Geology and Ground-Water Resources of the Fort Berthold Indian Reservation North Dakota

By R. J. DINGMAN *and* E. D. GORDON

With a section on

Chemical Quality of the Ground Water

By H. A. SWENSON

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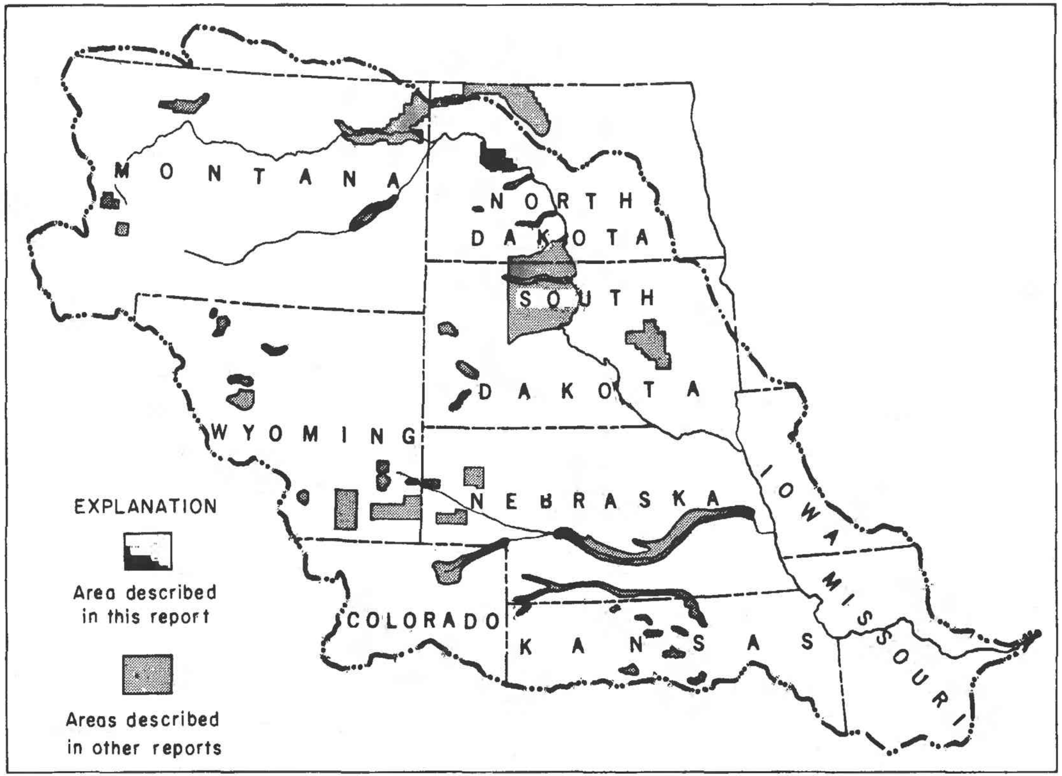
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
MISSOURI
COLORADO
KANSAS
EXPLANATION
Area described in this report
Areas described in other reports

GEOLOGY AND GROUND-WATER RESOURCES OF THE FORT BERTHOLD INDIAN RESERVATION NORTH DAKOTA

By R. J. Dingman and E. D. Gordon

ABSTRACT

The Fort Berthold Indian Reservation occupies about 1,000 square miles in west-central North Dakota. The Missouri and Little Missouri Rivers flow through the area and form part of its boundaries. Garrison Dam, which is under construction on the Missouri River 30 miles downstream from the east boundary of the reservation, will impound water in Garrison Reservoir and flood the valleys of both rivers throughout the area. The reservoir will divide the reservation into five parts, herein referred to as the eastern, northeastern, northern, western, and southern segments.

Rock formations ranging in age from Paleocene to Recent are exposed. The Fort Union formation of Paleocene age underlies the entire reservation, and it crops out along the Missouri and Little Missouri Rivers. Relatively thin glacial till and outwash deposits of late Pleistocene age mantle much of the upland in all of the segments. The glacial deposits commonly are less than 10 feet thick; in many places they consist only of scattered boulders on the bedrock surface. The major valleys have terrace deposits of Pleistocene and Recent age and alluvium of Recent age.

The principal mineral resources of the reservation are lignite, sand, and gravel. The lignite beds range in thickness from a few inches to about 30 feet. At least four separate beds, which range in thickness from 4 feet to more than 7 feet, are mined locally. Although many mines will be flooded after Garrison Dam is completed, many suitable mine sites will remain above the proposed reservoir level. Sand and gravel deposits are found in glacial outwash and in stream-terrace deposits.

On upland areas of the reservation ground water is available principally from the lignite and the associated fine- to medium-grained sandstone beds of the Fort Union formation. Few wells on the reservation are known to produce water from glacial material, although the recessional moraines are possible sources of shallow-water supplies. Small quantities of ground water are available from thin alluvial deposits in some places on the upland.

Most wells in the valleys produce water from the alluvium or the terrace deposits. However, several wells penetrate the underlying Fort Union formation. A few flowing wells in the Missouri River valley near Elbowoods produce water from either the lower part of the Fort Union formation or from the Cannonball formation, also of Paleocene age.

The chemical character of water from the Fort Union formation and the outwash and river gravels was determined from analyses of 39 samples from wells and springs. Water from bedrock may be either hard or soft, and it is moderately to highly mineralized. Water from the surficial deposits is uniformly hard, but it is less mineralized. Shallow wells in the eastern and northeastern segments produce water of good quality. Wells in these segments, and several springs in the western segment, could be used satisfactorily as domestic supplies. Spring water from lignite deposits on the reservation generally is colored and contains objectionable amounts of iron. Treatment of the water would improve its quality for domestic use.

The filling of Garrison Reservoir will cause a rise of the water levels in wells that tap aquifers now discharging below the operating level of the reservoir. All the permeable strata below this level will become saturated, and ground-water bodies that are now separated will become hydraulically united.

In addition to providing subsurface information, the drilling program of the U. S. Bureau of Indian Affairs provided wells for domestic and stock-water supplies. All test holes that tapped an adequate supply of potable water were reamed to a larger diameter, equipped with casing and well screen, and gravel-packed. The test-drilling program was completed in 1951; however, the drilling of domestic wells was continued under the supervision of the U. S. Geological Survey.

INTRODUCTION

PURPOSE AND SCOPE OF THE INVESTIGATION

This investigation is one of several being made by the U. S. Geological Survey as a part of the program of the Department of the Interior for development of the natural resources of the Missouri River basin. (See fig. 1.) It was made at the request of the U. S. Bureau of Indian Affairs and was financed largely by that agency. Its purpose was primarily to locate adequate water supplies and secondarily to locate sources of sand and gravel and of lignite on the uplands of the Fort Berthold Indian Reservation.

The present economy of the reservation is dependent largely upon the production of beef cattle, which graze on the bottom lands and on the adjacent uplands. Cottonwood forests in the valleys are heavily cut by the Indians for building homes, barns, and corrals, and for use as fuel. Lignite beds, exposed in many places along the sides of the valleys, are also a source of fuel; a family can obtain its annual supply by only a few days' work in one of the many small mines.

Garrison Dam is now under construction about 30 miles down the Missouri River from the east boundary of the reservation. When it is completed and Garrison Reservoir is filled, about 173,000 acres of bottom lands within the reservation will be flooded, causing the loss of grazing lands, stock and domestic water supplies, timber, sand and gravel, and lignite. Seventeen hundred Indians of the total Indian population of about 2,000 (1949) now reside on the bottom lands and must be moved to other parts of the reservation. Relocated families must have adequate water for domestic use, and if their range area is to be efficiently utilized, wells and ponds for the watering of stock must be properly located. Adequate water supplies must also be provided for the Indian Agency headquarters, hospital, boarding school, and for the several day schools that are to be constructed.

The investigation on which this report is based was made during 1949–51 and included the mapping of areal geology, inventory of all wells and springs, preparation of a contour map of the water table in the eastern segment, supervision of the drilling of test holes and production wells by the Bureau of Indian Affairs, and ascertaining the chemical quality of the ground water.

PERSONNEL

The investigation as a whole was under the general supervision of A. N. Sayre, chief of the Ground Water Branch, Water Resources Division, U. S. Geological Survey, and of G. H. Taylor, regional engineer in charge of ground-water investigations under the Missouri River basin development program. The quality-of-water studies were made under the general supervision of S. K. Love, chief of the Quality of Water Branch, and under the immediate supervision of P. C. Benedict, regional engineer in charge of quality-of-water studies in the Missouri River basin. The field and office work was under the direct supervision of G. A. LaRocque, Jr., district engineer in charge of ground-water studies in North and South Dakota.

D. A. Jobin assisted in the geologic mapping and inventory of springs during June, July, and August, 1950. H. C. Frick assisted in the field work from September 1950 to its completion, and he also assisted in the compilation of data for this report. E. A. Busch assisted in the geologic mapping and inventory of springs during May, June, and July, 1951. F. E. Busch and L. R. Reed determined the altitude of the land surface at the test holes.

PREVIOUS STUDIES

The lignite fields of the Fort Berthold Indian Reservation have been the subject of several investigations during the past half century. Reconnaissance studies were made by Wilder and Wood (1902) and by Smith (1910). A comprehensive study of lignite on the part of the reservation that lies east of the Missouri River was made by Pishel (1912), and a similar study of lignite on the part of the reservation that lies west of the Missouri River was made by Bauer and Herald (1921). In addition to information on the occurrence of lignite, these reports contain a few geologic sections and some information on the geologic structure of the reservation. Lignite beds in the area adjacent to the eastern segment were mapped by Andrews (1939).

The physiography and glacial geology of the area were studied in a very general way by Alden (1932). During the past few years, Benson and Lindvall[1] have mapped the geology of several quadrangles in the area adjoining the south boundary of the reservation. Two of these quadrangles (Beulah and Golden Valley) include small

[1] Benson, W. E., and Lindvall, R. M., Preliminary geologic maps of the Beulah and Golden Valley quadrangles: U. S. Geol. Survey unpublished (1954) manuscripts.

areas of the southern segment of the reservation and were used in preparing the geologic map included in this report (pl. 1).

The ground-water resources of the area are described briefly by Simpson (1929) in a report on the geology and ground-water resources of North Dakota.

The Missouri Basin Investigation Staff of the Bureau of Indian Affairs published (1948) a report on the problems that will be caused by the flooding of valley lands on the Fort Berthold Indian Reservation.

METHODS USED IN THE INVESTIGATION

Geologic mapping was begun in July 1949 and was completed in 1951. (See pl. 1.) The geology was mapped on aerial photographs and transferred to a base map by means of a sketchmaster. The base map was adapted from county highway maps of Dunn, Mercer, McLean, and Mountrail Counties. Drainage lines visible on the aerial photographs were reproduced on the base map.

A drilling program that combined test drilling with the construction of production wells was carried on by the Indian Agency during the 1950 field season and was continued in 1951. The purposes of this program were to provide rangeland water supplies to meet minimum requirements, to obtain basic hydrologic and stratigraphic information for use in the location of well sites for additional rangeland and domestic water supplies, and to obtain more information on the location and extent of sand and gravel deposits and of lignite beds.

The test holes were drilled at locations that would be suitable for rangeland wells. Those penetrating water-bearing zones capable of yielding adequate supplies of potable water were reamed to an 8-inch diameter before they were completed as production wells. Most of the wells were gravel-packed by the following method: The water-bearing section of the test hole was underreamed to a maximum diameter of 18 inches; a 4-inch casing with a continuous-slot well screen attached to it was installed in the hole; and the underreamed part of the well was back-filled with carefully sized and screened sand and gravel. The wells were then developed by approved methods, such as bailing and surging, to insure maximum production.

Of the 113 test holes that were drilled, 68 penetrated water-bearing materials and were completed as wells. (See fig. 2 and table 3.) The maximum depth of test holes was 510 feet, the minimum was 122 feet, and the average was about 350 feet. Except in

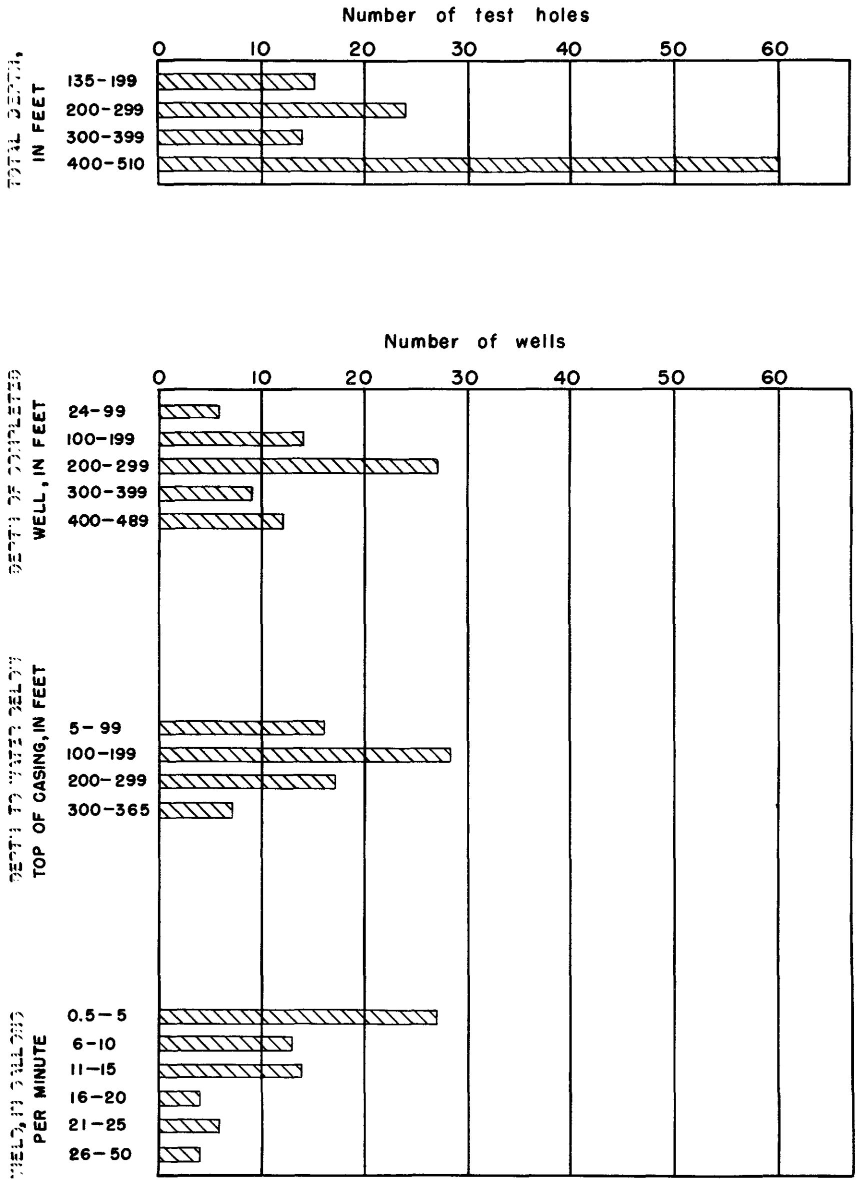

Figure 2.—Graphical summary of drilling program.

seven test holes drilled mainly for stratigraphic information, drilling was stopped at the depth at which an adequate water supply was obtained. Sample logs were made for all test holes from which samples were recovered (table 4).

The location of test holes was determined by the Bureau of Indian Affairs. Most of the holes were drilled on the uplands—some of them on ridges and hilltops—where they would be most beneficial as stock-water supplies. A few were drilled in the valleys.

All wells that were drilled as part of the program of the Bureau of Indian Affairs were inventoried. The altitude of the land surface at each test hole and of the measuring point of each well was determined by personnel of the Geological Survey; temporary benchmarks also were established. (See table 5.)

All other wells and all accessible springs on the reservation were inventoried. (See tables 6 and 7 and pl. 1.) In all but a few wells the total depth and the depth to water were measured. The total depth was measured to aid in ascertaining the aquifer from which water is produced. Altitudes above sea level of the measuring points of most wells in the eastern segment were established by an altimeter. Altitudes of a few wells in the Missouri River valley were determined from topographic maps (contour interval of 10 feet) prepared by the Corps of Engineers, Department of the Army.

WELL-NUMBERING SYSTEM

Wells, springs, and test holes on the Fort Berthold Indian Reservation are numbered according to their location within the land subdivisions of the Bureau of Land Management's survey from the fifth principal meridian and baseline. (See fig. 3.) The first numeral of a well number indicates the township, the second indicates the range, and the third indicates the section in which the well is located. The lowercased letters that follow the section number indicate the location of the well within the section. The first letter indicates the quarter section, the second indicates the quarter-quarter section, and the third indicates the quarter-quarter-quarter section, or 10-acre tract. The letters are assigned in a counterclockwise direction, beginning in the northeast quarter of the section or smaller subdivision thereof. If more than one well is within a 10-acre tract, the well number for each is assigned an additional arabic numeral indicating the order in which the well was inventoried.

GEOGRAPHY

LOCATION AND EXTENT OF THE AREA

The Fort Berthold Indian Reservation comprises about 1,000 square miles along both sides of the Missouri and Little Missouri Rivers in west-central North Dakota. (See figs. 4 and 5.) When construction of Garrison Dam is completed, the impounded water will reduce the land area of the reservation by about one-fifth and divide it into the eastern, northeastern, northern, western, and southern segments. (See fig. 5.)

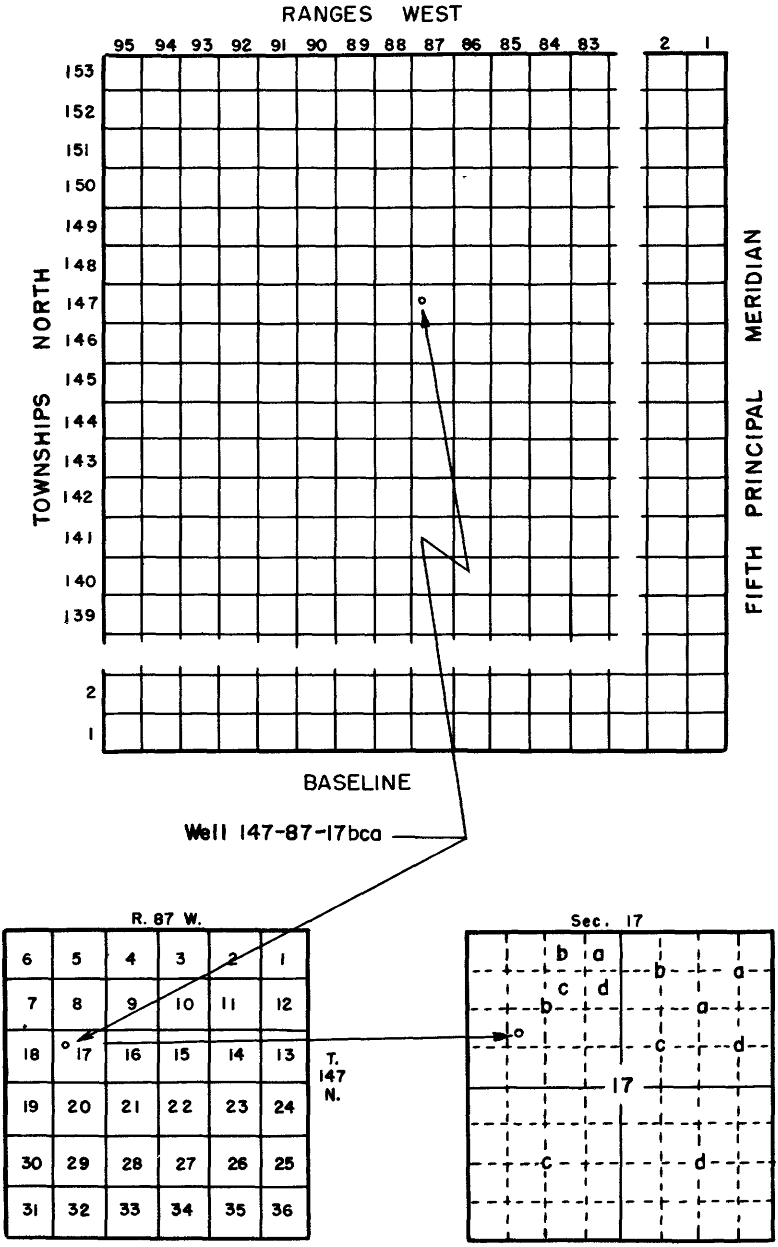

Figure 3. — Well-numbering system.

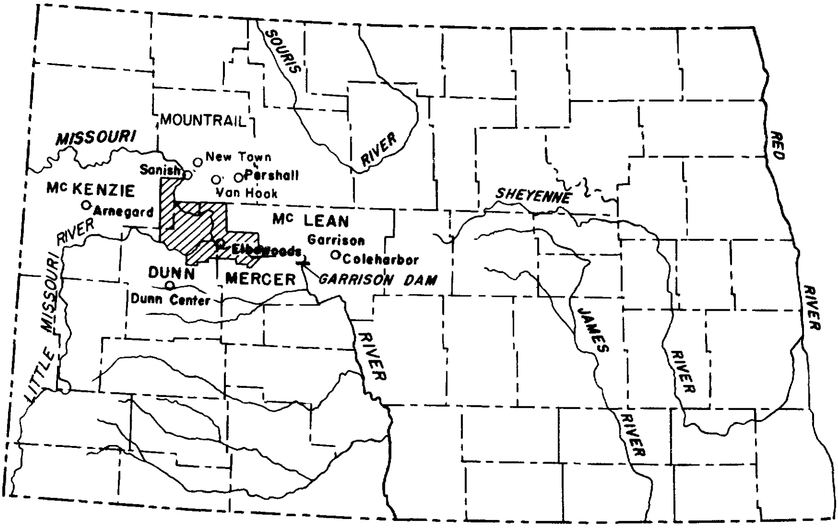

Figure 4.—Map of North Dakota showing location of Fort Berthold Indian Reservation.

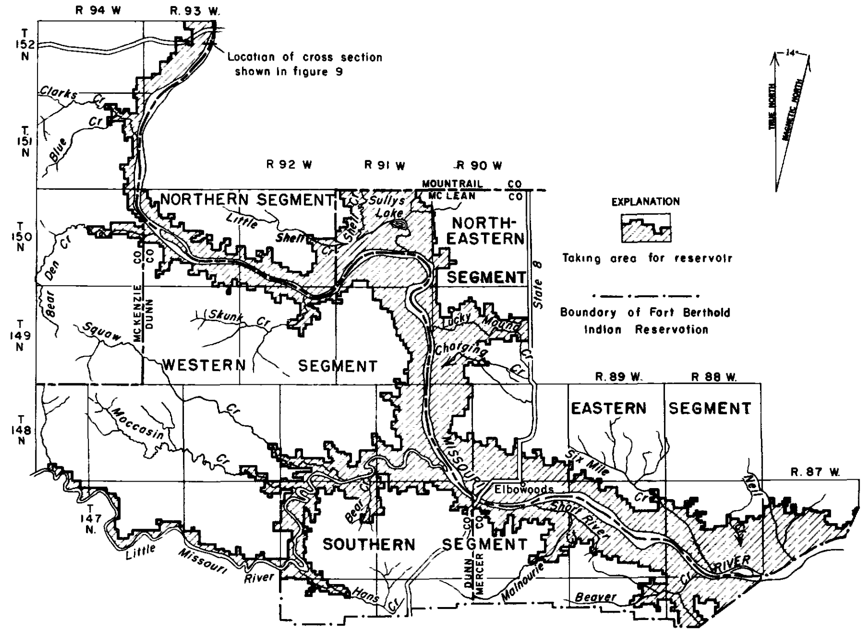

Figure 5.— Map of Fort Berthold Indian Reservation showing the taking area for Garrison Reservoir and the designation of the five segments of the reservation.

LAND USE

Much of the uplands and valley flats of the three segments east and north of the Missouri River is cultivated, small grains being the principal crops. The western and southern segments, although they have inadequate stock-water supplies, are used primarily as cattle range. Many Indian families living in the river valleys will have to be relocated on the uplands of the western segment. These and other upland areas on the reservation are now leased to non-Indian farmers and ranchers. On the western segment these leases will be terminated and the land subdivided into smaller ranches for the Indian families. If these are to be profitable, stock-water supplies must be provided.

CLIMATE

Although the climate of North Dakota is semiarid, plant growth is favored by the concentration of precipitation during the spring and summer months. On the reservation an average of 81 percent of the total annual precipitation falls during the 6 months from April to September. (See fig. 6.) During the 58-year period from 1892 to 1950, the average annual precipitation at Elbowoods was 15.45 inches. Thundershowers account for most of the precipitation during the summer; therefore, the amount measured during any 1 year at weather stations near the reservation varies considerably. (See fig. 7.) The maximum recorded annual precipitation at Elbowoods is 27.86 inches (1899), and the minimum is 4.94 inches (1934).

A graph showing the cumulative departure from average precipitation for stations on or near the reservation shows the recurrence of wet and dry periods. (See fig. 8.) From 1890 to 1916 the precipitation was generally above average. The period from 1916 to 1936 was generally dry, and precipitation was scant during the last 8 of these years. From 1940 to 1950 the precipitation was generally above average.

Periods of above-average precipitation provide more water for recharge of ground-water bodies. The water table rises, causing higher water levels in wells and increased flow from springs. During periods of average precipitation, ground-water levels and spring flows remain relatively constant. Long periods of below-average precipitation, such as during the drought years of the 1930's, lower the water levels and reduce the flow of springs.

Fall, winter, and early spring precipitation supplies most of the recharge to aquifers of the Fort Union formation—the heavy rains of late spring and early summer are usually thundershowers and

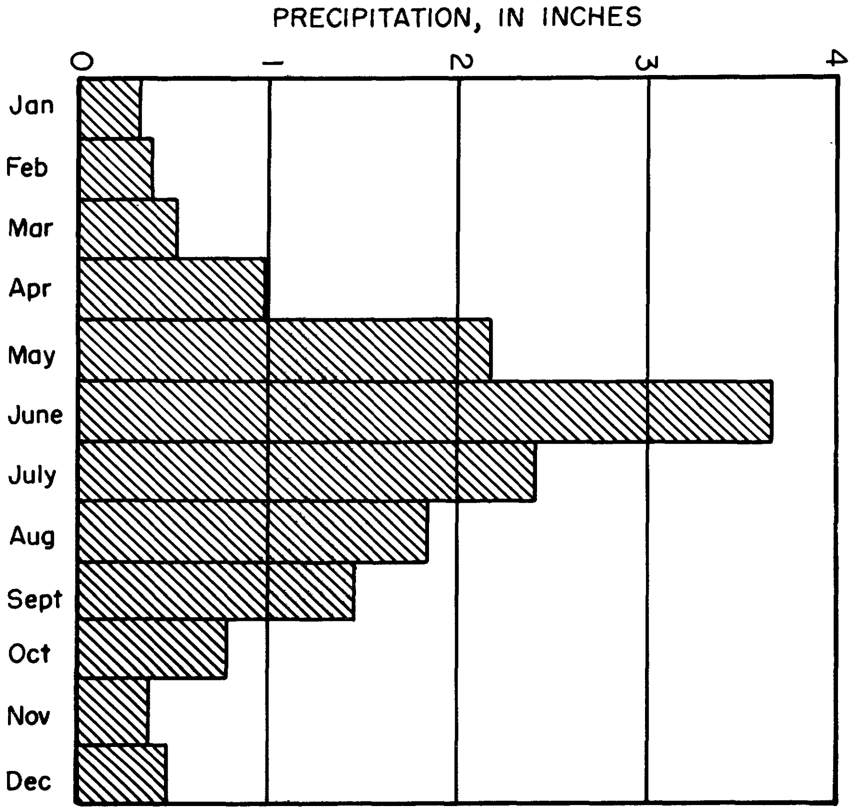

Figure 6.— Average monthly precipitation at Elbowoods, N. Dak., for period 1892–1950.

are lost through runoff and evapotranspiration. This conclusion is substantiated by the fact that water levels in observation wells are high in the early spring and steadily decline during the period of high precipitation.

The average length of the growing season is 117 days. The average date of the last killing frost in the spring is May 21, and the average date of the first killing frost in the fall is September 15. Killing frosts have been reported in all months of the year.

GEOMORPHOLOGY

The Fort Berthold Indian Reservation is in the Missouri plateau section of the Great Plains physiographic province on a rolling plain that has been deeply dissected by the Missouri and Little Missouri Rivers and their tributaries. Valleys are deeply intrenched

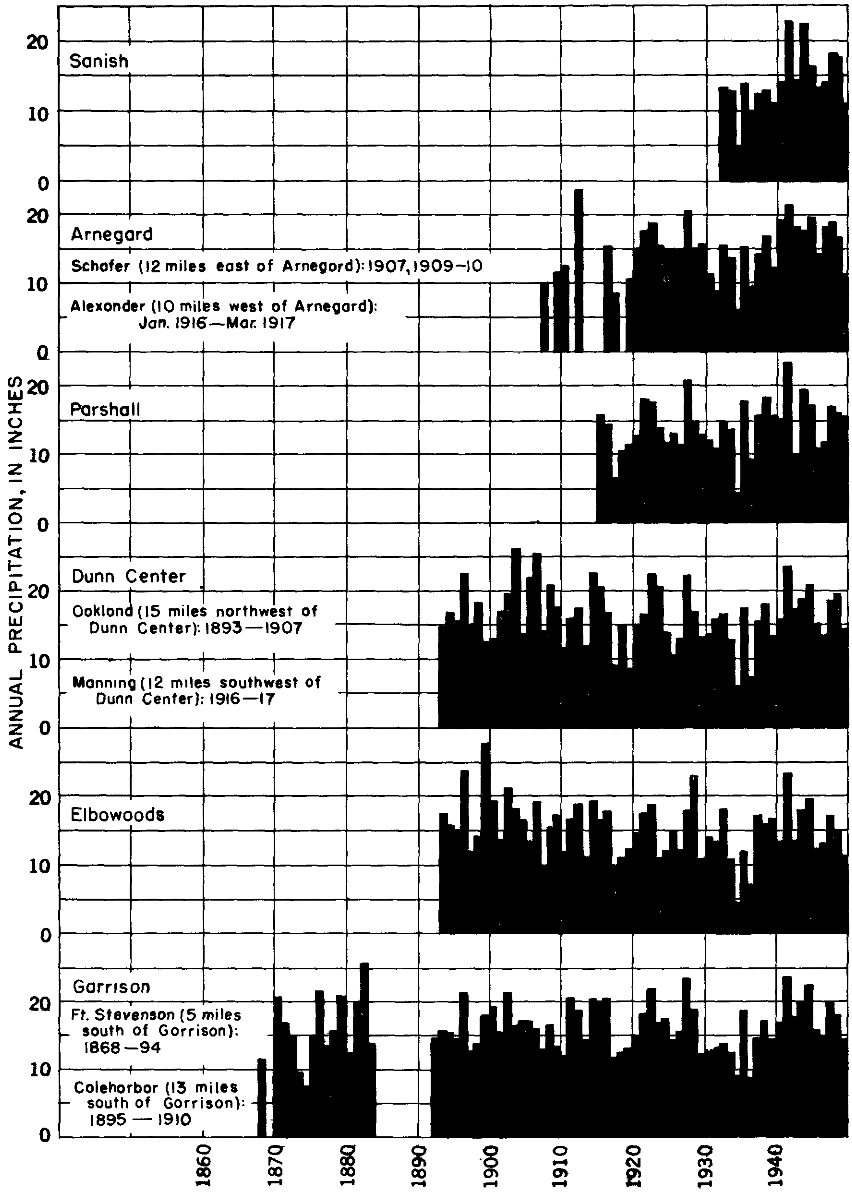

Figure 7.— Annual precipitation at weather stations in the vicinity of Fort Berthold Indian Reservation, 1868–1949.

and bordered by bluffs. The flood plain of the Missouri River is 300 to 500 feet below the general level of the uplands, and at the "Big Bend," south of Sanish, the tops of the buttes are 600 to 800 feet above the river. Near the western boundary of the reservation the Little Missouri has cut to a depth of 600 feet or more below the uplands. In some places typical badland topography has developed.

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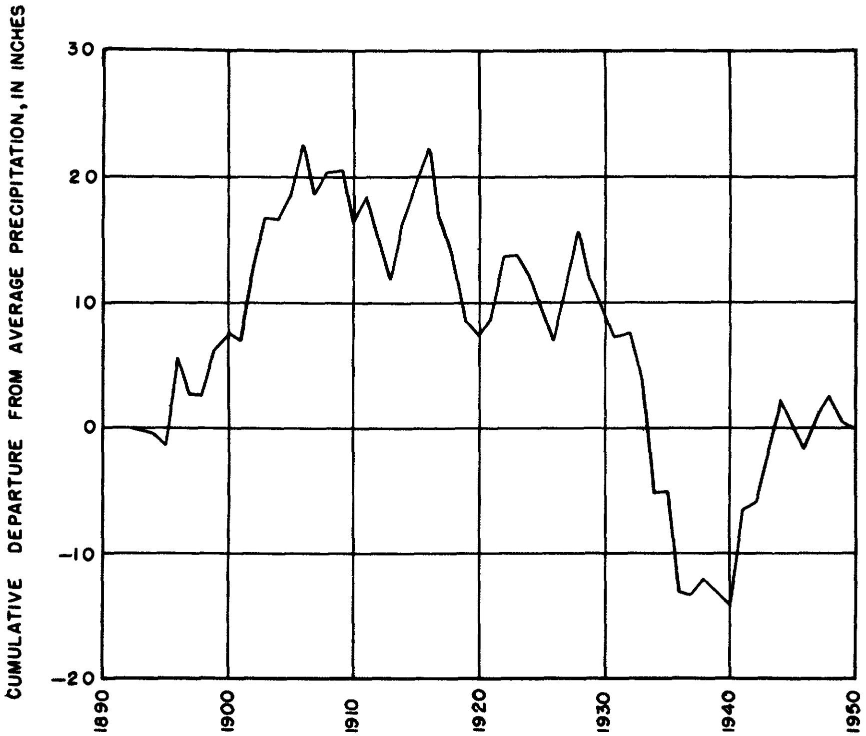

Figure 8.— Cumulative departure from average precipitation at Elbowoods, Dunn Center, and Garrison, N. Dak., for the period 1893–1950.

The entire reservation has been glaciated at least once, and the part east of the Missouri River has been glaciated several times. Alden (1932) considered the drift on the west side of the river to be of early Wisconsin (Iowan) or Illinoian age. Apparently it is older than that on the east side, which has not been appreciably altered by postglacial erosion. Undrained depressions are common and the topography of at least one area, in T. 148 N., R. 88–89 W., is typically morainic. That area, representing a recessional moraine, is a part of a lobe extending southward from a large moraine to the north.

The valley floor of the Missouri River is from 2 to 5 miles wide, and that of the Little Missouri River is from ½ to 1 mile wide, except in some stretches where it is narrower and little or no flood plain has developed. The present flood plains of the major valleys are fairly narrow in comparison to the total width of the valley floors. In many places flood plains and low terraces are covered with a dense growth of brush or cottonwoods, or both. A low terrace, which in this report is considered to be a part of the present flood plain, is from 8 to 10 feet above the average level of the river and is occasionally flooded. Most of the cottonwood forests grow on this terrace.

In general, the type of material and sequence of deposition are more reliable criteria for correlation of the terraces of this area than are the relative heights of the terraces above the river. These heights may vary considerably with the location of terraces in the valley. For example, in the Nishu area a terrace near the side of the valley is from 50 to 70 feet above river level, but at Independence the same terrace is near the center of the valley and only about 40 feet above the river. The similarity of these deposits indicates that they are contemporaneous.

The larger tributary creeks of the reservation have cut deep valleys into the relatively unconsolidated Fort Union formation. These valleys are graded to the alluvial terrace that is 35 to 40 feet above the Missouri River. The bottoms of the creek valleys are as much as 1 mile wide. Recent erosion has cut narrow trenches, 10 to 20 feet deep, into the valley floors. An exception to the general rule of broad, flat valleys, however, is the lower 5- or 6-mile reach of the valley of Bear Den Creek, which is steep sided and of fairly recent origin. At the Big Bend, where Bear Den Creek enters the Missouri River, the valley of the Missouri is relatively narrow and steep walled and contrasts markedly with the broad valleys both northwest and southeast of the Big Bend. Apparently the Big Bend stretch of the Missouri River valley is younger than the upstream and downstream stretches in this area; before the cutting of the present channel, the river followed a shorter route that cut off the Big Bend. The courses of two abandoned channels are shown in figure 9.

A broad flat-bottomed valley parallels the western boundary of the reservation from sec. 18, T. 150 N., R. 94 W. to sec. 12, T. 149 N., R. 95 W. From this point the valley extends southeast to join the valley of the Little Missouri River at sec. 34, T. 148 N., R. 92 W. (See pl. 1.) Although this valley probably was cut by a preglacial stream, the sediments underlying the valley floor definitely are of more recent age than the youngest glacial deposits in this part of the reservation and may have been deposited when drainage to the Missouri River was blocked by ice during one of the later glacial stages. The valley now is drained by two creeks that flow in opposite directions from a low divide in secs. 16 and 17, T. 149 N., R. 94 W. Bear Den Creek, a tributary of the Missouri River, drains the valley north of the divide. Squaw Creek drains the valley southeast of the divide and flows into the Little Missouri River.

At some time in the past the Missouri River cut its channel to a depth of 100 feet or more below the present river. The only available information concerning the depth to the bedrock channel on the reservation is for the area just south of Sanish in the extreme north part of the reservation. (See fig. 10.) As this area is downstream

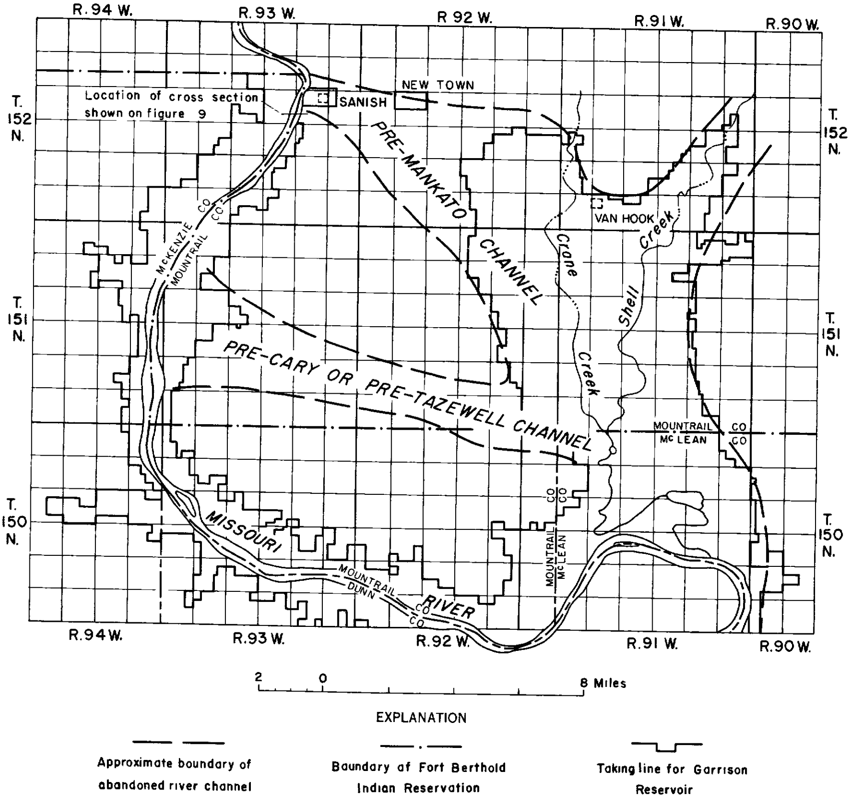

Figure 9.— Map showing abandoned channels of the Missouri River in the "Big Bend" ares.

