		98.06	Nov. 16, 1949	
- 6da	do	Dr		6	P	Ss	Ta	N	N	Tc	0	4,797.4	130.30	do	
- 8bb	Edwin Grapes	Dr	152	6	P	Ss	Ta	C, W	D, S	Tc	+1.0		121.42	Nov. 18, 1949	
- 8cb	Wm. DesEnfants	Dr		6	P	Ss	Ta	N	N	Tc	+.6		160.84	Nov. 16, 1949	
- 9ad	Earl Seegrist	Dr	200	6	P	Ss	Ta	C, W	S	Tc	+.3		173.67	Nov. 9, 1949	
- 9bb	Edwin Grapes	Dr		6	P	Ss	Ta	N	N	Tc	+.7		215.09	Nov. 18, 1949	
- 9ca	do	Dr	232	6	P	Ss	Ta	C, W	S	Tc	+.4		202.40	do	
-16bd	State of Wyoming	Dr	210	6	P	Ss	Ta	C, W	S	Tc	+.8	4,816.7	170.73	do	
-17ab	Wm. DesEnfants	Dr		6	P	Ss	Ta	C, W	S	Hpb	+.4		172.13	Nov. 20, 1949	

-18ad	Edwin Grapes	Dr	188	6	P	Ss	Ta	N	O	Tc	+.6	4,819.0	161.78	May 24, 1951	
-19bd	Bert Peterson	Dr	202	4	P	Ss	Ta	C, W	S	Hpb	+.8		167.69	Nov. 22, 1949	
-20ba	Keith Newman	Dr		6	P	Ss	Ta	C, W	S	Tc	+.8	4,794.7	144.35	Nov. 18, 1949	
-21ba	do	Dr		6	P	Ss	Ta	C, W	D, S	Ls		4,837.7	205	do	
-22bc	Bruce Parson	Dr	187	6	P	Ss	Ta	C, W	S	Tc	+.3	4,814.4	178.55	do	
-27bb	Keith Newman	Dr	180	6	P	Ss	Ta	C, W	S	Tc	+.1	4,793.2	158.96	do	
-27bc	do	Dr	137.0		N	Ss	Ta	N	N	Ls	0		104.99	do	
-28db	T. C. Lewis	Dr		6	P	Ss	Ta	N	N	Tc	+.3		111.79	Nov. 19, 1949	
-29ca	Keith Newman	Dr	178	8	P	Ss	Ta	C, W	S	Tc	+1.3	4,808.9	161.69	do	
-30aa	Edwin Grapes	Dr	186	6	P	Ss	Ta	C, W	S	Tc	+1.0	4,804.7	159.61	Nov. 18, 1949	
-32bc	T. C. Lewis	Dr	142	6	P	Ss	Ta	N	N	Tc	+.7		141.70	Nov. 19, 1949	
-32cc	do	Dr	165	6	P	Ss	Ta	C, W	S	Tc	+.7		127.70	do	
-34ac	Raymond Riley	Dr		6	P	Ss	Ta	C, W	S	Tc	0	4,738.4	112.23	do	
29-61- 1dd	A. S. Fisher	Dr	135	6	P	Ss	Ta	C, W	D, S	Hpb	0		109.51	Nov. 16, 1949	
- 3bb	E. Splittgerber	Dr		5	P	Ss	Ta	C, W	S	Tc	+.3		149.44	Nov. 20, 1949	
- 5bb	H. C. Britton	Dr	280	6	P	Ss	Ta	C, W	S	Tc	+.3		211.46	Oct. 13, 1949	
- 7aa	do	Dr	180	6	P	Ss	Ta	C, W	S	Tc	+.3	4,854.7	168.20	do	
- 8cd	do	Dr		6	P	Ss	Ta	N	O	Twc	+.4	4,773.2	92.48	May 24, 1951	
- 9ca	O. A. Armbrust	Dr		6	P	Ss	Ta	C, W	S	Bpb	+.2	4,792.1	105.14	Nov. 20, 1949	
-10dd	Edwin Grapes	Dr	202	6	P	Ss	Ta	C, W	S	Tc	+.6	4,870.0	184.68	Nov. 15, 1949	
-11ab	Wm. Coffee	Dr	155	6	P	Ss	Ta	C, W	D, S	Tc	−1.2	4,835.9	144.35	Nov. 16, 1949	
