Effect of Irrigation on Ground Water in Southern Canyon County Idaho

By P. R. STEVENS

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By P. R. Stevens

ABSTRACT

A plan to irrigate about 23,200 acres in the Dry Lake area, southern Canyon County, Idaho, between the Snake River and Lake Lowell, is under consideration by the U.S. Bureau of Reclamation. According to this plan, the main source of supply would be water pumped from a reservoir on the Snake River south of Melba. The water would be lifted about 470 feet to the plateau to be irrigated. The gross surface-water diversion for irrigation would be about 118,000 acre-feet yearly. Power to operate the pumps would be furnished by a hydroelectric plant to be constructed at the damsite south of Melba. About 3,000 acres in the Dry Lake area, now irrigated by ground water from wells, has been developed by private capital. This investigation was undertaken to appraise present ground-water resources with particular reference to changes in the ground-water regimen that might occur as a consequence of irrigation development of the Dry Lake area and to suggest lines for future investigations under the Guffey Development plan.

Sedimentary and igneous rocks exposed in the area range in age from Pliocene to Recent. The igneous rocks are composed of the Snake River basalt and associated pyroclastic rocks; the sedimentary rocks consist of fluviatile, lacustrine, and eolian materials including clay, silt, sand, and alluvial and lag gravel. The Snake River basalt is above the water table in most of the Dry Lake area, but to the east, in the area between Warrens and the eastern end of Lake Lowell, it is an important aquifer that yields large quantities of water to wells. The Idaho formation is the principal aquifer in the Dry Lake area. Permeable sands in that formation yield water to domestic, stock, and irrigation wells in quantities ranging from a few gallons per minute to more than 1,600 gpm. Clay and silt, which compose a large part of the Idaho formatiom, yield little or no water to wells. Moderately permeable eolian and fluviatile sediments mantle the surface and locally produce artesian conditions in the underlying Snake River basalt, which has a high formational permeability, by restricting the upward movement of ground water.

The principal sources of replenishment of ground water are by (a) direct infiltration of precipitation, (b) upward leakage of underflow from outside the area by way of leaky artesian aquifers, and (c) underflow from infiltration of unconsumed irrigation water from the irrigated area south of the ground-water divide which roughly parallels the Mora Canal. South of this divide unconfined ground water moves southward or westward to the Snake River, which serves as the major ground-water drain. North of the divide unconfined ground water moves northward out of the area.

The average depth of wells in the Dry Lake area is about 500 feet. Pumping lifts range from 170 to more than 550 feet. Specific capacities of wells range from more than 60 gpm per foot of drawdown to less than 3 gpm per foot of drawdown. The range is caused by large variations in the permeability of the Idaho formation and by differences in well construction.

The composition of ground water in southern Canyon County varies considerably. Sodium and calcium generally are the predominant cations and bicarbonate and sulfate the predominant anions. The suitability of the water for irrigation is evaluated by two standard criteria. According to these criteria most of the water probably can be used for irrigation. Temperatures of the ground water increase with increasing depth. The thermal gradient in some wells is 3° to 4° F for every 100-foot increase in depth, roughly twice the normal gradient. The waters from shallower wells generally have temperatures ranging between 60° and 70° F. The temperature of the water in well 1N–3W–12ba1, the deepest well (1,265 ft deep) in the Dry Lake area, was 92° F.

The proposed irrigation of the Dry Lake area would cause many changes in the ground-water regimen. The ground-water divide, which roughly parallels the Mora Canal, probably would shift to the south or southwest. A rise in the water table in the Dry Lake area would result in lower pumping lifts and an increase in the amount of ground water in storage. Yearly recharge of ground water under project operation is conservatively estimated at about 40,000 acre-feet in the Dry Lake area. Existing drainage problems south of Melba, south of Lake Lowell, and west of the Dry Lake area would be further complicated, owing to a rise in the water levels which might cause the spread of drainage problems to adjacent areas. Drainage problems due to a high water table are unlikely in the Dry Lake area. Drainage problems due to shallow perched water may develop, but they could be minimized by adequate drainage of waste water and efficient water-management practices.

A qualitative estimate based on available data indicates that about 40,000 acre-feet of ground water could be pumped from wells in the Dry Lake area under project conditions without exceeding the perennial yield. However, areas in which drainage problems already exist, and some adjacent areas to which drainage problems may spread, would not benefit directly from such pumping. Pumping ground water from wells in the Dry Lake area to supplement surface water for irrigation and to retard the rate of rise of the water table, and also pumping ground water from wells located in the areas afflicted with drainage problems principally to provide drainage benefits, might be highly beneficial. Details of the hydraulic properties of the aquifers are not now available, but they would be necessary for determining the optimum number, depth, spacing, pumping lifts, and capacities of wells and for estimating the drainage effects that might be expected from pumping ground water.

INTRODUCTION

Southern Canyon County lies south of Nampa, Idaho, and extends southward from Lake Lowell to the Snake River (fig. 1). The area included in the investigation and described in the report, occupies about 125 square miles in Tps. 1 S. to 2 N., Rs. 2 to 4 W. It includes the Dry Lake area of the Guffey Unit of the U.S. Bureau of Reclamation (pl. 1), which comprises approximately 61 square miles containing 23,200 irrigable acres, and areas bordering it, chiefly to the northwest and to the east.

Idaho State Route 45 is the main artery of north-south travel. A paved road at the north edge of the area and south of Lake Lowell is the principal thoroughfare between Marsing to the west and State Route 45. Boise, the State capital, is 25 miles east of the area and

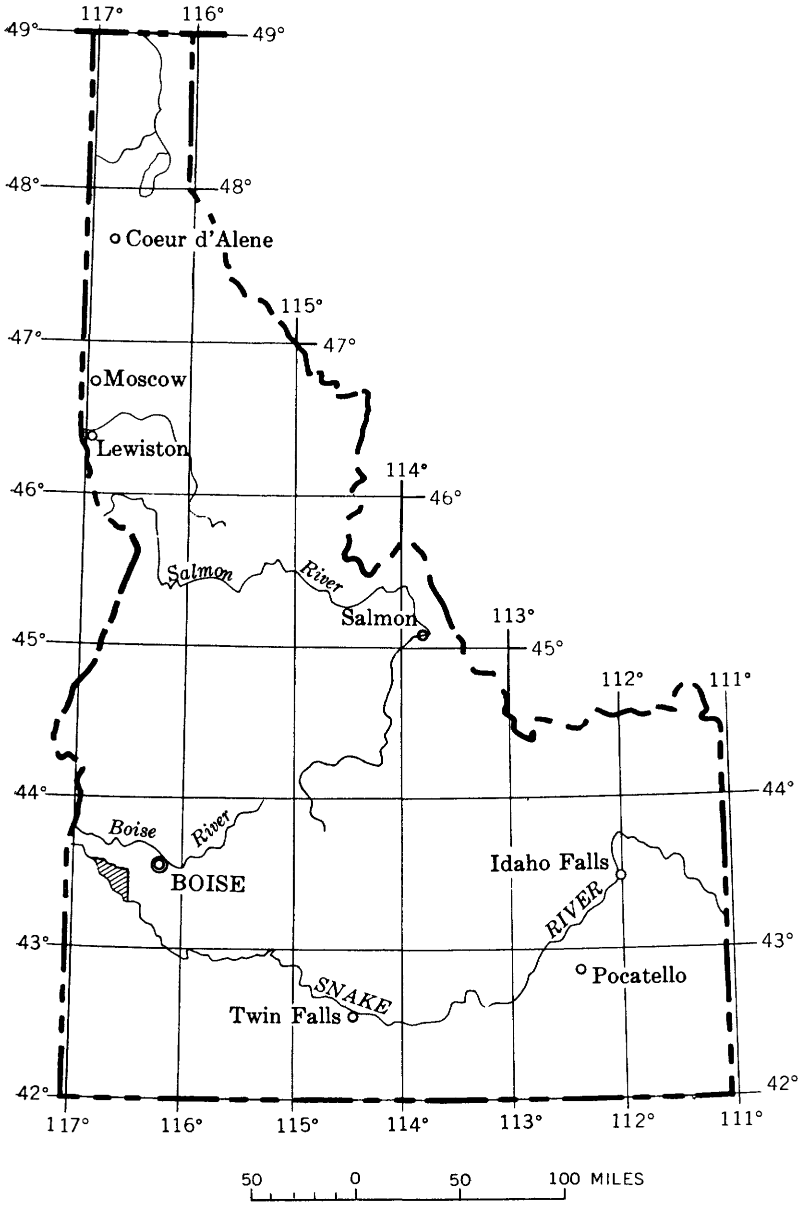

Figure 1.—Index map of Idaho showing area covered by this report.

is the major communications and service center. Nampa and Caldwell, just north of the area, are major communities served by the main line of the Union Pacific Railroad. A branch line of the Union Pacific Railroad serves Melba, a small community near the southeast corner of the area.

PURPOSE AND SCOPE OF INVESTIGATION

The report area (fig. 1) is only a few miles south of the Boise Valley, which has been irrigated for many years. However, only about half the report area (about 41,000 acres) is now irrigated. Surface water is the chief source of supply for irrigation; ground water is used for domestic needs and to supplement surface water for irrigation. Ground water is the principal source of irrigation water for about 3,000 acres under cultivation in the Dry Lake area.

The feasibility of irrigating about 23,200 acres of high-lying land, herein called the Dry Lake area, is presently being studied by the U.S. Bureau of Reclamation (Dry Lake area of the Guffey Unit, Mountain Home Division, Snake River Project, Idaho).

The present investigation was undertaken to appraise ground-water conditions and resources in southern Canyon County with particular reference to changes in the ground-water regimen that might occur as a consequence of irrigation development of the Dry Lake area and to suggest lines for future investigations under the Guffey Development plan.

