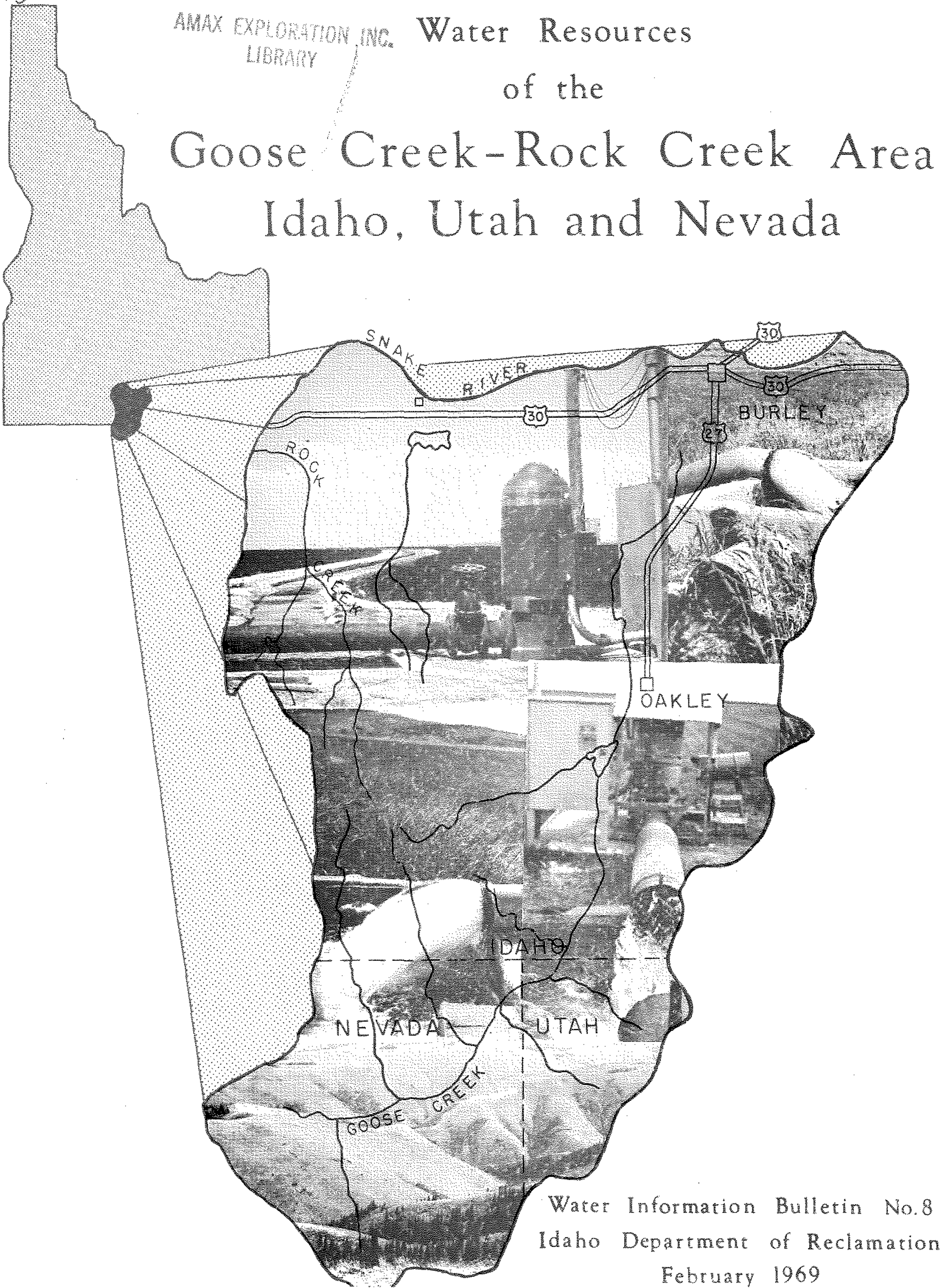
Water Resources of the Goose Creek-Rock Creek Area Idaho, Utah and Nevada



Water Information Bulletin No. 8
Idaho Department of Reclamation
February 1969

WATER INFORMATION BULLETIN NO. 8

WATER RESOURCES IN THE GOOSE CREEK-ROCK CREEK BASINS, IDAHO, NEVADA AND UTAH

By

E. G. Crosthwaite

United States Geological Survey

Prepared by the United States Geological Survey

in Cooperation with

Idaho Department of Reclamation

Published by

Idaho Department of Reclamation

R. Keith Higginson

State Reclamation Engineer

February 1969

CONTENTS

CONTENTS (Cont'd.)

ILLUSTRATIONS

ILLUSTRATIONS (Cont'd.)

ILLUSTRATIONS (Cont'd.)

TABLES

WATER RESOURCES IN THE GOOSE CREEK-ROCK CREEK BASINS,

IDAHO, NEVADA AND UTAH

By E. G. Crosthwaite

ABSTRACT

Agricultural development of most of the lowlands in the Goose Creek-Rock Creek basins, which are mostly in southern Idaho, has been accomplished using ground and surface water for irrigation. In some areas, the use of ground water has caused water levels in wells to decline significantly and there is marked interference between wells. As a result, the Idaho Department of Reclamation has restricted the further development of ground water pending an evaluation of the water resources of the basins.

Rocks of pre-Tertiary age, consisting of limestone, quartzite, shale, sandstone, granite, and metamorphosed sediments, crop out in the hills and mountains forming the headwater areas of the Goose Creek-Rock Creek basins. The limestone and associated rocks yield large supplies of water to irrigation wells along a fault zone at the northeastern edge of the Rock Creek Hills. Elsewhere the rocks of pre-Tertiary age are not known to yield large supplies to wells.

The Idavada Volcanics of Pliocene age, consisting of welded ash flows and tuffs of rhyolitic and latitic composition, with interbedded clay, silt, sand and gravel, blanket the Rock Creek Hills and are an important aquifer beneath the lowland. Joints and fault zones in the welded tuffs and flows, coarse-grained ash beds, sand, and gravel, yield small to moderately large quantities of artesian water to irrigation wells.

Basalt of the Snake River Group of Holocene and Pleistocene age underlies much of the lowland and is one of the more important aquifers in the area. It yields small to large amounts of water to irrigation wells. Ground water occurs in joints, flows, and in cindery and rubbly zones between flows. The water is mostly under water-table conditions.

Alluvium of Holocene to Pleistocene age, consisting of clay, silt, sand, and gravel, yields small to moderate supplies of water to irrigation wells from below the water table and from local perched water bodies.

Recharge to aquifers from precipitation on the area is estimated to average 94,000 acre feet annually. Recharge from percolation of Snake River water used for irrigation is estimated to average 345,000 acre-feet annually. The annual recharge is distributed to the water-bearing formations as follows: Idavada Volcanics and older rocks, 64,000 acre-feet; basalt, 330,000 acre-feet; and alluvial deposits, 45,000 acre-feet.

In the Oakley subarea, where the average annual withdrawal rate is about 25,000 acre-feet, many irrigation wells produce from alluvial deposits and a few basalt flows. Water levels in wells declined 1 to 2 feet per year during the period 1958-63 but, locally, declines have been as much as 5 feet per year. The effects of withdrawals from the underlying Idavada Volcanics are not known.

Sparse water-level data in the Golden Valley subarea indicate little net change in water-levels from 1963 to 1966 as a result of an average annual withdrawal of about 5,000 acre-feet. Locally there have been both declines and rises in the water levels.

In the Big Cedar-Buckhorn subarea, where annual withdrawals average 15,000 acre-feet, intensive development of the limestone aquifer for irrigation water has caused water-levels to decline at an average rate of 22 feet per year for the period 1960-66.

Average annual withdrawals of 30,000 acre-feet of ground water from basalt and alluvial aquifers in the Murtaugh subarea caused water levels to decline a few to a few tens of feet from 1952 to 1961, after which there was some recovery. Although, generally, static water-level declines have not been large, pumping levels have declined progressively in practically every well.

In the Artesian City subarea, annual withdrawals from the Idavada Volcancics averaging 30,000 acre-feet have lowered water levels from above land surface to 150 feet below land surface locally. The largest area of decline has been at Artesian City where water levels declined 110 feet during 1952-66. At some places in this subarea, interference between pumping wells is large.

The small average annual quantities of water withdrawn for irrigation in the Basin subarea (760 acre-feet) have not caused a significant change in water levels.

Generally, water used for irrigation in the Goose Creek-Rock Creek basin has a low sodium hazard. However, some ground water has a medium to high salinity hazard and water from the Snake River has a medium salinity hazard.

INTRODUCTION

The area covered by this report encompasses the basins of Goose Creek, Dry Creek, and most of Rock Creek which are mostly in eastern Twin Falls and western Cassia Counties in southern Idaho. All of the approximately 630 square miles of almost flat to gently rolling plain, extending from 60 to 20 miles south of the Snake River, and 1,000 square miles of mountainous terrain drain to the Snake River. Part of the mountainous terrain is in northeastern Nevada and northwestern Utah (fig. 1). The economy of the lowland is based on irrigation, agriculture, food processing, and livestock raising. The limited supply of surface water available has been used for irrigation for many years and is practically all appropriated. For this reason, some irrigable land still remains undeveloped, although large tracts of land have been developed with ground water since 1947. The growing use of ground water has caused water levels in wells to decline and has resulted locally in marked interference between wells. Pending an evaluation of the water resources, the Idaho Department of Reclamation ceased issuing permits for new irrigation wells on January 16, 1962.

The purposes of this report are to (1) describe the water-bearing formations and delineate their areal extent insofar as available well logs permit; (2) estimate the amount and disposition of precipitation as surface runoff and ground-water recharge; (3) describe the extent of ground-water development in the area; (4) summarize ground-water withdrawals; and (5) summarize the effects of those withdrawals on water levels.

The investigation of the water resources in the Rock Creek basin was begun in 1961 by the U. S. Geological Survey in cooperation with the Idaho Department of Reclamation. The investigation was expanded in 1963 to include

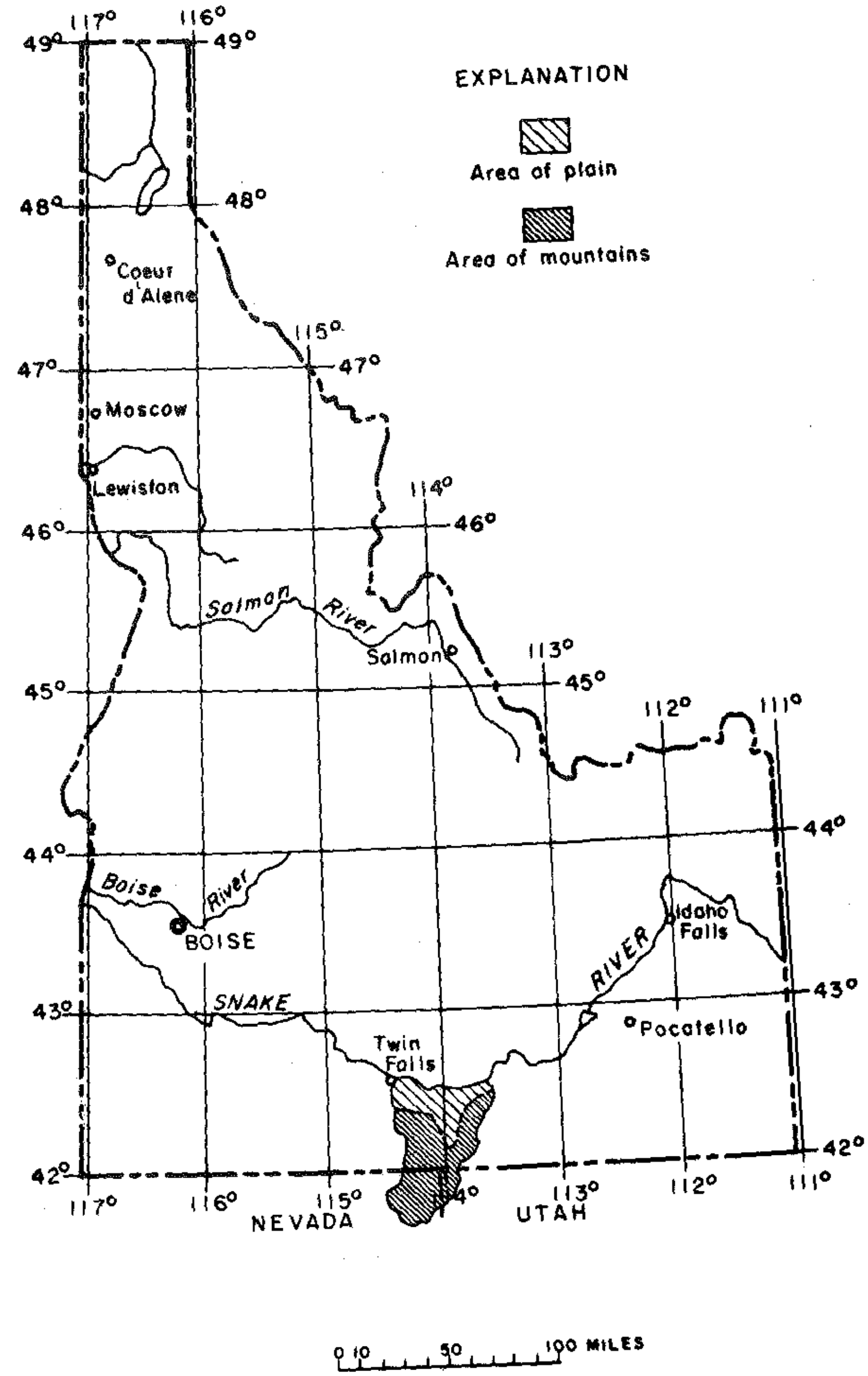


Figure 1.—Location of report area.

the Goose Creek basin at the request of the Idaho Department of Reclamation because water levels also were declining in that part of the area.

The wholehearted cooperation of well owners, well drillers, pump companies, and power suppliers, who furnished assistance in obtaining data and measurements, is gratefully acknowledged. Special acknowledgement is made to Tommy Thompson of the Layne-Bowler Pump Company for records of pumping equipment installed in wells and to the Idaho Power Company for power-consumption data. The U. S. Soil Conservation Service, Bureau of Land Management, and Forest Service furnished aerial photographs. Boley, Henry, and Weach Drilling Co., Mack Gray Drilling Co., and the Johnston Pump Company furnished valuable assistance in completion of the field work.

In addition, much information of value was gained from records of earlier geologic and hydrologic studies of the area, especially those of Piper (1923), Anderson (1931), Stearns, Crandall, and Steward (1938), Crosthwaite (1957), and Mundorff, Crosthwaite, and Kilburn (1964). Basis data on wells and drillers' logs of wells were compiled by West and Fader (1952) and Mower (1953). Unpublished data collected by S. W. West of the Geological Survey have been used extensively in preparation of the present report.

Well Numbering System

The well-numbering system used in Idaho by the U. S. Geological Survey indicates the location of wells within the official rectangular subdivisions of the public lands, with reference to the Boise base line and meridian. The first two segments of a number designate the township and range. The third segment gives the section number and is followed by two letters and a numeral, which indicate the quarter section, the 40-acre tract, and the serial number of the well within the tract. Quarter sections are lettered a, b, c, and d in counterclockwise order, from the northeast quarter of each section (fig. 2). Within the quarter sections, 40-acre tracts are lettered in the same manner. Thus, well 12S-22E-6bb1 is in the NW 1/4 NW 1/4 Sec. 6, Twp. 12-S, Rge. 22-E., and is the first well visited in that tract. Springs are numbered in the same manner as wells, but a capital letter "S" is inserted before the last numeral thusly: 14S-22E-27ddS1.

Climate

The area is semiarid with moderately cold winters and hot summers. Average annual precipitation ranges from about 9 inches on the lowlands to more than 30 inches on the Albion Range. Much of the precipitation falls as snow in the winter whereas the summers are relatively dry. Tables 1 and 2 summarize precipitation and temperature records at selected Weather Bureau and snow-course stations in and near the report area.

Evaporation data have been collected at Milner Dam for the period 1927-28, 1931-35, 1937-43 and at Minidoka Dam (on the Snake River 20 miles northeast of Burley) for the period 1949-61 (U. S. Weather Bureau, Annual Summaries of Climatological Data). Evaporation from the Weather Bureau land pan at Minidoka Dam averaged about 56.6 inches during the period May-October for the years 1949-61. According to Kohler, Nordenson, and Baker (1959, pl. 2) average annual lake evaporation in the report area is about 38 inches.

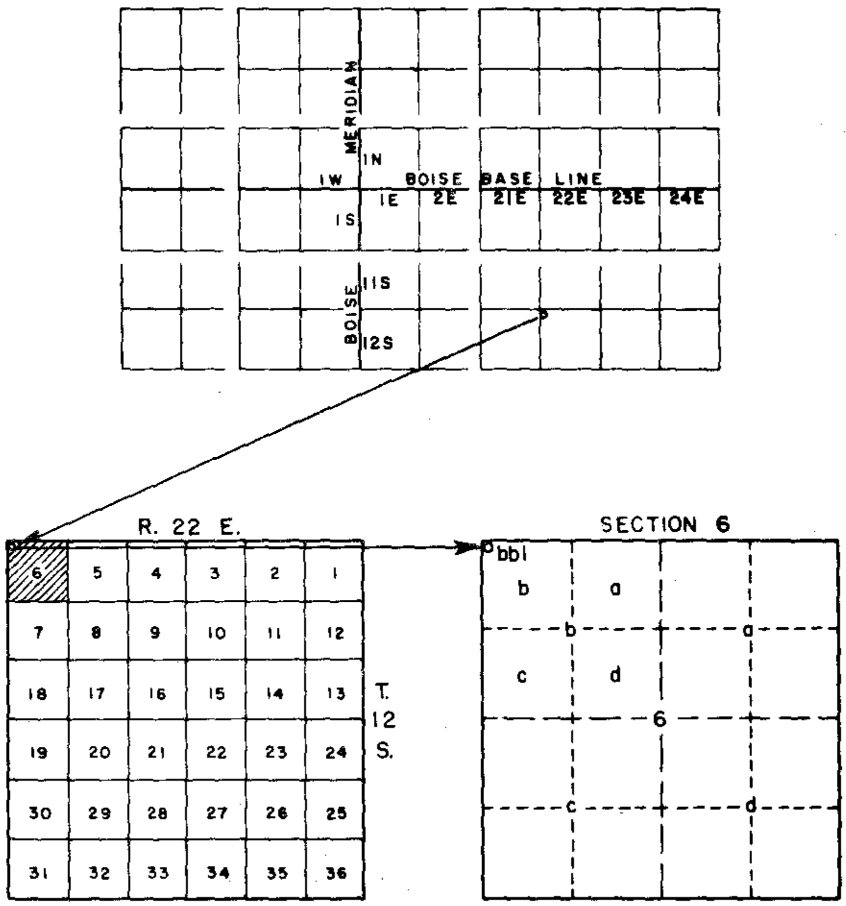


Figure 2.—Diagram showing well-numbering system.
(Using well 12S-22E-6bb1)

Table 1.--Mean annual precipitation and temperature at selected stations

(From records of the U. S. Weather Bureau through 1964)

Station	Years of record	Precipitation (inches)	Years of record	Temperature (F°)	Altitude (feet)
Burley	24	8.61	24	49.6	4,180
Oakley	61	10.08	62	48.7	4,600
Twin Falls 2 NE	59	8.74	57	49.6	3,770
Twin Falls 3 SE	40	8.78	35	48.9	3,765

Table 2.--Mean annual water contents of snow at selected snow courses

(From records of Soil Conservation Service, U. S. Dept. of Agriculture through 1964)

Snow course	Years of record	Average water content on April 1 (inches)	Altitude (feet)
Badger Gulch	18	13.5	6,660
Bostetter Ranger Station	29	16.3	7,500
Boy Scout Camp	17	14.9	7,600
Deadline	11	21.6	6,900
Howell Canyon	15	32.8	8,000
Magic Mountain	22	19.2	6,700

Landforms and Drainage

The Goose Creek-Rock Creek basins are southern tributaries of the Snake River in south-central Idaho. A plain or lowland makes up the northern parts of these basins and is a generally flat surface on which broad volcanic domes, called "buttes", rise to a maximum height of 350 feet above the plain. The lowland is bounded on the southeast by the Albion Range which rises to an altitude of 10,335 feet and on the southwest by the Rock Creek Hills which rise to an altitude of about 8,400 feet. Alluvial fans are well developed along the eastern side of the lowland adjacent to the Albion Range, but they are not prominent features in the southern and southwestern parts of the lowland. The lowland slopes northward from an altitude of about 4,600 feet at Oakley at 4,150 feet at Burley and to about 4,100 feet at Murtaugh. Generally, the lowland lies within the outcrop pattern of alluvium and basalt (fig. 3).

Southeast of Oakley is Middle (South) Mountain which lies mostly in Idaho. In Nevada and Utah, Gollyer Mountain, Bald Mountain, and the Goose Creek Mountains form the drainage divides bordering the Goose Creek basin.

