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GROUND-WATER FACTORS AFFECTING THE DRAINAGE OF AREA IV FIRST DIVISION, BUFFALO RAPIDS IRRIGATION PROJECT MONTANA

By E. A. Moulder, A. E. Torrey, and F. C. Koopman

UNITED STATES DEPARTMENT OF THE INTERIOR
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ABSTRACT

A drainage investigation of Area IV, First Division, Buffalo Rapids project, Montana, was conducted during the summer of 1950. The purpose of the study was to collect and interpret the geological and hydrological data that are needed for the design and construction of proper drainage facilities on waterlogged land.

Most of the area covered by this report consists of three flat to gently sloping stream terraces that border the Yellowstone River. The lower two terraces are irrigated at the present time, and the higher terrace is proposed for irrigation. The exposed bedrock consists of shale and sandstone beds of the Fort Union formation.

Natural surface drainage in most of the lower terrace is inadequate to prevent waterlogging. The ground water in the lower terrace area is derived principally by underflow from the upper two terraces, which are recharged by precipitation, irrigation, and canal leakage.

Data obtained from a pumping test provided the information on permeability that was necessary for the determination of the quantity and velocity of ground-water flow.

Open drains sufficiently deep to drain effectively the ground water in the waterlogged area are not considered economically feasible by the Bureau of Reclamation; consequently, relief wells spaced along a shallow open drain are recommended as a means of lowering the water table in the waterlogged area.

Supplementary data on the quality of ground water are included in this report.

INTRODUCTION

Location and extent of area

The First Division of the Buffalo Rapids irrigation project is in Dawson and Prairie Counties in eastern Montana. (See fig. 1.) It extends along the west bank of the Yellowstone River from 2 miles northeast of Fallon to 1 mile north of Glendive. The principal creeks have been used as boundaries to subdivide the project into ten separate areas numbered as shown in figure 2. Ground-water conditions in Area IV, T. 14 N., R. 54 E., are described in this report. The ground-water conditions throughout the project will be described in a forthcoming report.

Purpose and methods of investigation

Severe drainage problems have developed throughout the First Division of the Buffalo Rapids irrigation project. Because ground-water conditions are among the important factors that must be considered if the waterlogged land is to be reclaimed by drainage, the Bureau of Reclamation requested the Ground Water Branch of the U. S. Geological Survey to collect and interpret the geological and ground-water data necessary for the

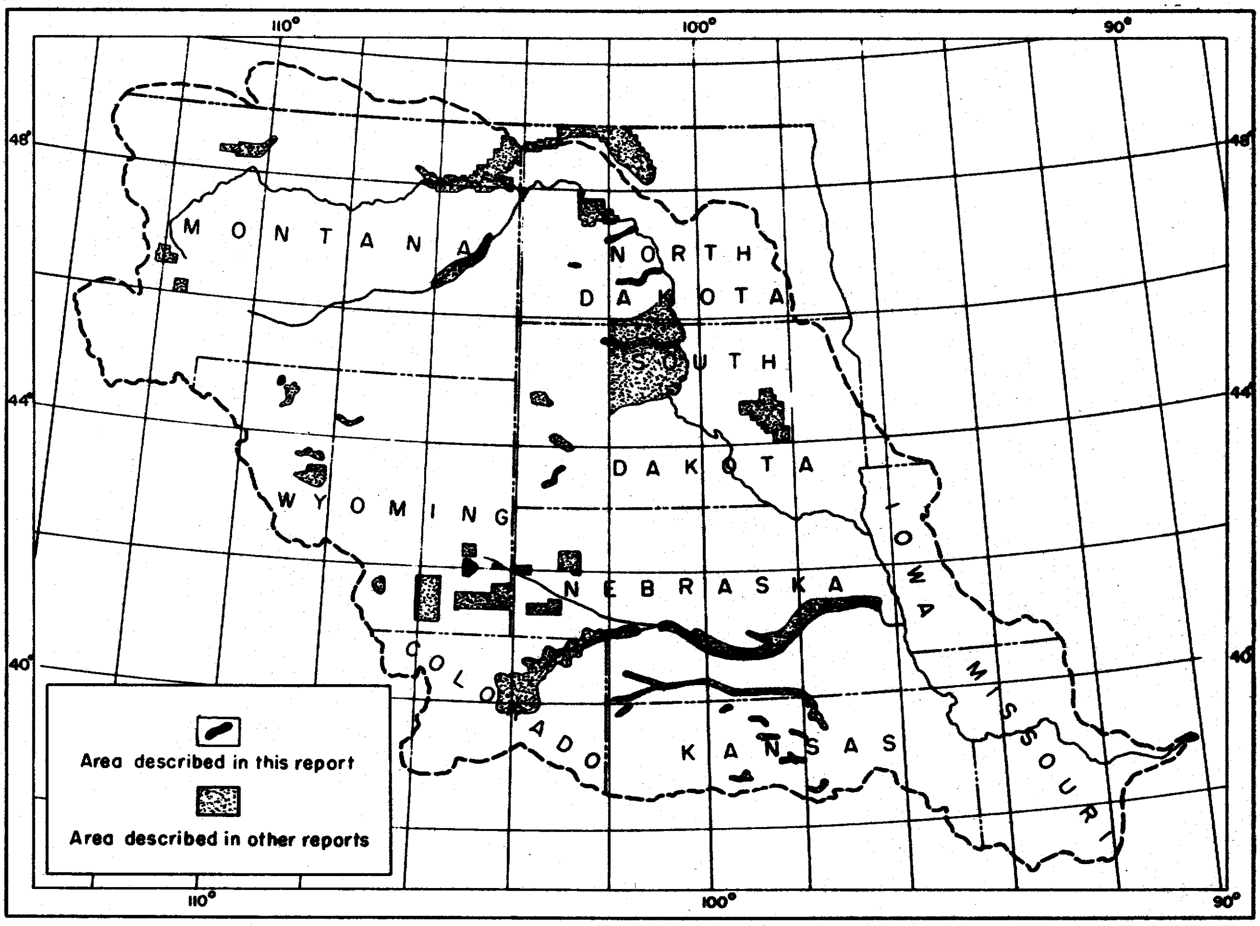

Figure 1.--Map of the Missouri River basin showing areas in which ground-water studies have been made under the Missouri basin development program.

design and construction of proper drainage facilities.

During the course of the investigation, the Geological Survey constructed a total of 85 test holes in order to determine the depth, thickness, and lateral extent of the water-bearing beds; 60 of the test holes were cased for permanent use as water-level observation wells. (See pl. 1.) The depth to water in most of the test holes was determined by the wetted-tape method. The altitude of the measuring points was determined by instrumental leveling,and contour maps of the ground-water surface for two dates were prepared. This information made it possible to locate the important areas of ground-water recharge and discharge and to determine the direction of ground-water movement. The coefficients of transmissibility and storage of the principal water-bearing beds were obtained by the pumping-test method.

The investigation was under the general supervision of A. N. Sayre, chief of the Ground Water Branch of the Geological Survey, and of G. H. Taylor, regional engineer in charge of ground-water investigations under the Missouri River basin development program. F. A. Swenson, district geologist, was in immediate charge of the field studies.

Previous investigations

A preliminary soil and drainage investigation of unit 61 (see fig. 2 for location) was made in the spring of 1948 by R. C. McConnell, of the Soil Conservation Service of the U. S. Department of Agriculture. At the time of this study, a large part of the land on this farm unit could not be farmed because of poor drainage. In his report on this investigation, McConnell suggested that further studies be made to determine the source and amount of ground-water recharge.

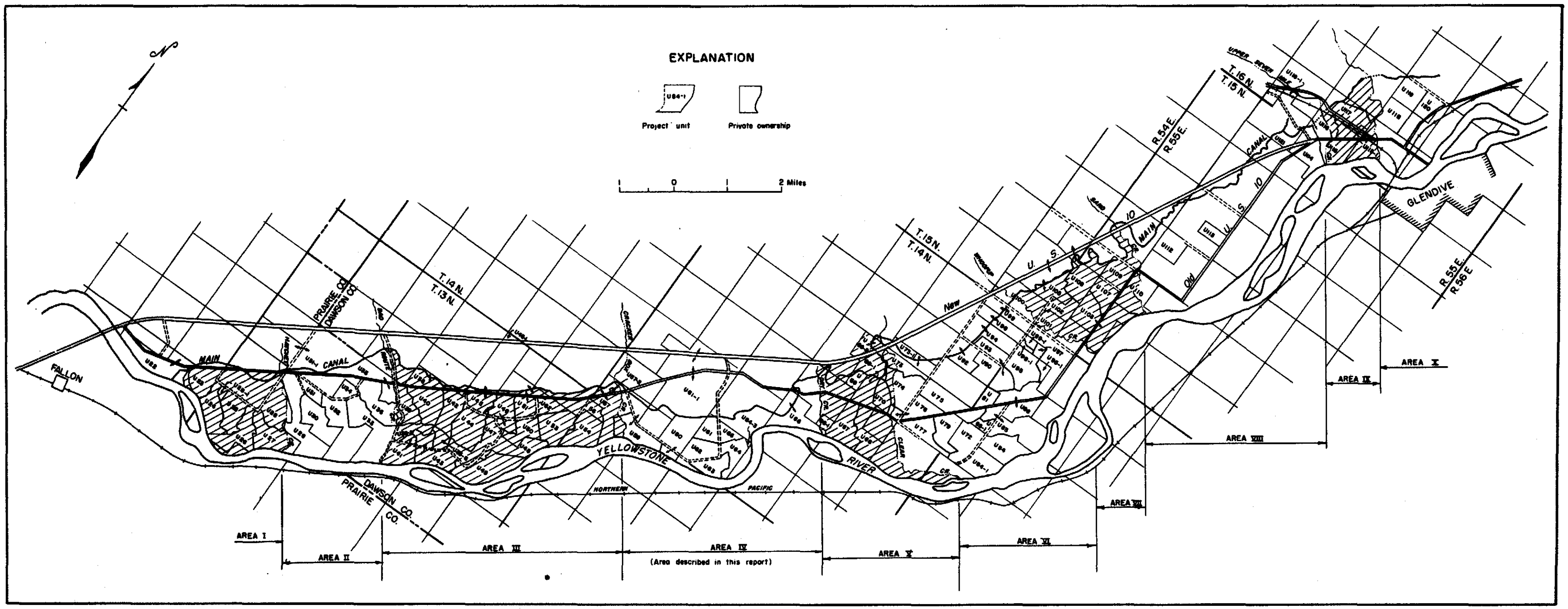

Figure 2.--Map of First Division, Buffalo Rapids project, Montana, showing areas covered by this investigation. (Based on map of farm units prepared by Soil Conservation Service, U. S. Department of Agriculture.)

A general investigation of the ground-water resources of the Yellowstone River valley between Miles City and Glendive was made in 1948 by A. E. Torrey and F. A. Swenson (1951) of the Geological Survey. This report recommended that detailed drainage studies of the waterlogged areas be made prior to the construction of drainage facilities. These and other references that were useful in this study are listed at the end of this report.

Acknowledgments

Personnel of the Bureau of Reclamation cooperated to the fullest extent in many of the field activities. William Harkin, of the Soil Conservation Service, supplied several maps and other pertinent data. Records of irrigation-water use and of crop yields were provided by Ford Martin, manager of the Buffalo Rapids Farm Association. Weather data were made available by Barney Nelson, weather observer at Terry, Mont.

The following Geological Survey personnel provided technical and analytical assistance to the writers: J. G. Ferris, district engineer, Ground Water Branch, Lansing, Mich.; A. I. Johnson, hydraulic engineer, Ground Water Branch, Lincoln, Nebr.; and P. C. Benedict, regional engineer, Quality of Water Branch, Lincoln, Nebr. E. A. Busch and party installed most of the observation wells, and F. E. Busch and party determined the altitude of the measuring point of the observation wells by instrumental leveling.

The cooperation of the farmers in the area made possible the smooth operation of field activities.

Well-numbering system

Each observation well, auger hole, trench or other type of test hole has been assigned two numbers. The temporary or field number of each is shown on plate 1. In general the lines of test holes are identified by letters in alphabetical order in a downstream direction, and the holes on each line are numbered in order in a direction away from the main canal. The cased observation wells were assigned whole numbers; the intermediate auger holes were given fractional numbers that indicate the relative position of the hole between observation wells. Wells and holes not on the lines were assigned numbers that indicate either their relative position to the lines or their functional part in the investigation.

A permanent number also was assigned to each well and test hole in accordance with a system that is based on the Bureau of Land Management survey of the area. The first number of the well number indicates the township, the second the range, and the third the section in which a well is located. The lower-case letters that follow the section number show the location of the well within the section. The first letter denotes the quarter section and the second the quarter-quarter section or 40-acre tract. The letters are assigned in a counterclockwise direction and begin in the northeast quarter of the section or quarter-quarter section. If more than one well is located in a 40-acre tract, consecutive numbers beginning with one are added to distinguish the individual wells. (See fig. 3.)

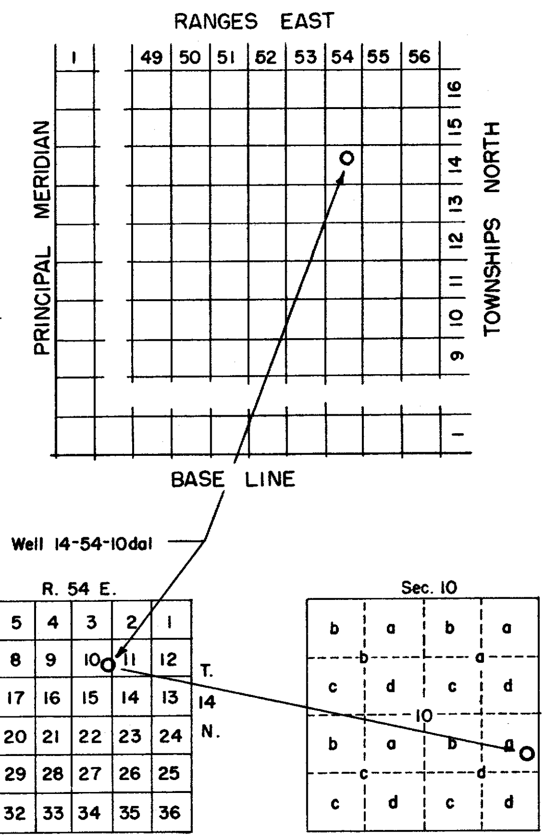

Figure 3.--Sketch showing well-numbering system.

GEOGRAPHY

Climate

The climate of east-central Montana is semiarid and is characterized by wide deviations from average precipitation and by a wide range in temperature. The following discussion is based on records that have been kept since 1890 by the weather station at Glendive.

The average annual precipitation at Glendive for the 60 years of complete record is 14.42 inches. The total annual precipitation has ranged from 4.83 inches (1934) to 26.02 inches (1916). If the driest months during the period of record (that is, the driest January, the driest February, etc.) were to occur in a single year the total annual precipitation at Glendive would be only 0.83 inch; likewise if the wettest months in this period were to occur in a single year, the total annual precipitation would be 45.79 inches.

The graph showing the cumulative departure from average precipitation at Glendive (fig. 4) indicates the long-term deficiencies and excesses of precipitation. The wet period that began, or was in progress, in 1890 reached its climax in 1916, when the total cumulative excess of precipitation was about 41 inches. The dry period that began in 1917 reached its climax in 1941, when the cumulative deficiency of precipitation was about 2.5 inches. Several years of below-average precipitation occurred between 1890 and 1916; likewise several wet years appeared in the dry cycle that reached its climax in 1941. Since 1941, the precipitation in the area has been about average. The precipitation for 1950, as recorded at the weather station in Terry, was 12.63 inches. (See fig. 5.)

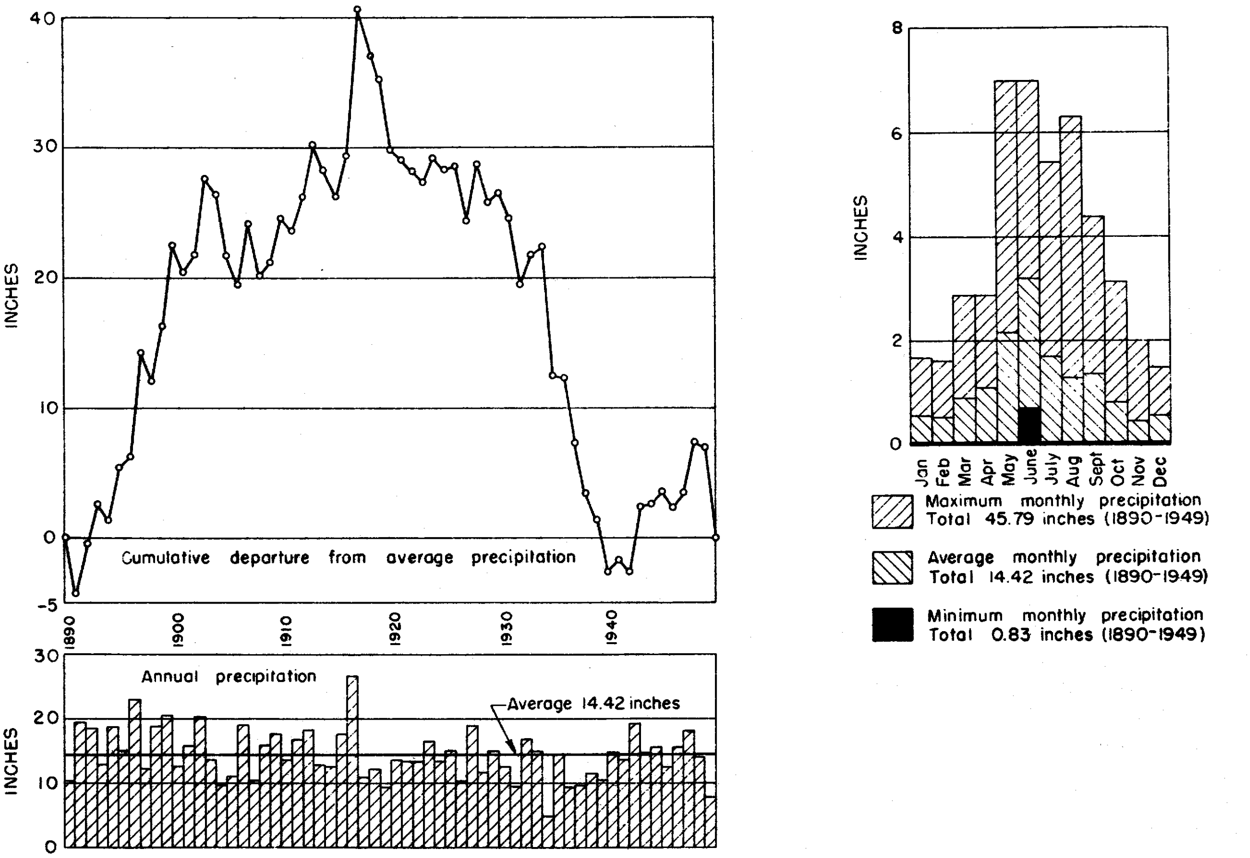

Figure 4.--Precipitation records at Glendive, Mont., 1890-1949. (From records of the U. S. Weather Bureau.)

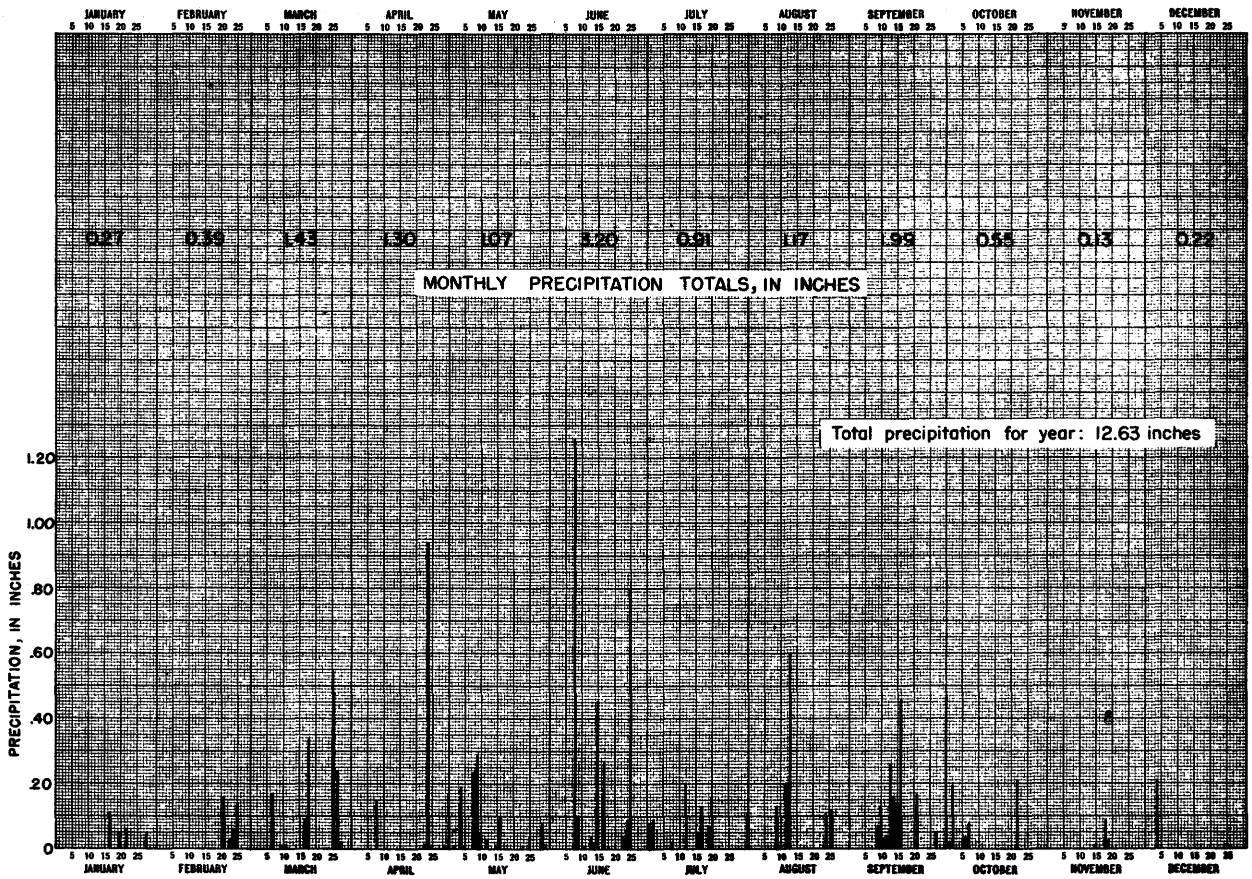

Figure 5.--Daily precipitation at Terry, Mont., 1950.