Some data were obtained from open-file and published reports. Ground-water conditions along the northern, eastern, and western margins of southern Canyon County are described in a report by Nace and others (1957).

Fieldwork was done during the summer and fall of 1956 and consisted of an inventory of all irrigation wells and some domestic and stock wells, periodic measurements of water levels, an inventory of pumpage of the irrigation wells, collection of samples of water for chemical analysis, and a geologic reconnaissance including mapping of rock units.

PROPOSED DEVELOPMENT

The Dry Lake area contains 23,200 irrigable acres, of which 3,000 acres are now irrigated with ground water. The Bureau of Reclamation has under consideration a plan (the Guffey Unit of the Mountain Home Division, U.S. Bureau of Reclamation, 1955) to provide irrigation water for the undeveloped land, using water from the Snake River. To accomplish this, Guffey dam would be constructed on the Snake River near Melba (pl. 1), which would raise the river water surface 105 feet. A hydroelectric plant with an installed capacity of 85,000 to 90,000 kilowatts would also be constructed. About 118,000 acre-feet of Snake River water would be diverted annually from Guffey reservoir to the Dry Lake area by a series of pumping plants. Power to operate the pumping plants would be furnished by the Guffey hydroelectric plant.

The following estimates of diversion requirements, conveyance losses, farm-delivery requirement, consumptive use requirements, and the annual crop irrigation requirement to be supplied from irrigation were made by the U.S. Bureau of Reclamation (1955, p. 20–22). Diversion requirements were estimated at 5.1 acre-feet per irrigable acre. Conveyance losses of 30 percent were estimated from a comparison with surrounding areas. It was estimated that 0.38 acre-feet per irrigable acre of the water lost in getting water to the crops could be captured within the area and reused. A farm delivery requirement of 3.8 acre-feet per irrigable acre was estimated from analysis of water use in nearby areas. Annual consumptive use requirements of 2.22 acre-feet per acre were estimated by the method proposed by Lowry and Johnson (Lowry and Johnson, 1942, p. 1243–1284) and were based on the 5 years with the highest consumptive-use requirement for the period 1927 through 1951 at Kuna (fig. 3). Allowing for effective precipitation, the annual crop irrigation requirement to be supplied from irrigation is 2.08 acre-feet, which was rounded to 2.1 acre-feet per productive acre.

The conclusion that the quality of Snake River water is satisfactory for irrigation on lands in the Dry Lake area was based upon results of a sampling program at Marsing by the Agricultural Experiment Station of the University of Idaho and upon the fact that Snake River water has been used without harmful effects for many years on lands similar to those of the Dry Lake area.

This investigation was made by the Geological Survey on behalf of the U.S. Bureau of Reclamation, Snake River Development Office. Investigations of ground water by the U.S. Geological Survey in Idaho are under immediate supervision of M. J. Mundorff, district geologist, Boise, Idaho.

ACKNOWLEDGMENTS

Dr. V. C. Bushnell, supervisor, Regional Laboratory Unit, U.S. Bureau of Reclamation, Region 1, made many of the chemical analyses of water samples.

Aerial photographs used in the geologic mapping and topographic sheets were provided by the Bureau of Reclamation.

Acknowledgment is made to all the individuals who gave information on their wells and especially to those who permitted repeated access to their properties for water-level measurements. Many well drillers supplied well logs (table 6) and other data. The assistance and cooperation of all of these individuals has been of great value.

WELL-NUMBERING SYSTEM

The well-numbering system used in Idaho indicates the locations of wells within the official rectangular subdivisions of the public lands, with reference to the base line and Boise meridian. The first two segments of a number designate the township and range. The third segment gives the section number, 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. Well 1N–3W–12ba1 is in the NE¼NW¼ sec. 12, T. 1 N., R. 3 W., and is the well first visited in that tract.

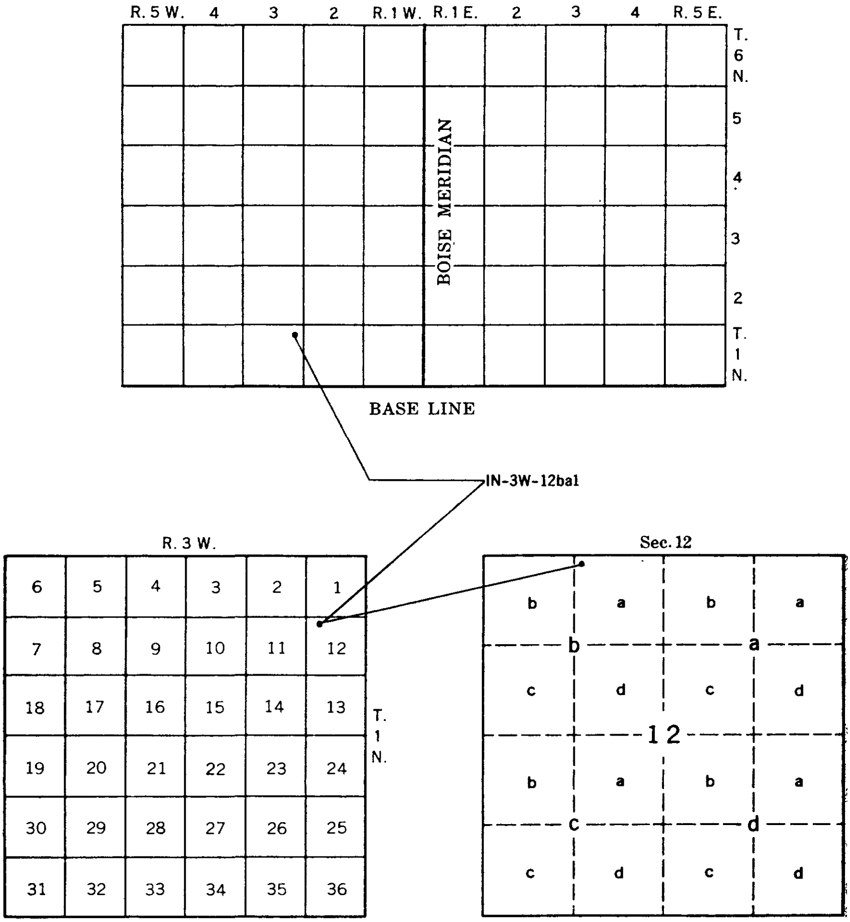

FIGURE 2.—Sketch showing well-numbering system.

PHYSICAL ENVIRONMENT

SURFACE FEATURES

The western Snake River Plain is a broad rolling plain bounded on the north by a high mountainous area and on the south by the Owyhee Mountains. The plain is underlain by Tertiary and Quaternary sediments and basalt flows. The surface is mantled by windblown and fluviatile sediments that subdue the local sharp relief on the volcanic rocks that underlie much of the plain. A high erosional remnant in the western Snake River Plain comprises southern Canyon County (fig. 3). The southwestern boundary of the area is formed by a scarp rising about 500 feet above the Snake River. The other boundaries of the area are not formed by distinct physiographic features, but consist of irregular low hills and low basalt cliffs.

McElroy, Powers, and Walters Buttes (pl. 2), just east of the Dry Lake area and Hat Butte, are extinct volcanic vents which

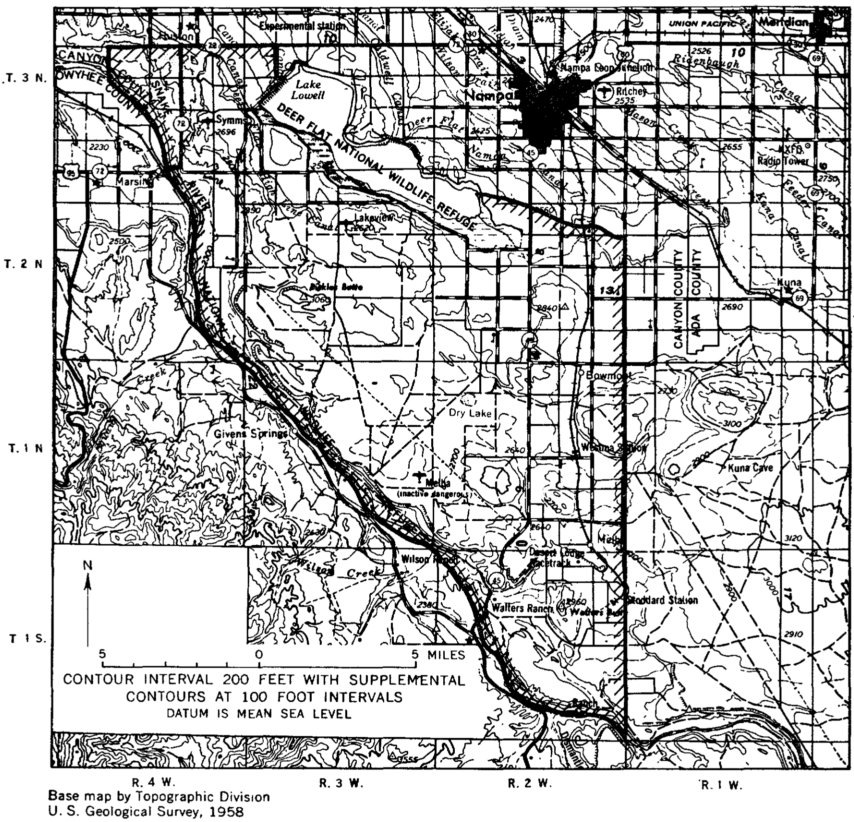

FIGURE 3.—Topographic map of southern Canyon County and vicinity, Idaho.

rise a few hundred feet above the general surface of the plain. All are smoothly rounded hills elongated in a northwest direction paralleling the trend of the regional structure. Other volcanic features include a diatreme (volcanic explosion pit) about three-fourths of a mile in diameter a mile south of Hat Butte and a small spatter cone east of McElroy Butte. All these features have moderately steep slopes; the soil, where present, is shallow and rocky and makes these areas unsuitable for irrigation development.