The largest stream is the Snake River which flows along the northern edge of the area. However, it receives no direct runoff from precipitation in the area except during some periods of high flow in Rock and Dry Creeks. The next largest perennial stream is Goose Creek which rises on the southern slopes of the Rock Creek Hills, flows southward into Nevada, eastward into Utah, and then northward into Idaho. Rock Creek drains the northern part of the Rock Creek Hills and is the third largest stream. Except for the reach of Goose Creek in Nevada and Utah, all streams flow in deep canyons or narrow valleys in the mountains. Because much of the flow of the streams

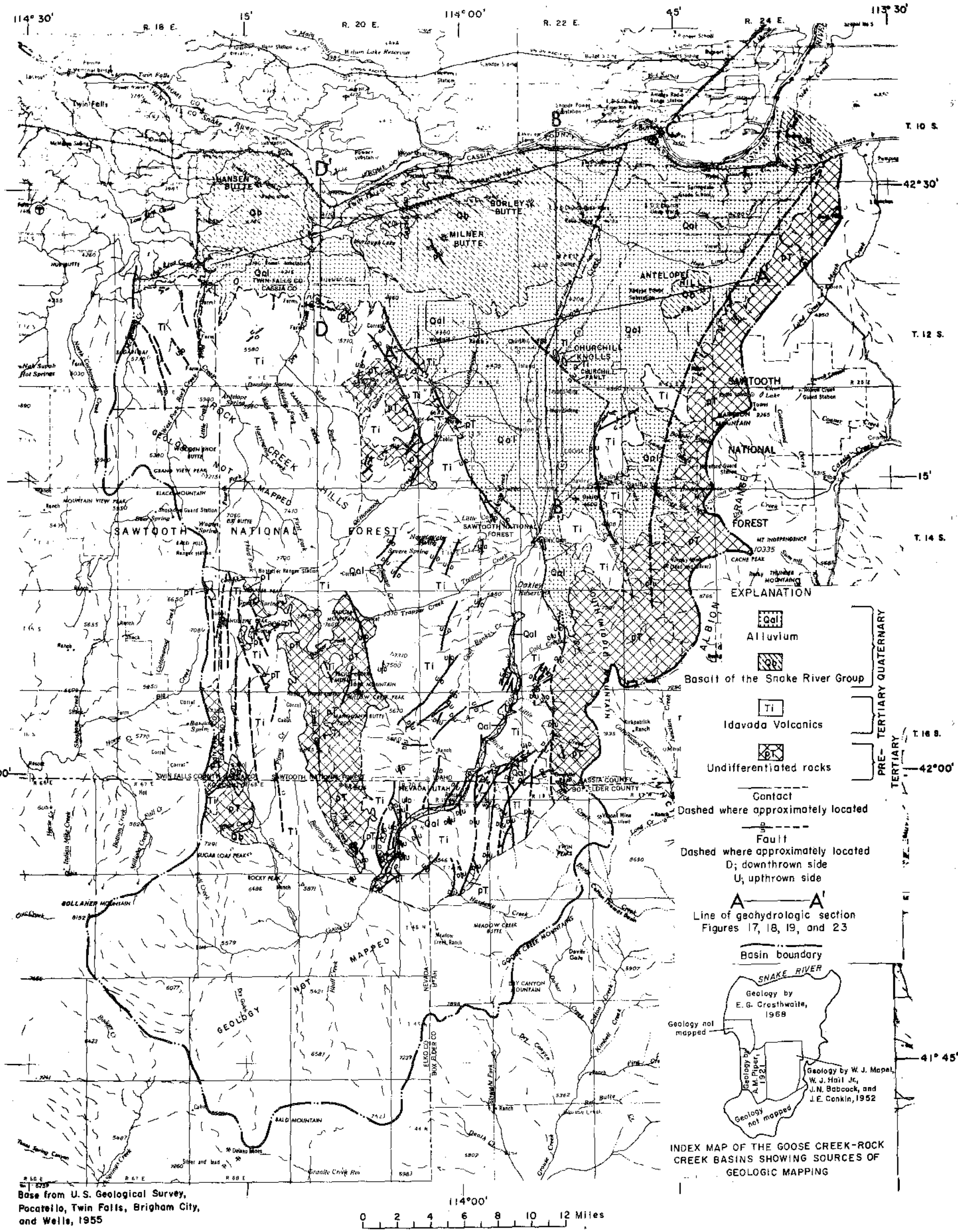


FIGURE 3.--Geologic map of the Goose Creek-Rock Creek basins, Idaho, Nevada, and Utah.

rising in the Goose Creek-Rock Creek basins is used for irrigation, few streams carry water for any great distance across the lowland except under rare conditions of heavy snowmelt or intense rainfall.

GEOLOGIC UNITS AND THEIR WATER-BEARING CHARACTERISTICS

The geologic materials underlying the Goose Creek-Rock Creek basins include many rock types such as limestone, quartzite, shale, sandstone, granite, metamorphosed sedimentary rocks, rhyolitic volcanic flows and welded tuffs, ash, pumice, basaltic volcanic rocks, clay, silt, sand, and gravel. In general, basalt and gravel are highly permeable whereas the metamorphosed sedimentary rocks, granite, shale, silt, and clay are nearly impermeable. The other rock types range from very permeable to relatively impermeable. The areal distribution of the geologic units is shown in figure 3, and their description and water-bearing characteristics are summarized in table 3. The areal extent of the saturated rocks in the lowland is shown on figures 4, 5, and 6. Figure 7 shows the approximate known areal extent of the limestone aquifer in the Buckhorn-Big Cedar part of the Rock Creek Hills.

HYDROLOGIC SETTING

Part of the precipitation that falls on the Goose Creek-Rock Creek area runs off in streams, part infiltrates, and part evapotranspires. The runoff in the upper part of the Goose Creek basin is stored in the Oakley Reservoir for irrigation use in the vicinity of Oakley. The water discharged by the smaller streams such as Birch, Cottonwood, and Willow Creeks is used for irrigation of small tracts of land. About half the flow of both Rock and Dry Creeks is diverted for irrigation and the remainder

Table 3. Geologic units and their water-bearing characteristics.

Period	Epoch	Rock unit	Thickness (feet)	Physical character and areal distribution	Water-bearing characteristics
QUATERNARY	Holocene and Pleistocene	Alluvium	0-300+	Clay, silt, sand, and gravel, unconsolidated to well compacted, generally poorly bedded. Includes windblown deposits which are intermingled with the alluvial deposits and which blanket almost the entire lowland. Alluvium floors the valley of Goose Creek, Rock Creek, and other streams in the lowland. South of Burley, alluvium deposited by the Snake River interfingers with alluvium deposited by Goose Creek. Alluvial fans and slope wash encroach on the stream deposits around the margin of the lowland. Drillers report considerable amounts of clay in the subsurface between Oakley and Burley which may be lakebeds. Basalt flows are intercalated with the alluvial deposits from near Oakley north and northwestward beyond the Churchill Knolls, and from Rock Creek eastward for 12 to 15 miles. Just north of the Rock Creek Hills basalt flows interfinger with alluvial deposits.	Sand and gravel beds in the alluvial deposits yield small to moderate supplies of water to irrigation wells. Sand and gravel in the Burley Irrigation District yield moderate to large supplies of shallow ground water. Availability of ground water for irrigation varies widely beneath lands of the Oakley Canal Co. and depends on the amount of deep percolation from surface-water irrigation and the demands on ground water. Alluvial deposits containing perched water downstream from the mouth of Buckhorn and Big Cedar Canyons yield small supplies locally to wells. Water occurs mostly under water-table conditions and in perched aquifers.
	Holcene and Pleistocene	Basalt (locally called lava) of the Snake River Group	0-600+	Olivine basalt, light to dark gray, dense to vesicular, aphanitic to porphyritic, irregular to crudely columnar jointed, thickness of flows ranges from a few to several tens of feet; includes some basaltic cinders, and rubbly basalt at the top, bottom, and within some flows, and also includes interflow sedimentary deposits. Crops out in the northern part of the lowland. Generally blanketed by up to 50 feet of windblown deposits. The basalt underlies and interfingers with alluvial deposits and overlies the Idavada Volcanics and the associated sedimentary deposits. May also include some basalts older than the Snake River Group.	Basalt aquifers yield small to large amounts of water to irrigation wells; permeability is highly variable. Contacts between flows, rubbly zones, and scoriaceous beds are best water producers. Thick, massive, sparsely jointed flows and interflow sedimentary deposits yield small supplies of water. One of the most important aquifers in the area. Water occurs mostly under water-table conditions.
ERTIARY	Pliocene	Idavada Volcanics (locally called rhyolite)	2,500+	Welded ash flows, bedded tuffs, and lava flows of rhyolitic and latitic composition. Flows are dense, many are massive, commonly vesicular and reddish-brown, gray, or black; jointing ranges from platy to columnar. The tuff or ash beds are fine to coarse grained, light colored, and commonly water laid. Includes clay, silt, sand, and gravel beds which are locally tuffaceous. Blankets the Rock Creek Hills and laps onto the Albion Range and South (Middle) Mountain; forms a prominent north-trending ridge east of Oakley and Churchill Knolls. Extends northward in the subsurface beneath the lowlands beyond the line between Tps. 11 and 12 S. The rocks are the equivalent of the Jenny Creek tuff and Cougar Point welded tuff (Axelrod, 1964, p. 9-11). In the Goose Creek basin, upstream from Oakley, older rhyolitic rocks, sedimentary rocks, and basalt are included in the formation. (See Piper, 1923, p. 31-32 and Mapel and Hail, Jr., 1959, p. 222 for details.)	Joints and fault zones in the welded tuffs and flows, and coarse-grained ash beds, sand, and gravel yield small to moderately large quantities of water to irrigation wells. Clay, silt, and fine-grained ash beds yield little water. The water is mostly under artesian pressure. An important aquifer in the area. In the Rock Creek Hills numerous seeps and small springs help maintain base flow in streams.
PRE-TERTIARY		Sedimentary, igneous, and metamorphosed rocks, undifferentiated	Unknown	Mostly dense, massive quartzite, schist, and marble in the Albion Range and South (Middle) Mountain, and limestone, shaly, cherty limestone, quartzite, sandstone, and shale in the Rock Creek Hills Includes some granite southeast of Oakley.	Limestone and cherty, shaly limestone yield large supplies of water to wells along a fault zone at the northeastern edge of the Rock Creek Hills. Exploration for water a short distance southwest of the fault zone has not been successful. The pre-Tertiary rocks have not been explored elsewhere. Limestone and sandstone might yield small to moderate quantities of irrigation water; but quartzite, schist, marble, and granite would yield only very small supplies from joints and other openings. Springs issuing from rocks in the mountains discharge a few to a few tens of gallons per minute.

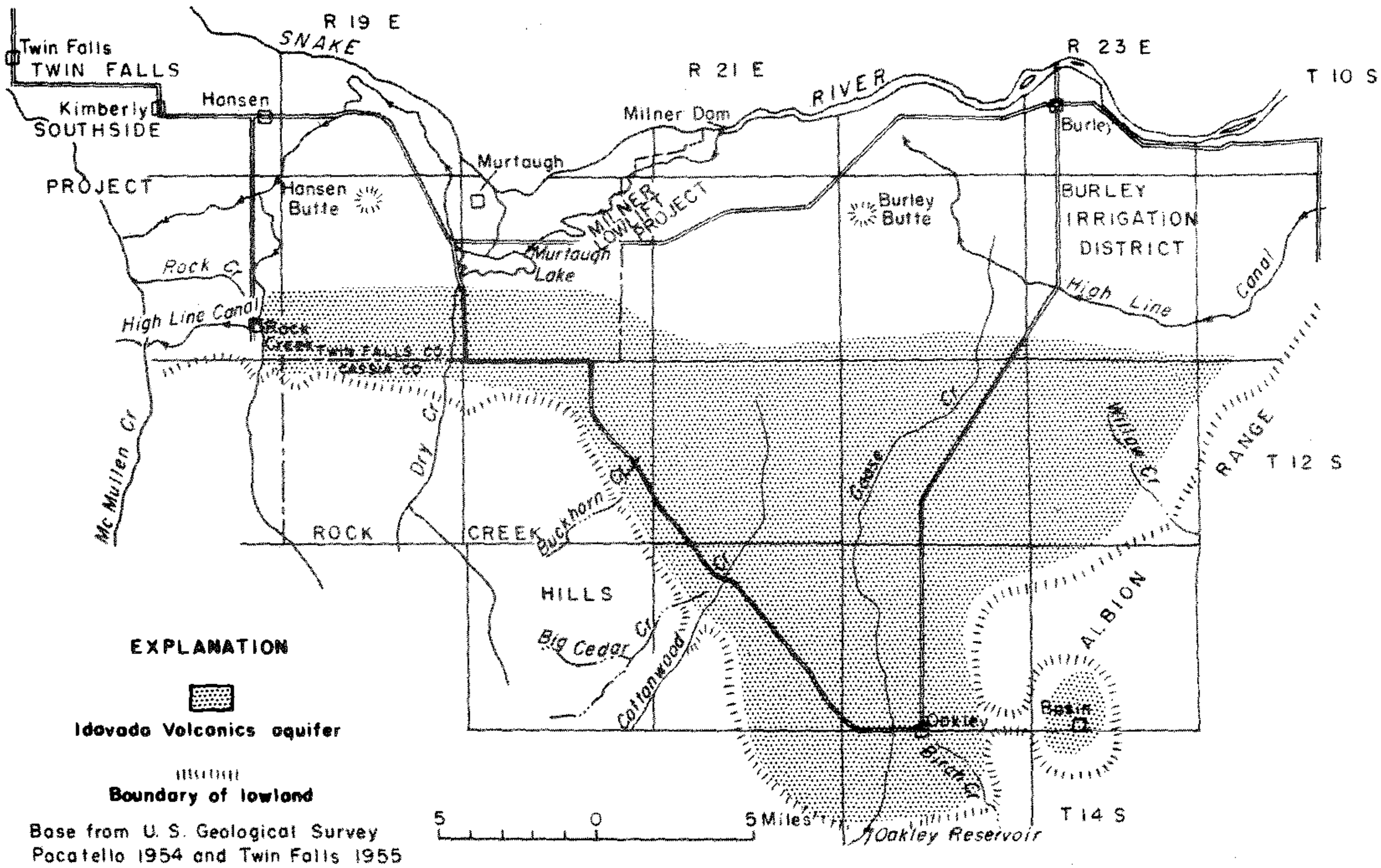


Figure 4.--The approximate areal extent of the Idavada Volcanics aquifer in the lowland. The aquifer probably extends north of the area shown on the map but has not been identified in well logs.

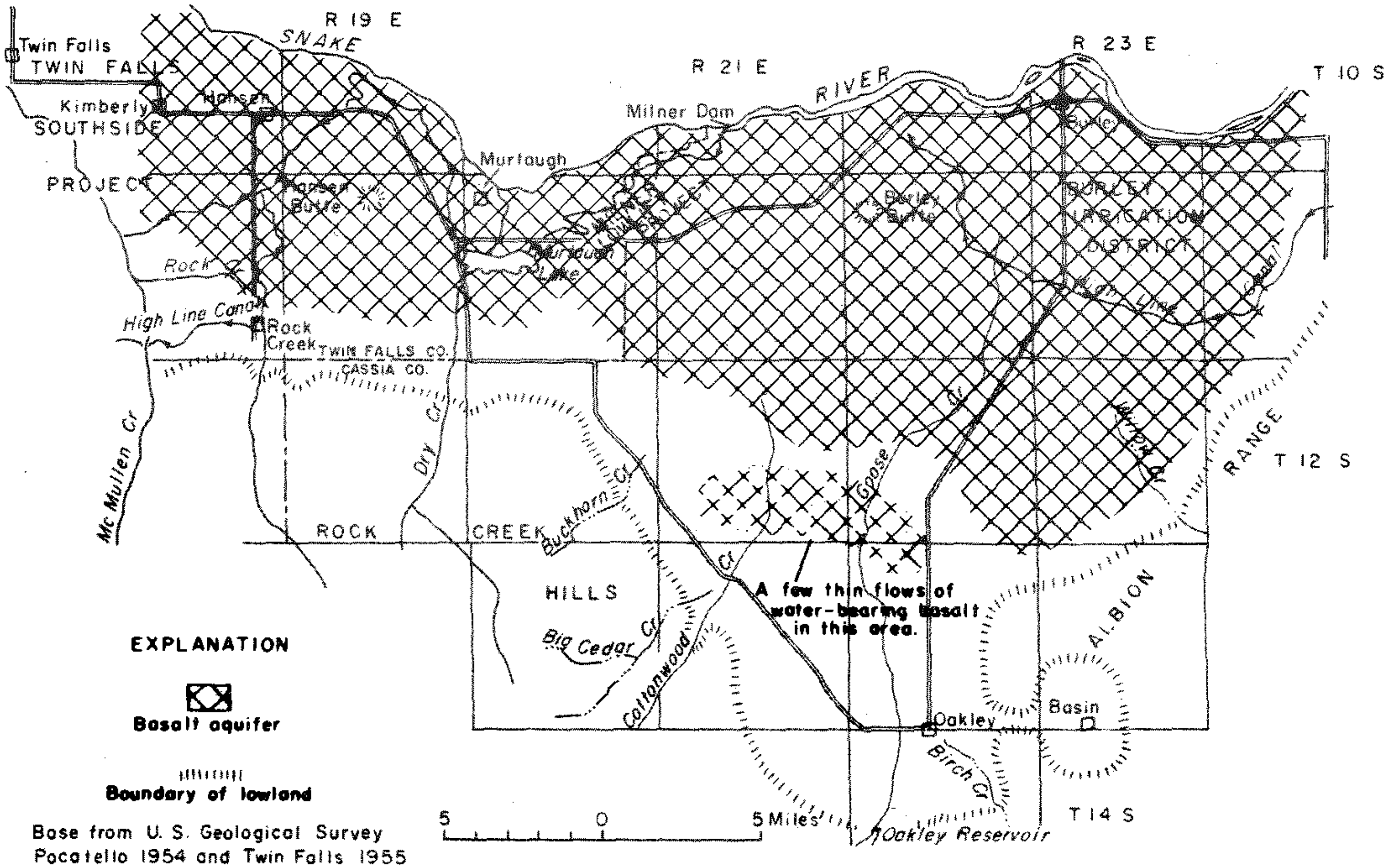


Figure 5.—The approximate areal extent of the basalt aquifer in the lowland.

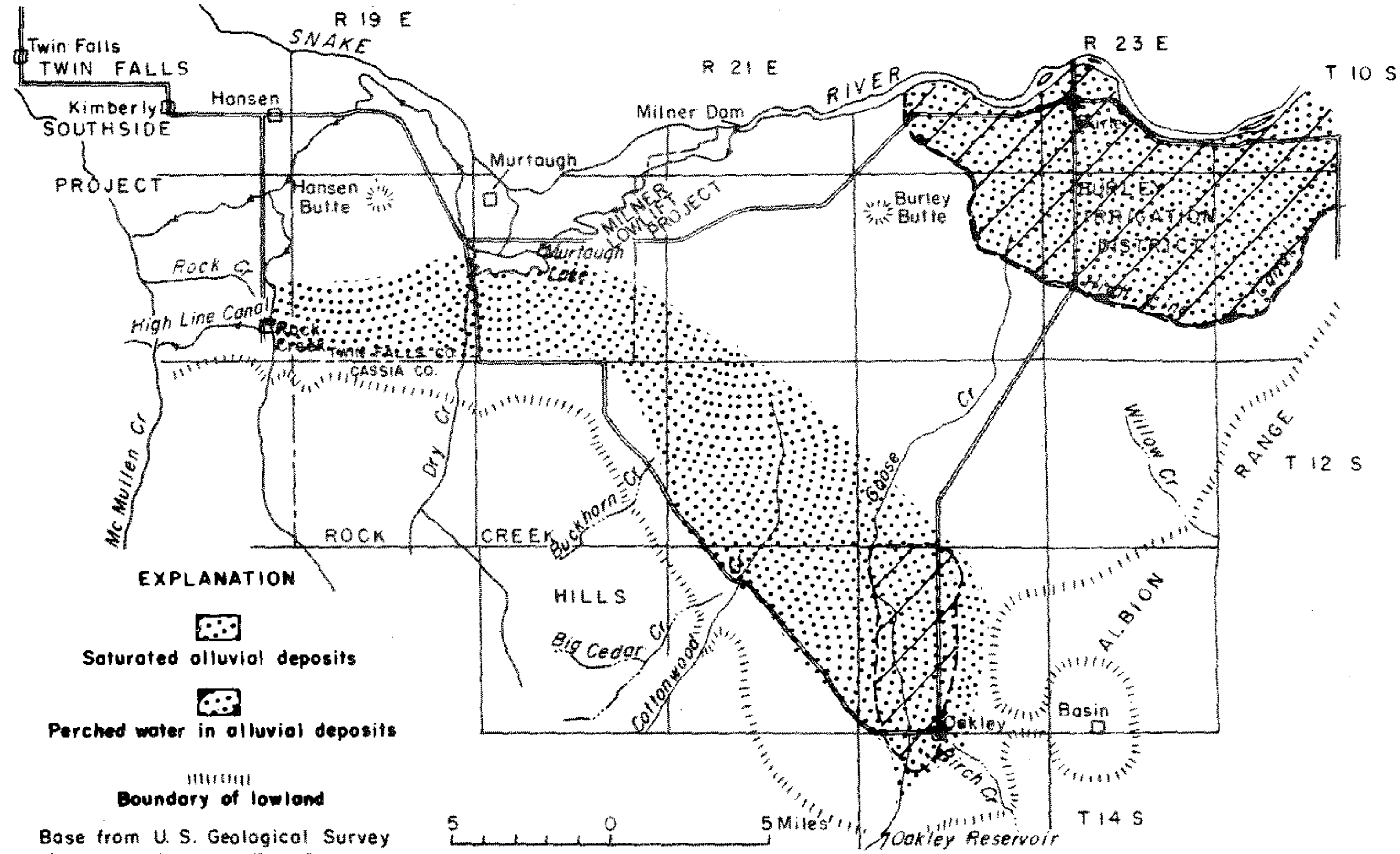


Figure 6.--The areal extent of saturated alluvial deposits in the lowland.