-12dd	Wm. DesEnfants	Dr		6	P	Ss	Ta	C, W	S	Tc	+1.8		181.46	Nov. 21, 1949	
-14dc	do	Dr		6	P	Ss	Ta	C, W	D, S	Tc	0	4,878.4	207.99	Oct. 13, 1949	
-15da	J. H. Burnham	Dr			P	Ss	Ta	C, W	D, S	Ls		4,895.9	210	do	
-16da	State of Wyoming	Dr	245	4	P	Ss	Ta	C, W	S	Tc	+1.6		196.84	Oct. 12, 1949	
-17bb	P. Benshoof	Dr	122	6	P	Ss	Ta	C, W	S	Tc	+.7		92.65	Oct. 11, 1949	
-18cd	do	Dr	90	6	P	Ss	Ta	N	N	Tc	0		53.33	do	
-19da	A. E. Browder	Dr	152	6	P	Ss	Ta	C, W	S	Tc	+.4		133.60	Oct. 12, 1949	
-21bb	R. P. Brott	Dr		6	P	Ss	Ta	C, W	S	Tc	+.5	4,821.1	152.22	do	
-22aa	Jack Burnham	Dr		6	P	Ss	Ta	N	N	Tc	0		187.17	Nov. 20, 1949	
-24ba	Bert Peterson	Dr	193	6	P	Ss	Ta	C, W	S	Tc	+.1	4,849.2	184.39	Nov. 19, 1949	
-24cc	do	Dr		6	P	Ss	Ta	C, W	S	Tc	+.5		194.21	Nov. 20, 1949	
-25ac	C. M. Roby	Dr	158	6	P	Ss	Ta	C, W	S	Tc	+.1		152.77	do	
-26cb	Bert Peterson	Dr		6	P	Ss	Ta	N	O	Tc	+.6	4,787.6	132.24	May 24, 1951	
-29aa	R. P. Brott	Dr	240	6	P	Ss	Ta	C, W	S	Tc	+1.7	4,849.8	201.90	Oct. 12, 1949	
-32cc	B. J. Lenz	Dr	140	6	P	Ss	Ta	C, W	S	Bpb	+.5	4,742.1	107.80	Aug. 23, 1950	
-34cc	Alvin Haase	Dr	143	5	P	Ss	Ta	C, W	S	Bpb	+1.3		98.21	June 22, 1950	
-35bb	C. M. Roby	Dr		6	P	Ss	Ta	C, W	S	Tc	+.3		127.45	Nov. 20, 1949	
-35dc	H. A. Glandt	Dr	127	6	P	Ss	Ta	C, W	S	Tc	+1.0		95.95	do	
29-62- 1dd	E. Splittgerber	Dr	200	6	P	Ss	Ta	C, W	S	Tc	+.3	4,871.7	162.15	Oct. 13, 1949	
- 4ab	J. V. Pfister	Dr	160	6	P	Ss	Ta	C, W	S	Tc	+.2		121.24	Aug. 24, 1950	
- 6ad	Frank Harris	Dr			P	Ss	Ta	C, W	S	Hph	+.5		63.05	Sept. 21, 1949	
- 7cd	do	Dr	94.6	4	P	Ss	Ta	N	N	Twc	+1.0		50.17	do	
-10dc	Rueben Hahn	Dr		6	P	Ss	Ta	C, W	S	Tc	+.3	4,735.8	61.06	Oct. 11, 1949	
-13bc	A. Sheer	Dr		6	P	Ss	Ta	C, W	S	Tc	+.9	4,707.4	43.72	do	
-15cd	Rueben Hahn	Dr	90	6	P	Ss	Ta	C, W	D, S	Tc	+.4	4,706.5	59.89	do	
-17bb	Frank Harris	Dr	160	6	P	Ss	Ta	N	N	Tc	+.6		106.85	Oct. 14, 1949	
-22cd	A Sheer	Dr	75	6	P	Ss	Ta	C, W	S	Tc	+.7	4,668.0	38.42	Oct. 11, 1949	
-24dd	A. E. Browder	Dr	163	6	P	Ss	Ta	C, W	S	Hpb	+.5	4,804.9	146.88	Oct. 12, 1949	
29-63- 6bd	Frank Harris	Dr	128		P	S, G, s	S	Qf, Ta	T, G	I	Hpb	+.4		24.88	Aug. 22, 1951	D850R, DD49.