The ancestral Snake River formed several terraces in southern Canyon County. The southermost terrace is bounded on the south and west by the present canyon of the Snake River and slopes gently northward for about 2 miles where it is terminated by a westward-trending ridge consisting of irregular low hills, mounds, and low cliffs of basalt. The area north of this terrace remnant is gently rolling: has rounded hills having long gentle slopes, small knolls, and dry washes. A shallow undrained depression, Dry Lake (pl. 2), contains water during part of the winter. Several remnants of a higher terrace, composed largely of river gravel, rise a hundred feet or more above the rolling upland in the northern part of the area.

Runoff in the area is small and ephemeral, and no integrated drainage system has developed. Most of the precipitation either is held temporarily in the soil or percolates downward to the ground-water reservoir. Much of the soil moisture evaporates, and the rest is used by the scanty vegetation.

The soils of the area were formed primarily from wind-deposited material. However, there are limited areas of reworked alluvial materials from which soils have developed. A limy zone of irregular thickness occurs at a depth of a few inches to several feet over most of the area. In some places this limy zone contains thin layers of caliche.

The prevailing native vegetation includes sagebrush, winterfat, shadscale, and some bunchgrass. Winterfat provides good winter grazing for sheep.

Most of the area is used for seasonal stock grazing, but about 3,000 acres is now irrigated with ground water. Seed crops, sugar beets, small grains, and corn are the principal cultivated crops.

CLIMATE

Southern Canyon County has moderately hot summers and mild winters. Hot periods, during which temperatures exceed 100° F, occur nearly every year, but are rarely of more than a few days' duration. Winters are mild and temperatures below zero are rare. The mean annual temperature at Kuna, which is representative of the area, is 50.1° F. The highest temperature officially recorded at Kuna is 111° F and the lowest is −28°. The frost-free period averages 143 days, but the average length of the growing season for hardy crops is about 211 days.

The average annual precipitation at Kuna (see following table) is 10.71 inches, of which only about 32 percent falls during the period between killing frosts (from near the end of April to the middle of October). About 74 percent of the precipitation occurs during the period of November through May. The precipitation from 1908 through 1955 has ranged from 4.55 inches in 1949 to 16.05 inches in 1912.

Average monthly temperature and precipitation at Kuna, Idaho, and average evaporation from open-water surface at Lake Lowell [1]

[From records of the U.S. Weather Bureau]

Month	Precipitation		Temperature (° F)	Evaporation [2 3] (inches)
	Inches	Percent of annual total		
January	1.20	11.21	28.3	1.0
February	1.00	9.34	33.8	1.5
March	1.10	10.27	41.9	2.1
April	1.05	9.80	49.3	4.3
May	1.17	10.93	56.7	5.8
June	.80	7.47	64.4	6.91
July	.33	3.08	73.2	7.95
August	.19	1.77	71.0	6.86
September	.53	4.95	61.5	4.97
October	.95	8.87	51.5	3.7
November	1.28	11.95	39.3	2.0
December	1.11	10.36	30.3	1.0
Average	10.71	100.00	50.1	Total 48.1 Adjusted total 33

[1] Average based on period November 1907 through 1945.
[2] Based on discontinuous records from 1916 through 1925 for season June through September. Evaporation for October through May estimated by comparison with records from stations at climatically similar locations in Western United States.
[3] Except for June, July, August, and September, adjusted by multiplying land-pan total by 0.69 (Follansbee, 1934), after Nace and others, 1957, table 13.

Records of precipitation at Kuna (fig. 4) disclose cyclic fluctuations, with both short- and long-term cumulative departures from normal. One wet period began about 1908 and ended about 1913, with a cumulative excess of precipitation of about 10 inches. A drier period began in 1922 and ended in 1936, with a cumulative deficiency for the period of 25 inches. The following wet period began in 1937 and ended in 1948, with the cumulative excess during the period of almost 17 inches. The present dry cycle began in 1949, and the cumulative deficiency of precipitation for the period 1949 through 1955 was nearly 9 inches.

Southern Canyon County lies in the belt of the prevailing westerly winds, but, because of the deflecting influences of topography, surface winds frequently deviate from the westerly direction. High velocity

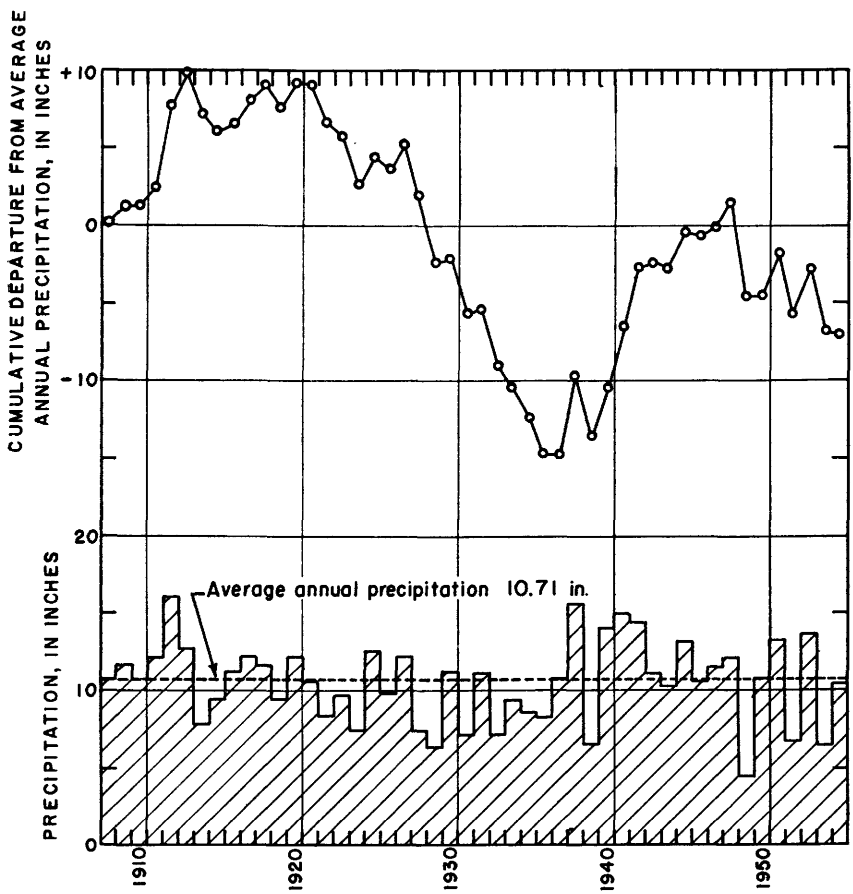

FIGURE 4.—Annual precipitation and cumlative departures from average annual precipitation at Kuna, Idaho, 1908–55.

winds of several hours' duration are common, though winds of destructive force are rare. Summer thunderstorms are infrequent and usually very mild. Hailstorms are not uncommon, but generally cover small areas and do little damage.

The relative humidity during the summer months is low, frequently dropping to less than 20 percent in late afternoon. Even during the winter months the relative humidity exceeds 70 percent infrequently and only for short periods.

Evaporation from open-water surfaces in land pans has been measured at Lake Lowell during the growing season (see table above). The estimated yearly rate of evaporation, adjusted to the reservoir water surface by multiplying by a factor of 0.69, is 33 inches (Nace and others, 1957, p. 30).

GEOLOGIC UNITS AND THEIR WATER-BEARING CHARACTERISTICS

The geologic units in southern Canyon County differ greatly in their water-bearing properties. The materials range from highly permeable sand, gravel, and basalt to almost impermeable clay layers. The quality of water in an area is controlled to a considerable degree by the lithology. A knowledge of the geology of an area is of primary importance in understanding the movement, availability, and quality of ground water. Geologic units and their water-bearing properties are summarized in table 1, and the areal distribution of the units is shown on the geologic map (pl. 2). Permeability (capacity to transmit water) determines the rate at which materials will accept recharge. It is an important factor in the rate of movement of ground water and largely determines the yields of wells. The permeability of sedimentary rocks depends upon size, shape, arrangement, and uniformity of the component grains and the presence or absence of cementing materials. In general, coarse sands or gravels are the most permeable materials, and fine sands, silts, and clays are progressively less permeable.

The amount of water held in storage depends on the porosity of the material, but the amount available from storage depends also on the dimensions of the pore space and the arrangement of the pores. In coarse materials most of the water may be withdrawn; in finer grained materials a much smaller proportion can be withdrawn; and in some clay little or no water can be obtained. Clay may have a porosity of as much as 50 percent, but the water is held by molecular attraction.

The principal geologic features and their bearing on the ground water in southern Canyon County are presented below.

A great troughlike depression, part of the Snake River downwarp of Kirkham (1931b), in the almost impermeable crystalline rocks of the Idaho and Owyhee batholiths, underlies the area between the Owyhee Mountains and the high mountainous area north of Boise. Within this trough a great, but undetermined, thickness of Tertiary fluviatile and lacustrine sediments (Payette formation) and volcanic rocks (Columbia River basalt, and Owyhee rhyolite of Kirkham (1931c), later determined to be mostly latite) were deposited. The presence of these sediments and volcanic rocks at depth in the area is inferred on the basis of evidence from surrounding areas. Because they neither crop out nor have been recognized in records of drill cuttings from drill holes in southern Canyon County, they are omitted from the discussion of geologic formations. Referring to the late Columbia River basalt and the Owyhee rhyolite, Nace and others (1957, table 7, p. 22) report, "Porosity and permeability generally low, but may be high in local beds. Fractures and brecciated fault zones yield abundant water at some places. Important source of artesian water in some localities in southwestern Idaho."