Land use

The Bureau of Reclamation started construction of the First Division of the Buffalo Rapids irrigation project in 1937, and the first irrigation water was delivered to some of the units in 1940. The area described in this report was developed for irrigation in 1942 and was first irrigated in 1943. The water delivery from 1943 to 1947 averaged about 1,000 acre-feet per year on about 670 acres of irrigable land (Buffalo Rapids Farm Assoc., 1943-47). The crops raised during that period were alfalfa, sugar beets, potatoes, beans, corn, oats, and barley. Good yields were recorded from 1944 to 1946, but in 1947 the yield of alfalfa dropped from an average of $1\frac{1}{2}$ tons to an average of $\frac{1}{2}$ ton per acre and the yield of sugar beets dropped from an average of 12 tons to an average of 8 tons per acre on units 61 and 65. (See fig. 6.) This drop in yield was due partly to waterlogging, which prevented harvesting part of the crop area. These units were not cultivated in 1948; unit 62, according to reports, was not cultivated in 1950 because the land was too wet for seeding. The wet areas first developed below the main canal at the northern edge of the cropped area and expanded toward the river. At the present time, the waterlogged area occupies about 190 acres, and an additional 240 acres are reported to be too wet for spring planting or for crop harvesting. The amounts of irrigation water applied to Area IV and the acreage irrigated in 1950 are shown in the table below figure 6.

The land bordering the Yellowstone River is subject to flooding during high river stages and for this reason is used primarily for pasture.

Topography

Three terraces, ranging in height from 20 to 190 feet above the river, are prominent

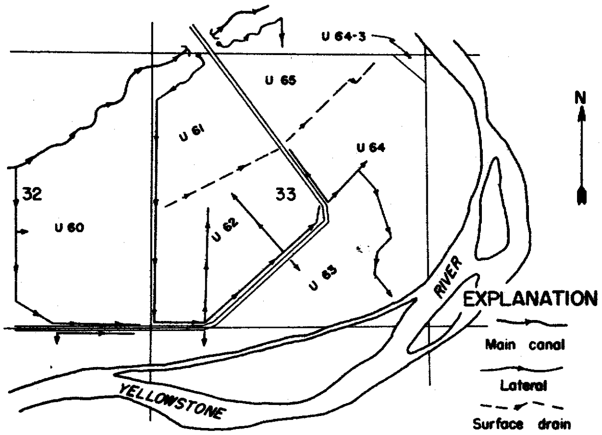

Figure 6.--Map showing farm units, Area IV, First Division, Buffalo Rapids project, Dawson County, Mont.

Irrigation water applied to Area IV, First Division, Buffalo Rapids project, Dawson County, Mont., 1950

Farm unit	Period	Acre-feet delivered	Acreage irrigated
60	July 13-16.....	7.04	14.08
	July 16-Aug. 14	84.09	168.18
	Aug. 22-30.....	24.81	49.62
	Sept. 26-Oct. 2	11.75	23.50
	Total........	127.69	255.38
63	July 20-Aug. 15	118.44	236.88
	Sept. 4-6......	12.17	24.34
	Total........	130.61	261.22
64	July 20-Aug. 15	62.69	125.38
	Sept. 4-6......	8.92	17.84
	Total........	71.61	143.22

physiographic features of the area covered by this report. Each terrace is a remnant of a former flood plain that was developed by the stream when its rate of downcutting was temporarily slowed or halted. During each such period the valley was broadened by the lateral cutting of wide-sweeping meanders. In the subsequent periods of rapid downcutting, the river carved a new channel into its former flood plain. The river then developed a new flood plain at a lower level. At the eastern end of the area described in this report the lower two terraces have been removed by river erosion, and the river now impinges directly against a sheer cliff that rises 150 feet above the river.

GEOLOGIC FORMATIONS AND GENERAL GROUND-WATER CONDITIONS

Rocks ranging in age from Paleocene to Recent are exposed in Area IV. A generalized section of the geologic formations is on the following page.

Fort Union formation

The Fort Union formation of Paleocene (Tertiary) age is the only bedrock exposed in the area. It is a continental deposit and consists of yellowish-gray to buff clay, shale, and sandstone, and lignite and carbonaceous shale. The shale, clay, and sandstone beds are irregular in their distribution and extent. Individual beds are lenticular; a large massive sandstone may grade laterally into shale, and a sequence of shale beds in one area may grade into one or more sandstone beds elsewhere. The Fort Union formation is exposed in the sheer cliff at the east end of the area, in banks of tributary valleys, and in the slope between the second and third terraces above the river. All water-bearing strata of any consequence are located below river level and are unlikely sources of recharge to the terrace deposits.

Terrace deposits

The three stream terraces are of Quaternary age. They are numbered 1, 4, and 5 in ascending order (see table below and pl. 2);

Terrace levels along Yellowstone River

Terrace	Height above river (feet)	Thickness of gravel underlying topsoil (feet)
1	20-35	4-11
4	60-90	10-15
5	150-190	7-25

terraces 2 and 3, which are present elsewhere in the Buffalo Rapids project, are absent in Area IV. The terraces are flat to gently rolling and are underlain by unconsolidated terrace deposits that range considerably in thickness. In general each terrace deposit

Generalized section of the geologic formations exposed in Area IV

System	Series	Formation	Lithologic character	Thickness (feet)
Quaternary.	Recent.	Alluvium.	Clay, silt, sand, and gravel.............	5-20
	Pleistocene.	Terrace deposits.	Silty and sandy soil with some clay; underlain by gravel that consists of rounded quartzite pebbles and cobbles, fragments of extrusive and intrusive igneous rocks.	8-40
Tertiary.	Paleocene.	Fort Union formation.	Yellowish-gray to buff clay, shale, and sandstone, with interbedded carbonaceous shale and lignite.	300±

is divided into two zones: the upper zone consists of fine sediment and its thickness is characteristic of the individual terrace; the lower zone is composed largely of gravel that rests on bedrock. An inspection of the gravel exposures along eroded banks indicates that lenses of sand and silt generally are interbedded with the gravel.

Northwest of the waterlogged area the slope from terrace 5 to terrace 1 is abrupt and very irregular, and the edge of the higher terrace is cut by numerous gullies. The gravel in the floor of the main gullies transmits much of the ground water that causes the waterlogging of terrace 1.

Terrace 5, which covers a large part of the area, is not irrigated at the present time, but it is proposed for irrigation by a relift. Seepage from irrigation of this upper terrace will increase the recharge to the ground-water supply of the lower terraces and may necessitate additional drainage facilities.

The main canal is on the colluvial slope between terrace 5 and the lower terraces in this area. For part of its length in section 32, the canal is cut into the underlying bedrock (pl. 2). Leakage from the canal in this reach is probably much less than where the canal is cut only into the colluvium.

Terrace 4, which occupies most of the southwestern part of the area, is irrigated from the main canal. The small stream that cuts through the center of the terrace serves as a drain. The terrace deposits apparently are sufficiently thick and permeable to transmit the recharge from the canal without becoming waterlogged.

About half of the irrigated land and most of the waterlogged land are on terrace 1. Half of this terrace can not be cultivated owing to the waterlogging and to the development of saline soils. The waterlogged area is becoming larger and will probably occupy most of the irrigated land on this terrace unless adequate drainage facilities are constructed.

Alluvium

The alluvial deposits along the Yellowstone River consist of clay, silt, sand, and gravel.

HYDROLOGIC FACTORS AFFECTING DRAINAGE

General conditions

Data from a network of observation wells and test holes, which were installed during the 1950 field season, are the basis for this analysis of subsurface hydrologic factors. (See table 1 and pl. 1.)

Most of the observation wells were constructed by jetting a 2-inch pipe 3 or more feet into the gravel (wherever possible the full thickness of gravel was penetrated). A $\frac{3}{4}$-inch pipe with an attached brass strainer then was inserted to the bottom of the hole inside the 2-inch pipe. When the larger pipe was removed, the gravel caved in around the strainer, and then the well was pumped until the water was clear. From time to time a check was made to determine whether the strainer was still open. A measurement of the water level in the well was made at weekly intervals until November, when the interval between measurements was lengthened to 2 weeks. Two water-level recording gages were installed in the area to provide a continuous hydrograph of water-level fluctuations. Data pertaining to the type of each observation well and its construction are given in table 1.

A test hole was hand-augered a few feet from most of the observation wells and at points intermediate between the observation wells. A log was prepared for each test hole (table 2). An analysis of these logs shows conclusively that the terrace gravel is the principal water-bearing material. Compared to the relatively permeable gravels, the overlying finer-grained sediments transmit a minor amount of water.

The ground water in a large part of terrace 1 is considered to be under artesian conditions as the piezometric surface of the ground water in the gravel is in the overlying sediments. Although these overlying finer-grained sediments act as a semiconfining bed, field observations show that they are saturated to a level that almost coincides with the average piezometric surface. The capillary fringe or nongravity water zone extends upward from the zone of saturation into the overlying more compact soils. In much of the waterlogged area, this capillary fringe extends to the land surface.

The hydraulic properties of both the permeable lower zone and the overlying semipermeable zone of terrace 1 are illustrated by reference to a hypothetical cross section (fig 7). A rapid increase in the rate of recharge to the permeable zone would cause a change in head near the source from position 1 to position 2. The corresponding increased pressure in the permeable zone, where it is overlain by the semiconfining materials, forces some of the water upward into the semipermeable zone. When the overlying material becomes saturated to a level that coincides with the piezometric surface, a state of equilibrium is reached. A rapid decrease of head near the source would result in both a corresponding lowering of the piezometric surface and a slow draining of the semipermeable zone until equilibrium is again established.

The effectiveness of a confining layer is indicated by the degree of correlation between changes of water level and changes in barometric pressure. The water level in well P reflects about 50 percent of the change in barometric pressure. (See fig. 8.)

Although considerable water is removed from the ground to satisfy evapotranspiration demands, no apparent diurnal fluctuations of the water level are registered by automatic recording gages. A possible explanation of the events that take place in this phase of the hydrologic cycle is as follows: during the summer days, when the evapotranspiration rate is high, the water held in the capillary interstices near the surface is depleted and the top few feet of the soil horizon become relatively dry; when night comes, the evapotranspiration demands lessen and the drier zones refill with capillary water. Because the demand for capillary water is fairly uniform, the withdrawal of water from the aquifer is nearly constant; hence no diurnal fluctuations of the piezometric surface could be expected.

A sizable quantity of water probably is discharged by evapotranspiration from the ground-water reservoir where its surface is close to the land surface; however, the effect on lowering the water table is obscured because of other influencing factors. There is very little surface flow from springs during the summer months because of increased evaporation rates. Evaporation rates of more than 0.5 inch in one day have been recorded at the Terry weather station. Records for the latter part of the summer indicate an average daily evaporation rate of slightly more than 0.2 inch per day for the summer months.

Natural surface drainage

Three natural drainageways (pl. 2) enter Area IV from the northwest. The western of these has a steep gradient. It flows in a deeply cut coulee that provides an adequate route for flow to the river at all stages and appears to provide ample drainage for all the irrigated land within its basin.

The small middle stream, which is parallel to the road, has no outlet to the river. During most of the year this stream has no surface flow beyond the siphon of the main canal, but during the colder months a small flow may be traced about 1,000 feet before it

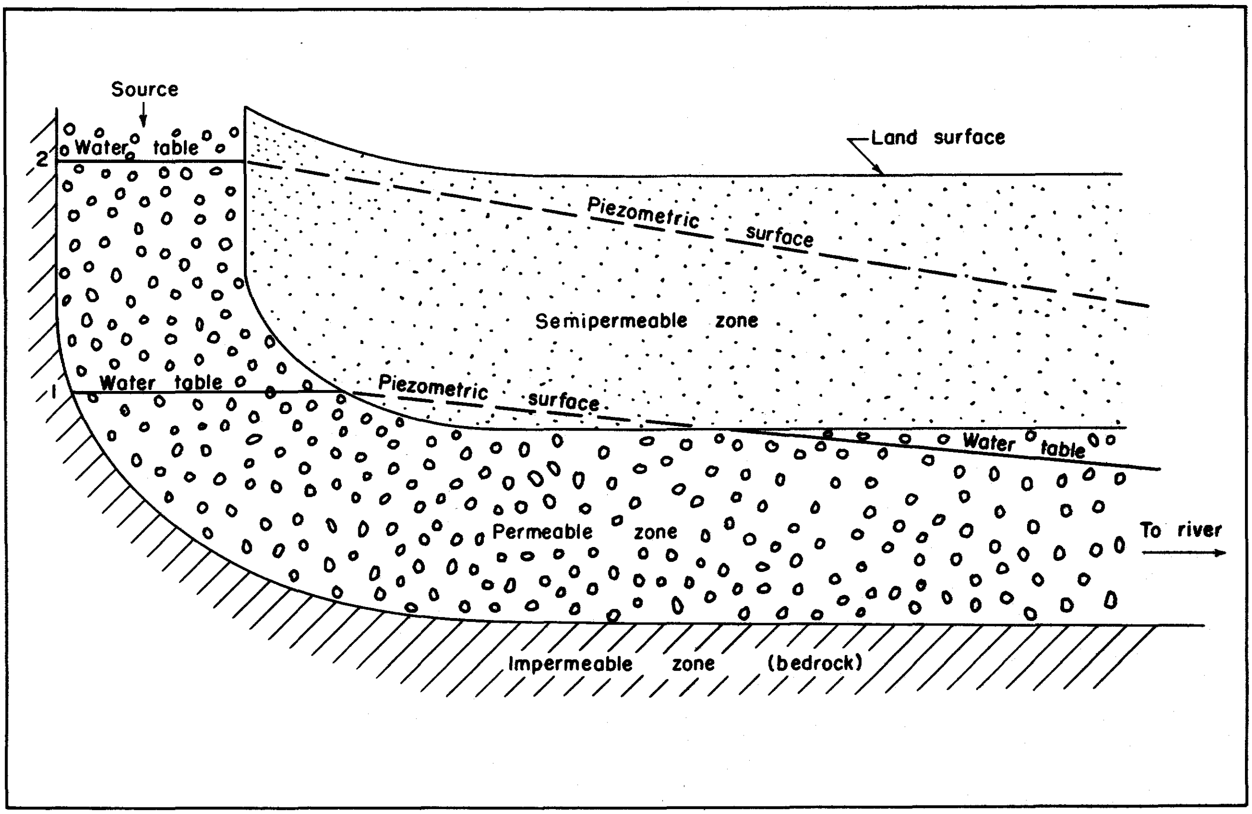

Figure 7.--Hypothetical cross section illustrating ground-water conditions in Area IV, First Division, Buffalo Rapids project, Dawson County, Mont.

is lost entirely by evaporation and percolation into the terrace deposits. The base flow of this stream is derived principally from ground water that issues from the gravel zone of terrace 5. During severe storms this stream discharges large quantities of water onto terrace 1. Where it enters the irrigated area, the stream has cut a gully that is as much as 6 feet deep and 10 feet wide. Cobbles as much as 4 inches across have been carried by the storm flows of high intensity that issue from this coulee. Because the gradient of the stream is sharply reduced upon entering the irrigated area, the stream's load of sand and gravel is deposited within a short distance. The stream has essentially no channel beyond 1,500 feet southeast of the siphon of the main canal. Although storm flows occur infrequently, surface drainage facilities should be designed to prevent the flooding of irrigated land at these times.

The eastern stream has an inadequate outlet to the river. Because the channel of this stream across the lower terrace is too shallow to transmit all the flood flow, the water spreads over the land and contributes to the waterlogging of this and surrounding areas. Although the drainage basin of this stream is comparable to the drainage basin of the middle stream, it appears to transmit fewer flash floods. Where this stream enters Area IV it has a small perennial flow.

Although the flow of the springs along the canal (pl. 1) reportedly has increased since the canal started carrying water, the springs derive water largely from the saturated deposits underlying terrace 5. The one farthest to the southwest contributes the most water to terrace 1 during periods when evaporation rates are low. The water from this spring flows along a narrow, deep cut, and ground

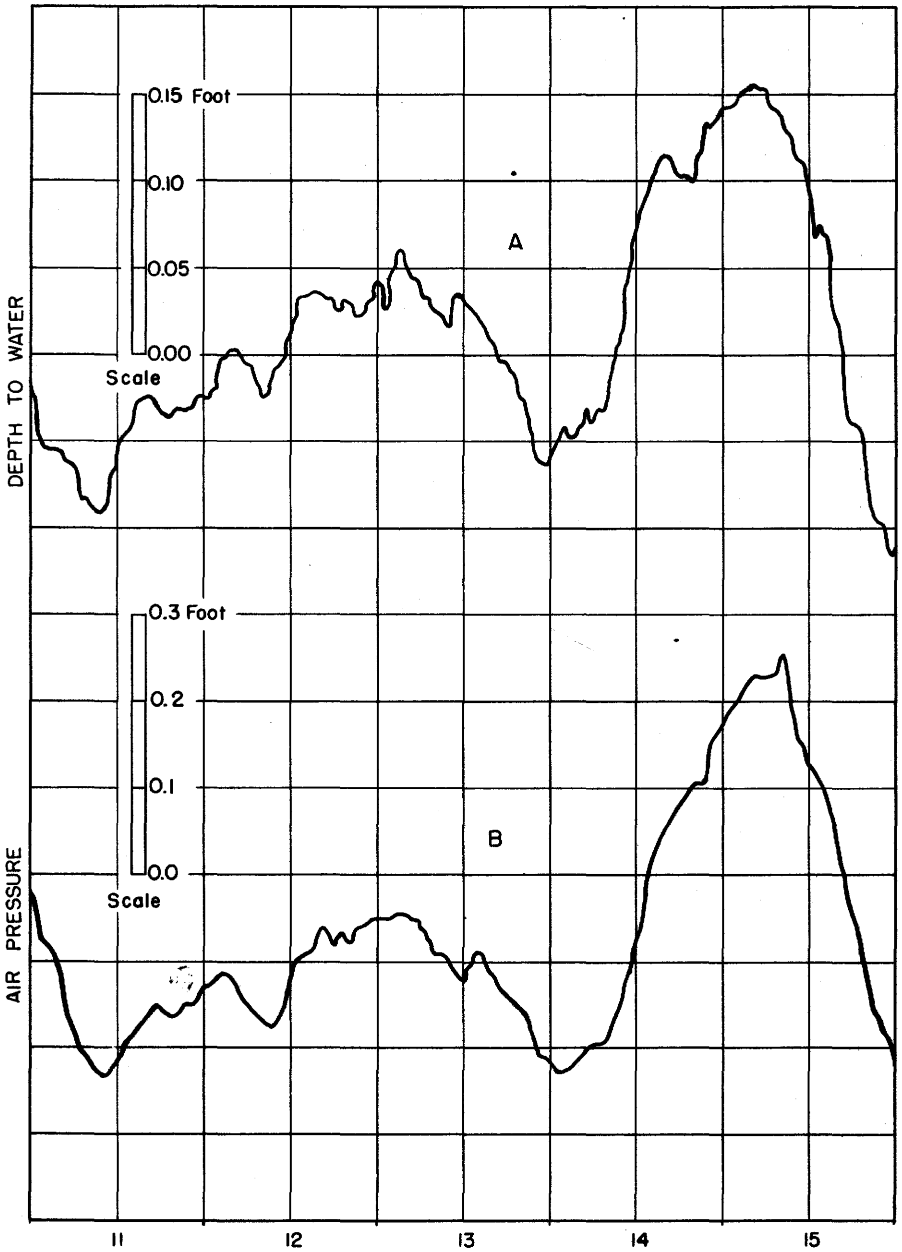

Figure 8.--A, hydrograph of water-level fluctuations in well P; B, barograph of air-pressure fluctuations (in feet of water) at Miles City airport, October 11-15, 1950.

water is discharged into the cut along most of its length. In the winter the flow forms a sizable frozen pond on the lower terrace level. The spring generally does not flow during the summer months because of increased evaporation rates.

The flow from the three springs that are nearest to the northeast corner of section 32 forms a pond on the northwest side of the irrigation lateral. When the pond reaches a certain stage, the excess water is discharged through a culvert underneath the lateral. Flow through the culvert occurs only during the cooler months.

During the cooler months, the flow from the springs on the northeast side of the road is partly intercepted by the irrigation lateral. The flow from these springs is evenly distributed and collects in the deep cut lateral, where it is held back near the section line by the gate of the lateral.

Natural subsurface drainage

The altitude of the water table in the alluvium of the Yellowstone River valley is approximately equal to the altitude of the river surface at its nearest point. Measurements of the water level in well G-3, which is close to the river bank, indicate that the water table and the river surface are essentially in equilibrium. Probably during high river stages, the ground-water flow is away from the river for short distances within this alluvial plain; however, the direction of ground-water flow in the lower terrace is not affected by changes in the stage of the river. Water levels for two different dates were used in the construction of the depth-to-water maps (figs. 9 and 10) and the piezometric-surface contour maps (figs. 11 and 12). These water levels were selected because, when plotted, they show the widest varying patterns for the period of record. Figures 11 and 12 show an area near the center of the drawing where the piezometric surface is relatively flat (2 feet in 1,000 feet). Indications that the upper surface of the underlying shale also is flat in this area may be seen by examining the logs of wells and the map showing the contours of the top of the gravel (fig. 13), if a fairly uniform thickness of gravel is assumed. The greater slope of the water-bearing bed from this relatively flat area to the river permits a more rapid movement of the water in that direction.

A further restriction to ground-water flow is the northeast-trending valley that is parallel to and about 2,500 feet southeast of the main canal. (See fig. 14.) Much of the ground water that is derived from the canal and upper terrace in the area near and northeast of the road moves in the direction of this valley. (See figs. 11 and 12.) The slope of the piezometric surface in this vicinity is steep, but the slope of the land surface is steeper. (See fig. 14.) Consequently in a down-gradient direction, the piezometric surface is progressively nearer the land surface.

Source of water

The ground water in the area covered by this report moves from the base of terraces 4 and 5 toward the river in a downstream direction. (See figs. 11 and 12.) According to the well drillers in this area and to information that was obtained from both test holes and from observations of surface exposures, an impermeable layer of the Fort Union formation underlies the gravel of each of the terraces. (See logs of wells Dw1 (13-54-5bbl), Dw2 (13-54-32dc), Dw3 (14-54-33ccl), and Dw4 (14-54-29ac) in table 2.) Consequently the ground-water reservoir of terrace 1 is recharged only by underflow from the higher terrace deposits, seepage of surface flows, irrigation water, and precipitation. The numerous gravel-laden gullies connecting the upper terraces with terrace 1 provide a subsurface route for the downward flow of ground water. It is concluded from examination of bedrock exposures and from drillers' reports that the few sandstone beds in the Fort Union formation that are above river level are not water bearing; for this reason the Fort Union formation is not considered a source of recharge to the ground water in the terrace deposits. Comparison of the chemical quality of water samples (see p. 22) also supports this conclusion.