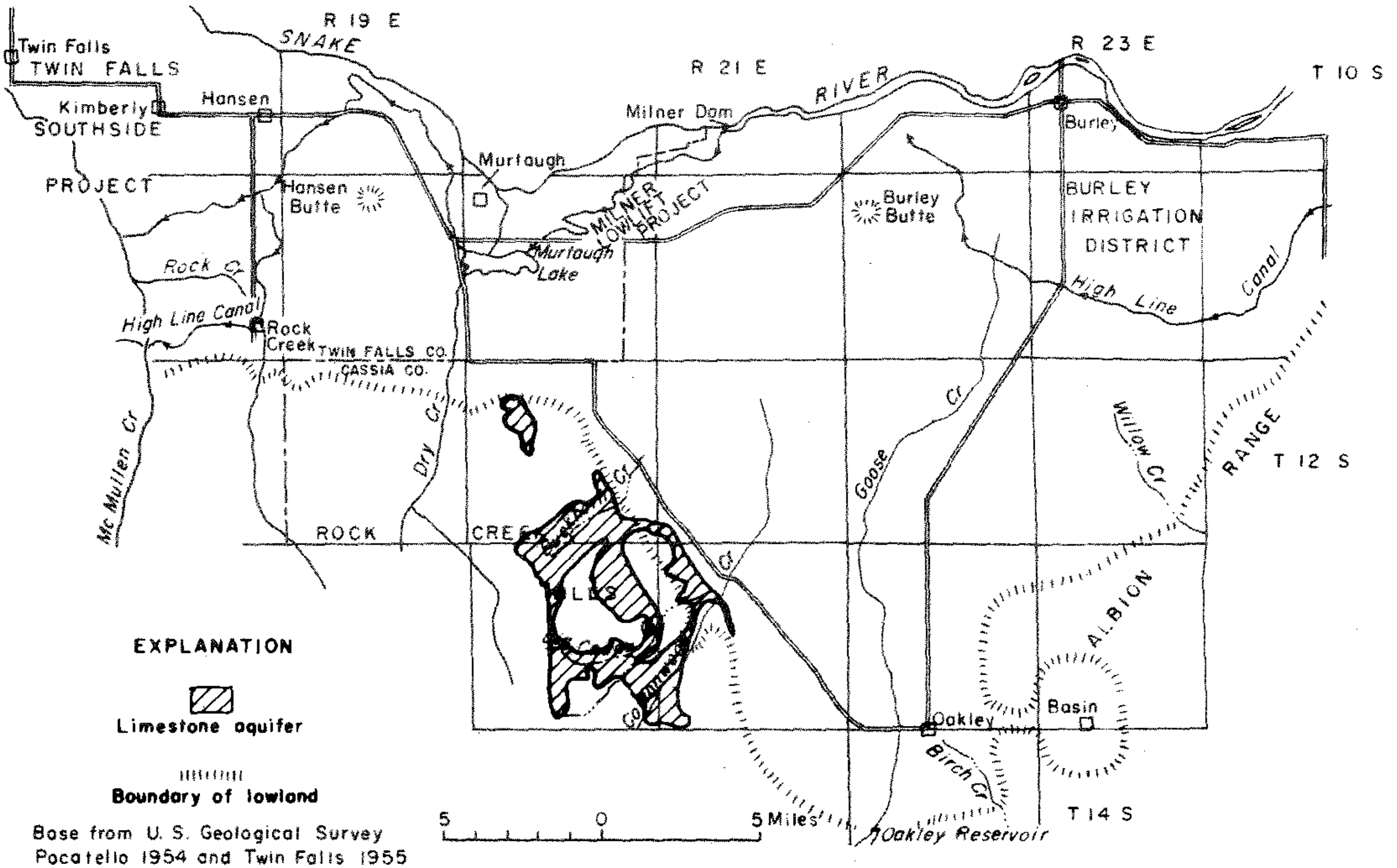


Figure 7.--The areal extent of the limestone aquifer. Successful irrigation wells have been drilled in the northeastern edge of the formation.

flows out of the project area. Some of the discharge of McMullen Creek is conveyed by canal out of the area for irrigation use elsewhere and a part leaves the area as surface flow; very little McMullen Creek water is used in the area of study. Water from the Snake River is diverted to the Burley Irrigation District, the Milner Low Lift and the Twin Falls South Side Projects.

The greatest amount of recharge from precipitation occurs in the mountains where precipitation rates are high. Little recharge from precipitation occurs in the lowland because precipitation rates are usually low and evapotranspiration rates are high. Water infiltrates the rocks in the mountains and moves downhill through the rocks toward the lowland. Some water is discharged by springs and seeps in stream channels, thus sustaining streamflow after snowmelt or heavy rains cease. The remainder moves into the aquifers beneath the lowland. Some of the precipitation that falls on the Rock Creek Hills enters the Idavada Volcanics, other rocks of Tertiary age, and the pre-Tertiary rocks, and moves underground to the lowlands where the water is under weak artesian pressure. Some of the water in the artesian system leaks upward into the basalt and alluvial deposits. Infiltration on the Albion Range and Middle (South) Mountain is comparable in mode of occurrence to that on the Rock Creek Hills except that there is a smaller area of Idavada Volcanics and related rocks to accept direct infiltration of precipitation.

Seepage losses from streams contribute to ground-water recharge, particularly in their lower mountainous reaches and after the streams emerge from the mountains where they flow over highly permeable alluvial deposits. Late summer and autumn streamflow is meager because the aquifers feeding the streams in the mountainous reaches become depleted and the alluvial deposits in the lowland absorb the streamflow.

Seepage losses from canals and percolation from fields in the vicinity of Oakley recharge the alluvial deposits beneath the irrigated land. Water derived from canal and field losses in the Burley Irrigation District recharges an underlying alluvial deposit that contains a few intercalated basalt flows. The water in this aquifer is perched above the main water table. Some water in the perched aquifer discharges to drains and to the Snake River, but the bulk of the water recharges the main water table in the basalt. Seepage losses in the Milner Low Lift and Twin Falls South Side Projects recharge the basalt aquifer and the alluvial deposits underlying the project areas. Some of the water in the basalt aquifer discharges to the Snake River below Milner Dam and some moves through the aquifer to the north side of the river.

AVAILABILITY OF WATER

Surface Water

All the flow of Goose and Trapper Creeks and part of the flow of Birch Creek is stored in the Oakley Reservoir. The average annual surface-water yield is estimated to be 50,000 acre-feet including ungaged inflow. Rock, Dry, and McMullen Creeks yield an estimated 32,000 acre-feet annually, of which about half leaves the area. A potential reservoir site on Rock Creek could store as much as 6,000 acre-feet of winter and spring runoff (U. S. Bureau of Reclamation, 1947, p. 127). No reservoir sites on other streams in the area have been investigated, and it is doubtful if any economical reservoir sites are available. Much of the floodflows and all the low flow of the smaller streams that reaches the lowland is used for irrigation. It is not practical to use all the floodflow, and the unused water seeps into the ground.

The amount of streamflow available from the small streams is not known. Long-term streamflow records are available for Goose, Trapper, and Rock Creek, but only short-term and miscellaneous measurements have been made on some of the smaller streams. Some of the estimates made in the following section are based on sparse data and for this reason no attempt was made to correlate the fragmentary records of small streams with the long-term records of the large streams.

Water in the Snake River is not considered indigenous to the report area. However, the Snake River water is a factor in the ground-water supply and that factor is discussed in a later section.

Ground Water

Ground water also is an important source of irrigation water. One of the objectives of this report is to provide an estimate of the amount of ground-water recharge derived from precipitation and infiltration of surface water. To do this it is first necessary to determine the water yield of the basin. Water yield is precipitation minus the sum of evaporation plus transpiration by native vegetation. By subtracting surface-water runoff and evapotranspiration by crops that are irrigated with surface water from water yield, a value assumed to be ground-water recharge is obtained.

Evapotranspiration and water yield are dependent upon both precipitation and temperature, so before either evapotranspiration or water yield can be evaluated estimates must be made of both precipitation and temperature.

Long-term precipitation data are available only from precipitation stations at Oakley, Burley, and Twin Falls, and from five snow-course stations in the Rock Creek Hills, and one snow-course station in the Albion Range. Short-term precipitation records are also available for stations at Almo, at Bostetter ranger station in the Rock Creek Hills, at the Vipont Mine on Middle Mountain, and at two locations high in the Albion Range.

A generalized isohyetal map of the Goose Creek-Rock Creek area was constructed using the available precipitation and snow-course data from sites within and adjacent to the area of study. No precipitation data were available for large parts of the Goose Creek basin; thus, the total volume of precipitation is poorly known and the part of this volume that is evapotranspired and the part that becomes ground-water recharge is even less well known.

The scarcity of temperature data within the study area was not considered a serious problem. Temperatures were assumed to decline with altitude at the same lapse rate, 1.78°C (3.2°F) per 1,000 feet, selected by Nace and others (1961). The temperatures thus derived were used in computing potential evapotranspiration.

Potential evapotranspiration was estimated for many points within the study area using the method proposed by Thornthwaite (1948). These potential-evapotranspiration figures are not presented in this report but were used in the computation of water yields as discussed below.

To offset the lack of detailed data, a technique used in the Raft River basin by Nace and others (1961) for estimating water yields was applied in the Goose Creek-Rock Creek area. This method was modified, somewhat, to allow for the effects of soil depth and texture on yield. Nace and other (1961) presented in their figure 8, an average curve relating the ratios of R:L to those of P:L; where R is annual water yield, L is annual potential evapotranspiration and P is annual precipitation. Points representing most basins do not lie on this line. In general, the points representing basins having a shallow, coarse-textured soil cover lie to the left of the average line, while those with deep, fine-textured soils lie to the right. Two additional curves were drawn (fig. 8) to represent areas of low and high water-holding capacity, or respectively, areas of high and low water yields. Yield values were computed for many points within the study area using the curves in figure 8 in conjunction with estimates of precipitation and potential evapotranspiration. In computing these yields it was assumed that the Rock Creek, Albion, and Middle (South) Mountain ranges were areas of low moisture-holding capacity while the plains north of Oakley were assumed to have high moisture-retention capability. The remaining foothills and upland areas in the southern end of the Goose Creek basin were assumed to have soils with average water holding capacities.

Precipitation in the Goose Creek-Rock Creek area is dependent upon exposure as well as altitude, so curves of elevation water yield could not be used as they were in Raft River basin by Nace and others (1961). Instead, water-yield values were computed for many selected points and water-yield contours were then fitted using altitude contours as basic guidelines.

The Goose Creek-Rock Creek basins were divided into four parts (fig. 9) to facilitate estimates of water yield of the basins and of recharge to the different aquifers.

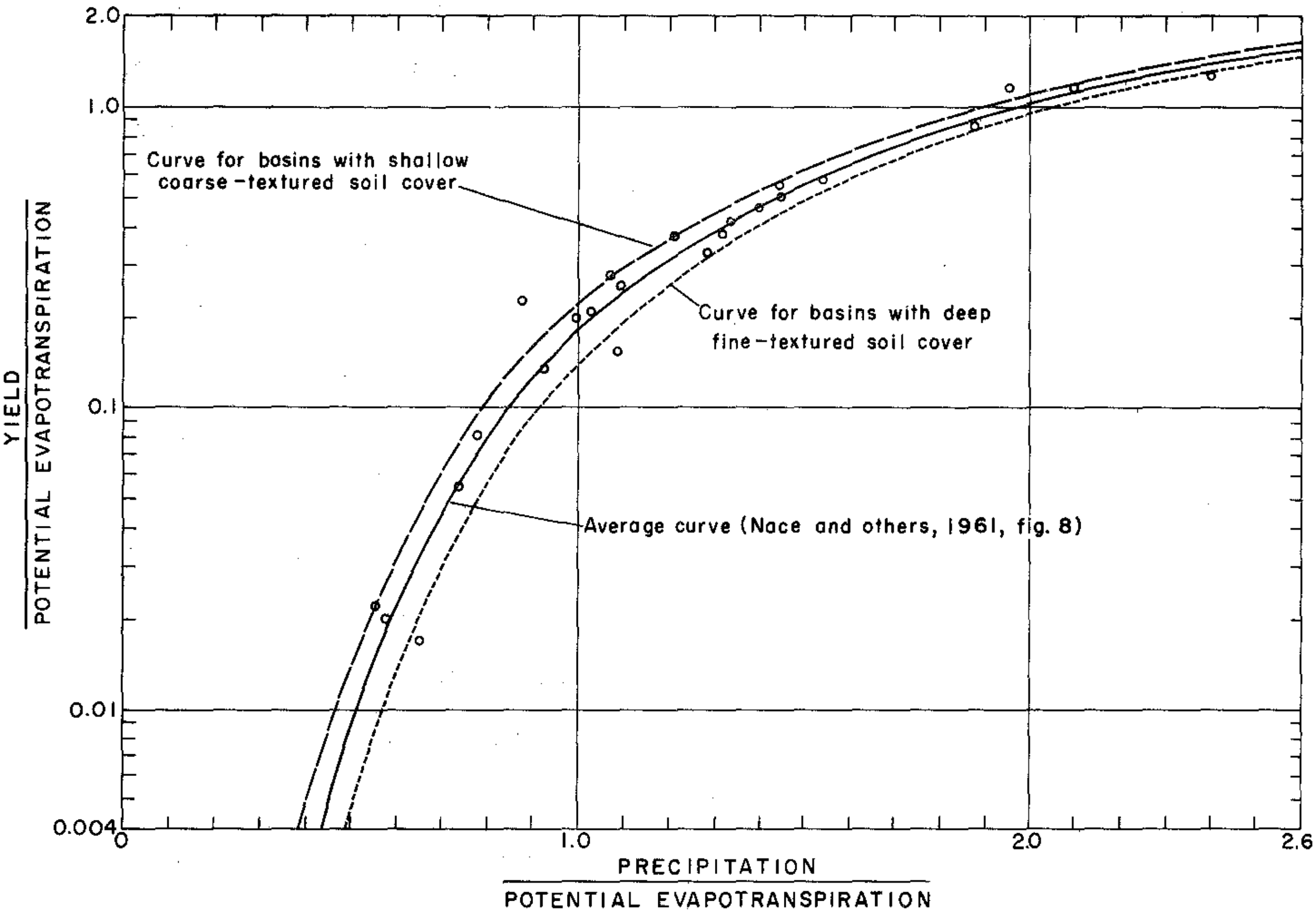


Figure 8.—Relation of annual water yield to precipitation and potential evapotranspiration.

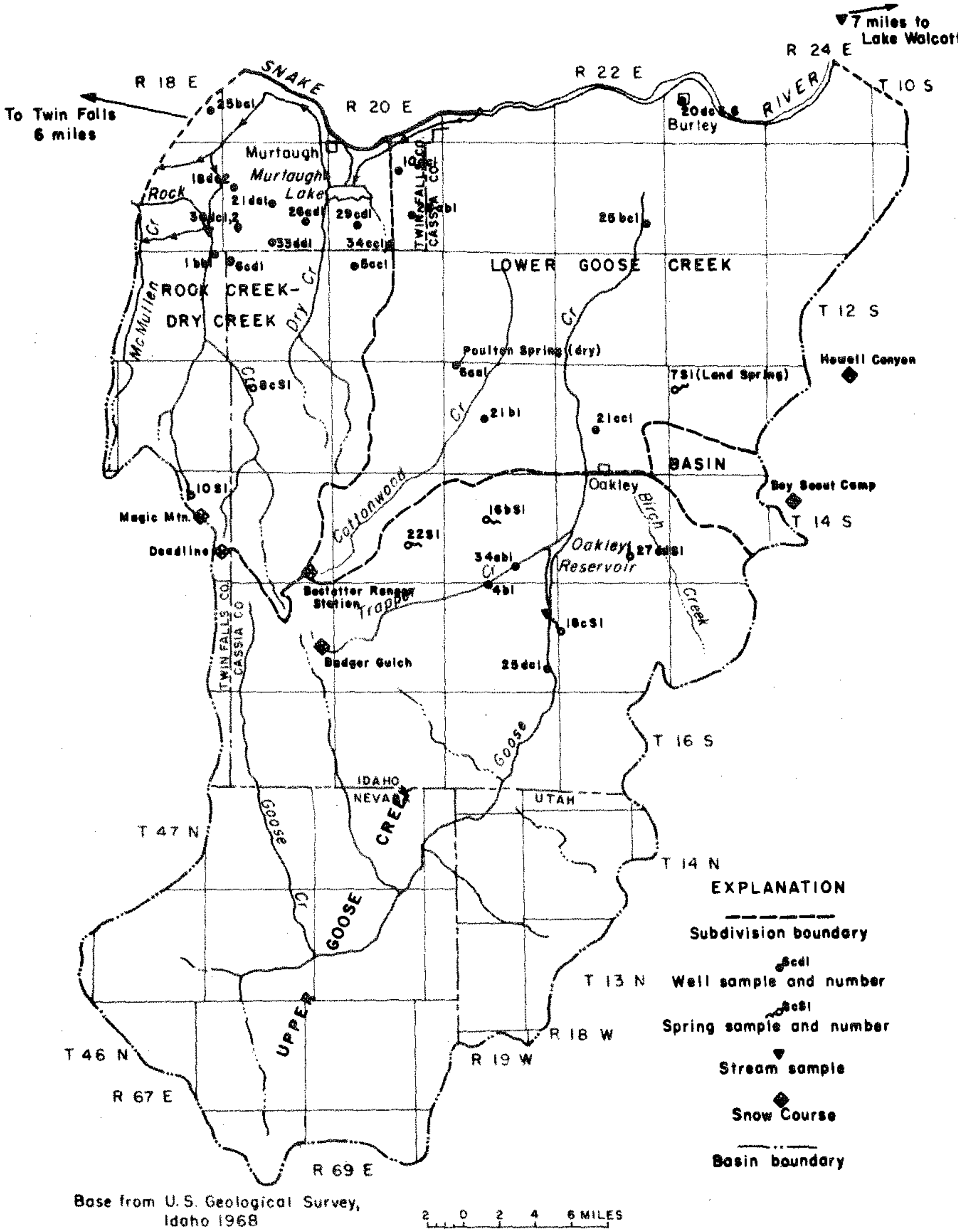


Figure 9.--Subdivisions used in estimating water yield and ground-water recharge and location of water-quality sampling points.

The following summarizes the average annual water yield in the 4 parts of the basins: Upper Goose Creek - 68,000 acre-feet, Lower Goose Creek - 22,000 acre-feet, Rock Creek-Dry Creek - 43,000 acre-feet, and Basin - 7,000 acre-feet. The total average annual water yield for the Goose Creek-Rock Creek basins is 140,000 acre-feet.

In order to assess the amount of ground-water recharged, the above water-yield values were adjusted for surface-water disposition and evapotranspiration by crops irrigated with surface water. For example, about 2,700 acres is irrigated in the Goose Creek basin above the Oakley reservoir. Assuming 1.8 acre-feet per acre evapotranspiration, the water yield is reduced by 5,000 acre-feet (rounded). Also, an average of 50,000 acre-feet per year is discharged from Oakley Reservoir and Birch Creek for irrigation in the lower Goose Creek part of the basin. Thus the water yield must be reduced by 55,000 acre-feet to obtain a value for ground-water recharge in the upper Goose Creek basin south of Oakley.

The following adjustments were made for the lower Goose Creek are: (1) of the 50,000 acre-feet of water derived from the Oakley Reservoir, and Birch Creek for use in the lower Goose Creek area, 24,000 acre-feet is evapotranspired by crops while 26,000 acre-feet percolates to the water table as ground-water recharge; (2) about 2,000 acre-feet of water enters the Lower Goose Creek area as ground-water discharge from the Basin area and 13,000 acre-feet as ground-water underflow from the upper Goose Creek area; and, (3) about 5,000 acre-feet of water is evapotranspired by crops irrigated from miscellaneous small streams in the Lower Goose Creek area. In summary, this results in an additional 36,000 acre-feet of water available for ground-water recharge.

Adjustments in the Rock Creek-Dry Creek area were made thusly: 9,000 acre-feet of surface water is evapotranspired by crops and 13,000 acre-feet runs out of the area for a net reduction of 22,000 acre-feet.

The adjustment for the Basin is a reduction of 5,000 acre-feet due to evapotranspiration by crops. A few hundred acre-feet of surface water flow out of Basin is arbitrarily included in this evapotranspiration figure.

The water yield values given previously can now be adjusted to show estimates of ground-water recharge thus: Upper Goose Creek - 13,000 acre-feet, Lower Goose Creek - 58,000 acre-feet, Rock Creek-Dry Creek - 21,000 acre-feet, and Basin - 2,000 acre-feet. The total quantity of precipitation recharged to the Goose Creek-Rock Creek basins annually is, therefore, 94,000 acre-feet. Table 4 summarizes the estimated water yield of the report area.

Table 4.--Summary of estimated water yield in the Goose Creek-Rock Creek basins.

	Upper Goose Creek	Lower Goose Creek	Basin	Rock Cr.-Dry Creek	Total
Approx. area (acres)	525,000	320,000	20,000	200,000	1,065,000
Ann. water yield (ac-ft)	68,000	22,000	7,000	43,000	140,000
Water yield (inches)	1.5	0.8	4.2	2.6	
Adjustments (ac-ft)					
Evapotranspiration by crops	-5,000	-5,000	-5,000	-9,000	
Underflow from upstream areas:					
Upper Goose Creek	-	13,000	-	-	-
Basin	-	2,000	-	-	-
Surface water outflow	-50,000	-	-	-13,000	-
Recharge from surface water irrigation	-	26,000	-	-	-
Available for ground-water recharge (acre-feet)	13,000	58,000	2,000	21,000	-

This method of estimating ground-water recharge should be used with caution because of the sparse and incomplete data used to make the estimate. This and similar methods of deriving ground-water recharge by subtracting evapotranspiration and surface-water outflow from precipitation can result in large errors. The estimates derived in this report should be regarded as preliminary and subject to revision when more and better data are available. Without belaboring further the inadequacy of the data, it should be pointed out that the water-bearing formations are capable of accepting and and transmitting the estimated quantities of ground-water recharge.

Recharge derived from Snake River water used in the Burley Irrigation District, Milner Low Lift, and Twin Falls South Side Projects was computed by subtracting a consumptive use of 1.8 acre-feet per acre irrigated from average annual diversions, and allowing 15, 5, and 10 percent, respectively, for the surface-water waste and drainage water that returns to the river. Because only a small part of the Twin Falls South Side Project is in the study area, only a part of the water supply of the project is considered in estimating ground-water recharge. Different percentages were used for the following reasons. The Burley Irrigation District is the only one that has drain ditches to alleviate a drainage problem. Thus, a large percentage of the unused water supply returns to the river. The Milner Low Lift Project is situated so that little of the water can return to the river, and it has no drainage problems of consequence. The Twin Falls South Side Project has no significant drainage problem in the area of study except along Rock Creek where few if any drains exist. However, because of the proximity of the canal to the river, waste water from irrigated fields readily returns to the river. Seepage measurements made in 1912 on the Twin Falls

South Side Canal from Milner to the Low Line Canal diversion (including that part of the system occupied by Murtaugh Lake) showed a loss of as much as 519 cfs (cubic feet per second) (D. H. Barks, in Wing, 1915). The manager of the canal company reported that the loss is now about 250 cfs at full canal stage (Alfred Peters, oral communication, January 14, 1965) and this loss is included in the computations. Water in excess of evapotranspiration and return flow to the river in the three projects is assumed to be ground-water recharge. The following amounts of ground-water recharge resulting from use of Snake River water were computed for the three projects:

Burley Irrigation District	180,000 acre-feet
Milner Low Lift Project	35,000 acre-feet
Twin Falls South Side Project	130,000 acre-feet
Total	345,000 acre-feet

While the quantity of recharge from these three projects is large, much of the water moves to the Snake Plain aquifer and Snake River and is available for use only in or near the project areas.