IDAHO FORMATION

The name "Idaho formation" was proposed by Cope (1884, p. 135) for the upper Tertiary sediments deposited in "Lake Idaho" in eastern

TABLE 1.—*Summary of geologic formations and their water-bearing properties*

Period	Epoch	Formation	Thickness (feet)	Physical characteristics	Water-bearing properties
Quaternary	Pleistocene and Recent	Alluvium	0–100+	Unconsolidated boulders, gravel, sand, silt, and clay; poorly to well sorted; bedding indistinct to distinct, lenticular, cut and fill structure common. Occurs on low terraces and on flood plain adjacent to Snake River. Overlies Snake River basalt at some places southeast of the area and lies on the Idaho formation elsewhere.	Overall porosity and permeability high but, owing to highly variable lithology, poor sorting and lenticular bedding, yields to wells probably would range widely. Actual yields unknown owing to lack of wells. Not an important source of water for Dry Lake area.
Tertiary and Quaternary	Pliocene to Recent	Snake River basalt	5–500	Olivine basalt, light- to dark-gray, vesicular; irregular and columnar jointing common; thickness of flows variable. Includes beds of basaltic cinders at some places. Overlies the Idaho formation and locally overlaps the terrace gravels.	Above water table except in eastern part of Dry Lake area. Rock permeability low, but formational permeability high because of joints and fractures. Wells yield up to 3,000 gpm, where water table is in the basalt.
	Pliocene (?) and Pleistocene	Terrace gravel	5–150+	Unconsolitated gravel and sand with lenses of silt and clay. Rounded to subangular fairly well sorted to well sorted granules to small cobbles of basalt, latite, granite, and quartzite with lenses of coarse to fine rounded fairly well sorted to well-sorted quartzitic and feldspathic sand. Bedding ranges from indistinct to distinct, very thin to thick; lenticular. Low angle, small- to medium-scale, trough and wedge-planer types of crossbedding common. Unconformably overlies Idaho formation and crops out in the westerm, northern, and eastern parts of area. Overlapped by Snake River basalt at lower margin of terrace	Entirely above water table in the area mapped. High permeability facilitates ground-water recharge in area of outcrop.
Tertiary	Pliocene	Idaho formation	Undetermined; may exceed 2,500 ft.	Fluviatile and lacustrine deposits of interbedded clay, silt, and sand and some lenses of gravel. Some units composed of fine to coarse subangular to subrounded fairly well sorted to well-sorted grains of quartz and feldspar and abundant mica. Bedding is flat, very thin and tabular, to thick and lenticular; low angle small- to medium-scale crossbedding of both trough and wedge types is conspicuious. Crops out in canyon of Snake River and is present in subsurface throughout area. Lies unconformably on uppermost Columbia River basalt and related volcanic rocks.	Principal water-bearing formation in the area. Water-bearing properties extremely variable. Permeable sands yield artesian and unconfined water to wells in quantities ranging from a few to more than 1,600 gpm. Strata are only moderately consolidated and are unstable in uncased wells. Aquifers are recharged by precipitation and interformational leakage from artesian aquifers in underlying formations.

Oregon and southern Idaho. Kirkham (1931a, p. 198–201, 234–239) redefined the Idaho formation by limiting it to a series of terrestrial deposits and lake beds, in places several thousand feet thick, overlying the Columbia River basalt and Owyhee rhyolite, and having a characteristic lithology and a flora and fauna of Pliocene and later age. Recent detailed geologic investigations in the Hagerman Valley of southern Idaho by H. A. Powers and H. E. Malde (written communication, 1959) have resulted in the proposal to raise the Idaho formation to group status and to introduce several new formational names. Future detailed geologic investigations in southern Canyon County may well result in abandonment of the term "Idaho formation" and introduction of new formational names in this area. However, in this report the term "Idaho formation" as defined by Kirkham is used.

The Idaho formation crops out in the canyon of the Snake River on the southern and western margins of southern Canyon County and is present in the subsurface throughout the mapped area. Where exposed, the formation consists of tabular beds of clay, silt, and sand and scattered lenses of sand and gravel. It forms low rounded hills, or where protected by a resistant overlying formation such as the Snake River basalt, it forms steep slopes. The clay and silt beds range from bluish gray through yellowish gray to very light gray and weather very light gray to yellowish gray. In many places they contain varying amounts of fine to medium quartz grains. In many beds no cement is apparent, but others are weakly cemented with calcium carbonate. The bedding of many of these units is indistinct. Where the beds are distinguishable, they range from very thin to thick and are tabular and lenticular. The unit is a coset containing flat and even sets and crossbedded sets. The crossbedding [1] is low angle (dips less than 20° from horizontal), small- to medium-scale (crossbeds less than 20 ft long), and both the trough type (individual sets bounded by curved surfaces of erosion) and the wedge type (converging planar surfaces) are present.

The sand units range from medium gray through light olive gray to light gray and weather to yellowish gray to moderate yellowish brown. They are composed of fine to coarse subangular to rounded quartz grains with considerable feldspar. Mica is common to abundant in the sands; dark accessory minerals also are common. Pyrite has been reported in drill cuttings. Silt and minor amounts of clay are present in most units. Sorting ranges from poor to good. The binding material is a weak calcareous, ferruginous, or argillaceous

[1] The descriptive terms of McKee and Weir (1953) are used to describe the stratification and cross-stratification.

cement; in some units no cement is apparent. The bedding is very thin to thick (½ in. to 4 ft) and is very lenticular.

The base of the Idaho formation is not exposed in the Dry Lake area, but the formation is presumed to overlie unconformably the uppermost bed of the Columbia River basalt or the Owyhee rhyolite of Kirkham (1931c). The top of the Idaho formation is formed by a very irregular erosion surface, in part buried, which has a relief of several hundreds of feet. The overlying formations are terrace gravels, basalt flows, and alluvium.

The total thickness of the Idaho formation in southern Canyon County is unknown, because no well has been drilled completely through it. The deepest wells include 1N–3W–12ba1, which was drilled to a reported depth of 1,265 feet, and 1S–2W–17ba1, which was drilled to a reported depth of 2,300 feet, without penetrating the Owyhee rhyolite or Columbia River basalt.

The Idaho formation is considered Pliocene in age by the U.S. Geological Survey.

WATER-BEARING PROPERTIES

Permeable beds of sand in the Idaho formation are the principal aquifers in the area. Water in some of the shallower aquifers is unconfined, but in some of the deeper aquifers it is confined under considerable artesian pressure. Pumped wells yield water in quantities ranging from a few gallons per minute to more than 1,600 gpm. The great range in yield is due to the extreme variation in permeability of the interbedded lenses of clay, silt, sand, and gravel. Recharge of ground water to the Idaho formation is by direct precipitation in areas of outcrop and by downward percolation through overlying formations.

TERRACE GRAVEL

Unconsolidated terrace gravel crops out in the western, northern, and eastern part of southern Canyon County (pl. 2). This deposit unconformably overlies the Idaho formation and is overlain by a thin mantle of windblown sand and silt of Recent age. The Snake River basalt overlaps the gravel in some places. The gravel unit ranges from pale brown to yellowish gray and consists of lenticular beds of gravel and sand with lentils of silt and clay. It forms hills that have moderate relief, or it occurs as a thin resistant cap on long gentle terrace slopes.

The gravel is composed of granules to small cobbles of basalt, latite, granite, quartzite; a few metamorphic rocks, and varying amounts of fine to very coarse sand. The gravel is rounded to subrounded and fair to well sorted. The bedding is generally indistinct.

Lenses of very coarse to fine rounded fairly well sorted to well-sorted sand composed principally of quartz and feldspar and numerous dark accessory minerals are interstratified with the gravel. Lenses of sandy clay and silt are also interspersed in the gravels. The bedding is very thin to thick and is lenticular. Where the bedding is distinct, crossbedding is conspicuous. The crossbedding is low angle, of small to medium scale, and both trough and wedge types are present. The upper few feet of the gravel at many places is firmly cemented by a calichelike lime zone. The thickness of the terrace gravel ranges from 5 feet where the gravel caps terraces to about 150 feet where it forms hills.

The age of these terrace gravels is not definitely known. No fossils have been reported from these deposits, and none were found during the geologic reconnaissance for this report. Their stratigraphic position, unconformably overlying the Idaho formation, seems to indicate a Pliocene(?) and Pleistocene age.

WATER-BEARING PROPERTIES

The high terrace gravel is above the water table in southern Canyon County. However, its high permeability facilitates ground-water recharge in the outcrop area by ready acceptance of most of the meager rainfall.

Undoubtedly, small ephemeral perched bodies of ground water form at places at the base of these deposits where they overlie the less permeable Idaho formation. These perched lenses probably are not significant as sources of water, but are very important to the recharging of the Idaho formation because water thus stored would slowly percolate into that unit.

SNAKE RIVER BASALT

I. C. Russell (1902, p. 38, 59, map) proposed the general term "Snake River basalt" to "designate the basaltic rocks that underlie by far the larger part of the Snake River Plains and to a great extent form their actual surfaces." The Snake River basalt and associated pyroclastics crop out in the southern, eastern, western, and central parts of southern Canyon County. The basalt is a light- to dark-gray vesicular olivine basalt. Irregular and columnar jointing is common in the flow layers. The individual flows range in thickness from a few feet to more than 75 feet. Beds of basaltic cinders were included in the Snake River basalt on the geologic map (pl. 2). The Snake River basalt overlies the Idaho formation unconformably, except in the areas adjacent to outcrops of terrace gravels where it overlaps the terrace gravels. Pillow lavas are abundant in the basal part of the basalt where it is exposed along the canyon of the Snake River.