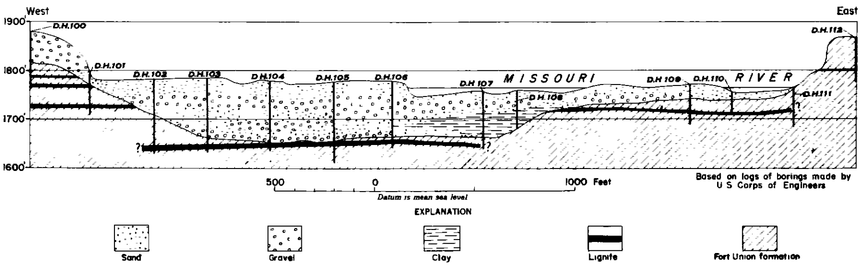

Figure 10.—Cross section of the Missouri River vslley in secs. 14 and 15, T. 152 N., R. 93 W., near Sanish, N. Dsk.

from the point where an old channel branches to the east from the present channel (fig. 9), it is possible that a deeper channel may exist upstream from this junction.

GEOLOGY

CENOZOIC GEOLOGIC HISTORY

TERTIARY PERIOD

At the beginning of the Cenozoic era a great shallow sea covered much of North Dakota. The western shoreline probably shifted east and west across the reservation several times. In the shallow water of this sea, thick layers of predominantly dark shale but with some sandstone were laid down early in the Paleocene epoch. These beds compose the Cannonball formation. (See table 1.)

A broad coastal swamp bordered the northwest shoreline of the sea, and large streams flowed sluggishly across it. From time to time the vegetation of the swamp accumulated into thick mats, which later were buried by dark-colored beds of sand or clay. These mats of organic material have been compressed and altered to lignite.

The older continental beds make up the Ludlow member of the Fort Union formation. Later, somewhat lighter colored beds were deposited in the same general area, and these beds compose the lower part of the Tongue River member of the Fort Union formation. Because the shoreline shifted, both the Ludlow member and the lower part of the Tongue River member interfinger with the Cannonball formation.

The sea retreated from this area during the later part of the Paleocene epoch. However, continental deposition of sand, silt, and clay and the accumulation of organic material continued throughout the epoch. All of the Paleocene continental deposits in west-central North Dakota are grouped together as the Fort Union formation, which is composed of the Ludlow, Tongue River, and Sentinel Butte shale members. Only the Tongue River member could be identified as being exposed on the reservation. In this area the upper part of the Tongue River member must contain beds that are equivalent in age to the Sentinel Butte shale member; however, the typical dark-gray shales and sands of the Sentinel Butte shale member are intercalated with so many light-colored beds that it cannot be identified as a separate unit from the Tongue River member. The relation of the members of the Fort Union formation to one another and to the Cannonball formation is shown in figure 11.

A much more detailed description of the environment and depositional conditions in North Dakota during the Paleocene epoch, with

Table 1.—*Geologic formations of the Fort Berthold Indian Reservation and vicinity*

System	Series	Formation	Thickness (feet)	Lithologic characteristics	Ground-water supply
Quaternary	Pleistocene and Recent, undifferentiated	Alluvium	0–160: 0–50	Silt and sand; lenses of gravel.	Source of some shallow supplies, including the Elbowoods well.
		Terrace deposits	0–50	Clay, fine sand, and some gravel.	Source of many shallow supplies. Some terrace deposits lie above the water table.
		Glacial drift	0–25; locally 130(?) in morainal area	Clayey till; some outwash sand and gravel.	Source of shallow supplies in the upland areas; very good water for domestic use.
Tertiary	Oligocene	White River formation[1]	200	Sand, clay, marl, and limestone; contains conglomerate near base.	
	Eocene	Golden Valley formation	200	Fine to coarse micaceous sand and silt (upper member); gray and purple shale and white clay (lower member).	Caps ridges and buttes; no wells or springs on the reservation are known to produce from this formation.
	Paleocene	Fort Union formation: Tongue River member; upper part includes beds equivalent in age to Sentinel Butte shale member.	900–1,100	Varicolored buff to gray-green sand and clay; many lignite beds.	Source of water for 80 to 90 percent of the wells and nearly all springs on the reservation.
		Fort Union formation: Ludlow member[2] / Cannonball formation	(Ludlow member) (?) / (Cannonball formation) 250–300	Somber gray to brown sand and clay; a few lignite beds (Ludlow member). Somber gray clay and sand; may contain marine fossils (Cannonball formation).	Cannonball formation may be source of water yielded by several flowing wells in valley areas.

[1]Not present on reservation.
[2]Not definitely known to be present.

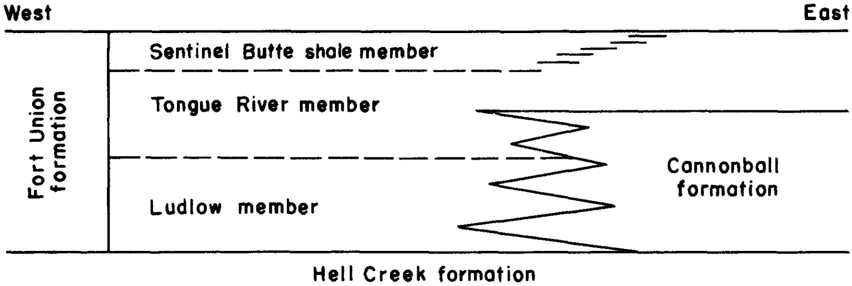

Figure 11.—Relation of members of the Fort Union formstion to one another snd to the Cannonball formation.

particular reference to the lignite beds, has been written by Roe (1950).

The maximum thickness of the Fort Union formation in this area is about 1,000 feet. It is wholly of continental origin, and apparently all of the beds were deposited in a swampy environment. The settling of the Williston basin, which was in progress at this time, permitted continued deposition near sea level.

The close of the Paleocene epoch was marked either by a change in the source of sediments or by a change in weathering conditions in the source area. No erosional break between formations of Paleocene and Eocene age is apparent; yet the type of material that was deposited changed considerably. The clay of the Golden Valley formation of Eocene age is very kaolinitic, and the sand and silt are more micaceous than most of the sand and silt of the Fort Union formation. Deposition of silt and clay by slowly moving streams continued in the lowlands during the early part of the Eocene epoch. The upper part of the Golden Valley formation consists mostly of fine to medium sand and contains some lenses of coarse sand. Apparently this area was uplifted slightly toward the close of the Eocene epoch, and as a result the gradient of the streams was increased slightly. A period of erosion followed the deposition of the Golden Valley formation and a surface of considerable relief apparently was developed. In some places the Golden Valley formation, which is about 200 feet thick, was entirely removed by erosion, and in these places the White River formation of Oligocene age was deposited directly on the Fort Union formation (Leonard, 1922). The thick beds of limestone and marl of the White River formation were probably deposited in fresh-water lakes; some of the sandy members are river deposits.

A long period of erosion followed the deposition of the White River formation, developing a smoothly rolling plain with broad, flat valleys and a few high buttes. This surface is preserved over much of North Dakota and has been altered only by the trenching of rivers and by the action of glaciers during the Quaternary period.

QUATERNARY PERIOD

The reservation area was glaciated a number of times during the Quaternary period. The record of possible invasions by Illinoian, Kansan, and Nebraskan ice sheets was almost completely destroyed by the advance and retreat of Wisconsin ice sheets of the oldest (Iowan) substage, an intermediate (Cary or Tazewell) substage, and the youngest (Mankato) substage. Each affected the topography and geology and caused changes in the drainage. Some of these changes were minor, whereas others affected the major streams.

Before the advance of the earliest ice sheet into North Dakota, the Missouri River drained northeastward from northeastern Montana across Canada into Hudson Bay. When blocked by the advancing ice, the river probably flowed eastward and southward along the margin of the ice until it reached the valley of a south-flowing stream or until ponding raised the water surface to a level at which the river could establish a course across the uplands. The course of the Missouri River in the vicinity of the reservation during or after the first three ice advances is not known.

Apparently, the present course of the Missouri through North Dakota is the result of diversion by the ice sheet of early Wisconsin (Iowan) age. The present valley does not represent the farthest advance of this ice sheet into North Dakota; however, the retreating ice front remained relatively stationary along the present course of the river for a sufficient time to allow the river to begin to cut its valley into the soft bedrock. Probably the river never returned to its original northeastward course after it was first diverted early in Pleistocene time.

Abandoned channels of the river indicate that minor changes in course have occurred since the Iowan substage. Near Sanish are two well-defined abandoned channels (fig. 9), and a third channel, less easily distinguished, which may have been used for only a short while. Although these channels have not been correlated definitely with Wisconsin substages, the writers believe that before the advance of the glacier of Mankato time the Missouri followed the broad valley that lies north of Sanish and turns south near Van Hook. This valley is between 1,850 and 1,900 feet above mean sea level and 250 to 400 feet below the general upland surface. Drilling by the Corps of Engineers at the site of New Town, in sec. 17, T. 152 N., R. 92 W., penetrated at least 185 feet of unconsolidated fill in this valley. The other old valley, which lies between Sanish and the present Missouri channel, is between 1,900 and 1,950 feet above mean sea level, but the thickness of its alluvial fill is not known. It may have been the channel of the Missouri River in pre-Cary or pre-Tazewell time. The present valley of the Missouri River from Sanish to Shell Creek is very young, by comparison, and was formed after the blocking of the river by the ice sheet of the Mankato substage.

The valley of Shell Creek from the Missouri River to Van Hook is much broader than the abandoned river channels described in the preceding paragraphs. Either a tremendous volume of melt water flowed through it when the glacier lay just north of Van Hook, or several smaller channels coalesced to form a large valley. Just east of Van Hook a broad valley extends northeast through the Shell Lake Wildlife Refuge toward the Des Lacs River. It is possible that the Des Lacs and Souris Rivers were blocked by ice that advanced from the northeast, causing them to overflow the divide and join the Missouri River.

STRATIGRAPHY

TERTIARY SYSTEM

PALEOCENE SERIES

CANNONBALL FORMATION

The Cannonball formation consists of marine beds that are equivalent in age to, and which interfinger with, the nonmarine Ludlow member of the Fort Union formation. In some localities the Cannonball interfingers also with the lower beds of the Tongue River member of the Fort Union formation. The Cannonball typically consists of dark-gray sand and clay and a few beds of thin nodular fossiliferous limestone. Fossils in the formation are principally those of small marine invertebrates; shark teeth have been reported from some localities.

Although not exposed on the reservation, the Cannonball formation is of economic importance because it is a possible source of artesian water in the river valleys. The Corps of Engineers reported that the top of this formation is at an altitude of 1,425 feet in a deep well drilled at the Garrison Dam site. On the reservation it probably lies at an altitude of 1,200 feet— that is, about 550 feet below the Missouri River and 900 to 1,100 feet below the general upland level. Logs of wells that penetrate the Cannonball formation on the reservation are not available.

FORT UNION FORMATION

LUDLOW MEMBER

The Ludlow member is the basal member of the Fort Union formation. It consists of beds of silty sand and clay that are somewhat darker in color than the sediments of the overlying Tongue River member. The Ludlow member contains lignite beds, but they are fewer than in the Tongue River member. The Ludlow member and the Cannonball formation are equivalent in age and interfinger in western and southern North Dakota; therefore, beds of either or both may underlie the reservation. The Corps of Engineers reported that the combined thickness of the two is more than 500 feet at the Garrison Dam site. Neither is present in the California Kamp well, which is 12 miles north of the northwest corner of the reservation and 80 miles northwest of the Garrison Dam site (Laird, 1946). If these data are correct, both the Cannonball formation and the Ludlow member thin to a featheredge between the dam site and the California Kamp well.

TONGUE RIVER MEMBER

The Tongue River member of the Fort Union formation underlies the entire reservation. The lower part of this member is equivalent in age to, and interfingers with, the Cannonball formation. West of the Missouri River the Tongue River member is overlain in a few areas by the Golden Valley formation. On most of the uplands the Tongue River member is mantled by a thin blanket of till, and in the valleys it commonly is covered by alluvium and terrace deposits. Excellent exposures of the member are found along the bluffs that border the valleys; a thickness of at least 500 feet is exposed in the badlands along the Little Missouri River near the western boundary of the reservation.

The Tongue River member consists of continental deposits of clay, fine- to medium-grained sandstone, and numerous lignite beds. Where freshly exposed, the clay and sandstone commonly are medium gray. Where weathered, the clay is greenish gray to yellowish buff and the sand is buff to light tan. Individual beds range in thickness from a few feet to slightly more than 50 feet; because they are lenticular, most of them cannot be traced from one exposure to another. A fairly persistent sandstone zone, which ranges in thickness from a few feet to 80 feet or slightly more, forms the uppermost part of the member on the reservation. Most of the beds are soft and relatively unconsolidated, but a few beds are a hard calcareous sandstone. Limestone lenses, ranging in thickness from a few inches to about 2 feet, were penetrated in a few of the test holes that were drilled in the Tongue River member. Zones containing reddish-brown clay-ironstone concretions in a clayey matrix are found at some horizons in the member. These concretions range from 1 inch in diameter to massive loglike bodies that are 30 feet or slightly more in length.

Typical stratigraphic section of middle part of Tongue River member in NW¼ sec. 9, T. 147 N., R. 89 W., near Nishu

[See page 29 for explanation of numbered beds]

	Feet
Shale, silty, gray, weathers yellowish	4.1
Lignite, woody, purple and brownish	.8
Lignite, earthy, brown	.2
Lignite, good quality	2.3
Clay, gray, with chalky nodules	.5
Covered slope	4.1
Shale, silty, gray, with limonite	2.0
Clay, medium light-gray	.8
Lignite	3.3
Clay, silty, gray	22.7
Lignite, woody, brown	.7
Lignite (bed 2)	7.0
Clay, silty, gray	6.3
Lignite, woody, brown	.4
Clay, silty, bentonitic, medium dark-gray, with many silicified tree stumps	3.3
Clay, medium light-gray, bentonitic, zone of clay ironstone concretions about 1 foot below top of bed	4.0
Lignite	.5
Clay, medium-gray	2.2
Shale, carbonaceous	.6
Lignite	.5
Clay, sandy, medium-gray	13.6
Lignite	2.3
Clay, sandy, gray	5.7
Clay, sandy, yellow-drab, with lenses of silty sandstone	8.8
Lignite, somewhat earthy	.6
Clay, silty, carbonaceous, gray	3.4
Clay, iron-stained	1.4
Clay, carbonaceous, gray to black	.2
Clay, silty, medium light-gray with thin limonitic zones, grading downward to fine sandy siltstone; concretionary clay-ironstone zone as much as 4 feet thick in upper part of bed	13.1
Clay, carbonaceous	.6
Clay, medium-gray	4.2
Sandstone, fine, drab-gray, with thin lignite partings	11.0
Shale, silty, soft, gray	1.9
Clay, chocolate-gray, somewhat lignitic at top	1.5
Clay, silty, gray; weathers yellow; clay-ironstone zone at base 1½ to 2 feet thick	11.9
Siltstone, sandy, gray to buff, with thick gray crossbedded sandstone lenses	35.3
Lignite (bed 1–A)	6.2
Clay, medium-gray	1.9
Shale, silty, gray; weathers buff; thin ironstone partings 1 to 2 feet apart in lower part of bed	24.7
Lignite (bed 1)	.2
Clay (bed 1)	.3
Lignite (bed 1)	.7
Clay (bed 1)	.1
Lignite (bed 1)	1.0
Clay, gray, with thin lignite partings (bed 1)	1.5
Lignite, brown (bed 1)	.4
Lignite (bed 1)	2.8
Clay, silty, gray, with a few concretions	10.0
	231.6

Composite stratigraphic section of Tongue River member along the Big Bend on the Missouri River, 10 miles west of the mouth of Shell Creek

[Measured by Pishel (1912). See page 29 for explanation of numbered beds. Strata above lignite bed 2 were measured in sec. 20, T. 150 N., R. 92 W.; strata between lignite beds 1 and 2 were measured in the SE¼ sec. 6, T. 150 N., R. 93 W.; strata below lignite bed 1 were measured in the NW¼ SW¼ sec. 31, T. 151 N., R. 93 W.]

	Feet	Inches
Shale, somber	30	0
Lignite (bed 3)	3	0
Shale, gray, sandy	8	0
Clay, ironstone concretions, yellowish	2	0
Shale, gray	25	0
Shale, sandy, yellowish-gray	23	0
Sandstone, soft, gray, shaly	4	0
Shale, yellowish, well stratified	6	0
Shale, carbonaceous with lignite lenses	3	0
Shale, gray, somber	3	0
Shale, yellowish-drab, sandy	3	0
Lignite (bed 2)	4	6
Shale, yellowish, sandy	27	0
Lignite	1	0
Shale, sandy, gray	25	0
Shale, carbonaceous		4
Sandstone, soft, gray, shaly	25	0
Shale, carbonaceous	3	0
Shale, gray	3	0
Shale, carbonaceous	2	0
Sandstone, gray, shaly	17	0
Shale, carbonaceous, with lignite streaks	11	0
Lignite		5
Shale, sandy, grayish-yellow	3	0
Sandstone, gray, soft	17	0
Lignite		8
Sandstone, brown, shaly	6	0
Lignite	1	0
Shale, gray, sandy	45	0
Sandstone, grayish-tan	10	0
Sandstone, yellowish-gray	10	0
Shale	1	0
Lignite	4	3
Shale, sandy	4	0
Shale	1	0
Lignite	2	11
Shale, carbonaceous		7
Lignite (bed 1)	3	6
Clay and sand (to river level)	75	0
	414	2

The lignite was formed in swampy areas as the result of the accumulation of plant materials. The swamps probably were interconnected during periods of deposition, but the amount of plant material that accumulated varied widely in different localities and resulted in a considerable range in thickness of individual beds. A few lignite beds in the Tongue River member are persistent over a large area and can be used to determine structure. For example, lignite bed 2 in Pishel's section is persistent throughout an area of many square miles. Other lignite beds are lenticular and are of small extent. On the reservation the beds range in thickness from less than 1 foot to at least 29 feet. Silicified tree stumps have been found in the upper part of lignite beds in many localities, and comparatively dense clay underlies the beds in many areas. The beds overlying the lignite range in composition from silty clay to fine- to medium-grained sandstone.

SENTINEL BUTTE SHALE MEMBER

The Sentinel Butte shale member of the Fort Union Formation was described originally by Leonard (1908, p. 51), as follows:

> The middle portion (Tongue River) is composed of light ash-gray and buff shales and and sandstones while the upper (Sentinel Butte) is formed of beds much darker in color, mostly a dark and somber gray with many brown, ferruginous, sandy nodules and concretions.

Apparently the two members were differentiated principally on the basis of the change from light- to dark-colored beds.

The part of the Fort Union formation that is exposed on the reservation (a thickness of 900 to 1, 100 feet) probably consists mostly of the middle and upper parts of the Tongue River member. As the Golden Valley formation conformably overlies the Fort Union formation, the Sentinel Butte member, if present, should directly underlie the Golden Valley formation. Thus far, differentiation between the Tongue River and Sentinel Butte members has not been possible on the reservation. The upper beds of the Tongue River member on the reservation may grade laterally into beds of the typical Sentinel Butte shale member in other areas.

EOCENE SERIES

GOLDEN VALLEY FORMATION

The Golden Valley formation, as described by Benson (1949) from an exposure near Golden Valley, N. Dak., consists of a lower member of purplish-gray carbonaceous clay and white sandy kaolinitic clay, and an upper member of fine to coarse micaceous sand and silt and small clay lenses. Its maximum thickness on the reservation is 150 to 200 feet.

On the reservation the basal beds of the lower member consist of medium- to dark-gray, somewhat kaolinitic clay, with zones of nodular limonitic concretions. These lower clay beds are very similar to the clay beds of the underlying Fort Union formation. The upper part of the lower member is a widespread bed of white sandy kaolinitic clay, which in some areas is stained yellow or orange where exposed to weathering. It is the most easily identified bed of the Golden Valley formation. In the southeastern part of T. 147 N., R. 92 W., the upper part of the lower member consists of white medium sand, which probably is a local facies of the white clay bed.

The upper member of the formation is a thick series of fine- to coarse-grained, buff to tan sandstone strata. The sandstone is generally soft and unconsolidated, but in some localities it is cemented and forms a resistant rock. The upper member makes up more than half of the total thickness of the Golden Valley formation on the reservation.

The Golden Valley formation caps some of the higher hills and ridges in the southern and western segments of the reservation. (See pl. 1.) It is particularly well exposed in the southwestern part of the western segment. In the eastern segment the only exposure is in the SE¼ sec. 10, T. 148 N., R. 90 W., where two small hills are capped by a part of the lower member of the formation. The white clay bed, which caps one of the hills, is used by the Indians as plaster in the construction of their homes; in a few years it probably will be completely removed.

Section of Golden Valley formation measured at the Blue Buttes in SW¼ sec. 29, T. 151 N., R. 94 W., on the southwest and south-southwest slopes of adjoining buttes

	Feet
Sand, medium, light-brown to tan on fresh exposures and dark gray where weathered; cross-laminated; conspicuous vertical joints; some bands and lenses of coarse, highly micaceous sand; consolidated to sandstone in some areas	54.3
Covered slope, probably underlain by lower part of bed described above	27.1
Sandstone, medium-grained, tan, micaceous, conspicuously cross-laminated with fine streaks of iron oxide parallel to bedding; few scattered small lenses of unconsolidated fine white sand; lower 4 to 6 feet are reddish- to yellowish-brown because of concentration of iron oxide; base of bed is undulatory	27.2
Clay, light-yellowish on exposed surface; purplish band 1 to 2 feet thick near top of bed; lower part of bed is silty clay	26.3
Concretionary zone (three(?) concretionary zones in silt matrix), dark purple; high manganese content indicated by color	3.7
Silt, clayey, yellowish-gray	17.1
Silt, fine, sandy, very light-yellow on weathered surface and very dark-gray on fresh exposure; contains limonitic lenses; somewhat consolidated and platy near top of bed	4.0
Sand, medium-fine, light brownish-gray to yellowish-gray, micaceous, cross-laminated, irregularly consolidated, and cliff-forming; lower 2 feet are iron-stained	12.3
Clay, sandy, dark purplish- gray	1.0
Clay, very light purplish-gray both where fresh or weathered	6.1
Clay, white with irregular orange splotches and bands	4.2
Covered slope to base of Blue Buttes (thickness estimated)	75
	258.3

The Blue Buttes (secs. 28, 29, 32, and 33, T. 151 N., R. 94 W.) were reported by Leonard (1922) to be capped by 200 feet of the White River formation. At that time, however, the Golden Valley formation had not been described. The upper 100 feet of the Blue Buttes is predominantly a massive light-gray highly micaceous medium-grained sandstone which weathers brown to dark gray. Lenses of white highly micaceous coarse-grained sandstone and thin beds of green clay are included in the strata. According to Benson (personal communication, 1950) the upper beds at Blue Buttes are very similar to strata of the Golden Valley formation at Medicine Buttes in the Medicine Buttes quadrangle of North Dakota. In the Killdeer Mountains, which are 25 to 30 miles to the southwest, the White River formation contains a conspicuous basal conglomerate and several thick limestone beds higher in the formation.

In view of the dissimilarity between the strata in the Blue Buttes and those of the White River formation in the Killdeer Mountains, the strata in the Blue Buttes are considered in this report to be a part of the Golden Valley formation.

QUATERNARY SYSTEM

PLEISTOCENE SERIES

GLACIAL DRIFT

Much of the upland area of the reservation is mantled by glacial drift. It is less than 10 feet thick in most places but is as much as 340 feet thick where it fills low areas and preglacial valleys in the bedrock surface. The fill in these preglacial valleys probably includes some alluvial materials interbedded with the drift. Several recessional moraines lie in the eastern and southern segments of the reservation. The youngest of these moraines covers about 10 square miles of T. 148 N., R. 89 W., and extends northeast beyond the reservation boundary. This moraine has been modified only slightly by erosion; therefore, depositional features such as kettles and kames may be easily recognized. Drillers report a thickness of more than 100 feet of glacial drift in the moraines.

TILL

Glacial till on the reservation is composed of a heterogeneous mixture of sand, gravel, and boulders in a clayey matrix. Generally, these materials are of local origin. For example, the till is very sandy in the southern part of the western segment where the upper sand bed of the Fort Union formation is exposed over an area of many square miles. Also, the clay in the till closely resembles the clay in the Fort Union formation from which it was derived. In some localities the till can be differentiated from clay of the bedrock only by the presence of a few pebbles in the till. On some slopes much of the matrix of the till has been eroded away, and the boulders that had been incorporated in it are now perched on pinnacles of till or occur as erratics on the bedrock surface.

OUTWASH DEPOSITS

Extensive deposits of outwash sand and gravel, which were deposited by melt water that issued from the ice, occur in several areas of the reservation. (See pl. 1.) Many of these deposits are well sorted, and the material is ideally suited for use in road construction. Some of the outwash deposits show the collapsed bedding that is characteristic of kames and kame terraces. One of the largest and best developed of these deposits is in secs. 15, 16, 21, and 22, T. 152 N., R. 93 W.

FLUVIOGLACIAL DEPOSITS

Many of the Pleistocene deposits on the reservation were laid down in the valleys by either glacial or nonglacial streams. They grade from alluvial silt to coarse outwash-type gravel that may include boulders several feet in diameter. In this report they are designated fluvioglacial deposits.

Benson did considerable detailed geologic work along the Knife and Missouri Rivers south of the reservation during the period 1946-50. He found that parts of the sequence of fluvioglacial and glacial fills in both valleys could be mapped as separate units on the basis of certain distinguishing characteristics. Correlation of the deposits in the Knife River valley with valley deposits of the Fort Berthold area was established in the field by Benson and the authors. As a result, the authors were able to extend the units mapped in the Knife River area into the reservation, and they were able to adopt most of Benson's nomenclature. Pleistocene units that were extended from the Knife River valley into the reservation are fill-terrace deposits and outwash gravel.

FILL TERRACE DEPOSITS

Three fills associated with glacial advances were identified by Benson in the Knife River area. The oldest consists of cross-bedded sand and gravel which is fairly well sorted. Pebble counts show that a large part of this material was derived from Canadian sources and a small part from the local bedrock or from the mountains far to the west. An intermediate deposit, either Cary or Tazewell in age, filled the valleys to a level 100 feet or more above their present floors. Remnants commonly occur at fairly high levels along the sides of the valleys. This deposit consists of clay, silt, very fine sand, and occasional lenses of gravel. More than half the pebbles in the gravel are of local or western origin. The youngest fill, probably of Mankato age, is present in the valleys and consists predominantly of coarse material that was derived from northern sources. Benson designated the fill-terrace deposits Qsd_1, Qsd_2, and Qsd_3, from oldest to youngest, and this system of designation was used in mapping the reservation. The oldest fill (Qsd_1) was not identified on the reservation, and only a few exposures near the mouth of Squaw Creek were identified as the intermediate fill (Qsd_2). Most of the fill in the tributary valleys on the reservation is either of Mankato age (Qsd_3) or of Recent age.

OUTWASH GRAVEL IN THE MISSOURI RIVER VALLEY

A thick deposit of fluvioglacial gravel underlies most of the terrace that is 35 to 40 feet above the present flood plain of the Missouri River. It is mostly of glacial origin but also contains 35 to 50 percent of well-rounded chert and quartzite pebbles of western origin. This deposit was mapped where it is exposed or where auger holes showed less than 3 feet of alluvium (older, as mentioned below) of the Missouri River overlying the gravel.

PLEISTOCENE AND RECENT SERIES, UNDIFFERENTIATED

OLDER ALLUVIUM OF THE MISSOURI RIVER VALLEY

Fine-grained deposits of postglacial alluvium and slope wash lie in the major valleys. They consist of clay, silt, and fine sand that contains local lenses of coarse sand and gravel. On the basis of the level of deposition, the alluvium is separated into two parts. The older alluvium filled the valleys to a level 35 to 40 feet above the present flood plains of the rivers and creeks of the reservation. The high terrace deposits of Recent alluvium in the creek valleys grade smoothly to the top of the older alluvial terrace of the Missouri River.

YOUNGER ALLUVIUM, SLOPE WASH, AND EOLIAN DEPOSITS

Flood plains of the rivers and creeks are underlain by alluvium that is lithologically similar to the older alluvium. However, this younger alluvium is separated from the older by a sharp erosional break. At some time within very recent geologic time the streams have been rejuvenated and have started to dissect the older alluvial deposits.

In many areas, small valleys on the uplands are partly filled by a combination of slope wash and alluvium. Generally, this fill is of insufficient areal extent to be shown on the geologic map (pl. 1). However, in a few localities it does supply water to shallow wells.

Loesslike eolian deposits of small areal extent are present in scattered localities in the eastern and northeastern segments of the reservation. They form a discontinuous mantle that is typically only a few inches thick. In a few localities, however, this material has filled shallow depressions and may be several feet thick. Because of the small areal extent of these deposits, and because they are considered unimportant to the occurrence of ground water, they are not shown on the geologic map.

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STRUCTURE

The bedrock of the reservation is nearly horizontal; however, two significant structural features have been recognized. The north-trending Nesson anticline is a few miles west of, and parallel to, the western boundary of the reservation. From its axis the beds dip east and southeast to a broad north trending syncline whose axis is near Elbowoods. Determinations of the altitude of the base of the Golden Valley formation at several places on the reservation confirm the general regional structure and indicate a difference in the altitude of this horizon of approximately 500 feet between the Blue Buttes and the axis of the syncline at Elbowoods.

Several minor flexures are imposed on the major structure. One is a relatively sharp, narrow syncline superimposed on the major syncline near Elbowoods. Another is an anticline that lies east of Elbowoods and north of the Missouri River; its axis trends northeast. Several of the major creeks flow along the axes of small synclines.

The average dip of the beds is only a few feet to the mile and the maximum dip is probably 100 to 150 feet per mile.

Lignite beds are not satisfactory units to use for control in mapping the geologic structure. This is particularly true if correlations across several miles of covered slopes are attempted. Information from test drilling indicates that the lignite beds thicken, thin, develop partings, and otherwise change character greatly within short distances, and that the lignite beds are more numerous and thicker in the subsurface than they are observed to be on the outcrop. Apparently, slumping of the unconsolidated sand and clay of the Fort Union formation over the slaked and weathered lignite near the outcrop completely conceals some of the lignite beds. Under some conditions, however, a lignite bed may be used successfully for structural mapping, especially if it is associated with some other geologic feature. For example, near Sanish a yellowish-white bed near the top of the bluffs along the river is underlain by a lignite bed; this combination probably is a good horizon for mapping purposes. The yellowish-white bed extends south into the valleys of Lucky Mound and Skunk Creeks. A similar sequence (possibly the same two beds) is present in the bluffs along Squaw Creek. Other recognizable combinations of clay or sand with a lignite bed may exist and may be usable as mapping horizons.

Structure appears to have considerable effect on the hydrology of the area. Springs are more numerous in the synclines, and the areas in which test drilling found no water may have been on anticlines.

MINERAL RESOURCES

PETROLEUM

As of February 1952, oil test wells had not been drilled on the reservation. At the time this report was compiled two wells were being drilled within 5 miles of the western boundary of the reservation. One had reached a depth of more than 13,000 feet without showing oil; the other, which was drilled on Keene dome near Keene, N. Dak., found good oil shows in formations of Mississippian age at a depth of 8,000 to 9,000 feet. Near Tioga, N. Dak., roughly 30 miles northwest of the northwestern corner of the reservation, oil is being produced from formations of Ordovician and Mississippian age. These formations undoubtedly extend beneath the reservation; however, it is not known whether they have structural or stratigraphic traps capable of holding oil.

LIGNITE

Pishel (1912) and Bauer and Herald (1921) mapped, by planetable traverse, the outcrops of lignite on the reservation. During the present investigation their maps were checked and found to be accurate; therefore, the outcrops were not remapped. Pishel assigned numbers to the beds that are fairly persistent throughout the eastern segment of the reservation and that are economically important, In T. 147 N., R. 89 W., the lignite beds are well exposed in the bluffs that border the river valley. A bed 65 feet above river level was designated bed 1–A, and the next important bed, which is 135 feet above bed 1–A, was designated bed 2; these beds are 5 to 7 feet thick. In T. 147 N., R. 87 W., a 3- to 4-foot lignite bed, which lies 60 to 80 feet above bed 2, was designated bed 3.

Andrews (1939) mapped the lignite in the area adjacent to the eastern segment of the reservation. A lignite bed in sec. 3, T. 147 N., R. 87 W., that was mapped by him as the Minter bed is correlated by the writers with bed 3, and a bed in sec. 12 of the same township that was mapped as the Minter bed is correlated by the writers with bed 2. Andrews correlated the Garrison Creek bed with Pishel's bed 2, and the Minter bed with bed 3. The writers' field work indicates that the Garrison Creek bed correlates with bed 1–A, and the Minter bed with bed 2.

Unweathered lignite is hard and massive and ranges in color from dull to glossy black. Weathered lignite is usually soft, somewhat woody or earthy in texture, and very dull brownish black. On exposure, fresh lignite rapidly weathers and slakes, often causing slumping of the beds that overlie the exposed face of the lignite; consequently, the thickness of the exposed lignite may be much less than the thickness of the unweathered bed. Almost everywhere the lignite beds are underlain by gray clay that varies considerably in both texture and permeability.

The lignite beds have burned in many places along the bluffs. While the beds were burning, the material overlying the lignite slumped and broke away in blocks, creating chimneylike openings. Air flowing through the openings allowed the lignite to continue burning, even under an overburden of as much as 30 to 40 feet. The overlying clay and sand were baked to a red to reddish-orange hard bricklike material, and where the heat was sufficiently intense, part of the overburden was fused into clinkerlike masses. The amount and intensity of the alteration seem to have been directly proportional to the thickness or quality, or both, of the burned lignite. In many places the bricklike beds and clinker beds have resisted erosion and now form the caps of many ridges and small cone-shaped remnants of the softer strata. Although lignite beds weather rapidly when exposed to air, they apparently resisted erosion by glaciers. In several localities, flat areas were formed when a glacier removed the unconsolidated material above a lignite bed and then slid over its surface. In at least one locality the lignite under the till has burned and produced a clinkerlike material that contains glacial pebbles.

Lignite beds in the eastern segment of the reservation range in thickness from a few inches to slightly more than 8 feet. A thickness of 9 feet of lignite is reported to have been penetrated at a depth of 40 feet in a well drilled north of the reservation in the SW¼ sec. 35, T. 148 N., R. 87 W. A thickness of 29 feet of lignite, including a 3-foot clay parting, was penetrated during the drilling of test hole 152-93-20bac.

Several beds of lignite 3 feet or more thick are exposed along the lower road between Elbowoods and Nishu. In that locality the lignite is mined by cutting short drifts into the beds. A minimum amount of timbering is used. The mining is done during the fall and winter, and the drifts are usually allowed to collapse during the summer. In secs. 4, 5, and 6, T. 147 N., R. 87 W., there are about half a dozen open-pit mines along the slopes of the hills. Mines in this locality are worked by stripping the overburden from the lignite until further mining becomes difficult or unprofitable. Along the outcrops are many favorable locations for mines; when it becomes necessary to close a mine, the operator may simply move to some location nearby and open a new one.

During the fall and early winter months of 1949 a lignite mine was operated in the SW¼ sec. 11, T. 148 N., R. 87 W., a bulldozer being used to remove the overburden. In sec. 23, T. 147 N., R. 87 W., a bed of very good lignite is exposed 8 feet above river level at a place where the river has removed the lower terrace deposits. This bed is about 6 feet thick and is covered by 20 feet of overburden. Lignite mines in the northern half of T. 147 N., R. 87 W., and the mine in sec. 11, T. 147 N., R. 88 W., are above the proposed water level of Garrison Reservoir. Mines along the bottom-land road between Elbowoods and Nishu will be submerged.

SAND AND GRAVEL

Sand and gravel deposits are sufficient to supply the needs of the reservation. Their source is either the glacial outwash deposits or the higher terrace deposits along the Missouri River or its tributaries.

Outwash deposits of sand and gravel are found in several places. In the glacial moraine in T. 148 N., R. 89 W., numerous sand and gravel deposits could be developed. Two small gravel pits are in secs. 1 and 4 of this morainic area, and one moderately large pit is on the reservation boundary on the north line of sec. 3. Gravel in the large pit is of rather poor quality because it contains a large percent of clay and many large boulders. Gravel in the small pits is of much better quality. Small hills composed of outwash sand and gravel are in the western half of secs. 24 and 25, T. 148 N., R. 91 W. In an outwash deposit in sec. 12, T. 147 N., R. 88 W., the Fort Berthold Indian Agency operates a gravel pit.

Some extensive gravel deposits are present beneath the higher stream terraces along the valleys. In the valley of Lucky Mound Creek one of the high terraces is underlain by gravel. This deposit is one of the largest potential sources of gravel in the eastern segment. One gravel pit is now being operated in these terrace deposits near the place where State Highway 8 crosses Lucky Mound Creek.

Most of the terrace gravel deposits in the eastern and southern segments will be flooded by the water of Garrison Reservoir, but many of the outwash deposits are on the highlands and will be above the level of the reservoir.

HYDROLOGY

Ground water is derived principally from precipitation within the reservation. A small part of the annual precipitation escapes direct evaporation and surface runoff and seeps through the soil and underlying strata. Precipitation that penetrates beyond the plant roots eventually reaches the zone of saturation, where it moves slowly to the streams and discharges by surface outflow or evapotranspiration.

In the uplands most of the ground-water supplies come from the Fort Union formation. Small amounts of water may be available from thin alluvial deposits in small valleys on the uplands or from glacial deposits.

In the lowlands most of the wells produce water from terrace deposits or from the alluvium of river valleys. Several wells in the river valleys obtain water from beds of the Fort Union that underlie the terrace and alluvial deposits. A few flowing wells in the valleys obtain water from either the lower part of the Fort Union formation or the upper part of the Cannonball formation; these wells range in depth from about 350 feet to 620 feet. Artesian pressures in the intermediate water-bearing strata of the Fort Union are not sufficient to cause the wells to flow.

WATER-BEARING PROPERTIES OF GEOLOGIC FORMATIONS

CANNONBALL FORMATION

A few wells on the reservation probably produce water from the Cannonball formation. The deepest of four flowing wells in the Missouri River valley near Elbowoods almost certainly obtains water from the Cannonball, and it is possible that the other three may also tap aquifers in the uppermost part of this formation.

The altitude of the contact between the Cannonball and Fort Union formations ranges from about 1,600 feet near the western boundary of the reservation to about 1,200 feet in the syncline near Elbowoods. Near the eastern edge of the reservation the contact is at an altitude of 1,400 to 1,450 feet. Test holes drilled in the northeast part of T. 147 N., R. 88 W., show a slight change in lithology below 1,450 feet. The writers interpreted this to be the contact between the two formations. Unfortunately, a few fragments of fossil shells that were obtained below 1,450 feet were too small to be identified.

The flowing wells near Elbowoods produce water from aquifers that are 350 to 620 feet below the surface. The owners reported that the aquifers are fine sand, that the initial flows were 5 to 10 gpm, and that the present flows are 0.5 to 3 gpm. A flow of 100 gpm was reported by the Corps of Engineers from the well that was drilled into the Cannonball formation at the Garrison Dam site.

Moderate supplies of water can be developed in the Cannonball formation from properly constructed wells. In the uplands, however, the cost of drilling wells 800 to 1,100 feet deep, as is required, would be prohibitive in many cases.

FORT UNION FORMATION

Lignite beds and fine-grained sandstone in the Fort Union formation are the source of water for nearly all wells and springs on the reservation. In general, the sequence of deposition of the units of the formation was clay, lignite, and then a bed of fine sand or silt. The clay beneath the lignite is not true underclay like that associated with higher rank coal deposits, but it is sufficiently tight and dense to restrict greatly the downward movement of ground water (Roe, 1950). Consequently, water accumulates in the lignite and in the overlying strata, which are much more permeable than the clay. The fine-grained sandstone probably releases water slowly to the lignite, where it accumulates in open joints. The lignite, in turn, transmits much of the water laterally to the outcrop area. In some places where tight clay directly underlies a bed of sand or silt, ground water accumulates in the sand or silt. The lignite beds and associated underclay are apparently the controlling factors in the lateral movement of ground water. Most of the springs in the Fort Union formation issue at the contact of a bed of lignite with the underlying clay. The lenticular nature of the lignite and clay beds and the variation in texture and permeability of the clay from one locality to another permit some downward movement of ground water through those beds.

The general movement of ground water in aquifers that lie above river level is toward the Missouri River. In the eastern segment this movement is indicated by the configuration of the perched water table above lignite bed 2. (See pl. 2.) As only a small part of the recharge to this aquifer moves into the eastern segment from the north, it is apparent that most of the recharge to this and shallower aquifers is local. Ground water in the aquifers that lie between lignite bed 2 and river level in the eastern segment possibly is derived in part by lateral percolation from the adjacent region to the north.