Recognizing that only crude approximations can be made, the ground-water recharge is apportioned to the various aquifers in the following manner. All recharge in the upper Goose Creek part of the area is assumed to be to the Idavada Volcanics and older rocks. In the lower Goose Creek part of the area, a larger part of the ground-water yield from precipitation recharges the Idavada Volcanics and older rocks than recharges the alluvial deposits because of the higher rate of precipitation in the mountains. On the other hand, practically all the recharge derived from irrigation water from Oakley Reservoir enters the alluvial deposits north of Oakley as does the water from small streams discharging to the lowland. Thus, it seems reasonable to allow for half of the recharge to be assigned to the alluvial deposits and half to the Idavada Volcanics and older rocks in this part of the area. All the recharge in the Basin subarea is assumed to enter the alluvial deposits and Idavada Volcanics. One half the recharge is arbitrarily assigned to each formation although water in the alluvial deposits discharges to the Idavada Volcanics. In the Rock Creek-Dry Creek part of the area, precipitation on the mountains recharges the Idavada Volcanics and older rocks and infiltration of irrigation water from the creeks recharges the alluvial deposits.

In the Lower Goose Creek area, percolation of water from the Burley Irrigation District recharges the basalt aquifer after the water passes downward through the alluvial and basaltic deposits which contain a perched water table in part of this area. Water from the Milner Low Lift and Twin Falls South Side Projects recharges mostly the basalt aquifer in the Rock Creek-Dry Creek area, but some recharges the alluvial deposits.

The total quantities of water recharged to the several aquifers underlying the Goose Creek-Rock Creek basin are given below:

Estimated average annual recharge to aquifers in the
Goose Creek-Rock Creek basin (acre-feet)

Area	Aquifer		
(see fig. 9)	Idavada Volcanics and older rocks	Basalt	Alluvial deposits
Upper Goose Creek	13,000	-	-
Lower Goose Creek	29,000	180,000	29,000
Rock Creek-Dry Creek	21,000	150,000	15,000
Basin	1,000	-	1,000
Total	64,000	330,000	45,000

Net recharge due to precipitation and to water from the Snake River probably is 400,000 to 500,000 acre-feet annually. One significant fact illustrated by these estimates is the importance of surface-water irrigation as a source of recharge.

The water-level contour map (fig. 10) shows the approximate shape and position of the water table. In general, the water table slopes away from the mountains toward the Snake River, but recharge caused by water derived from the Snake River strongly influences the shape of the water table beneath the areas of surface-water irrigation. Conversely, pumping ground water for irrigation has altered the original shape of the water table and near Artesian City, has produced a depression in the water table. The depth to water ranges from less than 50 feet near Rock Creek and around Murtaugh Lake to more than 450 feet on Hansen Butte and more than 500 feet on Burley Butte (fig.11).

The water-level contour map (fig. 10) depicts only the shallowest water-level measurements made. Different water levels may occur in several water-bearing zones, some of which are superposed and some of which merge laterally with each other. For example, water occurs in several sand and gravel beds in the alluvial fill beneath the area served by the Oakley Reservoir from Oakley northward for several miles. When a well is drilled into the alluvial deposits, the water level in the well changes from a fraction of a foot to tens of feet when the different water-bearing beds are penetrated by the bit. Often, but not always, the change is downward so that the depth to water in the well becomes greater as the well is drilled deeper. When water-bearing beds in the volcanic rocks are penetrated in the well, the water levels may decline several tens of feet

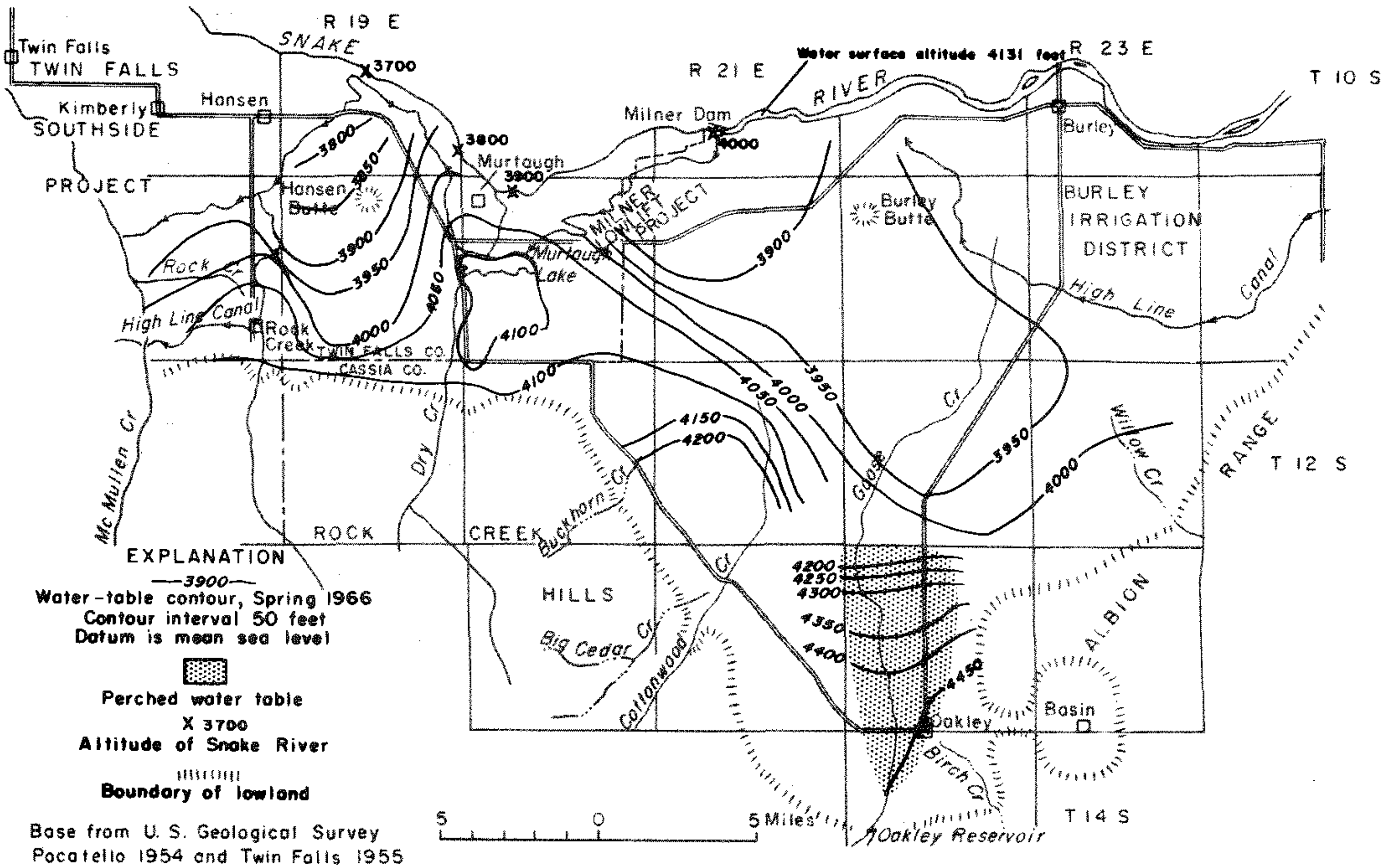


Figure 10.--Approximate configuration of the ground-water surface in the lowland.

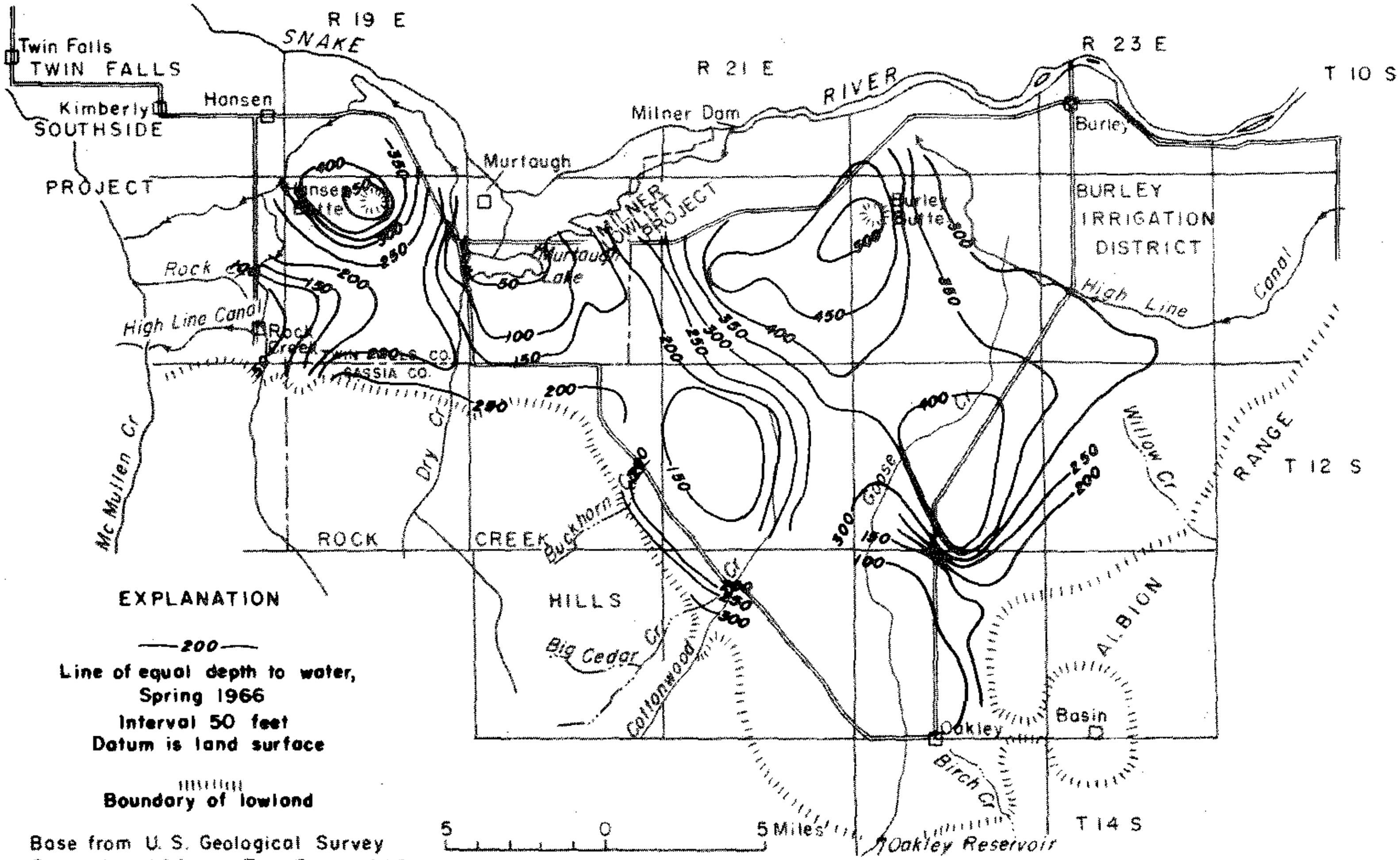


Figure 11.--Approximate depth to water in the lowland.

although the water in the volcanic rocks is under some artesian pressure.

If the alluvial deposits are cased off, the water level in a well tapping the silicic volcanic rocks will rise as much as 50 feet above the top of the aquifer. Commonly, the casing is perforated so that the well produces from both water-bearing formations. Often, water from the upper water-bearing zones can be heard cascading down the well. Generally, it appears that there is about 200 feet difference between the uppermost water level in the alluvial deposits and the water level in the volcanic rocks.

Northeast of the Churchill Fault (fig. 3) in the Kenyon subarea, the reverse occurs with respect to the head differential. Water levels in wells which penetrate the Idavada Volcanics tend to be a little higher in the deeper wells than in the shallower wells. However, the only significant difference in static water levels at different depths in these wells is in the subarea north of Oakley. The approximate position of the water level in the alluvial deposits and the Idavada Volcanics is shown later in the report in figure 18.

SURFACE-WATER USE

Much of the surface-water yield of the Rock Creek Hills and the Albion Mountains is diverted for irrigation; some runoff leaves the area in late winter and spring when snowmelt generates more streamflow than can be diverted from Rock and Dry Creek. The largest acreage irrigated with surface water generated in the Goose Creek-Rock Creek basins is the 12,000-15,000 acres located within 6 miles northward from Oakley. The Oakley Reservoir yields an average of about 45,000 acre-feet annually to these lands. Rock Dry, Cottonwood, Birch, Basin, and a few smaller creeks supply some irrigation water to the lands lying adjacent to their channels, principally in the lowland. The amount of surface water available for irrigation varies greatly from year to year. For example: The annual surface-water yield above the gage on Goose Creek above Trapper Creek, near Oakley, has ranged from 10,540 acre-feet in 1934 to 106,000 acre-feet in 1921.

The Snake River supplies irrigation water to 54,000 acres in the Burley Irrigation District, to 13,000 acres in the Milner Low Lift Irrigation District, and to 203,000 acres in the Twin Falls South Side Project of which about 15,000 acres are considered to be in the report area. The average annual amounts of water diverted to each of these irrigation tracts was 349,700 acre-feet (for the years 1941-64), 57,090 acre-feet (for the years 1944-64), and 1,260,000 acre-feet (for the years 1926-64), respectively. The amounts of water diverted to these tracts are published by the Geological Survey in the annual reports of surface-water records in Idaho. Additional water that might be used for irrigation is available from Snake River because in about 2 out of 3 years water flows past Milner Dam, the last major diversion point on the river.

GROUND-WATER USE AND EFFECTS OF WITHDRAWALS

Some of the first ranches established in the Goose Creek-Rock Creek area used ground water from Land, Poulton, and other springs for irrigation. In the early 1920's, wells drilled in search of oil discharged flowing artesian water into Goose and Trapper Creeks for storage in Oakley Reservoir. Also in the 1920's, wells drilled for irrigation at and near Artesian City, near the mouth of Buckhorn Canyon, and locally on Rock Creek encountered flowing artesian water. Poulton Spring and the wells at Artesian City and near the mouth of Buckhorn Canyon have ceased to flow.

Most of the irrigation wells in the area were drilled between 1945 and 1962, although a few wells have been drilled since 1962. Ground water is the only supply for much of the area, and it is a supplemental supply for some of the land irrigated from Oakley Reservoir, and from Rock, Dry, Basin, Birch, and Cottonwood Creeks. The greatest concentrations of irrigation wells are north of the Rock Creek Hills and south of the Burley Irrigation District (fig. 12). During the period 1961-65, an estimated average of 185,000 acre-feet of ground water was withdrawn annually from about 430 irrigation wells. At the rate of 3 acre-feet per acre, 185,000 acre-feet would irrigate 60,000 acres. Estimated annual withdrawals for irrigation for the period 1945 to 1966 are shown in figure 13. The estimated withdrawal in 1966 increased to 255,000 acre-feet because of unusally dry weather conditions that year.

The amount of ground water withdrawn by each well was estimated using the number of kilowatt hours of electricity consumed by each motor, the lift, or head, that the water was raised by the pump, and the efficiency of the pump and motor. The area of ground-water development was divided into subareas (fig. 14) and the location of each well within the subarea, the performance of nearby wells, and the general water-bearing characteristics of the aquifers were considered in evaluating the estimate for the withdrawal of each individual well. This subjective method of weighting the estimate was necessary because a significant number of wells have discharges which vary more than 50 percent during the irrigation season. A summary of the estimate of ground-water withdrawals by subarea is as follows:

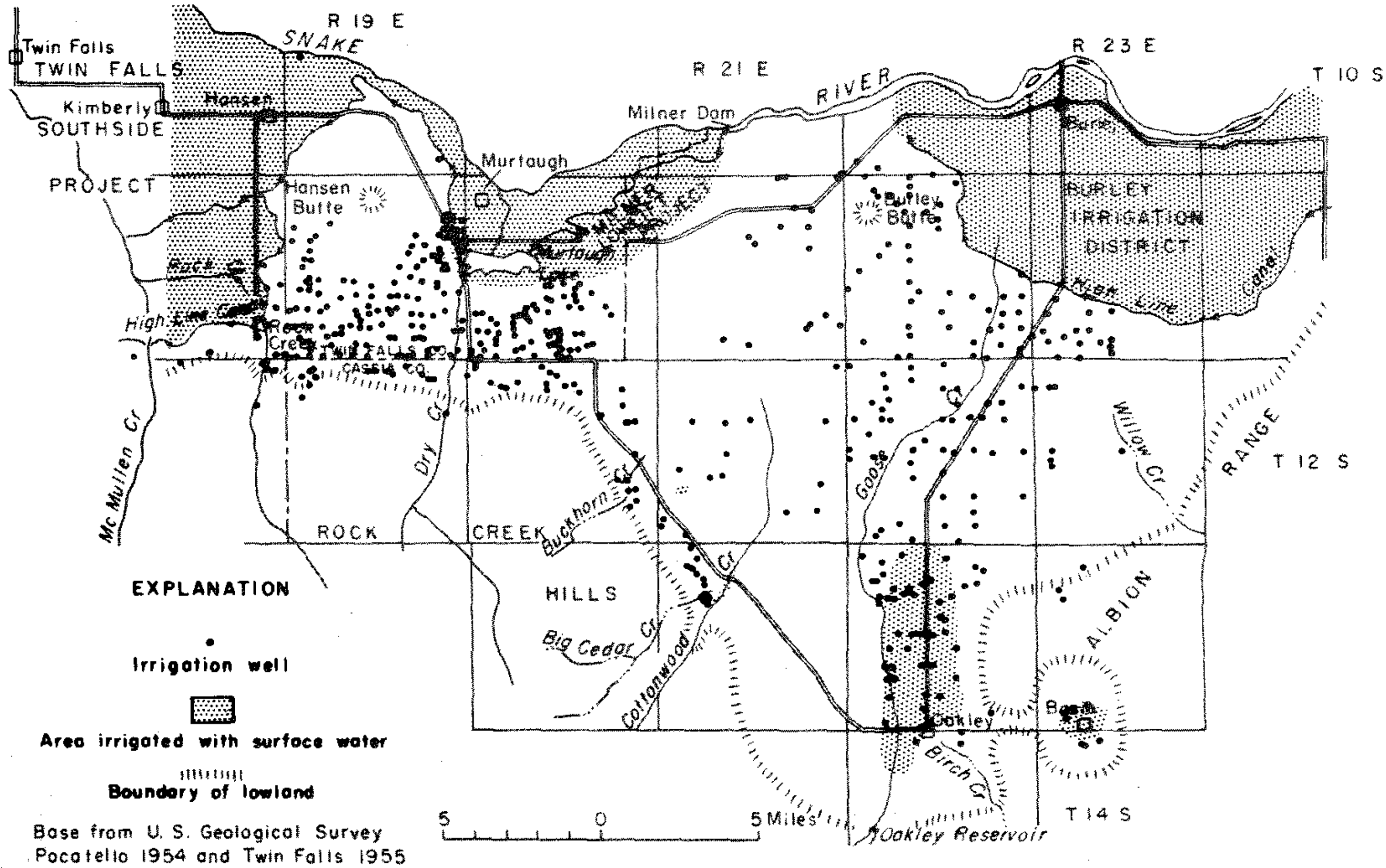


Figure 12.--Distribution of irrigation wells in the lowland.

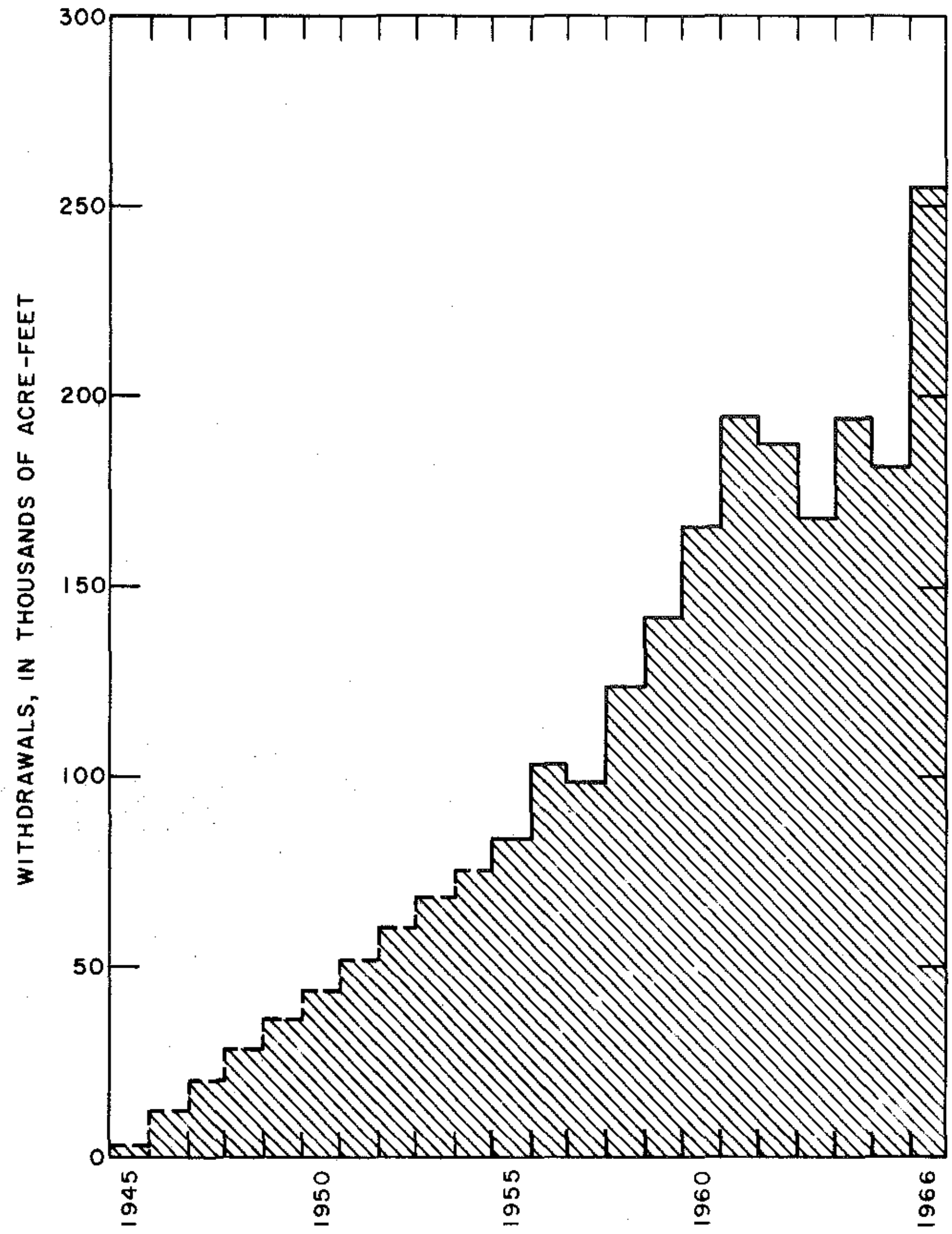


Figure 13.--Estimated annual ground-water withdrawals for irrigation in 1945-66.