- 8ca	David M. Foote	Dr	150	6	P	Ss	Ta	N	N	Tc	+.7	4,827.5	76.35	Sept. 23, 1949	
-10ab	L. W. Barr	Dr	60	18	P	Ss	Ta	T, G	I	Tc	+2.5	4,739.1	19.28	Nov. 7, 1949	D750E.

TABLE 7.—*Records of wells and springs in Goshen County*—Continued

Well no.	Owner or user	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below (−) land-surface (feet)	Measuring point: Height above mean sea level (feet)	Distance to water level below measuring point (feet)	Date of measurement	Remarks
29-63-18bb	Hargreaves Bros.	Dr	27	6	P	S, G	Qf	C, H	S	Tc	0	4,752.5	12.43	Sept. 23, 1949	
-21ca	A. Harris	Dr		6	P	Ss	Ta	C, W	S	Bpb	+.5	4,742.3	99.41	Sept. 17, 1949	
-27ac	do	Dr	140	6	P	Ss	Ta	C, W	S	Tc	+.6	4,656.5	94.75	do	
-28da	do	Dr		6	P	Ss	Ta	C, W	S	Bpb	+.5	4,665.6	80.34	do	
-29da	P. A. Singree	Dr	126	6	P	Ss	Ta	C, W	S	Tc	+.9	4,683.4	74.15	Sept. 18, 1949	
-30cb	A. Harris	Dr			P	Ss	Ta	C, W	S	Twc	+.1	4,682.8	44.84	do	
-33ad	do	Dr	80	6	P	Ss	Ta	C, W	D, S	Hpb	+.1	4,260.1	39.97	Sept. 17, 1949	
29-64- 5cb	R. T. Barnette	Dr		4	P	Ss	Ta	C, N	N	Tc	+.4	5,117.4	100	Aug. 17, 1950	
- 7bb	Ruth Frederick	Dr		6	P	Ss	Ta	C, W	S	Tc	+.3	5,118.5	69.63	do	
- 9db	Carl Brown	Dr	50	6	P	Ss	Ta	C, G	S	Tc	+.9	4,946.4	26.82	do	
-10ac	do	Dr	180	6	P	Ss	Ta	C, W	D, S	Tc	+.3	5,017.3	121.45	Sept. 23, 1949	
-12ab	Hargreaves Bros.	Dr	72	6	P	Ss	Ta	C, W	S	Tc	+.9	4,848.3	40.65	do	
-14ac	Carl Brown	Dr		6	P	Ss	Ta	C, W	S	Hph	+.4		21.56	Sept. 22, 1949	
-18bc	John Brown	Dr		6	P	Ss	Ta	N	N	Tc	+1.2	5,015.7	9.37	Aug. 16, 1950	
-20aa	R. F. Newell	Dr		6	P	Ss	Ta	N	N	Twc	+.3	4,912.6	25.09	do	
-22bd	C. C. Bass	Dr	52	6	P	Ss	Ta	C, W, H	D, S	Tc	+.7	4,809.2	30.13	Sept. 24, 1949	
-24cd	Cecil Pugsley	Dr	65		P	Ss	Ta	C, W	S	Tc	+1.0	4,723.8	20.09	Sept. 22, 1949	
-25db	do	Dr	115	6	P	Ss	Ta	C, W	S	Tc	+.3		64.43	do	
-27bc	C. C. Bass	Dr	87	6	P	Ss	Ta	N	O	Tc	0	4,856.4	66.92	May 24, 1951	
-29aa	State of Wyoming	Dr	80	6	P	Ss	Ta	C, H	D	Tc	+.4	4,877.6	46.72	Sept. 20, 1949	
-29da	W. C. Robinett	Dr	60	6	P	Ss	Ta	C, G	D, S	Tc	+.1	4,871.6	40	Sept. 24, 1949	
-31ac	Kermit Brown	Dr	143	6	P	Ss	Ta	C, W	S	Tc	+1.6	4,871.6	64.58	Aug. 16, 1950	
-34ca	W. C. Robinett	Dr	46	6	P	Ss	Ta	C, W	S	Tc	+.4	4,760.7	29.76	Sept. 24, 1949	