Cable-tool drilling rigs obtain a higher percent of producing wells in lignite than the hydraulic-rotary type of drill. The reason for this may be that the repeated jarring of the drill bit fractures the lignite, and that the fractures thus produced may connect with the water-filled fractures. Conversely, the rotary drill cuts through the lignite quite smoothly and probably produces few fractures; also, the drilling mud may seal off some of the aquifers. Blasting the lignite that is penetrated in rotary drilling might permit water to enter otherwise dry holes.

Little detailed information on the main zone of saturation is available. Almost all wells that penetrate bedrock strata produce water from a zone of permeable materials associated with one of the thicker lignite beds. In the eastern segment the main sources of water are associated with lignite beds 1–A and 2. (See fig. 12.)

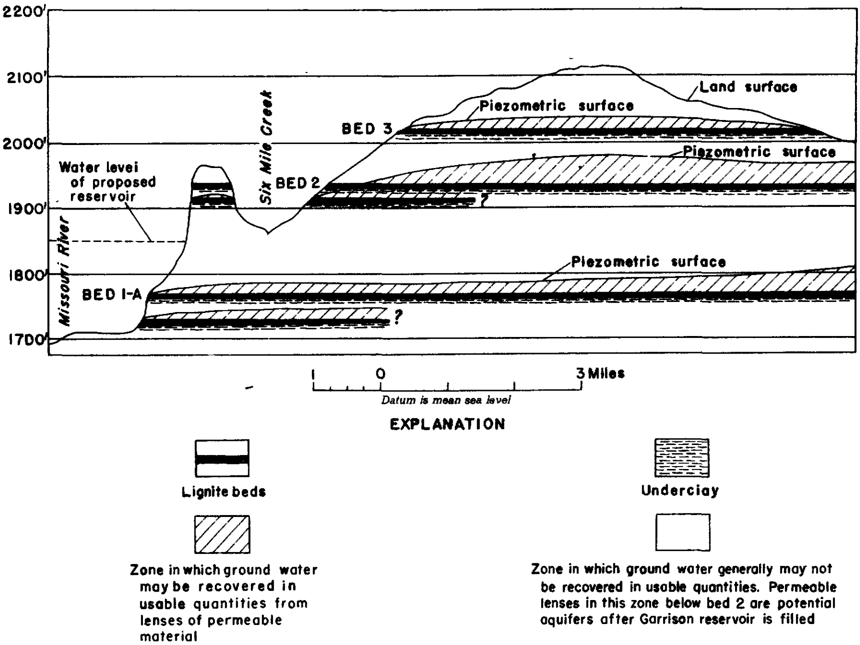

Figure 12.—Generalized cross section showing the probsble ground-water zones of the eastern segment of Fort Berthold Indian Reservation.

Ground water associated with bed 1–A may possibly be in the main zone of saturation of the Fort Union formation. Water levels in wells drilled into the bedrock that underlies the alluvium or terrace deposits are higher than the surface of the adjacent river. This indicates that ground water from the Fort Union probably moves into the unconsolidated materials of the valley fill, and also that the recharge to the Fort Union formation is not dependent on water from the river.

The amount of water obtained from wells and springs penetrating the Fort Union formation is rather small. As indicated by the results of the test-drilling program, production from completed wells ranged from less than 1 to 50 gpm. Well 149–94–25abc produced about 100 gpm before it was cased and screened, but only 45 gpm after it was completed. The reduced output was probably the result of using only 4 feet of fine-slot well screen. The amount of water yielded by springs that were inventoried during this investigation ranged from less than 1 to 180 gpm.

Organic compounds dissolved from the lignite of the Fort Union formation impart a brownish color to the water from some of the wells and springs. An inverse relation apparently exists between the flow of a spring and the discoloration of the water; water from a spring of small flow is more discolored than that from a spring of large flow.

GLACIAL DEPOSITS

Glacial deposits on the reservation are relatively unimportant as a source of ground-water supplies. Except in the recessional moraines and buried valleys, they are generally less than 10 feet thick. Only a few wells on the reservation are known to produce water from glacial materials; in the southern part of T. 149 N., R. 88 W., about 1 mile north of the reservation, a few shallow wells produce water from glacial outwash sand and gravel. It may be possible to develop shallow water supplies on the reservation near this locality. However, most of the wells in the area of the moraine have been drilled through the glacial materials to lignite or sandstone aquifers in the underlying Fort Union formation.

TERRACE AND ALLUVIAL DEPOSITS

Ground-water supplies in the bottom lands are obtained either from terrace and alluvial deposits or from the underlying bedrock formations. Most of the wells along major streams obtain their water supplies from alluvial and terrace deposits of late Pleistocene and Recent age; the ground water in these deposits is under water-table conditions. The altitude of the water table in the terrace deposits is controlled by the water level in the major streams. Generally, the highest terrace deposits lie above the water table and contain little or no available ground water.

OCCURRENCE OF GROUND WATER

EASTERN SEGMENT

The numerous farm wells of the eastern segment and the 31 test holes that were drilled there provide much information on the occurrence of the ground water. The main sources are associated with lignite beds 1—A and 2 in the Fort Union formation. (See fig. 12.) Most of the wells and springs obtain water from a zone of saturation that is supported by the clay bed underlying lignite bed 2. A map showing the contours of this water table (pl. 2) was constructed from water-level information collected as a part of the inventory of wells and springs. Small water supplies possibly can be developed at comparatively shallow depths from parts of the recessional moraine in the north-central part of the segment. However, test hole 148–89–11aa, which was drilled through 100 feet of glacial outwash in this moraine and 300 feet into the Fort Union formation, did not produce sufficient water to justify its completion as a well. Most of the farm wells in the moraine obtain water from the Fort Union formation.

Of the 31 test holes drilled in the eastern segment, 18 were completed as wells. The development of the wells was difficult where silt and very fine sand were present in the aquifers. Well 148–90–22bcc produced 20 to 25 gpm, but the water contained a considerable quantity of sand and silt, and after several days of pumping and development work the well was abandoned. Further test drilling in this segment should achieve results comparable to those of the 31 holes already drilled.

NORTHEASTERN SEGMENT

Twenty-five farm wells were inventoried on the uplands of this segment and the adjacent uplands outside of the reservation. The deepest well inventoried, which was reported to be 340 feet deep, is 2 miles north of Lucky Mound Creek. Many of the other farm wells in this segment are relatively shallow, large-diameter, bored wells having wooden casings. Almost all of the wells produce water from the zones of saturation associated with one or more of the lignite beds of the Fort Union formation. The authors know of only two wells (150–90–22ccc and 150–90–25daa) that produce from glacial materials. They were part of the test-drilling program, and they penetrated sediments in a buried preglacial valley. The depth to the valley bottom was not determined, because the wells reached only to 330 and 254 feet, respectively. Well 150–90–22ccc could not be drilled deeper than 330 feet because coarse gravel and cobbles caved into the holes.

NORTHERN SEGMENT

Less is known about ground-water conditions in the northern segment than in any other. In this segment there are very few springs and only one well. The paucity of springs probably indicates either that relatively little water is present above the main zone of saturation, or that the permeability is such that lateral movement of water is restricted. Either condition would reduce the probability that successful wells could be constructed in this segment. Only 3 of the 6 test holes in this segment penetrated water-bearing beds. One of the dry test holes (150–93–2cbb) was drilled at least 50 feet below the level of the Missouri River, which is less than 2 miles away. Either the main zone of saturation is below the river level, or the clay and lignite penetrated in the lower part of this test hole have very low permeability.

In view of the ground-water conditions and the poor results of the test-drilling program in this segment, it is estimated that less than half of any additional test holes could be completed as producing wells.

WESTERN SEGMENT

There were no wells on the uplands of the western segment before the test-drilling program was started; however, the inventory of several hundred springs indicated that considerable ground water is available. Thirty-two of the fifty test holes were completed as wells. This overall figure is somewhat misleading because ground-water conditions vary greatly from one natural drainage area to another. The natural drainage areas of the western segment are discussed below.

SQUAW AND MOCCASIN CREEK DRAINAGE AREAS

Only 6 of the 14 test holes that were drilled in Tps. 147 and 148 N., which include nearly all the drainage areas of Squaw and Moccasin Creeks, yielded sufficient water to be completed as wells. Much of this area is deeply dissected, and the area bordering the Little Missouri River has typical badland topography. The topographic relief between the level of the Little Missouri River and the uplands of this area is more than 600 feet. The top of the main zone of saturation probably is not much above the level of the river, and it is 500 to 600 feet below the general upland surface. The six completed wells produced water from semi-perched water bodies 150 to 300 feet below the land surface. Apparently, water is difficult to obtain in this part of the western segment, and the proportion of completed wells probably would not be increased greatly by drilling additional test holes.

SKUNK CREEK DRAINAGE AREA

The many large springs in this drainage area indicate that the opportunity for local recharge is good. This is because of the sandy nature of the thin cover of till and because of the thick sand beds that here form the upper part of the Fort Union formation. One of the largest springs on the reservation, near the southern end of the Skunk Creek drainage area, yields 110 gpm from openings at the contact of the sandstone with the thick lignite bed underlying it. This water-bearing zone is about 150 feet below the upland surface, but apparently it is absent in part of the area. Five of the eight test holes that were drilled produced water.

UPLANDS WEST OF SKUNK CREEK AND SOUTH OF BEAR DEN CREEK

The drilling program was very successful in the upland areas that lie west of Skunk Creek and south of Bear Den Creek. Nine of the twelve test holes drilled in this area were completed as wells. The water-levels in most were 250 to 350 feet below the upland surface. Further test drilling probably will result in a high proportion of completed wells.

BEAR DEN CREEK NORTH TO THE RESERVATION BOUNDARY

The best results of the entire drilling program were obtained in the area from Bear Den Creek north to the reservation boundary. Twelve of the fifteen test holes produced water. Several large springs are the result of the concentration of ground water in minor troughs on the flank of Keene dome. In all wells the water level is less than 200 feet below the land surface, and in eight of the wells it is less than 150 feet below the land surface. If test holes are not drilled too near the badland areas of Bear Den, Clark, and Blue Creeks, a high proportion of completed wells may be expected from future drilling operations.

SOUTHERN SEGMENT

Water-bearing material was penetrated in only 10 of the 20 test holes drilled in the southern segment. Because the aquifers are drained by many deep valleys, the main zone of saturation is far below the upland level. The 10 wells that were completed probably produced water from semiperched water bodies.

Small supplies of water might be developed at shallow depth by drilling into the alluvial and glacial deposits of some of the valleys. For example, well 147–91–27bdb, which penetrates a gravel bed 5 to 10 feet below the land surface, produced 0.5 gpm. If a well were drilled 24 inches or more in diameter and 25 to 30 feet deep, it might produce sufficient water for stock and domestic use.

A more careful selection of the location of test holes with respect to geology and hydrology probably would increase the proportion of test holes that could be completed as wells.

FLUCTUATIONS OF WATER LEVELS

Little is known concerning the fluctuations of ground-water levels on the reservation. Periodic measurement of water levels was started during the summer of 1949 and was continued through

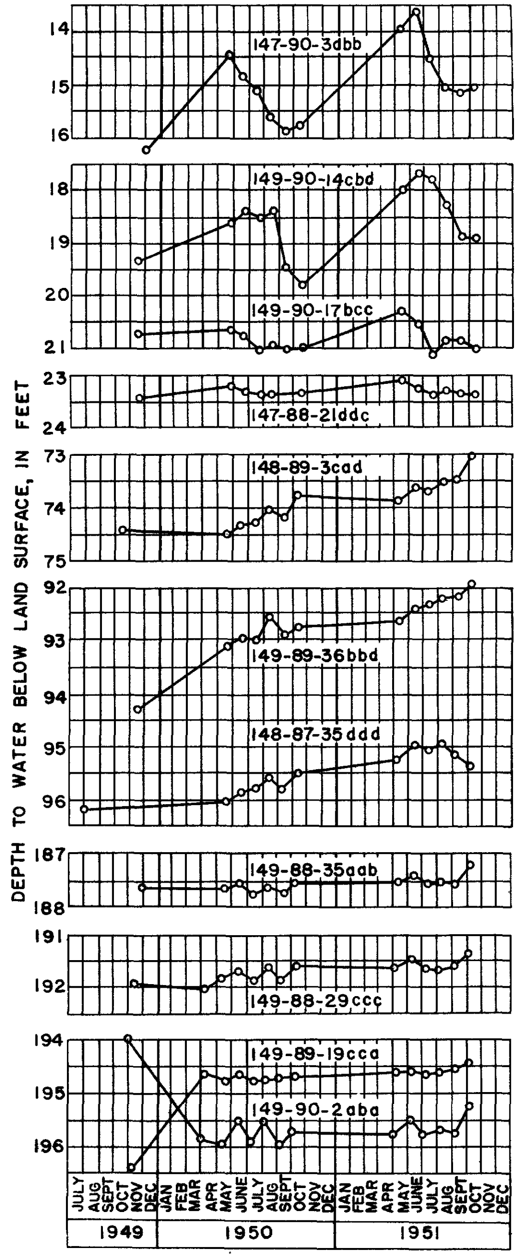

Figure 13.—Hydrographs of typical observation wells in the Fort Berthold area.

the 1951 field season. In general, water-level measurements show that in wells less than 50 feet deep the fluctuation is much greater than it is in deeper wells. (See fig. 13.) In the shallow wells the water level rose in response to the spring recharge in 1950 and 1951 and gradually declined throughout the rest of those years. In wells more than 50 feet deep the water level rose only slightly during the period 1949–51; in several of the observation wells that have water levels about 200 feet below the land surface, the fluctuation was only a few tenths of a foot. Some of the fluctuations in the observation wells are probably caused by variations in air pressure.

PROBABLY EFFECT OF GARRISON RESERVOIR ON GROUND-WATER CONDITIONS

The filling of Garrison Reservoir will cause a general rise of the water level in wells that tap aquifers now discharging at or below the operating level of the proposed reservoir. For a time, the back pressure of the reservoir water will decrease or prevent the discharge of ground water through springs below the reservoir level; this damming action will cause a rise in ground-water levels. Eventually, all of the permeable strata below reservoir level on the reservation undoubtedly will become saturated and hydraulically united. The rise in ground-water levels will continue until a new hydraulic gradient, based on the water level in the reservoir, is established. The water levels in wells near the reservoir should be the first to respond to the filling of the reservoir. However, several years may pass before ground-water and reservoir levels are in equilibrium throughout the reservation.

Within a few years the exposed faces of aquifers probably will become partially plugged by suspended matter in the reservoir water; much less water will then pass into the surrounding aquifers.

CHEMICAL QUALITY OF THE GROUND WATER

By H. A. SWENSON

The chemical quality of ground water on the Fort Berthold Indian Reservation was determined from analyses of 39 samples collected during the period August 8 to November 9, 1950, from 21 wells and 18 springs. The locations of these wells and springs, most of which are on the uplands, are shown on plate 1.

The analytical data are helpful in identifying the aquifers from which the water is derived. Of more practical significance, the analyses indicate the suitability of ground water in the uplands for domestic and stock uses. Adequate supplies of acceptable quality will be needed for relocated Indian families and for the facilities of the Indian Agency.

Of 39 samples, 30 are believed to represent water from the Tongue River member of the Fort Union formation and 2 from the Cannonball formation. Seven samples represent water from the Quaternary deposits, mostly outwash and alluvium. The distribution of the 39 samples with reference to the area that will be occupied by the reservoir and to the segments of the reservation (see map, fig. 5) is as follows:

Distribution of sampling points

Geographical area	Sampling pointa	
	Wells	Springs
Taking area for reservoir	11	0
Eaatern segment	2	2
Northeaatern segment	2	1
Northern segment	0	0
Western segment	4	12
Southern segment	2	3
Total	21	18

Seven of the eleven wells from which water samples were collected in the reservoir area provide water for schools on the reservation; 1 furnishes water to the Catholic mission; 1 supplies water to the town of Elbowoods, the Agency's headquarters (1951); and 2 supply water to farms. Samples from 4 wells and 3 springs in the eastern and northeastern segments were taken to evaluate the quality of the water. The chemical character of ground water in the western segment is described on the basis of 4 samples from test wells drilled in 1950 and from 12 samples of spring water. Samples from 2 test wells that were drilled in 1950 and from 3 springs were analyzed to determine the quality of ground water in the southern segment.

COMPOSITION OF THE MINERAL SUBSTANCE

The bulk of the residual salts from evaporated ground water is composed of the carbonates (mainly bicarbonates when in solution), sulfates, and chlorides of the alkalies and of the alkaline earths. Silica, iron, manganese, fluoride, nitrate, boron, and other constituents in water are normally in small but not necessarily insignificant amounts. The composition of this mineral substance is often an indication of the character of the bedrock strata or unconsolidated deposits that yield the water. The approximate amounts, in percent, of mineral solids of sodium, carbonate, and sulfate in water from the Tertiary rocks and Quaternary deposits are as follows:

Average composition of water from Tertiary rocks and Quaternary deposits

[Percent of mineral solids]

Constituent	Tertiary rocks		Quaternary deposits (7 samples)
	Soft water (hardness 100 ppm or less—10 samples)	Hard water (hardness more than 100 ppm—22 samples)	
Sodium (Na)	36	21	15
Carbonate (CO_3)	31	29	36
Sulfate (SO_4)	27	33	21

QUALITY OF WATER AND GEOLOGIC ORIGIN

Water from bedrock, as represented by water from the Tongue River member of the Fort Union formation, can be classified on the basis of hardness, which ranges from 20 to 905 ppm as calcium carbonate. Soft water (hardness of 100 ppm or less) usually comes from the wells or springs that derive water from the older, deeper lying beds. It is likely that the softening of the water is the result of a base-exchange process in which calcium and magnesium in the water are exchanged for sodium in the rock material. Hard water usually comes from wells that are less than 200 feet deep, or from springs that issue from shallow beds. The relationship of hardness to well depth for water from the Tertiary rocks is shown in figure 14.

The concentration of dissolved solids in water from the Fort Union formation ranges from 300 to 3, 220 ppm; the average concentration for the 32 samples from wells and springs is 1, 490 ppm.

The hardness of water yielded by Quaternary deposits is shown in figure 14. In seven samples the hardness ranged from 271 to 509 ppm, and the concentration of dissolved solids ranged from 456 to 1, 510 ppm. The heterogeneous nature of the Quaternary deposits is illustrated by the varied composition of mineral solids in the water.

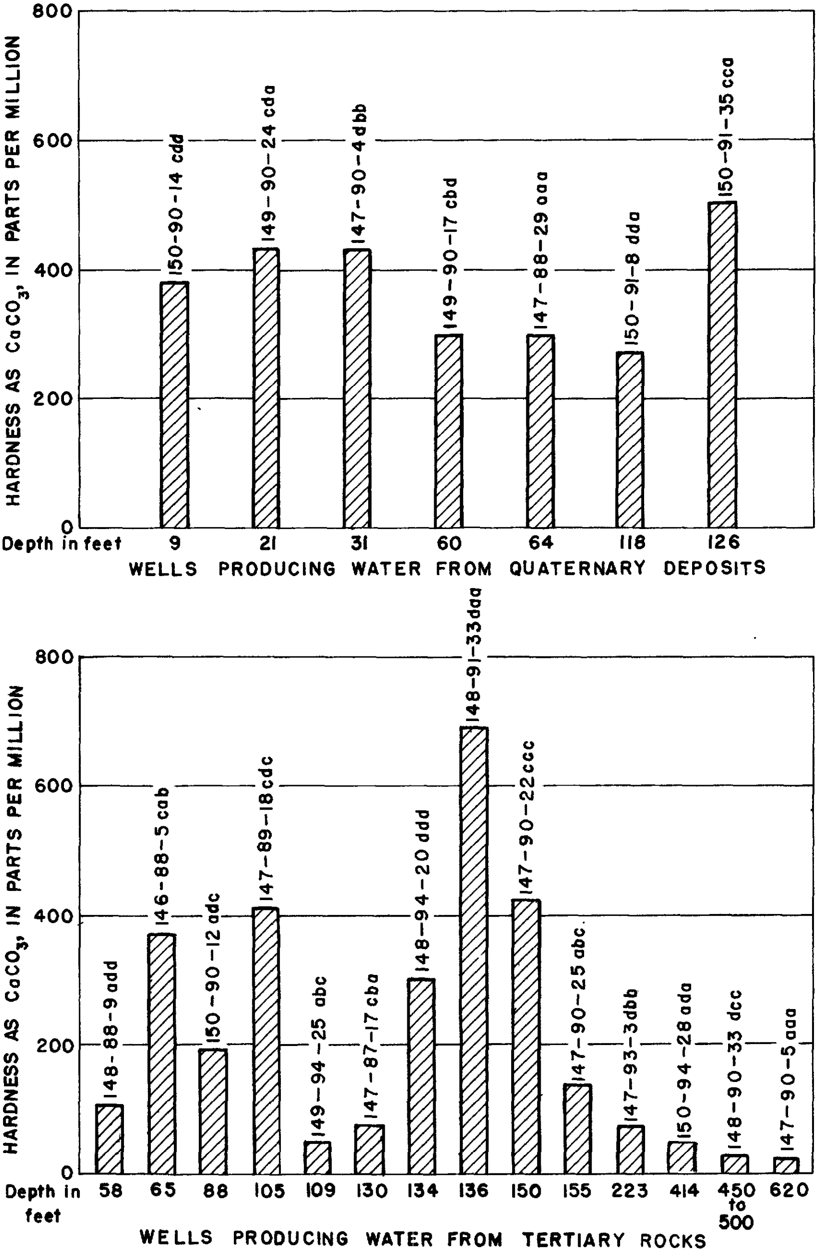

Figure 14.— Hardness of ground water in the Fort Berthold Indian Reservation.

Mineral solids in water from Quaternary deposits

Well number	Depth (feet)	Dissolved solids (ppm)	Totsl hardness (ppm)	Percent of mineral solids			
				Sodium	Carbonate	Sulfate	Calcium and magnesium
150–90–14cdd....	9	456	379	3.1	42.5	17.5	28.1
149–90–24cda....	21	520	427	1.4	36.3	9.2	27.9
147–90–4dbb......	31	982	429	17.7	33.3	24.4	14.1
149–90–17cbd....	60	516	297	11.6	43.8	10.3	18.8
147–88–29aaa....	64	1,450	298	27.6	29.5	29.7	6.9
150–91–8dda......	118	1,510	271	28.5	28.3	33.1	6.0
150–91–35cca....	126	986	509	15.6	37.5	24.6	17.6

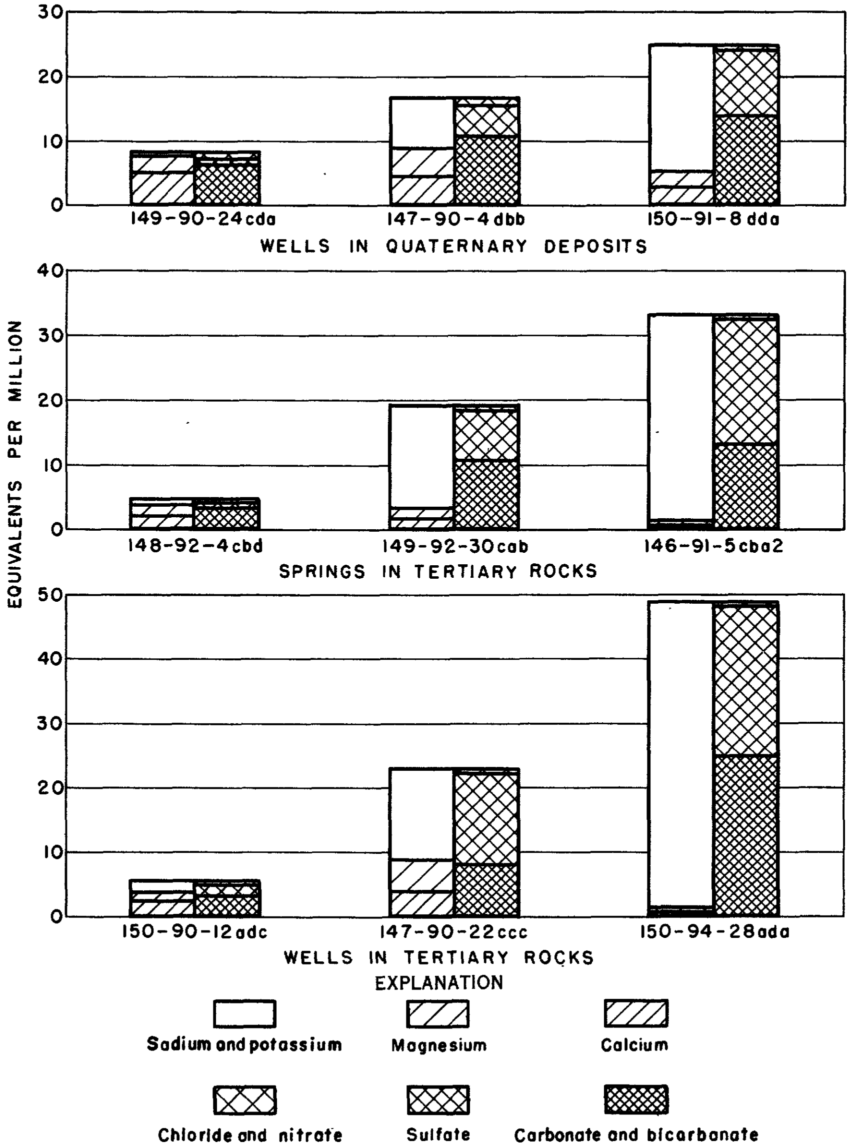

Figure 15.— Graphical anslyses of ground wster.

The chemical character of the water from wells and springs in Tertiary rocks and from wells in Quaternary deposits is shown graphically in figure 15, where concentrations of the principal constituents are plotted as equivalents per million.

QUALITY OF WATER AND DISTRIBUTION OF WELLS AND SPRINGS

Water samples were collected for chemical analysis from wells drilled by the Indian Agency in 1950 and 1951, from farm wells, and from springs in the uplands to obtain information on the quality of available ground water. Water for drinking and general domestic use can be evaluated according to standards of the U. S. Public Health Service (1946). These standards are for water that is to be used for drinking and culinary purposes on railroad cars, aircraft, and vessels engaged in interstate traffic. Although many of the potential supplies on the Fort Berthold Indian Reservation do not meet these rigid requirements, the water may yet be palatable and cause no adverse physiological effects. The standards, abridged, are as follows:

Maximum limits for certain constituents and for color in drinking water

[Public Health Service atandards, abridged. Expresaed in parts per million]

Iron and manganese	0.3	Fluoride	1.5
Magnesium	125.0	Dissolved solids	500.0[1]
Sulfate	250.0	Color	20.0[2]
Chloride	250.0		

[1]1,000 permitted.
[2]Filtered aupplies.

The Public Health Service standards place limits on the chemical, bacteriological, and sanitary properties of a water supply, but only the chemical requirements are considered in this investigation. Chemical analyses of all samples from wells and springs are listed in table 2.

Table 2.—*Analyses*

[Analytical results in parts per

Source	Month and day of collection (1950)	Depth (feet)	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)
Wells								
146-88-5cab	Aug. 9	65	.....	28	0.26	84	40	340
147-87-17bca	Aug. 9	130	.....	15	61	14	7.5	288
147-88-29aaa	Aug. 9	64	.....	31	29	70	30	400
147-89-18cdc	Aug. 9	105	.....	18	8.1	77	53	260
147-90-4dbb	Aug. 9	31	49	28	.25	86	52	174
147-90-5aaa	Aug. 10	620	49	12	.16	6.0	1.2	914
147-90-22ccc	Nov. 3	150	47	17	1.7	80	54	332
147-90-25abc	Nov. 3	155	.....	13	1.5	26	18	928
147-93-3dbb	Oct. 19	223	.....	26	.16	9.0	11	1,060
148-88-9add	Aug. 9	58	.....	10	.87	23	12	680
148-90-33dcc	Aug. 10	450-500	49	8.9	.14	6.0	2.0	996
148-91-33daa	Aug. 9	136	.....	26	44	144	81	820
148-94-20ddd	Oct. 12	134	.....	23	.44	74	28	250
149-90-17cbd	Nov. 8	60	45	30	3.4	63	34	60
149-90-24cda	Nov. 9	21	44	27	.04	105	40	7.1
149-94-25abc	Oct. 7	109	47	16	.42	13	5.2	874
150-90-12adc	Nov. 9	88	43	18	.12	44	20	40
150-90-14cdd	Nov. 9	9	43	22	.62	91	37	14
150-91-8dda	Nov. 3	118	46	33	.83	64	27	430
150-91-35cca	Nov. 8	126	50	27	3.8	128	46	154
150-94-28ada	Aug. 18	414	52	21	1.1	10	4.1	1,090
Springs								
146-91-5cba1	Aug. 9	......	48	15	0.20	11	8.3	744
146-91-5cba2	Aug. 9	......	.....	17	.25	37	28	169
147-91-23bdb	Aug. 9	......	....	14	7.3	22	11	304
147-94-4dda	Aug. 8	......	45	28	21	206	95	244
148-88-36cdd1	Aug. 9	......	52	19	25	56	39	317
148-90-21aab	Aug. 9	......	46	16	1.1	110	56	73
148-92-4cbd	Aug. 8	......	46	19	.27	42	23	18
148-92-11aca	Aug. 8	......	49	19	1.0	50	29	28
148-93-17bdd	Aug. 8	......	49	24	1.2	66	44	496
148-93-31dbd	Aug. 8	......	45	14	.83	121	68	162
149-92-30cab	Aug. 8	......	45	16	.19	38	22	359
149-92-35bda	Nov. 8	......	.....	17	.18	72	39	58
149-94-3aba	Aug. 8	......	48	13	.12	5.0	3.7	792
149-94-15ccd	Aug. 8	......	49	14	.22	34	23	477
149-94-36dad	Aug. 8	......	44	15	.54	7.0	5.2	500
149-94-36dbb	Aug. 8	......	....	35	.18	90	47	120
150-90-4bca	Nov. 8	......	45	17	.07	65	31	56
151-94-6bbd	Nov. 8	......	45	20	.04	25	10	542

of ground water

million except as indicated]

Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$		Percent sodium	pH	Specific conductance (micromhos at 25°C)
									Total	Noncarbonate			
						Wells							
7.6	804	.....	435	3.0	0.4	3.2	0.20	1,340	374	0	66	7.5	1,900
4.6	744	.....	85	3.0	.2	1.0	.20	818	66	0	90	7.9	1,200
10	856	.....	430	20	.4	3.8	.20	1,450	298	0	74	7.4	2,030
7.8	608	.....	440	4.0	.4	.7	.10	1,160	410	0	57	7.5	1,650
9.0	654	.....	240	21	.4	16	.20	982	429	0	46	7.6	1,420
3.3	1,940	.....	2.5	314	.6	.8	.20	2,210	20	0	99	8.1	3,460
8.5	493	.....	698	5.0	....	1.5	.30	1,440	422	18	63	7.9	2,010
5.6	1,200	14	1,150	17	.6	2.2	.00	2,770	139	0	93	8.2	3,900
4.4	1,510	86	920	11	1.0	2.5	.00	2,880	68	0	97	8.7	4,060
8.9	1,280	.....	490	5.0	.4	4.2	.20	1,860	107	0	93	7.3	2,650
4.0	2,420	.....	2.5	149	1.4	1.1	.20	2,360	23	0	99	8.1	3,540
8.4	1,090	.....	1,590	11	.2	7.1	.10	3,220	693	0	72	7.3	4,100
4.6	581	.....	378	2.0	.6	1.5	.10	1,050	300	0	64	8.0	1,490
4.4	452	.....	53	5.0	......	1.0	....	516	297	0	30	7.6	748
1.8	378	.....	48	23	.2	57	....	520	427	117	3	7.6	811
4.6	964	18	1,110	4.0	1.0	2.8	.30	2,520	54	0	97	8.3	3,440
2.8	196	.....	111	5.0	1.0	.9	.00	344	192	31	31	7.5	530
2.5	388	.....	80	10	.2	3.1	.00	456	379	61	7	7.9	708
11	854	.....	500	16	....	3.1	....	1,510	271	0	77	7.8	2,160
7.2	740	......	243	9.0	.4	5.9	.00	986	509	0	39	7.3	1,440
3.7	1,440	47	1,140	4.5	.8	2.7	.20	3,040	42	0	98	8.5	4,140
						Springs							
4.8	780	18	955	5.0	0.8	1.7	0.20	2,130	62	0	96	8.2	3,070
5.4	430	.....	218	1.0	.4	1.2	.20	706	208	0	63	7.4	1,050
4.6	602	......	270	2.0	.2	1.2	.20	974	100	0	86	7.5	1,410
7.6	756	......	760	2.0	.2	.9	.10	1,720	905	285	37	7.2	2,250
8.0	688	.....	415	5.0	.2	1.9	.20	1,230	300	0	69	7.3	1,750
3.8	484	......	278	2.0	.2	1.4	.20	804	505	108	24	7.2	1,140
4.4	236	.....	50	1.0	.2	.6	....	300	200	6	16	7.1	447
3.4	284	.....	75	1.0	.2	.9	.20	368	244	11	20	7.1	550
4.4	862	.....	700	2.0	.6	1.7	.20	1,760	346	0	75	7.7	2,500
5.2	590	.....	435	3.0	.4	1.2	.20	1,100	582	98	37	7.5	1,560
3.4	636	.....	420	2.0	.4	1.8	.20	1,180	186	0	80	7.7	1,740
3.4	398	.....	142	5.0	......	.6	....	518	340	14	27	7.2	825
3.6	972	59	790	3.0	1.4	5.2	.20	2,150	28	0	98	8.3	3,100
3.8	870	.....	500	2.0	.8	3.8	.30	1,490	180	0	85	7.5	2,140
3.4	720	.....	505	6.5	1.0	8.5	....	1,410	39	0	96	7.7	2,090
3.2	608	......	190	1.0	.6	1.0	.10	814	418	0	38	8.0	1,160
2.6	366	.....	98	13	.6	.5	....	470	290	0	29	7.6	715
2.2	1,010	.....	450	8.0	.6	1.7	....	1,560	104	0	92	8.0	2,310

TAKING AREA FOR GARRISON RESERVOIR

Eleven wells were sampled in the area that will be inundated upon completion of Garrison Dam. The suitability of these supplies for drinking and domestic purposes is as follows:

Chemical analysis, in parts per million, of domestic water supplies in taking area for Garrison Reservoir

Well	Owner	Iron	Magnesium	Sulfate	Chloride	Fluoride	Hardness	Dissolved solids
146-88-5cab...	Beaver Creek School.	0.26	40	435	3.0	0.4	374	1,340
147-87-17bca.	Byron Wilde...........	61	7.5	85	3.0	.2	66	818
147-88-29aaa.	Nishu School...........	29	30	430	20	.4	298	1,450
147-89-18cdc.	Red Butte School.....	8.1	53	440	4.0	.4	410	1,160
147-90-4dbb...	Town of Elbowoods...	.25	52	240	21	.4	429	982
-5aaa..	Jacob A. Rapp........	.16	1.2	2.5	314	.6	20	2,210
148-90-33dcc.	Catholic mission......	.14	2.0	2.5	149	1.4	23	2,360
148-91-33daa.	Charging Eagle Day.. School.	44	81	1,590	11	.2	693	3,220
149-90-17cbd.	Lucky Mound School.	3.4	34	53	5.0	....	297	516
150-91-8dda...	Shell Creek School...	.83	27	500	16	....	271	1,510
-35cca.	Independence School	3.8	46	243	9.0	.4	509	986

EASTERN SEGMENT

Water from well 148–88–9add, bored 58 feet deep and tapping the Fort Union formation, is moderately hard (hardness 107 ppm) and contains mostly sodium bicarbonate and sodium sulfate. This water is undesirable for drinking because of the high mineral content of 1,860 ppm, the iron content, and the characteristic "soda" taste. Nevertheless, it is used for both domestic and stock purposes.

A bored well (149–90–24cda), 21 feet deep, produces water from the Quaternary gravel deposits. The water is of the calcium bicarbonate type and, except for its nitrate content, is chemically acceptable for general domestic use. The nitrate (NO_3) concentration of 57 ppm may be indicative of some pollution from surface inflow. A nitrate content higher than 45 ppm is considered by some authorities to make water unsuitable for use by infants, because it may cause infant cyanosis ("blue babies").

Two springs, 148–88–36cdd1 and 148–90–21aab, issuing from lignite seams, furnish water that is used domestically. Except for excessive amounts of iron, these supplies are of good chemical quality.

NORTHEASTERN SEGMENT

In the northeastern segment samples were collected from two wells, 150–90–12adc and 150–90–14cdd, which are the least mineralized of samples collected from 21 wells on the reservation. However, water in well 150–90–14cdd contains 0.62 ppm of iron, which exceeds the recommended limit.

A sample was collected from spring 150–90–4bca that issues from lignite at a rate of about 3 gpm. This water is relatively low in mineral content (470 ppm of dissolved solids) and is used for the watering of stock.

WESTERN SEGMENT

Considerable attention was given to obtaining adequate water of good quality on the uplands in the western segment of the reservation. Samples were collected from four of the test wells that were drilled during 1950. The depths of these wells range from 109 to 414 feet. These wells tap the Fort Union formation and produce water of the following chemical characteristics:

Chemical characteristics of water from wells in western segment

Well number	Depth (feet)	Dissolved solids (ppm)	Hardness (ppm)	Remarks
147–93–3dbb	223	2,880	68	Soft; contains sodium bicarbonate and sulfate.
148–94–20ddd	134	1,050	300	Hard; contains cslcium bicarbonate.
149–94–25abc	109	2,520	54	Soft; contains sodium bicarbonate and sulfate.
150–94–28ada	414	3,040	42	Soft: contains sodium bicarbonate and sulfata; excessive iron.

Wells 147–93–3dbb, 149–94–25abc, and 150–94–28ada produce water that is objectionable for drinking purposes or general domestic use because of the high concentration of dissolved solids. Water from well 148–94–20ddd is hard but of much better quality.

In samples collected from 12 springs in the western segment, the concentration of dissolved solids ranged from 300 to 2,150 ppm, and the hardness ranged from 28 to 905 ppm. Average values for dissolved solids and hardness are 1,200 and 298 ppm, respectively. Several of these springs yield water of good quality except for color, which may be as high as 400 ppm on the standard platinum-cobalt scale. Color (straw to dark brown) in spring water is common in an area of lignite deposits.

SOUTHERN SEGMENT

Two wells were drilled in the southern segment in November 1950 to obtain data on the quantity and quality of the ground water. Well 147–90–22ccc, 150 feet deep, produces hard water (hardness 422 ppm) from the Fort Union formation. The mineral content of

1,440 ppm is higher than desirable, and the iron content of 1.7 ppm is excessive. Well 147–90–25abc, 155 feet deep, produces moderately hard water (hardness 139 ppm) from the Fort Union formation. It is almost twice as mineralized as the water from well 147–90–22ccc, and it contains about the same concentration of iron.

A soft water, essentially of the sodium bicarbonate, sodium sulfate type, is obtained from spring 146–91–5cba1 which issues from a bed of lignite. This water is of poor quality because of the high concentration of dissolved solids (2,130 ppm). In the same 10-acre tract a hard water of better quality flows from spring 146–91–5cba2. Spring 147–91–23bdb yields a soft water that contains 974 ppm of dissolved solids. This water is of good quality except for the high concentration of iron (7.3 ppm).

SUMMARY

Domestic and stock-water supplies on the Fort Berthold Indian Reservation are obtained principally from the lignite and sandstone beds of the Fort Union formation in the uplands and from alluvial deposits in the valleys. A few wells on the reservation are known to produce water from glacial deposits, although morainal and outwash deposits in part of the area are potential sources of shallow ground water.

The ground-water conditions of the uplands were of primary concern during this investigation because the valleys will be inundated by the water of Garrison Reservoir. At least 90 percent of the wells on the uplands produce water from the Fort Union formation. In most areas there are one or more zones of saturation supported by relatively impervious clay beds. At or below river level is a main zone of saturation that is seldom reached by wells on the uplands because of its great depth. Production from wells that penetrate the Fort Union formation ranges from less than 1 to 100 gpm.