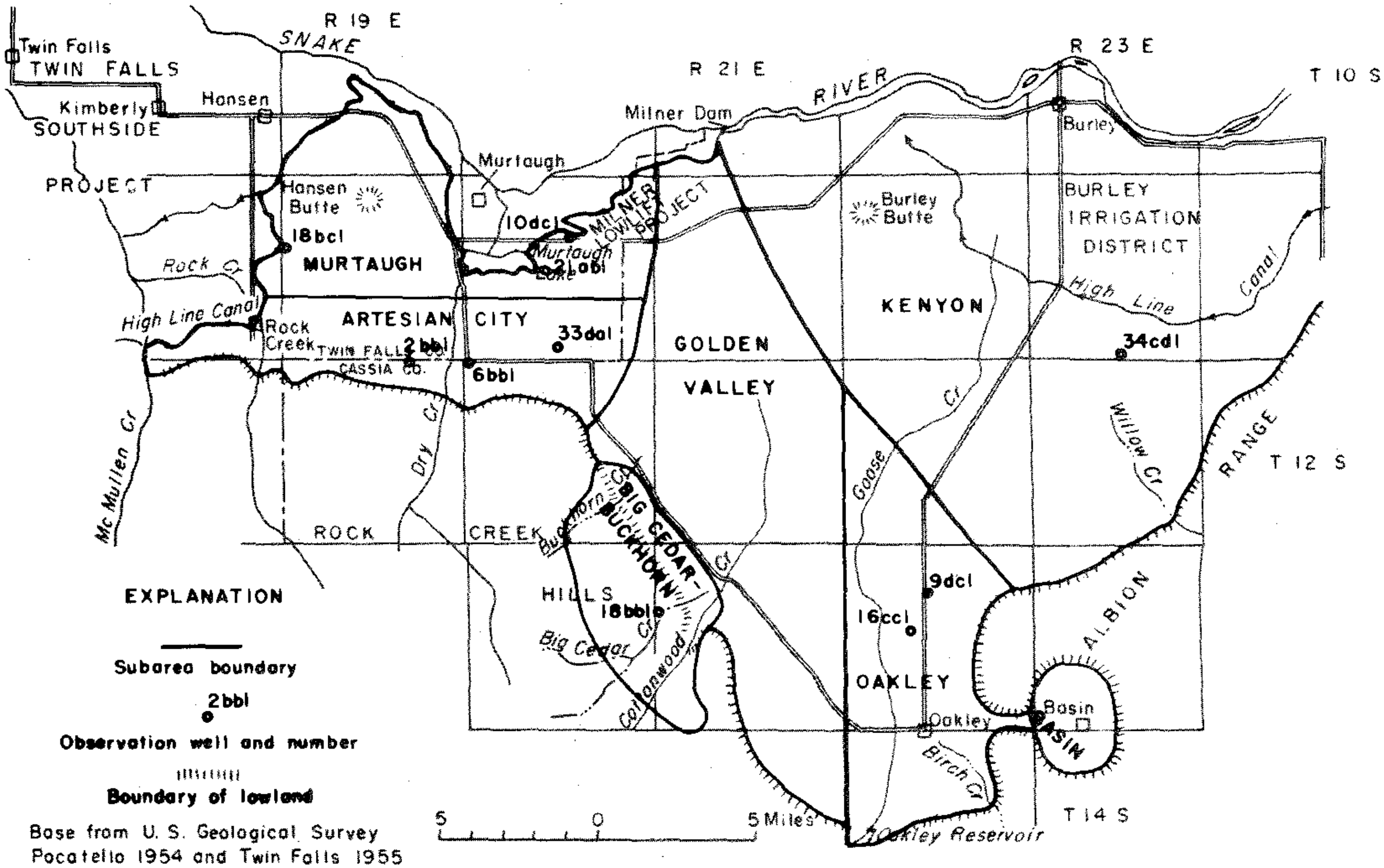


Figure 14.--Subareas in the lowland and location of observation wells for which hydrographs are available. (See figures 15, 20-22, 24.)

Summary of ground-water withdraws, in acre-feet, in the lowlands for the period 1961-65

Subarea	Average annual withdrawals 1961-65
Kenyon	80,000
Oakley	25,000
Golden Valley	5,000
Big Cedar-Buckhorn	15,000
Murtaugh	30,000
Artesian City	30,000
Basin	760
Total (rounded)	185,000

Effects of Pumping

As mentioned above, the area of ground-water irrigation was divided into seven parts, herein called subareas, to facilitate discussion of the effects of ground-water withdrawal. The divisions are based on differences in geologic and in hydrologic conditions but are arbitrary in part. For example, the boundary between the Murtaugh and Artesian City subareas is a compromise between wells producing predominately from basalt and alluvial deposits in the Murtaugh subarea and wells producing predominantly from the Idavada Volcanics in the Artesian City subarea. Water-bearing basalts interfinger with water-bearing alluvial deposits that overlie water-bearing Idavada Volcanics on both sides of the boundary between the two subareas and wells may produce from one, two, or all three formations. On the other hand, the Kenyon and Oakley subareas are separated by a fault which forms a reasonably distinct hydrologic boundary between the two areas.

Kenyon subarea.--Comparison of miscellaneous water-level measurements made in the spring and summer of 1958, and measurements made in the spring of 1963, suggest that the water levels in the Kenyon subarea are declining at an average rate of about 3 feet per year. In general, the larger declines have been in the southern and western parts of the subarea where a decline of as much as 6 feet in a year has been recorded, and the smallest have been along the northeastern side of the district, where little or no decline has been recorded. The hydrograph of well 11S-23E-34cd1 (fig. 15) shows net decline of about 5 feet for the period 1963-66. It also shows that the yearly fluctuation has increased from about 8 feet to about 15 feet. Small declines are to be expected along the northeastern side of the subarea because of the proximity of a substantial amount of recharge (180,000 acre-feet annually from the Burley Irrigation District) and the high transmissibility of the water-bearing formations. A substantial amount of ground water moves into the Kenyon district from the south and southwest, but the aquifers transmitting the water from those directions have only moderate transmissibility as indicated by the relatively steep water-table gradient (see fig. 10). The approximate decline in water level from April 1963 to April 1966 is shown on figure 16. Table 6 (at end of report) shows several years of water-level measurements made before the start of each irrigation season. Locally, a net rise of water levels of 1 to 5 feet occurred in the Kenyon district during the period April 1963 to April 1966, but most of the rises were adjacent to the High Line Canal of the Burley Irrigation District.

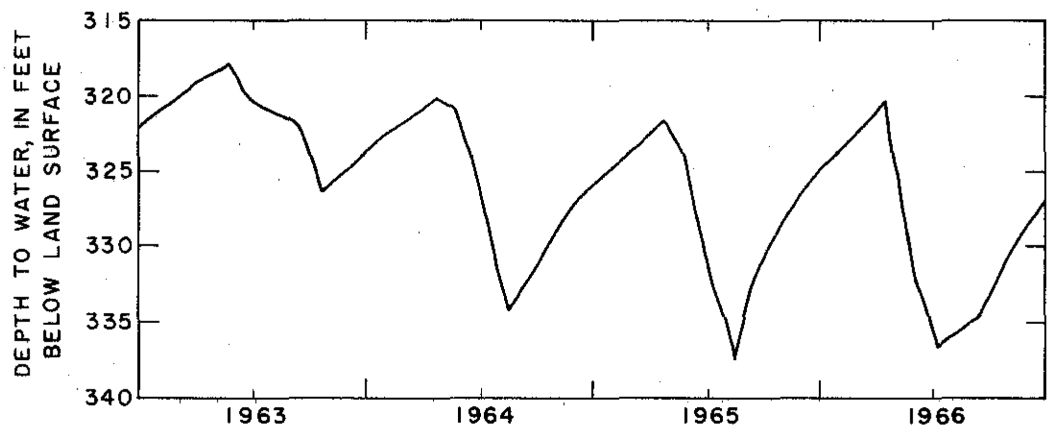


Figure 15.--Hydrograph of well 11S-23E-34cd1.

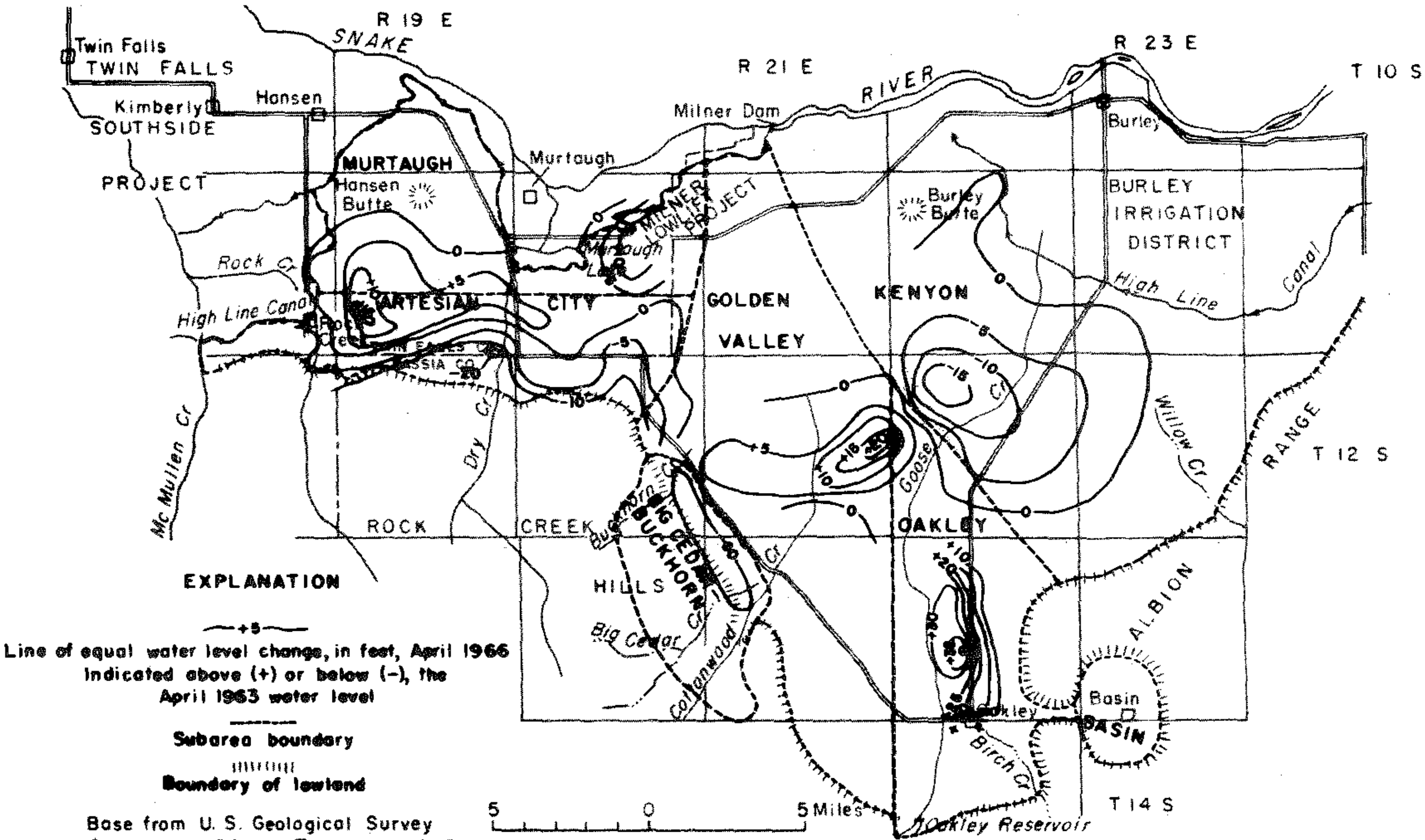


Figure 16.—Changes in ground-water levels, in the lowland April 1963 to April 1966.

The basalt aquifers in the Kenyon subarea yield large quantities of ground water to wells, but in the eastern (fig. 17) and southern parts of the subarea, the saturated basalt is relatively thin. If water levels decline in the future, the saturated thickness will become less and the transmissibility will decrease, resulting in progressively greater difficulty in sustaining a constant yield from wells producing from basalt in that part of the district. In the western and northwestern parts of the subarea (figs. 18 and 19), a much thicker section of basalt is saturated and well yields will not be so adversely affected.

Although as much as 600 feet of sedimentary deposits underlie the basalt and overlie the Idavada Volcanics (fig. 17), they contain only minor amounts of clean sand and gravel and yield only a small part of the water pumped by wells. The few wells penetrating the Idavada Volcanics indicate this formation is yielding but small quantities of water to wells in the Kenyon subarea. Thus, under present conditions (1966), the basalt supplies most of the water to wells.

Normally, when an aquifer system is developed and pumped at a relatively constant rate such as has occurred in this subarea since 1962, the water levels decline until a new equilibrium is attained. Present data are not sufficient to determine if water levels will stabilize in the Kenyon subarea. In fact, inconclusive evidence suggests that water level declines are accelerating in the southwestern part of the area due to the thinning of the saturated thickness of the basalt aquifer mentioned above.

Oakley subarea.--In the early period of development of the Oakley subarea, most wells produced from the alluvial deposits and a few basalt flows; these deposits could not supply all the water needed. For this reason, many

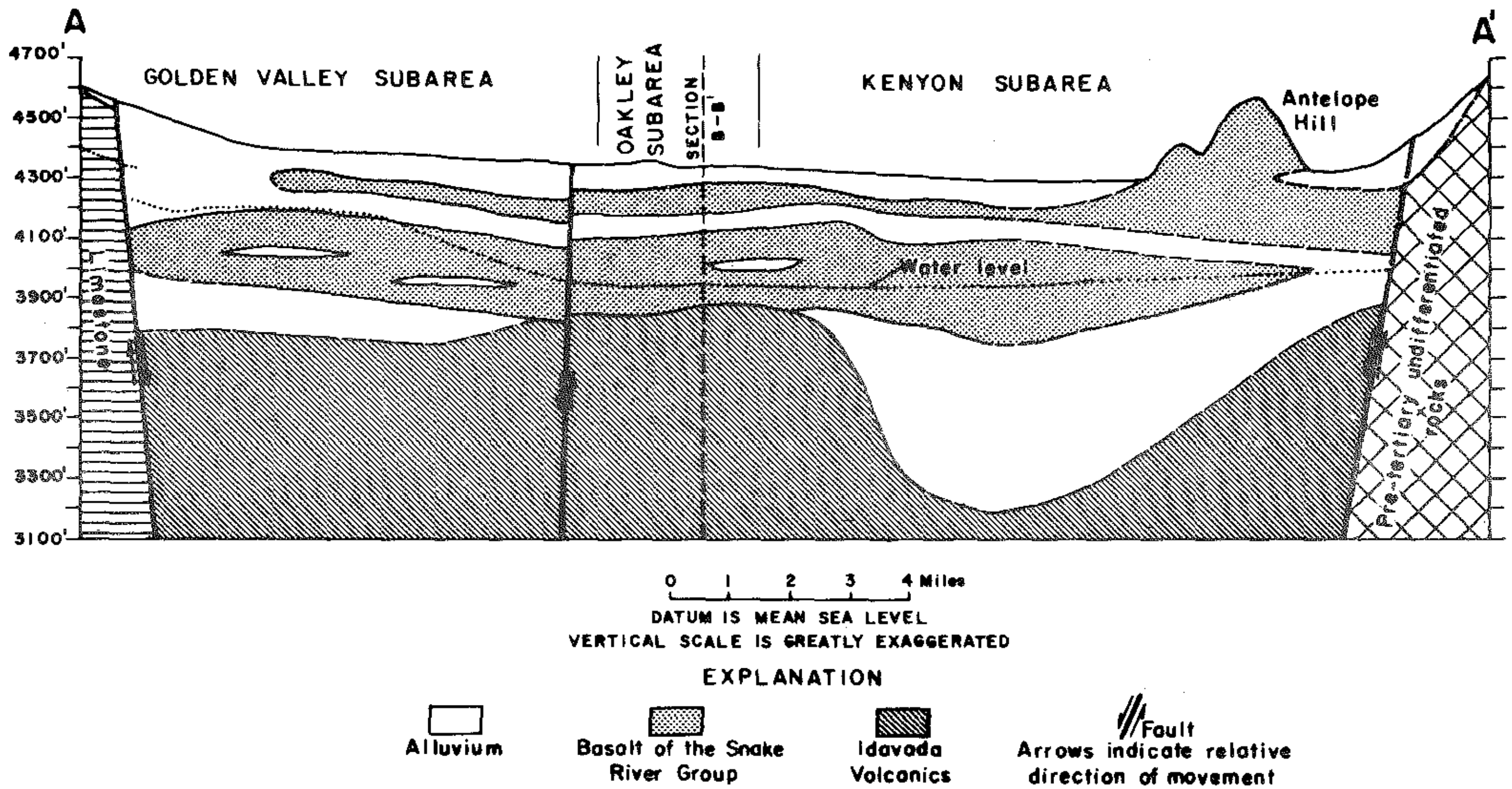


Figure 17.—Generalized geohydrologic section through Golden Valley, Oakley, and Kenyon subareas. (Section A -A', fig. 3.)

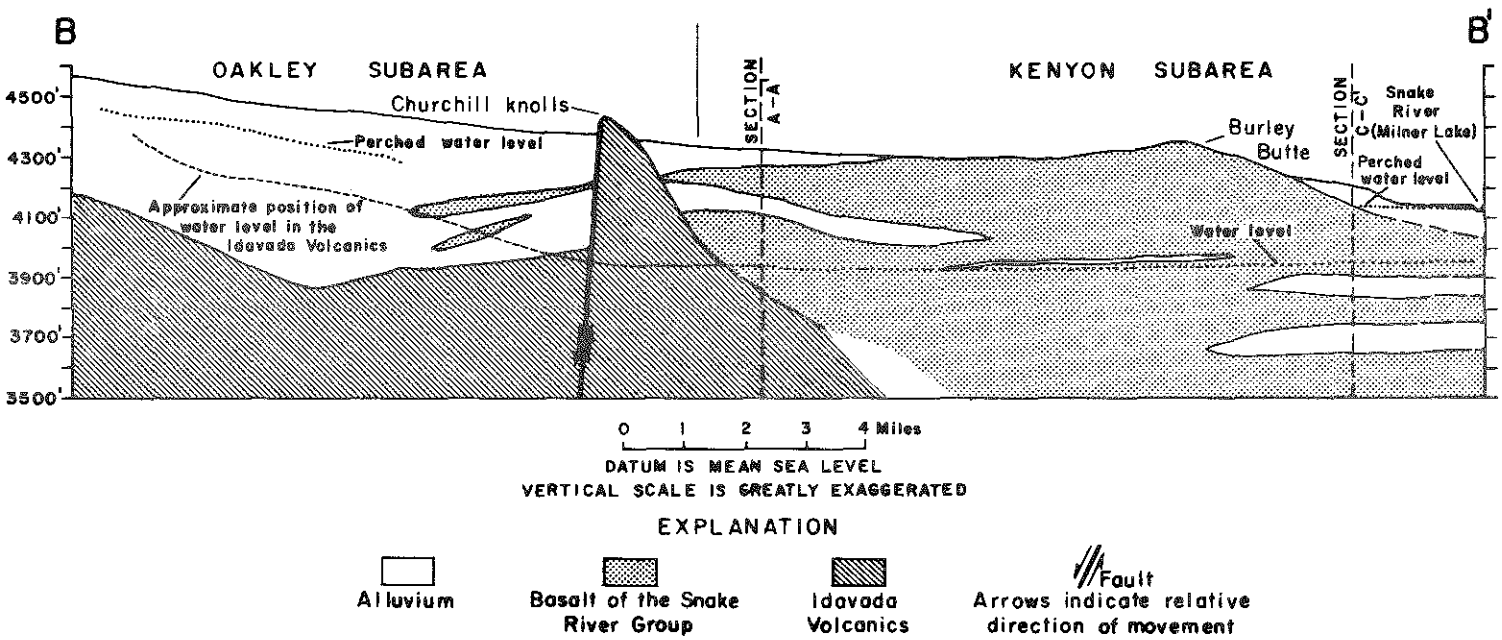


Figure 18.--Generalized geohydrologic section through Oakley and Kenyon subareas. (Section B-B', fig.3.)