Precipitation is the only possible source of recharge to the gravel that underlies terrace 5. Because highly permeable materials lie between the bottom of the main canal and the water table above the waterlogged area (see table 2 for logs of test holes H1, H2, T21, and T22, which are located along the canal) and because the rise of the level of ground water in terrace 1 reportedly has occurred since irrigation was begun, it is not surprising that the studies of canal leakage that were made by the Bureau of Reclamation in 1950 (pl. 1) show that some water is lost from the canal by seepage. Although the loss of water is small in comparison with standard permissible rates of leakage, it is nonetheless sizable in terms of ground-water recharge. Greater leakage probably occurred before the canal became lined with silt. The maps showing the contour of the piezometric surface (figs. 11 and 12) and the depth-to-water maps (figs. 9 and 10) indicate that the canal and the saturated deposits underlying terrace 5 are an important

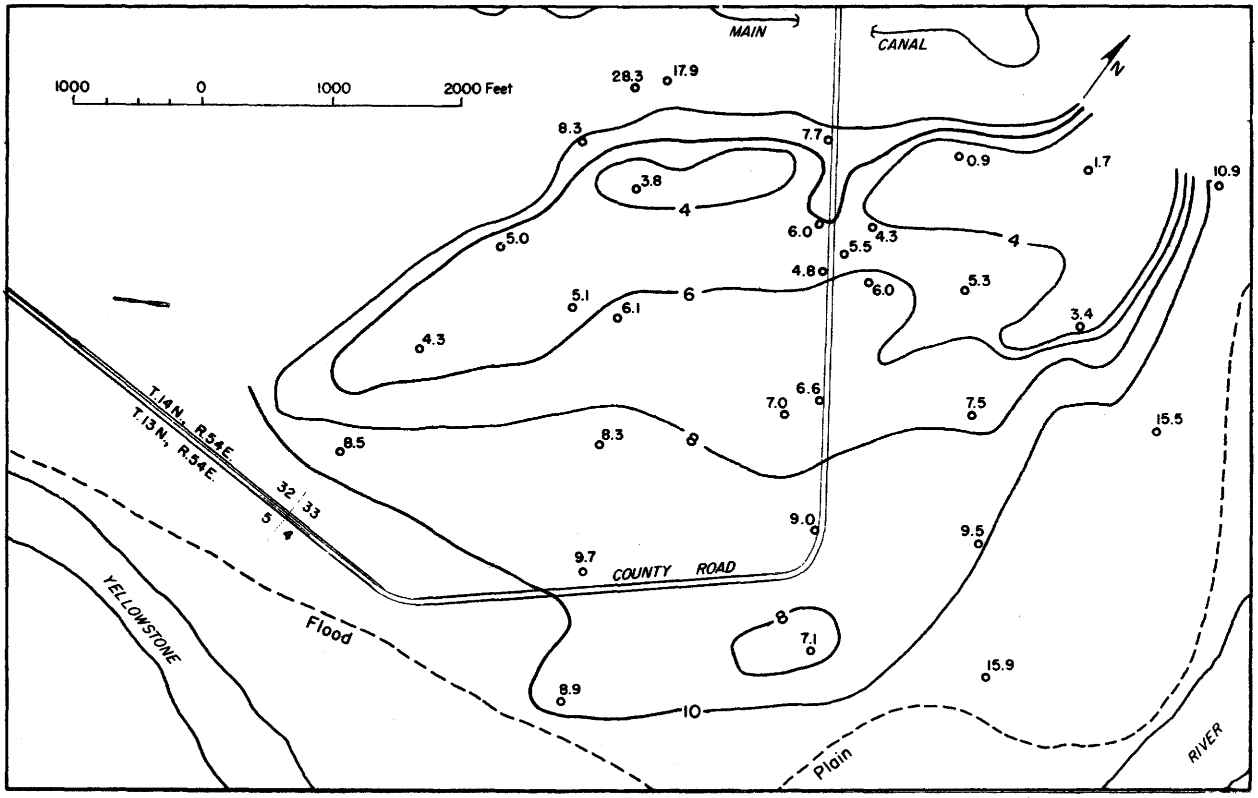

Figure 9.--Map showing depth to water, in feet below land surface, on August 14, 1950, in the waterlogged portion of Area IV, First Division, Buffalo Rapids project, Dawson County, Mont.

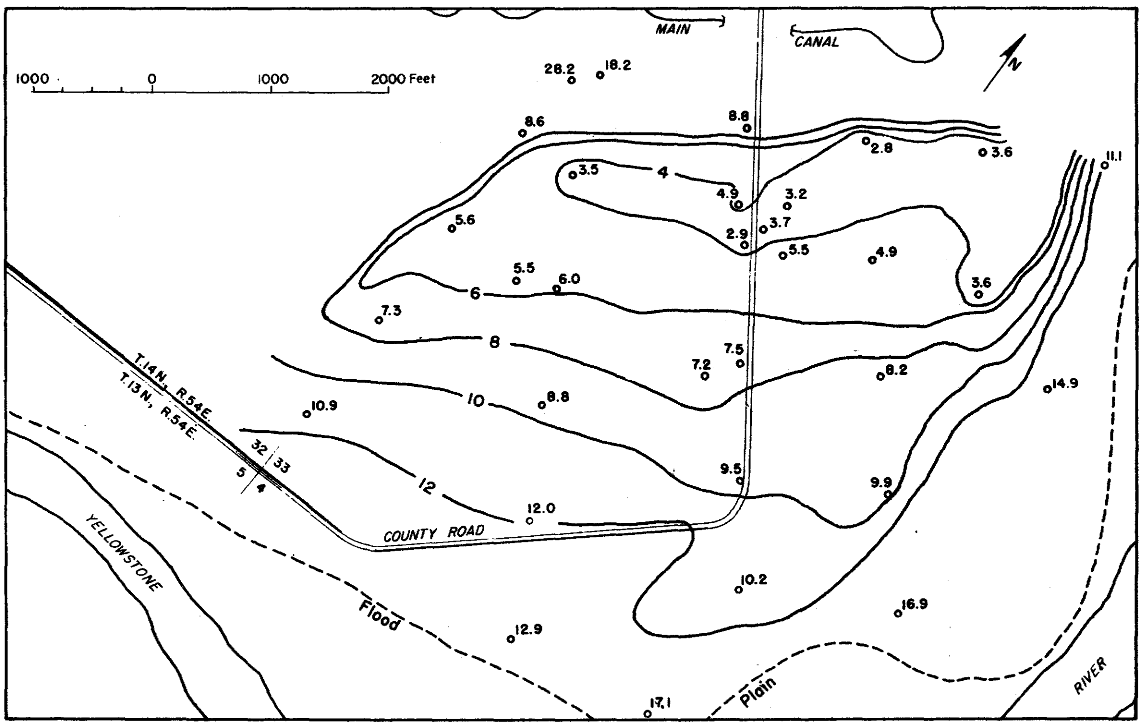

Figure 10.--Map showing depth to water, in feet below land surface, on December 18, 1950, in the waterlogged portion of Area IV, First Division, Buffalo Rapids project, Dawson County, Mont.

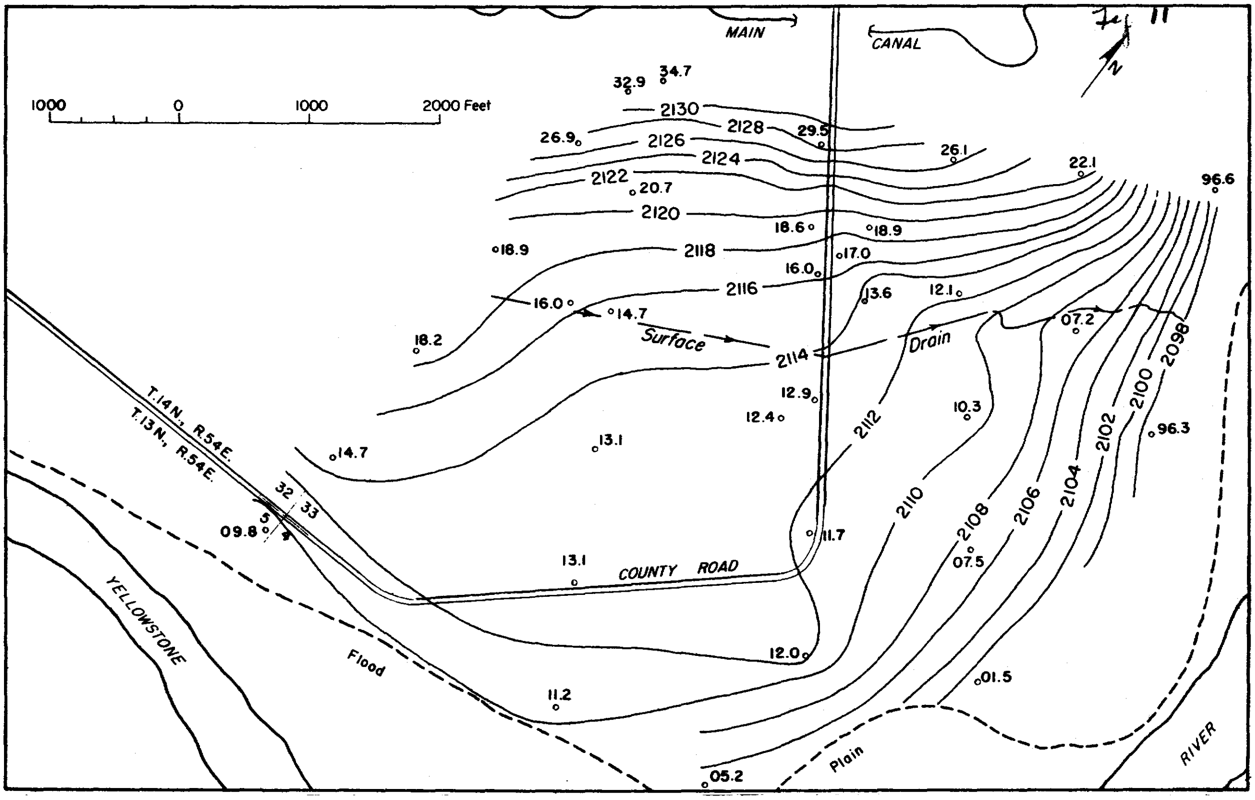

Figure 11.--Map showing the contour of the piezometric surface, in feet above mean sea level, August 14, 1950, in the waterlogged portion of Area IV, First Division, Buffalo Rapids project, Dawson County, Mont.

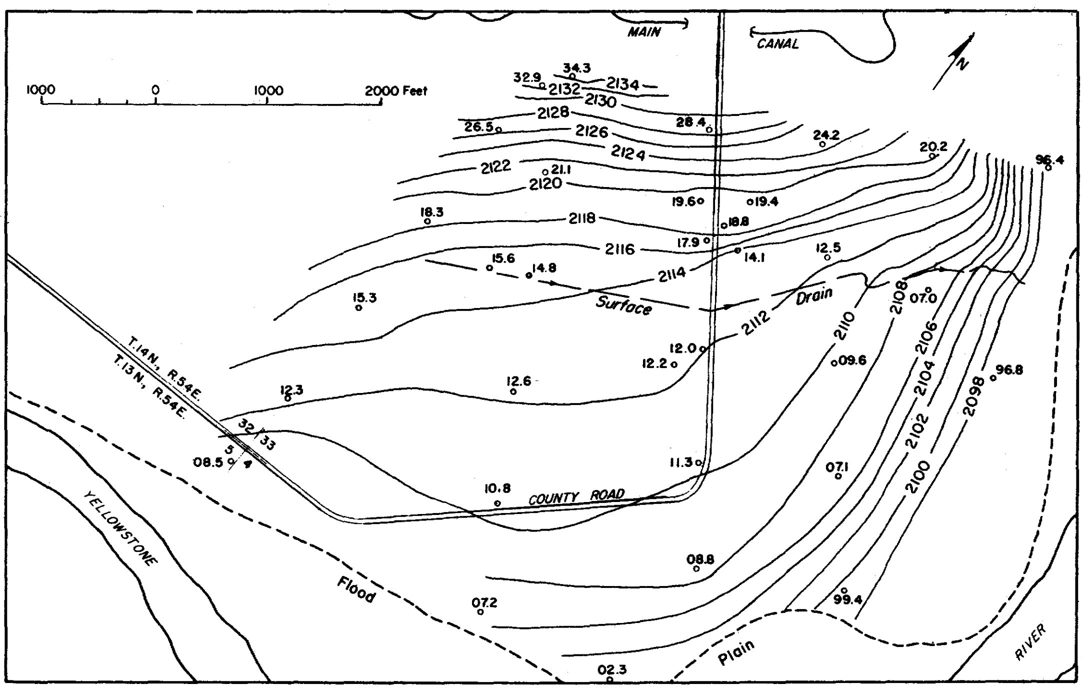

Figure 12.--Map showing the contour of the piezometric surface, in feet above mean sea level, December 18, 1950, in the waterlogged portion of Area IV, First Division, Buffalo Rapids project, Dawson County, Mont.

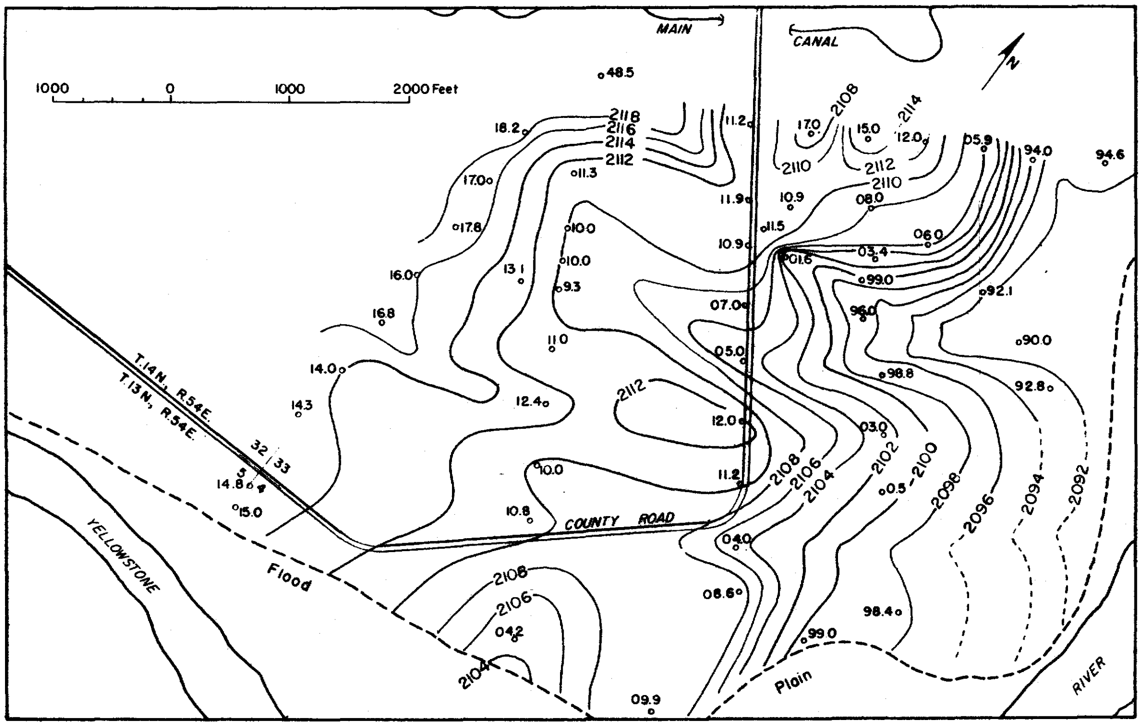

Figure 13.--Map showing the contour of the top of the subsurface gravel, in feet above mean sea level, in the waterlogged portion of Area IV, First Division, Buffalo Rapids project, Dawson County, Mont.

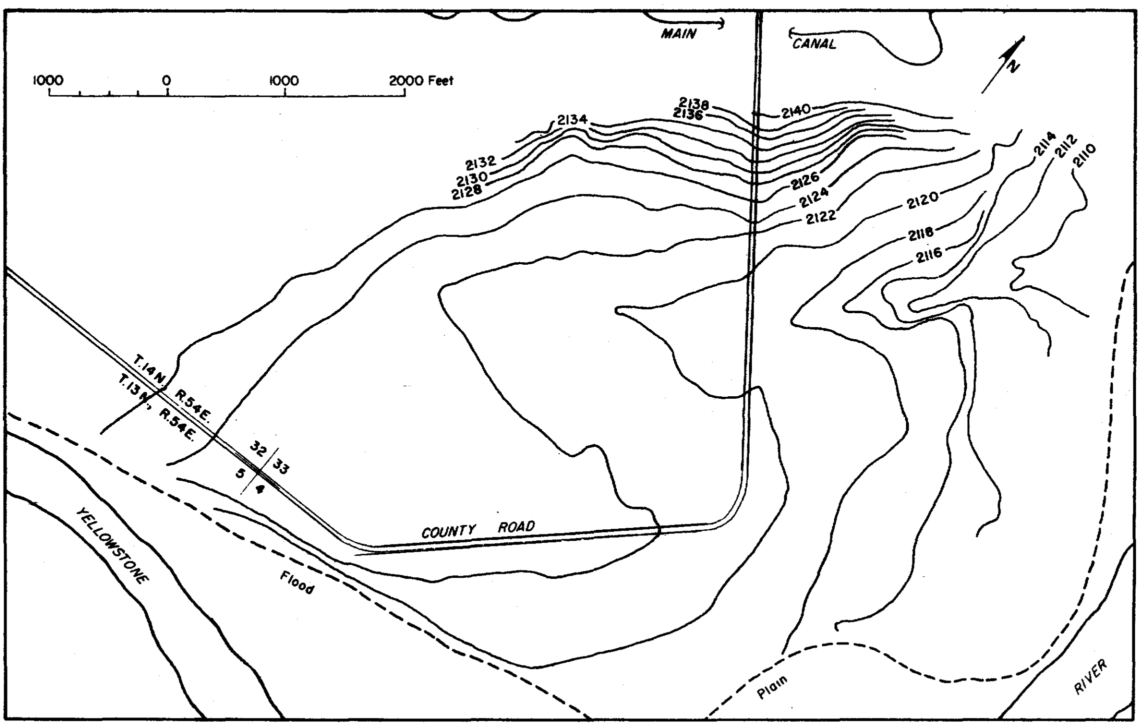

Figure 14.--Topographic map of the waterlogged portion of Area IV, First Division, Buffalo Rapids project, Dawson County, Mont. (Topography from maps prepared by Farm Security Administration, U. S. Department of Agriculture.)

source of the water that is producing the damaging high water levels in the lower terrace.

A study of the water-level fluctuations (table 3) furnishes a means for evaluating the relative effect of the recharge sources on different parts of the area.

Rising water levels during the irrigation season in well C1 (fig. 15), which is far removed from any irrigated land, may be attributed to canal leakage. The high water levels in June shown by well C2 are caused by percolation of accumulated precipitation and spring water in the immediate area. The high water levels shown by the hydrograph of well

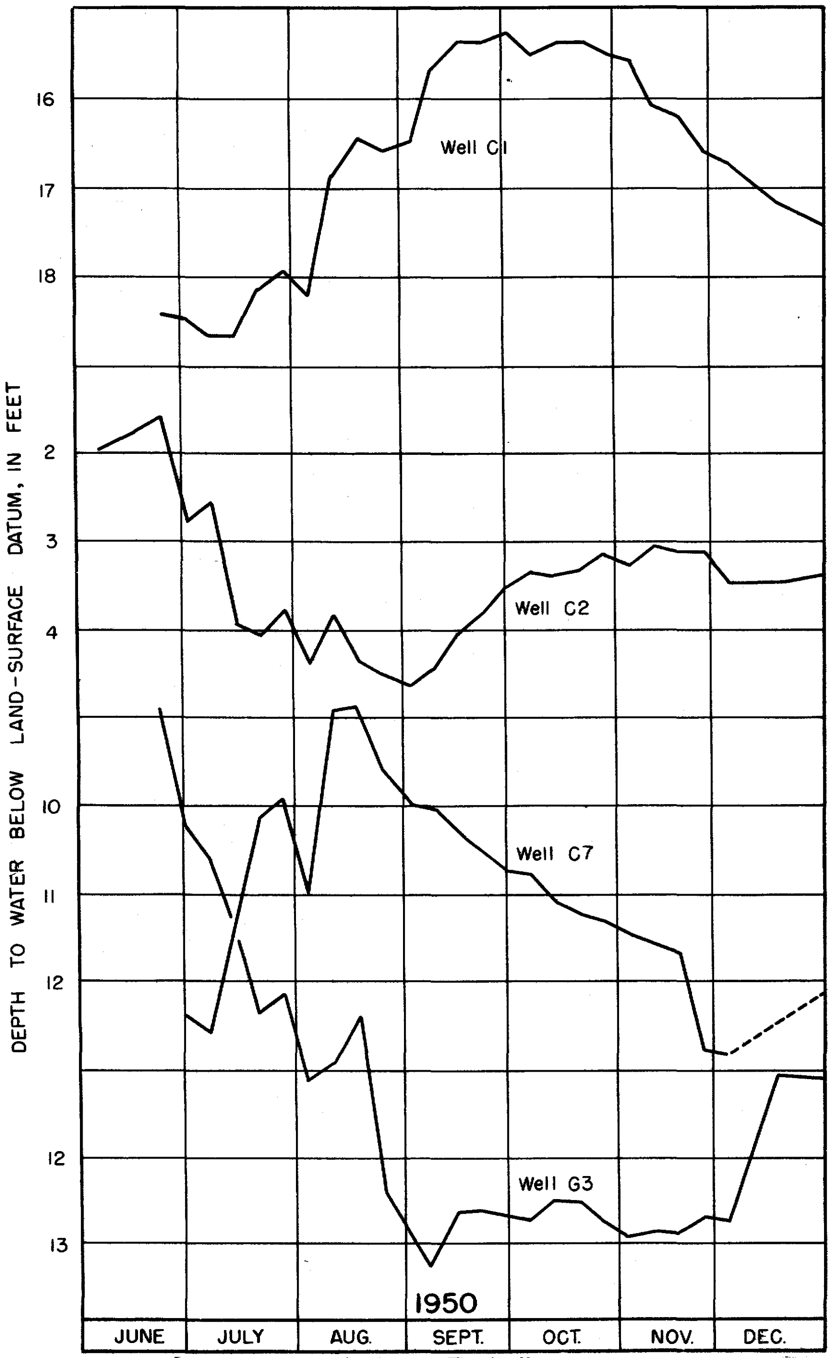

Figure 15.--Hydrographs showing water-level fluctuations in four wells in Area IV, First Division, Buffalo Rapids project, Dawson County, Mont.

C7 correspond with the irrigation data shown in the table beneath figure 6. The rise in water levels toward the end of the year shown by the hydrograph of well G3 is typical of water levels near the river's edge and the rise is attributed to a rising river stage.

Most of the recharge due to precipitation occurs late in the spring when the ground thaws and ponded water is able to reach the water table. Further records are necessary to determine the magnitude and extent of this source, but field observations indicate that it is important only in spots on farm units 61 and 65.

The major source of recharge in the southwestern part of the area is irrigation water. Under present conditions drainage in this area appears to be adequate; but probably, if farm units 61, 62, and 65 were irrigated again, the waterlogged area would gradually enlarge covering most of this lower terrace.

The gravel aquifer of terrace 4 obtains recharge from irrigation and precipitation and probably some effluent seepage from the main canal. In section 32, however, the main canal is cut into bedrock for much of its length on both sides of the creek (pl. 2); consequently leakage from the canal in this reach is probably negligible. Most of the upper half of terrace 4 east of the creek is not irrigated. Water levels in this area indicate that the creek effectively controls the water table nearby and that only a small area of terrace 1 has a high water table because of flow from this direction.

Effluent seepage from the irrigation of terrace 5 must be considered as a future source of recharge. The excessive groundwater flow from the higher terraces will be increased and additional drainage facilities may be required.

<u>Hydrologic properties of the principal aquifer</u>

Few test holes completely penetrated the full thickness of the gravel aquifer. To evaluate effectively the hydraulic properties of this aquifer a field permeability or pumping test was necessary; accordingly a pumping test was conducted on well P on August 22, 1950. (See pl. 1.) The location of the pumped well and the 16 observation wells that were measured during the test are shown in figure 16.