The many springs along the sides of the valleys have served for years as the only source of stock and domestic water for some of the Indian families. The largest spring flowed at the rate of 180 gpm when measured during the fall of 1950. Many springs yield from 10 to 50 gpm. According to the Indians, the flow of the springs was not appreciably reduced during the drought years of the 1930's.

The test-drilling program conducted as a part of this investigation provided hydrologic and subsurface geologic information for the entire reservation. During 1950 and 1951 a total of 113 test holes was drilled, 68 of which produced sufficient water to justify their completion as wells. Relocation of the Indian families to the uplands will require many more wells than have been completed in the present drilling program.

Water from bedrock, represented by the Tongue River member of the Fort Union formation, may be hard or soft, depending to a considerable extent on the depth of the well or the origin of the spring. This water is used extensively for domestic and stock purposes. Water from the Quaternary deposits is hard, but generally it is lower in mineral content than water from the Tongue River member of the Fort Union formation. The quality of water in wells that will be inundated upon completion of Garrison Dam was determined for future reference.

On the basis of four analyses of the ground water, it is apparent that shallow wells in the eastern and northeastern segments yield water of the best quality. A well 150 feet deep in the southern segment produced water of fair quality. Of 4 wells drilled in the western segment 3 produced water that contained more than 2, 500 ppm of dissolved solids.

Several springs, particularly in the western segment, could be used satisfactorily as supplies. However, some of the water is objectionable because it contains iron and is straw to dark brown in color.

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Table 3.—*Test holes drilled and wells completed in 1950–51*

[Use of well: D, domestic; S, stock; T, test well drilled primarily for stratigraphic information. Altitudes of land surfaces given in hundredths were determined with a spirit level; in tenths, with an alidade; in feet, with an altimeter]

Well number		Use of well	Total depth (feet)	Depth of completed well (feet)	Depth to water (feet)	Altitude of land surface (feet)	Yield (gpm)
Geological Survey	Indian Service						
146-88-10cba	12	D	310	298	152	...	15
146-89-5ad	52	S	400	...	...	2,149.6	Dry
146-89-8aab	10	D	400	...	...	...	Dry
146-89-9ccb	14	D	290	24	7	...	3
146-90-5daa	13	D	255	229	139	...	3
146-91-8caa	8	D	190	170	86	...	12
146-92-14bb	49	S	390	...	...	2,258.5	Dry
147-87-3cdb	36	D	500	...	...	2,014	Dry
147-87-12baa	33	D	145	...	...	...	Dry
147-87-12bab	34	D	480	465	206	1,959	30
147-87-13bcb	31	D	275	261	204	...	.2
147-87-13bcc	30	D	205	...	...	...	Dry
147-88-1abd	35	D	500	...	...	...	Dry
147-88-1acb	37	D	500	...	...	...	Dry
147-88-3aba	26	D	405	...	...	2,052	Dry
147-88-3abc	32	D	500	439	287	2,038	.2
147-88-11baa	60	S	400	...	...	1,996.2	Dry
147-88-11bab	27	D	500	...	...	1,961	Dry
147-88-11bdc1	28	D	195	...	...	...	Dry
147-88-11bdc2	29	D	500	461	167	1,879	25
147-88-12bad	61	T,S	500	489	229	1,961.7	25
147-88-12cab	25	D	500	483	219	1,950	15
147-88-12cbb	23	D	122	...	...	...	Dry
147-89-31ad	53	S	270	...	...	2,162.3	Dry
147-90-19cdc	51	S	405	...	...	2,151.4	Dry
147-90-20ddb	11	D	400	84	42	...	3
147-90-22ccc	50	S	150	150	74	2,028.8	8
147-90-25abc	54	S	163	155	98	1,869.3	2
147-91-17aad	48	S	400	...	...	2,169.2	Dry
147-91-22aad	43	S	400	88	50	2,256.5	2
147-91-25daa	9	D	186	126	9	...	1
147-91-27bdb	44	S	400	24	3	2,208.7	0.5[1]
147-91-30aaa	46	S	400	...	...	2,260.7	Dry
147-91-33add	47	S	405	...	...	2,307.6	Dry
147-92-21da	42	S	405	...	...	2,287.6	Dry
147-92-36bc	45	S	405	...	...	2,312.1	Dry
147-93-3dbb	38	S	250	223	163	2,000.55	12
147-93-15bcd	37	S	405	...	...	...	Dry
147-94-2ad	32	S	315	...	...	2,244.19	Dry
148-88-8ddc	20	D	195	183	118	...	1
148-88-13bcb	22	D	170	146	97	...	15
148-88-16daa	18	D	160	148	106	...	6
148-88-26bad	24	D	435	382	266	...	.2
148-88-35aca	21	D	505	476	305	2,062	1.2
148-89-7ddd	59	S	259	256	180	2,103.3	20
148-89-11aa	62	S	400	...	...	2,127.3	Dry
148-89-22dab	19	D	295	290	222	...	1.5
148-89-28acb	39	D	405	358	199	...	30
148-90-8bb	64	S	405	...	...	2,107.6	Dry
148-90-10cda	63	S	153	151	95	2,075.7	12
148-90-22bcc	65	S	270	235	135	1,926.8	25
148-90-23abc	17	D	175	167	121	...	2
148-90-23ddc	16	D	292	...	...	...	Dry
148-90-24dcc	15	D	391	359	315	...	.5
148-92-3dba	3	T,S	510	...	...	2,217.45	Dry
148-92-5	56	S	400	...	...	2,327.3	Dry
148-93-9bbc	4	T,S	510	40	19	1,955.26	12
148-93-20bca	29	S	450	...	...	2,211.40	Dry
148-93-32cdb	31	S	400	...	...	2,131.25	Dry
148-94-3abb	39	S	450	...	...	2,366.20	Dry
148-94-13aad	30	S	450	...	...	2,236.7	Dry
148-94-20ddd	35	S	135	134	44	2,307.52	21

[1]Small yield at shallow depth; well was cased at request of owner.

Table 3.—*Test holes drilled and wells completed in 1950–51*—Continued

Well number		Use of well	Total depth (feet)	Depth of completed well (feet)	Depth to water (feet)	Altitude of land surface (feet)	Yield (gpm)
Geological Survey	Indian Service						
148-94-26dca	33	S	290	290	223	2,262.63	8
148-94-33acd	34	S	200	147	78	2,279.39	17
148-95-1dbb	22	S	240	224	176	2,506.62	8
148-95-13adc	36	S	400	....	....	2,444.2	Dry
149-90-11ada	38	D	245	210	159	....	10
149-91-17bab	57	S	400	....	....	2,176.6	Dry
149-91-30ccd	55	S	375	....	....	2,195.2	Dry
149-91-33bcc	58	S	400	347	217	2,009.5	4
149-92-29dcc	41	S	404	404	297	2,183.9	12
149-93-10aaa	27	S	450	....	....	2,296.91	Dry
149-93-14ccc	28	S	450	432	316	2,248.67	12
149-93-18ddb	25	S	465	456	362	2,335.26	6
149-93-25ddd	2	T,S	510	147	100	2,064.55	4
149-93-34aca	40	S	372	357	288	2,121.2	2
149-94-7cad	19	S	450	423	243	2,267.17	12
149-94-9aba	15	S	420	....	....	2,389.02	Dry
149-94-14aaa	26	S	450	420	316	2,305.79	15
149-94-25abc	1	S	285	109	32	2,128.91	45
149-94-27daa	20	S	450	....	....	2,361.23	Dry
149-94-29abb	21	S	240	224	75	2,396.76	7.5
149-95-25aa	24	S	450	....	....	2,385.26	Dry
149-95-36dbd	23	S	225	223	156	2,503.81	10
150-90-13aca	40	D	305	298	218	....	10
150-90-16cbb	5	D	405	....	....	2,042.5	Dry
150-90-22ccc	6	D	330	297	216	2,045.1	20
150-90-25daa	7	D	260	258	173	2,005.2	15
150-90-28ddc	2	D	265	255	174	2,004.8	25
150-92-2aba	67	S	405	383	151	1,930.8	25
150-92-14abd	68	T,S	500	362	153	1,947.6	15
150-93-1dda	69	S	330	296	224	2,177.6	1
150-93-2adc	3	D	405	....	....	2,141.7	Dry
150-93-2cbb	4	D	495	....	....	2,166.8	Dry
150-93-11baa	1	D	405	....	....	2,224.2	Dry
150-94-28ada	17	S	420	414	287	2,266.0	15
150-94-32ccb	16	S	420	391	359	2,372.08	3
150-94-35acb	18	S	420	368	250	2,244.1	20
150-95-13dcc	10	T,S	510	222	150	2,169.58	6-10
151-94-9add	14	T,S	510	....	....	2,124.54	Dry
151-94-28daa	12	S	240	233	172	2,348.49	1.5
151-95-24acd	13	S	390	....	....	2,357.68	Dry
151-95-36acb	11	S	225	196	165	2,297.94	9
152-93-18dcb	41	D	225	209	111	....	50
152-93-20baa	42	D	255	253	162	1,975	4
152-93-20bac	5	T,S	510	205	129	1,932.46	8-10
152-94-11dac	44	D	190	89	23	....	5(?)
152-94-16cca	8	S	180	178	88	2,145.60	8
152-94-25ccc	43	D	230	229	107	2,075	1
152-94-25daa	7	S	255	240	106	2,014.02	3
152-94-32bbb	9	S	225	203	105	2,185.90	4
152-94-33bbb[2]	45	D	275	....	....	2,188	....
152-94-35dca	6	S	210	204	160	2,116.02	5

[2]Last well drilled in 1951; not completed at time of report.

Table 4.—*Logs of test holes and wells drilled in 1950–51*

[Wells drilled in 1950 are marked by an asterisk; the drillers' logs for these wells were modified after examination of drill cuttings with a binocular microscope. Other wells were drilled in 1951; the drillers' logs for these wells were not modified by microscopic examination of drill cuttings]

146-88-10cba

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil	5	5	Clay, gray, with thin lignite bed	38	226
Clay, yellow	13	18	Sand	2	228
Sand and clay	20	38	Clay, gray	14	242
Sand	18	56	Lignite	3	245
Lignite	7	63	Clay, gray, with lignite streaks	10	255
Sand	33	96	Lignite	20	275
Lignite	6	102	Clay, gray	33	308
Clay, gray and green	52	154	Sand	2	310
Sand	34	188			

*146-89-5ad

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand, clay, and scoria	5	5	Clay, silty, gray	13.5	225
Sand and clay	10	15	Lignite	7	232
Sand	15	30	Clay, silty, dense, gray	35	267
Sand and gray clay	5	35	Clay, carbonaceous, brown	3.5	270.5
Sand and chert fragments	10	45	Clay, gray	34.5	305
Sand	27	72	Clay, gray, and lignite	5	310
Sand with gray clay and lignite fragments	6	78	Clay, gray	13	323
Sand	45	123	Lignite	7	330
Clay, gray	40	163	Clay, gray	5	335
Clay, carbonaceous, gray and brown	5.5	168.5	Sand	10	345
Lignite	2.5	171	Clay, silty and sandy, gray	22	367
Clay, silty and sandy, dense, gray	29	200	Clay, gray, with small amount of lignite	4	371
Sand	5	205	Clay, gray	4	375
Clay, sandy, gray	4.5	209.5	Clay, gray, with small amount of lignite	5	380
Clay, silty, gray, with small amount of limestone	2	211.5	Clay, silty, gray	20	400

*146-89-8aab

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil	5	5	Clay, gray	12	175
Sand and clay	3	8	Sand and clay	10	185
Gravel	5	13	Clay, sandy	12	197
Clay, gray	3	16	Lignite	7	204
Lignite	5	21	Clay, sandy, gray	6	210
Clay, gray	65	86	Sand	2	212
Lignite	2	88	Clay, gray	77	289
Clay, gray	24	112	Lignite	6	295
Sand	1	113	Clay, gray	21	316
Clay, gray	37	150	Sand	15	331
Sand and clay	13	163	Clay, gray	7	338
			Sand	64	402

*146-89-9ccb

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil	5	5	Clay, gray and brown	14	209
Gravel	9	14	Sand	2	211
Lignite	2	16	Clay, gray	15	226
Clay, gray	39	55	Clay, gray, with thin lignite beds	16	242
Clay, gray, with thin lignite beds	28	83	Lignite	5	247
Clay, gray, and sand	44	127	Sand	2	249
Clay, gray	7	134	Lignite	3	252
Sand	16	150	Clay, gray, with layers of sand	17	269
Lignite	5	155	Sand	21	290
Sand	24	179			
Clay, gray, and a small amount of sand	16	195			

Table 4,—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
146-90-5daa					
Topsoil	4	4	Clay, gray	4	54
Clay, gray	14	18	Lignite	6	60
Lignite	7	25	Clay, gray	112	172
Clay, sandy	5	30	Sand	44	216
Sand	20	50	Lignite	2	218
			Clay, gray	37	255
146-91-8caa					
Clay, yellow	5	5	Lignite	6	68
Clay, yellow, and gravel	3	8	Clay, gray	12	80
Clay, yellow	6	14	Lignite	5	85
Clay, carbonaceous, and lignite	6	20	Clay, gray	33	118
Clay, gray	15	35	Lignite	6	124
Clay, brown, and gravel	7	42	Clay, gray	28	152
Clay, gray	20	62	Sand	11	163
			Lignite	5	168
			Clay, sandy	22	190
***146-92-14bb**					
Silt, brown	3	3	Clay, gray	7	172
Clay, silty, tan	3	6	Lignite	4	176
Silt, sandy, tan, with pebbles	2	8	Clay, silty, gray	31	207
Clay, silty, brown	7	15	Sand	28	235
Sand	2	17	Clay, sandy, gray	5	240
Clay, sandy, tan	7	24	Sand	14	254
Sand	16	40	Lignite	6	260
Sand, with pebbles and fragments of concretions	5	45	Lignite and carbonaceous clay	2	262
Sand, and a small amount of clay	5	50	Clay, silty, gray	3	265
Sand	5	55	Lignite	3	268
Sand, pebbles, and silty clay	4	59	Clay, silty, gray, and lignite	6	274
Clay, gray	35	94	Sand	21	295
Lignite	6	100	Clay, gray-green	5	300
Clay, gray	16	116	Sand	5	305
Clay and lignite	1	117	Lignite and small amount of sand	6	311
Clay, sandy, gray	3	120	Lignite	3.5	314.5
Clay, gray-green, with small amount of lignite	5	125	Clay, gray	8	322.5
Clay, gray	11	136	Lignite	1.5	324
Lignite	4.5	140.5	Clay, gray	21	345
Clay, gray	4.5	145	Lignite	15	360
Sand	10	155	Clay, gray, and lignite	5	365
Clay, gray	5	160	Sand and lignite	5	370
Clay, silty, gray, with small amount of lignite	5	165	Lignite and small amounts of clay and sand	5	375
			(No sample)	15	390
147-87-3cdb					
Topsoil	2	2	Sandstone	2	280
Clay, yellow	25	27	Sand, gray	22	302
Lignite (no sample)	1	28	Lignite	6	308
Clay, blue	22	50	Clay, sandy, gray	44	352
Lignite	2	52	Sandstone, hard (no sample)	4	356
Clay, gray (no sample)	86	138	Sand	47	403
Sandstone, hard (no sample)	4	142	Clay, gray	19	422
Silt	44	186	Sandstone (no sample)	2	424
Lignite	7	193	Clay, gray	13	437
Clay, sandy	14	207	Lignite	9	446
Clay and lignite	6	213	Clay, gray	21	467
Clay, sandy, gray	3	216	Sandstone, medium-grained (no sample)	1	468
Sand, medium, gray	22	238	Clay, gray	32	500
Lignite	7	245			
Clay, sandy, gray, with thin layers of lignite	33	278			

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
147-87-12baa					
Topsoil	2	2	(No sample)	130	145
Clay and gravel, yellow	13	15			
147-87-12bab					
Sand	23	23	Sand, gray	89	249
Clay, sandy, brown	7	30	Sandstone (no sample)	4	253
Clay, blue	51	81	Sand, medium, gray	3	256
Clay, gray	34	115	(No sample)	176	432
Lignite	5	120	Sandstone, hard (no sample)	2	434
Clay, gray	6	126	Sand, medium, gray	36	470
Clay, sandy, gray	34	160	Clay, gray (no sample)	10	480
147-87-13bcd					
Till	30	30	Lignite	6	148
Clay, gray	30	60	Clay, gray	28	176
Gravel	44	104	Lignite	9	185
Lignite	3	107	Silt	11	196
(No sample)	7	114	Sand, fine	12	208
Clay, gray	26	140	Sandstone, medium-grained (no sample)	4	212
Clay, gray	2	142	(No sample)	63	275
147-87-13beb					
Clay	3	3	Clay, yellow	28	40
Clay, yellow, and gravel	9	12	(No sample)	165	205
147-88-1abd					
Topsoil	5	5	Sandstone	1	258
Clay	19	24	Clay	3	261
Clay, sandy	8	32	Lignite	4	265
Lignite	6	38	Clay	25	290
Clay	3	41	Clay, sandy	8	298
Sand	25	66	Lignite	7	305
Clay, sandy	6	72	Clay	20	325
Sand	5	77	Sand	21	346
Clay, sandy	13	90	Lignite	9	355
Lignite	11	101	Clay	29	384
Clay, sandy	11	112	Lignite	4	388
Clay	56	168	Clay	6	394
Lignite	19	187	Sand	9	403
Clay	18	205	Clay	21	424
Sandstone	7	212	Lignite	7	431
Clay	32	244	Clay	26	457
Lignite	5	249	Sand	23	480
Clay	8	257	Clay	20	500
147-88-1acb					
Topsoil	2	2	Clay	25	191
Clay	13	15	Lignite	4	195
Clay, sandy	21	36	Clay	9	204
Clay	5	41	Sandstone	1	205
Lignite	6	47	Clay	5	210
Sandstone	2	49	Clay, sandy	20	230
Clay	9	58	Clay	34	264
Sandstone	2	60	Clay, sandy	6	270
Clay, sandy	5	65	6and	20	290
Clay	53	118	Lignite	6	296
Lignite with thin layers of clay	22	140	Clay	11	307
			Lignite	4	311
Clay	15	155	Clay	66	377
Clay, sandy	6	161	Cignite	9	386
Clay	4	165	Clay	17	403
Sandstone	1	166	Clay, sandy	9	412

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
147-88-1acb—Continued					
Clay	36	448	Sandstone	1	484
Sandstone	4	452	Clay	16	500
Clay	31	483			
147-88-3aba					
Topsoil	4	4	Clay, silty and sandy, dense	31	241
Clay, sandy, dense	8	12	Lignite	4	245
Sand	3	15	Clay, sandy	10	255
Clay, carbonaceous, yellow, gray, green	46	61	Sand	4	259
Sand	1	62	Clay, with thin layers of sand	42	301
Clay, sandy	6	68	Lignite	5	306
Clay, green	13	81	Clay	11	317
Lignite	4	85	Lignite	3	320
Clay, sandy, dense	12	97	Clay	16	336
Lignite	5	102	Clay, sandy	11	347
Clay, sandy, dense	29	131	Lignite	7	354
Sand	1	132	Clay	11	365
Clay, sandy	15	147	Lignite	27	392
Lignite	9	156	Clay	13	405
Clay, sandy, dense	44	200			
Clay, brown, with thin layers of lignite	10	210			
147-88-3abc					
Topsoil	3	3	Lignite	4	237
Clay, sandy	9	12	Clay	5	242
Gravel and sand	6	18	Sandstone	2	244
Gravel, containing pebbles of lignite, sandstone, etc	7	25	Clay	22	266
Gravel and sand	8	33	Lignite	3	269
Sand	19	52	Clay	20	289
Sandstone	5	57	Lignite	7	296
Clay	8	65	Clay	40	336
Lignite	6	71	Lignite	6	342
Clay	29	100	Clay	12	354
Clay, sandy	28	128	Lignite	5	359
Sandstone	11	139	Clay	20	379
Clay	28	167	Lignite	4	383
Lignite	11	178	Clay	11	394
Clay	6	184	Lignite	7	401
Lignite	4	188	Clay	7	408
Clay	20	208	Clay, sandy	8	416
Lignite	4	212	Lignite	4	420
Clay	21	233	Clay	20	440
			Sand	10	450
			Clay	50	500
147-88-11baa					
Clay, silty, gray	15	15	Clay, gray	2	225
Sand	20	35	Sand and clay	7	232
Lignite	2	37	Lignite	5	237
Clay, gray	8	45	Clay, silty, brown	3	240
Lignite	6	51	Sand and clay, gray	15	255
Clay, gray	29	80	Sand	5	260
Lignite	10	90	Lignite	5	265
Clay, gray	56	146	Sand and clay, gray	5	270
Lignite	26	172	Sand	43	313
Clay, gray	18	190	Lignite	6	319
Lignite	5	195	Sand	16	335
Clay, gray	3	198	Lignite	5	340
Limestone	9	207	Clay, gray	35	375
Clay, gray	11	218	Sand and clay, gray	15	390
Lignite	5	223	Sand	10	400

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

147-88-11bab

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil	3	3	Clay, gray, with thin layers of lignite	68	217
Clay, gray and yellow	14	17	Clay, sandy, gray	18	235
Lignite	3	20	Lignite	3	238
Clay, gray	5	25	Clay, gray	7	245
Lignite	7	32	Sand	14	259
Clay, gray	15	47	Clay, sandy, gray	25	284
Lignite	8	55	Lignite	6	290
Clay, sandy, gray	35	90	Clay, gray	19	309
Sand	2	92	Lignite	5	314
Clay, gray	21	113	Clay, gray	31	345
Lignite	15	128	Sand	25	370
Clay, gray, with thin layers of lignite	19	147	Lignite	10	380
Sand	2	149	Clay, silty and sandy, dense	82	462
			Sand	3	465
			Clay, silty	35	500

147-88-11bdc1

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Scoria	21	21	Sand	11	126
Clay	43	64	Clay, gray	6	132
Lignite	6	70	Lignite	3	135
Sand	8	78	Clay, sandy	15	150
Clay, gray	37	115	Sand	10	160
			Clay, gray	35	195

147-88-11bdc2

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	18	18	Lignite	3	160
Lignite	9	27	Clay	15	175
Clay	11	38	Sand	32	207
Lignite	3	41	Lignite	7	214
Clay	8	49	Clay, sandy	21	235
Lignite	2	51	Lignite	3	238
Clay, sandy	7	58	Clay	15	253
Limestone	7	65	Clay, sandy	5	258
Clay, sandy	5	70	Lignite	4	262
Lignite	4	74	Clay	17	279
Clay, gray	14	88	Lignite	3	282
Clay, white	7	95	Clay	10	292
Clay, silty, gray	9	104	Lignite	5	297
Lignite	6	110	Clay	35	332
Clay, sandy	13	123	Clay, sandy	17	349
Lignite	5	128	Sandstone	2	351
Clay, green	12	140	Clay, silty	64	415
Sandstone, soft	1	141	Silt and sand	49	464
Clay	7	148	Lignite	6	470
Clay, sandy	9	157	Clay	30	500

147-88-12bad

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Clay, silty, brown	15	15	Clay, green	5	190
Sand	10	25	Sand	15	205
Clay, gray and brown	7	32	Clay, carbonaceous, sandy, gray, brown	20	225
Lignite	10	42	Sand	45	270
Clay, gray	3	45	Lignite	10	280
Sand and clay, gray and brown	50	95	Clay, silty, brown	7	287
Lignite	8	103	Lignite	1	288
Clay, silty, gray	2	105	Sand and clay, silty	12	300
Lignite	10	115	Lignite	5	305
Sand	5	120	Clay, gray	13	318
Clay, silty, gray	10	130	Lignite	1	319
Sand	5	135	Sand and clay, silty	16	335
Clay, brown and gray	29	164	Lignite	5	340
Lignite	5	169	Clay, gray	5	345
Clay, gray	11	180	Lignite	10	355
Lignite	5	185	Clay, silty, gray	20	375

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Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
147-88-12bad—Continued					
Sand and clay, gray	4	379	Clay, gray	25	420
Limestone and lignite	1	380	Limestone	3	423
Sand and clay, gray	10	390	Clay, gray	47	470
Sand	5	395	Sand	30	500
147-88-12cab					
Topsoil	3	3	Sand	37	253
Clay, yellow	21	24	Lignite	8	261
Gravel	8	32	Clay, gray	3	264
Lignite	1	33	Sand	6	270
Clay, gray	22	55	Clay, gray	3	273
Sand	8	63	Lignite	9	282
Clay, gray	15	78	Clay, gray	18	300
Lignite	8	86	Lignite	8	308
Clay, gray	3	89	Clay, gray	30	338
Lignite	6	95	Lignite	13	351
Clay, gray	64	159	Clay, gray	34	385
Lignite	1	160	Clay, sandy, gray	20	405
Clay, gray	8	168	Clay, gray	23	428
Lignite	3	171	Sand	10	438
Clay, sandy, green	21	192	Clay, silty	52	490
Sand	1	193	Lignite	4	494
Clay, gray	10	203	Clay	6	500
Lignite and carbonaceous clay	13	216			
147-88-12cbb					
Topsoil	2	2	Clay, gray	20	49
Clay, yellow, and gravel	3	5	Sand	23	72
Lignite	3	8	Lignite	16	88
Clay, gray	12	20	Clay, gray	3	91
Lignite	9	29	Lignite	14	105
			Clay, gray	17	122
***147-89-31ad**					
Clay, sandy, brown; pebbles	10	10	Clay, silty, brown, sandy; pebbles	13	23
			(No sample)	247	270
***147-90-19cdc**					
Silt, brown	5	5	Lignite	6	138
Clay, silty, brown; pebbles	5	10	Clay, silty, gray	7	145
Clay, silty, tan	17	27	Clay, gray, with small amount of lignite	5	150
Silt, gray	6	33	Clay, silty and sandy, dense, gray	118	268
Sand, gray	4	37	Clay, gray, and carbonaceous clay	2	270
Clay, silty, gray	5	42	Sand and silty clay	6	276
Lignite	2	44	Lignite	3	279
Clay, silty, gray-brown	8	52	Clay, silty, dense, gray	26	305
Clay, gray	20	72	Lignite	.5	305.5
Clay, sandy, gray	2.5	74.5	Clay, gray	26.5	332
Lignite	5.5	80	Lignite	3	335
Silt, gray	7.5	87.5	Clay, silty, dense, gray	40	375
Clay, silty, gray	12.5	100	Lignite	4	379
Clay, sandy, gray	5	105	Clay, silty, dense, gray	26	405
Sand, silty, gray	15	120			
Sand and sandy clay	12	132			
147-90-20ddb					
Clay, yellow	16	16	Lignite	3	93
Sand	30	46	Clay, gray and green	40	133
Lignite	4	50	Lignite	3	136
Clay, gray	40	90	Clay, sandy	43	179

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
147-90-20ddb—Continued					
Lignite	3	182	Sand	41	356
Clay, sandy, dense, gray	110	292	Lignite	2	358
Lignite	5	297	Clay, sandy	12	370
Clay, sandy	18	315	Clay, gray	30	400
***147-90-22ccc**					
Soil, silty and clayey, brown	5	5	Sand	37	52
Clay, silty, brown	10	15	Clay, gray(?), (no sample)	98	150
***147-90-25abc**					
Silt, tan; pebbles	10	10	Clay, gray	5	100
Silt, brown	10	20	Clay, sand, and lignite	5	105
Clay, silty, brown	4	24	Sand and lignite	10	115
Lignite	6	30	Sand and clay	5	120
Clay	5	35	Clay, sand, and lignite	2.5	122.5
Sand	5	40	Lignite	1	123.5
Clay, gray	11	51	Sand and small amount of lignite	6.5	130
Lignite	7.5	58.5	Clay, silty, gray, and small amount of lignite	5	135
Clay, silty, carbonaceous, brown	1.5	60	Sand	10	145
Clay, sandy, gray	5	65	Sand and lignite	5	150
Sand, clay, and lignite	5	70	Sand, lignite, and silty clay	10	160
Sand	15	85	Lignite	3	163
Sand, and small amount of lignite	9	94			
Silt, sand, clay, and lignite	1	95			
***147-91-17aad**					
Silt, sandy, brown; pebbles	5	5	Clay, silty, gray	9	240
Soil, silty, and sandy, brown	5	10	Clay, gray, and small amount of lignite	5	245
Clay, silty and sandy, brown	10	20	Clay, gray	22	267
Clay, silty, tan	5	25	Clay, gray and brown, and small amount of lignite	2	269
Clay, silty, gray	19	44	Clay, gray	11	280
Clay, silty, gray, and limestone	3	47	Lignite and small amount of clay	7	287
Clay, silty, gray	3	50	Clay, gray	15	302
Lignite	3	53	Lignite	8	310
Clay, silty, gray and tan	27	80	Clay, gray, and small amount of lignite	5	315
Clay, carbonaceous, gray and brown	5	85	Lignite and small amount of clay	15	330
Clay, carbonaceous, gray and brown, and lignite	5	90	Sand, clay, and lignite	5	335
Clay, sandy, gray	5	95	Clay, silty and sandy, dense, gray	13	348
Sand and lignite	5	100	Lignite and clay	12	360
Clay, silty, dense, gray	45	145	Clay, gray	5	365
Clay, sandy, gray, and lignite	5	150	Clay, carbonaceous, gray	5	370
Clay, silty, dense, gray	20	170	Clay, silty and sandy, gray	10	380
Lignite and small amount of clay	5	175	Sand and sandy clay	10	390
Clay, gray	20	195	Clay, carbonaceous, gray, and lignite	10	400
Clay, gray, and lignite	5	200			
Clay, gray	11	211			
Clay, gray and lignite	8	219			
Clay, gray, and small amount of lignite	12	231			
***147-91-22aad**					
Sand	85	85	Clay, gray, and small amount of lignite	6	250
Clay, silty, gray	25	110	Clay, gray	24	274
Clay, gray	40	150	Clay, sandy, gray	6	280
Clay, silty, gray	30	180	Clay, silty, gray	10	290
Clay, gray	15	195	Clay, gray	10	300
Clay, silty, gray	5	200	Clay, silty, gray	15	315
Clay, sandy, gray	44	244			

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
***147-91-22aad—Continued**					
Clay, gray	15	330	Clay, gray	3	368
Lignite	3	333	Lignite	8	376
Lignite and small amount of clay	7	340	Clay, gray, and small amount of lignite	4	380
Clay, gray	23.5	363.5	Clay, gray	15	395
Clay and small amount of lignite	1.5	365	Clay, gray, and small amount of lignite	5	400
147-91-25daa					
Topsoil	3	3	Sand and clay, gray	5	65
Clay, yellow	9	12	Lignite	5	70
Clay, gray, with thin lignite beds	31	43	Sand and clay, gray	6	76
Clay, gray, and sand	7	50	Clay, gray	6	82
Sand	1	51	Sand and clay, gray	51	133
Clay, gray	9	60	Clay, gray and green	42	175
			Sand and clay, gray	9	184
			Sand	2	186
***147-91-27bdb**					
Clay, silty and sandy, brown	5	5	Sand and small amount of lignite	5	180
Clay, silty and sandy, brown; pebbles	5	10	Clay, silty and sandy, dense, gray	5	185
Clay, sandy, gray	25	35	Clay, gray	50	235
Clay, gray	5	40	Clay, gray, and lignite	8	243
Sand	10	50	Clay, gray	13	256
Lignite	4	54	Clay, silty, gray, and lignite	4	260
Clay, gray	6	60	Clay, silty, gray	10	270
Clay, gray, and lignite	6	66	Lignite	15	285
Clay, gray	11	77	Lignite and gray silty clay	10	295
Lignite	2	79	Clay, sand, and lignite	5	300
Clay, silty, gray	5	84	Sand	5	305
Sand	16	100	Clay and sand	15	320
Lignite, sand, and clay	10	110	Clay, sandy, gray	5	325
Clay, silty, gray	30	140	Clay, silty, gray	25	350
Sand	5.5	145.5	Lignite	8	358
Sand and small amount of lignite	2.5	148	Lignite and gray clay	12	370
Clay, silty and sandy, dense, gray	22	170	Lignite	10	380
Sand	5	175	Lignite and gray clay	10	390
			Clay, silty, gray	6	396
			Clay, gray, and small amount of lignite	1.5	397.5
			Clay, gray	2.5	400
***147-91-30aaa**					
Clay, silty and sandy, brown, gray, and tan	50	50	Clay, silty and sandy, dense, gray	45	260
Sand	34	84	Sand	37	297
Lignite	6	90	Lignite	3	300
Clay, silty, dense, gray	36	126	Clay, gray-green	5	305
Lignite	3	129	Sand	4	309
Clay, silty and sandy, gray	11	140	Clay, silty, gray-green	11	320
Clay, gray-green, and small amount of lignite	5	145	Clay, gray	5	325
Clay, gray-green	5	150	Clay, gray, and small amount of lignite	6	331
Clay, gray	10	160	Lignite	4	335
Clay, gray, and small amount of lignite	4	164	Clay, gray	5.5	340.5
Clay, silty and sandy, dense, gray	16	180	Lignite	3.5	344
Sand	15	195	Clay, gray	16	360
Clay, sandy, gray	5	200	Clay, gray, and small amount of lignite	5	365
Clay, gray	4	204	Clay, silty, gray-green	13	378
Lignite and sandy clay	6	210	Clay, gray-green	2	380
Lignite and sand	5	215	Lignite	7	387
			Lignite and clay	3	390
			Clay, gray, and small amount of lignite	10	400

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

*147-91-33add

	Thickness (feet)	Depth (feet)
Clay, silty, yellow and tan	13	13
Clay, gray and brown	8	21
Sand	4	25
Clay, gray, and small amount of lignite	5	30
Clay, gray	6	36
Lignite	4	40
Clay, gray, and lignite	5	45
Clay, gray	7.5	52.5
Sand	5.5	58
Clay, gray, and sand	9	67
Lignite	8	75
Clay, gray	15	90
Lignite and small amount of sand	2.5	92.5
Sand	3.5	96
Clay, gray	5	101
Clay, gray, silty, carbonaceous, gray and brown	4	105
Clay, gray	13	118
Lignite	3	121
Clay, gray	17.5	138.5
Sand and lignite	1.5	140
Clay, silty, gray, and lignite	1	141
Lignite	2	143
Clay, silty and sandy, dense gray	57	200
Clay, gray, and sand	4	204
Clay, gray, silty	1.5	205.5
Sand	9.5	215
Clay, silty, carbonaceous, brown	5	220
Clay, silty and sandy, dense, gray	35	255
Sand	5	260
Sand and clay	5	265
Sand	20	285
Lignite	1	286
Clay, gray	4	290
Clay, silty, green	25	315
Clay, silty, gray	45	360
Sand	5	365
Clay, silty, brown, and sand	6	371
Sand	4	375
Sand and sandy clay, gray	5	380
Sand	4	384
Clay, silty, gray-green and gray-brown	21	405

*147-92-21da

	Thickness (feet)	Depth (feet)
Sand and sandy clay	10	10
Clay, sandy, brown	5	15
Sand	68	83
Clay, sandy, gray	7	90
Clay, gray	6	96
Limestone	1	97
Clay, gray	8	105
Lignite	10	115
Clay, gray	40	155
Clay, silty, gray, and small amount of lignite	5	160
Clay, gray	7.5	167.5
Sand	8.5	176
Clay, gray	15	191
Lignite	6	197
Clay, silty, dense, gray	16	213
Clay, sandy, gray	4.5	217.5
Lignite	1.5	219
Clay, sandy, gray	6	225
Clay, gray	7	232
Lignite	1.5	233.5
Clay, gray	29.5	263
Lignite and small amount of brown clay	4	267
Clay, silty, dense, gray	40	307
Lignite	3	310
Clay, gray	5	315
Lignite and clay	5	320
Clay, silty, gray	10	330
Lignite and clay	3	333
Clay, silty, gray	14.5	347.5
Sand	7.5	355
Clay, sandy, gray	5	360
Sand	45	405

*147-92-36bc

	Thickness (feet)	Depth (feet)
Soil, silty and sandy, brown	5	5
Clay, silty, tan	26	31
Sand, silty, brown	5.5	36.5
Gravel	2	38.5
Gravel and silty and sandy clay	2.5	41
Clay, pebbles, and lignite fragments	1.5	42.5
Clay, gray	27.5	70
Clay, silty, gray	15	85
Clay, gray	5	90
Clay, carbonaceous, gray	2	92
Clay, gray	11	103
Lignite	3	106
Clay, gray, and small amount of lignite	1.5	107.5
Sand	2.5	110
Clay, sandy, gray	4	114
Clay, gray	46	160
Clay, silty and sandy, gray	10	170
Clay, gray, and lignite	4	174
Clay, sandy, gray	6	180
Clay, silty, dense, gray	20	200
Clay, gray-green	10	210
Clay, gray	5	215
Clay, gray, and small amount of lignite	5	220
Clay, silty and sandy, dense, gray	28	248
Lignite	2	250
Clay, gray	20	270
Clay, silty, gray	10	280
Clay, sandy, gray	5	285
Sand and sandy clay	20	305
Clay, sandy, gray	5	310
Sand	5	315
Clay, silty and sandy, gray	10	325
Lignite and gray clay	5	330
Clay gray, and small amount of lignite	5	335
Clay, silty and sandy, dense, gray	25	360
Sand	5	365

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
147-92-36bc—Continued					
Clay, sandy, gray	5	370	Clay, gray, and sand	5	400
Sand	18	388	Sand and small amount of brown carbonaceous clay	5	405
Clay, silty, gray	7	395			
***147-93-3dbb**					
Clay, silty, gray	5	5	Clay, silty, dense, gray	15	100
Clay, silty brown	20	25	Lignite	4	104
Clay, gray	5	30	Clay, silty, gray	36	140
Lignite and gray clay	5	35	Clay, sandy, gray	10	150
Clay, gray	5	40	Clay, silty, gray	25	175
Lignite and clay	5	45	Sand	5	180
Clay, silty, dense, gray	15	60	Clay, silty, gray	5	185
Sand	5	65	Sand	15	200
Clay, sandy	5	70	Clay, sandy, gray	7.5	207.5
Clay, gray	6	76	Sand	22.5	230
Lignite and clay	9	85	Clay, sandy, gray	4	234
			Clay, silty, gray	6	240
			Clay, sandy, gray	5	245
			Sand	5	250
***147-93-15bcd**					
Clay, silty and sandy, brown	5	5	Lignite and gray clay	5	115
Clay, silty, brown, with a few pebbles	8.5	13.5	Clay, silty, gray	46	161
Clay, silty, gray to brown	6.5	20	Lignite	5	166
Lignite and tan clay	6.5	26.5	Clay, silty, gray	44	210
Lignite and red shale	3.5	30	Lignite	5	215
Clay, silty and sandy, gray and tan	7	37	Clay, gray	5	220
Clay, silty and sandy, carbonaceous, gray	13	50	Lignite	5	225
Sand	5	55	Clay, silty, gray	5	230
Clay, silty and sandy, dense, gray	20	75	Lignite and gray clay	5	235
(No sample)	15	90	Clay, gray	16	251
Clay and lignite	5	95	Clay and lignite	4	255
Lignite	10	105	Clay, silty, gray	10	265
Clay, gray	5	110	Lignite and silty clay	5	270
			Clay, gray	35	305
			Lignite and gray clay	5	310
			Clay, gray	5	315
			Lignite and clay	10	325
			Clay, gray	35	360
			Lignite	15	375
			Clay, gray	30	405
***147-94-2ad**					
Sand	30	30	Sand	22	140
(No sample)	15	45	Lignite and gray clay	9	149
Lignite	12	57	Clay, silty, gray	31	180
Lignite and sand	6	63	Lignite	4	184
Lignite	7	70	Clay, silty and sandy, gray	26	210
Sand	20	90	Sand	13	223
Clay, sandy, gray	24	114	Clay and sand	3	226
Lignite	4	118	(No sample	89	315
148-88-8ddc					
Topsoil	3	3	Clay, gray	36	104
Clay, yellow	20	23	Lignite	3	107
Lignite and gray clay	5	28	Clay, gray	11	118
Clay, sandy, dense, gray	10	38	Lignite	12	130
Sand	12	50	Clay, gray	25	155
Clay, gray	8	58	Sand	35	190
Lignite	10	68	Lignite	4	194
			Clay, gray	1	195