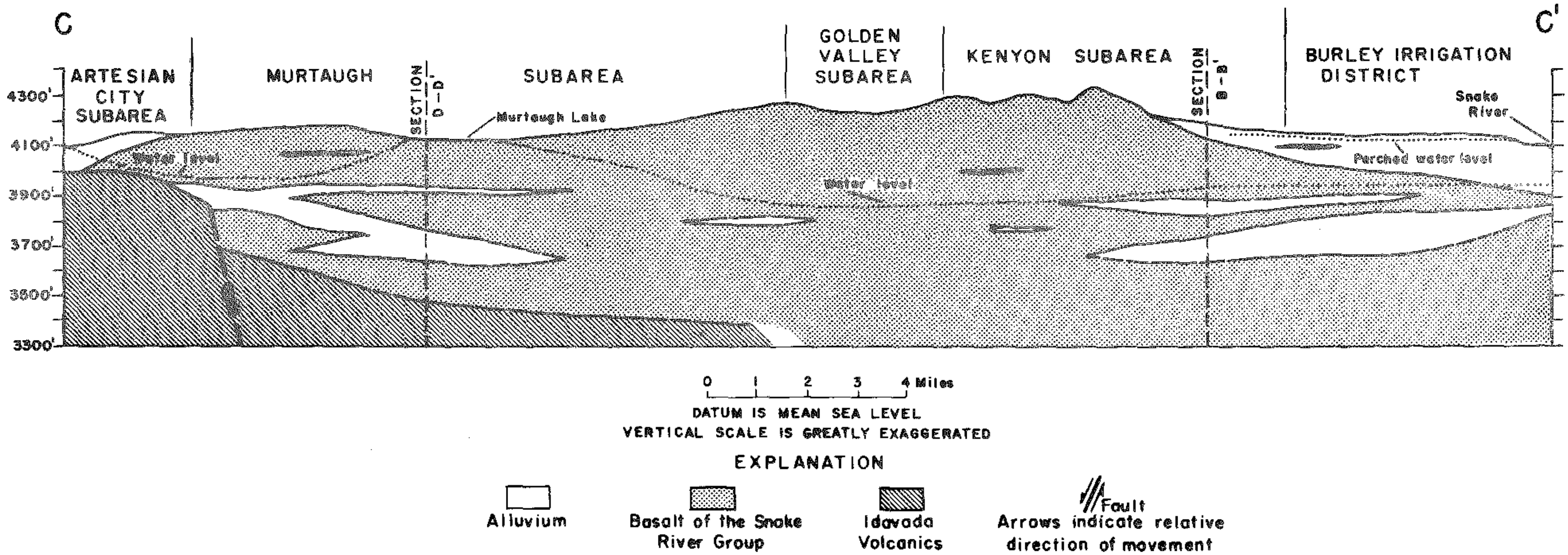


Figure 19.--Generalized geohydrologic section from Artesian City subarea through Burley Irrigation District. (Section C-C', fig. 3.)

old wells were deepened and new wells were drilled to tap the underlying Idavada Volcanics. Figure 18 shows the approximate positions of the water levels in the two rock units. In general, during the period 1958-63, the average annual water-level decline was 1 to 2 feet per year in the alluvial deposits, but locally the declines have been much greater. The decline has been as much as 5 feet per year east of Oakley and about the same magnitude 1 or 2 miles northwest of Oakley. Piper (1923) reported that in 1921 the water table was 10 to 20 feet below land surface at the eastern limits of Oakley. The water table is now estimated to be 100 feet below land surface. Because part of the Oakley subarea has two water supplies (ground and surface water), the yearly demand for ground water fluctuates more widely than in the Kenyon subarea. In some years (1957 and 1965) of relatively abundant surface-water supplies and the resultant lower demand for ground water, water levels in the alluvial deposits rose several tens of feet at some places and this rise persisted into the following year (fig. 20).

Figure 16 shows a water-level rise of more than 30 feet in the alluvial deposits for the period April 1963 to April 1966. This rise was caused by the combination of a relatively abundant surface-water supply from the Oakley Reservoir during the 1965 irrigation season, which provided larger irrigation seepage losses then in previous years to build up the water table, and by small use of ground water. Locally, water levels recovered almost to their 1958 levels.

The data now available are not adequate to evaluate the effects of ground-water withdrawals from the Idavada Volcanics.

Golden Valley subarea.--Water-level data are sparse in the Golden Valley subarea. Generally, there appears to have been no significant change

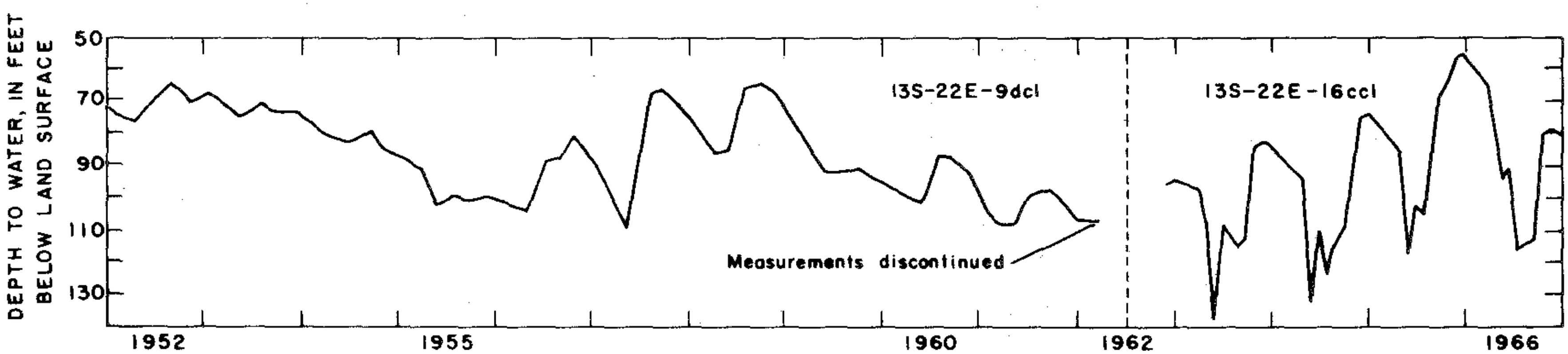


Figure 20.—Hydrographs of wells 13S-22E-9dcl and 13S-22E-16ccl showing fluctuations of water levels in the alluvial deposits in the Oakley subarea.

in water levels except in the extreme western part where, although the exact amount is unknown, a decline of at least 100 feet has been reported. Ground-water withdrawals are relatively small (on the order of 5,000 acre-feet annually) and no district-wide declines would be expected. Much water is imported to the subarea from the Big Cedar-Buckhorn subarea and seepage of this water becomes recharge, tending to offset the depletion caused by withdrawals. Seepage of imported water has built up the water table in the eastern table in the eastern part of the subarea during the period 1963-66 (fig. 17) and the rise may continue.

Big Cedar-Buckhorn subarea.--Intensive development of water in the limestone of Paleozoic age in the Big Cedar-Buckhorn subarea began in 1959 with the largest number of wells being drilled in 1960 and 1961. The wells are concentrated along the foot of the Rock Creek Hills from the mouth of Cottonwood Creek Canyon to Buckhorn Canyon. Water levels started to decline in 1960 and have continued to decline. The hydrograph of well 13S-21E-18bb1 (fig. 21) illustrates the amount of decline since 1961 at the southeastern end of the subarea. The decline has averaged about 22 feet per year and there is no indication that the rate of decline is changing. At the north-western end of the developed area, the decline also has averaged about 22 feet per year and no significant change in this rate is anticipated.

The estimated annual water yield of this subarea is about 10,000 acre-feet. About 5,000 acre-feet runs off as surface water leaving about 5,000 acre-feet for ground-water recharge. Estimated ground-water withdrawals are about 15,000 acre-feet annually. On this basis, withdrawals are about three times as large as recharge.

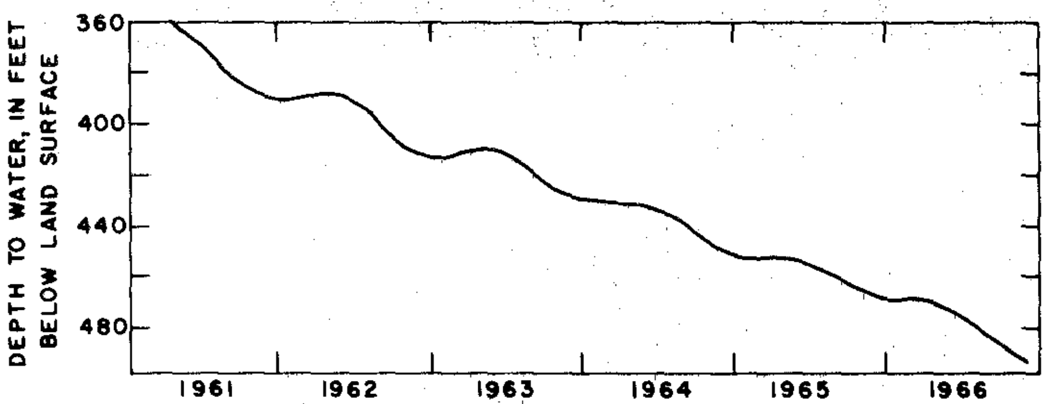


Figure 21.--Hydrograph of well 13S-21E-18bb1.

The surface-drainage area which contributes flow to this subarea appears to coincide reasonably well with the ground-water drainage area. However, the Idavada Volcanics dip from the drainage divide toward the lowland and, as they form at least half the rock outcrops, they probably transmit some of the ground-water recharge out of the area before it enters the limestone aquifer. Thus, all the estimated ground-water recharge in the Cottonwood, Big Cedar, Little Cedar, and Buckhorn Creeks drainage may not replenish the limestone aquifer and withdrawals may be many times larger than recharge.

Regardless of the accuracy of the estimates of recharge and withdrawals, the large and consistent decline of water levels in the area of pumping during the pumping season and the lack of recovery during the nonpumping season suggests that water pumped from the formation is not being fully replaced by recharge.

Murtaugh subarea.--Development of ground water in basalt and alluvial deposits in the Murtaugh subarea began in the later 1940's with the greatest rate of development occurring in the early 1950's. Most wells are only a few hundred feet deep but a few are 800 to 1,100 feet deep. In general, pumping levels range from 100 to 300 feet. The depth to water ranges from about 50 to 250 feet except in the northwestern part of the subarea where it exceeds 450 feet on Hansen Butte (fig. 11). Pumping of ground water caused static water levels to decline a few to a few tens of feet from 1952, when water-level records began, to 1961, after which there was some recovery (fig. 22). The recovery of water levels probably was caused by several factors, but the relative importance of each factor has not been evaluated. One of the factors is the annual amount of surface water

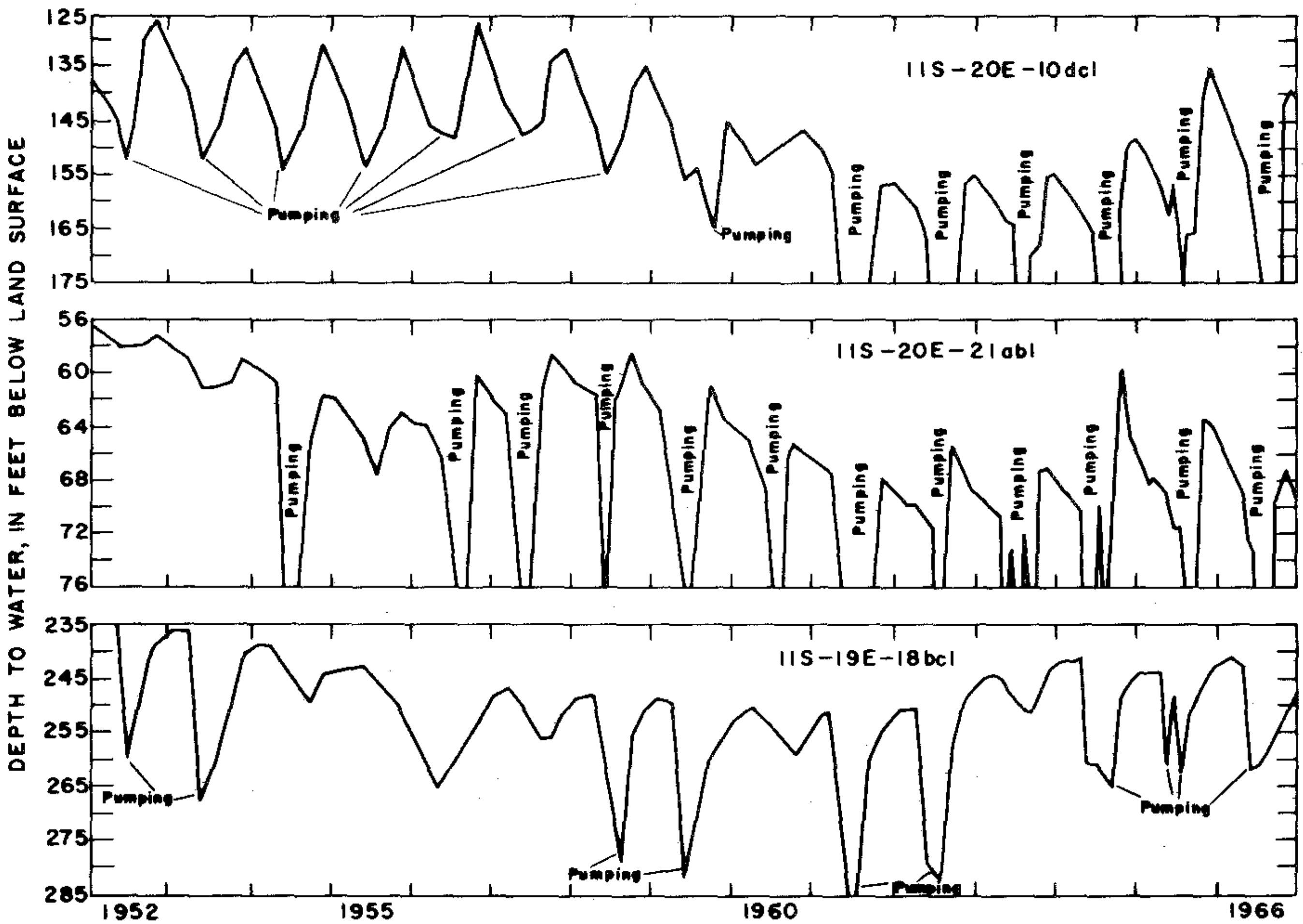


Figure 22.-Hydrographs of wells 11S-20E-10dc1, 11S-20E-21ab1, and 11S-19E--18bc1.

diverted through the Twin Falls South Side Canal, the major source of recharge to the Murtaugh subarea. Beginning in 1954, after the largest annual rate of ground-water development, diversion through the canal declined from 1.34 million acre-feet in 1953 to 1.15 million acre-feet in 1961 after which there was a sharp increase in diversions to as much as 1.35 million acre-feet in 1966.

Another factor which influences the demand for ground water is the precipitation which falls just before and during the growing season. From 1952 through 1960 annual precipitation that would affect crop growth was average or below average two-thirds of the time. In the period 1961-65, precipitation was above average every year, particularly in 1965, but in 1966 it was materially deficient.

Another factor was the abandonment of some irrigation wells that had low yields and did not warrant the expense of pumping. Also the Milner Low Lift Irrigation District expanded from 9,100 acres in 1950 to 13,400 acres in 1966. An unknown but probably small part of the expanded area formerly had a ground-water supply.

Water-level measurements contained in table 6 show that the net change in water levels for the period 1954-66 ranged from less than 5 feet, in the northeastern part of the subarea where ground-water withdrawals are small, to 22 feet in the southwestern part of the subarea where ground-water withdrawals are much larger. Although the net decline in water levels, measured in the spring of the year, has not been large, pumping levels have declined progressively in practically every well, and after a few years of production the length of pump column in almost every well was increased.

The basalt and alluvial deposits yield moderate amounts of water to wells. In general, yields range from 100 to 1,000 gpm (gallons per minute) and average about 500 gpm. A few wells yield as much as 2,500 gpm. In the northern part of the subarea, irrigation wells are usually successful because there are few alluvial deposits between basalt flows (fig. 23). In the southern part of the subarea, alluvial deposits become much thicker but contain some sand and gravel beds which yield small supplies to wells. Some wells were deepened to obtain water from the Idavada Volcanics in the southern part of the subarea.

Artesian City subarea.--Development of ground water in the Artesian City subarea began in 1909 when a flowing artesian well was drilled at a warm spring at Artesian City (Stearns, 1938, p. 168). Later several flowing wells were drilled nearby and in the canyon of Rock Creek. Intensive development of ground water began in the late 1940's and reached a peak rate in the mid 1950's. The yields of most wells declined after being put into production and the pump column in practically all wells has been extended at least once in order to maintain an adequate yield. Also, many wells were deepened and some were reconditioned after collapse of the well bore. Several wells drilled for irrigation have been abandoned because of inadequate yield. By 1952 the water level at Artesian City was about 40 feet below land surface and by 1966 it had declined to about 150 feet. Declines of similar magnitude have been recorded at other places in the area (fig. 24).

The greatest recorded water-level declines have been concentrated in the southcentral part of the subarea from Artesian City westward for 2 or 3 miles, while lesser declines occurred in the northern part of the subarea.

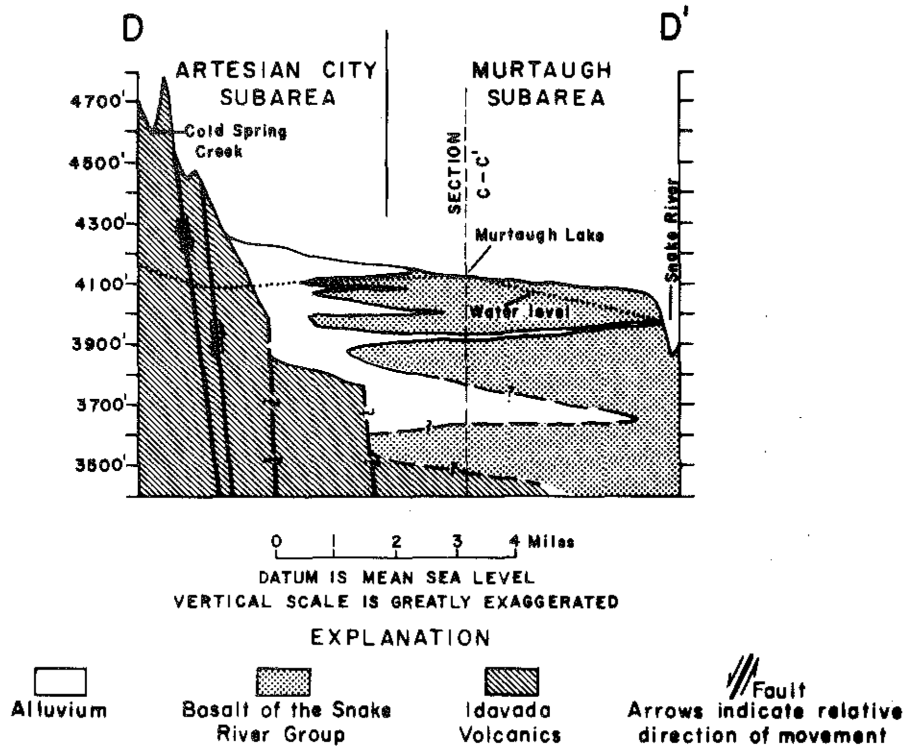


Figure 23.--Generalized geohydrologic section through Artesian City and Murtaugh subareas. (Section D-D', fig. 3.)

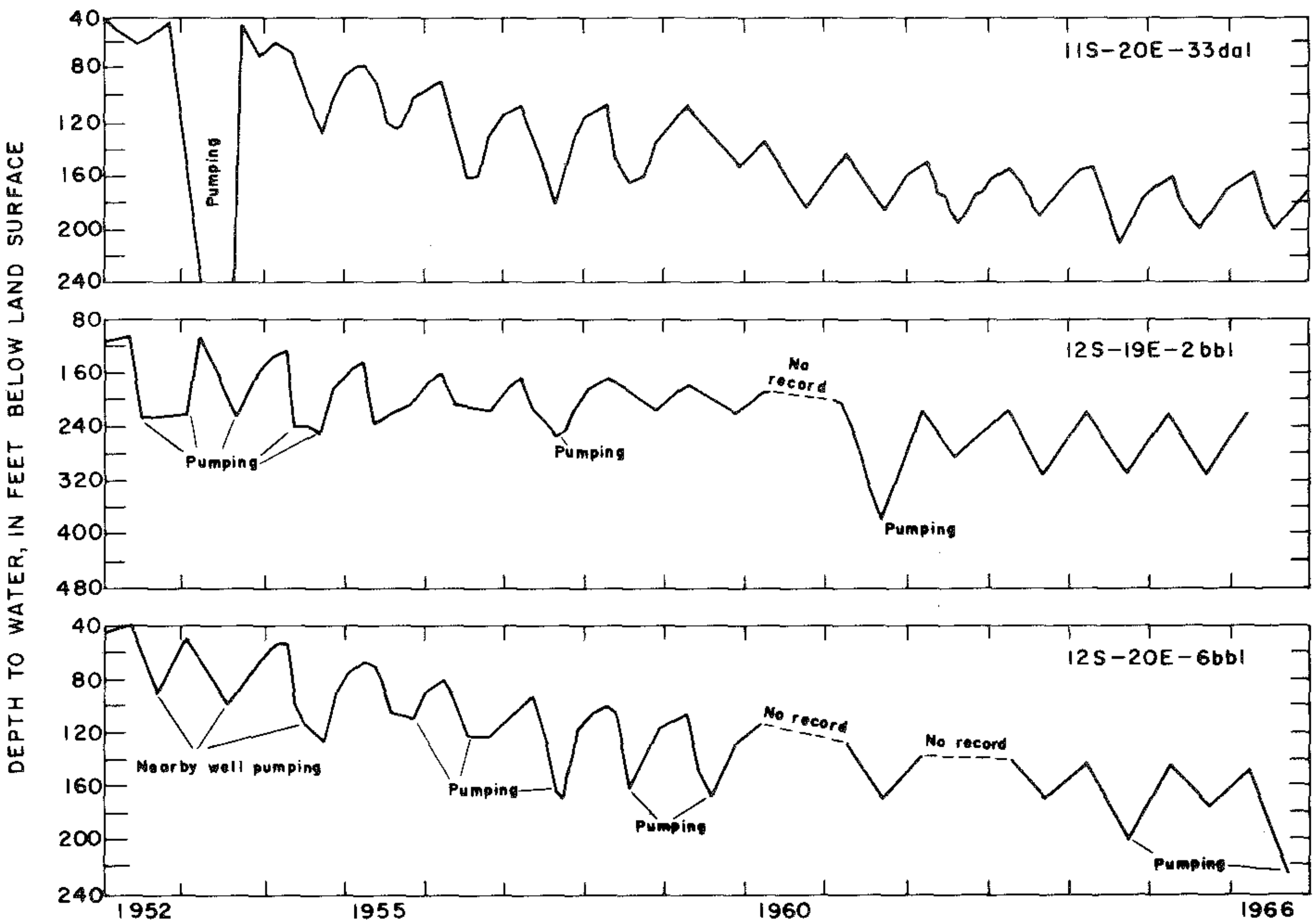


Figure 24.--Hydrographs of wells 11S-20E-33dal, 12S-19E-2bbl, and 12S-20E-6bbl.