-35ba	Cecil Pugsley	Dr		6	P	Ss	Ta	C, W	S	Tc	+.3	4,760.6	74.97	do	
-36ba	State of Wyoming	Dr		4	P	Ss	Ta	C, W	S	Tc	+.1	4,668.9	17.03	Sept. 22, 1949	
29-65-25ba	J. Edward Hay	Dr		6	P	Ss	Ta(?)	N	N	Tc	+.1	4,974.6	17.91	Aug. 16, 1950	
30-60- 4bb	E. F. Langdon	Dr	240	8	P	Ss	Ta	C, W	D, S	Twc	+.3	4,873.9	178.73	Nov. 8, 1949	
- 4da	C. E. Lewis	Dr	185	8	P	Ss	Ta	C, W	D, S	Hpb	+.2		147.49	do	
- 6ab	Carl Dallam	Dr	235	6	P	Ss	Ta	C, W	S	Tc	+.2	4,915.6	190.39	do	
- 6dd	do	Dr	190	6	P	Ss	Ta	C, W	D, S	Twc	+1.2	4,863.6	152.24	Nov. 10, 1949	
- 7ad	do	Dr	175	6	P	Ss	Ta	C, W	S	Hpb	−4.3		125.81	do	
- 8cd	do	Dr	150	6	P	Ss	Ta	N	N	Tc	0		100.28	do	
- 9aa	Wm. Immesoete	Dr		6	P	Ss	Ta	N	O	Tc	+.2	4,816.1	133.93	May 24, 1951	
- 9bc	do	Dr	180	6	P	Ss	Ta	C, W	D, S	Tc	0		133.88	Nov. 9, 1949	
-15cb	F. J. Langdon	Dr		6	P	Ss	Ta	C, W	D, S	Tc	+.1	4,784.1	123.59	Nov. 8, 1949	

-17aa	John Hammond	Dr		6	P	Ss	Ta	C, W	S	Hpb	+.7		116.64	Nov. 9, 1949	
-17dd	V. C. West	Dr		6	P	Ss	Ta	C, W	S	Tc	+1.1		142.14	Nov. 10, 1949	
-18cc	Rice Estate	Dr		6	P	Ss	Ta	C, W	S	Hpb	+.8		77.31	do	
-19db	Carl Dallam	Dr	165	6	P	Ss	Ta	C, W	S	Hpb	+.4		113.91	do	
-21ad	G. E. Redifer	Dr	135	7	P	Ss	Ta	C, G	S	Tc	+.2	4,747.7	99.85	Nov. 8, 1949	
-27ba	W. C. Parson	Dr	54	6	P	Ss	Ta	C, W	S	Hpb	+.1	4,695.9	53.19	do	
-28ab	A. J. Fisher	Dr		6	P	Ss	Ta	N	N	Tc	0		54.44	do	
-28cd	W. C. Parson	Dr		6	P	Ss	Ta	C, W	S	Tc	+.1		102.81	Nov. 9, 1949	
-29bb	Otto York	Dr	117	6	P	Ss	Ta	N	N	Tc	+.6	4,776.0	100.73	Nov. 18, 1949	
-31ad	W. C. Parson	Dr		6	P	Ss	Ta	C, W	S	Twc	+.5	4,788.5	115.66	Nov. 9, 1949	
-32cd	Otto York	Dr	847	7	P	Ss	Ta	N	N	Ls		4,740	90	Nov. 17, 1949	
-33aa	H. H. Petersen	Dr	160	6	P	Ss	Ta	C, W	S	Hpb	+1.7		135.38	Nov. 9, 1949	
-33ca	do	Dr	160	6	P	Ss	Ta	C, W	S	Hpb	0		130.71	do	
-34bd	do	Dr	186	6	P	Ss	Ta	C, W	D, S	Hpb	+.3	4,785.4	146.01	do	
30-61- 2aa	Niles Simpson	Dr	180	6	P	Ss	Ta	C, W	S	Tc	+.5	4,852.2	102.08	Nov. 10, 1949	
- 2cd	do	Dr		6	P	Ss	Ta	N	N	Tc	+1.2		120.00	do	
- 6bb	A. M. Henderson	Dr		6	P	Ss	Ta	C, W	S	Hpb	+.5	4,884.8	77.33	Aug. 24, 1950	
- 9db	H. L. Baldwin	Dr	145	6	P	Ss	Ta	C, W	S	Tc	+.3		94.43	Nov. 17, 1949	D25E.