The surface of the Snake River basalt has been modified to some extent by erosion, but the surface in much of the area appears to have changed very little since the basalt was extruded. The basalt ranges in thickness from a few feet in the western part of the area to more than 500 feet at well 1N–2W–36bd1 at Melba. It is reported to be 230 feet thick at well 1N–3W–2cb1, 276 feet thick at well 1N–2W–17dc1, and ranges from 50 to 100 feet in the canyon of the Snake River.

The Geological Survey uses the term "Snake River basalt" as a general term for undifferentiated basalt flows ranging in age from Pliocene to Recent. The basalt flows in southern Canyon County probably are of Pleistocene age.

WATER-BEARING PROPERTIES

The Snake River basalt is above the water table in most of southern Canyon County, except along the east side of the area. Although intergranular permeability generally is very low, irregular open zones are very permeable at the contacts of successive flows and in the upper fractured, scoriaceous, and vesicular parts of the flow and in pillow lavas at the base of the basalt. Thus, the unit as a whole has a high permeability. Where it lies below the water table, the basalt yields large quantities of water to wells.

Flowing wells in T. 1 S., R. 2 W., sec. 3 and 14 obtain water from a basalt aquifer at shallow depths, and flows exceeding 3,000 gpm have been reported from some of these wells. In this area the basalt is mantled by a thin layer of fluviatile and windblown material. A calichelike lime zone has formed in these deposits greatly reducing their permeability. Because of its low permeability, the caliche zone acts as a confining layer that restricts the upward movement of water under artesian pressure from the basalt.

Because the Snake River basalt and related pyroclastics have a high formational permeability, precipitation has easy access to the ground-water reservoir. Considerable recharge also results from irrigation in the eastern part of the area.

QUATERNARY DEPOSITS

Unconsolidated deposits of Quaternary age include landslide material, stream alluvium, and eolian deposits. Landslide material derived from the Idaho formation and the Snake River basalt occurs at close intervals along the southern and western escarpment. These landslides cover the Idaho formation along much of the canyon of the Snake River. Alluvium occurs along the courses of some intermittent streams, but is thin and of little consequence to the occurrence of ground water. Eolian sand and silt form surface deposits covering much of the area. Active dunes are present at places on the top of cliffs bordering the Snake River. These deposits are above the water table, but their relatively high permeability permits ready transmission of ground-water recharge.

The only deposit of Quaternary age mapped separately on plate 2 is the alluvium along the Snake River. The alluvium ranges widely in grain size. On the low terraces adjoining the area the alluvium ranges from giant boulders of basalt to fine sand and silt. The boulders are well rounded to subangular and, in the area south of Warrens, constitute the bulk of the deposit, but in other areas they are scarce or missing. Most of the boulders are basalt, but granite and agglomerate boulders also are present. Rounded cobbles and pebbles of basalt, latite, quartzite, granite, and agglomerate fill the spaces between the boulders. These boulder gravels resemble the gravels of H. A. Powers (written communication, 1955) which occur far east of the area in Melon Valley, Twin Falls County, Idaho. Powers correlates the period of deposition of the upper part of the gravel with the period of overflow of Lake Bonneville into the Snake River via Marsh Creek. Gray sand, subangular to subrounded, fairly well sorted to well-sorted, composed of quartz and basalt, and having numerous accessory minerals, covers large areas on the low terraces north and west of the great concentration of boulders near Warrens.

Very young alluvium is found in the Snake River valley at altitudes lower than those of the terraces. This alluvium is composed of sand, silt, clay, and some gravel. The bedding is thin to thick and very lenticular. Cut-and-fill structure is conspicuous. On the geologic map alluvial material on the terraces is not differentiated from the younger alluvium in the valley below; both were mapped as Quaternary alluvium. The thickness of the alluvium ranges widely, probably exceeding 100 feet on some of the terraces but being only a few feet next to the river.

The overall porosity and permeability of the alluvium is generally high but—because of its variable lithology, poor sorting, and lenticular bedding—yields to wells probably range widely. Higher yields probably could be obtained near the river where pumping would induce recharge of river water. The yields to wells and other hydrologic properties of the alluvium can only be estimated because few wells tap the alluvium.

STRUCTURE

Structurally, southern Canyon County lies somewhat south of the axis of the Snake River downwarp. The downwarp is broad and gentle, and the beds are only slightly inclined; reliable measurements of dip are difficult to obtain. Measurements taken on sand beds in the Idaho formation in the western part of the area indicate that the

Idaho dips about 3½° NE. Whether or not these dips reflect the general attitude of the formation throughout the area, has not been determined. The regional structure trends northwest; low dips to the northeast have been reported in adjacent areas.

No faults were observed within the area. However, south of the area there are several fault zones from which hot springs issue. The presence of hot water in the Idaho formation suggests that there may be faulting in the subsurface and that the hot water rises along such fault zones.

No folds were observed in the sedimentary strata within the area, but broad gentle folds may be present in the subsurface.

WATER RESOURCES

SURFACE WATER

There are no perennial streams or lakes in southern Cayon County and the only surface-water supply available for irrigation is that of the Snake River. Measurements of the discharge of the Snake River have been made by the Geological Survey since August 1912 at a point 4½ miles downstream from Swan Falls in the NE¼ sec. 35, T. 1 S., R. 1 W. The average discharge of the Snake River for the period of record at this station is 10,890 cfs (cubic feet per second), or about 7.8 million acre-feet of water annually. The minimum discharge at the station was 3,900 cfs, and maximum discharge was 47,300 cfs (Wells and others, 1957, p. 124).

GROUND WATER

Ground water at different places in southern Canyon County occurs under perched, unconfined (water-table), and confined (artesian) conditions. Ground water is perched when it is separated from the underlying main body of ground water by unsaturated rock; it is unconfined when the static water level in wells coincides with the upper surface of the zone of saturation. Where ground water is under sufficient pressure to rise above the level at which it is encountered by a well, it is confined ground water, sometimes termed "artesian." Confined ground water occurs in aquifers overlain by confining beds which, because of their position and their low permeability relative to that of the aquifer, give the water in the aquifer artesian head. If the pressure is sufficient to force the water above the surface, a well will flow.

OCCURRENCE

Perched ground water occurs in the Idaho formation and the Snake River basalt where water percolating downward from the surface reaches clay and silt beds or unfractured basalt of low permeability which retards its downward progress. Water accumulates in the more permeable materials overlying the clay and silt beds or unfractured basalt beds and forms a perched-water body. Several perched-water bodies are present at different altitudes in different parts of the area. Owing to the lenticularity of the beds in the Idaho formation and the variable lithology of the basalt flows, these perched-water bodies are of small areal extent and are not important aquifers.

Permeable sands in the Idaho formation which yield most of the unconfined ground water are the most important aquifers in southern Canyon County. Because the Idaho formation is heterogeneous and lenticular, the porosity and the vertical and horizontal permeability range widely.

The Snake River basalt is above the water table in most of the area. However, it is an important aquifer along the eastern border of the area, where it contains unconfined ground water. Openings between successive flows, scoriaceous and fractured zones, and lava tubes impart a high formational permeability to the basalt, and it yields water freely where saturated.

Confined ground water occurs at depth in permeable sand of the Idaho formation. The confining beds are not completely impermeable, but they are much less permeable than the lenses of sand comprising the aquifer; consequently, the confining beds produce artesian conditions not by completely preventing percolation of water but by retarding percolation. Accordingly, water leaks from the sands which comprise the artesian aquifer through the confining beds into the unconfined ground-water body. The porosity and permeability of the sand beds in which the artesian water occurs is highly variable because of abrupt lateral and vertical changes in lithology and the lenticularity of the beds.

SOURCE

The ultimate source of all the ground water in southern Canyon County is precipitation. Some is derived from precipitation directly on the area and some from percolation of surface water imported for irrigation. Also, water in the leaky artesian aquifers in the Idaho and Payette formations and Columbia River basalt and associated volcanic rocks is derived from precipitation on the northern flanks of the Owyhee Mountains where these formations crop out. Water leaking from the artesian aquifers contributes to recharge of the water-table aquifer in the area.

MOVEMENT

The general direction of flow of the unconfined ground water in the area can be inferred from the water-table contour map (pl. 1). Movement is down gradient at about right angles to the contour lines. In detail, the form of the water table and direction of ground-water movement probably are more complex than indicated on plate 1. The details, however, cannot be shown at the scale of plate 1 or resolved from the available data.

A well-defined ground-water divide is shown on plate 1 extending northwest from the New York and Mora Canals, about a quarter of a mile south of Bowmont, paralleling the Mora Canal to near the south side of Lake Lowell. South of the divide, the movement of unconfined ground water is generally south and southwest to the Snake River. North of the ground-water divide the movement of unconfined ground water is northward out of the area into Lake Lowell.

Movement of confined ground water in the artesian aquifers of the Idaho and underlying formations is northeast, downdip, away from the Owyhee Mountains, and toward the axis of the Snake River downwarp.

WATER-TABLE FLUCTUATIONS

Water-table changes, in general, reflect changes in the amount of ground water in storage. An annual rise and fall of the water table corresponds to an annual cycle of changes in the relative quantities of ground-water recharge and discharge. The yearly range in water-table fluctuations is about 6 to 8 feet in southern Canyon County. In the unirrigated part, the low water level occurs in the autumn, usually in September, following the period of least precipitation; and the high occurs in the spring, in April or May, near the end of the period of maximum precipitation. However, the period of record and the frequency of depth-to-water measurements are inadequate to show long-term or short-term trends in the fluctuations of the water table in the unirrigated part of the area.

In the irrigated area adjoining the Dry Lake area the yearly range in water-table fluctuations is about 2 to 6 feet. The low water level occurs in the spring, usually in May or June before irrigation water has been turned onto the fields; and the high occurs in the fall, usually in October or November after most of the irrigation has been completed. Thus, in the irrigated area, the effects of precipitation are masked by water-level fluctuations caused by recharge from irrigation.