However, water levels rose as much as 15 feet in the northern part between April 1963 to April 1966 (fig. 16). The large rise was caused by the exceptionally high water yield of Rock Creek in 1965. When available, surface water is used for irrigation in this part of the subarea and consequently, as in 1965 when a large supply of surface water was available, a relatively small amount of ground water was pumped. Table 6 shows that the declines between April 1954 and April 1963 ranged from about 10 to nearly 100 feet. Water from Dry Creek is used near Artesian City, but the supply was not adequate to reverse the water-level trend, and a net decline of about 20 feet was recorded just west of Artesian City during the period April 1963 to April 1966 (fig. 16).

At some places, interference between wells is large. For example, the water level in non-pumping well 12S-19E-3ad1 declined at an average rate of 2 feet a day, for a total decline of 133 feet, from April 22 to June 27, 1961, when 6 wells 1,400 feet to 4,500 feet away were pumped at a combined rate of about 4,500 gpm. Reportedly, well interference occurs at other places, but it may not be as severe. After the start of the irrigation season, the pumping levels in practically all wells decline progressively and by midsummer, yields may be reduced by more than 50 percent.

The permeability of the Idavada Volcanics is highly variable both laterally and vertically. Individual flows are not consistent in thickness and degree of jointing and the ash, sand, and gravel beds wedge out between flows. Faulting has disarrayed the rocks (fig. 23 section D-D') and the original rocks along the faults have been altered at some places. The altered rock contains jasper, pyrite, secondary calcium carbonate, and silica. Commonly, ash beds are altered to clay. Along fault zones, broken rock may increase the permeability of the formation. On the other hand, alteration products in the fault zones may restrict the movement of ground water. These factors explain the large differences in yield between closely spaced wells. Small amounts of water are obtained from a few basalt flows which extend into the northern part of the subarea and from the alluvial deposits.

Most sustained well yields range from 200 to 700 gpm. A few wells maintain a pumping rate in excess of 1,100 gpm for an entire irrigation season. The water-level records show no apparent change in the annual rate of decline, other than a temporary change caused by an unusually abundant surface-water supply in an occasional year. Estimated annual withdrawals (30,000 acre-feet) are several times larger than the estimated average annual recharge of 11,000 acre-feet to the Idavada Volcanics. So long as the present annual rate of withdrawal continues, no decrease in the rate of water-level declines can be expected until water levels are lowered enough to stop natural discharge and induce recharge from the overlying aquifers in the discharge area. It is not known how much the water levels would need to be lowered to accomplish this and there is no assurance that the total of salvaged discharge and induced recharge would be adequate to stabilize water levels.

Basin subarea.--Only 2 of a total of 5 irrigation wells in the Basin subarea are used frequently for irrigation. About 760 acre-feet of water is withdrawn annually from alluvial deposits and the Idavada Volcanics. There are no observation wells in the Basin subarea but infrequent measurements of water levels indicate that no significant changes have occurred during the past 15 years.

QUALITY OF WATER

Water moving through or over earth materials dissolves some of the products of rocks weathering and the chemical content thus gained affects the suitability of water for various purposes. Chemical analyses of 36 ground-water and 4 surface-water samples are given in table 5. Also shown in the table is the suitability of each water for irrigation according to common methods of classification.

Several of the analyses shown in table 5 do not represent water used for irrigation. Some of the analyses indicate a water of unusual composition that is believed to be uncommon. Water from spring 14S-22E-27dS1 is unusual in that it is very low in calcium and magnesium, very high in fluoride, and is an extremely soft water.

Most of the ground water used for irrigation is a calcium bicarbonate water with significant amounts of sodium, magnesium, chloride, and sulphate ions. The limited number of analyses does not permit relating specific types of water to the several water-bearing formations.

Suitability of Water for Irrigation

Several methods are used to classify water as to its suitability for irrigation. The most common methods involve the concentration and relative ratios of several of the chemical constituents. However, such factors as the structure and chemical composition of the soil, type of crops grown, methods of cultivation, and fertilization of the soil determine how successfully a particular water may be utilized. One of the most important factors is the leaching or flushing of soluble salts left in the soil by

Table 5.—Chemical analyses of water in the Goose Creek-Rock Creek area.
(Chemical constituents in milligrams per liter) or (Approximate parts per million)

Agency making analysis: IPHS, Idaho Public Health Service; USBR, U.S. Bureau of Reclamation; USGS, U.S. Geological Survey; UPRR, Union Pacific Railroad.
Water-bearing formation: B, basalt; G, gravel; Ti, Idavada Volcanics and associated rocks; Pal, undifferentiated rocks of Paleozoic and older age.
Use of water: D, domestic; I, irrigation; PS, public supply; S, stock; U, unused.

Well, spring or stream	Depth of well (feet)	Date of collection	Temperature (°F)	Agency making analysis	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)	Total dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Residual sodium carbonate (meq per l)	Sodium-adsorption ratio (SAR)	Specific conductance (micromhos at 25° C)	pH	Class (page -)	Water-bearing formation	Number on classification diagram (fig. 24)	Present use of water
U.S. Public Health Service drinking-water standards (1962)	Maximum recommended amounts					0.3		125				250	250	1.5	45		500											
10S-18E-25ba1	371	–	65	IPHS	–	0.0	58	40	10e/		246	175	78	0.3	–	–	702	309	–	7	0	.25	–	7.6	-S1	B,G	–	PS
10S-23E-20dc3	1,115	1/26/45	–	IPHS	–	0.02	33	11.4	–		144	21	40	0.3	–	–	282	118	0	–	0	–	–	–	–	B,G	–	PS
20dc3	1,115	4/ 9/49	67	USGS	62	–	32	12	33e/		144	24	40	–	1.7	–	276	–	12	36	0	1.26	407	–	C2-S1	B,G	1	PS
20 a/	–	12/13/45	68	IPHS	–	0.15	26	7.5	–		–	23	32	0.5	–	–	278	96	–	–	0	–	–	7.8	–	B,G	–	PS
20 b/	–	5/17/29	–	UPRR	–	–	41	9.5	38e/		156	32	45	–	–	–	288	141	–	37	0	1.39	–	–	-S1	B,G	–	PS
20dc6	486	–	66	IPHS	58	0.05	30	7.3	42e/		122	23	33	0.6	0.6	–	291	105	–	47	0	1.75	–	7.3	-S1	B,G	–	PS
11S-19E-18da2	431	5/17/54	–	USGS	58	–	138	34	72e/		240	223	144	0.2	9.7	–	854	484	288	24	0	1.41	1,230	7.6	C3-S1	B	2	I
21da1	535	5/17/54	80	USGS	71	–	22	3.9	21e/		108	9.5	12	0.4	0.6	–	191	71	0	39	0.35	1.09	229	7.5	C1-S1	B,G,Ti	3	I
26ad1	159	5/17/54	62	USGS	60	–	38	11	20e/		120	30	37	0.2	1.1	–	266	140	42	24	0	.73	377	7.3	C2-S1	B,G	4	I
30dc1	300	9/26/52	55	USGS	57	0.05	134	20	65	12	248	252	60	0.3	8.3	0.06	731	416	214	25	0	1.38	1,040	7.4	C3-S1	G	5	I
30dc2	700	9/26/52	53	USGS	56	0.04	149	23	72	12	276	270	78	0.2	10	0.06	806	466	240	25	0	1.45	1,160	7.4	C3-S1	G,Ti	6	I
33dd1	625	9/25/52	90	USGS	59	0.03	25	4.1	15	8.0	118	11	13	0.4	1.6	0.03	195	79	–	27	0	.73	251	7.6	C2-S1	Ti	7	I
11S-20E-10dc1	180	5/17/54	57	USGS	47	–	54	36	137e/		426	127	59	0.3	20	–	676	282	0	51	1.33	3.55	1,070	7.7	C3-S1	B	8	I
26ab1	483	/52	66	USGS	66	–	36	8.7	21e/		164	13	16	–	1.2	–	229	–	–	27	.18	.82	333	–	C2-S1	B	9	D
29cd1	350	5/17/54	61	USGS	38	–	96	29	29e/		175	68	141	0.1	10	–	547	358	215	15	0	.67	873	7.8	C3-S1	G,B	10	I
34cc1	274+	9/25/52	88	USGS	28	0.05	43	8.9	11	7.4	186	13	4.5	0.7	0.6	0.05	209	144	–	13	.17	.40	326	7.5	C2-S1	B,Ti	11	I
11S-22E-25bc1	–	5/ 1/59	52	USBR	–	–	55	12	12	6.	163	24	40	2.1	3.	.00	–	–	–	12	0	.37	434	7.7	C2-S1	B	12	I
12S-18E- 1bb1	755	3/21/52	100	USGS	60	0.00	17	2.1	17	5.4	90	6.3	9.0	0.6	4.8	0.07	168	51	0	39	.45	1.03	186	7.6	C1-S1	Ti	13	I
12S-19E- 6cd1	1,210	9/26/52	81	USGS	77	–	19	3.6	19e/		93	8.2	12	–	1.9	–	186	62	0	40	.28	1.04	211	–	C1-S1	Ti	14	I
12S-20E- 5cc2	297	9/25/52	83	USGS	18	–	29	8.2	22		160	9.7	9.0	–	0.6	–	175	106	0	31	.50	.94	294	–	C2-S1	Ti	15	I
13S-19E- 8c-S1	–	9/ 4/56	60	USGS	42	0.00	21	3.7	7.4	2.1	98	3.5	1.0	0.2	0.1	–	121	68	0	19	.25	.39	164	7.2	C2-S1	Ti	16	PS
13S-21E- 6aa1 c/	–	/22	–	USGS	62	0.07	29	8.6	17e/		119	13	6.2	–	–	–	206	108	–	26	.20	.71	–	–	-S1	Pal	–	U
21b-1	60	9/ 4/56	62	USGS	50	0.01	26	4.9	6.6	8.3	130	2.8	3.5	0.2	0.3	–	171	85	0	13	.43	.31	226	7.3	C2-S1	Ti	17	D
13S-22E-21cc1	–	5/ 1/59	52	USBR	–	–	56	25	17	1.5	69	8.3	17	2.2	3.6	0.12	–	–	–	17	0	.71	636	7.2	C2-S1	?	18	I
13S-23E- 7--S1	–	/21	60	USGS	47	0.03	78	15	20e/		220	34	53	–	2.3	–	374	256	–	15	0	.54	–	–	-S1	Ti	–	I
14S-18E-10--S1	–	9/ 1/56	52	USGS	67	0.04	3.4	0.4	2.5	4.7	25	2.0	1.5	0.4	1.0	–	91	10	0	25	.28	1.08	52	6.4	C1-S1	Ti	19	S
14S-20E-22--S1	–	9/ 1/56	40	USGS	49	0.01	1.8	0.00	4.6	1.9	15	.6	1.0	0.1	2.8	–	81	4	0	59	.16	.94	39	6.2	C1-S1	Ti	20	S
14S-21E-16b-S1	–	9/ 1/56	52	USGS	50	0.01	25	5.9	18	1.6	109	13	1.7	0.2	1.0	–	183	87	0	31	.32	.84	252	7.3	C2-S1	Ti	21	S
34ab1	983	/22	112	USGS	79	0.05	5.4	1.4	41e/		61	12	4.8	–	–	–	198	19	–	82	1.38	4.07	–	–	-S1	Ti	–	I
14S-22E-27dd-S1	–	/21	114	USGS	78	0.06	2.7	0.9	84e/		69	26	52	–	0.23	–	308	10	–	95	.56	16.55	–	–	-S3	Pal	–	S
27dd-S1	–	9/ 3/56	120	USGS	76	0.01	2.1	0.0	87	2.5	67	23	54	6.8	0.0	0.1	295	5	0	96	1.53	11.28	415	9.4	C2-S2	?Pal	22	U
15S-21E- 4b-1	852	/22	106	USGS	45	0.06	9.4	1.5	43e/		98	27	11	–	–	–	180	30	–	65	1.12	2.00	–	–	-S1	Ti	–	I
25dc1	2,435	/22	107	USGS	64	0.07	4.0	1.2	106e/		159	22	17	–	–	–	344	15	–	94	3.84	11.92	–	–	-S2 ?	Ti	–	I
15S-22E-18c-S1	–	9/ 3/56	66	USGS	82	–	45	6.7	24	11	169	14	40	0.1	1.4	–	312	140	1	25	0	.88	427	7.9	C2-S1	Ti	23	S
Snake River at Lake Walcott d/	–	–	–	USGS	18	–	46	15	24e/		186	41	19	0.6	0.7	–	–	179	19	23	0	.79	429	–	C2-S1	–	24	I
Rock Creek at Rock Creek	–	7/23/58	–	USGS	34	–	82	35	29	14	392	21	50	0.2	4.3	–	248	158	20	25	0	.56	374	7.6	C2-S1	–	25	I
Goose Creek above Reservoir	–	4/25/60	–	USGS	32	–	28	4.7	9.7	4.3	112	12	8.9	0.2	0.7	–	165	90	0	18	0	.44	230	7.9	C1-S1	–	26	I
Goose Creek above Reservoir	–	8/ 2/60	–	USGS	34	–	55	10	20	12	209	37	20	0.4	0.7	–	296	178	7	18	0	.65	461	7.7	C2-S1	–	27	I

a/ Composite sample of 2 deep wells. b/ Composite sample of several wells. c/ Composite samples of spring and 4 flowing wells.
d/ Average of 3 samples. e/ Total Sodium (Na) plus Magnesium (Mg).

evapotranspiration. Most of the agricultural soils are of windblown and alluvial origin. They are generally permeable, and this permits flushing of the soils so that harmful salts ordinarily do not accumulate.

Irrigation water are commonly classified according to a diagram (fig. 25) developed by the U. S. Salinity Laboratory Staff (1954). In this diagram the salinity hazard is estimated from the electrical conductance and the sodium hazard from the sodium adsorption ratio (SAR). The SAR is defined by the equation:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++}\ Mg^{++}}{2}}}$$

where the ionic concentrations are expressed in milliequivalents per liter.

According to this method of classification, most of the irrigation water sampled had a low sodium hazard. Seven of the samples had a medium salinity hazard and five, a high salinity hazard. The samples of irrigation water with medium salinity hazard are from wells 11S-19E-26ad1, 11S-19E-33dd1, 11S-20E-26ab1, 11S-20E-34cc1, 11S-22E-25bc1, 12S-20E-6cc2, and 13S-22E-21cc1. Those with a high salinity hazard are from wells 11S-19E-18da2, 11S-19E-30dc1, 11S-19E-30dc2, 11S-20E-10dc1, and 11S-20E-29cd1. Most of the samples with a medium or high salinity hazard are from basalt and alluvial deposits, but some are from the Idavada Volcanics. Some crops, such as field beans and red clover, have a relatively low tolerance to saline water and soils. The remainder of the sampled water with medium or high salinity hazard either is not used for irrigation or is mixed with water from other sources.

Water from the Snake River has a medium salinity hazard but return flow of Snake River water in other parts of Idaho, in areas similar to the Burley

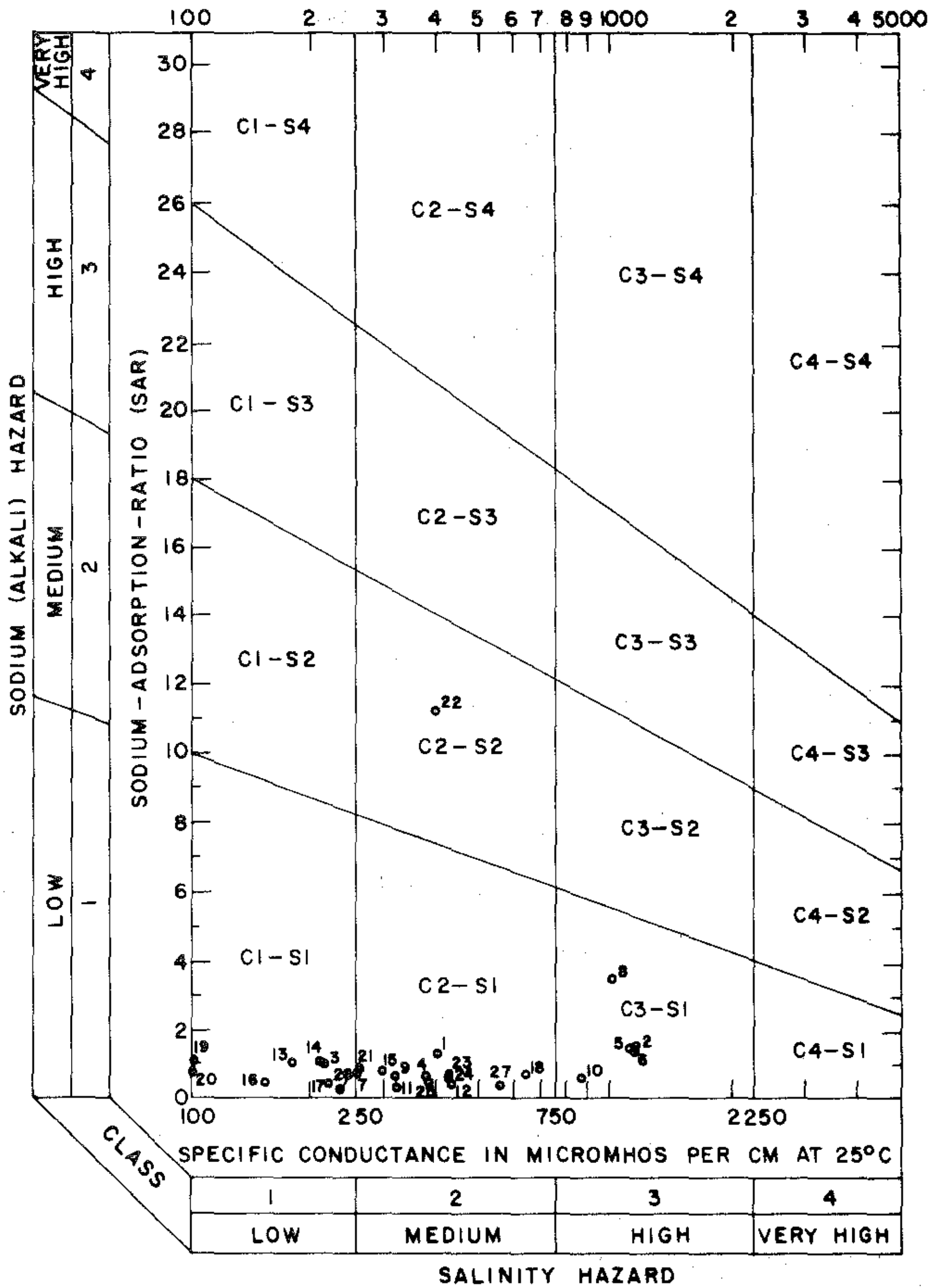


Figure 25.--Classification of water for irrigation.

(Sample numbers are keyed to Table 5.)

Irrigation District, has a high salinity hazard. Percolation of irrigation water to the main water table in the Burley area undoubtedly had modified, and will continue to modify, the chemical character of the ground water. The amount of this modification cannot be determined at the present time. To date, Snake River water or return-flow water has caused no known significant salinity problems. One sample from Goose Creek and the sample from Rock Creek had a medium salinity hazard. These waters have caused no known salinity problems.

Another method of determining the utility of water for irrigation is the "residual sodium carbonate" (RSC) method which is defined by the equation:

$$RSC = (CO_3^{-2} + HCO_3^{-}) - (Ca^{+2} + Mg^{+2})$$

where the concentration of ions is expressed in milligrams per liter (Eaton, 1950, U. S. Salinity Lab., 1954). The water sampled from well 11S-20E-10dc1 is marginal for irrigation use according to this classification. The sample for well 14S-21E-34ab1 is marginal and the sample from well 15S-21E-25cd1 is not safe; but the small yield of these last two wells is mixed with several times their volume of water in Goose Creek before being used for irrigation. Spring 14S-22E-17dS1 is marginal but this spring water is not an important source of irrigation supply.

Boron is essential to plant growth but a small excess is toxic to plants. The concentration of boron in the 7 samples analyzed for this constituent would have little effect on the plants commonly grown in the area.

Suitability of Water for Domestic Use

Results from chemical analysis of water samples collected in the Goose Creek-Rock Creek area and the recommended maximum concentration of chemical constituents as set forth in U. S. Public Health Service drinking water standards (1962) are shown in table 5. The Public Health Service also has standards not shown in the table such as freedom from bacteria or harmful organisms, color, taste, turbidity, and odor. Most of the water sampled meet U. S. Public Health Service recommendations for the constituents determined, except that, six samples had higher dissolved solids than is desirable, three had excessive fluoride, and two had excessive sulphate. Except for the samples containing excessive fluoride, none of the water sampled would be unsuitable for domestic use.

SUMMARY

There are four water-bearing formations that yield water for irrigation in the Goose Creek-Rock Creek basins. Limestone and associated rocks of Paleozoic age yield large supplies near a fault zone along the northeastern side of the Rock Creek Hills. Welded tuffs, ash flows, and sand and gravel of the Idavada Volcanics of Pliocene age yield small to moderately large supplies of artesian water to irrigation wells in the Oakley and the Artesian City subareas, and in the southern parts of the Kenyon, Golden Valley, and Murtaugh subareas. Basalt of the Snake River Group of Holocene and Pleistocene age, yields small to large quantities of water to wells principally in the Kenyon and Murtaugh subareas, but some water is produced from basalt in the Oakley, Golden Valley, and Artesian

City subareas. Alluvial deposits of Holocene to Pleistocene age yield small to moderate supplies of water to irrigation wells in the Oakley, Golden Valley, and Basin subareas and in the northern part of the Artesian City and southern part of the Murtaugh subareas.

An estimated average of 140,000 acre-feet of the precipitation that falls annually on the basin becomes water yield. Goose Creek yields about 90,000 acre-feet annually and Rock, Dry, and McMullen Creeks about 43,000 acre-feet annually. Several smaller streams yield a few thousand acre-feet annually. Practically all the streamflow is used for irrigation except for about half the flow of Rock Creek, all the flow of McMullen Creek, and part of the flood flows of the small streams.

The total quantity of water recharged to aquifers from precipitation in the Goose Creek-Rock Creek basins annually averages about 94,000 acre-feet. Upper Goose Creek receives 13,000 acre-feet, Lower Goose Creek 58,000 acre-feet, Rock Creek 21,000 acre-feet, and Basin 2,000 acre-feet. These estimates of ground-water recharge are preliminary and subject to revision when more and better data are available.