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
148-88-13bcb					
Topsoil	3	3	Clay, gray	13	75
Clay, yellow, and gravel	11	14	Sand	73	148
Lignite	3	17	Lignite	2	150
Clay, yellow	13	30	Clay, gray	7	157
Clay, gray	24	54	Lignite	3	160
Lignite	8	62	Clay, gray	10	170
148-88-16daa					
Topsoil	1	1	Lignite	9	58
Clay, yellow	13	14	Clay, gray	20	78
Clay, yellow, with pebbles	6	20	Lignite	10	88
Clay, sandy, gray	5	25	Lignite and clay	4	92
Lignite	1	26	Lignite	3	95
Clay, gray	23	49	Clay, sandy	8	103
			Sand	57	160
148-88-26bad					
Soil	2	2	Sand	1	207
Clay, yellow and brown	16	18	Clay, gray and green	16	223
Sand with thin lignite bed	12	30	Sand	1	224
Clay, gray	5	35	Clay, gray	26	250
Sand	20	55	Lignite with thin layers of clay	13	263
Clay, sandy, gray	5	60	Clay, gray	15	278
Lignite	6	66	Lignite	2	280
Clay, brown, gray and green	14	80	Clay, gray	5	285
Sand	51	131	Lignite	9	294
Lignite	4	135	Clay, sandy, gray	53	347
Clay, gray	22	157	Lignite	3	350
Sand	8	165	Clay, silty and sandy, gray	34	384
Clay, gray	25	190	Lignite	2	386
Lignite	7	197	Clay, gray	44	430
Clay, gray	9	206	Lignite	5	435
148-88-35aca					
Topsoil	5	5	Lignite	8	244
Gravel	3	8	Sand	6	250
Clay, brown and yellow	10	18	Lignite	1	251
Lignite	3	21	Sand	2	253
Clay, sandy, dense, gray	52	73	Clay, gray	42	295
Lignite	3	76	Lignite	2	297
Clay, gray	11	87	Clay, gray	10	307
Sand	2	89	Sand	1	308
Clay, gray	14	103	Clay, gray	22	330
Lignite	7	110	Sand	1	331
Clay, gray	18	128	Clay, gray	29	360
Lignite	9	137	Sand	1	361
Clay, gray	31	168	Clay, gray	19	380
Sand	1	169	Lignite	5	385
Clay, gray	44	213	Clay, gray	65	450
Lignite	8	221	Clay, gray, with thin lignite beds	30	480
Clay, gray	15	236	Clay, gray	25	505
148-89-7ddd					
Topsoil	3	3	Lignite (no sample)	5	95
Clay, brown, and gravel	12	15	(No sample)	34	129
(No sample)	45	60	Lignite (no sample)	4	133
Sand and clay	10	70	(No sample)	67	200
(No sample)	20	90	Lignite (no sample)	25	225
			Sand (no sample)	34	259

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

148-89-11aa

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Silt	5	5	Clay, sandy, gray	15	225
Sand and gravel	10	15	Sand	5	230
Clay, sandy, and gravel	15	30	Lignite and clay	10	240
Sand and gravel	5	35	Clay, sandy	5	245
Clay, gray	15	50	Lignite	15	260
Lignite	5	55	Lignite with thin layers of clay	15	275
Sand	10	65	Clay, gray	10	285
Lignite	5	70	Lignite	5	290
Sand	10	80	Clay, gray	5	295
Lignite	5	85	Lignite	5	300
Sand and gravel	15	100	Sand	50	350
Lignite	5	105	Lignite	5	355
Clay, sandy	15	120	Clay, gray	10	365
Clay, gray, with thin layers of lignite	15	135	Clay and sand	10	375
Clay, silty, gray	20	155	Lignite	5	380
Lignite	10	165	Lignite with green clay	10	390
Sand	45	210	Clay, gray-green, with thin layers of lignite	10	400

148-89-22dab

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil	2	2	Sand with streaks of lignite	14	87
Clay, yellow and brown	10	12	Sand	70	157
Sand	3	15	Clay, gray, with thin layers of sand	3	160
Clay, sandy, brown	11	26	Clay, gray and green, with thin lignite beds	8	168
Sand	8	34	Lignite with thin beds of clay	37	205
Clay, gray	11	45	Clay, gray	38	243
Lignite	4	49	Sand	52	295
Clay, gray	9	58			
Lignite	7	65			
Clay, sandy, gray	8	73			

148-89-28acb

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil	8	8	Clay, silty	6	130
Lignite	1	9	Clay, sandy	25	155
Clay, baked	1	10	Sandstone	1	156
Clay	3	13	Clay, sandy	16	172
Sand	27	40	Clay	34	206
Clay	7	47	Lignite	7	213
Sand	5	52	Clay	19	232
Sandstone	1	53	Sandstone	1	233
Clay	3	56	Clay	20	253
Sand	15	71	Lignite	2	255
Lignite	3	74	Clay	49	304
Sand	10	84	Lignite	3	307
Lignite with thin layers of clay	10	94	Clay, sandy	11	318
Sandstone	1	95	Sand, fine	19	337
Clay	13	108	Clay, sandy	9	346
Lignite	2	110	Lignite	2	348
Clay	14	124	Clay	40	388
			Lignite	3	391
			Clay	14	405

148-90-8bb

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Silt, sandy	9	9	Sand	5	195
Clay, sandy, brown; contains gravel	16	25	Clay, gray	7	202
			Lignite	3	205
Sand	55	80	Clay, gray to brown	10	215
Clay, gray	7	87	Clay, gray	25	240
Lignite	1	88	Sand	15	255
Clay, gray	18	106	Clay, gray	15	270
Lignite	5	111	Clay, sandy, gray	15	285
Clay and sand	24	135	Sand and clay, gray	65	350
Sand	20	155	Sand	36	386
Clay, gray	7	162	Lignite	4	390
Lignite	5	167	Clay, gray and brown, with thin lignite beds	15	405
Clay, gray	23	190			

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
148-90-10cda					
Sand and gravel	11	11	Sand	15	45
Clay, gray	9	20	Sand (no sample)	15	60
Clay, sandy, gray	5	25	Sand	86	146
Sandy clay (no sample)	5	30	Lignite	1	147
			Clay, gray	6	153
148-90-22bcc					
Topsoil	3	3	Sand	5	125
Sand	7	10	Lignite	7	132
Sand with gravel	25	35	Clay, gray and brown	3	135
Clay, gray and brown, with			Sand and clay, gray	12	147
lignite bed	5	40	Lignite	5	152
Clay, brown	5	45	Sand and clay, gray	11	163
Clay, gray, and sand	25	70	Lignite	2	165
Sand	5	75	Clay, gray and green	13	178
Lignite	5	80	Lignite	2	180
Clay, gray	36	116	Sand and clay, gray	15	195
Lignite	4	120	Sand	75	270
148-90-23abc					
Topsoil	3	3	Sand	2	89
Sand	4	7	Clay, gray	45	134
Sand and gravel	11	18	Lignite	3	137
Sand	27	45	Clay, gray	9	146
Clay, gray	42	87	Sand	26	172
			Lignite	3	175
148-90-23ddc					
Topsoil	2	2	Sand	43	181
Sand	47	49	Lignite	34	215
Lignite	1	50	Sand	40	255
Clay, gray and green	28	78	Clay, gray	10	265
Sand	2	80	Sand	12	277
Clay, silty, gray	45	125	Clay	5	282
Lignite	3	128	Lignite	9	291
Clay, gray	10	138	Sand	1	292
148-90-24dcc					
Sand	13	13	Clay, gray	7	170
Clay, gray	17	30	Clay, sandy	13	183
Sand	3	33	Sand	2	185
Lignite	1	34	Clay, sandy to dense	17	202
Clay, gray	6	40	Lignite	2	204
Lignite	2	42	Clay, gray	21	225
Clay, gray	5	47	Lignite	3	228
Lignite	1	48	Clay, sandy to dense, gray,		
Clay, gray	25	73	green, and brown	93	321
Lignite	2	75	Lignite	3	324
Clay, gray	17	92	Clay, gray	26	350
Sand	3	95	Sand	15	365
Clay, sandy, dense	63	158	Lignite	2	367
Lignite	5	163	Clay, gray	22	389
			Sand	2	391
***148-92-3dba**					
Clay, silty, brown	4	4	Clay, silty and sandy, dense,		
Clay, gray and tan	18	22	gray	21.5	93.5
Sand	18	40	Lignite	3.5	97
Clay, gray	13	53	Clay, gray	12.5	109.5
Lignite	3	56	Limestone	.5	110
Clay, gray	14	70	Clay, gray	10	120
Lignite, limestone, sandstone,			Sand	5	125
and clay	2	72	Clay, silty, gray	12	137

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
***148-92-3dba—Continued**					
Lignite	1	138	Lignite	2.5	344.5
Clay, silty, gray	4	142	Clay, sandy, gray	8	352.5
Lignite	5	147	Lignite and clay	2.5	355
Clay, silty, gray	34	181	Sand	5	360
Clay, gray; sand and lignite	4	185	Clay, gray	30	390
Clay, silty, carbonaceous, brown	10	195	Lignite	2	392
Sand and clay	8	203	Sand	6.5	398.5
Clay, gray	10	213	Lignite	3.5	402
Sand	77	290	Clay, sandy, dense, gray	20	422
Sand and lignite	5	295	Lignite	10	432
Lignite	5	300	Clay, silty, gray	13	445
Sand	25	325	Sand	23.5	468.5
Clay, silty, gray	10	335	Lignite	1	469.5
Sand, lignite, and clay	7	342	Sand	20.5	490
			Sand and lignite	5	495
			Sand	15	510
148-92-5					
Sand	5	5	Clay, gray	5	230
Sand and gravel	20	25	Lignite	5	235
Clay, brown	10	35	Clay, gray	5	240
Sand	25	60	Lignite	5	245
Clay, brown, and sand	10	70	Clay, gray	45	290
Sand	30	100	Lignite	8	298
Clay and sand	35	135	Sand and clay, gray	17	315
Sand	50	185	Lignite	5	320
Lignite	10	195	Sand and clay, gray	5	325
Clay, gray	10	205	Clay, gray	55	380
Clay, gray, and sand	20	225	Lignite	5	385
			Clay, gray-green	15	400
***148-93-9bbc**					
Clay, gray to brown	20	20	Lignite	1.5	224.5
Clay, gray to brown, with pebbles	5	25	Clay, silty, gray	27.5	252
Gravel	25	50	Lignite	5	257
Sand	5	55	Clay, silty, gray	13	270
Clay, gray	7	62	Sand	5	275
Lignite	4	66	Clay, silty, gray to tan	35	310
Clay, gray	9	75	Sand	50	360
Lignite	5	80	Lignite and tan clay	5	365
Clay, silty, gray	10	90	Clay, gray	20	385
Sand	111	201	Clay, gray, and lignite	5	390
Lignite	3	204	Clay, silty, dense, gray	40	430
Clay, silty, carbonaceous, gray	19	223	Sand	20	450
			Clay, sandy, gray	5	455
			Sand	50	505
			Lignite and sand	5	510
***148-93-20bca**					
Clay, silty, brown	30	30	Lignite and clay	12	235
Clay, silty and sandy, brown and gray with pebbles	15	45	Clay, gray	5	240
Clay, silty and sandy, gray, with pebbles	15	60	Lignite and silty clay	10	250
Clay, sandy, gray, and lignite	5	65	Clay, lignite, and sand	10	260
Clay, sand, lignite, and pebbles	8	73	Clay, silty, gray	20	280
Sand	12	85	Clay, gray, and lignite	5	285
Lignite	5	90	Clay, sandy, dense, gray	15	300
Clay and lignite	5	95	Lignite	5	305
Sand, clay, and lignite	10	105	Clay, silty and sandy, gray	20	325
Sand	50	155	Sand, clay, and lignite	20	345
Clay, silty and sandy, gray	60	215	Sand	23	368
Sand, clay, and lignite	8	223	Clay, lignite, and limestone	5	373
			Sand	52	425
			Lignite	5	430
			Lignite and gray clay	20	450

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

•148-93-32cdb

	Thickness (feet)	Depth (feet)
Silt, tan	10	10
Clay, silty, tan, with pebbles	22	32
Sand, clay, and pebbles	14	46
Lignite, sand, and brown clay	4	50
Clay, silty, gray, and sand	10	60
Lignite and gray clay	5	65
Clay, gray	40	105
Lignite and gray clay	7	112
Clay, gray	50	162
Lignite and gray clay	3	165
Clay, gray	65	230
Clay and lignite	4	234
Lignite	6	240
Clay, gray	32.5	272.5
Sand	7.5	280
Clay, silty, dense, gray	12.5	292.5
Lignite	7.5	300
Lignite and clay	10	310
Clay, silty, dense, carbonaceous, gray	40	350
Lignite and clay	10	360
Lignite	5	365
Clay, silty, gray	10	375
Clay and lignite	5	380
Clay, silty, gray	5	385
Lignite	5	390
Clay, gray	10	400

•148-94-3abb

[Descriptions of materials drilled below depth of 192.5 feet are questionable because of partial loss of circulation]

	Thickness (feet)	Depth (feet)
Clay, silty, tan and brown	46	46
Chert, silty clay, and rock fragments	9	55
Chert, sandstone, and clay	5	60
Clay, silty, gray	14	74
Lignite	6	80
Clay, gray	20	100
Sandstone(?), clay(?), and pebbles(?)	15	115
Clay, silty, gray	10	125
Lignite	5	130
Clay, lignite, and chert fragments(?)	16	146
Clay, gray(?)	64	210
Lignite(?)	4	214
Lignite and clay(?)	6	220
Lignite with small amount of clay(?)	60	280
Clay and lignite(?)	10	290
Clay, gray(?)	3	293
Clay and lignite(?)	2	295
Clay, gray(?)	25	320
Lignite(?)	40	360
Lignite and clay(?)	65	425
Sand(?)	5	430
Lignite(?)	17	447
Lignite(?)	3	450

•148-94-13aad

	Thickness (feet)	Depth (feet)
Clay, silty, brown	10	10
Sand and brown clay	5	15
Clay, silty, dense, brown and gray	13	28
Lignite	5	33
Clay, silty, gray	4	37
Lignite	7	44
Clay, gray to brown	4	48
Clay, gray, and lignite	2	50
Clay, silty, dense, gray	80	130
Clay, silty, brown, and small amount of lignite	5	135
Clay, silty and sandy, gray	20	155
Sand	70	225
Clay, silty and sandy, dense, gray	21	246
Lignite and gray clay	8	254
Clay, silty, dense, gray	53	307
Lignite	3	310
Clay, silty, dense, gray	20	330
Clay, carbonaceous, gray	9	339
Clay, silty, gray	6	345
Clay, gray	7	352
Lignite	4	356
Clay, silty, gray	79	435
Clay, gray, and small amount of lignite	5	440
Sand	10	450

•148-94-20ddd

	Thickness (feet)	Depth (feet)
Clay, silty, brown	11	11
Clay, silty, gray	6	17
Gravel	6	23
Sand and clay, silty, brown	6	29
Clay, silty, tan, and red chert	3	32
Clay, silty and sandy, brown, with pebbles	6	38
Silt, sand, clay, and pebbles	5	43
Clay, silty, gray, with pebbles	2	45
Clay, silty and sandy, gray	74	119
Clay, silty, gray, with pebbles	3	122
Clay, silty, gray	13	135

•148-94-26dca

	Thickness (feet)	Depth (feet)
Clay, silty, and sandy, brown	15	15
Sand	5	20
Clay, silty, gray	28	48
Lignite	8	56
Clay, silty and sandy, dense, gray	87	143

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
		148-94-26dca—Continued			
Lignite	7	150	Sand	79.5	267.5
Clay, silty, gray	26	176	Clay, silty and sandy, gray	12.5	280
Lignite and clay	9	185	Sand	10	290
Clay, silty, brown	3	188			
		*148-94-33acd			
Clay, silty, brown	5	5	Sand	12.5	130
Clay, silty, gray	10	15	Clay, sandy, gray	5	135
Clay, sandy, gray and brown	5	20	Sand	13	148
Sand	10	30	Lignite	2	150
Clay, silty, gray, brown and tan	22	52	Clay, gray	5	155
			Clay, carbonaceous	5	160
Sand	23	75	Clay, silty, gray	4	164
Clay, silty and sandy, gray	42.5	117.5	Lignite	4	168
			Clay, gray	32	200
		*148-95-1dbb			
Clay, silty and sandy, brown	6	6	Lignite, clay, and sand	5	235
Sand and several sandstone lenses	224	230	Lignite and sandy clay	5	240
		*148-95-13adc			
Clay, brown	5	5	Clay, gray	37	237
Clay, silty, tan	20	25	Lignite	3	240
Clay, silty and sandy, dense, gray	20	45	Lignite and clay	6	246
			Clay, gray	39	285
Sand	5	50	Lignite and gray clay	4	289
Clay, silty, dense, gray	32	82	Clay, silty, gray	21	310
Lignite and gray clay	8	90	Sand	5	315
Clay, silty and sandy, dense, gray	40	130	Clay, silty, gray	5	320
			Clay, sandy, gray	10	330
Lignite and gray clay	5	135	Clay, gray	9	339
Clay, silty and sandy, gray	15	150	Lignite and clay	16	355
Sand	12	162	Clay, gray	10	365
Lignite	8	170	Lignite and gray clay	5	370
Clay, silty, gray	25	195	Clay, carbonaceous, gray	10	380
Lignite and clay	5	200	Clay, gray	20	400
		149-90-11ada			
Topsoil	2	2	Clay, sandy, gray	5	95
Clay, yellow, with small rocks	8	10	Clay, very sandy, gray	10	105
Clay, sandy, yellow	33	43	Clay, gray	31	136
Sandstone	2	45	Sand, medium, gray	59	195
Clay, sandy, gray	28	73	Sand, coarse, gray	20	215
Lignite	2	75	Lignite and gray, sandy clay	5	220
Clay, gray	15	90	Lignite	10	230
			Clay, gray	15	245
		149-91-17bab			
Topsoil	3	3	Lignite	4	257
Clay, silty, brown	22	25	Clay, silty, gray-brown	11	268
Clay, sandy, dense, gray	40	65	Lignite	2	270
Sand	15	80	Clay, gray	35	305
Clay, gray	33	113	Clay, gray-brown, with thin layers of lignite	28	333
Sand	76	189			
Lignite	1	190	Sand	2	335
Clay, gray	34	224	Clay, gray-brown	30	365
Lignite	2	226	Lignite	10	375
Clay, silty, dense, gray to brown	27	253	Clay, gray	2	377
			Sand	8	385
			Clay, gray, sandy	15	400

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
149-91-30ccd					
Clay	5	5	Clay, gray	13	215
Sand and clay with pebbles	5	10	Lignite	5	220
Sand	37	47	Clay, gray	65	285
Clay, gray, and lignite	2	49	Clay, brown	15	300
Clay, carbonaceous, brown	11	60	Clay, gray	17	317
(No sample)	20	80	Sand and clay, gray	3	320
Lignite	10	90	Clay, gray	15	335
Clay, gray	35	125	Clay, sandy	10	345
Lignite	5	130	Lignite	5	350
Clay, gray	65	195	Clay, sandy, gray	10	360
Lignite	7	202	Lignite	10	370
			Lignite and gray sandy clay	5	375
149-91-33bcc					
Clay, brown and gray	16	16	Sand	2	267
Lignite	10	26	Clay, silty, gray	3	270
Clay, dense, sandy, gray	39	65	Sand	5	275
Lignite	5	70	Lignite	12	287
Sand	50	120	Clay, gray	13	300
Clay, silty, gray	5	125	Lignite	3	303
Sand	10	135	Clay, gray	5	308
Clay, gray	8	143	Limestone	4	312
Lignite	1	144	Sand	3	315
Clay, gray	11	155	Clay, gray, and sand	15	330
Sand	5	160	Sand	24	354
Clay, silty, gray	5	165	Lignite	3	357
Lignite	3	168	Sand and gray clay	3	360
Clay, silty, gray	27	195	Clay, gray	15	375
Sand	48	243	Clay, sandy, gray	10	385
Lignite	10	253	Clay with thin layers of lignite	15	400
Clay, gray	12	265			
***149-92-29dcc**					
Clay, sandy, silty, brown, with pebbles	10	10	Clay, silty, gray	35	220
Clay, tan	5	15	Lignite and gray clay	10	230
Clay, gray, and a small amount of lignite	5	20	Clay, silty, gray	5	235
Clay, silty, gray	30	50	Clay, gray	15	250
Clay, gray, and a small amount of lignite	1	51	Lignite and gray clay	5	255
Lignite	9	60	Clay, gray	35	290
Clay, silty, gray	10	70	Lignite and gray clay	10	300
Lignite	10	80	Clay, gray	7	307
Clay, silty, gray	15	95	Clay, silty, gray	23	330
Clay, gray	10	105	Clay, gray, and a small amount of lignite	10	340
Clay, silty, gray	5	110	Clay, silty, gray	15	355
Clay, gray	5	115	Clay, sandy, gray	5	360
Clay, silty, gray	19	134	Lignite and sandy clay	10	370
Lignite and gray silty clay	6	140	Lignite	3	373
Clay, gray	10	150	Clay, silty, brown, and lignite	2	375
Clay, silty, gray	10	160	Lignite	5	380
Lignite	9	169	Clay, gray	6	386
Clay, gray	16	185	Lignite	4	390
			Clay, gray	14	404
***149-93-10aaa**					
Clay, silty and sandy, tan	4	4	Silt	4.5	39.5
Sand, clay, and lignite fragments	4	8	Clay, silty, brown	11.5	51
Clay, silty and sandy, tan	2	10	Sand	4	55
Clay, silty, gray and brown	25	35	Sand and clay	10	65
			Sand	21	86

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
		*149-93-10aaa—Continued			
Lignite and clay	1	87	Lignite	3	278
Lignite	9	96	Lignite and gray clay	7	285
Clay, silty, gray	4	100	Clay, gray	1.5	286.5
Clay, gray, and lignite	9	109	Lignite	2.5	289
Lignite	2	111	Clay, gray	11	300
Lignite and gray clay	4	115	Clay, carbonaceous, gray, and lignite	5	305
Lignite	9.5	124.5	Clay, silty, dense, carbonaceous, gray	10	315
Clay, gray	6.5	131	Lignite and gray clay	7	322
Lignite	3	134	Lignite	3	325
Clay, silty, gray	25	159	Clay, silty, dense, gray	77	402
Lignite	2	161	Lignite and clay	3	405
Clay, silty and sandy, dense, gray	38	199	Clay, gray	7	412
Lignite	1	200	Lignite	2	414
Clay, gray	20	220	Clay, silty, gray	26	440
Lignite and gray clay	5	225	Clay, gray, and lignite	4	444
Clay, gray	20	245	Lignite and small amount of gray clay	6	450
Lignite	5	250			
Clay, silty, dense, gray	25	275			
		*149-93-14ccc			
Sand and gravel	30	30	Clay, silty, brown, and small amount of lignite	2	230.5
Silt, sand, and clay	10	40	Clay, silty, dense, gray	63.5	294
Clay, carbonaceous	5	45	Lignite and clay	3	297
Lignite and gray clay	5	50	Clay, silty, gray	17	314
Lignite	5.5	55.5	Clay, gray, and small amount of lignite	6	320
Lignite, clay, and chert fragments	.5	56	Clay, gray	9	329
Clay, carbonaceous, brown	4	60	Clay, silty, gray, and small amount of lignite	8	337
Sand	8	68	Clay, silty, gray	23	360
Lignite, sand, and clay	2	70	Lignite	6.5	366.5
Lignite	9	79	Lignite and clay	1.5	368
Clay, silty, dense, gray	85	164	Clay, silty, gray	15	383
Lignite and gray clay	2	166	Lignite	7	390
Clay, gray	28	194	Clay, gray	25	415
Lignite	7	201	Sand	35	450
Clay, silty, gray to tan	27.5	228.5			
		*149-93-18ddb			
Sand	45	45	Sand	3	240
Lignite and gray clay	1	46	Clay, silty, dense, gray	60	300
Clay, silty, carbonaceous, gray	14	60	Clay, gray, and lignite	5	305
Lignite	1	61	Clay, gray	4	309
Clay, silty, gray	29	90	Sand	3	312
Clay, gray	24	114	Lignite	1.5	313.5
Limestone	1	115	Clay, silty, gray	16.5	330
Clay, silty, gray	10	125	Sand	5	335
Clay, gray	21	146	Clay, gray	40	375
Lignite	4	150	Lignite	4	379
Clay, gray	21	171	Clay, gray	26	405
Lignite	1	172	Lignite	3	408
Clay, silty, gray	8	180	Clay, gray	7	415
Lignite and carbonaceous clay	4	184	Lignite and clay	5	420
Clay, silty, gray	37	221	Clay, gray	6	426
Clay, silty, carbonaceous, gray and brown	16	237	Clay, silty and sandy, dense, gray	24	450
			Sand	15	465
		*149-93-25ddd			
Clay, silty, brown	55	55	Clay, silty, dense, gray	25	125
Sand	10	65	Sand	5	130
Clay, sandy, gray	15	80	Clay, silty, dense, gray	15	145
Clay, silty, dense, gray	10.5	90.5	Lignite	5	150
Lignite	3.5	94	Clay, gray	5	155
Lignite and brown clay	6	100	Lignite and clay	3	158

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
		*149-93-25ddd—Continued			
Clay, gray	5.5	163.5	Clay, silty, gray	10	355
Lignite	2.5	166	Lignite and sand	5	360
Clay, silty and sandy, gray	4	170	Lignite	6	366
Sand	10	180	Clay, sandy, dense, gray	14	380
Clay, sandy, dense, gray	11	191	Sand	10	390
Lignite	2	193	Lignite	12	402
Clay, silty and sandy, gray	17	210	Clay, silty, dense, gray	36	438
Lignite	4.5	214.5	Lignite	7	445
Clay, silty, dense, gray	18.5	233	Clay, silty and sandy, dense, gray	20	465
Lignite and sand	12	245	Lignite	5	470
Sand	26	271	Clay, silty, gray	14.5	484.5
Lignite and sandy clay	4	275	Lignite	3.5	488
Sand	10	285	Clay, silty, gray	7	495
Lignite and sand	4	289	Lignite and gray to tan clay	15	510
Sand	49	338			
Lignite	7	345			
		*149-93-34aca			
Clay, silty, brown	17	17	Sand	4	205
Clay, gray	5	22	Clay, silty, gray	22	227
Lignite	4	26	Sand	28	255
Clay, silty, gray	8	34	Lignite and clay	10	265
Clay, carbonaceous	6	40	Clay, silty and sandy, dense, gray	43	308
Clay, silty	65	105	Lignite	7	315
Silt	5	110	Clay, silty, dense, gray	10	325
Clay, silty, brown	10	120	Sand	10	335
Limestone	1	121	Sand and lignite	5	340
Clay, silty, brown	10	131	Sand	5	345
Clay, gray, and limestone	4	135	Sand and clay	5	350
Clay, silty, gray	27	162	Clay, gray	5	355
Clay and lignite	1	163	Sand	5	360
Clay, silty, dense, gray	25	188	Clay, silty, carbonaceous, brown and gray	5	365
Lignite	2	190	Sand	5	370
Clay, silty and sandy, gray	5	195	Clay, silty, and sandy, gray	2	372
Clay and lignite	6	201			
		*149-94-7cad			
Clay, tan	30	30	Lignite	15	191
Clay, gray	3	33	Sand	4	195
Clay, gray, with lignite fragments	8	41	Clay, sandy, gray	5	200
Lignite	5	46	Sand	5	205
Clay, gray	14	60	Lignite	7	212
Clay, silty, gray	9	69	Clay, gray	3	215
Lignite	2.5	71.5	Sand	5	220
Clay, silty, gray	18.5	90	Clay, sandy, gray	5	225
Clay, gray	10	100	Clay, silty, gray	5	230
Clay, gray, carbonaceous, and lignite	2	102	Lignite	3	233
Clay, gray	10	112	Clay, sandy, gray to brown	7	240
Lignite	1	113	Sand	37	277
Clay, silty, dense, carbonaceous, gray	19	132	Clay, gray and yellow; lignite and pebbles	3	280
Lignite	3	135	Sand	67	347
Clay, gray	5	140	Lignite, sand, and clay	1	348
Lignite	6	146	Sand	2	350
Clay, sandy, gray	16	162	Lignite	10	360
Sand	14	176	Lignite and clay	25	385
			Clay, silty and sandy, dense, gray	50	435
			(No sample)	15	450
		*149-94-9aba			
Clay, sand, silt, and pebbles	10	10	Clay, silty, gray	5	25
Sand and pebbles	5	15	Clay and lignite	5	30
Sand	5	20	Clay, silty, dense, gray	72	102

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
* 149-94-9aba—Continued					
Sand	8	110	Lignite	10	285
Clay, sandy	5	115	Clay, silty, gray	9	294
Sand	4	119	Clay and lignite	2	296
Lignite	1	120	Clay, silty, gray	4	300
Sand	5	125	Sand	15	315
Clay and sand	5	130	Clay, silty, gray	7.5	322.5
Lignite	5	135	Sand	13.5	336
Clay, gray	15	150	Lignite	10	346
Lignite	5	155	Sand, silty, clay, and lignite	4	350
Clay, silty, gray	14	169	Clay, gray	5	355
Lignite	1.5	170.5	Clay and lignite	10	365
Clay, gray	14.5	185	Lignite	2	367
Sand and clay	10	195	Sand, clay, and lignite	3	370
Lignite	5	200	Sand	30	400
Clay, silty, dense, gray	20	220	Lignite	5	405
Lignite	7	227	Lignite and clay	5	410
Clay, gray	13	240	Lignite	4	414
Sand	5	245	Clay, gray	6	420
Clay, silty, dense, gray	30	275			
*149-94-14aaa					
Clay, tan, and a few pebbles	15	15	Lignite	2	276
Sand and gravel	4.5	19.5	Clay, gray	46	322
Gravel	9.5	29	Lignite	3	325
Clay, tan; silt and a few pebbles	11.5	40.5	Clay, silty, dense, gray	30	355
Clay, gray	57	97.5	Clay, gray, and small amount of lignite	5	360
Lignite	3.5	101	Clay, silty, gray	5	365
Clay, gray	25.5	126.5	Clay, gray, and small amount of lignite	5	370
Clay, carbonaceous, gray, and lignite	1.5	128	Clay, silty and sandy, dense, gray	27.5	397.5
Clay, silty, gray	22	150	Sand	22.5	420
Clay, silty, carbonaceous, brown	7	157	Clay, gray, and small amount of lignite	5	425
Lignite	3	160	Sand	5	430
Clay, silty, dense, gray	50	210	Clay, gray, and small amount of sand	5	435
Clay, gray, and small amount of lignite	10	220	Sand	15	450
Clay, silty, gray	20	240			
Sand	34	274			
*149-94-25abc					
Clay, silty, brown, and pebbles	25	25	Lignite and clay	2	150
Clay, silty, tan	20	45	Clay, gray	10	160
Sand	7	52	Lignite and sandy clay	5	165
Lignite	4	56	Lignite	15	180
Clay, silty and sandy, dense, gray	54	110	Clay and lignite	5	185
Lignite and sandy clay	5	115	Clay, silty, gray	15	200
Clay, gray	33	148	Lignite	10	210
			Lignite and clay	5	215
			Silt, sand, clay, and lignite	10	225
			(No sample)	60	285
*149-94-27daa					
Clay, silty, tan	5	5	Clay, gray	7	169
Sand	10	15	Lignite	3	172
Clay, silty, tan	19	34	Clay	5	177
Sand	4	38	Lignite	3	180
Clay, silty, dense, gray	47	85	Clay, gray	13	193
Sand	5	90	Lignite	7	200
Clay, silty, dense, gray	13	103	Clay, silty, dense, gray	43	243
Lignite	2	105	Lignite	3	246
Clay, silty, gray	50	155	Clay, silty, gray	4	250
Lignite	7	162	Sand	12	262

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
149-94-27daa—Continued					
Clay, silty, dense, gray	31	293	Lignite	4	349
Lignite	2	295	Clay, gray	26	375
Clay, silty, dense, gray	20	315	Lignite	2	377
Clay, gray, and lignite	4	319	Sand	13	390
Clay, silty, dense, gray	15	334	Lignite	9	399
Lignite	2	336	Clay and lignite	8	407
Clay, gray	9	345	Sand and lignite	7	414
			Sand	36	450
***149-94-29abb**					
Clay, tan, and sandy silt	11	11	Sand	21	96
Clay, silty and sandy, gray to tan	14	25	Clay, silty, dense, gray	39	135
Sand	5	30	Sand	5	140
Clay, silty, brown	6	36	Clay, silty, dense, gray	15	155
Clay, carbonaceous, brown	4	40	Lignite	2	157
Clay, silty, dense, brown	10	50	Clay, silty, dense, gray	34	191
Sand	5	55	Lignite	7	198
Clay, silty, brown	7	62	Clay, gray	27.5	225.5
Clay, carbonaceous, brown	13	75	Lignite	7.5	233
			Clay, gray	7	240
***149-95-25aa**					
Clay, silty, tan	3	3	Lignite	3	198
Sand	3	6	Clay, gray, and thin lignite beds	6	204
Clay, silty and sandy, dense, gray	24	30	Clay, silty, dense, gray	59	263
Lignite	.5	30.5	Sand	7.5	270.5
Clay, silty and sandy, gray and tan	19.5	50	Lignite and clay	2.5	273
Sand	5	55	Clay, silty, dense, gray	37	310
Clay, gray	5	60	Sand	5	315
Clay, carbonaceous, black	2	62	Lignite	5	320
Clay, gray	10.5	72.5	Clay, silty, gray	10	330
Limestone	3	75.5	Sand	15	345
Clay, gray	4.5	80	Lignite and gray clay	6	351
Sand and clay	6	86	Clay, silty, gray	9	360
Lignite	1	87	Lignite and clay	2.5	362.5
Clay, gray	8	95	Clay, silty, gray	9	371.5
Sand	5	100	Sand	12.5	384
Clay, silty, dense, gray	35	135	Lignite	2	386
Sand	20	155	Clay, gray	4	390
Clay, silty, gray	6	161	Sand and sandy clay	9	399
Lignite interbedded with clay	20	181	Lignite	1	400
Clay, silty, gray	14	195	Sand	5	405
			Lignite and clay	4	409
			Clay, gray	6	415
			Silt	5	420
			Sand	30	450
***149-95-36dbd**					
Silt, brown	7	7	(No sample)	25	105
Clay, sand, and silt	3	10	Clay, silty, dense, gray	40	145
Clay, silty, gray to tan	5	15	Silt, gray	6	151
Sand	30	45	Lignite and sand	4	155
Clay, silty, gray and tan	10	55	Clay, carbonaceous, gray	5	160
Clay, silty and sandy, carbonaceous, gray	20	75	Clay, silty and sandy, gray	55	215
Clay, sandy, gray and tan	5	80	Sand	10	225
150-90-13aca					
Gravel and boulders	6	6	Sand	14	82
Clay, yellow	12	18	Sandstone	3	85
Clay, blue	5	23	Clay, blue, with sand	25	110
Clay, sandy, yellow	32	55	Lignite	3	113
Clay, very sandy, gray	13	68	Sand, fine, gray	15	128

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
150-90-13aca—Continued					
Lignite	4	132	Clay, sandy, gray	13	243
Clay, gray	23	155	Lignite	3	246
Sand, medium, gray	10	165	Clay, sandy, gray	27	273
Sand, fine, gray	60	225	Clay, gray	7	280
Lignite	5	230	Clay, sandy, gray	12	292
			Sand, fine, gray	13	305
150-90-16cbb					
Topsoil	3	3	Lignite	20	120
Clay, silty, yellow, with pebbles	54	57	Sand	65	185
Gravel	4	61	Lignite	2	187
Clay, sandy, yellow	4	65	Sand	73	260
Clay, sandy, brown, with lignite	6	71	Lignite	7	267
Clay, sandy, gray	12	83	Sand	60	327
Clay, gray	17	100	Lignite	2	329
			Sand	14	343
			Lignite	3	346
			Clay, gray	59	405
150-90-22ccc					
Topsoil	4	4	Sand	105	200
Clay, brown	38	42	Lignite	4	204
Sand and lignite	15	57	Sand	66	270
Clay, silty, brown	4	61	Gravel	15	285
Clay, gray	34	95	Sand	15	300
			Gravel	30	330
150-90-25daa					
Soil	3	3	Clay, brown and gray, with pebbles	23	45
Gravel	9	12	Sand	29	74
Sand and small amount of lignite	10	22	Clay, brown and gray, and sand	30	104
			Sand	156	260
150-90-28ddc					
Topsoil and gravel	10	10	Sand	25	120
Clay, brown, gray and tan	20	30	Lignite	3	123
Sand	15	45	Sand	12	135
Clay and sand	15	60	Clay, gray and brown	13	148
Sand	28	88	Lignite	2	150
Clay, brown	7	95	Sand	115	265
150-92-2aba					
Topsoil	2	2	Sand and clay, gray	10	200
Sand and gravel	3	5	Clay, gray	33	233
Clay, with pebbbles	25	30	Lignite	2	235
Clay, gray	40	70	Clay, sandy, gray	20	255
Sand	34	104	Clay, gray	60	315
Clay, (gray and brown	6	110	Clay, sandy, gray	13	328
Lignite	5	115	Lignite	17	345
Sand and clay	5	120	Clay, gray-green	22	367
Sand	5	125	Lignite	3	370
Lignite	5	130	Clay, sandy, gray-green	7	377
Sand	3	133	Lignite	3	380
Clay, gray	4	137	Clay, gray-green	8	388
Lignite	3	140	Lignite	2	390
Clay, gray	9	149	Clay, gray-green	3	393
Sand	36	185	Lignite	2	395
Lignite	5	190	Clay, gray to brown	10	405

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
150-92-14abd					
Gravel	5	5	Lignite	3	270
Gravel and clay	10	15	Clay, gray	55	325
Clay, gray	40	55	Lignite	15	340
Lignite	2	57	Clay, gray-green	5	345
Clay, gray	18	75	Sand	35	380
Clay, silty, brown	25	100	Lignite	5	385
Silt, brown	15	115	Clay, gray	10	395
Clay, gray	30	145	Sand	10	405
Lignite	5	150	Lignite	5	410
Clay, gray	30	180	Clay, gray	5	415
Sand	20	200	Sand and tan sandy clay	5	420
Lignite	5	205	Clay, gray and tan	15	435
Clay, silty and sandy, gray	28	233	Lignite	15	450
Lignite	2	235	Sand	26	476
Clay, gray	10	245	Clay, gray	4	480
Sand	10	255	Lignite	5	485
Lignite	8	263	Clay, sandy, gray	7	492
Clay, gray	4	267	Lignite	8	500
150-93-1dda					
Topsoil	3	3	Clay, silty, gray	5	220
Clay, silty and sandy, with gravel	7	10	Lignite	5	225
Clay, silty, gray-brown	5	15	Sand	5	230
Sand	60	75	Clay, gray	10	240
Lignite	5	80	Clay, gray, with lignite streaks	15	255
Clay, silty, dense, gray	55	135	Sand with lignite streaks	15	270
(No sample)	15	150	Sand	40	310
Sand	62	212	Lignite	5	315
Lignite	3	215	Clay, sandy, gray	15	330
150-93-2adc					
Topsoil	5	5	Clay, gray	26	146
Clay, brown with gravel	25	30	Lignite	8	154
Sand	10	40	Clay, gray	129	283
Lignite	1	41	Lignite	7	290
Sand	18	59	Clay, gray	25	315
Lignite	4	63	Clay, gray and brown, with thin lignite beds	15	330
Clay, gray	53	116	Clay, silty, gray	60	390
Lignite	4	120	Sand	15	405
150-93-2cbb					
Topsoil	3	3	Clay, sandy, dense, gray	26	230
Clay, yellow, with pebbles	42	45	Sand	1	231
Clay, gray	5	50	Clay, gray	89	320
Clay, sandy, yellow	16	66	Lignite	3	323
Clay, carbonaceous, and lignite	2	68	Clay, gray	77	400
Clay, gray	9	77	Sand	10	410
Lignite	3	80	Clay, gray	16	426
Clay, silty, gray and brown	90	170	Limestone	4	430
Lignite	3	173	Sand	8	438
Clay, gray and brown	26	199	Limestone	1	439
Clay, brown, with small amount of lignite	5	204	Lignite	11	450
			Limestone	3	453
			Lignite	9	462
			Clay, gray	33	495
150-93-11baa					
Topsoil	3	3	Sand with thin lignite bed	35	135
Clay, brown and gray	17	20	Clay, silty, gray	10	145
Clay, gray and green	13	33	Lignite	10	155
Lignite	6	39	Clay, brown and gray	40	195
Clay, gray and green	61	100	Sand	10	205