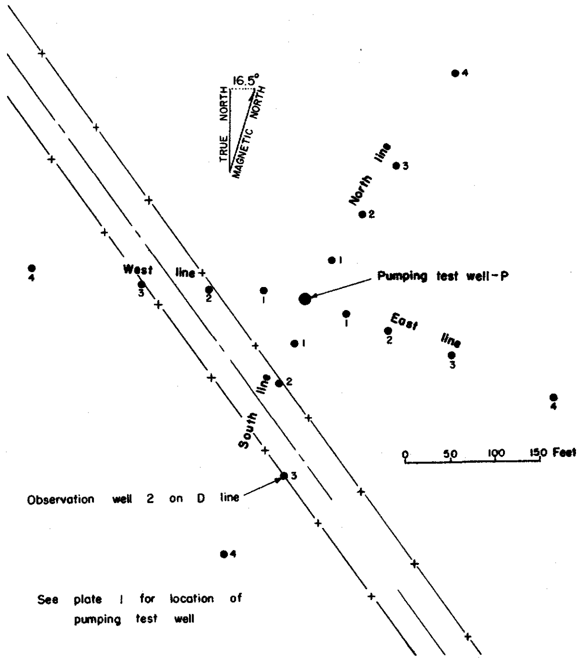

Figure 16.--Map showing location of test wells used for pumping test in Area IV, First Division, Buffalo Rapids project, Dawson County, Mont.

The pumped well is a 4-inch diameter, steel-cased, drilled well that penetrates the entire thickness of the gravel aquifer. The casing is slotted with 3/32-inch horizontal sawcuts. A centrifugal pump capable of delivering about 40 gpm for the required lift was used for the test. The pumped water was discharged into a shallow dug trench, which led away from the test site, and was dumped into a shallow drain several thousand feet from the pumping well. The discharge of the pumped well was measured by means of a Parshall flume that was installed in the trench.

The observation wells used in the pumping test were similar to the other observation wells that were installed throughout the area. After the wells were installed they were pumped until the water was clear; they were in condition then to reflect quickly and accurately the small changes in water level. Periodic measurements were made of the water level in them during the 24 hours of pumping and during the 24 hours after pumping ceased. These measurements are shown in table 4. The pumping rate was controlled within close limits throughout the test by a gate valve in the discharge pipe. Analysis of the test data was made by the Theis nonequilibrium method and checked by the gradient formula and by the Theis recovery formula (Wenzel, L. K., and Fishel, V. C., 1942). Considerable comparative work was done in checking the reliability of the test results with the geologic conditions that are shown by the geologic sections through the pumped well (pl. 3).

The observation wells nearest the pumped well gave results that are slightly different from the others. Those wells farthest from the pumped well produced such small changes in relation to the effects caused by changes in barometric pressure that corrections are required in order to obtain true curves. Results from the second and third wells of each line of observation wells were in close agreement; the barometric effects on the water level in these wells, as computed, were relatively small in comparison to the pumping effect throughout most of the test.

To illustrate the close agreement of the test data to the "type curve," data from well So2 were plotted (fig. 17) and, with the axes of the two graphs parallel, the data curve was superimposed on the "type curve" (fig. 18) until the two curves coincided. The coordinates of the match point, which is any arbitrary point that is common to both curves, were substituted in the Theis equation, and the equation was solved as shown (fig. 17). The match-point coordinates that were selected for the various wells and the corresponding transmissibility and storage coefficient values are shown on the summary sheet (table 5). The results give an average transmissibility of 5,040 gpd per foot and an average storage coefficient of 0.005. The low storage coefficient clearly indicates artesian conditions.

Division of the value for transmissibility by the thickness of the aquifer gives the permeability, which is about 560 gpd per square foot. The permeability can also be determined by laboratory methods. The permeability value for the one relatively undisturbed sample that was collected for this purpose was calculated as 611 gpd per square foot. These values, which are rather low for a water-bearing gravel, may be reconciled by the the fact that the gravel shows a rather large percentage of fine materials.

The hydraulic properties of the aquifer, as determined by the pumping test, are considered fairly representative of the critical area because of the central location of the pumped well and because of the large radial area of influence of this well. From the values of the transmissibility, the storage coefficient, and the hydraulic gradient, the velocity and the quantity of the ground-water flow may be computed.

Quantity of water

To aid in the estimation of the amount of water that flows from the higher terraces through the aquifer of the lower terrace, a cross section was selected along the 2,122-foot contour line on the piezometric surface. The length of this contour line from the creek in the northeast part of the area (pl. 4) to the section line between section 32 and 33 is about 4,700 feet. The slope of the water table at this section was estimated by making eight uniformly spaced measurements between the 2,120 and 2,124 lines. The average slope was found to be approximately 0.015. This value and the value for transmissibility, as determined from the pumping-test data, may be substituted in the following modification of Darcy's equation, which gives the rate of ground-water flow. In Darcy's equation,

$$Q = PIA \qquad (1)$$

where

Q = gallons per day,
P = permeability in gallons per day per square foot,
I = slope as a ratio, and
A = area of section, in square feet,

let

$$A = mL \qquad (2)$$

where

m = thickness of aquifer, in feet, and
L = length of section, in feet

and let

$$P = \frac{T}{m} \qquad (3)$$

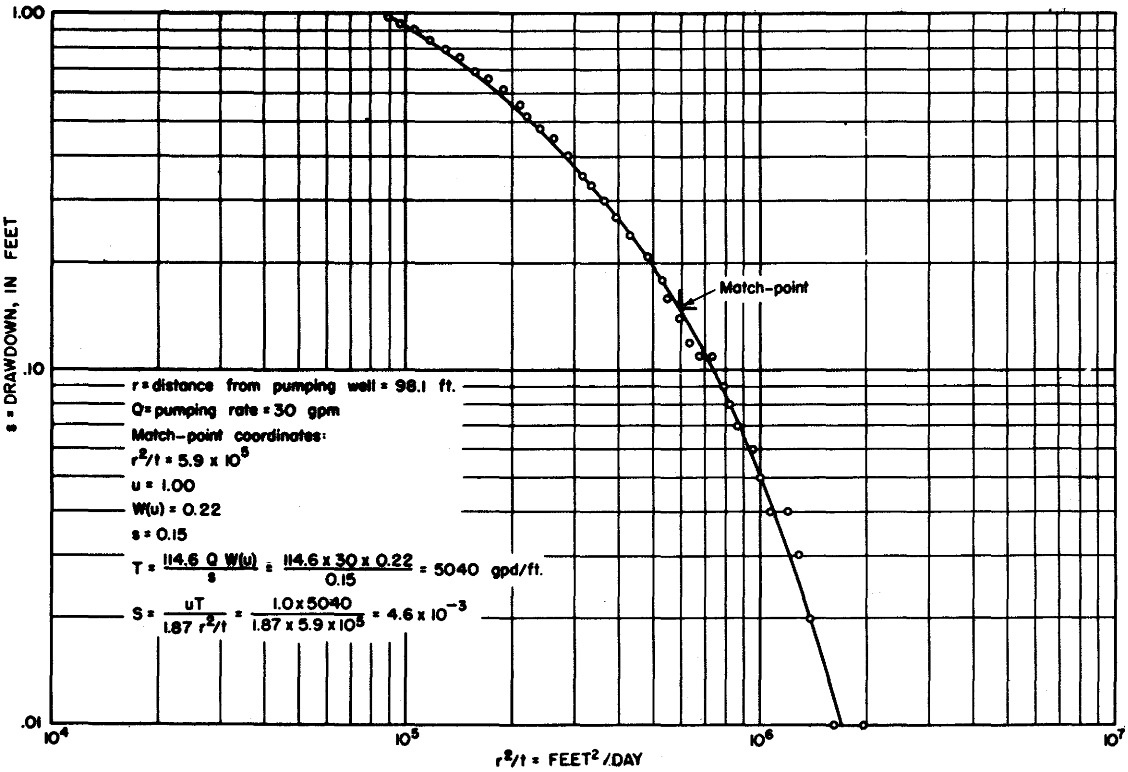

Figure 17.--Logarithmic plot of drawdown of water level in observation well So2, pumping-test site, Area IV, First Division, Buffalo Rapids project, Dawson County, Mont.

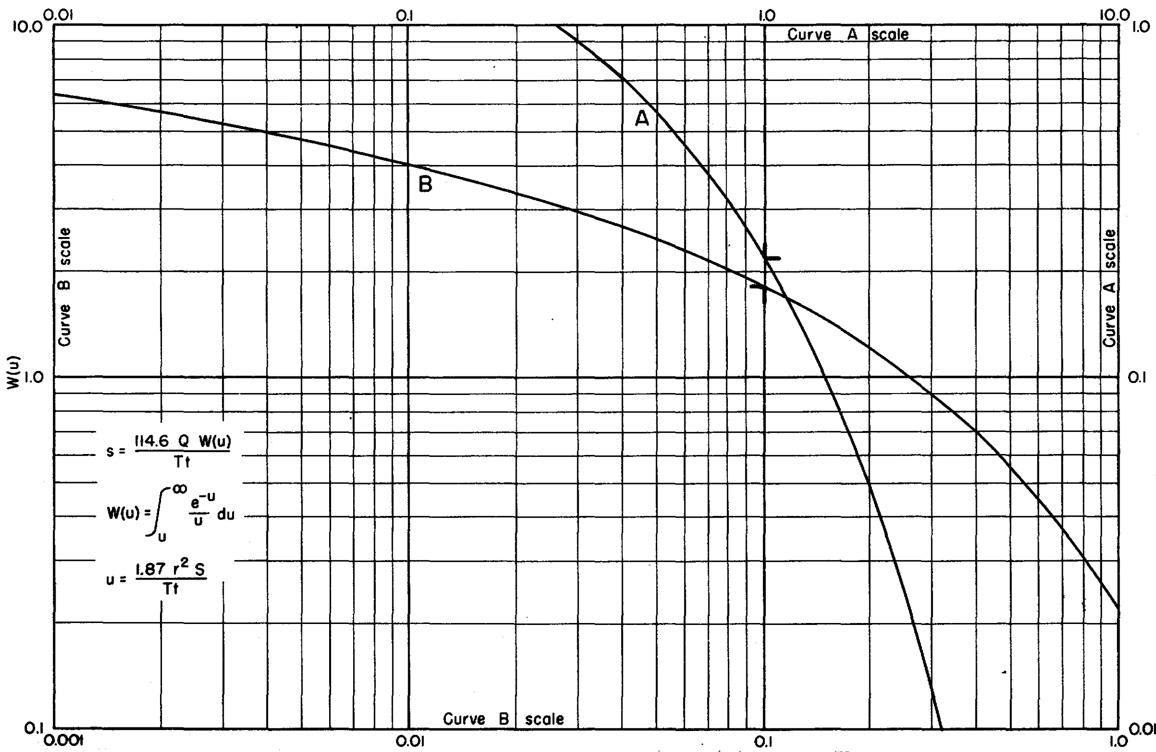

Figure 18.--Logarithmic graph of the well-function-type curve.

where

T = transmissibility.

Substituting (2) and (3) in (1),

$$\dot{Q} = \frac{T}{m} \cdot I \cdot mL = TIL$$

which is the modified Darcy equation. Substituting the numerical values in this equation,

$$Q = 5{,}000 \times .015 \times 4{,}700 = 350{,}000 \text{ gpd} = 240 \text{ gpm} = 0.54 \text{ cfs}$$

which is the estimated rate of ground-water flow from the upper terraces to the lower terrace. A comparison of the water levels in wells D1 and D2 indicate that the gradient ranged from 0.01 to 0.02 during the period of record; thus the rate of ground-water flow ranged correspondingly from 235,000 to 470,000 gpd.

The rate of canal leakage in this same area was obtained from ponding tests that were conducted by the Bureau of Reclamation. (See pl. 1 for location of ponds.) The results of these tests give the rate of leakage as 450,000 gpd or 0.694 cfs. This value was obtained by measuring the net subsidence of ponded water during a 24-hour period in a stretch of canal 5,644 feet long and then computing the change in volume that occurred during that period.

Inasmuch as the canal carries water only about 5 months of the year, the average yearly rate of leakage is about 200,000 gpd. A comparison of this rate with the average rate of underflow indicates that leakage from the canal accounts for about half of the underflow.

The rate of flow of ground water is equal to the product of the porosity of the aquifer, the cross-sectional area, and the velocity of the ground water; that is

$$Q = pAv \text{ or } v = Q/pA,$$

where

v = velocity
p = porosity.

The area of the cross section is Lm (4,700 x 9 square feet). The porosity of the gravels in this area was determined in the Geological Survey hydrologic laboratory at Lincoln, Nebr., to be about 40 percent. In cubic feet per day, the rate of flow (Q) is 235,000 / 7.48. Substituting these values, the velocity of the ground water is

$$v = \frac{Q}{pA} = \frac{235{,}000}{7.48 \times 4{,}700 \times 9 \times 0.40} = 1.86 \text{ feet per day.}$$

At this rate, a given quantity of water would flow a distance of a mile towards the river in 7.8 years.

SUGGESTED METHODS OF DRAINAGE

In this area both the surface and ground water should be considered when designing adequate drainage facilities. The system that will most effectively drain the ground water from this area should include the following:

1. A direct hydraulic connection between the gravel aquifer and the drainage channel.

2. Drains that intercept the piezometric surface where it is nearest the land surface.

3. Drains that intercept the ground water at a right angle to the direction of flow.

4. Drains that are constructed to provide maximum effectiveness.

5. Drains that are as far up gradient as practicable.

The surface topography, of course, will determine the practicability of the above recommendations.

The important hydrologic data to be considered in drainage design are shown on a map (pl. 4). The map indicates that the gravel is at a considerable depth beneath most of the land that is to be drained (fig. 19); hence an open drain would have to be excessively deep to intercept the aquifer. A deep open drain or tile drain with relief wells installed at intervals along the bottom should be effective, and such a choice would allow flexibility in the location of the

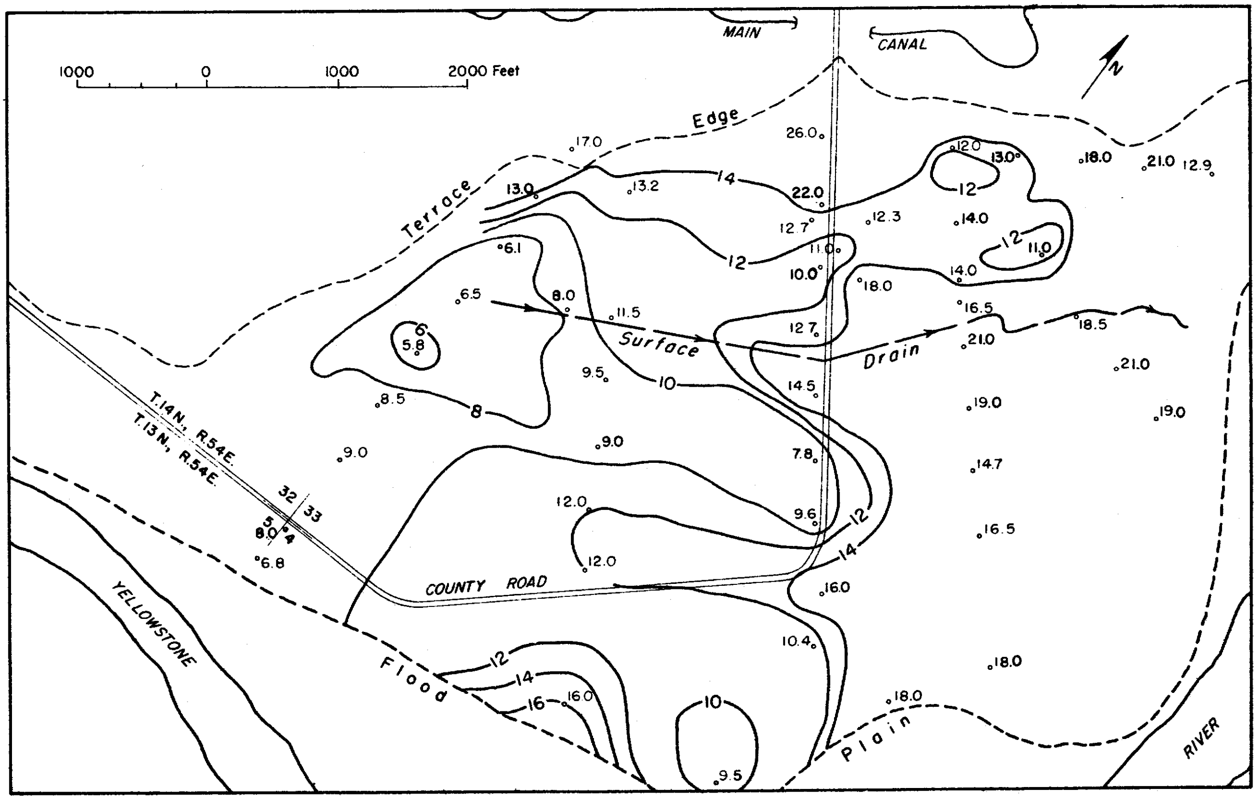

Figure 19.--Map showing depth to gravel, in feet below land surface, in the waterlogged portion of Area IV, First Division, Buffalo Rapids project, Dawson County, Mont.

drain. If this type were selected, a suitable location may be chosen after further study of the hydrologic data.

The depth-to-water maps (fig. 9 and 10) show an area that has persistently high water levels. A drain that parallels the piezometric surface contours and that conforms to the surface topography may be located any place within the area of high water levels. A drain is usually more effective when it drains down gradient from the point of interception; consequently the drain in this area should be located at the upper end of the high-water-level area. A drain constructed to flow in a northeasterly direction could start in section 32 on the 2,130-foot surface contour and extend across the area--it would obtain the desired slope by following the surface topography. Trial locations should be drawn on the map, and the logs should be studied to determine whether the other factors are favorable.

The relief wells need not be spaced at regular intervals. In some locations it may be desirable to space the wells more closely than in others. For instance, near the mouth of the coulee of the middle stream where the subsurface flow is greater, the wells should be spaced at smaller intervals; in places where the aquifer is thin, the wells should be spaced at larger intervals.

To aid in determining the average spacing between relief wells, an estimate of the quantity of flow to be expected from these wells may be made. The specific capacity (rate of flow per foot of drawdown) of the pumping-test well for a long period of pumping is estimated to be a little less than 3 gpm per foot. Assuming that the relief wells will have a similar specific capacity and that the head loss (comparable to drawdown) will average 4 feet, then 10 to 12 gpm will flow from each well. As time progresses, the cone of influence for each well will overlap the cone of influence of the neighboring wells and the rate of flow will slowly diminish. The approximate amount of interference between wells can be computed, but in view of the factors involved in making such an estimate, other arbitrary means of selecting the spacing between wells seem equally satisfactory. Assuming that it is desirable to remove 300 gpm from the ground-water reservoir and that each well (considering mutual interference and unforeseen losses) will produce at an average long-time rate of 6 gpm, 50 wells would be necessary. Thus for a drain 5,000 feet long, an interval of 100 feet would be required.

The relief wells should be as efficient as possible. A small diameter well that is properly screened and developed will perform as satisfactorily as a large caisson that is sunk to the top of the gravel. To increase its efficiency, a well should be developed by either surging or pumping or by both methods in order to remove the fine materials around the screen and thus reduce the friction of flow. Compressed-air equipment is versatile and effective for this purpose. Because the lenses of relatively impermeable material in the aquifer probably reduce the rate of vertical flow of water, the relief well should penetrate as much of the aquifer as possible--this would aid the interception of horizontal flow and also increase the area of exposure to the gravel.

Because most of the underflow from the upper terraces is transmitted to terrace 1 by the gravel that fills the deep-cut gullies (log C1, p. 34); a drain cut into bedrock along the slope between terrace 1 and the higher terraces would intercept only a small part of the underflow to terrace 1. Canal lining would eliminate that source, but would offer no protection from proposed irrigation on terrace 5, nor from natural recharge.

During the spring, excess surface water from snowmelt and spring showers causes costly delays in planting. Much of this water, which is in the form of surface runoff, should be intercepted and provided with an outlet before it percolates into the ground. Shallow ditches with suitable outlets to the river would prevent most of the spring flooding.

QUALITY OF THE WATER

During the course of this investigation six water samples were collected from test holes that were installed in Area IV by the Geological Survey. These water samples were analyzed in Lincoln, Nebr., by C. J. Zabel of the Geological Survey. The analytical results for these samples and for two water samples collected in 1948 are given in the table on the following page. A detailed study of these water analyses has not been made, but several pertinent remarks can be made.

The sample of water from the Yellowstone River, which is used for irrigation, is moderately mineralized. The water is moderately hard and the sulfate and bicarbonate radicals are present in about the same quantities. The water is relatively low in percentage of sodium and, although a wide range in mineralization may occur during the irrigation season, the water would be considered suitable for irrigation according to the standards suggested by Wilcox (1948, p. 27). It must be emphasized, however, that the mineral content of the river water varies with water discharge and that a single analysis may be representative of conditions only at the time of sampling.

The chemical character of the ground-water samples is in marked contrast to that of the river water; the ground-water samples are considerably more mineralized. The increased mineral content is the result of more effective solution by the ground water of the compounds of sulfates and carbonates of calcium, magnesium, and sodium that are present in the minerals of the soil and rocks. As a result of concentration of the water because of evaporation, several of the shallow wells yield water with high dissolved solids.

Wells G3, C4, and P are in or close to the waterlogged land. In these wells the water is more highly mineralized than the water in the other wells that were sampled and is characterized by greater quantities of sulfate than bicarbonate. Wells C6 and E5 are in areas of good underdrainage, and the water furnished by them has probably been somewhat freshened by downward percolation of irrigation water. Water from these wells resembles the Yellowstone River water more closely than the water from the other wells that were sampled.

The increase in the mineral content of the water from the pumped well during the pumping test was minor and probably is of no significance. This change is possibly the result of the influx of more mineralized water from the waterlogged area that is up gradient from it.

Chemical analyses and related physical measurements of water samples
[Analytical results in parts per million except as indicated]

Well no. Coordinate system	Field	Date of collection	Depth of well (feet)	pH	Specific conductance (micromhos at 25°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$ Total	Hardness as $CaCO_3$ Noncarbonate	Percent sodium
14-54-28dd	G3	10-11-50	16.5	7.3	4,550	20	6.2	200	102	910	9.2	1,070	1,970	35	0.8	2.9	0.20	3,780	920	43	68
33ba10	P	[a]8-22-50	40	8.1	2,580	20	3.4	70	103	420	7.0	600	975	17	.8	3.4	.30	1,920	599	107	60
		[b]8-23-50	40	7.8	2,660	20	.30	103	106	422	7.4	702	995	18	.8	4.1	.30	2,020	692	116	57
33bc9	C4	10-12-50	13.3	7.6	2,460	22	2.6	81	58	450	8.9	644	795	13	.8	.5	.30	1,750	440	0	68
33cc1	Dw3	10-15-48	412	7.9	2,580	11	.02	4.5	2.0	733	4.8	1,950	2.4	24	1.4	.9	.00	1,760	19	0	98
33cd1	C6	10-11-50	17.0	7.5	1,310	20	10	74	58	153	6.1	509	304	13	.8	13	.20	920	424	7	43
33da2	E5	10-12-50	21.5	7.6	2,180	22	4.1	87	62	376	7.8	736	625	17	1.0	7.5	.30	1,570	470	0	63
Stream location																					
Yellowstone River near Fallon.......		10-16-48	.....	8.4	920	14	.02	70	28	59 (Na + K)		213	214	12	.5	2.4	.20	604	290	115	31

a Collected 2 hours after pumping began.
b Collected 23 hours after pumping began.