Ground-water recharge derived from Snake River water is estimated to be 180,000 acre-feet annually in the Burley Irrigation District, 35,000 acre-feet annually in the Milner Low Lift Project, and 130,000 acre-feet annually in that part of the Twin Falls South Side Project that lies in the report area. Total estimated ground-water recharge from all sources is estimated to be on the order of 400,000 to 500,000 acre-feet annually.

Estimated annual recharge is apportioned to the water-bearing formations thusly: Idavada Volcanics and older rocks - 64,000 acre-feet, basalt - 330,000 acre-feet, and the alluvial deposits - 45,000 acre-feet.

About 430 wells withdraw ground water for irrigation. During the 1961-65 irrigation seasons an estimated average of 185,000 acre-feet was pumped each year. Average annual withdrawals by subarea for the 5-year period was as follows:

Kenyon	80,000 acre-feet
Oakley	25,000 acre-feet
Golden Valley	5,000 acre-feet
Buckhorn-Big Cedar	15,000 acre-feet
Murtaugh	30,000 acre-feet
Artesian City	30,000 acre-feet
Basin	760 acre-feet
Total (rounded)	185,000 acre-feet

Ground-water withdrawals have caused water levels to decline from a few to several tens of feet in different parts of the basins. The amount of decline depends on the permeability of the water-bearing materials and the amount and proximity of sources of recharge as well as on quantities withdrawn. In the Kenyon subarea, water-levels appear to be declining at an average rate of about 3 feet per year. The smallest declines have been near the Burley Irrigation District and the greatest in the southern and western parts of the subarea where water levels dropped 15 feet between April 1963 and April 1966. The basalt aquifers are quite thin in this part of the subarea and as they become dewatered the water level declines may be accelerated.

In the Oakley subarea, the older wells produced from alluvial deposits and a few basalt flows. As these water-bearing formations did not yield large supplies, some wells were deepened to the Idavada Volcanics. This reduced the draft on the shallower aquifer and water levels in the shallower aquifers declined only 1 or 2 feet per year during the period 1958-63. However, in years of abundant water supply from Oakley Reservoir, many wells are used sparingly or not at all and water levels rise several feet in the alluvial and basalt aquifers. No data are available to evaluate the effects of ground-water withdrawals from the Idavada Volcanics in this subarea.

Sparse water-level data indicate no significant net change in water levels in the Golden Valley subarea. Ground-water withdrawals are on the order of 5,000 acre-feet annually and water is imported from the Big Cedar-Buckhorn subarea. Seepage of imported water offsets withdrawals for irrigation.

Water levels began declining in the Big Cedar-Buckhorn subarea as soon as intensive development began in 1959. Water levels have dropped an average of 22 feet per year for the period 1961-66. Annual withdrawals are estimated to be about 3 times greater than the annual recharge.

In the Murtaugh subarea, pumping of ground water has caused water levels to decline a few feet in the northern part of the subarea where withdrawals are small, to a few tens of feet in the southwestern part of the subarea where withdrawals are relatively large. Although the decline in water levels as measured in the spring of the year have not been large, pumping levels have declined progressively and practically every pump column has been lengthened since the well was put into production.

In the Artesian City subarea, intensive development of ground water began in the late 1940's and continued through the 1950's. Yields of most wells declined, many wells were deepened and reconditioned, and more powerful pumps were installed to compensate for falling water levels. From 1952 to 1966 the water level in a well at Artesian City declined 110 feet. The largest declines have been from Artesian City westward for 2 or 3 miles. At some places water levels in non-pumping wells decline at a rate of 2 feet per day when wells 1,500 to 4,500 feet distant are pumped. Estimated annual withdrawals are several times larger than the estimated annual recharge.

Only a small amount of ground water is withdrawn in the Basin subarea and no significant changes in water levels have been measured.

The irrigation water sampled generally had a low sodium hazard, but seven ground-water samples had a medium salinity hazard and five had a high salinity hazard. Most of the water samples that had a medium or high salinity hazard are from basalt and alluvial deposits, but some are from the Idavada Volcanics. Water from Snake River and from Rock and Goose Creeks have a medium salinity hazard.

Table 6.--Water-level change in the Goose Creek-Rock Creek Area

(Water level in feet below land surface)

Well Number	Date 1954	Water level	Date 1963	Water level	Change 1954 to 1963	Date 1966	Water level	Change 1963 to 1966
				Kenyon subarea				
10S-22E-32cb1	--	--	--	--	--	4- 1	436.5	--
11S-21E-11ad1	--	--	--	--	--	4- 1	458.5	--
11S-22E- 3cc1	--	--	4-19	334.3	--	3-30	338.4	- 4.1
4cb2	--	--	3-28	353.3	--	3-26	351.3	+ 2.0
8aa1	--	--	4-19	336.1	--	3-30	335.5	+ 0.6
10cd1	--	--	4-19	179.3	--	3-30	176.5	+ 2.8
16bb1	--	--	4-18	381.5	--	3-30	383.3	- 1.8
16cb1	--	--	4-18	365.5	--	3-30	369.6	- 4.1
21ac1	--	--	4-16	356.4	--	3-31	358.8	- 2.4
21bc1	--	--	4-18	370.2	--	3-30	374.0	- 3.8
24ab2	--	--	4-18	309.3	--	4- 1	303.8	+ 5.5
25bc1	--	--	4-18	324.0	--	3-31	322.5	+ 1.5
25cc1	--	--	--	--	--	3-31	327.0	--
35bc1	--	--	4-18	322.2	--	3-29	348.4	-26.2
35cc1	--	--	4-16	351.8	--	3-29	356.8	- 5.0
11S-23E-32ab1	--	--	4-18	319.4	--	3-29	322.0	- 2.6
33cc2	--	--	4-17	318.3	--	3-29	317.6	+ 0.7
34cd1	--	--	3-28	319.1	--	3-25	321.2	- 2.1
12S-22E- 1dc1	--	--	4-18	350.8	--	4- 4	375	-24
5bc1	--	--	--	--	--	4- 6	382.4	--
5cc1	--	--	--	--	--	4- 6	387.5	--
16cc1	--	--	4-17	408.6	--	4- 5	410.7	- 2.1
21cc2	--	--	4-17	420.9	--	4- 5	422.2	- 1.3
22cb1	--	--	4-18	407.2	--	4- 5	415.3	- 8.1
12S-23E-30dc1	--	--	4-17	199.0	--	4- 5	199.7	- 0.7
				Oakley subarea				
12S-22E- 6bb1	--	--	--	--	--	4- 6	401.4	--
6cc1	--	--	4-12	373.7	--	4- 6	370.9	+ 2.8

Table 6.--Water-level change in the Goose Creek-Rock Creek Area

(Water level in feet below land surface)

Well Number	Date 1954	Water level	Date 1963	Water level	Change 1954 to 1963	Date 1966	Water level	Change 1963 to 1966
			Oakley subarea (Cont.)					
12S-22E- 7ad1	--	--	--	--	--	4- 6	366.1	--
8bc1	--	--	4-16	375.0	--	4- 4	391.1	-26.1
18ac1	--	--	4-18	331.8	--	4- 5	323.2	+ 8.6
18cc1	--	--	4-12	354.4	--	4- 5	326.8	+27.6
19bb1	--	--	--	--	--	4- 5	325.2	--
20dd1	--	--	--	--	--	4- 5	316.0	--
34dc1	--	--	--	--	--	4- 5	420.8	--
13S-22E- 3bc2	--	--	--	--	--	--	--	--
7aa1	--	--	--	--	--	4- 6	83.4	--
8da1	--	--	4-17	130.7	--	4- 6	99.6	+31.1
9dd1	--	--	4-16	127.2	--	4- 6	116.0	+11.2
10dd1	--	--	--	--	--	4- 7	120.5	--
15bc1	--	--	4-16	132.9	--	4- 6	124.2	+ 8.5
15cb1	--	--	4-17	145.4	--	4- 6	139.0	+ 6.5
16ca1	--	--	4-16	107.2	--	4- 6	80.7	+26.5
20cd1	--	--	4-16	112.7	--	4- 6	80.1	+32.6
20cd2	--	--	--	--	--	4- 6	80.7	--
21cd1	--	--	4-17	90.0	--	4- 6	50.6	+39.4
21dc2	--	--	--	--	--	4- 6	40.3	--
28cd1	--	--	4-16	86.7	--	4- 6	61.5	+25.2
28dd1	--	--	4-16	92.7	--	4- 6	73.7	+19.0
			Golden Valley subarea					
12S-20E-11ad1	--	--	4-11	193.6	--	4- 1	196.3	- 2.7
12cc2	--	--	4-11	141.4	--	4- 1	146.0	- 4.6
13cc1	--	--	4-11	311.1	--	4- 5	307.5	+ 3.6
12S-21E- 1ab1	--	--	4-12	414.3	--	4- 4	418.4	- 2.1
11cc1	--	--	4-11	263.8	--	4- 8	263.2	+ 0.6
11ad1	--	--	3-28	346.7	--	3-20	345.8	+ 0.9
16cc1	--	--	4-11	104.9	--	4- 5	100.6	+ 4.3
16dc1	--	--	3-26	108.8	--	3-23	106.6	+ 2.2

Table 6.--Water-level change in the Goose Creek-Rock Creek Area

(Water level in feet below land surface)

Well Number	Date 1954	Water level	Date 1963	Water level	Change 1954 to 1963	Date 1966	Water level	Change 1963 to 1966
				Golden Valley subarea (Cont.)				
12S-21E-20db1	--	--	4-11	113.6	--	4- 5	106.1	+ 7.5
21dc1	--	--	--	--	--	4- 5	108.1	--
25cc1	--	--	4-15	329.3	--	4- 5	329.3	0.0
26cc1	--	--	--	--	--	4- 5	303.4	--
28cd1	--	--	--	--	--	4- 5	145.1	--
				Big Cedar-Buckhorn subarea				
12S-20E-25bb2	--	--	3-26	125.5	--	3-22	192.6	-67.1
26da1	--	--	--	--	--	4- 7	238.9	--
13S-21E- 8ba1	--	--	--	--	--	4- 7	233.0	--
8ba2	--	--	--	--	--	4- 7	183.0	--
8cd2	--	--	--	--	--	4- 7	291.2	--
17ba1	--	--	4-15	252.3	--	4- 7	314.7	-62.4
18bb1	--	--	4-15	411.5	--	4- 7	470.3	-58.8
				Murtaugh subarea				
10S-19E-18ba1	4-12	223.2	4-11	232.0	- 9.8	4- 7	229.9	+ 7.9
11S-18E-23bd1	4-14	13.3	4- 9	13.9	- 0.6	3-29	14.5	- 0.6
11S-19E-13cd3	4-15	59.8	4- 9	60.0	- 0.2	3-30	60.2	- 0.2
17aa1	--	--	3-26	324.1	--	3-22	319.1	+ 5.0
18ba1	3-25	238.6	3-26	244.7	- 6.1	3-22	242.2	+ 2.5
18dc1	4-13	193.1	3-26	202.0	-10.9	3-22	198.8	+ 3.2
19ad1	4-14	123.7	4- 8	154.0	-30.3	3-29	142.9	+12.1
19ad2	4-14	163.2	--	--	--	3-29	184.6	--
19da2	4-14	115.4	4- 8	144.5	-29.1	3-30	136.1	+ 8.4
19da3	4-14	117.8	--	--	--	3-29	142.7	--
24cb1	4-15	133.0	3-26	167.6	-34.6	3-30	155.1	+12.5
11S-20E-10dc1	4-12	145.9	3-26	159.8	-13.9	3-22	148.4	+11.4
21ab1	4-13	60.7	3-26	70.2	-10.5	3-22	67.4	+ 2.8
21dc1	--	--	3-26	70.8	--	3-22	68.3	+ 2.5
22bc1	4-12	115.3	--	--	--	4- 1	119.4	--

Table 6.--Water-level change in the Goose Creek-Rock Creek Area

(Water level in feet below land surface)

Well Number	Date 1954	Water level	Date 1963	Water level	Change 1954 to 1963	Date 1966	Water level	Change 1963 to 1966
				Murtaugh subarea (Cont.)				
11S-20E-22bd1	4-12	124.5	4-10	140.7	-16.4	4- 1	129.4	+11.3
22cd1	4-12	146.4	4-10	156.9	-10.3	4- 1	151.2	+ 5.7
22cd2	4-12	139.7	4-10	150.7	-11.0	4- 1	144.9	+ 5.8
				Artesian City subarea				
11S-18E-34dc1	4-13	8.2	4- 8	15.0	- 6.8	--	--	--
36bc2	--	--	--	--	--	3-29	31.6	--
36ac1	4-13	19.7	4- 8	25.1	- 5.4	3-29	34.0	- 8.9
36dd1	4-13	58.2	--	--	--	3-29	80.5	--
11S-19E-27bc1	4-14	157.3	4- 9	205.6	-48.3	3-30	200.8	+ 5.2
27ba1	4-14	162.0	4- 9	214.1	-52.1	3-30	208.9	+ 5.2
28ba1	4-14	139.8	--	--	--	3-30	188.8	--
28cd2	4-14	154.5	4- 9	205.6	-51.1	3-30	199.3	+ 6.3
28cd3	4-14	159.4	--	--	--	3-30	194.6	--
28dd1	4-14	161.5	4- 9	224.4	-62.9	3-30	217.1	+ 7.3
29bc1	4-14	71.0	4- 8	90.3	-19.3	3-30	77.9	+12.4
29dd1	4-14	142.0	4- 9	199.6	-57.6	3-30	191.2	+ 7.4
30ab1	4-13	59.6	4- 8	83.8	-24.2	3-30	68.1	+15.7
30ad2	4-14	71.4	4- 8	105.6	-34.2	3-30	83.6	+22.0
30bd1	4-13	61.3	4- 9	76.8	-13.5	3-30	71.1	+ 5.7
30bd3	4-13	52.2	4- 7	63.1	-10.9	3-29	61.4	+ 2.7
30dc2	4-14	83.1	4- 9	98.3	-15.2	3-29	93.1	+ 5.2
31ad1	4-14	123.5	3-26	149.4	-25.9	3-22	139.7	+ 9.7
31cd1	4-15	86.8	4- 8	127.3	-40.5	3-29	110.2	+17.1
31cd2	4-15	98.9	4- 8	110.0	-11.1	3-29	124.2	-14.2
31da1	4-14	163.8	4- 8	214.3	-50.5	3-29	208.2	+ 6.1
32aa1	4-14	147.2	4- 9	204.0	-56.8	3-30	191.8	+12.2
33dd1	4-15	92.3	--	--	--	--	--	--
35cc2	4-15	86.2	4- 9	185.1	-98.9	3-30	198.0	-12.9
36dc1	4-15	67.2	4- 9	163.8	-96.6	3-30	186.4	-22.6
11S-20E-26ba1	4-13	123.7	4-10	135.3	-11.6	4- 1	135.3	0.0
28bb1	4-13	64.5	4-10	76.3	-11.8	3-31	75.0	+ 1.3

Table 6.--Water-level change in the Goose Creek-Rock Creek Area

(Water level in feet below land surface)

Well Number	Date 1954	Water level	Date 1963	Water level	Change 1954 to 1963	Date 1966	Water level	Change 1963 to 1966
			Artesian City subarea (Cont.)					
11S-20E-28dc1	4-13	95.0	4-10	106.5	-11.5	3-31	105.0	- 1.5
29aa1	4-13	59.4	--	--	--	3-31	70.0	--
29bd1	4-14	61.4	--	--	--	3-31	74.3	--
29cd1	4-13	77.2	3-26	96.4	-19.2	3-22	95.1	+ 1.3
30dc1	4-14	60.8	4-10	69.7	- 8.9	3-31	63.8	+ 5.9
31aa1	4-13	77.7	4-10	99.6	-21.9	3-31	95.6	+ 4.0
31ad1	4-13	87.1	4-10	105.1	-18.0	3-31	104.4	- 0.7
32ad1	4-13	121.9	4-10	132.1	-10.2	3-31	130.0	+ 2.1
32ba1	4-13	82.3	4-10	100.7	-18.4	3-31	99.8	+ 0.9
32cc1	4-13	114.9	3-26	134.7	-19.8	3-22	133.3	+ 1.4
33ac1	4-13	124.7	4-10	138.2	-13.5	3-31	139.3	- 1.1
33da1	4-13	62.4	3-26	151.3	-88.9	3-22	158.6	- 7.3
33dd1	4-13	108.2	4-10	163.6	-55.4	3-31	166.5	- 2.9
12S-18E- 1ac1	4-13	58.0	4-11	58.0	0.0	3-29	57.9	+ 0.1
1bd1	4-13	Flow	4-11	1.6	--	3-29	4.9	- 3.3
12cb1	4-13	3.6	--	--	--	--	--	--
24cb1	4-13	2.8	4- 8	4.2	1.4	3-29	4.1	+ 0.1
12S-19E- 2bb1	4-15	124.3	4- 9	207.7	-83.4	3-31	221.5	-13.8
3ad1	--	--	--	--	--	3-31	247.8	--
3bc1	--	--	--	--	--	3-31	232.0	--
4ad1	4-15	137.3	4- 9	220.1	-82.8	--	--	--
12S-20E- 2dd1	--	--	--	--	--	4- 1	190.6	--
3cd1	--	--	--	--	--	4- 1	252.2	--
4ac1	--	--	3-26	199.5	--	3-22	203.9	- 4.4
6bb1	4-14	49.5	4-10	140.4	-90.9	3-27	144.6	- 4.2
6bc1	4-14	93.9	4-10	185.8	-91.9	3-31	189.9	- 4.1
6dd1	4-14	126.7	4-10	212.7	-86.0	3-31	216.6	- 3.9
7aa1	4-14	146.6	4-10	234.7	-88.1	--	--	--

REFERENCES

Anderson, A. L., 1931, Geology and mineral resources of eastern Cassia County, Idaho: Idaho Bur. Mines and Geology Bull. 14, 169 p.

Axelrod, D. J., 1964, The Miocene Trapper Creek flora of southern Idaho: Univ. of Calif. Publ. Geol. Sci., vol. 51, 180 p.

Blaney, H. F., and Criddle, W. D., 1949, Consumptive use of water in irrigated areas of the Colorado River basin: Washington, U. S. Soil Conservation Service, 49 p.

Crosthwaite, E. G., 1957, Ground-water possibilities south of the Snake River between Twin Falls and Pocatello, Idaho: U. S. Geol. Survey Water-Supply Paper 1460-C, p. 99-145.

Eaton, F. M., 1950, Significance of carbonates in irrigation waters: Soil Sci. vol. 69, p. 123-133.

Hem, J. D., 1959, Study and interpretation of the chemical characteristics of natural water: U. S. Geol. Survey Water-Supply Paper 1473, 269 p.

Kohler, M. A., Nordenson, T. J., and Baker, D. R., 1959, Evaporation maps for the United States: U. S. Weather Bur. Tech. Paper 37, 13 p.

Love, S. K., 1954, Quality of surface waters for irrigation, western United States, 1951: U. S. Geol. Survey Water-Supply Paper 1264, 153.

Mapel, W. J., and Hail, W. J., Jr., 1959, Tertiary geology of the Goose Creek district, Cassia County, Idaho Box Elder County, Utah, and Elko County, Nevada: U. S. Geol. Survey Bull. 1055-H, p. 217-254.

Mower, R. W., 1953, Records of wells, ground-water levels, and ground-water withdrawals in the lower Goose Creek basin, Cassia County, Idaho: U. S. Geol. Survey open-file rept., 92 p.

Mundorff, M. J., Broom, H. C., and Kilburn, Chabot, 1963, Reconnaissance of the hydrology of the Little Lost River basin, Idaho: U. S. Geol. Survey Water-Supply Paper 1539-Q, 51 p.

Mundorff, M. J., Crosthwaite, E. G., and Kilburn, Chabot, 1964, Ground-water for irrigation in the Snake River basin in Idaho: U. S. Geol. Survey Water-Supply Paper 1654, 224 p.

Nace, R. L., West, S. W., and Mower, R. W., 1957, Feasibility of ground-water features of the alternate plan for the Mountain Home Project, Idaho: U. S. Geol. Survey Water-Supply Paper 1376, 121 p.

Nace, R. L., and others, 1961, Water resources of the Raft River basin, Idaho-Utah: U. S. Geol. Survey Water-Supply Paper 1587, 138 p.

Nelson, M. W., and Wilson, J. A., 1965, Summary of snow survey measurement for Idaho: U. S. Dept. Agriculture, Soil Conserv. Service and Idaho Dept. of Reclamation, 152 p.

Piper, A. M., 1923, Geology and water resources of the Goose Creek basin, Cassia County, Idaho: Idaho Bur. Mines and Geology Bull. 6, 78 p.

Stearns, H. T., Crandall, Lynn, and Steward, W. F., 1938, Geology and ground-water resources of the Snake River Plain in southeastern Idaho: U. S. Geol. Survey Water-Supply Paper 774, 268 p.

Thornthwaite, C. W., 1948, An approach toward a rational classification of climate: Geog. Rev. vol. 38, p. 55-94.

U. S. Army, Corps. of Engineers, 1956, Snow hydrology, summary report of the snow investigations: North Pacific Division, Corps. of Engineers, 437 p.

U. S. Bureau of Reclamation, 1947, The Columbia River: U. S. Dept. Int., 398 p.

U. S. Geological Survey, 1956, Compilation of records of surface waters of the United States through September 1950, pt. 13, Snake River basin: U. S. Geol. Survey Water-Supply Paper 1317, 566 p.

_____, 1963, Compilation of records of surface waters of the United States, October 1950 to September 1960, pt. 13, Snake River basin: U. S. Geol. Survey Survey-Water Paper 1737, 282 p.

_____, Water data reports for Idaho, 1961-66: Water Resources Division.

U. S. Public Health Service, 1962, Drinking water standards, 1962: U. S. Public Health Service Pub. 956, 61 p.

U. S. Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkaline soils: U. S. Dept. Agriculture Handbook 60, 160 p.

U. S. Weather Bureau, Climatological Data, Annual Summaries, 1902-64.

West, S. W., and Fader, S. W., 1952, Records of wells and ground-water withdrawals in the Dry Creek area, Cassia and Twin Falls Counties, southern Idaho: U. S. Geol. Survey open-file rept., 114 p.

Wing, Herbert, 1915, Tenth biennial report of the State Engineer of Idaho: Boise, Idaho, p. 138-145.