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
150-93-11baa—Continued					
Clay, gray and brown	8	213	Clay, silty, gray	31	269
Lignite	2	215	Lignite	1	270
Clay, gray	15	230	Clay, gray and brown	69	339
Lignite	2	232	Lignite	1	340
Clay, gray	3	235	Clay, gray and brown	30	370
Lignite	3	238	Lignite	5	375
			Clay, gray	30	405
***150-94-28ada**					
Sand and pebbles	12	12	Clay, silty, brown	4	174
Clay, silty, brown	3	15	Lignite	3	177
Clay, gray and brown	8	23	Sand	15	192
Clay, gray	4	27	Lignite	3	195
Lignite	3	30	Clay, sandy, gray	5	200
Clay, gray	30	60	Lignite	3	203
Lignite	2	62	Clay, gray	6	209
Clay, silty, dense, gray	8	70	Sand	46	255
Clay, carbonaceous, brown	3	73	Lignite	7	262
Clay, silty, gray	11	84	Sand	23	285
Clay, carbonaceous, dark	1	85	Clay, sandy, gray	7	292
Clay, gray	5	90	Lignite	5	297
Clay, silty, brown	4	94	Lignite and clay	3	300
Lignite and clay	4	98	Clay, gray	15	315
Clay, silty and sandy, dense, gray	43	141	Sand	10	325
Lignite and clay	3	144	Clay, gray	22	347
Clay, gray	21	165	Lignite and silty clay	3	350
Lignite	5	170	Clay, silty, gray	10	360
			Sand	60	420
***150-94-32ccb**					
Clay, tan	20	20	Sand	2	165
Clay, carbonaceous, tan	10	30	Clay, silty, dense, gray	15	180
Clay, tan to gray	15	45	Lignite and gray clay	5	185
Clay, sandy, gray and brown	15	60	Clay, gray	5	190
Clay, silty, gray	5	65	Clay, sandy, gray, and lignite	5	195
Clay, gray	9	74	Lignite	5	200
Lignite	6	80	Clay, silty, gray, and lignite	10	210
Clay and lignite	10	90	Clay, sandy, gray to tan	5	215
Clay, gray	10	100	Sand, clay, and lignite	5	220
Limestone and gray clay	5	105	Lignite	5	225
Clay, carbonaceous, gray	10	115	Clay, silty and sandy, dense, gray	40	265
Clay, gray, and small amount of lignite	14	129	Clay, gray, sandy, and lignite	5	270
Lignite	9	138	Clay, gray	10	280
Limestone	3	141	Lignite	5	285
Lignite	4	145	Sand	5	290
Clay, gray	5	150	Clay, silty and sandy, dense, carbonaceous, gray	40	330
Clay, sandy, gray	8	158	Lignite	5	335
Lignite and clay	5	163	Clay, silty and sandy, gray	45	380
			Sand	40	420
***150-94-35acb**					
Silt, sand, and rock fragments	5	5	Sand	5	200
Clay, silty, brown	25	30	Lignite	2	202
Clay, gray	4	34	Sand	4	206
Lignite	1	35	Clay, sandy, dense, gray	8	214
Clay, silty and sandy, dense, gray	55	90	Lignite and clay	6	220
Sand	52	142	Clay, gray	6	226
Clay, silty, dense, gray	19	161	Lignite and clay	1	227
Lignite	1	162	Clay, gray	11	238
Clay, silty, gray	18	180	Clay, and small amount of lignite	2.5	240.5
Lignite	10	190	Clay, silty, dense, gray	11.5	252
Clay, sandy, gray	5	195			

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
150-94-35acb—Continued					
Clay, silty, gray, and small amount of lignite	1	253	Sand and lignite	2	280
Clay, gray	6	259	Clay, silty, dense, gray	45	325
Lignite	9	268	Lignite	3	328
Clay, sandy	2	270	Clay, gray	17	345
Sand	8	278	Sand	70	415
			Clay, silt, sand, and lignite	5	420
***150-95-13dcc**					
Sand, with pebbles	20	20	Lignite	4	234
Silt, brown	5	25	Clay, silty and sandy, dense, carbonaceous, gray and brown	51	285
Clay, sandy, gray, and gravel	7	32	Lignite	4	289
Clay, gray	2	34	Clay, gray	41	330
Lignite	9	43	Clay, silty, gray and brown	20	350
Clay, gray	1	44	Clay, silty, dense, gray	30	380
Lignite	6.5	50.5	Clay, gray, and lignite	5	385
Clay, silty, dense, gray	29.5	80	Clay, silty, dense, gray and tan	29	414
Sand	7	87	Lignite	6	420
Clay, silty, dense, gray	9	96	Clay, silty, gray to brown	14	434
Clay, brown, and lignite	6	102	Lignite	3	437
Clay, silty, gray	20	122	Clay, gray	26	463
Sand	63	185	Lignite	6	469
Sand and gray clay	20	205	Clay, gray to tan	28	497
Clay, silt, lignite, and sand	15	220	Lignite	4	501
Lignite	6.5	226.5	Clay, gray	9	510
Clay, gray	3.5	230			
***151-94-9add**					
Clay, sandy, brown, with pebbles	10	10	Clay, silty, gray	20	225
Clay, silty, brown and gray	15	25	Lignite	17	242
Sand	1.5	26.5	Clay, silty, gray	5	247
Clay, silty, gray	7.5	34	Lignite	2	249
Clay, sandy	2	36	Clay, silty, dense, gray	48	297
Lignite	4	40	Lignite	6	303
Clay, silty, gray	5	45	Lignite and gray dense silty clay	32	335
Lignite and silty clay	5	50	Clay, silty, gray and brown	25	360
Sand	5	55	Lignite	15	375
Clay, silty, gray	21	76	Lignite and clay	10	385
Lignite	7	83	Lignite	10	395
Clay, silty, gray	17	100	Lignite and clay	30	425
Lignite	5	105	Clay, gray, silty	60	485
Sand	30	135	Lignite	4	489
Lignite	6	141	Lignite and gray clay	6	495
Lignite and gray clay	12	153	Clay, gray	5	500
Clay, silty, gray	47	200	Lignite	5	505
Sand	5	205	Lignite and brown clay	5	510
151-94-28daa					
Clay, silty and sandy, tan	10	10	Clay, silty, dense, gray	57	173
Clay, silty, gray	23	33	Lignite	3	176
Lignite and gray clay	1	34	Clay, silty, dense, gray	32	208
Clay, silty, dense, gray	79	113	Clay, carbonaceous, brown	5	213
Lignite	3	116	Clay, silty, dense, gray	27	240
***151-95-24acd**					
Clay, brown	5	5	Clay, carbonaceous, gray to brown	4	54
Clay, silty, gray	16.5	21.5	Lignite	1	55
Lignite	.5	22	Clay, gray	5	60
Clay, gray, and tan shale	9	31	Lignite	4	64
Lignite and clay	2	33	Clay, silty, gray	6	70
Clay, silty, gray	14	47	Silt	4	74
Clay, carbonaceous, gray	3	50			

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
		*151-95-24acd—Continued			
Lignite, sand, clay, and limestone	5	79	Clay, silty, gray	8	198
Sand	6	85	Lignite and clay	2	200
Clay, gray and brown	5	90	Clay, silty, gray	7	207
Lignite	5	95	Lignite	3	210
Clay, silty, gray	11	106	Clay, silty, gray	27	237
Lignite	3	109	Lignite	13	250
Sand	9	118	Clay, gray	25	275
Lignite	2	120	Lignite	19	294
Lignite and gray clay	5	125	Clay, silt, and sand	16	310
Clay, gray	5	130	Clay, gray	3	313
Sand	35	165	Lignite	11	324
Lignite	1	166	Clay, silty, dense, carbonaceous, gray	34	358
Sand	14	180	Clay, gray	32	390
Clay, brown, lignite, and sand	2	182			
Silt	8	190			
		*151-95-36acb			
Clay, silty, brown, with pebbles	15	15	(No sample)	57	150
Sand and gravel	10	25	Clay, silty, dense, gray and brown	15	165
Clay, silty, brown, with pebbles	15	40	(No sample)	45	210
(No sample)	47	87	Lignite(?) (no sample)	15	225
Lignite(?) (no sample)	6	93			
		152-93-18dcb			
Clay and gravel	11	11	Sand, medium to coarse, gray	56	221
Sand, medium to coarse, brown	154	165	Clay and sand	4	225
		152-93-20baa			
Topsoil	18	18	(No sample)	13	118
Sand	7	25	Sand	5	123
Clay	5	30	Sandstone	4	127
(No sample)	15	45	Sand	13	140
Sand, coarse	12	57	Lignite	5	145
Clay	43	100	(No sample)	110	255
Lignite	5	105			
		*152-93-20bac			
Sand, gravel, and clay	10	10	Clay, gray, and limestone	7	282
Clay, silty and sandy, brown, with pebbles	18	28	Clay, silty, gray, and lignite	1	283
(No sample)	34	62	Clay, gray	13	296
Clay, silty and sandy, carbonaceous, brown	1	63	Lignite	2	298
(No sample)	12	75	Lignite and clay	7	305
Sand	60	135	Clay, gray	25	330
(No sample)	40	175	Clay, silty, gray	28	358
Sand(?) and gray clay(?) (no sample)	15	190	Lignite and clay	7	365
Sand	20	210	Lignite	7	372
Lignite and clay	15	225	Clay, gray, and lignite	8	380
Clay, silty, gray	3.5	228.5	Clay, silty, dense, gray	10	390
Lignite and clay	2	230.5	Lignite and clay	7	397
Clay, gray	22	252.5	Sand and clay	13	410
Lignite	2.5	255	Clay, silty and sandy, dense, gray	56	466
Lignite and gray clay	11	266	Lignite	16	482
Clay, silty, dense, gray	9	275	Lignite and clay	3	485
			Lignite	10	495
			Lignite and clay	15	510
		152-94-11dac			
Topsoil	2	2	Silt, gray, with pebbles	44	86
Silt	8	10	Lignite	1	87
Gravel	2	12	Sand, silty	18	105
Clay, sandy and silty, brown and gray, with pebbles	30	42	Lignite	2	107
			Sand, brown and gray	11	118

Table 4.—*Logs of test holes and wells drilled in 1950–51*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
152-94-11dac—Continued.					
Sand, fine, gray	17	135	Clay, sandy, gray	16	170
Lignite	13	148	Clay, sandy, gray	20	190
Clay, gray	6	154			
*152-94-16cca					
Clay, brown; sand and pebbles	5	5	Clay, silty, gray	25	125
Clay, silty, brown, and pebbles	10	15	Clay, gray	2.5	127.5
Clay, gray to brown	5	20	Lignite	2.5	130
Clay, carbonaceous, gray	4	24	Clay, gray	5	135
Clay, gray to brown	3	27	Sand	10	145
Clay, silty, tan	5	32	Clay, gray, and sand	5	150
Clay, carbonaceous, gray	13	45	Sand	5	155
Clay, silty, gray	35	80	Silt	3	158
Clay, silty, carbonaceous, gray	10	90	Lignite	11	169
Clay, gray	5	95	Clay, gray and tan	11	180
Sand	5	100			
152-94-25ccc					
Topsoil	7	7	Clay, sandy	12	162
Sand and gravel	8	15	Lignite	8	170
Sand	22	37	Sandstone	1	171
Lignite	5	42	Clay	29	200
Sand	20	62	Clay, silty	15	215
Clay	88	150	(No sample)	15	230
*152-94-25daa					
Clay, silty, gray	5	5	Sand	7	217
Gravel and clay	15	20	Clay, gray, and silt	1	218
Clay, silty, brown	14	34	Sand	7	225
Sand and gravel	16	50	Sand and gray clay	3.5	228.5
Sand	10	60	Lignite	7.5	236
Clay, silty, brown	72	132	Sand	4	240
Clay, silty, gray	58	190	Clay, sandy, gray, and sand	5	245
Lignite	2.5	192.5	Lignite and gray clay	10	255
Clay, silty and sandy, dense, gray	17.5	210			
*152-94-32bbb					
Clay, silty, brown, with pebbles	10	10	Lignite	5	143
Clay, silty, gray and brown	33	43	Lignite and clay	2	145
Lignite	7	50	Clay, gray	5	150
Clay, silty, dense, gray	35	85	Clay, slightly silty, gray	10	160
Sand	18	103	Clay, silty, gray	5	165
Lignite	7	110	Sand	51	216
Clay, gray, and lignite	5	115	Lignite	8	224
Clay, silty, dense, gray	23	138	Clay, gray	1	225
152-94-33bbb					
Topsoil and gravel	10	10	Clay, sandy	23	128
Clay and gravel	18	28	(No sample)	147	275
(No sample)	77	105			
*152-94-35dca					
Clay, silty, gray	28	28	Sand	12.5	127.5
Clay, gray	3	31	Lignite and clay	.5	128
Clay, silty, tan, and lignite	1	32	Sand and clay	12	140
Clay, carbonaceous, gray and brown	3	35	Clay, gray	5	145
Clay, silty, gray	10	45	Clay, sandy, dense, brown	5	150
Clay, gray and tan	21	66	Sand	13	163
Clay and lignite	2.5	68.5	Sand and carbonaceous clay	12	175
Clay, silty, gray	6.5	75	Clay, silty and sandy, gray	5	180
Clay, silty, gray and brown	23	98	Sand and clay	6	186
Lignite and brown silty clay	.5	98.5	Lignite	4	190
Clay, silty and sandy, gray, tan, and brown	16.5	115	Clay, sandy, gray	5	195
			Clay, silty, gray	15	210

Table 5.—*Temporary benchmarks established in 1950–51*

[Bureau of Land Management survey markers are marked "General Land Office" on the stakes in the field]

No.	Altitude	Location	Description
T1	2,212.98	152-94-19bdda	Top of Indian allotment marker, center of section.
T2	2,264.87	152-94-19cddd	Top of Indian allotment marker, center of south line of section.
T3	2,195.38	152-94-30dddd	Top of General Land Office marker at section corner.
T4	1,904.27	152-93-18dddd	Top of Indian allotment marker at section corner.
T5	1,936.79	152-93-19addd	Top of General Land Office marker, center of east line of section.
T6	2,005.61	152-94-25addd	Copper nail and washer in corner fence post; fence runs east and south from corner.
T7	2,081.96	152-94-25cdc	Copper nail and washer in east gatepost of east-west fence.
T8	2,059.61	151-94-2dabc	Red X on a boulder, east side of trail at top of hill north of Clark Creek.
T9	2,335.36	151-94-28daad	Red X on top of large boulder, east side of trail near top of slope.
T10	2,321.75	151-94-28addd	Top of General Land Office marker, center of east line of section.
T11	2,105.13	151-94-9addd	Top of General Land Office marker, center of east line of section.
T12	2,200.64	151-94-7dddd	Top of General Land Office marker, southeast corner of section.
T13	2,373.83	151-95-24acad	Red X on a rock on hill about 100 ft east of well.
T14	2,281.19	150-95-1cddd	Top of Indian allotment marker, center of south line of section.
T15	2,303.74	150-94-33addd	Copper nail and washer in fence post by a bent General Land Office marker.
T16	2,283.17	150-94-27dddd	Top of Indian allotment marker, southeast corner of section.
T17	2,272.89	150-94-26cddd	Top of General Land Office marker, center of south line of section.
T18	2,255.15	150-94-26dddd	Top of General Land Office marker, southeast corner of section.
T19	2,351.88	149-94-4bdcd	Red X on rock, 4 ft northwest of west gatepost in east-west fence; rock marked "BM no. 13."
T20	2,365.29	149-94-4cddd	Top of General Land Office marker, center of south line of section.
T21	2,270.77	149-94-7cadd	Red X on top of rock about 50 ft northwest of a well site, east of crest of ridge.
T22	2,389.02	149-94-9abab	Red X on top of rock at a well site, northwest of crest of ridge.
T23	2,239.84	149-94-3cddd	Top of General Land Office marker, center of south line of section.
T24	2,295.80	149-94-11dddd	Top of General Land Office marker, southeast corner of section.
T25	2,307.62	149-94-12cddd	Top of General Land Office marker, center of south line of section.
T26	2,358.25	149-93-18acdc	Red X on top of rock, 50 ft west of gate in north-south fence, on south side of trail.
T27	2,278.09	149-93-18dddd	Top of General Land Office marker, southeast corner of section.
T28	2,105.39	149-94-25abdd	Top of Indian allotment marker, center of NE¼ sec. 25.
T29	2,491.82	148-95-1bddd	Top of Indian allotment marker, center of section.
T30	2,471.34	149-94-32dddd	Top of General Land Office marker, southeast corner of section.
T31	2,398.16	149-94-29abbb	Red X on rock about 100 ft north of a well and about 150 feet west of trail.
T32	2,506.81	149-95-36dbd	Red X on rock 25 ft east of a well about 150 ft north of east-west road, and about one-quarter mile east of west boundary of reservation.
T33	2,336.23	149-94-27addd	Top of General Land Office marker, center of east line of section.
T34	2,216.01	149-93-15dddd	Top of General Land Office marker, southeast corner of section.
T35	2,185.48	149-93-22dddd	Copper nail and washer in corner fence post southeast corner of section.
T36	2,057.12	149-92-31bbbb	U. S. Coast and Geodetic Survey reference point—bronze disk marked "Loney Azimuth," set in concrete post on south side of east-west road and on east side of branch trail going south.

Table 5.—*Temporary benchmarks established in 1950–51*—Continued

No.	Altitude	Location	Description
T37	2,026.43	149-93-35dddd	Top of General Land Office marker, southeast corner of section.
T38	2,251.08	150-94-28aadd	Top of Indian allotment marker about 300 ft northeast of a well.
T39	2,345.94	150-94-32cddd	Top of Indian allotment marker, center of south line of section.
T40	2,080.97	149-92-31aadd	Copper nail and washer in a 4- by 6-in. timber at southeast corner of cattle guard.
T41	2,339.79	148-92-4cbbb	White X on a rock about 30 ft south of east-west road and at junction with main trail to Independence.
T42	2,284.08	148-91-30addd	Top of Indian allotment marker, center of east line of section.
T43	2,215.98	149-91-19bddd	Top of Indian allotment marker, center of section.
T44	2,202.59	149-91-18cddd	Copper nail and washer in corner fence post at northwest corner of field.
T45	2,200.79	148-92-2ccc	U. S. Coast and Geodetic Survey reference mark—bronze disk marked "Saddle Butte Azimuth" set in concrete post about 30 ft north of road at point where road bends sharply to south.
T46	2,017.81	149-91-31dddd	Top of Indian allotment marker, southeast corner of section.
T47	2,177.11	149-92-25dddd	Top of Indian allotment marker, southeast corner of section.
T48	2,366.20	148-94-3abca	White X on large boulder near testhole location on east-facing slope about 300 ft southwest of the head of wooded ravine.
T49	2,278.31	149-93-31cddd	Top of General Land Office marker, center of south line of section.
T50	2,290.93	148-94-2bcca	Copper nail and washer in south gatepost of north-south fence.
T51	2,268.20	148-94-15cddd	Top of General Land Office marker, center of south line of section.
T52	2,298.77	148-94-20dddd	Top of General Land Office marker, southeast corner of section.
T53	2,298.74	148-94-29dddd	Top of Indian allotment marker, southeast corner of section.
T54	2 271.18	148-94-33bddd	Top of Indian allotment marker, center of section.
T55	2,357.45	147-94-3aada	Bronze disk marked "Brock and Weymouth, Inc., Phila., Pa., 1943 A-Sc McCartin" in concrete post at high point on east side and near the head of deep ravine.
T56	2,248.04	147-94-2addd	Top of General Land Office marker, center of east line of section.
T57	2,209.94	148-94-26dddd	Top of General Land Office marker, southeast corner of section.
T58	2,146.24	148-93-31cadb	White X on a rock by west gatepost in east-west fence on hill north of McGregor Camp.
T59	2,243.33	148-93-18dddd	Top of General Land Office marker, southeast corner of section.
T60	2,241.05	148-93-19addd	Top of General Land Office marker, center of east line of section.
T61	2,100.96	148-92-11bddd	Top of Indian allotment marker, center of section.
T62	2,017.35	148-92-14cddd	Top of General Land Office marker, center of south line of section.
T63	1,778.48	148-92-27cddd	Top of General Land Office marker, center of south line of section.
T64	1,973.01	148-92-20dddd	Top of General Land Office marker, southeast corner of section.
T65	1,999.67	147-93-5abdd	Top of Indian allotment marker, center of NE¼ sec. 5 on valley flat north of trail.
T66	1,947.64	147-93-4addd	Top of General Land Office marker, center of east line of section.
T67	2,002.35	147-93-3bddd	Top of Indian allotment marker, center of section, 300 ft northwest of a well.
T68	2,154.1	148-90-9bddd	Top of General Land Office marker, center of section.
T69	1,791.6	147-90-24bddd	Top of section marker, center of section.
T70	2,005.0	150-90-25cddd	Top of section marker, center of south line of section.
T71	2,019.1	150-90-27dddd	Top of section corner marker, southeast corner of section.
T72	2,024.8	150-90-28dddd	Top of section corner marker, southeast corner of section.
T73	2,036.4	150-90-21dddd	Top of section corner marker, southeast corner of section.
T74	2,033.5	150-90-29dddd	Top of section corner marker, southeast corner of section.
T75	2,034.1	150-90-31aaaa	Top of 4- by 4-in. timber at northwest corner of cattle-guard, northeast corner of section.
T76	1,957.3	150-92-11cddd	Top of section marker, center of south line of section.
T77	2,137.5	150-93-1dddd	Top of section corner marker, southeast corner of section.

Table 5.—*Temporary benchmarks established in 1950–51*—Continued

No.	Altitude	Location	Description
T78	2,304.9	147-92-26dddd	Top of section corner marker, southeast corner of section.
T79	2,125.3	146-90-7cddd	Top of section marker, center of south line of section.
T80	2,179.6	146-90-1dddd	Top of section corner marker, southeast corner of section.
T81	2,114.1	147-90-19cddd	Top of section marker, center of south line of section.
T82	1,997.7	150-90-36aaa	Bolt on northeast corner of cattle guard.
T83	2,043.6	150-90-17cddd	Top of section marker, center of south line of section.
T84	2,033.5	150-90-20dddd	Top of section corner marker, southeast corner of section.
T85	2,452.9	148-95-12cddd	Top of General Land Office marker, center of south line of section.

RECORDS OF WELLS AND SPRINGS

Table 6.—*Records of wells*

[Well number: See text for description of well-numbering system.
Type of well: B, bored; Dn, driven; Dr, drilled; Du, dug.
Depth of well: Reported depths below land surface are given in feet; measured depths are given in feet and tenths.
Type of casing: C, concrete (includes brick or tile); P, iron or steel pipe; S, stone; T, clay tile; W, wood.
Water-bearing material: Cl, clay; G, gravel; L, lignite; S, sand; SiS, silty sand; Ss, sandstone.
Method of lift: Cy, cylinder; F, flow (gpm); J, jet; N, none; P, pitcher pump; R, rotary; VC, vertical centrifugal.
Use of water: D, domestic; N, not used; O, observation; P, public supply; S, stock.
Measuring point: Bp, base of pump; Esp, end of spout; Hp, hole in pump; Hpb, hole in pump base; Hc, hole in casing; L, land surface; Tca, top of casing; Tco, top of cover; Tcu, top of curb; Tp, top of pump; Twb, top of wood box.
Depth to water: Reported depths are given in feet below land surface; measured depths are given in feet, tenths, and hundredths below measuring point.
Remarks: Ca, chemical analysis made of water in well; L, log of well included in report]

Well number	Owner or tenant	Type of well	Depth of well below land surface (ft)	Diameter of well (in.)	Type of casing	Water-bearing material	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above or below (-) land surface (ft)	Measuring point: Altitude above mean sea level (ft)	Depth to water level below measuring point (ft)	Date of measurement	Remarks
Eastern segment McLean County														
147-86-4cba	Florence Barr	Dr	214	4	P	Ss	Cy	D,S	....	....	1,917	144	1949	
-6bda	Frank Johnson	B	100.4	18	W	....	Cy	D,S	Tco	0.8	1,880	83.33	11-16-49	
-7bad	John Kovarik	B	40	18	W	L	Cy	S	Tco	.6	1,893	16.31	11-16-49	
147-87-12bab	Matthew Whitebear, Sr.	Dr	464.8	4	P	S	N	D	Tca	1.7	....	207.28	10-23-51	L
-13bcb	Matthew Whitebear, Jr.	Dr	261.4	4	P	S	N	D	Tca	2.3	....	206.77	10-10-51	L
147-87-16cdd	Jackson Ripley	Du	84.5	24	W	....	Cy	D,S,O	Tco	.2	1,781	73.70	11-18-49	
-17bca	Byron Wilde	Dr	130	4	P	S	Cy	D,O	Hpb	1.0	1,802	84.57	11-18-49	Ca
-18cbb	Henry Brewer	B	81.8	24	W	S	Cy	D,S	Tco	.6	1,777	73.09	11-18-49	
-18daa	Thomas White	Dr	91.4	4	P	....	Cy	D	Tca	1.5	1,782	72.44	11-18-49	
-19ccc	George Karlin	Du	6.3	24	T	S,G	R	D	Tca	1.2	1,720	5.45	11-21-49	
-29bad	Matthew Whitebear, Sr.	Dr	21.9	8	P	....	Cy	S	Bp	.9	1,738	11.87	11-18-49	
-29daa	Davis Painte	B	36.6	24	W	....	Cy	D	Tco	.5	1,724	16.00	11-18-49	
-29dba	Eleanor Whitebear	B	38.5	24	W	....	Cy	S	Tco	.2	1,731	14.77	11-18-49	
-30bab	Alfred Kreuger	Dn	7.0	1¼	P	S	P	D,S	Bp	3.5	1,720	8.55	11-21-49	
147-88-1dcc	Oren Taylor	B	152.6	24	W	L	Cy	D,S	Hpb	.4	2,003	137.39	1949	

TABLE 6

-3abc	Jonathan Price	Dr	439.2	4	P	S	N	D	Tca	1.7	...	288.72	10-23-51	L
-7bca	Ed Badger	Dr	56.4	16	C	L	Cy	D	Tco	.2	1,853	29.15	11- 7-49	
-7cac	Mrs. Lottie Hosie	B	26.0	24	W	...	Cy	D,S	Tco	1.2	1,821	16.60	11- 7-49	
-11bdc	Eugene White	Dr	461.3	4	P	SiS	N	D	Tca	1.4	...	168.85	10-11-51	L
-12bad	Affiliated Tribes	Dr	489.2	4	P	S	N	N	Tca	2.2	1,961	231.52	7- 2-51	L
-12cab	Franklin Howard	Dr	483.3	4	P	...	N	D	Tca	.8	...	220.22	10- 8-51	L
-14cbc1	Levi Waters	Dr	99.6	5	P	...	Cy	D,S,O	Tco	1.0	1,821	55.81	9-22-49	
-14cbc2	do	B	117.3	14	C	...	N	N	Tca	.1	1,793	9.96	11-21-49	
-15add	Mrs. Fred Fox	B	16.1	18	W	L	N	D,S	Tca	.8	1,826	13.60	9-22-49	
-16acd	Harold Ziegler	B	55.3	23	P	...	N	N	Tca	.6	1,880	41.42	9-23-49	
-19dbc	Mrs. Winnie Seminole	B	52.6	14	C	L	Cy	D,S	Tca	.1	1,783	39.09	11-22-49	
-20ccd	Mrs. Georgianna Reed	B	51.8	14	C	...	Cy	D	Tco	.6	1,756	42.36	11-22-49	
-21cbc	Mrs. Abbie Shell	B	15.4	14	C	...	Cy	D	Tco	.3	1,760	11.48	11-21-49	
-21ddc	James Eagle	B	25.7	24	W	S	N	D,O	Tcu	1.0	1,774	23.44	11-21-49	
-22bab	Mrs. Mildred Huber	B	7.5	24	W	L(?)	N	D	Tcu	.1	1,805	4.81	11-21-49	
-27aab	Thomas Yellowface	Du	6.6	24	W	S	N	D,S	Tca	2.0	1,726	3.78	11-21-49	
-29aaa	U. S. Bur. of Indian Affairs—Nishu School.	Dr	64	4	P	...	Cy	D,P	...	...	1,758	37	1949	Ca
147-89-1acd	Phillip Spotted Horse	Dr	100.8	4	P	...	Cy	D	Tca	1.0	1,936	90.33	9-20-49	
-1cdc	Mrs. Harry Gillette	B	47.8	24	W	L(?)	Cy	N	Tco	.6	1,868	36.15	11-22-49	
-3add	Mrs. Helen Gough	Du	5.0	30	W	L	N	D	Tca	1.8	1,912	4.83	9-28-49	
-11dad	Willard Yellowbird	B	71.5	24	W	...	N	N	Tcu	1.1	1,972	49.21	11- 7-49	
-13add	Phillip Hand	Dr	114.13	4	P	...	Cy	O	Hpb	.8	1,918	82.40	9-26-49	
-13dcc	do	Du	5.7	30	W	L(?)	N	D,S	Tca	.8	1,749	2.20	11-22-49	
147-90-1aab	John W. Chase	B	57.1	6	P	L	Cy	D,S	Tca	.9	1,780	38.18	12- 2-49	
-2bcb	Mrs. Elizabeth Packineau	Dr	52.4	4	P	L	Cy	D,S	Tca	1.2	1,744	18.36	12- 6-49	
-3adb	Mrs. Ruth Smith	B	20.0	6	C	S	Cy	D,S	Esp	3.3	1,743	14.68	12- 6-49	
-3dbb	Evan Hall	Dr	39.3	6	P	...	Cy	S,O	Hpb	.8	1,736	16.22	12-.6-49	
-4acd	American Missionary Assoc.	Du	26.4	30	C	S,G	N	N	Tca	-6.0	1,742	17.15	12- 9-49	Ca
-4dbb	U. S. Bur. of Indian Affairs—Elbowoods municipal well.	Du	30.6	96	C	...	VC	P	Tco	2.4	1,743	[1]26.88	12- 8-49	
-5aaa	Jacob A. Rapp	Dr	620	3-1¼	P	S	F	D,S	...	...	1,739	[2]25+	1936	Ca
-5bbc1	Ben Slocumb	Dn	36	1¼	P	S	Cy	D	...	...	1,737	8	1936	
-5bbc2	do	Dn	32	1¼	P	S	Cy	S	L	...	1,737	7.95	12- 8-49	
-9bbc	Tribal land (old fairground)	Dn	25	1¼	P	S	Cy	N	Tp	3.5	1,732	11.07	12- 8-49	
148-86-19dcd	Gerhard Korstad	Dr	56.1	5½	P	L	Cy	D,S	Hpb	2.0	1,907	52.94	11-16-49	

See footnotes at end of table.

Table 6.—*Records of wells*—Continued

Well number	Owner or tenant	Type of well	Depth of well below land surface (ft)	Diameter of well (in.)	Type of casing	Water-bearing material	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above or below (-) land surface (ft)	Measuring point: Altitude above mean sea level (ft)	Depth to water level below measuring point (ft)	Date of measurement	Remarks
Eastern segment, McLean County—Continued														
-31aaa	Wimburn G. Merriam	Du	17.4	16	C	L	Cy	D,S	Tco	0.2	1,862	12.65	11-16-49	
-31bbb1	John Kovarik	B	11.8	24	P,W	....	N	D	Tca	1.4	1,861	11.06	11- 9-49	
-31bbb2	do	B	77.8	18	W	....	Cy	N	Tco	1.1	1,893	24.88	11-16-49	
148-87-6dca	Roland Moll	Du	19.4	36	W	S	Cy	D,S,O	Tca	.6	1,971	12.62	11-10-49	
-7baa	Lucy Kerzmann	Du	21.5	48	C,W	....	Cy	D,S,O	Tco	.4	1,971	7.96	7-26-49	
-7ddd	John Klabunde	B	74.1	24	C	....	Cy	D,S	Tco	1.0	1,982	52.05	11-10-49	
-8bba	Anton J. Kerzmann	B	40.3	24	W	....	Cy	D,S	Tco	1.0	1,982	32.03	11-10-49	
-17cdd	Gordon Matheny	B	81.4	24	W	S	Cy	D,S	Tco	1.2	1,996	63.44	11-14-49	
-18bab	Henry Kerzmann	B	90.3	24	W	L	Cy	D,S,O	Tco	1.1	1,907	71.03	11-10-49	
148-87-19adc	George Fitzgerald	B	73.3	24	W	....	Cy	D,S	Tco	1.5	2,007	44.20	11-14-49	
-19ddb	Lynn Ziegler	B	67.7	24	W	L	Cy	S	Tca	.3	2,015	43.25	11-15-49	
-26daa	Henry Martin	B	74	24-18	W,C	L	Cy	D,S	Tco	.3	1,943	57.65	11-16-49	
-27ada1	Fred Kerzmann	B	51.0	24	W	Cl	Cy	D,S	Tco	1.3	1,963	35.75	11-16-49	
-27ada2	do	Dr	135.0	6	P	L	Cy	D,S	Hpb	1.6	1,963	80.94	11-17-49	
-27cad	Freeman Crawford	B	78.1	18	W	....	Cy	D,S	Tco	1.4	1,983	69.55	11-15-49	
-27dad1	John Kerzmann	Dr	222.0	5½	P	L	Cy	D,S	Hc	-6.9	1,988	138.68	11-17-49	
-27dad2	do	B	74.6	24-18	W	L,S	Cy	S	Tco	1.6	1,988	64.64	11-17-49	
-29bba	Lynn Ziegler	B	22.3	24	W	....	N	N	Tco	.2	2,013	10.50	11-14-49	
-30aca	Joe Reuter	Dr	23.7	5	P	....	N	N	Tca	.8	2,005	23.24	11-14-49	
-31baa	A. J. Deering	Dr	152.1	6	P	L	Cy	D,S,O	Hc	1.3	2,014	118.22	11-15-49	
-33bbb	Joseph Ruhland	Dr	109.8	4	P	L	Cy	D,S	Tca	.7	1,999	87.64	11- 8-49	

-34aaa	Joe Peterson	B	95.8	18-16	W, C	....	Cy	D	Tco	.8	1,954	37.70	11-15-49	
-34aad	do	Du	20.8	30	W	L	Cy	S	Tco	2.2	1,945	15.19	11-15-49	
-35cbc	Mrs. Margaret Peterson	B	49.1	24	W	L	N	N	Tca	.0	1,981	42.01	8- 5-49	
-35ddd	Julius Kolden	Dr	110.7	5	P	....	Cy	O	Tca	.5	1,977.9	96.24	8- 5-49	
148-88-8ddc	Don Howling Wolf	Dr	183.3	4	P	S	N	D	Tca	1.9	....	120.30	10- 5-51	L
-9add	David Robinson	B	58.0	24-18	W	L	Cy	D, S, O	Tco	.5	2,041	45.05	7-25-49	Ca
-10ddd	Harold Ziegler	B	33.0	24	W	L	Cy	S, O	Tco	1.2	2,002	33.30	11- 4-49	
-11bdb	....	Du	23.12	36	W	L	Cy	N	Tco	1.8	1,982	17.86	8-30-49	
-12ab	George F. Kerzmann	Dr	250	3-2	P	L	Cy	D, S	....	....	1,988	170	1944	
-13bcb	Katie H. Star	Dr	145.7	4	P	S	N	D	Tca	1.4	....	98.11	10- 8-51	L
-14aad1	Harold Ziegler	B	58.1	24-15	W	L	Cy	D, S	Tco	1.4	2,031.6	39.64	7-25-49	
-14aad2	do	Dr	127.7	6-3	P	....	Cy	D, S	Tco	1.3	2,033.1	103.59	11- 1-49	
-15aad	do	Du	13.5	36	W	....	N	N	Tco	.6	1,995	10.35	8- 6-49	
-16adc	Mamie White	B	38.9	24	W	....	Cy	D, S	Tco	.6	2,019	20.26	7-25-49	
-16daa	John White	Dr	148.3	4	P	S	N	D	Tca	1.0	....	107.40	10- 5-51	L
148-88-18bbc	Burton B. Bell	B	119.3	18	C	L	Cy	D	Tco	.6	2,152	64.46	12- 2-49	
-21bab	....	Du	11.1	60	S	....	N	N	Tco	1.5	2,082	6.30	8- 8-49	
-22bdb	....	Du	5.5	30	W	....	N	N	Tcu	1.5	2,038	4.74	7-26-49	
-26aaa	Harold Ziegler	B	32.6	24	W	....	N	O	Tca	1.5	2,040.1	11.57	8-26-49	
-26bad	Joe Packineau	Dr	381.6	4	P	S	N	D	Tca	1.8	....	267.79	10- 9-51	L
-35aca	Philip Ross	Dr	475.6	4	P	L(?)	N	D	Tca	.9	....	306.28	10- 9-51	L
148-89-3cad	Leon Billedeau	Dr	103.7	4¼	P	....	Cy	S, O	Hpb	1.9	2,117	74.48	10-21-49	
-4cdd	Maurice Danks, Jr	Dr	205	4¼	P	S, L	Cy	D, S	....	....	2,106	182	1932	
-6cad	Sivert P. Lunden	Dr	41.5	6	P	S	Cy	D	Tca	1.5	2,070	21.63	10-21-49	
-7ddd	Affiliated Tribes	Dr	256.5	4	P	S	N	N	Tca	1.1	2,103	181.51	8-14-51	L
-8cab	Woodrow Overlee	Dr	198.2	4	P	....	Cy	D, S	Tca	.2	2,106	176.96	10-21-49	
-13bcc	Donald Nelson	B	127.4	22-14	W	....	Cy	D, S	....	....	2,158	112+	1949	
-22dab	John Wilkinson	Dr	289.8	4	P	S	N	D	Tca	.9	....	223.03	10- 9-51	L
-24cbd1	Nels J. Nelson	B	61.7	22-18	W	Cl, S	Cy	D, S, O	Tco	.8	2,116	44.12	11-28-49	
-24cbd2	do	Dr	145.3	4¼	P	L	Cy	D	Tca	1.4	2,126	101.30	10- 4-49	
-27dcc	Earnest Wilkinson	B	41.1	24	W	....	N	D, S	Tca	1.2	1,960	27.71	11-28-49	
-27ddc	Gordon Nelson	Dr	120.3	5	P	....	Cy	D, S	Hpb	.8	1,981	62.35	11-28-49	
-28acb	Bill Deane	Dr	357.5	4	P	S	N	D	Tca	2.0	....	200.85	10-23-51	L
-29dbc	Robert Bear	Dr	41.0	4	P	L	Cy	D, S	Tca	1.2	1,987	21.38	11-28-49	

See footnotes at end of table.