The sample collected during the last half of the pumping test had less than 10 percent of the iron concentration that was reported for the sample collected during the first half of the test.

The analysis of the water from well Dw3, which taps the Fort Union formation, contrasts markedly with the analyses of the samples of ground water in the terrace deposits. This dissimilarity is further evidence that ground water in the terrace deposits is not recharged by ground water from the Fort Union formation.

SUMMARY AND RECOMMENDATIONS

Most of terrace 1, in the area covered by this report, has inadequate subsurface drainage. High water levels are maintained by the hydrostatic pressure of the water in the terrace gravel, which underlies the less permeable soil zone. The main source of recharge for this aquifer is ground water from the two higher terraces, which receive recharge from precipitation and canal leakage. If terrace 5 is irrigated as proposed, the recharge to the lower terraces will be increased.

To reclaim the area that is waterlogged at the present time and to prevent further damage to adjoining land, artificial drainage is necessary. A deep open drain with appropriately spaced relief wells is suggested as a possible solution. Supplementary surface drainage facilities also should be incorporated in the drainage system.

The following recommendations are made to further the study of the effectiveness of artificial drainage in this and other areas.

1. A careful log of operations and observations should be kept during the construction of the drainage works, and these data should be made available to interested parties.

2. The flow at the outlet of the drains should be measured.

3. The flow from the developed relief wells should be measured.

4. The program of periodic water-level measurements in observation wells should be continued.

5. All data from this investigation should be compiled and analyzed in one complete report.

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Table 1.--Records of wells and test holes

Well no.: See text for description of well-numbering systems.
Driller: BR, Bureau of Reclamation; GS, Geological Survey; P, private driller.
Type of well: B, bored; BJ, bored and jetted; D, dug; Dr, drilled; J, jetted.
Type of casing: G, galvanized; N, none; S, steel.
Measuring point: LS, land surface; Tp, top of pipe; Tsf, top of shelter floor.

Altitude of measuring point: Altitudes determined by instrumental leveling are given in feet, tenths, and hundredths; altitudes determined from topographic map are given in feet.
Depth to water: Measurements in cased wells are given in feet, tenths, and hundredths; measurements in uncased test holes given in feet and tenths.
Remarks: Ca, water sampled for chemical analysis; E, altitude of measuring point estimated.

Well no.		Driller	Date drilled	Type of well	Depth of well below land-surface datum (feet)	Diameter of well (inches)	Type of casing	Depth to gravel (feet)	Measuring point			Depth to water below land-surface datum	Date of measurement	Remarks
Coordinate system	Field								Description	Height above land-surface datum (feet)	Altitude above mean sea level (feet)			
13-54-4bb1	B6	GS	7- 6-50	J	17.8	$\frac{3}{4}$	G	8.0	Tp	3.6	2,126.44	12.27	9- 5-50	
4bb2	B6$\frac{1}{4}$	BR	7- 6-50	B	10.1	3	N	6.8	LS	.0	2,122	....	....	
5ab	A3	GS	5-19-50	J	13.6	2	S	10.6	Tp	2.9	2,134.05	Dry	9- 5-50	
5bb1	Dw1	P	1942	Dr	106.0	4	S	12.0	Tp	.75	2,176	21.77	9-21-48	
5bb2	Cb5	GS	6-15-50	J	18.9	2	S	9.6	Tp	4.9	2,173.52	Dry	9- 5-50	
14-54-27bc1	Ci1	GS	10-24-50	J	14.3	$\frac{3}{4}$	G	6.5	Tp	3.7	2,217.43	11.21	11-20-50	
27bc2	Ci2	GS	10-24-50	J	12.7	$\frac{3}{4}$	G	....	Tp	3.7	2,215.90	8.74	11-20-50	
27bc3	Ci3	GS	10-25-50	J	10.2	$\frac{3}{4}$	G	3.0	Tp	4.0	2,215.34	7.05	11-20-50	
27bc4	Ci4	GS	10-24-50	J	14.2	$\frac{3}{4}$	G	9.0	Tp	3.8	2,220.45	12.01	11-20-50	
28cd1	E1	GS	6-26-50	BJ	11.9	$\frac{3}{4}$	G	12.0	Tp	4.0	2,131.01	1.42	9- 5-50	
28cd2	H1	GS	9-25-50	J	28.2	$\frac{3}{4}$	G	12.0	Tp	6.0	2,223.85	24.40	10- 9-50	
28cd3	H2	GS	9-28-50	J	26.0	$\frac{3}{4}$	G	15.0	Tp	3.5	2,218.93	22.96	10- 9-50	
28dc1	G2$\frac{1}{2}$	GS	6-20-50	B	21.5	3	N	21.0	LS	.0	2,115	2.3	6-20-50	
28dc2	G2	GS	6-26-50	BJ	22.5	$\frac{3}{4}$	G	18.0	Tp	3.1	2,126.95	2.65	9- 5-50	
28dc3	G1$\frac{1}{2}$	GS	6-28-50	B	17.8	3	N	13.0	LS	.0	2,125	1.5	6-19-50	
28dd	G3	GS	6-26-50	BJ	16.5	$\frac{3}{4}$	G	12.9	Tp	4.8	2,112.32	12.85	9- 5-50	Ca
29ac	Dw4	P	....	Dr	1,020.0	4	S	28.0	LS	.0	2,290	Flowing	9-21-48	E
31ca1	Cb1	GS	6- 7-50	J	8.9	2	S	8.0	Tp	6.0	2,209.64	5.71	9- 5-50	
31ca2	Cb2	GS	6- 8-50	J	16.5	$\frac{3}{4}$	G	8.0	Tp	3.2	2,206.72	6.03	9- 5-50	
31db	Cb3	GS	7- 2-50	J	24.1	$\frac{3}{4}$	G	18.5	Tp	4.8	2,202.64	14.15	9- 5-50	

Table 1.--Records of wells and test holes--Continued

Well no.		Driller	Date drilled	Type of well	Depth of well below land-surface datum (feet)	Diameter of well (inches)	Type of casing	Depth to gravel (feet)	Measuring point			Depth to water below land-surface datum	Date of measurement	Remarks
Coordinate system	Field								Description	Height above land-surface datum (feet)	Altitude above mean sea level (feet)			
14-54-31dd	Cb4	GS	7- 2-50	J	27.8	3/4	G	12.8	Tp	4.7	2,188.96	25.12	9- 5-50	
32aa	T21	BR	5-11-50	D	7.0	60	N	....	LS	.1	2,197	....	....	
32ac	A1	GS	6-21-50	J	27.0	3/4	S	19.4	Tp	3.6	2,198.81	20.43	9-11-50	
32ca	A2	GS	8- 4-50	J	28.8	3/4	G	19.5	Tp	3.9	2,175.79	27.66	9- 5-50	
32dc	Dw2	P	1942	Dr	415.0	4	S	8.0	LS	.0	2,130	Flowing	9-21-48	
33aa1	F2½	BR	8-18-50	B	21.5	3	N	21.0	LS	.0	2,111	14.0	8-18-50	
33aa2	F3	GS	6-27-50	BJ	23.5	3/4	G	19.0	Tp	4.2	2,115.85	15.94	9- 5-50	
33ab3	E2	GS	6-26-50	BJ	17.0	3/4	G	14.0	Tp	4.1	2,121.50	5.60	9- 5-50	
33ab4	E1½	BR	8-17-50	B	14.0	3	N	14.0	LS	.0	2,122	4.5	8-17-50	
33ab5	E2¼	GS	6-28-50	B	16.5	3	N	16.5	LS	.0	2,116	2.5	6-28-50	
33ab6	E2½	BR	6-27-50	B	21.0	3	N	21.0	LS	.0	2,117	3.5	6-27-50	
33ab7	F1½	BR	8-18-50	B	11.0	3	N	11.0	LS	.0	2,117	....	....	
33ab8	F2	GS	6-26-50	BJ	20.9	3/4	G	18.5	Tp	4.7	2,115.33	3.46	9- 5-50	
33ac4	D3	GS	6-26-50	BJ	16.6	3/4	G	14.5	Tp	4.9	2,124.42	6.75	9- 5-50	
33ac5	E3	GS	6-22-50	BJ	21.1	2	S	19.0	Tp	5.8	2,123.56	7.44	9- 5-50	
33ac6	D3½	GS	6-18-50	B	12.5	3	N	12.5	LS	.0	2,120	8.0	6-22-50	
33ad1	E3½	BR	8-18-50	B	14.7	3	N	14.7	LS	.0	2,118	8.0	8-18-50	
33ad2	E4	GS	6-21-50	BJ	21.3	3/4	G	16.5	Tp	5.4	2,122.36	8.56	9- 5-50	
33ba6	D1	GS	6-26-50	BJ	28.5	3/4	G	26.0	Tp	2.7	2,139.85	5.27	9- 5-50	
33ba7	D1½	GS	6-27-50	B	25.0	3	N	22.0	LS	.0	2,127	3.0	6-26-50	
33ba8	DE	GS	6-23-50	B	17.5	3	N	....	LS	.0	2,135	6.8	6-23-50	
33ba9	D2	GS	6-20-50	BJ	14.5	3/4	G	10.0	Tp	4.0	2,124.86	3.79	9- 5-50	
33ba10	P	P	8-20-50	Dr	40.0	4	S	11.0	Tp	.5	2,122.97	5.49	8-22-50	Ca
33ba11	No1	GS	8-20-50	BJ	17.1	3/4	G	11.0	Tp	4.4	2,127.16	4.58	8-22-50	
33ba12	No2	GS	8-20-50	BJ	15.3	3/4	G	12.0	Tp	6.1	2,128.81	4.32	8-22-50	
33ba13	No3	GS	8-20-50	BJ	18.0	3/4	G	11.0	Tp	3.6	2,126.44	4.30	8-22-50	
33ba14	No4	GS	8-20-50	BJ	15.9	3/4	G	12.3	Tp	3.5	2,126.72	4.33	8-22-50	
33ba15	Ea1	GS	8-20-50	BJ	19.5	3/4	G	10.5	Tp	4.4	2,126.14	3.94	8-22-50	

33ba16	Ea2	GS	8-20-50	BJ	18.3	¾	G	9.0	Tp	3.0	2,123.92	3.47	8-22-50	
33ba17	Ea3	GS	8-20-50	BJ	15.2	¾	G	11.4	Tp	2.5	2,122.69	3.05	8-22-50	
33ba18	Ea4	GS	8-20-50	BJ	18.9	¾	G	18.0	Tp	4.8	2,124.43	6.06	8-22-50	
33ba19	So1	GS	8-20-50	BJ	16.1	¾	G	10.5	Tp	5.3	2,127.24	4.16	8-22-50	
33ba20	So2	GS	8-20-50	BJ	17.7	¾	G	10.5	Tp	3.7	2,126.34	5.08	8-22-50	
33ba21	We1	GS	8-20-50	BJ	16.3	¾	G	11.5	Tp	5.4	2,128.40	4.67	8-22-50	
33ba22	We2	GS	8-20-50	BJ	17.7	¾	G	12.0	Tp	3.8	2,127.33	4.99	8-22-50	
33ba23	We3	GS	8-20-50	BJ	15.0	¾	G	11.5	Tp	3.8	2,127.17	4.86	8-22-50	
33ba24	We4	GS	8-20-50	BJ	18.2	¾	G	12.7	Tp	3.3	2,127.85	5.99	8-22-50	
33bb3	T22	BR	5-11-50	D	7.0	60	N	2.0	LS	.0	2,213	....	....	
33bb4	B1	GS	5-16-50	BJ	47.2	2	S	12.0	Tp	3.4	2,164.62	26.95	9- 5-50	
33bb5	C1	GS	6- 6-50	J	28.0	¾	G	4.0	Tp	4.3	2,156.84	17.50	9- 5-50	
33bc4	B2	GS	6-21-50	BJ	22.1	2	S	17.0	Tp	1.6	2,136.77	8.38	9- 5-50	
33bc5	B2½	BR	8-17-50	B	13.0	3	N	13.0	LS	.0	2,130	7.5	8-17-50	
33bc6	C2	GS	6-26-50	BJ	6.2	¾	G	13.2	Tp	3.7	2,128.21	4.62	9- 5-50	
33bc7	C3	GS	6- 5-50	BJ	13.6	¾	G	12.5	Tp	3.8	2,128.37	4.79	9- 5-50	
33bc8	C3½	BR	8-17-50	B	12.0	3	N	12.0	LS	.0	2,122	5.5	8-17-50	
33bc9	C4	GS	6- 5-50	BJ	13.3	¾	G	11.5	Tp	3.7	2,124.53	6.77	9- 5-50	Ca
33bc10	C3¾	BR	9-26-50	B	12.0	3	N	12.0	LS	.0	2,122	6.0	9-26-50	
33bc11	C1⅔	BR	8-17-50	B	13.5	3	N	....	LS	.0	2,126	4.0	8-17-50	
33bd4	D2½	GS	6-23-50	B	12.7	3	N	12.7	LS	.0	2,120	4.15	6-23-50	
33bd5	So4	GS	8-20-50	BJ	14.1	¾	G	9.0	Tp	5.3	2,126.22	4.15	8-22-50	
33bd6	R	GS	5-19-50	B	12.0	7	G	8.0	Tsf	2.2	2,121.67	7.22	9- 5-50	
33ca2	C5	GS	6-27-50	BJ	14.4	¾	G	9.0	Tp	3.9	2,125.29	8.67	9- 5-50	
33ca3	C4½	BR	6-17-50	B	10.0	3	N	9.5	LS	.0	2,121	8.0	8-17-50	
33ca4	C5½	GS	6-22-50	B	12.0	3	N	12.0	LS	.0	2,122	8.0	6-22-50	
33cb2	B3	GS	6-21-50	BJ	14.6	¾	G	6.1	Tp	3.9	2,127.82	5.41	9- 5-50	
33cb3	B3½	BR	8-17-50	B	7.5	3	N	6.5	LS	.0	2,123	4.0	8-17-50	
33cb4	B4	GS	6-21-50	BJ	12.3	¾	G	5.8	Tp	4.2	2,126.78	5.99	9- 5-50	
33cb5	BC	GS	6-21-50	J	12.2	¾	G	8.0	Tp	5.0	2,126.11	5.66	9-11-50	
33cc1	Dw3	P	1942	Dr	412.0	4	S	1.0	Tp	....	2,120	Flowing	9-21-48	Ca
33cc2	B4½	BR	8-17-50	B	8.5	3	N	8.5	LS	.0	2,123	6.0	8-17-50	
33cc3	B5	GS	6-21-50	BJ	19.1	¾	G	9.0	Tp	4.4	2,127.67	9.05	9- 5-50	
33cd1	C6	GS	6-29-50	BJ	17.0	¾	G	12.0	Tp	4.5	2,127.26	10.35	9- 5-50	Ca
33cd2	C7	GS	6-28-50	BJ	19.3	¾	G	16.0	Tp	2.1	2,122.25	10.00	9- 5-50	

Table 1.--Records of wells and test holes--Continued

Well no.		Driller	Date drilled	Type of well	Depth of well below land-surface datum (feet)	Diameter of well (inches)	Type of casing	Depth to gravel (feet)	Measuring point			Depth to water below land-surface datum	Date of measurement	Remarks
Coordinate system	Field								Description	Height above land-surface datum (feet)	Altitude above mean sea level (feet)			
14-54-33da1	T	GS	6-28-50	DB	18.0	3	N	18.0	LS	0.0	2,117	14.4	6-28-50	
33da2	E5	GS	6-20-50	BJ	21.5	3/4	G	18.0	Tp	4.0	2,120.35	16.55	9- 5-50	Ca
33db1	D4	GS	6-26-50	BJ	13.6	3/4	G	9.6	Tp	3.8	2,124.58	7.93	9- 5-50	
33db2	D4½	GS	6-21-50	B	16.0	3	N	16.0	LS	.0	2,120	11.0	6-21-50	
33db3	D5	GS	5-26-50	BJ	13.2	3/4	G	10.4	Tp	4.3	2,123.32	6.50	9- 5-50	
33dc	CD	GS	8-18-50	J	20.5	3/4	G	9.5	Tp	5.2	2,124.59	16.13	9-11-50	

Table 2.--Logs of wells and test holes

[See text for description of well-numbering systems. Land-surface altitudes determined by instrumental leveling are given in feet, tenths, and hundredths above mean sea-level datum; altitudes determined from topographic map are given in feet. Unless otherwise indicated, all holes were logged by Bureau of Reclamation or Geological Survey personnel when hole was bored or drilled; a, logged by Geological Survey personnel when hole was jetted; b, logged by private driller.]

	Thickness (feet)	Depth (feet)
13-54-4bb1. (B6). Land-surface altitude, 2,122.84 feet[a]		
Sand and gravel..........	8.0	8.0
Gravel, coarse...........	7.7	15.7
Sand.....................	.8	16.5
Gravel...................	1.5	18.0
13-54-4bb2. (B6¼). Land-surface altitude, 2,122 feet		
Loam, sandy..............	5.2	5.2
Sand, fine, loamy........	1.6	6.8
Gravel...................	3.3	10.1
13-54-5ab. (A3). Land-surface altitude, 2,131.15 feet[a]		
Topsoil, sandy, loamy....	10.6	10.6
Gravel...................	6.3	16.9
13-54-5bb1. (Dw1). Land-surface altitude, 2,176 feet[b]		
Topsoil, sandy, loamy....	12.0	12.0
Gravel...................	28.0	40.0
Clay.....................	10.0	50.0
Sand.....................	15.0	65.0
Clay.....................	20.0	85.0
Sand.....................	21.0	106.0
13-54-5bb2. (Cb5). Land-surface altitude, 2,168.62 feet		
Topsoil, loamy...........	8.5	8.5
Sand.....................	1.1	9.6
Gravel...................	10.0	19.6
14-54-27bc1. (Ci1). Land-surface altitude, 2,213.73 feet[a]		
Loam, clayey.............	1.5	1.5
Loam, silty..............	5.0	6.5
Sand and gravel..........	3.0	9.5
Clay, gray...............	4.8	14.3

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet
14-54-27bc2. (Ci1). Land-surface altitude, 2,212.20 feet[a]		
Loam, fine sandy.........	9.0	9.0
Clay.....................	3.7	12.7
14-54-27bc3. (Ci3). Land-surface altitude, 2,111.34 feet[a]		
Loam, sandy..............	3.0	3.0
Gravel...................	2.0	5.0
Loam, black to brown.....	1.0	6.0
Clay, light-brown........	1.0	7.0
Clay, gray...............	3.2	10.2
14-54-27bc4. (Ci4). Land-surface altitude, 2,216.65 feet[a]		
Loam, sandy..............	9.0	9.0
Gravel...................	.5	9.5
Sand.....................	2.5	12.0
Clay.....................	2.2	14.2
14-54-28cd1. (E1). Land-surface altitude, 2,127.01 feet		
Clay, light..............	2.0	2.0
Clay, medium.............	.9	2.9
Loam, fine sandy.........	.3	3.2
Clay, heavy..............	4.0	7.2
Sand, fine, loamy........	4.8	12.0
Gravel...................	4.6	16.6
14-54-28cd2. (H1). Land-surface altitude, 2,217.85 feet[a]		
Gravel...................	10.5	10.5
Sand.....................	1.5	12.0
Gravel...................	16.2	28.2
14-54-28cd3. (H2). Land-surface altitude, 2,215.43 feet[a]		
Gravel...................	13.0	13.0
Coal.....................	1.0	14.0
Sand.....................	1.0	15.0
Gravel...................	11.0	26.0
14-54-28dc1. (G2½). Land-surface altitude, 2,115 feet		
Loam, clayey.............	2.0	2.0
Loam.....................	.3	2.3
Loam, clayey.............	.2	2.5
Loam, silty..............	.3	2.8
Clay, medium.............	1.5	4.3
Loam, sandy..............	.4	4.7
Clay, heavy..............	.9	5.6
Loam.....................	1.5	7.1

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-28dc1--Continued		
Clay, heavy	0.6	7.7
Clay, light	1.1	8.8
Loam, fine sand	.7	9.5
Clay, heavy	.6	10.1
Loam, fine sandy	2.6	12.7
Loam, clayey	.6	13.3
Loam, sandy	.7	14.0
Loam, clayey, silty	1.5	15.5
Loam, fine sandy	1.0	16.5
Loam, clayey, silty	1.0	17.5
Loam, fine sandy	.5	18.0
Loam, clayey, silty	1.0	19.0
Loam, fine sandy	.5	19.5
Loam, clayey, sandy	.8	20.3
Loam, fine sandy	.7	21.0
Gravel	.5	21.5
14-54-28dc2. (G2). Land-surface altitude, 2,123.85 feet		
Loam	1.0	1.0
Loam, clayey	1.0	2.0
Clay, light	5.5	7.5
Loam, sandy	2.0	9.5
Sand	.5	10.0
Loam, silty	1.0	11.0
Loam, very fine sandy	1.0	12.0
Clay, heavy	1.0	13.0
Loam, clayey, silty	.5	13.5
Clay, heavy	2.5	16.0
Sand, fine	2.0	18.0
Gravel	4.5	22.5
14-54-28dc3. (G1½). Land-surface altitude, 2,125 feet		
Clay, heavy	4.0	4.0
Clay, medium	4.5	8.5
Loam, very fine sandy	2.5	11.0
Loam, fine sandy	2.0	13.0
Gravel	.3	13.3
Sand	4.5	17.8
14-54-28dd. (G3). Land-surface altitude, 2,107.52 feet		
Clay, light	2.2	2.2
Loam, very fine sandy	2.3	4.5
Loam, silty	2.0	6.5
Loam, very fine sandy	.5	7.0
Sand, fine, loamy	.3	7.3
Loam, very fine sandy	.7	8.0
Loam, silty	1.0	9.0
Loam, very fine sandy	3.9	12.9
Gravel	3.6	16.5

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-29ac. (Dw4). Land-surface altitude, 2,290 feet (estimated)[b]		
Topsoil, sandy, loamy	1.0	1.0
Clay, yellow	27.0	28.0
Gravel	7.0	35.0
Clay, gray, (Fort Union)	785.0	820.0
Clay, sandy, gray	120.0	940.0
Sand, blue	80.0	1,020.0
14-54-31ca1. (Cb1). Land-surface altitude, 2,203.64 feet[a]		
Topsoil, loamy, sandy	2.0	2.0
Gravel	2.5	4.5
Clay	3.5	8.0
Gravel	1.0	9.0
Gravel, sandy	2.0	11.0
Gravel	5.2	16.2
14-54-31ca2. (Cb2). Land-surface altitude, 2,203.52 feet[a]		
Topsoil, loamy, sandy	2.5	2.5
Gravel	2.5	5.0
Clay and gravel	3.0	8.0
Gravel	1.0	9.0
Sand	2.0	11.0
Gravel	5.5	16.5
14-54-31db. (Cb3). Land-surface altitude, 2,197.84 feet		
Topsoil, loamy, sandy	1.0	1.0
Sand and gravel	8.0	9.0
Sand	.5	9.5
Clay, sandy	6.5	16.0
Sand	2.5	18.5
Gravel	6.6	25.1
14-54-31dd. (Cb4). Land-surface altitude, 2,184.26 feet		
Topsoil, loamy, sandy	3.8	3.8
Gravel	2.4	6.2
Clay, sandy	1.5	7.7
Gravel	3.5	11.2
Sand	1.6	12.8
Gravel	20.6	33.4
14-54-32aa. (T21). Land-surface altitude, 2,197 feet		
Topsoil, loamy, sandy	1.0	1.0
Sand and silt with some gravel	6.0	7.0