-12bd	Wm. McKelvey	Dr		6	P	Ss	Ta	C, W	D, S	Tc	0		117.64	Nov. 15, 1949	
-13ac	Jack Burnam	Dr	80	6	P	Ss	Ta	C, W	S	Tc	+.1		78.63	do	
-13ca	do	Dr		6	P	Ss	Ta	C, W	S	Twc	+1.0	4,820.1	102.01	Nov. 16, 1949	
-14aa	H. M. Petersen	Dr	120	6	P	Ss	Ta	C, W	S	Tc	+1.3	4,793.6	66.17	Nov. 15, 1949	
-15ba	do	Dr	168	6	P	Ss	Ta	C, W	S	Tc	+1.2		107.23	Nov. 10, 1949	
-15dc	Wm. Coffee	Dr	186	6	P	Ss	Ta	C, W	S	Tc	+.9		154.70	Nov. 15, 1949	
-16dc	State of Wyoming	Dr		6	P	Ss	Ta	C, W	S	Tcu	+1.0		172.45	Nov. 17, 1949	
-17bb	H. L. Baldwin	Dr	160	6	P	Ss	Ta	C, W	S	Twc	+.4		135.53	do	
-18ac	do	Dr	190	6	P	Ss	Ta	C, W	S	Twc	+.6		156.61	do	
-21ab	Lewis Bass	Dr	256	6	P	Ss	Ta	C, W	S	Bpb	+.5		211.60	do	
-21bd	do	Dr		6	P	Ss	Ta	N	N	Tc	0	4,930.3	180.97	Nov. 16, 1949	
-23ca	Wm. Coffee	Dr	178	6	P	Ss	Ta	C, W	S	Tc	+1.2		155.64	Nov. 15, 1949	
-25cb	A. J. Fisher	Dr		6	P	Ss	Ta	C, W	S	Hpb	+1.2	4,827.3	121.50	Nov. 16, 1949	
-27dd	Wm. Coffee	Dr	148	6	P	Ss	Ta	C, W	S	Tc	+1.5	4,855.9	144.60	do	Ca.