Table 6.—*Records of wells*—Continued

Well number	Owner or tenant	Type of well	Depth of well below land surface (ft)	Diameter of well (in.)	Type of casing	Water-bearing material	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above or below (-) land surface (ft)	Measuring point: Altitude above mean sea level (ft)	Depth to water level below measuring point (ft)	Date of measurement	Remarks
Eastern segment, McLean County—Continued														
-33abc	Mrs. Mary Wheeler	Du	13.7	36	W	....	N	D, S	Tcu	2.6	1,942	8.85	11-28-49	
-33bad	Mrs. Mary Wheeler and Mrs. Cecilia Mason.	Dr	68.3	4	P	....	Cy	N	Tca	-.1	1,969	58.50	11-28-49	
-34bbd	Thomas Yellowface	Dr	85.0	4	P	....	Cy	D, S	Tca	1.0	1,968	60.82	11-28-49	
-34dbd	Mrs. Letha Howard	Dr	87.6	4	P	....	Cy	D, S	Hpb	.8	1,932	75.94	11-28-49	
-36caa1	John Slobojan	B	30.5	4¼	P	S, G	VC	D, S	Tca	-6.1	1,957	20.14	11-22-49	
-36caa2	do	Dr	124.6	6	P	L	Cy	D, S, O	Hp	1.5	1,966	90.98	11-22-49	
148-90-10cda	Affiliated Tribes	Dr	151.4	4	P	S	N	N	Tca	1.5	2,077	96.51	7- 2-51	L
148-90-13bbb	Lyle P. Holtan	Dr	73.2	4	P	....	Cy	S	Hp	1.3	2,057	56.10	10-21-49	
-13daa	Ole Dalby	B	43.6	15	W	L	Cy	O	Tca	1.1	2,039	28.30	7-27-49	
-22bcc	Affiliated Tribes	Dr	234.8	4	P	S	N	N	Tca	1.1	1,928	136.54	7- 2-51	L
-23abc	Martin Cross	Dr	167.1	4	P	S	N	D	Tca	1.7	....	122.61	10-18-51	L
-24bcd	Alice Old Dog	Dr	98.6	4	P	....	Cy	O	Hpb	1.1	2,077	65.89	9- 2-49	
-24dcc	Guy Packineau	Dr	358.8	4	P	S	N	D	Tca	2.1	....	316.94	10-29-51	L
-26abb	Lyle P. Holtan	Dr	108.0	4½	P	L	Cy	D, S	Hpb	.7	1,959	85.60	9-22-49	
-26bbd	John Bears Tail	Dr	54.9	4	P	Ss	Cy	D	Tca	1.0	1,898	43.48	12- 6-49	
-27dbb	Assumption Abbey	Dr	57.8	6	P	Ss	Cy	D, S, O	Hpb	.3	1,826	33.70	12- 7-49	
-29cab	H. C. Oderman	Dn	37	2	P	G	Cy	D, S	....	....	1,760	29	1949	
-29dbc	Martha Voight	Dn	29	1¼	P	....	Cy	D, S	....	....	1,745	26	1949	
-30adc	Clarence Perkins	Dr	64.3	4¼	P	....	Cy	D, S	Tca	1.3	1,755	21.15	12- 7-49	
-31dad	Mrs. Grinell	Dr	36.7	5	P	....	Cy	O	Tco	1.6	1,735	10.05	12- 7-49	
-32dca	Walter Face	Dr	55.0	4	P	S	Cy	D, S, O	Tca	1.1	1,741	20.09	12- 8-49	
-33add	Fred Wheeler	Dr	56.0	4	P	....	Cy	D, S	Tca	1.3	1,766	38.78	12- 7-49	

-33bbc........	Minnie Youngwolf........	Dr	38.3	48	W	....	Cy	D, S	Tco	.8	1,768	34.42	12- 7-49	
-33ccc........	Maggie Grinnell........	B	22	8	P	G	Cy	D, S	....	....	1,741	18	1947	
-33dbd........	Lawrence Sears........	Du	....	....	....	....	Cy	N	....	....	1,748	....	....	
-33dcc........	Catholic Mission........	Dr	450-500	2	P	Ss	F	D	....	....	1,745	36+	1949	Ca
-33dcd........	........do........	Du	25	30	W(?)	....	Cy	D	....	....	1,745	20	1949	
-34bad........	Mrs. Lillie Wolf........	B, Dr	92.8	6	P	....	Cy	D, S	Hpb	2.0	1,798	65.96	7-27-49	
-34bcd........	Helen Wilkinson........	Dr	116	4	P	L	Cy	D, S	....	....	1,790	58	1949	
-34cca........	Martin Cross........	Dr	96.2	4¼	P	L(?)	Cy	D, S	....	....	1,766	37	1949	
-35cbc........	Peter Coffey........	Dr	88.3	6	P	....	Cy	D, S	Tca	1.7	1,794	58.66	12- 6-49	
-35cdd........	Guy Packineau........	Dr	61.9	4¼	P	S	Cy	D, S	Hpb	2.1	1,753	32.18	12- 5-49	
-35dcc........	Goodbear Estate........	Dr	68.1	4	P	S	Cy	N	Hpb	1.8	1,775	54.36	12- 6-49	
148-91-1bbb1........	Joe Voight........	Dr	580	2	P	S	F	D, S	....	....	1,772	....	....	
-1bbb2........	........do........	Du	15.4	42	S	....	N	N	Tcu	.8	1,738	11.70	12- 7-49	
-1ccc........	Carl Schettler........	Dr	30	5	P	S, G	Cy	D, S	....	....	1,739	20	1949	
-2bdb........	Mrs. Gladys Ervin........	Dr	99.3	4¼	P	....	Cy	S, O	Hpb	.9	....	22.43	12- 6-49	
-10aaa........	Mrs. Grinnell........	Dr	37.6	5	P	S	Cy	D, S	Hpb	1.7	1,736	12.95	12- 6-49	
-11dcb........	James Martin........	Dr	119.7	4	P	L	Cy	D, S	Hpb	1.0	1,776	53.80	11- 1-49	
-14baa........	David Grinnell........	Dr	124.1	4¼	P	....	Cy	D, S	Hpb	1.2	1,770	52.10	12- 6-49	
-23dcb........	Carl Whitman........	Dr	60.4	4¼	P	....	Cy	D, S	Hpb	1.3	1,758	30.87	12- 9-49	
-25abc........	John Voight........	Dr	57.6	5	P	....	Cy	D, S	Hpb	.3	1,765	41.76	12- 7-49	
-25bdb........	Theodore Spotted Bear........	Dr	55.8	4¼	P	L	Cy	D, S	Tca	1.4	1,742	20.20	12- 7-49	
-25dca........	Frank Voight........	Dr	590	1½	P	S	F	D, S	....	....	1,740	....	....	
149-87-27cbb........	Mrs. Julia Schmidt........	B	76.5	24	W	S	Cy	S	Bp	.8	2,055	65.00	11-29-49	
-28daa........	Floyd Hill........	B	75.8	24	W	S	Cy	D, S	Tcu	.7	2,054	65.39	11-29-49	
-29ddd........	Olaf Lofberg........	Du	34.8	36	C	S	Cy	D, S	Tco	1.0	2,010	31.30	11-29-49	
-30dba........	B. G. Brumwell........	Dr	76.8	5	P	....	Cy	D, S	Tca	2.2	1,993	25.41	12- 5-49	
-31aba........	Mrs. Nana Thornburg........	Du	15.8	24	W	....	N	N	Bp	1.2	1,984	12.27	11-29-49	
-31cad........	Wes Cummings........	Dr	245	5	P	....	Cy	N	....	....	2,010	193	1949	
-32bbc........	Olaf Lofberg........	Dr	110.3	5	P	....	N	N	Tca	.7	1,991	66.24	11-29-49	
-32cdb........	........do........	Dr	199.6	5	P	....	N	N	Tco	1.0	1,984	169.23	8-30-49	
-33bcd........	Edward Finess........	B	31.6	18	W	....	N	N	Tcu	.5	2,000	18.36	11-29-49	
-34baa........	Arnold Hill........	B	81.1	24	W	S	Cy	S	Tco	.7	2,047	53.79	11-29-49	
149-88-25cca........	H. A. Rudtstadt........	Dr	241.3	5	P	....	Cy	N	Tca	1.7	1,990	172.77	12- 5-40	
-25dda........	........do........	B	19.6	18	C	S, G	VC	D, S	Tcu	.6	1,983	14.10	11-29-49	
-27ddd........	Thomas Pavlak........	Dr	268.0	4¼	P	....	Cy	O	Hpb	2.4	2,003	184.07	11-29-49	
-28cdd........	John Haugen........	Du	22.3	48	W	G	Cy	D, S	Tco	2.0	2,019	17.60	11-28-49	

See footnotes at end of table.

Table 6.—*Records of wells*—Continued

Well number	Owner or tenant	Type of well	Depth of well below land surface (ft)	Diameter of well (in.)	Type of casing	Water-bearing material	Method of lift	Use of water	Measuring point			Depth to water level below measuring point (ft)	Date of measurement	Remarks
									Description	Distance above or below (-) land surface (ft)	Altitude above mean sea level (ft)			
							Eastern segment, McLean County—Continued							
-29cc1	H. A. Hector	Dr	194.8	2	P	....	N	O	Tca	0.9	2,008	191.92	11-22-49	
-29ccc2	.........do	B	35.4	18	P	....	Cy	N	Tca	1.7	2,003	19.33	11-23-49	
149-88-31bbb	Stanton Lee	Dr	154.0	4¼	P	....	Cy	D,S	Hpb	.5	2,037	140.04	11-23-49	
-32aac	E. Kloppadel	Dr	271.4	4¾	P	L	Cy	D,S	Hpb	1.6	2,047	222.60	11-28-49	
-32bbc	Earl Zahnow	Dr	175.2	4¼	P	L	Cy	D,S	Hpb	.6	2,032	160.49	11-28-49	
-32ccb	Mike Weinand	Dr	184.3	4	P	....	Cy	D,S	Hpb	.6	2,059	165.33	11-30-49	
-33bbb	Carl Olson	B	48.8	24	W	S,G	Cy	S	Tcu	1.0	1,998	28.76	11-28-49	
-33cad	Mr. Fisher	Du	14.1	18	P	....	N	N	Tco	-1.0	2,008	7.10	11-29-49	
-33ddd	Christopher Hill	Dr	231.3	5	P	....	Cy	N	Tca	.9	2,049	223.98	10-24-49	
-34abc	Severin Johnson	Dr	....	2	P	....	Cy	N	....	....	....	....	....	
-34ccc	George W, Albrecht	Dr	239.9	5	P	S	Cy	D,S	Hpb	1.6	2,047	222.07	11-30-49	
-35aab	Oscar R. Johnson	Dr	254.0	5	P	....	Cy	D,S,O	Hpb	1.1	2,004	187.67	12- 5-49	
-35baa	.........do	Dr	275.5	5	P	S	Cy	D,S	Hpb	1.4	2,020	204.55	12- 5-49	
-35ddd	Wes Cummings	Dr	268.9	4	P	S	Cy	D,S	Hpb	1.2	2,029	207.10	10-24-49	
-36cbb	Byron Brumwell	B	43.5	18	P	....	Cy	N	Tco	.0	1,991	11.60	10-29-49	
149-89-17cdd	Herbert Theobald	Dr	156.5	5	P	....	Cy	N	....	....	2,017	Dry	11-22-49	
-18adb	Walter Meyer	Dr	112.6	4¼	P	G(?)	Cy	D,S	Tca	1.5	1,915	83.4	11-21-49	
-19add	Oscar Hay	Dr	155	2	P	L	Cy	D,S	....	....	1.991	125	1949	
-25cbb	Clara Bently	Dr	....	2	P	....	Cy	N	....	....	....	....	....	
-25dcc	Woodrow Overlee	Dr	97.3	4¼	P	....	Cy	O	Hpb	1.4	2,025	78.27	11-23-49	
-27dbb	Everett Moll	Dr	130	2	P	....	Cy	D,S	....	....	2,036	124	1949	
-29bcc	John Eide	Dr	157.9	6	P	....	Cy	D,S	Hpb	1.5	1,992	128.90	11-29-49	

-30baa	John Eide	Dr	116.1	4¼	P	....	Cy	D,S	Tca	.4	1,934	78.82	11-21-49	
-30cba	John Sutton	Dr	186.7	4¼	P	....	Cy	N	Hpb	1.2	2,028	169.19	11-21-49	
-30cca	I. O. Sholas	Dr	223.1	4¼	P	....	N	O	Tca	1.3	2,045	194.05	11-10-49	
-32ddd	Solomon Ammon	Dr	158.9	6	P	....	Cy	D,S	Tca	1.2	2,050	133.90	10-21-49	
-33ccd	Forest Theobald	Dr	170	2	P	S	Cy	N	....	....	2,043	135	1913	
-34baa	Jake Weikem	Dr	123.2	6	P	....	N	N	Tca	.4	2,017	106.15	11-29-49	
-36bbb	Lloyd Sharp	Dr	126.9	4¼	P	L	Cy	D,S,O	Hpb	1.6	2,036	94.30	11-22-49	
149-90-14cbd	George Foote	Dr	110.7	4¼	P	L	Cy	D,O	Hpb	.6	1,793	19.35	11-17-49	
15cbc	Henry Blue Stone	Dr	33.1	4¼	P	....	Cy	D,S	Hpb	2.1	1,782	12.85	11-17-49	
-17cbd	U.S. Bur. of Indian Affairs—Lucky Mound School.	Dr	60	4	P	....	Cy	D,P	....	....	....	20	1950	Ca
-18ccb	Thomas Youngbird	B	38.2	18	W	S,G	N	N	Tco	.0	1,767	32.54	11-16-49	
-19ddc	George Packineau	Du	21.6	36	W	....	Cy	D,S	Tco	2.1	1,749	15.30	12- 6-49	
-24cda	Buell Brugh	B	21.15	20	P	G	N	D	Tca	1.2	1,903	16.30	11-28-49	Ca
-30dcc	John White Body	Du	11.6	18	P	....	N	D	Tca	2.4	1,778	13.05	12- 6-49	
-31dad	Bertha White Body	Dr	44.1	4¼	P	....	Cy	D,S	Tco	1.1	1,750	16.48	12- 8-49	
-31dca	Joe Beston	Du	8.5	48	W	S	Cy	D	Tcu	.8	1,739	6.20	12- 6-49	
-32bad	Ralph Wells, Sr.	Dr	89.1	4¼	P	L	Cy	D,S	Hpb	1.4	1,760	37.10	12- 6-49	
-34daa	....	Du	7.0	36	W	S	N	N	Tcu	.8	1,913	6.14	12- 1-49	
						Northeastern segment, Mclean County								
149-89-6cba	Martin Miller	Dr	216.3	6-4	P	....	Cy	D,S	Hpb	1.8	1,994	162.98	11-22-49	
-6ddd	Zenis Stouck	Dr	129.2	4¼	P	....	Cy	....	Tca	.1	1,958	126.98	11-21-49	
-7bac	Charles Miller	Dr	200	2	P	....	Cy	D,S	....	....	1,992	140	1949	
-7cdd	Dort Meyers	B	18	1¼	P	S	Cy	D,S	....	....	1,832	10	1946	
-7dca	Gordon Lyon	Du	20	8	C	S	Cy	D,S	....	....	1,846	15	1925	
-8cbc	........do	Du	16.3	18	C	....	N	N	Tcu	2.6	1,842	12.26	11-22-49	
149-90-1abc	Tom Haugen	Dr	212.8	4¼	P	....	Cy	D,S	Hpb	1.9	2,011	159.56	11-17-49	
-2aba	Frank Homme and Martin Miller	Dr	340	4¼	P	....	N	O	Tca	2.2	2,027	196.40	11-17-49	
-2bba	Martin Miller	Du	102.4	24	W	....	Cy	D,S	Tco	1.0	1,935	88.50	11-16-49	
-11ada	Elsie Foote	Dr	209.8	4	P	S	N	D	Tca	2.0	....	161.41	10-29-51	L
-14bda	James Foote	Dr	177	5	P	L	N	N	....	....	1,805	....	....	
-17bcc	Clarence Johnson	Du	21.6	24	W	S,G	Cy	D,O	Tcu	.6	1,763	20.51	11-17-49	
-17bdc	Barbara Johnson	B	19.3	24	W	S	Cy	D	Tco	.4	1,762	17.20	11-17-49	
-18add	Otto Christenson	B	22.5	18	W	S	Cy	D,S	Tco	.6	1,768	21.36	11-17-49	
149-91-12abd	Phillip Spotted Wolf	B	53.3	18	W	....	Cy	S	Tco	.6	1,770	31.74	11-17-49	

See footnotes at end of table.

Table 6.—*Records of wells*—Continued

Well number	Owner or tenant	Type of well	Depth of well below land surface (ft)	Diameter of well (in.)	Type of casing	Water-bearing material	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above or below (-) land surface (ft)	Measuring point: Altitude above mean sea level (ft)	Depth to water level below measuring point (ft)	Date of measurement	Remarks
Northeastern segment, McLean County—Continued														
149-91-12dba	Stephen Rabbit Head	B	54.8	18	W	G	Cy	D, S	Hpb	1.2	1,775	35.60	11-17-49	
-13aab	Pat Harney	B	42.7	18	W	S	N	N	Tco	1.4	1,762	21.58	11-16-49	
150-89-6ada	Mrs. Hattie Lunde	B	76.6	24	T	......	Cy	D, S	Tco	1.6	......	34.62	8-30-50	
-6bbc	Donald Needham	B	86.4	18	W	......	Cy	D, S	Tco	.7	......	76.20	8-30-50	
-7cdb	......do	Dr	98.2	6	P	......	Cy	S	Tca	1.0	......	84.80	8-24-50	
-18ccd	Peter V. Torgonson	Dr	109.7	4	P	S	Cy	D, S	Hpb	.9	......	103.19	8-25-50	
-19bba	Jesse Torgonson	Dr	110	4	P	S	Cy	D, S	Tca	1.6	......	95.67	8-25-50	
-19cdd1	Ivan Avery	Dr	68	4	P	......	J	D	......	......	......	56	1946	
-19cdd2	......do	Dr	67.7	4	P	L(?)	Cy	S	......	1.0	......	56.39	8-25-50	
150-90-3cdc	Bud Grove	B	102.2	12	T	......	Cy	N	......	.8	......	80.57	8-24-50	
-12adc	Clarence Olson	B	88.5	18-12	W	Cl, S	Cy	D, S	Tca	.8	......	78.39	8-24-50	Ca
-12ccc	Erick Erickson	Dr	200.6	4	P	......	Cy	......	Tca	.9	......	176.11	8-24-50	
-13aca	Mark Necklace	Dr	298.2	4	P	S	N	D	Tca	.9	......	218.45	10-29-51	L
-14cdd	Ann Rutledge Lockwood	Du	8.7	18	P	S	P	D	Tca	2.1	......	9.42	10-17-50	Ca
-22ccc	Eunice Grinnell	Dr	297.0	4	P	S, G	N	D	Tca	1.2	2,046.3	217.46	8-28-51	L
-25daa	Tom Blue Stone	Dr	258.2	4	P	S	N	D	Tca	1.1	2,006.3	173.67	8-28-51	L
-28ddc	Ed Grinnell	Dr	255.3	4	P	S	N	D	Tca	.9	2,005.7	174.92	8-28-51	L
-30bdc	......	......	47.4	......	......	......	Cy	N	Tcu	.9	......	34.22	9-21-50	

Northeastern segment, Mountrail County													
151-89-31dca........	John Woken........................	B	32.7	....	......	S(?)	Cy	D, S	Tco	1.3	....	8.70	8-30-50	
151-90-28ddd........	Albert Vorwerk....................	B	150	18	W	....	Cy	D, S	....	....	....	....	....	
-31aaa........	Chris Spitzer.....................	Du	15.4	36	W	L	Cy	D, S	Tco	....	....	10.42	8-24-50	
-32bdb........	James Woldock.....................	B	48.7	24	W	L	Cy	D, S	Tca	.0	....	34.35	8-24-50	
-32daa........	Peter Starvos.....................	Dr	125	2½	P	....	Cy	....	....	....	....	....	....	
-33dbd........	A. J. Kohls.......................	B	108.0	12	T	....	Cy	D, S	Tco	2.0	....	102.09	8-24-50	
-34ddd........	....	Dr	141.9	2	P	....	N	N	Tca	1.6	....	123.10	10-17-50	
151-90-35baa........	Paul Broste.......................	Dr	146.5	6	P	....	Cy	D	....	....	....	116	1950	
-35daa........	J. H. Schram......................	B	120	24	W	Cl	Cy	D, S	....	....	....	100	1950	
-36bad........	Ed Schroeder......................	Dr	111.1	6	P	....	Cy, J	D, S	Tca	.8	....	80.44	8-30-50	
-36dda........	Eugene Solomonson.................	Dr	116.2	6	P	....	Cy, J	D, S	Tca	1.0	....	74.73	8-30-50	
Northern segment, McLean County														
150-91-8dda........	Affiliated Tribes.................	Dr	118	4	P	....	Cy	D, P	....	....	....	50	1950	Ca
Northern segment, Mountrail County														
150-92-2aba........	Affiliated Tribes.................	Dr	383.0	4	P	L(?)	N	N	Tca	2.1	1,932.9	152.92	8-14-51	L
-14abd........	..........do......................	Dr	362.2	4	P	S	N	N	Tca	2.1	1,949.7	154.88	8-14-51	L
150-93-1dda........	..........do......................	Dr	295.6	4	P	S	N	N	Tca	1.5	2,179.1	225.40	8-14-51	L
-11dab........	Alfred Pickar.....................	B	38.4	24	W	L	Cy	D, S	Tca	1.5	....	32.74	11- 7-50	
Southern segment, Dunn County														
146-91-8caa........	Helen Crowsheart Grinnell.........	Dr	169.7	4	P	....	N	D	Tca	2.7	....	88.44	9- 6-51	L
147-91-22aad........	Robert Lincoln....................	Dr	87.7	4	P	L, S	N	N	Tca	1.2	....	51.08	11- 9-50	
-25daa........	John Star.........................	Dr	126.0	4	P	....	N	D	Tca	1.2	....	10.30	9- 6-51	L
-27bdb........	John Stone........................	Dr	24.3	4	P	G	N	N	Tca	1.5	....	4.87	11- 9-50	L
148-91-33daa........	U. S. Bur. of Indian Affairs— Eagle Day School.	Dr	135.7	4	P	L	Cy	D, P	Tcu	.9	1,814	74.65	9- 8-49	Ca
Southern segment, Mercer County														
146-88-5cab........	Affiliated Tribes.................	Dr	65	4	P	L	....	D	Tca	....	....	20	1950	Ca
-10cba........	Emma Lockwood Jones...............	Dr	298.3	4	P	S	N	D	Tca	1.1	....	152.85	6-10-51	L
-10ddc........	J. Renner.........................	Dr	124.5	6	P	....	Cy	D, S	Tca	.8	1,905.7	99.7	7-17-51	
-11ccc........	A. O. Smith.......................	Du	12	4	W	....	Cy	D	....	....	1,854.2	8	1951	

See footnotes at end of table.

Table 6.—*Records of wells*—Continued

Well number	Owner or tenant	Type of well	Depth of well below land surface (ft)	Diameter of well (in.)	Type of casing	Water-bearing material	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above or below (-) land surface (ft)	Measuring point: Altitude above mean sea level (ft)	Depth to water level below measuring point (ft)	Date of measurement	Remarks
							Southern segment, Mercer County—Continued							
-15bad	E. Pfining	Dr	84	6	P		Cy	D, S			1,923.3	70	1951	
-15ddd1	Henry Renner, Jr.	Du	5.68	4	W		N	D, S	Twb	2.6	1,918.5	3.22	7-17-51	
146-88-15ddd2	Henry Renner, Jr.	Dr	22	6	P		Cy	D			1,926.2	10	1951	
-16caa1	Edwin Jose	Du, Dr	27	4-6	W		Cy	D			1,823.5	10	1951	
-16caa2	do	Du	15	36	W		Cy	S				9	1951	
-22bcc	Alfred Christman	B	32.6	18	W		Cy	D, S	Tcu		1,892.6	24.80	7-17-51	
146-89-7ccc	Fred Hauff	B	21.8	24	W		N	N	Tca	5.0	2,095.4	2.5	7-19-51	
-9ccb	George Gillette	Dr	24.4	4	P	G	N	D	Tca	.8		7.08	9-10-51	L
-17bcd	John Link		78	6	P		Cy	D, S			2,091.1	68	1951	
-18cad		Dr	85.5	6	P		Cy	S	Tca	2.0	2,123.3	66.02	7-19-51	
-18dda	Ben Fredricks	Dr	68	6	P		Cy	D, S			2,089.7	60	1951	
-20bbb		Dr	95.5	8	P		Cy	D, S	Bp	1.2	2,113.4	67.37	7-19-51	
146-90-5daa	Maria Chase	Dr	228.8	4	P	S	N	D	Tca	1.3		139.90	9-18-51	L
-7dca	Emanule Briedly	Du	16.58	4	C		Cy	D	Twb	1.6	2,080.2	12.69	7-19-51	
-10ddd	Valier Barnett		104	6	P		Cy	D, S	Hp	1.6	2,149.0	90.46	7-19-51	
-13dcc	Louise Link	Dr	146	6	P		Cy	D, S			2,191.3	124	1951	
-14cab		Dr	122.5	6	P		Cy		Hp	1.0	2,188.8	113.60	7-19-51	
-14ddc	William Glass	Dr	149	6	P		Cy	D, S			2,201.3	127	1951	
-15add		Du	12	4	W		Cy	D, S			2,168.0	6	1951	
-15bcc	Dave Wegner	Dr	125	6	P		Cy	D, S			2,181.9	117	1951	
-16cbb	do	Dr	83.0				Cy				2,166.5	Dry	7-19-51	
-16dab		Dr	101.5	6	P		Cy	D, S	Hp	3.0	2,166.4	94.55	7-19-51	

147-89-17ccc	James Holding Eagle	B	41.5	24	C	....	Cy	D,S	Tco	.8	1,762.0	36.30	7-17-51	
-18cac	Herbert Sitting Crow	B	50.0	24	T	....	Cy	D	Tco	.7	1,759.0	23.40	7-17-51	
-18cdc	Affiliated Tribes	Dr	105	4	P	L	Cy	....	Tca	....	....	60	1950	Ca
147-90-20ddb	Ernest Stone	Dr	83.6	4	P	....	N	D	Tca	1.1	....	43.29	9-18-51	L
-22ccc	Affiliated Tribes	Dr	150.5	4	P	SiS	N	N	Tca	1.6	2,030.4	75.40	11- 9-50	Ca,L
-25abc	do	Dr	154.7	4	P	SiS	N	N	Tca	1.4	1,870.7	99.61	11- 9-50	Ca,L
-36ddd	L. P. Darcy	Dr	180	2	P	....	Cy	D,S	....	....	2,178.6	120	1951	
Western segment, Dunn County														
147-93-3dbb	Affiliated Tribes	Dr	222.9	4	P	Ss	N	N	Tca	1.8	2,002.35	164.63	10-24-50	Ca,L
148-93-9bbc	do	Dr	40.0	4	P	G	N	N	Tca	2.0	1,957.26	20.95	10-24-50	L
148-94-20ddd	do	Dr	134.5	4	P	G	N	N	Tca	2.1	2,309.62	45.63	10-24-50	Ca,L
-26dca	do	Dr	290.6	4	P	SiS	N	N	Tca	1.2	2,263.83	224.28	10-24-50	L
-33acd	do	Dr	146.8	4	P	SiS	N	N	Tca	2.0	2,281.39	79.92	10-24-50	L
148-95-1dbb	do	Dr	223.9	4	P	SiS	N	N	Tca	1.2	2,507.82	177.40	10-24-50	L
-35bcc	Christianson	Dr	300	2	P	S	F	S	....	....	....	....	....	
149-92-29dcc	Affiliated Tribes	Dr	403.5	4	P	SiS	N	N	Tca	1.2	....	298.14	10-20-50	L
149-93-14ccc	do	Dr	432.1	4	P	SiS	N	N	Tca	1.4	2,250.07	317.90	10-25-50	L
-18ddb	do	Dr	465	4	P	SiS	N	N	Tca	2.2	2,337.46	364.54	10-25-50	L
-25ddd	do	Dr	146.7	4	P	SiS	N	N	Tca	1.1	2,065.65	101.13	10-24-50	L
-34aca	do	Dr	357.4	4	P	SiS	N	N	Tca	1.0	....	288.50	10-25-50	L
150-91-35cca	do	Dr	126	4	P	S	Cy	D,P	....	....	....	60	1950	Ca
Western segment, McKenzie County														
149-94-7cad	Affiliated Tribes	Dr	422.7	4	P	SiS	N	N	Tca	1.9	2,269.07	245.21	10-24-50	L
-14aaa	do	Dr	419.5	4	P	SiS	N	N	Tca	1.6	2,307.39	317.60	10-24-50	L
-25abc	do	Dr	109.0	4	P	L(?)	N	N	Tca	1.3	2,130.21	33.14	10- 5-50	Ca,L
-29abb	do	Dr	224.1	4	P	L	N	N	Tca	1.4	2,398.16	76.66	9-20-50	L
149-95-36bdb	do	Dr	222.8	4	P	SiS	N	N	Tca	2.1	2,505.91	157.61	10-20-50	L
150-94-28ada	do	Dr	414.0	4	P	SiS	N	N	Tca	1.2	2,267.2	288.32	10-20-50	Ca,L
-32ccb	do	Dr	397	4	P	SiS	N	N	Tca	1.4	2,373.48	359.98	10-24-50	L
-35acb	do	Dr	367.7	4	P	SiS	N	N	Tca	.7	2,244.8	250.30	10-20-50	L
150-95-13dcc	do	Dr	222.3	4	P	L	N	N	Tca	1.4	2,170.98	151.17	8-18-50	L
151-94-28daa	do	Dr	232.6	4	P	L(?)	N	N	Tca	1.0	2,349.49	172.80	8-18-50	L

See footnotes at end of table.

Table 6.—*Records of wells* —Continued

Well number	Owner or tenant	Type of well	Depth of well below land surface (ft)	Diameter of well (in.)	Type of casing	Water-bearing material	Method of lift	Use of water	Measuring point: Description	Measuring point: Distance above or below (-) land surface (ft)	Measuring point: Altitude above mean sea level (ft)	Depth to water level below measuring point (ft)	Date of measurement	Remarks
Western segment, McKenzie County—Continued														
151-95-36acb	Affiliated Tribes	Dr	195.9	4	P	L(?)	N	N	Tca	1.0	2,298.94	166.47	8-18-50	L
152-93-8bbb1	F. K. Goodall	Du	18.20	4	W	....	Cy	S	Tco	.5	1,820.1	13.83	7-18-51	
152-93-8bbb2	F. K. Goodall	B	42.8	24	C	....	N	D	Tca	2.4	1,829.9	26.36	7-18-51	
-10bcb	....	Dr	41.8	6	P	....	Cy	N	Tca	2.8	1,787.2	19.69	7-18-51	
-17bcc	Frank Deserly	Dr	72.1	6	P	....	Cy	S	Tca	1.0	1,878.2	62.78	7-18-51	
-18dcb	Bill Smith	Dr	209.0	4	P	S	N	N	Tca	1.0	....	111.84	10-29-51	L
-20baa	Snowbird	Dr	253.1	4	P	S	N	N	Tca	1.2	1,976	163.26	10-29-51	L
-20bac	Mabel Snow	Dr	205.1	4	P	SiS	N	N	Tca	1.0	1,933.46	129.90	8-15-50	L
-22baa	Minto Grady	B	22.5	24	W	....	N	N	Tcu	.5	1,780.5	17.00	7-18-51	
-28baa	Jim Dawson	B	28.05	4	C	....	Cy	D, S	Tco	1.5	1,788.7	21.13	7-18-51	
-32bbb	....	B	22.7	24	W	....	Cy	....	Tco	.8	1,778.4	13.88	7-18-51	
152-94-6cad	Rae Hendrickson	Du	6.8	4	S	....	N	D	Tco	1.0	2,052.3	6.80	7-18-51	
-9bab	....	Du	9.21	4	W	....	N	....	Tco	.8	2,001.2	6.32	7-18-51	
-10abd1	Lewis Skardi	B	34.96	10	T	....	Cy	D	Tco	1.5	1,969.0	26.54	7-18-51	
-10abd2	do	B	37.7	24	W	....	Cy	S	Tco	.0	1,979.0	11.58	7-18-51	
-11dac	Delancey Yellowface	Dr	88.7	4	P	SiS, Gr	N	N	Tca	1.4	....	24.72	11- 5-51	L
-16cca	Affiliated Tribes	Dr	177.6	4	P	L	N	N	Tca	.8	2,146.40	89.29	8-15-50	L
-25ccc	Charles Blake, Jr	Dr	228.7	4	P	S	N	N	Tca	1.4	2,076	108.12	11- 5-51	L
-25daa	Affiliated Tribes	Dr	240.3	4	P	L	N	N	Tca	.0	2,014.02	105.64	8-15-50	L
-32bbb	do	Dr	203.0	4	P	SiS	N	N	Tca	1.2	2,187.10	106.00	8-15-50	L
-33bbb	Charles Grady, Jr	Dr	277+	....	....	....	N	N	....	....	2,188	....	....	L

-35dca.........	Affiliated Tribes......................	Dr	204.3	4	P	L	N	N	Tca	1.0	2,117.02	161.26	8-15-50	L
152-95-23baa.........	..........do.............................	Dr	55.8	24	W	....	Cy	S	Tco	1.1	....	45.57	8-15-50	

[1]Pumping level.
[2]Pressure sufficient to lift water to tank 25 feet above land surface.
[3]Height of water level above land surface.

Table 7.—*Records of springs*

[Geologic source: A, alluvium; C, clinker; G, gravel, undifferentiated; Ga, alluvial gravel; Gg, glacial drift; L, lignite; S, sand; Ss, sandstone. Use of water: D, domestic; N, none; S, stock. Flow: E, estimated; M, measured]

Spring number	Owner	Topographic situation	Geologic source	Use of water	Altitude	Flow (gpm)	Date of observation
		Eastern segment, McLean County					
147-87-5acb	Tribal land	Side of coulee	L	S	....	0.3(E)	8-17-49
-5acd	Virginia Gerard	Bottom of coulee	L(?)	N	1,932	1 (E)	8-12-49
-5dca1	......do	Coulee bank	L	N	....	.1(E)	8- 5-49
-5dca2	......do	Side of coulee	L	S	....	1 (E)	8- 5-49
-6dcb	Tribal land	Side slope of coulee	L	S	1,942	1.5(E)	12- 5-49
-7abb	Oscar J. Howard	Bottom of coulee at valley side	L	S	1,861	3 (E)	8-17-49
-7bba	Rose Howard	Side slope of coulee	L	S	1,915	1 (E)	12- 5-49
-8aaa	Tribal land	Coulee	L	S	....	2 (E)	8- 5-49
-8abb	Josephine Gerard	Side of coulee	L	S	....	3 (E)	8- 5-49
-10acd	White Basket	......do	....	N	1,894	.1(E)	8- 9-49
-12dcd	Tribal land	......do	L	S	1,855	.5(E)	8- 8-49
-13acd	Ft. Stevenson Military Reservation.	Head of coulee	L	S	1,770	.5(E)	8- 8-49
-17aad	Anna D. Wilde	Side of coulee	L	N	....	.5(E)	8-19-49
-17bbc	Byron Wilde	Bottom of small coulee	L	S	....	1 (E)	8-18-49
147-88-4cbb	Elizabeth Price	......do	C	S	....	1 (E)	9-22-49
-4dac	Mother Bed	Valley side	L	D	1,962	.7(M)	9-22-49
-5bcb	Philomena Felix	......do	L	D,S	1,926	15 (E)	9-22-49
147-88-9dbc	Polly Wells	Side of coulee	L	D	1,878	0.3(E)	11- 2-49
-9dbd	......do	Valley side	L	N	....	1 (E)	9-23-49
-11bad	Peter Beauchamp	Bottom of coulee, near head	L	S	1,920	4 (E)	8-28-49
-13cab	Sybert Perkins	Side slope	L(?)	N	1,819	.1(E)	8-22-49
-13cca	White Calf	Base of bluff	L	D,S	1,760	2.7(M)	8-22-49
-14bdd	Levi Waters	Side of coulee	L	S	1,822	2 (E)	8-26-49
-19bcd	Bull Head	Side slope	L	....	....	.5(E)	9-30-49
-22baa	Out of His Head	Head of coulee	....	S	....	1 (E)	9-22-49
147-89-4ccc	Otter Woman	Side of bluff	L	S	....	4 (E)	9-28-49
-11abd	Yellow Bird	Coulee	L	N	....	1.5(E)	9-26-49
-14bcb	Delia E. Bates	Side slope of draw	L	S	....	.2(E)	9-28-49

-14dbd	Sitting Bear	Steep terrace wall	L	N		1 (E)	9-28-49
148-87-32bdd	Mrs. John Sullivan	Head of small draw	L	N		2 (E)	11- 9-49
148-88-8bad	Yellow Bird	Valley flat, near head	L(?)		2,032	.5(E)	9- 7-49
-19cdb	Spotted Horse	Edge of draw	L(?)		2,001	.5(E)	11- 9-49
-28ccb	Last Child	Top of slope, edge of valley	L	S	2,036	.8(M)	11- 8-49
-31dbc[1]		Edge of draw	L	D,S	1,991	2 (E)	11- 8-49
-36cdd1	B. J. Youngbird	Bottom of small coulee	L	D	1,990	.3(E)	8-26-49
-36cdd2	do	Side of coulee	L	S	1,990	.2(E)	8-26-49
148-89-13ddb	Hattie B. Water	Bottom of small draw		N	2,070		10- 4-49
-22add	John Butcher	Bottom of draw, at side	L(?)	S		1.5(E)	10- 6-49
-24abb	Simon Shallop	Valley bottom, at side	L(?)	D,S	2,079	1 (E)	10- 4-49
-25abd	Chief in House	Base of slope	L	S	1,987		9-27-49
-26dad	Assinaboine Woman	Side slope, head of gulley	L		1,993	1 (E)	9-30-49
-29ccc	Tribal land	Side of bluff	L			.2(E)	12- 1-49
-29ccd	do	Side of bluff, head of draw	L	S		1.5(E)	12- 1-49
-32abd	do	Foot of bluff	L	S	1,896	1 (E)	12- 1-49
148-90-7cbc	Kate Charging	Coulee	L	S	1,923	7 (E)	10- 3-49
148-90-14cab	White Face	Bottom of coulee			1,984		10-17-49
-14ccc	do	do		S	1,953		10-17-49
-15acd	Ruthyn Carl Voight	Valley	A	S		3 (E)	10-20-49
-16abd	Blanche Fox	Valley bottom	A	S	1,976	1 (E)	10-31-49
-16cac	Mary Malnouri	do	L(?)	S		1.5(E)	10-25-49
-16cad	do	do	L(?)	S	1,938	7 (E)	10-24-49
-16cbb	Ruthyn Carl Voight	do	L	S		1 (E)	10-27-49
-16dcd	Buffalo Paunch	Side of coulee	L	D,S	1,904	5 (E)	12- 1-49
-18ccd1	Eugene Lee Voight	Edge of bottom of coulee	L	S		4 (E)	11-16-49
-18ccd2	do	Side of coulee	L	S	1,916; 1,878	3.5(E)	12- 1-49
-19bbb	State land	Coulee side slope	L	S		1.5(E)	11-21-49
-21aab[1]	Maggie Grinnell	Side of coulee	L	D,S	1,886	4 (E)	10-19-49
-25acd	Rattles Medicine	Side of bottom of coulee	L	S	1,868	1 (E)	10-10-49
-27dba	Harry Eaton	Side slope	L	S	1,833	1 (E)	10-14-49
-28acd	Margaret Hall	Edge of bottom of small coulee.	L	S		3 (E)	12- 7-49
148-91-11ddc	James Martin	High on side of deep coulee	L	S	1,856	.5(E)	11- 8-49
-12adc	George Charging	Edge of bottom of coulee	L	S	1,866	3.5(E)	10-31-49
-12bdd	Black Crow	Coulee	L	S	1,868	2 (E)	10-31-49

See footnotes at end of table.