DEPTH TO WATER

The approximate depth to water below land surface in southern Canyon County in 1956 is shown on plate 3. Depths to the water table ranged from a few feet to more than 400 feet below the land surface. The depth-to-water map is only approximate, owing to lack of control in much of the area.

The depth to the artesian aquifers is known accurately in a few wells, but is not known at all in most of the area. Water with artesian pressure has been found is some of the deeper wells in the Idaho formation, but the depth of the aquifers has been recorded in only a few places.

RECHARGE AND DISCHARGE

Part of the precipitation on the Dry Lake area is intercepted by vegetation and is evaporated or sublimated. The amount of precipitation intercepted in this manner depends upon the density of the vegetative cover, the intensity and duration of the precipitation, the relative humidity, and the wind velocity. The density of the vegetative cover in the Dry Lake area is low, but the intensity and duration of the precipitation and the relative humidity also are low. The wind velocity, however, is high. The amount of precipitation thus intercepted in southern Canyon County is unknown. Comparison of the Dry Lake area with controlled laboratory areas in California, Montana, and Oregon (U.S. Army, Corps of Engineers, 1956, p. 90–96, 124, 129, 135) suggests that interception in the area may be about 5 percent of the total precipitation. Surface runoff in the Dry Lake area is very small. Most of the remaining precipitation enters the ground, where most of it restores soil moisture; the rest becomes ground water. The estimated average yearly volume of precipitation on the 61 square miles comprising the Dry Lake area is about 34,000 acre-feet. Precipitation less precipitation intercepted by plants amounts to about 32,000 acre-feet—the amount of precipitation which reaches the ground. The disposition of precipitation reaching the ground in the Dry Lake area is estimated by assuming that 0.6 foot of water is evapotranspired on this nonirrigated area. Therefore, yearly evapotranspiration is estimated to be about 23,000 acre-feet. Precipitation reaching the ground less evapotranspiration is about 9,000 acre-feet, the amount apparently available for ground-water recharge when surface runoff, which is very small, is neglected. Small changes in the estimates of interception, evapotranspiration, and precipitation would alter this estimate of recharge materially because of the relatively small difference between precipitation and evapotranspiration plus interception. Therefore, this estimate is indicative only of the general magnitude of recharge from precipitation on the Dry Lake area and may be in error as much as plus or minus 25 percent. Actual recharge probably substantially exceeds this amount because of recharge from the upward leakage of underflow from outside the area by way of leaky artesian aquifers, recharge from seepage losses from the Mora Canal, and recharge from the irrigated area south of the ground-water divide. Data are insufficient to permit estimates of the volume of recharge from these sources at this time.

The water table fluctuates nearly continuously in response to discharge of water from the ground-water reservoir and to recharge, which replenishes the supply. The natural discharge from southern Canyon County is to the Snake River, which intersects the water table and serves as a ground-water drain. The amount of water in storage depends upon the relative rates of recharge and discharge. A decline in the water table represents a decrease in stored water because discharge is in excess of recharge. A rise in the water table occurs when recharge exceeds discharge. An estimate of the volume of ground-water discharge from the area would require additional data and is beyond the scope of this report. The total volume of ground water pumped from wells for irrigation in the Dry Lake area was estimated to be 9,000 acre-feet in 1956. This estimate was derived from the reported discharge of wells, the number of acres irrigated, and the length of the pumping season in the Dry Lake area.

CHEMICAL QUALITY OF THE WATER

Chemical quality largely determines the suitability of the water for irrigation and domestic use. The proposed Guffey Unit contemplates extensive use of water from the Snake River and expanded use of ground water for irrigation; therefore, the quality of water from these sources is described below.

GROUND WATER

Chemical analyses and discharge temperatures of 32 samples of ground water from southern Canyon County are given in table 2. The concentration of dissolved solids ranged from 156 to 1,220 ppm (parts per million). The waters generally contain calcium or sodium as the predominant cation and bicarbonate or sulfate as the predominant anion. The concentration of magnesium ranges widely, from 0 to 92 ppm. It is absent in one sample, is a minor constituent in many, and, in some, makes up a relatively large part of the total cations.

Minor constituents include potassium, carbonate, chloride, fluoride, nitrate, and boron. In five samples analyzed for fluoride the concentrations ranged from 0.4 to 14 ppm. If the concentration of fluoride is higher than 1.5 ppm, it may cause mottling of the tooth enamel of children who use the water during the period of calcification of the permanent teeth. Nitrate in the waters analyzed ranged from 0 to 196 ppm. Nitrate is a final oxidation product of nitrogenous matter, and its presence in water supplies at concentrations of more than several parts per million may indicate contamination by sewage or other organic matter or nitrate from the application of fertilizer to the soil.

Water temperatures ranged from 58° to 120° F; generally, however, they were in the range from 63° to 81° F, some 15° to 30° F above the mean annual air temperature.

The areal distribution of water sampled and a graphic representation of the chemical analyses of the water are shown on plate 4, which also shows contours on the water table.

Water in the Idaho formation is high in sodium and bicarbonate where its composition has not been materially altered by infiltration of unconsumed irrigation water. Water from wells 2N-3W-35ca1, 1N-3W-12ba1, 1N2W-6ad1, 1N-2W-36bd1, and 1S-2W-17ab1 (table 2) are representative of native water in the Idaho formation. Givens Hot Springs, in Owyhee County just south of the Snake River, issues from the Idaho formation along a northwest-trending fault and has a temperature of 120° F. The water is a sodium bicarbonate water, but it also contains appreciable carbonate. Except for silica which was 75 ppm in the sample, other constituents are present in only minor amounts. It contains slightly less bicarbonate, calcium, and magnesium than the native water in the Idaho formation, which is a mixture of hot water derived by interformational leakage from underlying artesian aquifers and water recharged from precipitation.

Water from wells in the Idaho formation near or in the irrigated areas has larger amounts of calcium, magnesium, and sulfate than the native water in the formation. Nitrate and chloride generally are present in larger amounts also. Bicarbonate and sodium are variable, but generally are present in smaller proportions. These differences in concentration are caused in large part by unconsumed water infiltrating from canals and fields which mixes with water in the Idaho formation. Analyses of water from the following wells show the chemical composition of the mixed water: 2N-3W-5bb1, 7aa1, 8da1, 9bc1, 22cb1, 23cc1; 1N-2W-3cb1, 4da1, 5cb1, 8ab1, 10ba1, 16cb1, 17da1, and 17dc1. As will be noted, the chemical composition of the mixture of infiltrate and native water in the Idaho formation is not uniform but differs from well to well. These differences in chemical composition are believed, by the author, to be principally due to variations in the chemical composition of, and the proportion of, the infiltrate.

The surface water used for irrigation throughout the irrigated area has a common source, the Boise River. Water diverted at Boise Diversion Dam, 22 miles east of Bowmont, flows in the New York Canal to about 3 miles southeast of Kuna (fig. 3), and thence in the Mora Canal to southern Canyon County. The chemical quality of this water does not change appreciably in transit from the Boise Diversion Dam to southern Canyon County (Nace and others, 1957, table 25, p. 89). Chemical analyses of surface waters are given in table 3. The analysis of water from the Ridenbaugh Canal, which derives its water from the Boise River, is representative of the chemical quality of the surface water used for irrigation throughout the irrigated area. It is a calcium bicarbonate water low in dissolved solids. Calcium makes up 57 and sodium 26 percent of the cations; bicarbonate makes up 82 and sulfate 12 percent of the anions. However, in percolating downward through the soil the water dissolves minerals from the soil and from fertilizers that are applied to the soil; the chemical content of the water, therefore, generally increases considerably.

Because of differences in soil mineralogy and texture and differences in farming and irrigation practices, the unconsumed irrigation water which infiltrates to the water table differs in chemical composition from place to place. The principal factors which cause differences in the chemical composition and content of the infiltrate are (a) canal seepage, (b) agricultural practices, (c) formational differences, and (d) recycling. A brief review of how these factors influence the infiltrate follows.

Canal seepage.—In areas where canal seepage losses are high the infiltrate may consist largely of canal water low in dissolved solids which dilutes the water in the Idaho formation, or the canal water may dilute the infiltrate from unconsumed irrigation water and this mixture combines with the water in the Idaho formation. The composition and relatively low dissolved solids of the water from wells 1N–2W–3cb1, 4da1, 5cb1, 8ab1, and 10ba1 may be the result of such dilution and mixing.

Agricultural practices.—The composition and quantity of fertilizers and soil amenders used on the soil and taken into solution by the irrigation water are determined by farming practices; the salts in the soil differ from place to place; organic debris from crops provides soluble nitrogenous matter and weak acids to the infiltrate which may cause its solvent power to exceed substantially that of natural recharge water; and the evaporation of irrigation water and transpiration by plants, which differs from place to place with irrigation practices and crops grown, all cause differences in the concentration of minerals and composition of the water. Water affected by irrigation use is distinguished by a higher dissolved solids content and higher proportions of calcium, sulfate, chloride, and nitrate than the water in the Idaho formation. Water from wells 2N–3W–5bb1, 7aa1, 8da1, 9bc1, 22cb1, 23cc1; 1N–2W–16cb1, 17da1, and 17dc1 is so distinguished. The differences in concentration and composition of the water from these wells may be the result of agricultural practices.

Formational differences.—Fine-textured sediments, which are abundant in the Idaho formation and in the soils of the area, commonly contain minerals of high base-exchange capacity which exchange calcium and magnesium for an equivalent amount of sodium in the water. The reaction is reversible, and if the ratio of sodium to total cations in the water is sufficiently high, sodium is exchanged for an equivalent amount of calcium and magnesium. Sometimes when two waters of differing chemical composition are brought together they react chemically and some of the product of products of the reaction may precipitate, thus changing the chemical composition of the remaining solution.