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-32ac. (A1). Land-surface altitude, 2,195.21 feet[a]		
Clay....................	8.0	8.0
Silt....................	2.0	10.0
Clay....................	5.4	15.4
Sand....................	4.0	19.4
Gravel..................	12.6	32.0
14-54-32ca. (A2). Land-surface altitude, 2,171.89 feet[a]		
Topsoil, sandy, loamy....	19.5	19.5
Gravel..................	9.5	29.0
14-54-32dc. (Dw2). Land-surface altitude, 2,130 feet[b]		
Topsoil, sandy, loamy....	8.0	8.0
Gravel..................	7.0	15.0
Clay, (Fort Union).......	120.0	135.0
Sand....................	30.0	165.0
Clay....................	30.0	195.0
Coal....................	7.0	202.0
Clay....................	28.0	230.0
Coal....................	10.0	240.0
Clay....................	40.0	280.0
Sandstone...............	3.0	283.0
Coal....................	10.0	293.0
Clay....................	43.0	336.0
Sandstone...............	2.0	338.0
Coal....................	10.0	348.0
Clay, gray..............	28.0	376.0
Sandstone...............	4.0	380.0
Clay....................	5.0	385.0
Sandstone...............	30.0	415.0
14-54-33aa1. (F2½). Land-surface altitude, 2,111 feet		
Loam, very fine sandy....	1.0	1.0
Loam, silty.............	1.0	2.0
Loam, very fine sandy....	1.2	3.2
Loam, silty, clayey......	1.3	4.5
Loam, fine sandy.........	1.0	5.5
Loam, silty.............	.5	6.0
Loam, fine sandy.........	1.0	7.0
Loam, clayey, sandy......	3.0	10.0
Loam, clayey, silty......	2.0	12.0
Loam....................	1.0	13.0
Loam, fine sandy.........	1.2	14.2
Sand....................	6.8	21.0
Gravel..................	.5	21.5
14-54-33aa2. (F3). Land-surface altitude, 2,111.7 feet		
Loam, very fine sandy....	3.2	3.2

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-33aa2.--Continued		
Sand, fine, loamy........	0.6	3.8
Loam, very fine sandy....	2.0	5.8
Loam, silty.............	.4	6.2
Sand....................	.8	7.0
Loam, very fine sandy....	3.0	10.0
Loam, silty.............	.7	10.7
Sand....................	1.2	11.9
Gravel and sand..........	.3	12.2
Loam, silty.............	.8	13.0
Sand....................	6.0	19.0
Gravel..................	5.0	24.0
14-54-33ab3. (E2). Land-surface altitude, 2,117.40 feet		
Loam....................	0.5	0.5
Loam, fine sandy.........	2.5	3.0
Loam, clayey............	2.0	5.0
Loam, fine silt, and sand, fine, loamy...........	2.0	7.0
Loam, clayey............	.5	7.5
Clay, heavy.............	3.5	11.0
Loam, very fine sandy....	2.0	13.0
Loam, silty.............	1.0	14.0
Gravel..................	4.0	18.0
14-54-33ab4. (E1½). Land-surface altitude, 2,122 feet		
Clay, light.............	1.5	1.5
Loam, silty.............	1.5	3.0
Clay, medium............	5.0	8.0
Clay, light.............	1.5	9.5
Loam, very fine sandy....	.8	10.3
Clay, heavy.............	.2	10.5
Loam, fine sandy.........	3.5	14.0
Gravel..................	....	14.0
14-54-33ab5. (E2¼). Land-surface altitude, 2,116 feet		
Loam, fine silty.........	1.7	1.7
Loam, clayey............	1.9	3.6
Clay, heavy.............	.4	4.0
Loam....................	.5	4.5
Loam, sandy.............	1.2	5.7
Clay, heavy.............	.5	6.2
Loam, fine sandy.........	3.7	9.9
Clay, medium............	2.1	12.0
Loam, silty.............	.9	12.9
Sand, fine, loamy, and loam, fine sandy.......	3.6	16.5
Gravel..................	....	16.5

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-33ab6. (E2½). Land-surface altitude, 2,117 feet		
Loam, fine sandy.........	1.0	1.0
Loam.....................	1.5	2.5
Loam, clayey.............	.5	3.0
Clay, light..............	.5	3.5
Loam, sandy..............	1.0	4.5
Clay, heavy..............	1.0	5.5
Loam.....................	.9	6.4
Loam, fine sandy.........	.6	7.0
Loam, silty, and loam, clayey.................	3.2	10.2
Sand, loamy, and sand....	5.8	16.0
Sand, coarse.............	1.0	17.0
Sand, loamy, and sand....	4.0	21.0
14-54-33ab7. (F1½). Land-surface altitude, 2,117 feet		
Loam, very fine sandy....	1.8	1.8
Clay, medium.............	3.2	5.0
Loam, clayey, sandy......	1.0	6.0
Loam, fine sandy.........	.5	6.5
Clay, heavy..............	.7	7.2
Loam, fine sandy.........	1.8	9.0
Loam.....................	.5	9.5
Loam, fine sandy.........	1.5	11.0
Gravel...................	....	11.0
14-54-33ab8. (F2). Land-surface altitude, 2,110.63 feet		
Clay, light..............	1.0	1.0
Loam, silty..............	.5	1.5
Clay, medium.............	1.3	2.8
Loam, fine sandy.........	.3	3.1
Clay, medium.............	.4	3.5
Loam, silty..............	.9	4.4
Clay, medium.............	.4	4.8
Sand, fine, loamy........	.5	5.3
Loam, silty..............	.3	5.6
Clay, heavy..............	2.0	7.6
Loam, silty..............	2.9	10.5
Loam, very fine sandy....	8.0	18.5
Gravel...................	2.4	20.9
14-54-33ac4. (D3). Land-surface altitude, 2,119.52 feet		
Loam, very fine sandy....	1.0	1.0
Loam.....................	3.0	4.0
Loam, fine sandy.........	.5	4.5
Gravel...................	.5	5.0
Loam, fine sandy.........	3.0	8.0
Sand, very fine..........	1.0	9.0

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-33ac4--Continued		
Loam, sandy, and sand, loamy.................	5.5	14.5
Gravel...................	2.1	16.6
14-54-33ac5. (E3). Land-surface altitude, 2,117.76 feet.		
Loam.....................	0.8	0.8
Loam, clayey.............	1.0	1.8
Loam, silty..............	.3	2.1
Loam, very fine sandy....	1.0	3.1
Loam, silty..............	.7	3.8
Sand, fine, loamy........	.9	4.7
Loam, silty..............	1.1	5.8
Loam, very fine sandy....	1.7	7.5
Loam, silty..............	2.5	10.0
Clay, light..............	.5	10.5
Loam, silty..............	4.5	15.0
Sand.....................	4.0	19.0
Gravel...................	2.0	21.0
14-54-33ac6. (D3½). Land-surface altitude, 2,120 feet		
Loam, very fine sandy....	1.5	1.5
Sand, fine, loamy........	1.2	2.7
Loam, fine sandy.........	.5	3.2
Loam.....................	.5	3.7
Loam, silty..............	.5	4.2
Sand, fine...............	.5	4.7
Sand, medium.............	.7	5.4
Loam, fine sandy.........	.8	6.2
Sand, fine, loamy........	.7	6.9
Sand, fine...............	.9	7.8
Gravel, fine, and sand...	4.7	12.5
Gravel...................	....	12.5
14-54-33ad1. (E3½). Land-surface altitude, 2,118 feet		
Loam, very fine sandy....	3.3	3.3
Loam.....................	.7	4.0
Sand, fine, loamy........	1.5	5.5
Loam, fine sandy.........	1.0	6.5
Loam, very fine sandy....	.5	7.0
Sand, loamy..............	1.0	8.0
Loam, very fine sandy....	1.0	9.0
Sand, fine, loamy........	1.0	10.0
Loam.....................	1.0	11.0
Loam, fine sandy.........	1.0	12.0
Sand, loamy, and sand....	2.7	14.7
Gravel...................	....	14.7

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-33ad2. (E4). Land-surface altitude, 2,115.96 feet		
Loam, fine sandy	1.0	1.0
Loam, clayey, silty	2.0	3.0
Loam, silty	1.0	4.0
Loam, fine sandy	2.5	6.5
Sand	.5	7.0
Loam	1.0	8.0
Loam, fine sandy	2.0	10.0
Loam	1.0	11.0
Loam, fine sandy	1.0	12.0
Loam, clayey	1.5	13.5
Loam, fine sandy	2.0	15.5
Sand	1.0	16.5
Gravel	5.5	22.0
14-54-33ba6. (D1). Land-surface altitude, 2,137.15 feet		
Loam, clayey	2.2	2.2
Loam	1.2	3.4
Sand, loamy	1.1	4.5
Loam	.6	5.1
Sand, loamy	.9	6.0
Clay, light	1.5	7.5
Loam, clayey	1.0	8.5
Sand, loamy	1.5	10.0
Clay, light	.5	10.5
Sand	1.0	11.5
Loam, sandy, and loam	1.0	12.5
Clay, medium	.5	13.0
Loam, sandy, and loam	1.0	14.0
Clay, medium	.4	14.4
Loam, fine sandy	.6	15.0
Loam, sandy, and loam	7.0	22.0
Clay	4.0	26.0
Gravel	2.5	28.5
14-54-33ba7. (D1½). Land-surface altitude, 2,127 feet		
Clay, medium	1.6	1.6
Loam, clayey	.4	2.0
Loam	1.5	3.5
Loam, fine sandy	1.5	5.0
Sand, loamy	.6	5.6
Loam	.4	6.0
Loam, very fine sandy	1.5	7.5
Loam, clayey	2.2	9.7
Gravel	.3	10.0
Loam, sandy	.8	10.8
Sand, loamy	.3	11.1
Clay, heavy	.7	11.8
Sand, medium	.3	12.1
Clay, heavy	6.2	18.3

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-33ba7--Continued		
Loam, fine sandy	0.8	19.1
Loam, silty	.9	20.0
Loam, sandy	2.0	22.0
Gravel and sand	2.0	24.0
Clay, heavy, blue, (Fort Union)	1.0	25.0
14-54-33ba8. (DE). Land-surface altitude, 2,135 feet		
Loam, clayey	2.5	2.5
Loam, clayey, sandy	.6	3.1
Gravel and clay	.4	3.5
Clay, light	.6	4.1
Sand and gravel	1.4	5.5
Loam, clayey	.7	6.2
Sand, medium	1.0	7.2
Loam, clayey	.8	8.0
Sand	1.3	9.3
Loam, clayey	.6	9.9
Sand, loamy, and sand	7.6	17.5
14-54-33ba9. (D2). Land-surface altitude, 2,120.86 feet		
Clay, medium	2.0	2.0
Loam, fine sandy, and loam	5.5	7.5
Sand	2.5	10.0
Gravel	1.0	11.0
Loam, sandy	2.0	13.0
Gravel	2.0	15.0
Sand	1.5	16.5
Clay (Fort Union)	2.5	19.0
14-54-33ba10. (P). Land-surface altitude, 2,122.47 feet		
Loam, silty	0.3	0.3
Sand with cobbles	2.7	3.0
Loam, very fine sandy	.2	3.2
Sand	.3	3.5
Loam, silty	1.0	4.5
Loam, clayey	1.5	6.0
Loam, silty	4.0	10.0
Loam, very fine sandy	.2	10.2
Sand, coarse	.8	11.0
Gravel	9.0	20.0
Clay, blue (Fort Union)	20.0	40.0
14-54-33ba11. (No1). Land-surface altitude, 2,122.76 feet		
Loam, sandy	1.0	1.0
Loam	.5	1.5
Sand and gravel	1.0	2.5

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-33ba11--Continued		
Loam, clayey, silty......	1.8	4.3
Clay, medium.............	2.2	6.5
Loam, silty..............	1.5	8.0
Loam, very fine sandy....	2.0	10.0
Sand.....................	1.0	11.0
Gravel...................	6.1	17.1

14-54-33ba12. (No2). Land-surface altitude, 2,122.71 feet

	Thickness (feet)	Depth (feet)
Loam, fine sandy.........	2.0	2.0
Sand, fine to medium.....	1.2	3.2
Sand, fine...............	.8	4.0
Loam, very fine sandy....	1.0	5.0
Loam, clayey.............	1.0	6.0
Loam, clayey, very fine sandy.................	3.5	9.5
Sand.....................	2.5	12.0
Gravel...................	3.3	15.3

14-54-33ba13. (No3). Land-surface altitude, 2,122.84 feet

	Thickness (feet)	Depth (feet)
Loam, fine silty.........	1.0	1.0
Sand.....................	.5	1.5
Loam.....................	.5	2.0
Sand, coarse.............	.8	2.8
Loam, silty..............	2.2	5.0
Loam, clayey.............	4.0	9.0
Loam, very fine sandy....	1.5	10.5
Sand.....................	.5	11.0
Gravel...................	7.0	18.0

14-54-33ba14. (No4). Land-surface altitude, 2,123.22 feet

	Thickness (feet)	Depth (feet)
Loam, clayey.............	1.2	1.2
Loam, very fine sandy....	1.1	2.3
Sand, medium.............	.7	3.0
Loam, very fine sandy....	.2	3.2
Sand, coarse.............	.3	3.5
Loam, silty..............	2.5	6.0
Loam, clayey.............	1.0	7.0
Clay.....................	.5	7.5
Loam, clayey.............	2.5	10.0
Sand, fine...............	.5	10.5
Loam, very fine sandy....	.5	11.0
Sand.....................	1.3	12.3
Gravel...................	3.6	15.9

14-54-33ba15. (Ea1). Land-surface altitude, 2,121.74 feet

	Thickness (feet)	Depth (feet)
Loam, silty..............	1.0	1.0
Sand, medium.............	1.0	2.0
Loam, very fine sandy....	.5	2.5

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-33ba15--Continued		
Loam, silty..............	5.5	8.0
Loam, very fine sandy....	2.0	10.0
Sand.....................	.5	10.5
Gravel...................	9.0	19.5

14-54-33ba16. (Ea2). Land-surface altitude, 2,120.92 feet

	Thickness (feet)	Depth (feet)
Sand.....................	1.0	1.0
Loam, fine sandy.........	2.5	3.5
Loam, clayey.............	2.0	5.5
Loam, silty..............	2.5	8.0
Sand, medium.............	1.0	9.0
Gravel...................	9.3	18.3

14-54-33ba17. (Ea3). Land-surface altitude, 2,120.19 feet

	Thickness (feet)	Depth (feet)
Loam, clayey.............	1.0	1.0
Loam, fine silty.........	5.0	6.0
Loam, sandy..............	5.0	11.0
Sand.....................	.4	11.4
Gravel...................	3.8	15.2

14-54-33ba18. (Ea4). Land-surface altitude, 2,119.63 feet

	Thickness (feet)	Depth (feet)
Loam, clayey.............	3.0	3.0
Loam, very fine silty....	3.5	6.5
Sand.....................	.5	7.0
Loam, clayey.............	1.5	8.5
Clay.....................	.5	9.0
Clay, loamy..............	1.0	10.0
Loam, silty..............	3.0	13.0
Sand, medium.............	5.0	18.0
Gravel...................	.9	18.9

14-54-33ba19. (So1). Land-surface altitude, 2,121.94 feet

	Thickness (feet)	Depth (feet)
Loam, sandy..............	0.5	0.5
Sand.....................	2.5	3.0
Loam, fine sandy.........	.5	3.5
Loam, silty..............	1.0	4.5
Loam, clayey.............	.5	5.0
Loam, silty..............	5.0	10.0
Sand.....................	.5	10.5
Gravel...................	5.6	16.1

14-54-33ba20. (So2). Land-surface altitude, 2,122.64 feet

	Thickness (feet)	Depth (feet)
Gravel...................	3.7	3.7
Loam, clayey.............	.8	4.5
Loam, silty..............	5.0	9.5
Sand.....................	1.0	10.5
Gravel...................	7.2	17.7

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-33ba21. (We1). Land-surface altitude, 2,123.00 feet		
Loam, sandy	0.5	0.5
Gravel and sand	2.5	3.0
Loam, sandy	1.0	4.0
Loam, silty	6.0	10.0
Loam, very fine sandy	.5	10.5
Sand	1.0	11.5
Gravel	4.8	16.3
14-54-33ba22. (We2). Land-surface altitude, 2,123.53 feet		
Sand, gravel, and cobbles	3.0	3.0
Loam, very fine sandy	1.0	4.0
Loam, silty	7.0	11.0
Sand	1.0	12.0
Gravel	5.7	17.7
14-54-33ba23. (We3). Land-surface altitude, 2,123.37 feet		
Loam, sandy	2.8	2.8
Loam, silty	.2	3.0
Sand	1.0	4.0
Loam, silty	1.2	5.2
Loam, clayey	.8	6.0
Loam, silty	4.0	10.0
Loam, very fine sandy	1.0	11.0
Sand	.5	11.5
Gravel	3.5	15.0
14-54-33ba24. (We4). Land-surface altitude, 2,124.55 feet		
Loam, silty	1.0	1.0
Loam, sandy	1.0	2.0
Loam, silty	2.3	4.3
Sand	.7	5.0
Loam, silty	.5	5.5
Loam, clayey	.5	6.0
Loam, silty	4.0	10.0
Loam, sandy	.5	10.5
Loam, silty	2.0	12.5
Sand	.2	12.7
Gravel	5.5	18.2
14-54-33bb3. (T22). Land-surface altitude, 2,213.0 feet		
Topsoil, clayey	2.0	2.0
Gravel, subrounded, well-graded, maximum size of pebbles 3 inches (60 percent); sand; trace of silt	5.0	7.0

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-33bb4. (B1). Land-surface altitude, 2,161.22 feet		
Clay, medium	2.0	2.0
Loam, clayey, sandy	6.0	8.0
Clay, sandy	4.0	12.0
Clay and gravel	35.0	47.0
14-54-33bb5. (C1). Land-surface altitude, 2,152.54 feet		
Topsoil, silty	4.0	4.0
Gravel	9.2	13.2
Sand	1.0	14.2
Sand and gravel	8.8	23.0
Clay, sandy	11.3	34.3
14-54-33bc4. (B2). Land-surface altitude, 2,135.17 feet		
Loam, clayey	1.4	1.4
Loam, sandy	1.0	2.4
Clay, medium	2.6	5.0
Clay, heavy	2.0	7.0
Clay, medium	2.3	9.3
Loam, sandy	.3	9.6
Clay, light	.9	10.5
Loam, clayey	2.0	12.5
Loam, sandy	1.5	14.0
Sand	3.0	17.0
Gravel	5.3	22.3
14-54-33bc5. (B2½). Land-surface altitude, 2,130 feet		
Clay, medium	2.0	2.0
Loam, clayey, silty	2.0	4.0
Clay, heavy	3.0	7.0
Clay, light	.5	7.5
Sand, loamy	1.0	8.5
Loam, silty	1.0	9.5
Sand, fine, loamy	1.2	10.7
Sand	2.3	13.0
Gravel	....	13.0
14-54-33bc6. (C2). Land-surface altitude, 2,124.51 feet		
Clay, loamy	1.0	1.0
Loam, fine sandy	2.0	3.0
Clay, loamy	1.0	4.0
Loam, fine sandy	.9	4.9
Loam, very fine sandy	.9	5.8
Clay, sandy	1.2	7.0
Clay, medium	1.2	8.2
Loam, clayey, sandy	1.8	10.0
Sand	2.5	12.5
Gravel	4.5	17.0

Table 2.--Logs of wells and test holes--Con.

14-54-33bc7. (C3). Land-surface altitude, 2,124.57 feet

	Thickness (feet)	Depth (feet)
Clay, light.............	1.0	1.0
Loam, fine sandy.........	2.0	3.0
Clay, light.............	1.0	4.0
Loam, fine sandy.........	.9	4.9
Loam, very fine sandy....	.9	5.8
Clay, sandy.............	1.2	7.0
Clay, medium............	1.2	8.2
Loam, clayey, sandy......	1.8	10.0
Sand....................	2.5	12.5
Gravel..................	1.1	13.6

14-54-33bc8. (3$\frac{1}{2}$). Land-surface altitude, 2,122 feet

	Thickness (feet)	Depth (feet)
Loam, very fine sandy....	1.0	1.0
Loam, fine sandy.........	2.0	3.0
Clay, medium............	3.0	6.0
Loam, fine sandy.........	1.0	7.0
Sand, fine..............	1.0	8.0
Clay, heavy.............	1.5	9.5
Sand, fine, loamy........	.5	10.0
Clay, sandy.............	1.3	11.3
Loam, sandy.............	.7	12.0
Gravel..................	....	12.0

14-54-33bc9. (C4). Land-surface altitude, 2,120.98 feet

	Thickness (feet)	Depth (feet)
Loam, fine sandy.........	2.3	2.3
Clay, medium............	1.2	3.5
Loam, clayey, sandy......	.9	4.4
Loam, sandy.............	1.6	6.0
Loam....................	2.0	8.0
Sand, very fine.........	2.4	10.4
Sand....................	1.1	11.5
Gravel..................	3.3	14.8
Clay, blue (Fort Union)..	1.4	16.2

14-54-33bc10. (C3$\frac{3}{4}$). Land-surface altitude, 2,122 feet

	Thickness (feet)	Depth (feet)
Loam....................	1.3	1.3
Loam, very fine sandy....	1.7	3.0
Clay, heavy.............	1.5	4.5
Clay, light.............	1.0	5.5
Loam, very fine sandy....	1.1	6.6
Sand, fine, loamy........	.9	7.5
Clay, heavy.............	2.5	10.0
Loam, silty.............	2.0	12.0
Gravel..................	....	12.0

Table 2.--Logs of wells and test holes--Con.