Table 7.—*Records of springs*—Continued

Spring number	Owner	Topographic situation	Geologic source	Use of water	Altitude	Flow (gpm)	Date of observation
Eastern segment, McLean County, Continued							
-12cdb	Thomas Whitearm	Coulee	L	S	1,866	1 (E)	10-31-49
-13ddc	Thomas Blue Stone	Valley side	L(?)	S	1,904	.2(E)	12- 1-49
-24aac	Lillie Jane Sears	do	L	S	1,854; 1,834	5 (E)	11-15-49
Northeastern segment, McLean County							
149-90-16abc	Carl Whitman	Bank of Lucky Mound Creek		N		10 (E)	11-10-50
-16acc	Annie Youngbird	Creek bank	G			2.5(E)	11-28-49
150-90-4bca[1]		Northeast valley side	L	S		3 (E)	11- 8-50
150-90-4bcd		Northeast valley side	L	D, S		4 (E)	11- 8-50
-30aab	Mink	Gully mouth on east slope	Ss(?)	S		8.0(M)	11-13-50
150-91-24ddb	Tribal land	Gully on east bank of river valley	L	N		.8(E)	11-14-50
Northeastern segment, Mountrail County							
151-90-32bbc		Gully head on north valley slope	L	S		.2(E)	11-14-50
-32bca		Northeast valley slope	L	N		1.2(E)	11-14-50
Northern segment, McLean County							
150-91-8baa		Valley side	Gg	S		3.6(M)	5-17-51
-18bad	Lead Woman	do	L	S		.7(E)	5-17-51
-18bdb	do	do	L	S		.5(E)	5-17-51
Northern segment, Mountrail County							
150-92-8dda	Daniel Drags Wolf	Valley side	L	N		.8(E)	5-22-51
-9dab	Laura No Arm	Junction of two valleys	L	S		6.1(M)	5-22-51
-9dbc	Otter	West side of valley	L	S		4.0(M)	5-22-51
-12aca	Dorothy Stevenson	Valley side	L	S		3.5(M)	5-18-51
-16bac	Robert Dancing Ball	West side of small valley	Gg	S		3.0(M)	5-22-51
-22dad	Looking for Medicine	Head of gully	L	N		.2(E)	5-17-51
-27bbd	June Berries	Coulee	Gg	N		.1(E)	5-17-51
-34aad		River bluff	L	S		.8(E)	5-17-51

-34bbd		do.	L	S		.8(E)	5-17-51
-35bdc	Young Woman	Valley bottom	Gg	S		.8(E)	5-17-51
150-93-2abd	William Big Head	East side of valley	L	S		.4(M)	7-20-51
150-93-6adc	Mabel Evans	Valley side	L	S		6.0(M)	5- 9-51
-8aba	Dorothy Driver	do.	L	S		.1(E)	5- 9-51
-8bbb	Norman Eagle	Valley bottom	L	S		1.0(E)	5- 9-51
-9dbb1	Maggie Red Feather	Valley side		S		.1(E)	5- 9-51
-9dbb2	do.	do.		S		.1(E)	5- 9-51
-10acd	Laura No Arm	do.	L	S		.2(E)	5-10-51
-10cab	Otter	East side of valley	L	S		2.0(E)	5-10-51
-10daa	do.	Valley side		S		2.0(E)	5-10-51
-11bcc	Julia Horn	do.	C	S		1.0(E)	5-10-51
Southern segment, Dunn County							
146-91-4bdc		Wooded gully	Ss(?)	N		1.1(M)	10-24-50
-4cbb	Ole Christensen	do.	Ss(?)	N		2.1(M)	10-24-50
-5aca		Wooded valley forks	L	N		7.5(M)	10-30-50
-5bcb	Lester Crowsheart	Southeast end of small valley	L(?)	S		.6(M)	10-31-50
-5cba1[1]	Richard Crowsheart	Floor of small valley	L	N		.2(E)	10-30-50
-5cba2[1]	do.	South slope of small valley	L	S		6.4(M)	10-30-50
-6daa	Hides and Eats	North side of small valley	L	S		5.5(M)	10-30-50
-7ada1	Helen Whitecalf	East slope of valley	L	S		.5(M)	10-31-50
-7ada2	do.	Northeast side of valley	L	N		.2(E)	10-31-50
-7dac	Helen Crowsheart	East side of valley	L	N		3.4(M)	10-31-50
-7dca	do.	Northwest side of valley	L	N		.1(E)	10-31-50
-7ddb	do.	do.	L	N		.9(M)	10-31-50
-9dba		Northwest end of small valley	L(?)	S		.6(M)	10-25-50
-9dcd		Gully on northwest valley slope	Gg	N		.2(E)	10-25-50
-10acb	Lead Woman	Floor of valley		N		2.0(M)	10-25-50
146-91-10cbd		Small valley		N		1.1(M)	10-25-50
-14acd		Floor of valley	L(?)	N		1.6(M)	10-25-50
-17dbb		North side of swampy area	L	N		4.7(M)	10-31-50
-17dbc		East end of swampy area	L	N		2.8(M)	10-31-50
-18acd		East side of small valley	L	S		2.8(M)	10-31-50
146-92-2cbd	Leonard Smith	Stream bed	L	N		.2(E)	11- 7-50
-2dca	Geraldine Nagle	North side of valley	L	S		30.0(M)	6- 5-51
-11aca	Sarah Smith	Southwest side of valley	L	S		2.0(E)	5-28-51
-12bca	Mamie Smith	do.	L	S		5.0(E)	5-28-51

See footnotes at end of table.

Table 7—*Records of springs*—Continued

Spring number	Owner	Topographic situation	Geologic source	Use of water	Altitude	Flow (gpm)	Date of observation
Southern segment, Dunn County—Continued							
-12bcb	Mamie Smith	Southern side of valley	L	S	....	4.0(E)	5-28-51
-13ccc	....	West slope of valley	....	N	....	1.4(M)	11- 8-50
-14cda	....	North slope of wooded valley	Ss	S	....	.8(M)	11- 8-50
-15cba	Felicia Duckett	Wooded valley	L	S	....	1.1(M)	5-29-51
147-91-3abb	....	West slope of valley	L	S	....	2.2(M)	10-24-50
-3ccd	May Blanche Benson	South end of small valley	L	N	....	.6(E)	10-20-50
-8cad1	Julia Spotted Bear	North side of valley	L	N	....	.5(E)	10-27-50
-8cad2	do	Southeast end of gully	L	N	....	.2(E)	10-27-50
-8cca	do	South slope of valley	L	N	....	.1(E)	10-27-50
-12aaa	Susan Bull	South slope	L	N	....	.1(E)	8-25-50
-12bda	Margaret Bull	West slope	....	N	....	.1(E)	8-25-50
-12bdd	do	Head of gully on south slope	L	N	....	.7(M)	8-25-50
-14bbc	Medicine in the Woods	Northwest slope of valley	L	S	....	1.2(M)	10-20-50
-15abc	Zora Lincoln	Southeast slope of valley	L	N	....	.6(E)	10-20-50
-15bad	Robert Lincoln	Southwest end of valley	L	N	....	3.0(M)	10-20-50
-17dda	Theodore Spotted Bear	Fork of small valley	L	N	....	1.2(M)	10-27-50
-20cba	Claude M. Huber	Gully on west slope	L(?)	N	....	.3(E)	10-26-50
147-91-21bbc	Anton Wilhelm	South slope of small valley	L	N	....	.5(E)	10-27-50
-21bbd	do	do	L	S	....	1.2(M)	10-27-50
-21bdc	do	North slope of wooded valley	L	S	....	.4(E)	10-27-50
-22abb	Robert Lincoln	Junction of two valleys	L(?)	S	....	6.0(M)	10-23-50
-23bdb[1]	Jesse Ball	Floor of small valley	L	S, D	....	.5(E)	11- 6-51
-24acc	Eagle Woman	Base of east stream bank	Ga	D	....	.3(E)	10-23-50
-25bac	....	....	L	N	....	.5(E)	8-18-50
-25dad	Wolf Head	....	L(?)	S	....	4.2(M)	8-18-50
-26bdb	Maria M. Lincoln	Northwest gully slope	Ga(?)	S	....	.7(M)	10-23-50
-26cac	Charles Huber's children.	Southwest slope in gully	G(?)	S	....	13.3(M)	10-23-50
-29acd1	Ray C. Atkins	Southeast of wooded valley	L	D	....	.6(E)	10-26-50
-29acd2	do	Floor of small valley	L	N	....	.2(E)	10-26-50
-29ada	do	Northeast slope of wooded valley	L	S	....	1.2(E)	10-26-50
-31abd	Lester Crowsheart	North end of swampy area	L	S	....	8.5(M)	10-30-50
-31dcc	do	Southwest side of valley	L(?)	N	....	.2(E)	10-30-50

-32bcb	Edgar Crowsheart	Small wooded valley	L	N		.3(E)	11- 1-50
-33bca	Phillip Atkins		L(?)	N		.2(E)	10-26-50
-35bab	Charles Huber's children	Gully north of river		N		2.0(M)	8-23-50
147-92-3ddd	Louella Benson	Gully on west valley side	L	N		.1(E)	11- 4-50
-11bbb	Philip Benson	West side of valley	L	N		.2(E)	11- 4-50
-12dbb	Elizabeth Janice Grinnell	Stream bed floor	L	N		.2(E)	11- 4-50
-16bca	Victor Youngbear	Northwest side of valley	L	S		1.3(M)	5-25-51
-21bad	Sybert Perkins	Northeast side of valley	L	S		.6(E)	5-25-51
-23add		West end of deep cut gorge	L	N		1.8(M)	11- 7-50
-23bdd1	Suzie Charging	Mouth of wooded valley	L	N		1.5(M)	11- 7-50
-23bdd2	do	West slope of valley	L	N		.2(E)	11- 7-50
147-92-24dad	Felix Huber	Gully on east side of stream	L	S		1.0(M)	11- 6-50
-24dda	do	East side of valley	L	S		1.0(M)	11- 6-50
-25acb	Albert Charging	Gully on northwest valley side	L	N		.2(E)	11- 6-50
-25bcd	do	Fork of wooded valley	L	N		.5(E)	11- 6-50
-25bda	do	Gully on north side of valley	L	N		.1(E)	11- 6-50
-25cab		Northwest side of valley	L	S		.5(M)	11- 6-50
-26bcb	Nathan L. Soldier	West side of wooded valley	L	N		3.4(M)	11- 7-50
148-91-31dcd	Bug Woman	West end of small valley	L	N		.1(E)	10-27-50
-32ccc	Adolph Fox	South slope of small valley	L	N		.1(E)	10-27-50
		Southern segment, Mercer County					
146-88-5cdc	Gertrude Malnouri		L	N		.5(E)	8-16-50
-7dbd	Rattling Bird	Southeast slope of valley	L	N		3.0(M)	8-16-50
-8abb	Guy Bateman		L	S		.2(M)	8-16-50
-9bbd	Big Cheyenne		L			1.5(M)	8-16-50
146-89-8ada		Base of river valley slope		N		3.0(M)	8-15-50
-8bca		Head of south flowing tributary.		N		23.5(M)	8-14-50
-12cab		Southwest side of valley	L	S		1.0(M)	8-16-50
-13bda			L	S		1.5(M)	8-16-50
-14aca	Annie L. Sioux		L	S		.5(E)	8-16-50
146-90-5cdb	Joseph Chase			N		.8(M)	8-18-50
-7ddb		South facing river bank		N		.1(E)	8-23-50
-10bbc	Evan Webb Star	Creek bottom		S		1 (E)	8-23-50
147-88-31ccc	John Star	Gully behind house	L(?)	S		.3(E)	8-16-50
147-89-27ddb	Little Soldier		L	S		.3(E)	8-15-50
-28cca	Mathew Mason	Junction of two gullies	L(?)	S		1.5(M)	8-14-50

See footnotes at end of table.

Table 7.—*Records of springs*—Continued

Spring number	Owner	Topographic situation	Geologic source	Use of water	Altitude	Flow (gpm)	Date of observation
		Southern segment, Mercer County—Continued					
147-89-32bdb	....	Head of valley	....	S	....	2.0(M)	8-14-50
-35dac	....	....	L	S	....	1.8(M)	8-15-50
-36aad	Ella Rand	Base of high terrace	L	N	....	.2(E)	8-16-50
-36dab	....	....	A(?)	S	....	.8(M)	8-16-50
147-90-7dac1	Thomas Blackcrow	Southwest slope at gully head	L	S	....	1.0(M)	8-25-50
-7dac2	do	Southeast slope at gully head	L	N	....	.1(E)	8-25-50
-9ddc	Goes In Every House	East valley wall	L	N	....	4.7(M)	8-18-50
-10ddc	....	Northeast slope	L	N	....	.8(M)	8-18-50
-11cdd	Alfred Chase	Side slope of coulee	A(?)	S	....	.3(M)	8-14-50
-15cab	Assinaboine Woman	East slope near base	L(?)	S	....	4.9(M)	8-18-50
-18dbd	....	....	L(?)	N	....	.8(M)	8-17-50
-19acb	Joanna G. Sage	West valley slope	....	S	....	1.2(M)	8-17-50
-20bac	Ernest Medicine Stone	Southwest slope near base	L	S	....	1.9(M)	8-17-50
-21cba	Yellow Eagle	Junction of two valleys	....	S	....	3.5(M)	8-18-50
-22bad	Louise S. Chase	....	L	D, S	....	.3(M)	8-23-50
-27acd1	Christine Little Owl	Bottom of coulee	L	D, S	....	7.5(M)	8-23-50
-27acd2	do	North side of coulee	L	N	....	1.0(M)	8-23-50
-27dbc	Little Owl	Bottom of coulee	L(?)	N	....	2.5(M)	8-23-50
-30acc	....	North valley slope	L	N	....	.1(E)	8-18-50
-30dda	James Horn	Terrace base north of river	G	N	....	.9(M)	8-18-50
-36bbb	Cloud Chase	Bottom of draw	L	D, S	....	.9(M)	8-23-50
		Western segment, Dunn County					
147-92-5bdb	John Fredricks	River bluff	L	S	....	7.5(M)	6-29-51
147-93-15cac	Marjorie Packineau	North side of valley	L	S	....	.8(E)	7-11-51
147-94-3ada	Mary H. Wolf	Small valley	L(?)	N	....	.3(E)	7-19-51
-4dda[1]	Little Swallow	Junction of two valleys	....	D, S	....	8.1(M)	7-19-51
148-91-5abd	Black Chest	South slope of river bank	L	S	....	5.0(M)	9- 5-50
-5baa	do	Point of spur	L	N	....	.2(E)	9- 5-50
-7baa	David Grinnell	East bank	L	S	....	2.1(M)	9- 6-50
-7bac	do	do	L(?)	N	....	.2(E)	9- 6-50
-7bbd1	do	West bank	....	N	....	.3(E)	9- 6-50
-7bbd2	do	East side of valley floor	L(?)	S	....	2.2(M)	9- 6-50
-8bac	....	Base of north valley scarp	L	S	....	17.5(M)	9- 5-50
-8bbd	....	Head of small valley	L(?)	N	....	12.0(M)	9- 5-50

-8bdb		West slope of small valley		N		20.0(M)	9- 5-50
-17bdc	Joe Whitecalf	Southwest slope of valley	L(?)	N		7.5(M)	9- 5-50
-17dbb	Youngbear	South slope	L	S		.9(M)	9- 5-50
-18ada	Leo Standish	Head of wooded gully	Ss	N		.3(E)	9- 5-50
-19cbc	Robert Bird Bear	Gully head on west slope	L	S		4.5(M)	9- 7-50
-20abb	Crows Breast	Southwest slope of valley	L	S		5.2(M)	9- 5-50
148-92-1cbc	Pauline Charging	Base of north facing scarp	L	N		1.7(M)	9- 6-50
-1cbd	do.	North facing scarp	L	N		.3(E)	9- 6-50
-2aca	Luther E. Grinnell	North slope of butte	L	N		.7(M)	9- 6-50
-2adc	Pauline Charging	Top of north facing butte	L	N		1.7(M)	9- 6-50
-3bcd	Emma M. Baker	Southeast slope in grove		N		5.0(M)	9- 5-50
-4cbd[1]	Youngbear	North end of wooded gully	L	S		36.0(M)	9- 9-50
-6ddb		Southeast slope of wooded gully	L	S		4.7(M)	10- 3-50
148-92-7cca	Mathew Youngbird	North end of valley	L	S		3.3(M)	10- 4-50
-8bab		East slope of valley	L	N		.2(E)	10- 3-50
-9dbd	Youngbear	Gully on north valley slope	L	N		.3(E)	9-29-50
-11aca[1]		South side of butte	L	S		2.9(M)	9- 5-50
-11cdd	Freida Baker	Base of east bank	L	N		.2(E)	9- 6-50
-15aab	Samuel Youngbear	North bank of coulee	L	N		.1(E)	9-22-50
-15adb		West slope of coulee	L	N		.1(E)	9-22-50
-16cab		Bottom of valley		N		1.5(E)	9- 7-50
-16dbc		North slope of valley		N		5.1(M)	9- 7-50
-16dbd		Northeast slope of valley	L	N		.8(M)	9- 7-50
-21add		Gully on southwest bluff	L(?)	N		5.3(M)	9- 7-50
-23bbc	Peter Standish	Base west bank	L(?)	N		8.0(M)	9- 7-50
-23cbd		do.		N		.3(E)	9- 7-50
-25ada		Base of slope	L(?)	N		.2(E)	9- 7-50
-26abd		East side of valley	L(?)	S		2.4(M)	9- 5-50
-31ccb	Charles B. Hawk	Small valley	C(?)	S		6.0(M)	6-25-51
-34bab		Base of northwest river bluff	L(?)			2.6(M)	9- 7-50
148-93-1dac	Chippewa Woman	Valley head	Ss	S		23.8(M)	6-28-51
-5aaa	Little Crow	West valley slope	L	N		1 (E)	10-18-50
-9ccb	Ramona Hopkins, Sr.			S		.2(E)	6-28-51
-10aab	Albert Whitman	Valley head	L	S		2.2(M)	6-26-51
-11bab	Carl Whitman, Jr.	do.	L	N		2.0(E)	6-26-51

See footnotes at end of table.

Table 7.— *Records of springs*— Continued

Spring number	Owner	Topographic situation	Geologic source	Use of water	Altitude	Flow (gpm)	Date of observation
		Western segment, Dunn County—Continued					
-11bbc	Carl Whitman, Jr.	Valley head	L	N		1.5(E)	6-26-51
-15acc	Lloyd Howard	Valley side	L	N		1.0(E)	6-26-51
-17bdd[1]	Una Francis Eagle	do	L	N		2.5(M)	8- 3-50
-31dbd[1]	Agnes Everett	North side of valley		S		.2(E)	7-12-51
-31dcc	Anna Gordon	Side of bluff	L	D, S		3.0(M)	6-25-51
148-94-1bcc		Southwest valley slope	L	N		.2(E)	8-22-50
-1dcc	Yellow Wolf	Southeast side of coulee	L	N		.8(E)	7-10-51
-10bcc	Alice Bell	Side slope		S		.5(E)	7-10-51
-12aab	Lloyd Yellow Wolf	South side of valley	L	S		.3(E)	7-19-51
-12bad	do	Head of small valley	S	S		6.0(M)	7-19-51
-14bdc	Justina R. Baker	Valley floor		S		.5(E)	7-19-51
-23cbc	Evelyn D. Bateman	Head of gully		S		35.0(M)	7-19-51
-23ccc	do	Valley side		S		.5(E)	7-12-51
148-95-11aca	Alice Rush	Valley bottom	L(?)	S		.2(E)	7-12-51
-24acc	Little Wolf	End of small gully		S		5.0(M)	7-12-51
149-91-4caa	Brown Woman	Side slope of valley		S		4.5(M)	8- 9-50
-8aab	Alfred Goodbird	Valley bottom	L	N		6 (E)	8-10-50
-8aac	do	Side of valley	L	N		3.5(E)	8-10-50
-9bca	Edward Bird	Northwest slope	C	N		2.0(M)	8-30-50
-9bcb	do	Southwest slope	L	N		.8(M)	8-30-50
-10dac	Crow Turns	South slope	L	N		.1(E)	8-29-50
-15baa	Hester Yellow Wolf	do	L	N		.4(M)	8-29-50
-15cba	do	West slope of small draw	L	N		1.6(M)	8-29-50
-15dac	James Baker	Near top of north gully wall		N		4.8(M)	8-28-50
-15ddc	Hester Yellow Wolf	Near top of bluff	L(?)	S		2.6(M)	8-29-50
-16bac	Francis Charging	South slope in tree grove	L	D		6.7(M)	8-30-50
-16bca	White Fingernails	South slope	L	S		4.6(M)	8-30-50
-19dda	Trilby Bird	South slope in tree grove	L(?)	S		.9(M)	8-30-50
-23bca	Ree Woman	Head of gully	L	N		.9(M)	8-29-50
-23cad	Emily Yellow Wolf		L	S		.6(M)	8-29-50
-25bcc	Roderick Lonefight			N		1.0(M)	8-29-50
-26caa1	Howard Mandan	Spur between tributaries	L(?)	N		.1(E)	8-28-50

149-91-26caa2	Howard Mandan	Gully head on northwest slope	L	N	....	.1(E)	8-28-50
-26cab	........do	Gully head on southwest slope	L	N	....	.5(E)	8-28-50
-26dbd	....	South slope	....	....	....	2.1(M)	8-28-50
-27adb	Lucy Lonefight	West end of valley in woods	....	N	....	3.6(M)	8-29-50
-29aba	Sioux Woman	Southwest slope	....	N	....	2.8(M)	8-30-50
-29cdd	Edward Hale	Base of north slope	L	S	....	2.9(M)	8-30-50
-31baa	Stella Tail	Head of draw	....	N	....	7.5(M)	8-29-50
-31ccd	Lucy Wolf	Gully head in woods	....	N	....	3.8(M)	8-29-50
-32ccc	....	Valley flat	....	N	....	2.2(M)	8-30-50
-34ddb	All Blossoms	Southwest slope	L	N	....	.3(E)	9- 5-50
-35abc	Snake Comes Out	North slope	L	N	....	1.5(M)	8-28-50
-35aca	....	North bank of creek	L	N	....	.1(E)	8-28-50
-35acb1	....	West slope of valley	L	N	....	.7(M)	8-28-50
-35acb2	....	Base of south slope	L	N	....	.4(E)	8-28-50
-35bac	Last Child	Near base of valley slope	L	N	....	.1(E)	8-28-50
-35dba	Beaver Woman	South valley slope	L	N	....	.6(M)	8-28-50
-36bcc	Lucy Ribs	North slope	L	N	....	.1(E)	8-28-50
-36ccd	....	Base of north slope	L	N	....	1.3(M)	8-28-50
149-92-1dad	....	East valley slope	L	N	....	3.2(M)	9-26-50
-3ddd	Ada Jeanette Smith	East slope of Skunk Creek	L	S	....	.5(M)	9-26-50
-5cab	Celina Wilkinson	East slope of canyon	L	N	....	1 (E)	10- 5-50
-6bba	Carlyle Stevenson	West valley wall	L	N	....	3.5(E)	10-17-50
-7acd	Ernest Wilkinson, Jr.	West valley slope	L	N	....	6.1(M)	10- 4-50
-8abd	Joseph Ward	East valley slope	L	N	....	2.8(M)	10- 5-50
149-92-8bdd	Augustus Wilkinson	Southwest slope of hill	L	N	....	.2(E)	10- 4-50
-9ddd	....	East slope of small valley	L	N	....	.1(E)	9-27-50
-13abb	Maggie Baker	East slope of valley	L	N	....	2.5(M)	9-26-50
-13aca	........do	South valley slope	....	N	....	2.6(M)	8-30-50
-14bcc	Hugo Lawrence	East valley bank	L	N	....	1 (E)	9-28-50
-15caa	....	East valley slope	L	N	....	.1(E)	9-28-50
-15cac1	Evelyn Gertrude McKinley	........do	L	N	....	1.7(M)	9-26-50
-15cac2	........do	........do	L	N	....	.2(E)	9-26-50
-15cac3	........do	East slope of small valley	L	N	....	.1(E)	9-28-50
-15ccb1	........do	Base of southwest slope	L	N	....	8.0(M)	9-26-50
-15ccb2	........do	South slope	L	N	....	.1(E)	9-28-50
-16bab	Young Beaver	Bottom of small canyon	L	N	....	1.4(M)	10- 4-50

See footnotes at end of table.

Table 7.—*Records of springs*—Continued

Spring number	Owner	Topographic situation	Geologic source	Use of water	Altitude	Flow (gpm)	Date of observation
Western segment, Dunn County—Continued							
-16ccc	Jessie Whiteowl	East valley slope	L	N		0.4(E)	10-11-50
-16ddd		East slope of tributary valley	L	N		6.0(M)	9-28-50
-17aab		Bottom of valley	L	N		.1(E)	10-4-50
-19ddc	Ruth Whiteowl	South slope of tributary valley	L(?)	N		3.2(M)	10-13-50
-21aac	Simon Whiteowl		L	N		.2(E)	10-10-50
-21abc	do	West end of valley spur	L	N		.2(E)	10-10-50
-21bda	do	North end of spur	L	N		3.6(M)	10-10-50
-21daa	Whiteowl	Southwest side of valley	L(?)	N		.3(E)	10-10-50
-22bac	Grace B. McKinley	Head of small draw	L	N		.1(E)	9-28-50
-22bbb	do	West slope of tributary	L	N		.1(E)	9-26-50
-22bbd	do	East slope of valley	L	N		.1(E)	9-28-50
-22bda	do	West slope of coulee	L	N		.1(E)	9-28-50
-25bcc1		West slope	L	N		.1(E)	8-30-50
-25bcc2		do		N		.5(E)	8-30-50
149-92-25cdc		West-southwest valley slope		S		7.5(M)	8-30-50
-26cac	Lawrence Baker	Near bottom of draw	Ss(?)	N		1.7(M)	9-29-50
-26cbd	do	Floor of wooded draw	Ss(?)	N		4.1(M)	9-29-50
-27bbb	Simon Whiteowl	Bank of valley	L	D, S		50.2(M)	10-10-50
-27caa	Guy Blackhawk	Bottom of wooded draw	L	N		3.4(M)	9-28-50
-30cab[1]	Alfred Goodbird	Valley flat	L	S		55.0(M)	8-31-50
-33aba	Nellie Bull		Ss(?)	N		24.8(M)	10-11-50
-33aca	do	Southwest bank of small valley	Ss	N		5.4(M)	10-11-50
-33acb	do		Ss	N		8.6(M)	10-11-50
-33bbc	do		Ss	N		3.2(M)	10-11-50
-35bac	Philip Baker	Bottom of draw	L	N		[2]30 (E)	8-30-50
-35bda[1]		South slope of wooded draw	L	N		[2]80 (E)	8-30-50
-36bab		Bottom of wooded gully		D, S		1.0(M)	8-30-50
149-93-1ccd	Paul F. Beston	Spur between two valleys	L	N		1.7(E)	9-16-50
-1cdd1	Caroline Stevenson	East slope of valley	L	N		2.0(M)	10-16-50
-1cdd2	do	do	L	N		1.0(M)	10-16-50
-2bab	Catherine Vivian Goodbear	West side of valley flat	L	N		.5(E)	10-12-50
-2bca	do	Valley bottom	L	N		2.7(M)	10-12-50
-2dbc	Lawrence Kingdon Goodbear.	Bottom of small valley	L	N		3.0(M)	10-12-50

-4dda		Head of valley	L	N		2.8(M)	8- 7-50
-10cdd	Harry Levings	South end of gully	L	N		1.8(M)	10-17-50
-11cdc		Tributary valley		N		.7(E)	10-17-50
-11cdd		North slope of main valley		N		2.0(M)	10-17-50
-11dab	Agnes Dancing Bull	West end of small valley	L	N		.2(E)	10-17-50
-12aaa1	Alice Horn	South slope of valley	L	N		.4(E)	10-16-50
149-93-12aaa2	Alice Horn	West slope of valley	L	N		.2(E)	10-16-50
-12acc	do	West side of valley flat	L	N		13.5(M)	10-17-50
-12acd	do	East side of valley	L	N		.3(E)	10-17-50
-14ada	William Weeks	Bottom of small draw	L	N		.5(E)	10-17-50
-14dab		Bottom of draw	L	N		.8(E)	10-17-50
-16bbb	Jack Lonefight, Jr.			S		.7(E)	8- 7-50
-18adb	Blackeagle	Head of valley	L	N		3.0(M)	8- 2-50
-20bdb	Guy Fox	Base of small bank		N		1.6(M)	8-22-50
-21ddc	Chester Smith		L	S		3 (E)	8- 8-50
-23aba		West slope of valley	L	N		11.0(M)	10-17-50
-26aaa	Paul Wolfchief	Northwest side of marshy area		N		6.8(M)	10-18-50
-26dcb		North end of small valley		N		5.2(M)	10-18-50
-29bcd	Bessie B. Fox		L(?)	S		4.3(M)	8- 8-50
-31acd		Slope		N		.1(E)	8-22-50
-31bba		West slope of tributary valley	L(?)	N		4.0(M)	8-22-50
-31cbc	Whitecorn	Base of south slope	L	N		1.5(M)	8-22-50
-32bbb	Bessie B. Fox	Valley flat		N		4 (E)	8- 8-50
-32bcc	Youngfox		S			5 (E)	8-22-50
-32cbc	Whitecorn	Head of water grass in gully	L(?)	N		1.0(M)	8-22-50
-32cdd	Joseph Stinkface		L	N		2.2(M)	8-22-50
-33aac		West slope of valley	L	N		.2(E)	10-18-50
-34cbb	Bernice Smith	Northeast slope of valley	L	N		.5(E)	10-19-50
-34ccc	Joseph Stinkface	Southwest slope of valley	L	N		1 (E)	10-19-50
-34cdc		Northeast slope of valley	L	N		.1(E)	10-19-50
-35dac		Northwest end of gully	L(?)	N		.6(E)	10-18-50
-35ddc	Turtle Woman	Base of northwest slope	L	N		.7(E)	10-18-50
150-93-19bac		East side of valley	L	N		.5(E)	8- 1-50
-19dcd	Alfred Old Dog		L	N		.1(E)	8- 1-50
-30ccc	Edward Bracklin	South side of valley	L	N		2 (E)	8- 1-50
Western segment, McKenzie County							
149-94-3aba[1]		West side of valley	L	N		1.6(M)	7-28-50
-6acd		Side and head of short valley	L	N		.7(E)	7-28-50

See footnotes at end of table.

Table 7.—*Records of springs*—Continued

Spring number	Owner	Topographic situation	Geologic source	Use of water	Altitude	Flow (gpm)	Date of observation
Western segment, McKenzie County—Continued							
-8dab		North side of valley	L	S		0.7(E)	7-28-50
-15ccd[1]	Vivian Lonefight	North side of main valley	L	N		1.7(M)	11- 2-50
-16caa	Thomas P. Packineau	East slope of valley	L	N		6.0(M)	9-21-50
-16cab	do.	Small ravine entering valley	L	N		5.0(M)	9-21-50
-16cac		North slope of broad valley	L	N		5.8(M)	9-21-50
-17ddc		South slope of broad valley	L	S		3.0(M)	9-20-50
-18adc	Plenty Sweetgrass	Floor of valley	L	N		.1(E)	9-19-50
-18dab	George Harris	Northwest bank of stream		N		.1(E)	9-19-50
-19caa	Kale Badbrave	East valley bank		N		3 (E)	9-19-50
-21adb	Arthur Mandan	Southwest side of large valley	L	N		2.4(M)	11- 2-50
-21bab	Ruth Packineau	do.		N		2.5(E)	11- 2-50
-29ada1	Arthur Bradfield	East side of wooded valley	L(?)	N		5.5(M)	11- 2-50
-29ada2	do.	Fork of wooded valley	L	N		.5(E)	11- 2-50
-33aca	Elsie Smith	South bank of valley		N		.8(M)	11- 3-50
-33bdd	Samuel Smith	Large marshy area	Ss(?)	N		10.0(M)	11- 3-50
-33dba	Elsie Smith		Ss(?)	N		1.0(M)	11- 3-50
-36caa1	Valerian Goodbear	Base of north side of hill	L	N		15.0(M)	8-22-50
-36caa2	Goodbear	West slope of valley	L	S		2.2(M)	8-22-50
-36dad[1]	do.	South slope of valley	L(?)	S		6.5(M)	1950
149-94-36dbb[1]	Goodbear	Kennedy's Camp	L	S		6.7(M)	1950
150-94-3cad	Louise Standing Soldier Chase	Northeast slope	L	N		2 (E)	7-12-50
-3dba	do.	Southeast slope	L	N		.5(E)	7-12-50
-6dbc	Medicine Crow	Valley bottom	L	N		2.0(M)	7-26-50
-7bbd	Bears Opinion	Valley floor	L	N		.3(E)	7-26-50
-12bdb		West slope	L	N		6 (E)	7-11-50
-18cdb	Joseph Gough	Mouth of tributary	L	N		9 (E)	7-25-50
-18cdd	do.	West bank	L	N		4.7(E)	7-25-50
-18dab		Near base of north bank	L	N		1.5(E)	7-25-50
-19cdc		South side of Bear Den valley	L	N		2.0(M)	7-27-50
-22bcc		Near base of valley slope	L	N		.7(E)	7-28-50
-23bcb		West side of valley	L	S		3.0(M)	7-28-50
-30bba	John Birdsbill	South side of Bear Den	L	N		3.0(M)	7-27-50
150-95-1aaa	Yellow Hair	West side of gully	L	N		.7(E)	7-20-50

-12aad	Scabby Elk	North end of gully	L	N	...	.5(E)	7-26-50
151-94-1abc	Harry Huntsalong	Valley bottom	L	N	...	22.0(M)	9-12-50
-1acb	...	Valley floor	L	N	...	5.7(M)	9-13-50
-1dbb	Mark Huntsalong	do	L	N	...	4.3(M)	9-13-50
-1dcb	do	...	L	N	...	.1(E)	8-13-50
-4aaa	Henry Dragswolf	Base of west valley slope	L	N	...	5.0(M)	9-12-50
-6bbd[1]	Ralph Wells, Jr.	North side of creek	L	N	...	2 (E)	9-11-50
-6bd	do	Where Clark Creek cuts lignite	L	N	...	180.0(M)	9-11-50
-6bdd	do	North side of creek	L	N	...	9.8(M)	8-11-50
-7baa	Mabel Marsh	North slope	L	N	...	.7(E)	7-24-50
-7bac	...	Base of north slope	L	N	...	4.9(M)	9-12-50
-14acd	Nora Jones	West valley slope	L	N	...	.5(E)	7-11-50
-14add	...	Alluvial flat	...	N	...	.2(E)	9-12-50
151-94-19cdb	Martha Heart	Base of slope	L(?)	N	...	1.5(E)	7-24-50
-19dda	Suzie Heart	Near top of bank	L(?)	N	...	7.0(M)	9-12-50
-22dca	White Body	Base of valley side	...	S	...	7.0(M)	9-12-50
-23dac	Francis Wm. Deane	Northwest valley slope	L	N	...	1.0(M)	7-11-50
-24baa	...	West cut bank of road	L	N	...	2.0(M)	7-11-50
-24bca	...	West slope of hill	L	S	...	8.0(M)	7-11-50
-28aaa	May Dickens Bird Lying Down.	Valley floor	L	N	...	1 (E)	7-18-50
-30bdd	Grace Parshall	Near top of west bank	L	N	...	.7(E)	7-20-50
-31adb	Arlene Whitearm	Northwest slope of small valley	L(?)	N	...	.5(E)	7-20-50
-31daa1	Ruby W. Parshall	North slope of gully	L	N	...	.5(E)	7-20-50
-31daa2	do	Valley floor	L	N	...	.3(E)	7-20-50
-33abc	...	West slope	L	N	...	3 (E)	7-12-50
-35ada	Joseph White Body	do	L	N	...	4 (E)	7-11-50
151-95-25daa	...	Top of west bank	L	N	...	1 (E)	7-20-50
152-93-15bdc	Dragswolf	South slope of small valley	Gg	N	...	3.5(M)	9-15-50
152-94-7dcd	...	...	L	N	...	2.5(E)	6-21-50
-7ddb	Richard Younghawk	Valley floor	L	N	...	2.5(E)	6-21-50
-15cbb	Rose Hopkins	Side of gully	L	N	...	.5(E)	6-23-50
-18aac	Richard Younghawk	Side of gully bottom	L	N	...	3 (E)	6-21-50
-18cba	Wolf Ghost	...	Gg	N	...	5 (E)	6-21-50
-21cab	...	West slope of gully	L	N	...	.3(E)	6-23-50
-22aba	...	Slope of valley	L	N	...	2.5(E)	6-28-50
-25abb	...	Valley floor	...	N	...	2 (E)	6-30-50
-36aac	...	Side slope of valley	L	N	...	4.8(M)	9-13-50

[1]Chemical analysis made.
[2]Combined flow of springs 149-92-35bac and 149-92-35bda measured 110 gpm.

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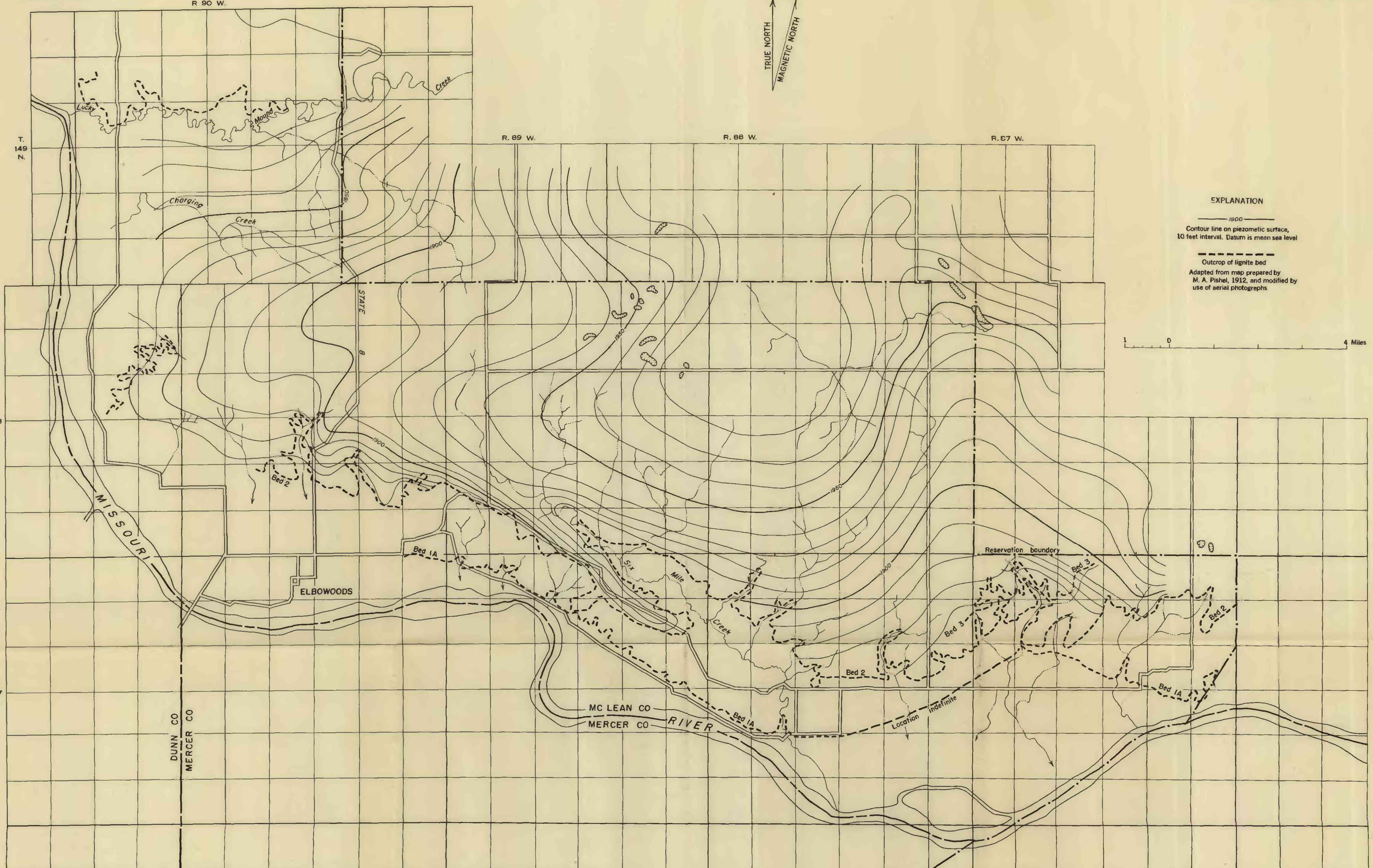
MAP OF FORT BERTHOLD INDIAN RESERVATION, NORTH DAKOTA, HOWING AREAL GEOLOGY AND LOCATION OF WELLS, SPRINGS, AND BENCMARKS



Base map adapted from Mc Lean County highway transportation map

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MAP OF EASTERN SEGMENT OF FORT BERTHOLD INDIAN RESERVATION SHOWING CONTOURS OF THE WATER TABLE ABOVE LIGNITE BED 2, FALL 1949