Recycling.—The use of ground water as a supplement to the surface water for irrigation or as the sole source of irrigation water is widespread in southern Canyon County. The effect on the quality of the infiltrate is to increase the dissolved solids and to change the composition. Analysis of the water in well 2N–3W–34db1 may show the effect of recycling. The water in this well is a sodium sulfate water which contains appreciably greater amounts of calcium and magnesium than the sodium bicarbonate water in well 2N–3W–35ca1 only 1 mile to the east. Well 34db1 is in the southwestern part of an area that is irrigated entirely by ground water. Well 35ca1 is just east of this irrigated area which extends northward for about 3 miles. Analyses of the waters from wells 2N–3W–22cb1 and 23cc1 show the composition of the ground water used to irrigate this land. These waters contain appreciable calcium, magnesium, and sulfate in addition to sodium and bicarbonate and are a mixture of native water from the Idaho formation and infiltrate from unconsumed irrigation water. The infiltrate from the area irrigated with ground water mixes with the native water in the Idaho formation. The composition of this mixture is suggested by the analysis of water from well 2N–3W–34db1. The water-table contours (pl. 4) indicate that well 2N–3W–35ca1 is southeast of the area through which this mixed ground water moves; this is substantiated by the analysis of water from this well.

Characteristic water from the Snake River basalt is typically a calcium magnesium bicarbonate water low in dissolved solids. The chemical composition of the ground water in the Snake River basalt in southern Canyon County is indicated by analyses of water from wells 1N–2W–27cc1, 34ac1; 1S–2W–3dd2, 14ac2, and 14ad1. These analyses indicate that the composition of these waters ranges widely. Calcium is the predominant cation in two samples and sodium in three, but magnesium in each makes up a relative large part of the total cations. Bicarbonate is the predominant anion in three samples and sulfate in two. The concentration of dissolved solids ranges from 268 to 1,220 ppm. However, the wells are all in an irrigated area, and most of the recharge to these aquifers is infiltrate from unconsumed irrigation water; hence, the samples cannot be considered as representing the native water, but rather as representing the infiltrate. The range of the chemical composition of this water also indicates that the infiltrate from unconsumed irrigation water differs markedly from place to place.

TABLE 2.—*Chemical analyses of ground water from southern Canyon County*

[Chemical constituents in parts per million. Analyses by the U.S. Geological Survey and Bureau of Reclamation]

Well	Date of collection	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$: Carbonate	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25° C)	pH
2N-3W-5bb1	Aug. 27, 1956	63	------	------	72	26	65	6	261	0	126	51	------	22	0.52	541	287	73	845	7.3
7aa1	do	64	------	------	67	19	52	4	413	0	21	3	------	4	.33	426	246	93	665	7.4
8da1	Aug. 28, 1956	64	------	------	37	13	36	6	147	0	61	24	------	6	.32	493	146	25	471	7.7
9bc1	Aug. 27, 1956	61	------	------	35	10	33	3	125	0	56	20	------	3	.14	268	129	26	419	7.8
22cb1	May 6, 1954	80	59	0	40	11	55	6.5	242	------	62	8.0	0.6	0	.28	354	145	0	509	8.2
23cc1	Aug. 28, 1956	73	------	------	24	10	61	6	194	0	44	22	------	1	.33	305	101	0	476	8.0
34db1	Aug. 27, 1956	81	------	------	29	16	126	13	164	0	268	8	------	1	.26	550	138	4	859	7.8
35ca1	do	81	------	------	6	1	77	4	198	5	17	6	------	Tr.	.27	248	19	0	388	8.4
1N-3W-12ba1	do	90	------	------	13	4	100	14	308	13	6	8	------	1	.38	355	49	0	554	8.6
1N-2W-3cb1	Aug. 28, 1956	69	------	------	22	8	24	2	112	------	25	12	------	4	.02	184	88	0	288	7.8
3cb1	May 10, 1954	69	40	0	18	6.3	24	3.8	114	0	21	10	.4	3.2	.08	188	71	0	258	8.2
4da1	Aug. 27, 1956	72	------	------	18	5	27	2	118	0	15	6	------	2	54	156	66	0	243	7.9
5cb1	do	72	------	------	25	4	31	2	129	1	23	9	------	1	.58	189	79	0	295	8.1
6ad1	do	76	------	------	12	2	59	4	173	6	10	6	------	1	.49	216	38	0	338	8.4
8ab1	do	73	------	------	21	3	34	2	121	1	22	10	------	1	.40	181	65	0	283	8.2
10ba1	Aug. 28, 1956	69	------	------	19	8	20	2	112	0	15	7	------	3	.09	159	81	0	248	7.7
16cb1	do	78	------	------	92	34	69	7	134	0	225	96	------	26	.10	684	370	259	1,070	7.7
16cb1	May 6, 1954	68	35	0	83	29	72	6.3	136	------	217	89	.6	23	.34	619	327	215	950	8.1
17da1	Aug. 28, 1956	72	------	------	39	15	69	6	181	0	93	59	------	11	.20	428	159	11	669	7.8
17dc1	do	73	------	------	50	29	60	9	193	0	138	50	------	12	.19	504	244	86	787	7.7
27cc1	do	64	------	------	127	71	98	13	121	0	330	139	------	196	.08	1,080	610	511	1,700	7.7
34ac1	do	64	------	------	98	92	184	20	344	0	627	22	------	19	.54	1,220	624	342	1,910	7.6
36bd1	do	77	------	------	12	6	81	4	207	8	25	12	------	4	.21	291	55	0	455	8.4
1S-2W-3dd2	do	65	------	------	54	31	78	4	266	0	185	33	------	26	.12	600	263	45	937	7.8
3dd2	Oct. 29, 1953	63	42	------	62	37	97		268	------	224	35	------	20	------	637	307	87	995	7.5
14ac2	Aug. 28, 1956	64	------	------	51	31	104	7	384	0	112	16	------	25	.32	573	255	0	896	7.6
14ad1	Aug. 29, 1956	58	------	------	47	14	17	2	236	0	17	4	------	6	.10	268	175	0	418	7.7
15bb1	Aug. 28, 1956	64	------	------	43	25	151	9	449	0	109	32	------	13	.46	656	211	0	1,020	7.4
17ab1	Aug. 27, 1956	70	------	------	16	5	109	12	373	0	1	13	------	1	.63	397	61	0	620	7.8
17ab1	Oct. 6, 1954	78	67	.02	13	2.7	111	12	312	------	.8	12	7	.8	.22	397	44	0	595	7.8
1N-2W-34ac1	Sept. 6, 1956	64	------	------	75	76	180	18	373	------	519	35	------	30	.37	1,060	501	195	1,650	7.6
Givens Hot Springs, 1N-2W-16cc	May 18, 1956	120	75	0	2.0	0	123	1.4	150	35	31	23	14	.2	------	379	2	0	542	9.2

SURFACE WATER

The U.S. Geological Survey has maintained a sampling station at King Hill on the Snake River, about 100 miles upstream from southern Canyon County, since March 1951. Chemical analyses of the water at this station sampled on September 21 to 30, 1953, and at the time of maximum and minimum dissolved-solids content for the period of record are given in table 3. A summary of the yearly weighted average of chemical constituents for the period of record is also given in the table. Comparison of the analysis of water from the Snake River at Marsing Bridge (pl. 4) with an analysis of water from the Snake River at King Hill for the same period indicates that the quality of the water at both places was very similar. This similarity suggests that between King Hill and Marsing Bridge the quality of the water in the Snake River does not change appreciably, which should be expected because the average gain of the Snake River between King Hill and Murphy (35 miles upstream from Marsing Bridge) is about 4 percent of the average flow at King Hill. There is no appreciable inflow between Murphy and Marsing Bridge. Therefore, although the annual variation in the quality of the water in the Snake River at Marsing Bridge is unknown, it probably is similar to the annual variation at King Hill. Figure 5 shows the fluctuations in dissolved solids and discharge of the Snake River at King Hill. Concentration of dissolved solids is at a maximum during periods of low flow and at a minimum during periods of greatest discharge.

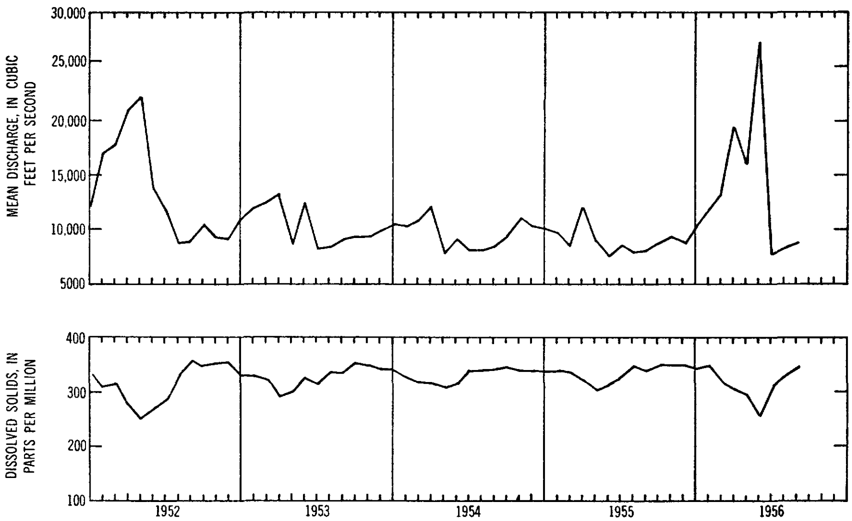

FIGURE 5.—Dissolved solids and mean discharge of the Snake River at King Hill, Idaho, 1952–56.