14-54-33bc11. (C1$\frac{2}{3}$). Land-surface altitude, 2,126 feet

	Thickness (feet)	Depth (feet)
Clay, light.............	1.5	1.5
Loam, clayey, sandy......	1.5	3.0
Loam, sandy.............	1.0	4.0
Clay, medium............	2.0	6.0
Clay, heavy.............	6.0	12.0
Clay, heavy, blue (Fort Union)................	1.5	13.5

14-54-33bd4. (D2$\frac{1}{2}$). Land-surface altitude, 2,120 feet

	Thickness (feet)	Depth (feet)
Loam, clayey............	1.8	1.8
Sand, fine, loamy........	.7	2.5
Loam, clayey............	.5	3.0
Loam, sandy.............	.4	3.4
Loam, clayey............	1.1	4.5
Loam, fine sandy.........	.9	5.4
Loam, clayey............	.4	5.8
Loam, very fine sandy....	1.0	6.8
Clay, medium............	.3	7.1
Loam, fine sandy, and sand, fine, loamy......	2.4	9.5
Loam, clayey, sandy......	.7	10.2
Loam, silty.............	.8	11.0
Loam, fine sandy.........	1.7	12.7
Gravel..................	....	12.7

14-54-33bd5. (So4). Land-surface altitude, 2,120.92 feet

	Thickness (feet)	Depth (feet)
Loam, silty.............	5.0	5.0
Loam, very fine sandy....	3.0	8.0
Sand, very fine..........	1.0	9.0
Gravel..................	....	9.0

14-54-33bd6. (R). Land-surface altitude, 2,119.47 feet

	Thickness (feet)	Depth (feet)
Loam, sandy.............	8.0	8.0
Gravel..................	4.0	12.0

14-54-33ca2. (C5). Land-surface altitude, 2,121.39 feet

	Thickness (feet)	Depth (feet)
Loam, fine sandy.........	3.5	3.5
Loam....................	1.0	4.5
Loam, fine sandy.........	4.5	9.0
Gravel..................	5.4	14.4

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-33ca3. (C4½). Land-surface altitude, 2,121 feet		
Loam, very fine sandy....	2.5	2.5
Loam....................	1.5	4.0
Sand, fine, loamy........	.8	4.8
Loam, clayey.............	2.2	7.0
Clay, medium.............	1.0	8.0
Loam, clayey, silty......	.8	8.8
Sand, loamy..............	.7	9.5
Gravel...................	.5	10.0
14-54-33ca4. (C5½). Land-surface altitude, 2,122 feet		
Loam, very fine sandy....	0.8	0.8
Sand, fine, loamy........	3.2	4.0
Loam, very fine sandy....	.9	4.9
Sand, fine, loamy........	1.6	6.5
Loam, silty..............	1.0	7.5
Sand, very fine, loamy...	1.6	9.1
Loam, silty..............	.9	10.0
Sand, fine, loamy........	1.0	11.0
Sand.....................	1.0	12.0
Sand and gravel..........	....	12.0
14-54-33cb2. (B3). Land-surface altitude, 2,123.92 feet		
Loam, clayey, sandy......	1.2	1.2
Loam, sandy..............	1.0	2.2
Clay, heavy..............	1.8	4.0
Clay, light..............	.5	4.5
Loam, clayey, sandy......	1.6	6.1
Gravel...................	9.4	15.5
14-54-33cb3. (B3½). Land-surface altitude, 2,123 feet		
Loam, fine sandy.........	2.5	2.5
Loam.....................	1.5	4.0
Loam, very fine sandy....	2.5	6.5
Sand and gravel..........	1.0	7.5
14-54-33cb4. (B4). Land-surface altitude, 2,122.58 feet		
Loam, sandy..............	2.5	2.5
Loam.....................	1.5	4.0
Loam, fine sandy.........	1.8	5.8
Gravel...................	7.8	13.6
14-54-33cb5. (BC). Land-surface altitude, 2,121.11 feet[a]		
Clay, loamy..............	8.0	8.0
Gravel...................	6.0	14.0

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-33cc1. (Dw3). Land-surface altitude, 2,120 feet[b]		
Topsoil, sandy, loamy....	1.0	1.0
Gravel...................	26.0	27.0
Clay, gray (Fort Union)..	53.0	80.0
Sandstone................	2.0	82.0
Clay, gray...............	78.0	160.0
Coal.....................	7.0	167.0
Clay, gray...............	32.0	199.0
Sandstone................	2.0	201.0
Clay, gray...............	29.0	230.0
Sandstone................	2.0	232.0
Coal.....................	16.0	248.0
Clay, gray...............	76.0	324.0
Coal.....................	6.0	330.0
Clay, gray...............	50.0	380.0
Sandstone................	32.0	412.0
14-54-33cc2. (B4¼). Land-surface altitude, 2,123 feet		
Loam, very fine sandy....	3.0	3.0
Loam, silty..............	1.5	4.5
Clay, sandy..............	.9	5.4
Loam, very fine sandy....	2.6	8.0
Sand, fine, loamy........	.5	8.5
Gravel...................	....	8.5
14-54-33cc3. (B5). Land-surface altitude, 2,123.27 feet		
Loam, sandy..............	2.5	2.5
Loam.....................	1.5	4.0
Loam, sandy..............	.5	4.5
Loam.....................	2.0	6.5
Loam, fine sandy.........	1.5	8.0
Loam, very fine sandy....	1.0	9.0
Gravel...................	11.0	20.0
14-54-33cd1. (C6). Land-surface altitude, 2,122.76 feet		
Loam, fine sandy.........	6.0	6.0
Sand, fine, loamy........	2.0	8.0
Loam, fine sandy.........	3.5	11.5
Loam.....................	.5	12.0
Gravel...................	4.8	16.8
14-54-33cd2. (C7). Land-surface altitude, 2,120.15 feet		
Loam, fine sandy.........	3.0	3.0
Sand, fine, loamy........	4.0	7.0
Loam, very fine sandy....	2.0	9.0

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-33cd2--Continued		
Loam, silty, and loam....	2.0	11.0
Loam, very fine sandy....	2.0	13.0
Loam, clayey............	1.0	14.0
Loam, and loam, fine sandy	2.0	16.0
Gravel and coal..........	6.0	22.0
Clay, blue (Fort Union)..	.6	22.6
14-54-33da1. (T). Land-surface altitude, 2,117 feet		
Sand, very fine, loamy...	1.5	1.5
Loam, very fine sandy....	3.4	4.9
Loam, fine sandy.........	.6	5.5
Gravel and sand..........	.7	6.2
Loam, silty.............	2.3	8.5
Sand, fine..............	.5	9.0
Loam, fine sandy.........	.7	9.7
Sand, very fine.........	.3	10.0
Loam, very fine sandy....	1.5	11.5
Loam, silty.............	2.5	14.0
Sand, fine, loamy........	.4	14.4
Loam, very fine sandy....	2.9	17.3
Sand, fine, loamy........	.7	18.0
Gravel..................	....	18.0
14-54-33da2. (E5). Land-surface altitude, 2,116.35 feet		
Loam, very fine sandy....	7.0	7.0
Sand, loamy.............	1.0	8.0
Loam, very fine sandy....	.5	8.5
Sand....................	.5	9.0
Loam, clayey............	3.5	12.5
Loam, very fine sandy....	5.5	18.0
Gravel..................	3.5	21.5
14-54-33db1. (D4). Land-surface altitude, 2,120.78 feet		
Loam, fine sandy........	2.5	2.5
Gravel.................	.5	3.0
Loam...................	2.0	5.0
Loam, fine sandy........	2.5	7.5
Loam, clayey...........	.5	8.0
Sand, loamy............	1.0	9.0
Sand, fine, loamy.......	.6	9.6
Gravel.................	4.0	13.6
14-54-33db2. (D4½). Land-surface altitude, 2,120 feet		
Loam, very fine sandy...	2.6	2.6
Loam, silty...........	.6	3.2
Loam, very fine sandy...	3.0	6.2
Loam, sandy...........	.6	6.8

Table 2.--Logs of wells and test holes--Con.

	Thickness (feet)	Depth (feet)
14-54-33db2--Continued		
Loam, silty.............	1.9	8.7
Loam, sandy.............	2.3	11.0
Loam, clayey............	2.1	13.1
Loam, sandy.............	1.9	15.0
Loam, clayey............	.5	15.5
Clay....................	.5	16.0
Sand and gravel.........	....	16.0
14-54-33db3. (D5). Land-surface altitude, 2,119.02 feet		
Loam, fine sandy.........	4.0	4.0
Loam, sandy.............	1.0	5.0
Loam, fine sandy.........	2.0	7.0
Sand, fine, loamy........	1.5	8.5
Loam, fine sandy.........	1.9	10.4
Gravel..................	2.8	13.2
14-54-33dc. (CD). Land-surface altitude, 2,119.39 feet[a]		
Loam, sandy.............	6.0	6.0
Sand, and gravel.........	3.5	9.5
Gravel..................	8.5	18.0
Sand....................	2.0	20.0

Table 3.--Measurements of depth to water in observation wells, 1950

[Feet below land-surface datum]

Date	Water level	Date	Water level	Date	Water level
13-54-4bb1. (B6)					
July 10	13.55	Sept. 5	12.27	Oct. 30	13.68
17	13.62	11	12.60	Nov. 6	13.83
24	13.54	18	12.91	13	13.97
31	13.24	25	13.22	20	14.00
Aug. 7	12.94	Oct. 2	13.25	27	14.10
14	13.01	9	13.15	Dec. 4	14.03
21	12.85	16	13.42	18	14.25
28	12.78	23	13.52		
14-54-27bc1. (Ci1)					
Oct. 30	10.39	Nov. 13	11.02	Nov. 27	11.30
Nov. 6	10.68	20	11.21		
14-54-27bc2. (Ci2)					
Oct. 30	8.22	Nov. 13	8.61	Nov. 27	8.82
Nov. 6	8.40	20	8.74		

Table 3.--Measurements of depth to water in observation wells, 1950--Continued

14-54-27bc3. (Ci3)

Date	Water level	Date	Water level	Date	Water level
Oct. 30	6.50	Nov. 13	6.93	Nov. 27	7.10
Nov. 6	6.71	20	7.05		

14-54-27bc4. (Ci4)

Date	Water level	Date	Water level	Date	Water level
Oct. 30	11.29	Nov. 13	11.82	Nov. 27	12.11
Nov. 6	11.65	20	12.01		

14-54-28cd1. (E1)

Date	Water level	Date	Water level	Date	Water level
June 26	2.49	Aug. 28	1.30	Oct. 23	0.94
July 3	2.29	Sept. 5	1.42	30	1.10
10	2.45	11	.82	Nov. 6	1.37
17	2.59	18	.40	13	1.60
24	2.74	25	.50	20	1.78
31	2.37	Oct. 2	.60	27	2.00
Aug. 7	1.52	9	.49	Dec. 4	2.07
14	.87	16	.78	18	2.75
21	.88				

14-54-28cd2. (H1)

Date	Water level	Date	Water level	Date	Water level
Oct. 9	24.40	Oct. 30	25.38	Nov. 20	25.90
16	24.77	Nov. 6	25.60	27	26.05
23	25.11	13	25.74	Dec. 18	26.35

14-54-28cd3. (H2)

Date	Water level	Date	Water level	Date	Water level
Oct. 9	22.96	Oct. 30	23.87	Nov. 20	24.25
16	23.48	Nov. 6	24.07	27	24.26
23	23.82	13	24.15	Dec. 18	24.75

14-54-28dc2. (G2)

Date	Water level	Date	Water level	Date	Water level
July 24	4.16	Sept.11	2.09	Oct. 30	1.72
31	4.09	18	1.51	Nov. 6	2.05
Aug. 7	2.32	25	1.71	13	1.96
14	1.73	Oct. 2	1.57	20	2.33
21	1.99	9	1.63	27	2.46
29	2.08	16	1.73	Dec. 4	2.49
Sept. 5	2.65	23	1.63	18	3.60

14-54-28dd. (G3)

Date	Water level	Date	Water level	Date	Water level
June 26	6.88	Aug. 29	12.39	Oct. 23	12.52
July 3	8.20	Sept. 5	12.85	30	12.74
10	8.58	11	13.22	Nov. 6	12.89
17	9.31	18	12.62	13	12.83
24	10.35	25	12.60	20	12.83
31	10.13	Oct. 2	12.65	27	12.68
Aug. 7	11.14	9	12.32	Dec. 4	12.74
14	10.92	16	12.49	18	11.07
21	10.37				

14-54-31ca1. (Cb1)

Date	Water level	Date	Water level	Date	Water level
June 26	6.95	July 17	5.68	Aug. 7	5.68
July 3	6.42	24	5.63	14	5.37
10	5.38	31	5.31	21	6.30

Table 3.--Measurements of depth to water in observation wells, 1950--Continued

14-54-31ca1. (Cb1)--Continued

Date	Water level	Date	Water level	Date	Water level
Aug. 28	5.82	Oct. 9	6.51	Nov. 13	7.13
Sept. 5	5.71	16	6.78	20	7.22
11	5.88	23	6.97	27	7.20
18	5.96	30	7.10	Dec. 4	7.29
25	6.60	Nov. 6	7.14	18	7.53
Oct. 2	6.20				

14-54-31ca2. (Cb2)

Date	Water level	Date	Water level	Date	Water level
June 26	6.31	Aug. 21	5.81	Oct. 23	5.59
July 3	6.45	28	6.03	30	6.10
10	6.08	Sept. 5	6.03	Nov. 6	6.38
17	6.33	11	6.01	13	6.68
24	6.12	18	6.00	20	6.85
31	5.84	25	6.12	27	7.01
Aug. 7	5.95	Oct. 2	6.17	Dec. 4	7.11
14	5.70	9	6.12	18	7.29

14-54-31db. (Cb3)

Date	Water level	Date	Water level	Date	Water level
July 3	15.14	Aug. 28	11.94	Oct. 23	15.78
10	15.33	Sept. 5	14.15	30	15.99
17	12.60	11	14.71	Nov. 6	16.16
24	14.24	18	14.78	13	16.33
31	14.16	25	15.18	20	16.45
Aug. 7	14.66	Oct. 2	15.20	27	16.55
14	14.99	9	15.28	Dec. 4	16.57
21	14.85	16	15.65	18	16.80

14-54-31dd. (Cb4)

Date	Water level	Date	Water level	Date	Water level
July 3	25.17	Aug. 28	25.13	Oct. 18	25.05
10	25.74	Sept. 5	25.12	23	25.09
17	25.79	11	25.06	30	25.18
24	25.60	18	25.04	Nov. 6	25.17
31	25.21	25	25.10	13	25.20
Aug. 7	25.72	Oct. 2	24.74	20	25.22
14	24.98	9	24.99	27	25.22
21	25.14				

14-54-32ac. (A1)

Date	Water level	Date	Water level	Date	Water level
June 26	21.28	Aug. 21	20.28	Oct. 23	20.49
July 3	21.31	28	20.63	30	20.54
10	20.50	Sept.11	20.43	Nov. 6	20.59
17	21.23	18	20.28	13	20.60
24	21.02	25	20.40	20	20.66
31	20.71	Oct. 2	20.44	27	20.70
Aug. 7	20.66	9	20.38	Dec. 4	20.76
14	20.53	16	20.49	18	20.82

14-54-32ca. (A2)

Date	Water level	Date	Water level	Date	Water level
Aug. 7	27.34	Aug. 28	27.84	Sept.18	27.84
14	26.83	Sept. 5	27.66	25	27.87
21	27.53	11	27.79	Oct. 2	27.62

Table 3.--Measurements of depth to water in observation wells, 1950--Continued

Date	Water level	Date	Water level	Date	Water level
14-54-32ca. (A2)--Continued					
Oct. 9	27.76	Oct. 30	27.90	Nov. 20	28.05
16	27.76	Nov. 6	27.94	Dec. 18	28.45
23	27.85	13	27.90		
14-54-33aa2. (F3)					
July 10	13.06	Sept. 5	15.94	Oct. 30	16.55
17	13.55	11	16.50	Nov. 6	16.60
24	13.65	18	16.54	13	16.58
31	13.53	25	16.45	20	16.63
Aug. 7	13.92	Oct. 2	16.52	27	16.44
14	15.48	9	16.45	Dec. 4	15.47
21	15.32	18	16.42	18	14.90
29	15.98	23	16.42		
14-54-33ab3. (E2)					
June 26	2.07	Aug. 28	5.62	Oct. 23	4.46
July 3	3.23	Sept. 5	5.60	30	4.36
10	4.98	11	5.57	Nov. 6	4.51
17	4.59	18	5.20	13	4.19
24	4.78	25	5.36	20	4.34
31	4.52	Oct. 2	4.92	27	4.42
Aug. 7	5.66	9	5.09	Dec. 4	5.85
14	5.34	16	4.81	18	4.90
21	5.48				
14-54-33ab8. (F2)					
June 26	2.38	Aug. 29	3.68	Oct. 23	3.28
July 3	1.80	Sept. 5	3.46	30	3.17
10	3.10	11	3.55	Nov. 6	3.30
17	3.39	18	3.47	13	3.11
24	3.37	25	3.49	20	3.25
31	3.14	Oct. 2	3.50	27	3.37
Aug. 7	3.70	9	3.46	Dec. 4	3.57
14	3.42	18	3.36	18	3.60
21	3.51				
14-54-33ac4. (D3)					
June 26	5.69	Aug. 28	7.13	Oct. 23	6.87
July 3	6.11	Sept. 5	6.75	30	6.97
10	6.48	11	6.80	Nov. 6	6.99
17	6.86	18	6.66	13	6.97
24	6.12	25	6.71	20	7.10
31	5.96	Oct. 2	6.79	27	7.28
Aug. 7	7.20	9	6.64	Dec. 4	7.39
14	6.62	16	6.83	18	7.52
21	6.65				
14-54-33ac5. (E3)					
June 26	7.74	July 17	8.16	Aug. 7	8.74
July 3	7.79	24	8.16	14	7.50
10	5.90	31	7.78	21	7.30

Table 3.--Measurements of depth to water in observation wells, 1950--Continued

Date	Water level	Date	Water level	Date	Water level
14-54-33ac5. (E3)--Continued					
Aug. 28	7.47	Oct. 9	7.35	Nov. 13	7.60
Sept. 5	7.44	16	7.43	20	7.76
11	7.18	23	7.46	27	7.83
18	6.94	30	7.57	Dec. 4	7.91
25	7.18	Nov. 6	7.68	18	8.16
Oct. 2	7.35				
14-54-33ad2. (E4)					
July 10	10.44	Sept. 5	8.56	Oct. 30	8.85
17	10.30	11	7.40	Nov. 6	9.13
24	9.60	18	7.68	13	9.04
31	9.54	25	7.85	20	9.30
Aug. 7	10.25	Oct. 9	7.96	27	9.45
14	9.48	16	7.86	Dec. 4	9.53
21	7.32	23	8.73	18	9.86
29	7.59				
14-54-33ba6. (D1)					
June 26	8.55	Aug. 21	7.94	Oct. 16	7.40
July 3	8.64	28	8.28	23	7.52
10	8.86	Sept. 5	5.27	30	7.59
17	9.20	11	5.83	Nov. 6	7.79
24	9.05	18	6.42	13	7.78
31	8.77	25	6.78	20	8.00
Aug. 7	6.89	Oct. 2	7.12	Dec. 4	8.42
14	7.66	9	7.22	18	8.77
14-54-33ba9. (D2)					
June 19	0.39	Aug. 21	3.91	Oct. 23	2.55
26	.16	28	4.11	30	2.43
July 3	1.23	Sept. 5	3.79	Nov. 6	2.57
10	2.24	11	3.47	13	2.27
17	2.89	18	3.18	20	2.42
24	3.46	25	3.00	27	2.48
31	3.31	Oct. 2	3.93	Dec. 4	2.94
Aug. 7	3.67	9	2.80	18	2.94
14	4.82	16	2.88		
14-54-33ba10 (P)					
Sept. 26	3.50	Oct. 8	3.34	Oct. 21	3.22
27	3.60	10	3.26	22	3.18
28	3.66	11	3.28	23	3.02
29	3.67	12	3.23	24	3.20
30	3.57	13	3.18	25	3.02
Oct. 1	3.45	14	3.26	26	2.98
2	3.43	15	3.07	27	3.03
3	3.37	16	3.33	28	3.10
4	3.22	17	3.12	29	3.10
5	3.15	18	3.19	30	3.06
6	3.03	19	3.29	31	3.16
7	3.24	20	3.10	Nov. 1	3.19

Table 3.--Measurements of depth to water in observation wells, 1950--Continued

14-54-33ba10--Continued

Date	Water level	Date	Water level	Date	Water level
Nov. 2	3.18	Nov. 20	3.21	Dec. 8	3.41
3	3.21	21	3.23	9	3.62
4	2.99	22	3.11	10	3.48
5	2.86	23	3.38	11	3.48
6	3.18	24	3.26	12	3.53
7	3.06	25	3.26	13	3.50
8	3.15	26	3.18	14	3.51
9	3.29	27	3.14	15	3.53
10	3.15	28	3.25	16	3.62
11	3.11	29	3.12	17	3.71
12	3.16	30	3.16	18	3.68
13	3.05	Dec. 1	3.00	19	3.66
14	2.92	2	3.19	20	3.58
15	3.03	3	3.22	27	3.42
16	3.24	4	3.35	28	3.47
17	3.07	5	3.64	29	3.54
18	3.02	6	3.52	30	3.45
19	3.09	7	3.31	31	3.32

14-54-33bb4. (B1)

Date	Water level	Date	Water level	Date	Water level
June 19	29.61	Aug. 21	28.00	Oct. 23	27.14
26	29.70	28	27.99	30	27.15
July 3	29.70	Sept. 5	26.95	Nov. 6	27.15
10	29.84	11	27.73	13	27.43
17	30.04	18	27.37	20	27.65
24	29.75	25	27.19	27	27.86
31	29.54	Oct. 2	27.24	Dec. 4	27.90
Aug. 7	27.38	9	27.16	18	28.23
14	28.28	16	27.16		

14-54-33bb5. (C1)

Date	Water level	Date	Water level	Date	Water level
June 26	19.48	Aug. 28	17.60	Oct. 23	16.38
July 3	19.51	Sept. 5	17.50	30	16.52
10	19.70	11	16.68	Nov. 6	16.60
17	19.70	18	16.38	13	17.10
24	19.18	25	16.38	20	17.22
31	18.97	Oct. 2	16.26	27	17.60
Aug. 7	19.25	9	16.38	Dec. 4	17.75
14	17.89	16	16.38	18	18.19
21	17.48				

14-54-33bc4. (B2)

Date	Water level	Date	Water level	Date	Water level
June 19	8.43	Aug. 21	8.43	Oct. 23	8.02
26	8.66	28	8.52	30	7.93
July 3	8.74	Sept. 5	8.38	Nov. 6	8.07
10	9.90	11	8.50	13	7.93
17	9.16	18	8.40	20	8.10
24	8.62	25	8.20	27	8.23
31	8.30	Oct. 2	8.29	Dec. 4	8.55
Aug. 7	8.13	9	8.15	18	8.61
14	8.28	16	8.07		

Table 3.--Measurements of depth to water in observation wells, 1950--Continued

14-54-33bc6. (C2)

Date	Water level	Date	Water level	Date	Water level
June 19	3.88	Aug. 21	4.34	Oct. 23	3.31
26	1.56	28	4.50	30	3.17
July 3	2.75	Sept. 5	4.62	Nov. 6	3.28
10	2.52	11	4.44	13	3.06
17	3.90	18	4.04	20	3.12
24	4.05	25	3.84	27	3.12
31	3.73	Oct. 2	3.52	Dec. 4	3.48
Aug. 7	4.38	9	3.34	18	3.46
14	3.81	16	3.38		

14-54-33bc7. (C3)

Date	Water level	Date	Water level	Date	Water level
June 26	1.87	Aug. 28	4.64	Oct. 23	3.37
July 3	3.01	Sept. 5	4.79	30	3.24
10	3.70	11	4.60	Nov. 6	3.36
17	4.28	18	4.24	13	3.15
24	4.27	25	4.02	20	3.20
31	4.23	Oct. 2	3.91	27	3.20
Aug. 7	4.68	9	3.60	Dec. 4	3.23
14	4.28	16	3.47	18	3.65
21	4.42				

14-54-33bc9. (C4)