-28bb	H. M. Petersen	Dr		6	P	Ss	Ta	N	N	Tc	+1.4	4,954.8	213.66	Oct. 11, 1949	
-29dc	H. C. Britton	Dr		6	P	Ss	Ta	C, W	S	Twc	+.5	4,893.0	157.35	Oct. 13, 1949	
-33ac	H. M. Petersen	Dr	162	6	P	Ss	Ta	C, G	S	Tc	+.7		160.17	Nov. 16, 1949	
-35ab	Wm. Coffee	Dr	131	6	P	Ss	Ta	N	N	Tc	0		132.29	Nov. 15, 1949	
-35cd	do	Dr	140		P	Ss	Ta	N	N	Tc	0		122.44	do	
30-62- 1dc	A. M. Henderson	Dr		6	P	Ss	Ta	C, W	S	Tc	+.4		178.00	Aug. 24, 1950	
- 2ac	do	Dr		7	P	Ss	Ta	C, W	S	Hpb	+.4	4,973.6	167.15	do	
- 4da	do	Dr		7	P	Ss	Ta	C, W	S	Hpb	+.2		231.23	do	
- 5da	H. Watsserburger	Dr	203	6	P	Ss	Ta	C, W	S	Hpb	+.9		183.40	do	
- 6ba	C. C. Canfield	Dr	255	6	P	Ss	Ta	C, W	D, S	Ls		5,071.4	250	do	
-13ad	H. L. Baldwin	Dr	190	6	P	Ss	Ta	C, W	S	Twc	+.5		172.93	Nov. 17, 1949	
-20cc	Lorain Rymill	Dr	132.5	6	P	Ss	Ta	C, W	S	Tc	0		105.84	Sept. 21, 1949	
-25db	E. Splittgerber	Dr			P	Ss	Ta	C, W	S			5,005.9	305	Aug. 24, 1950	
-27da	Charles Podolak	Dr	320	6	P	Ss	Ta	C, W	D, S	Hpb	+1.1		291.30	do	
-29da	do	Dr	100	6	P	Ss	Ta	C, W	S	Tc	+.2	4,836.3	85.19	do	
-32ad	O. R. Vondra	Dr	125	6	P	Ss	Ta	C, W	D, S	Hpb	+.1	4,821.4	87.39	Sept. 21, 1949	
-36dc	State of Wyoming	Dr	220	5	P	Ss	Ta	C, W	S	Tc	+.4	4,925.8	195.43	Oct. 13, 1949	
30-63- 4ba	Nick Kaan	Dr		6	P	Ss	Ta	C, W	S, O	Bpb	+.3	4,954.6	56.06	May 24, 1951	
- 6ab		Dr		4	P	Ss	Ta	C, W	S	Tc	+.5		27.30	Sept. 16, 1949	
- 7ad	Paul Brozovich	Dr	135	6	P	Ss	Ta	C, W	S	Twc	+.7		86.27	Sept. 22, 1949	

TABLE 7.—*Records of wells and springs in Goshen County*—Continued

Well no.	Owner or user	Type of supply	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below (−) land-surface (feet)	Measuring point: Height above mean sea level (feet)	Distance to water level below measuring point (feet)	Date of measurement	Remarks
30-63-11bb	Josephine Spahm	Dr		7	P	Ss	Ta	N	N	Tc	+.7	4,941.3	101.98	Aug. 23, 1950	
-12ad	L. O. Butler	Dr		6	P	Ss	Ta	C, W	D, S	Tc	0		113.14	do	
-13cd	Robert R. Hoy	Dr	183		P	Ss	Ta	N	N	Ls	0		178.36	do	
-17da	R. F. Pearce	Dr		6	P	Ss	Ta	N	N	Tc	+.3		155.10	Sept. 22, 1949	
-23ad	Robert R. Hoy	Dr		6	P	Ss	Ta	C, W	D, S	Tc	0		73.96	Aug. 23, 1950	
-24dd	Mrs. W. L. Rymill	Dr	85	6	P	Ss	Ta	C, W	D, S	Twc	+.2	4,842.3	75.81	Sept. 21, 1949	
-26ca	Frank Harris	Dr		6	P	Ss	Ta	C, W	S	Twc	+.3		42.20	Aug. 23, 1950	
-30ba	Howard H. Kenberry	Dr	210	6	P	Ss	Ta	N	N	Tc	+.9		173.45	Sept. 23, 1949	
-31da	Frank Harris	Dr		6	P	Ss	Ta	C, W	S	Twc	+.9	4,849.6	59.25	do	
30-64- 1cc		Dr		6	P	Ss	Ta(?)	C, W	S	Hpb	+.4		98.04	Sept. 17, 1949	
-21dd	Frank Jordon	Dr		6	P	Ss	Ta	C, W	S	Tc	+.4	5,123.1	45.06	Aug. 17, 1950	
-27aa	do	Dr		7	P	Ss	Ta	N	N	Tc	+.8	5,054.1	34.78	do	
-33dc	Ross Starner	Dr	130	6	P	Ss	Ta	C, W	S	Tc	−.2	5,152.1	86.68	Sept. 23, 1949	
-34da	do	Dr		6	P	Ss	Ta	C, W	S, O	Tpb	+.3	5,025.4	62.49	May 24, 1951	T52, Ca.

[a] Slope wash and weathered bedrock.

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