Date	Water level	Date	Water level	Date	Water level
June 19	3.45	Aug. 28	6.57	Oct. 23	6.07
26	3.02	Sept. 5	6.77	30	5.99
July 3	4.03	11	6.83	Nov. 6	6.00
10	4.60	18	6.70	13	5.90
17	5.07	25	6.62	20	5.89
24	5.49	Oct. 2	6.60	27	5.91
31	5.04	9	6.47	Dec. 4	5.94
Aug. 7	6.19	16	6.15	18	6.00
21	6.25				

14-54-33bd6 (R)

Date	Water level	Date	Water level	Date	Water level
June 19	5.67	July 7	6.00	Aug. 25	7.16
20	5.67	8	6.04	26	7.02
21	5.74	9	6.12	30	7.06
22	5.77	10	6.14	31	7.06
23	5.84	11	6.16	Sept. 2	7.18
24	5.92	19	6.48	4	7.22
25	5.88	25	6.78	5	7.22
26	5.68	26	6.74	9	7.20
27	5.48	28	6.78	10	7.16
28	5.53	30	6.81	11	7.10
29	5.58	31	6.86	12	7.07
30	5.62	Aug. 7	7.17	13	7.05
July 1	5.68	9	7.23	14	7.03
2	5.74	12	7.25	15	7.00
3	5.79	13	7.18	16	6.98
4	5.87	15	7.04	17	6.94
5	5.94	17	7.07	18	6.92
6	5.98	21	7.05	19	6.92

Table 3.--Measurements of depth to water in observation wells, 1950--Continued

14-54-33bd6 (R)--Continued

Date	Water level	Date	Water level	Date	Water level
Sept. 20	6.90	Oct. 21	6.82	Nov. 20	7.00
21	6.92	22	6.83	21	7.00
22	6.90	24	6.85	22	6.99
23	6.87	25	6.82	23	7.05
24	6.87	26	6.78	24	7.06
25	6.84	27	6.80	25	7.03
26	6.83	28	6.78	26	7.02
27	6.87	29	6.80	27	7.02
28	6.87	31	6.86	Dec. 1	7.02
29	6.88	Nov. 1	6.86	2	7.03
30	6.87	2	6.87	4	7.04
Oct. 1	6.88	3	6.88	5	7.16
2	6.87	4	6.85	6	7.17
4	6.85	5	6.79	7	7.10
5	6.78	6	6.88	8	7.18
6	6.75	7	6.88	10	7.19
7	6.78	8	6.90	11	7.18
8	6.82	9	6.96	12	7.18
9	6.78	11	6.90	15	7.19
10	6.82	12	6.92	17	7.20
11	6.79	13	6.92	19	7.22
12	6.82	14	6.85	20	7.22
13	6.82	15	6.88	22	7.25
15	6.79	16	6.98	24	7.28
16	6.81	17	6.92	25	7.32
17	6.80	18	6.90	26	7.32
19	6.85	19	6.93	31	7.32

14-54-33ca2. (C5)

Date	Water level	Date	Water level	Date	Water level
July 10	6.79	Sept. 5	8.67	Oct. 30	8.61
17	7.12	11	8.76	Nov. 6	8.68
24	7.44	18	8.77	13	8.56
31	7.37	25	8.82	20	8.62
Aug. 7	8.23	Oct. 2	8.46	27	8.64
14	8.30	9	8.82	Dec. 4	8.69
21	8.45	16	8.70	18	8.77
28	8.55	23	8.67		

14-54-33cb2. (B3)

Date	Water level	Date	Water level	Date	Water level
June 19	3.49	Aug. 21	5.07	Oct. 23	5.00
26	4.87	28	5.25	30	5.00
July 3	4.57	Sept. 5	5.41	Nov. 6	5.11
10	4.95	11	5.46	13	5.08
17	5.38	18	5.17	20	5.23
24	5.60	25	5.24	27	5.28
31	5.31	Oct. 2	5.15	Dec. 4	5.52
Aug. 7	5.19	9	6.07	18	5.60
14	4.99	16	6.05		

Table 3.--Measurements of depth to water in observation wells, 1950--Continued

14-54-33cb4. (B4)

Date	Water level	Date	Water level	Date	Water level
June 26	5.39	Aug. 28	5.62	Oct. 23	6.49
July 3	5.92	Sept. 5	5.99	30	6.57
10	6.21	11	6.15	Nov. 6	6.63
17	6.47	18	6.08	13	6.74
24	5.83	25	6.31	20	6.82
31	5.43	Oct. 2	6.34	27	6.94
Aug. 7	5.40	9	6.30	Dec. 4	7.02
14	4.34	16	6.44	18	7.30
21	4.94				

14-54-33cb5. (BC)

Date	Water level	Date	Water level	Date	Water level
June 26	3.05	Aug. 28	5.53	Oct. 30	5.04
July 3	3.88	Sept. 11	5.66	Nov. 6	5.31
17	4.81	18	5.43	13	5.24
24	5.17	25	5.35	20	5.26
31	4.83	Oct. 2	5.34	27	5.33
Aug. 7	5.40	9	5.20	Dec. 4	5.37
14	5.09	16	5.17	18	5.50
21	5.33	23	5.09		

14-54-33cc3. (B5)

Date	Water level	Date	Water level	Date	Water level
June 19	9.39	Aug. 21	8.78	Oct. 23	9.87
26	10.59	28	8.65	30	10.05
July 3	9.63	Sept. 5	9.05	Nov. 6	10.22
10	9.79	11	9.19	13	10.32
17	9.63	18	9.51	20	10.47
24	9.07	25	9.70	27	10.63
31	8.95	Oct. 2	9.20	Dec. 4	10.76
Aug. 7	8.89	9	9.38	18	10.91
14	8.54	16	9.77		

14-54-33cd1. (C6)

Date	Water level	Date	Water level	Date	Water level
June 19	10.84	Aug. 21	9.90	Oct. 23	11.30
26	10.94	28	10.25	30	11.38
July 3	10.82	Sept. 5	10.35	Nov. 6	11.50
10	10.89	18	10.59	13	11.52
17	10.95	25	10.80	20	11.64
24	10.54	Oct. 2	10.97	27	11.74
31	11.36	9	11.07	Dec. 4	11.81
Aug. 7	9.85	16	11.24	18	11.95
14	9.68				

14-54-33cd2. (C7)

Date	Water level	Date	Water level	Date	Water level
July 3	12.37	Aug. 28	9.58	Oct. 23	11.22
10	12.60	Sept. 5	10.00	30	11.32
17	11.50	11	10.05	Nov. 6	11.48
24	10.15	18	10.27	13	11.55
31	9.91	25	10.52	20	11.69
Aug. 7	11.05	Oct. 2	10.74	27	12.79
14	8.92	9	10.77	Dec. 4	12.84
21	8.87	16	11.07		

Table 3.--Measurements of depth to water in observation wells, 1950--Continued

Date	Water level	Date	Water level	Date	Water level
		14-54-33da2. (E5)			
June 26	16.44	Aug. 29	16.63	Oct. 23	17.28
July 3	16.06	Sept. 5	16.55	30	17.23
10	15.88	11	16.77	Nov. 6	17.44
17	15.84	18	16.98	13	17.42
24	15.89	25	17.04	20	17.56
31	15.63	Oct. 2	17.18	27	17.62
Aug. 7	16.36	9	17.22	Dec. 4	17.67
14	15.85	16	17.26	18	16.90
21	16.32				
		14-54-33dd1. (D4)			
June 26	8.86	Aug. 28	8.30	Oct. 23	8.55
July 3	9.85	Sept. 5	7.93	30	8.62
10	9.12	11	7.63	Nov. 6	8.80
17	9.14	18	7.80	13	8.82
24	8.65	25	7.96	20	8.98
31	8.40	Oct. 2	8.22	27	9.12
Aug. 7	8.08	9	8.30	Dec. 4	9.28
14	9.13	16	8.45	18	9.46
21	7.87				

Table 3.--Measurements of depth to water in observation wells, 1950--Continued

Date	Water level	Date	Water level	Date	Water level
		14-54-33db3. (D5)			
June 26	10.59	Aug. 28	7.64	Oct. 23	8.45
July 3	10.36	Sept. 5	6.50	30	8.68
10	10.38	11	5.81	Nov. 6	8.93
17	10.38	18	7.56	13	9.10
24	9.84	25	7.08	20	9.36
31	9.64	Oct. 2	7.53	27	9.55
Aug. 7	6.51	9	7.83	Dec. 4	9.80
14	7.07	16	8.07	18	10.19
21	7.20				
		14-54-33dc. (CD)			
Aug. 21	14.35	Oct. 9	17.62	Nov. 13	18.47
28	15.57	16	17.80	20	18.62
Sept. 11	16.13	23	18.00	27	18.00
18	16.62	30	18.24	Dec. 4	18.18
25	17.05	Nov. 6	18.39	18	17.11
Oct. 2	17.36				

Table 4.--Data for pumping test conducted August 22, 1950, in Area IV, First Division, Buffalo Rapids project, Dawson County, Mont.
[Drawdown measurements not corrected for changes in barometric pressure]

Time since pumping started (minutes)	Drawdown, in feet, for indicated well no.															
	No1	No2	No3	No4	Ea1	Ea2	Ea3	Ea4	So1	So2	So3	So4	We1	We2	We3	We4
0	....	....	....	....	0.00	....	....	....	0.00	....	....	....	0.00	....	....	....
1	0.00	....	....	....	.09	....	....	....	....	....	....	....	.00	....	....	....
1.75	.03	....	....	....	.15	....	....	....	.17	....	....	....	.05	....	....	....
2.5	.13	....	....	....	.23	....	....	....	.19	....	....	....	.06	....	....	....
3.25	.19	....	....	....	.27	....	....	....	.24	....	....	....	.16	....	....	....
4	.26	....	....	....	.30	....	....	....	.31	....	....	....	.26	....	....	....
4.75	.32	....	....	....	.38	....	....	....	.38	....	....	....	.34	....	....	....
5.5	.37	....	....	....	.45	0.00	....	....	.46	0.00	....	....	.34	....	....	....
6.25	.43	....	....	....	.50	.01	....	....	.52	.01	....	....	.41	....	....	....
7	.49	....	....	....	.57	....	....	....	.57	.01	....	....	.48	....	....	....
7.75	.53	....	....	....	.62	.00	....	....	.63	.01	....	....	.50	....	....	....
8.5	.58	....	....	....	.67	.01	....	....	.70	.01	....	....	.56	....	....	....
10	.67	0.03	....	....	.74	.01	....	....	.81	.02	....	....	.66	....	....	....
11.5	.75	.04	....	....	.81	.01	....	....	.91	.04	....	....	.75	0.00	....	....
13	.82	.06	....	....	.94	.02	....	....	.99	.04	....	....	.81	.02	....	....
14.5	.89	.05	....	....	1.02	.02	....	....	1.07	.06	....	....	.89	.03	....	....
16	.94	.08	0.00	....	1.08	.03	....	....	1.11	.07	....	....	.93	.04	....	....
17.5	1.01	.07	....	....	1.10	.04	....	....	1.22	.09	....	....	1.01	.05	....	....

Table 4.--Data for pumping test conducted August 22, 1950, in Area IV, First Division, Buffalo Rapids project, Dawson County, Mont.--Continued

Time since pumping started (minutes)	Drawdown, in feet, for indicated well no.															
	No1	No2	No3	No4	Ea1	Ea2	Ea3	Ea4	So1	So2	So3	So4	We1	We2	We3	We4
19	1.05	0.08	0.01	....	1.19	0.05	....	....	1.29	0.11	....	....	1.06	0.07	....	....
20.5	1.11	.12	.01	....	1.23	.06	....	....	1.34	.11	....	....	1.11	.07	....	....
22	1.15	.10	.02	....	1.31	.08	....	....	1.40	.12	....	....	1.18	.09	0.00	....
23.5	1.20	....	.03	....	1.37	.09	0.00	....	1.46	.14	....	....	1.24	.10	.01	....
25	1.26	.14	.04	....	1.43	.11	.01	....	1.51	.16	....	....	1.31	.11	.01	....
26	1.30	....	.04	....	1.47	.13	.01	....	1.57	.18	....	....	1.32	....	.02	....
27.5	1.34	....	....	....	1.50	.15	.01	....	1.61	.19	....	....	1.35	.12	.02	....
29	1.40	.20	.05	....	1.58	.18	.02	....	1.65	.21	....	....	1.39	.13	.03	....
32	1.46	.20	....	....	1.64	.20	.01	....	1.73	.24	0.00	....	....	.14	.03	....
35	1.53	.22	....	....	1.70	.22	.02	....	1.80	.27	.01	....	1.46	.16	.05	....
38	1.57	.24	....	....	1.76	.25	.03	....	1.87	.30	....	....	1.52	.19	.07	....
41	1.62	.24	....	....	1.85	.31	.04	....	1.94	.33	.01	....	1.56	.20	.09	....
44	1.67	.25	....	....	1.90	.32	.07	....	1.99	.35	.03	....	1.61	.22	.08	0.00
48	1.73	.28	.06	....	1.97	.38	.07	....	2.06	.40	.03	....	1.64	.24	.08	.01
53	1.78	.30	.05	....	2.05	.40	....	....	2.13	.45	.04	0.00	1.68	.26	....	.02
58	1.84	.34	....	....	2.19	.45	.08	....	2.19	.48	.05	.01	1.75	.29	.10	.04
63	1.85	....	.07	0.00	....	....	.10	....	2.23	.52	.06	.01	1.79	.31	....	.05
64.5[a]	....	.34	.12	....	2.20	.45	.10	....	2.24	.56	.08	.03	1.76	.32	.22	.09
71[b]	1.91	.38	.13	....	2.28	.52	.13	....	2.34	.62	.12	.03	1.86	.33	.18	.09
79[b]	1.97	.40	.16	.02	2.35	.57	.19	....	2.42	.66	.12	.03	1.95	.35	.21	.10
87[b]	2.02	.42	.18	....	2.45	.62	.23	....	2.52	.69	.12	.03	1.98	.35	.24	.10
95[b]	2.06	.44	.18	.02	2.47	.69	.25	....	2.54	.76	.13	.04	2.02	.39	.25	.10
104[c]	2.10	.49	.20	.02	2.54	.69	.26	....	2.57	.80	.16	.05	2.06	.41	.27	.12
116[c]	2.15	.54	.22	.02	2.61	.75	.27	....	2.61	.85	.18	.06	2.10	.42	.28	.13
128[c]	2.20	.55	.23	.00	2.67	.81	.28	....	2.69	.91	.20	.07	2.14	.46	.28	.14
140[c]	2.24	.56	.26	.03	2.73	.86	.32	....	2.74	.94	.22	.08	2.16	.49	.28	.15
153[d]	2.27	.58	.27	.02	2.77	.91	.37	....	2.79	.98	.25	.10	2.21	.50	.28	.15
169[d]	2.33	.62	.29	.01	2.87	.99	.41	0.00	2.87	....	.28	.11	2.26	.51	.35	.18
191-205[e]	2.35	.64	.30	.05	2.92	1.06	.49	.02	2.93	1.10	.29	.11	2.28	.54	.36	.19
209-222[e]	2.42	.71	.32	.06	2.95	1.10	.53	....	2.97	1.14	.32	.12	2.33	.58	.38	.21
230-240[e]	2.43	.69	.33	.07	3.00	1.14	.57	.03	3.01	1.17	.35	.16	2.35	.59	.40	.25
250-263[e]	2.46	.73	.34	.09	3.03	1.19	.59	.03	3.05	1.21	.35	.15	2.36	.61	.42	.22
270-283[e]	2.51	.77	.35	....	3.10	1.24	.60	.04	3.07	1.25	.38	.18	2.39	.62	.43	.24
290-299[e]	2.52	.77	.38	.10	3.10	1.26	.64	.04	3.09	1.26	.40	.19	2.43	.63	.46	.29
310-324[e]	2.53	.79	.39	.10	3.13	1.30	.69	.04	3.12	1.30	.42	.22	2.44	.65	.47	.30
340-352[e]	2.55	.84	.42	.14	3.17	1.37	.72	.05	3.15	1.34	.45	.23	2.44	.71	.49	.30
371-385[e]	2.61	.87	.44	.17	3.18	1.38	.75	.05	3.17	1.38	.47	.25	2.46	.74	.50	.33
400-412[e]	2.64	.88	.48	.18	3.22	1.41	.77	.06	3.19	1.40	.50	.26	2.51	.76	.55	.33
431-447[e]	2.67	.92	.49	.20	3.25	1.43	.80	.08	3.23	1.46	.53	.27	2.55	.79	.57	.35
460-473[e]	2.69	.96	.52	.20	3.27	1.49	.89	.08	3.25	1.48	.55	.29	2.56	.81	.60	.37
490-503[e]	2.70	.96	.53	.23	3.32	1.52	.90	.10	3.25	1.50	.57	.31	2.58	.83	.61	.38
520-534[e]	2.73	.98	.56	.27	3.34	1.55	.94	.11	3.29	1.54	.60	.33	2.61	.86	.63	.41
580-595[e]	2.77	1.00	.59	.29	3.37	1.58	.99	.13	3.33	1.59	.65	.38	2.61	.89	.68	.44

See footnotes at end of table.

Table 4.--Data for pumping test conducted August 22, 1950, in Area IV, First Division, Buffalo Rapids project, Dawson County, Mont.--Continued

Time since pumping started (minutes)	Drawdown, in feet, for indicated well no.															
	No1	No2	No3	No4	Ea1	Ea2	Ea3	Ea4	So1	So2	So3	So4	We1	We2	We3	We4
640-654[e].........	2.80	1.07	0.64	0.34	3.44	1.66	1.05	0.16	3.38	1.63	0.68	0.42	2.68	0.93	0.72	0.46
696-726[e].........	2.86	1.14	.68	.36	3.48	1.72	1.12	.18	3.44	1.68	.71	.44	2.73	.97	.73	.51
759-785[e].........	2.87	1.12	.72	.37	3.50	1.75	1.18	.18	3.43	1.69	.72	.46	2.74	.98	.73	.52
819-840[e].........	2.91	1.17	.75	.41	3.53	1.76	1.18	.19	3.44	1.71	.74	.47	2.75	.99	.76	.52
880-899[e].........	2.89	1.14	.70	.36	3.53	1.76	1.17	.16	3.44	1.70	.73	.45	2.74	.99	.75	.52
938-957[e].........	2.92	1.16	.71	.37	3.54	1.80	1.17	.19	3.47	1.73	.77	.48	2.74	1.01	.77	.58
998-1,018[e].......	2.92	1.17	.74	.38	3.55	1.81	1.19	.19	3.45	1.74	.77	.49	2.74	1.02	.77	.55
1,059-1,079[e].....	2.90	1.18	.71	.35	3.54	1.84	1.20	.16	3.42	1.72	.75	.44	2.72	.98	.76	.52
1,120-1,137[e].....	2.91	1.16	.70	.35	3.52	1.85	1.18	.15	3.41	1.71	.74	.44	2.71	.98	.76	.53
1,180-1,198[e].....	2.89	1.15	.69	.33	3.50	1.83	1.17	.14	3.39	1.69	.73	.43	2.68	.97	.74	.53
1,240-1,258[e].....	2.88	1.15	.68	.33	3.48	1.82	1.15	.12	3.38	1.66	.71	.40	2.68	.97	.74	.50
1,300-1,319[e].....	2.86	1.14	.67	.30	3.49	1.81	1.13	.10	3.36	1.67	.69	.40	2.67	.95	.72	.48
1,359-1,377[e].....	2.91	1.12	.66	.29	3.47	1.81	1.14	.09	3.37	1.64	.69	.41	2.64	.94	.72	.48
1,420-1,441[e].....	2.87	1.13	.66	.29	3.47	1.81	1.14	.09	3.35	1.64	.70	.40	2.66	.93	.73	.50

a, b, c, d - Exact time of reading may be computed by the formula shown below. Let t = time since pumping started, in minutes, and n = digit of well number.

a t + (n - 1) 1.5
b t + (n - 1) 2
c t + (n - 1) 3
d t + (n - 1) 4

e Readings made between indicated times.

Table 5.--Summary of pumping-test results

[Well pumped for 24+ hours, beginning 1:20 p.m., August 22, 1950; measurements of water-level recovery made for 23+ hours beginning 2:00 p.m., August 23, 1950. Average discharge rate of pumped well was 30 gpm. Water-level measurements were made by wetted-tape method and are estimated to be accurate to 0.01 feet. All observation wells remained open for period of test]

		Well no.															
		No1	No2	No3	No4	Ea1	Ea2	Ea3	Ea4	So1	So2	So3	So4	We1	We2	We3	We4
r (distance from pumping well in feet).....		50.8	112.3	179.4	299	49.6	99.3	176.4	299.5	49.5	98.1	197.2	298.7	47.6	108.5	183.5	307.2
T (transmissibility)...		....	....	5,040	5,040	5,040	5,040	5,040	5,040	....	5,040	5,040	5,040	....	5,040	5,040	5,040
S (storage coefficient)		....	....	4.9×10^{-3}	7.7×10^{-3}	....	5.4×10^{-3}	5.0×10^{-3}	1.35×10^{-2}	....	4.6×10^{-3}	4.8×10^{-3}	4.2×10^{-3}	....	4.7×10^{-3}	3.8×10^{-3}	3.4×10^{-3}
Match-point coordinates	s	....	....	0.15	0.15	....	0.15	0.15	0.15	....	0.15	0.15	0.15	....	0.15	0.15	0.15
	r^2/t	....	....	5.5×10^5	3.5×10^5	....	5.0×10^5	5.4×10^5	2.0×10^5	....	5.9×10^5	5.6×10^5	6.4×10^5	....	5.7×10^5	7.0×10^5	8.0×10^5
	u	....	....	1.00	1.00	....	1.00	1.00	1.00	....	1.00	1.00	1.00	....	1.00	1.00	1.00
	W(u)	....	....	0.22	0.22	....	0.22	0.22	0.22	....	0.22	0.22	0.22	....	0.22	0.22	0.22
Total s	Drawdown (feet)....	2.87	1.13	0.67	0.32	3.47	1.76	1.27	0.10	3.35	1.65	0.70	0.41	2.66	0.93	0.75	0.48
	Recovery (feet)....	2.26	0.72	0.30	0.02	2.88	1.26	0.71	0.00	2.80	1.09	0.33	0.08	2.16	0.61	0.35	0.18
Top of strainer (feet below measuring point)		21.1	21.0	21.2	19.0	23.5	20.9	17.3	23.3	21.0	21.0	18.1	19.0	21.3	21.1	18.4	21.1
Measuring point	Distance above land surface (feet)......	4.4	6.1	3.6	3.5	4.4	3.0	2.5	4.8	5.3	3.7	4.0	5.3	5.4	3.8	3.8	3.3
	Altitude above mean sea level (feet)	2,127.16	2,128.81	2,126.44	2,126.72	2,126.14	2,123.92	2,122.69	2,124.43	2,127.24	2,126.34	2,124.86	2,126.22	2,128.40	2,127.33	2,127.17	2,127.85
Altitude of water level before pumping (feet above mean sea level).		2,117.18	2,118.39	2,118.54	2,118.89	2,117.80	2,117.45	2,117.14	2,113.57	2,117.78	2,117.56	2,116.94	2,116.77	2,118.33	2,118.54	2,118.51	2,118.56
Depth of well (feet below measuring point)		21.5	21.4	21.6	19.4	23.9	21.3	17.7	23.7	21.4	21.4	18.5	19.4	21.7	21.5	18.8	21.5