TABLE 3.—*Chemical analyses of surface water in or adjacent to southern Canyon County*

[Chemical constituents, in parts per million. Analyses by the U.S. Geological Survey and U.S. Bureau of Reclamation]

	Lake Lowell		Ridenbaugh Canal	Snake River [1]	Snake River [2] 5 years: Oct. 1951 through Sept. 1956		Weighted average	
	3N-3W-19da	3N-3W-36bb	2N-1W-7bc	3N-4W-34d				
Date of collection	Sept. 16, 1953	Sept. 25, 1953	Sept. 15, 1953	Sept. 25, 1953	May 1-10, 1952	Sept. 1-10, 1952	Oct. 1951 to Sept. 1956	Sept. 21-30, 1953
Temperature	75	65	66	64				
Mean discharge (cfs)					22,200	8,935	10,977	8,894
Silica (SiO_2)	30	25	13	32	26	37	34	41
Iron (Fe)		.00	.00	.00	.07	.02		
Calcium (Ca)	30	28	11	44	40	46	47	47
Magnesium (Mg)	8.2	8.7	1.5	25	16	21	20	22
Sodium (Na)	46 (Sodium and potassium, bracketed)	35	5.8	36	22	36	32	38
Potassium (K)		2.9	1.6	5.4	3.6	4.7	4.5	4.6
Bicarbonate (HCO_3)	148	128	46	222	174	224	214	224
Carbonate (CO_3)								
Sulfate (SO_4)	63	65	5.4	65	39	56	55	61
Chloride (Cl)	15	6	1.0	28	20	27	26	28
Fluoride (F)		.4	.2	.6	.5	.5		
Nitrate (NO_3)	.7	3.7	.8	3.4	2.4	3.3	3.0	3.8
Boron (B)		.04	.02	.02				
Dissolved solids:								
Parts per million	266	238	63	346	[3] 252	[3] 359	325	350
Tons per acre-foot					.34	.49	.44	.48
Tons per day					15,100	8,660	9,588	8,400
Hardness as $CaCO_3$:								
Carbonate	109	106	34	213	166	202	199	208
Noncarbonate	0	1	0	31	23	18	23.6	24
Percent sodium					22	27	25.4	28
Sodium-adsorption ratio					.7	1.1	.98	1.1
Specific conductance (micromhos at 25°C)	404	389	90.1	556	405	546	515	549
pH	7.4	6.9	6.9	7.6	7.9	8.0		
Color					5	7		

[1] At Marsing Bridge.
[2] Near King Hill; daily samples, composite analysis every 10 days.
[3] Concentration: Minimum dissolved solids, recorded May 1-10, 1952; maximum dissolved solids recorded Sept. 1-10, 1952. Average weighted according to stream discharge.

SUITABILITY OF THE WATER FOR IRRIGATION

The principal factors that determine the chemical suitability of water for irrigation are (a) the concentration of dissolved solids, (b) the amount of sodium in proportion to the total cations, (c) the concentration of bicarbonate, under some conditions, and (d) the concentration of boron.

Most crops do not grow well in saline soils and water with a high concentration of dissolved solids tends to deposit salts in the soil, thus making it toxic to plants and decreasing its productivity. Specific conductance or electrical conductivity of water is used widely as an approximate measure of the concentration of dissolved solids in water.

The U.S. Department of Agriculture (U.S. Salinity Laboratory Staff, 1954) recognize 4 classes of water with respect to salinity hazard, expressed as electrical conductivity, in micromhos: low, 0 to 250; medium, 251 to 750; high, 751 to 2,250; very high, more than 2,250. The amount of sodium in proportion to the total cations is an important factor. In moderate proportions calcium and magnesium maintain good structure (texture) in the soil. Calcium is relatively abundant in the waters of the Dry Lake area. A high proportion of sodium in irrigation water tends to destroy the friable condition of the soil by dispersing the mineral particles, which causes the soil to become tight and impermeable so that it will not drain freely when it is wetted.

Two widely used criteria for evaluating the sodium hazard of irrigation waters are the "percent sodium" (Wilcox, 1948) and the "sodium-adsorption-ratio" (U.S. Salinity Laboratory Staff, 1954). The suitability of a water is affected to some extent by the type and character of soil texture, soil-drainage conditions, and water management and soil-amendment practices. Consequently, no one of these criteria is by itself absolute.

The percent sodium is the ratio of the milliequivalents per liter of sodium to the sum of the milliequivalents per liter of calcium, magnesium, sodium, and potassium, expressed as a percentage. The percent sodium is plotted against electrical conductivity on a standard diagram which defines the classes of suitability. Values of percent sodium calculated from analyses of southern Canyon County water are given in table 4, and the classification of the waters is shown in figure 6.

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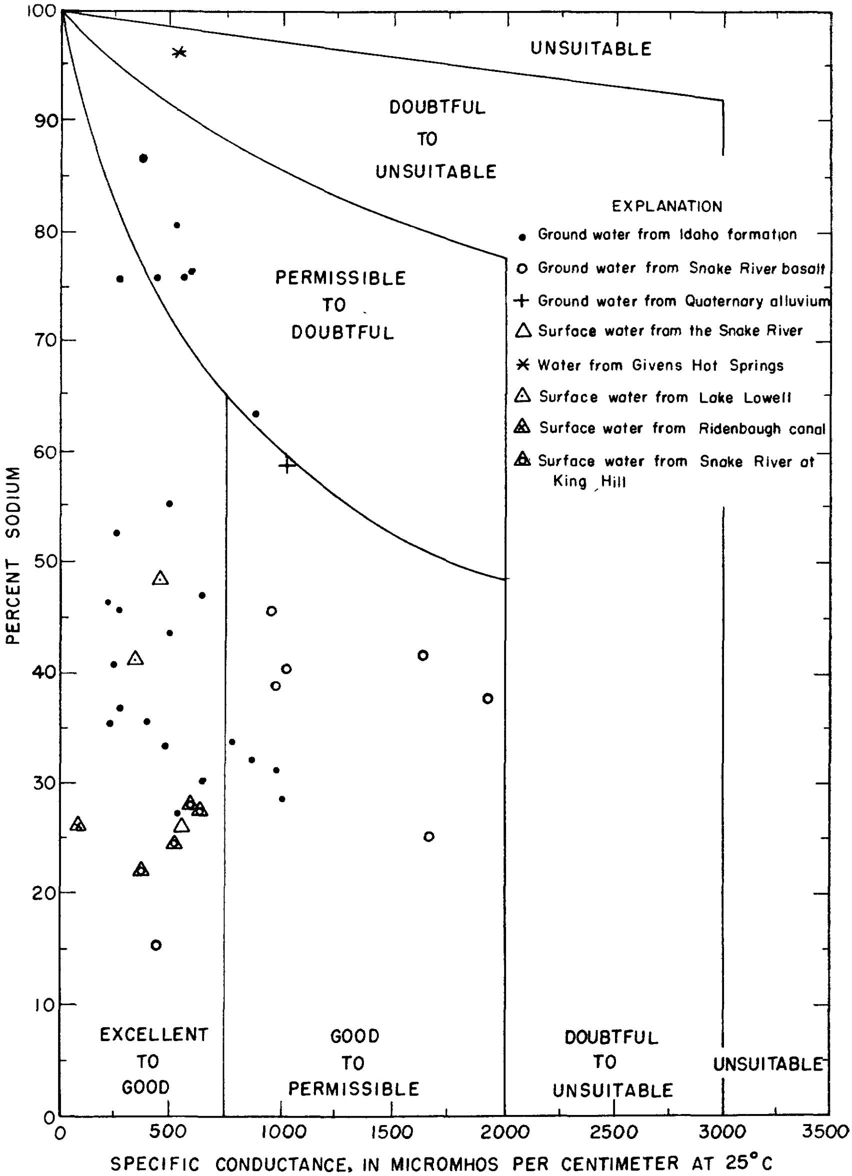

FIGURE 6.—Classification of waters from southern Canyon County. After Wilcox (1948).

A second method of evaluating the sodium hazard of irrigation water is the "sodium-adsorption-ratio" (SAR) method. The sodium-adsorption ratio is derived by the equation,

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

in which Na^+, Ca^{++}, and Mg^{++} represent respective concentrations of the ions in milliequivalents per liter. For classification, the SAR values are plotted against electrical conductivity on a standard diagram which defines four ranges of salinity hazard and sodium hazard. SAR values derived from analyses of southern Canyon County waters are given in table 4 and are plotted in figure 7.

The suitability of the waters for irrigation according to the criteria developed by the U.S. Salinity Laboratory Staff (1954) is given in table 4. The indicated classes grade one into another. The classifications assume average conditions of soil texture, infiltration capacity, drainage, quantity of irrigation water applied, climate, and salinity tolerance of the crops. A large deviation from average in one or more of these factors might permit successful use of a water of doubtful quality. Conversely, a water low in both dissolved solids and proportion of sodium might cause damage to the soil. All waters tested in southern Canyon County are in classes C_1S_1, C_2S_1, or C^3S_1.

According to the U.S. Salinity Laboratory Staff (1954, p. 79–81), waters of class C_1S_1 can be used to irrigate most crops on most soils. They generally will not cause excessive soil salinity, and sodium adsorption by the soil will not be harmful except to sodium-sensitive crops, such as stone-fruit trees.

Water of class C_2S_1 is only slightly less suitable for irrigation, and plants with moderate salt tolerance usually can be grown without special practices for salinity control.

Water of class C_3S_1 cannot be used on soils that have restricted drainage. Even if drainage is adequate, crops that have good salt tolerance should be selected and special management for salinity control may be necessary.

Boron in very small amounts is essential to normal plant growth, but in larger amounts it is very toxic to certain plants. However, the concentration that will injure boron-sensitive plants is often approximately that required for normal growth of nonsensitive plants. More than 3.7 ppm of boron is toxic even to plants that have a relatively high boron tolerance (U.S. Salinity Laboratory Staff, 1954). The maximum boron content of waters analyzed from the Dry Lake

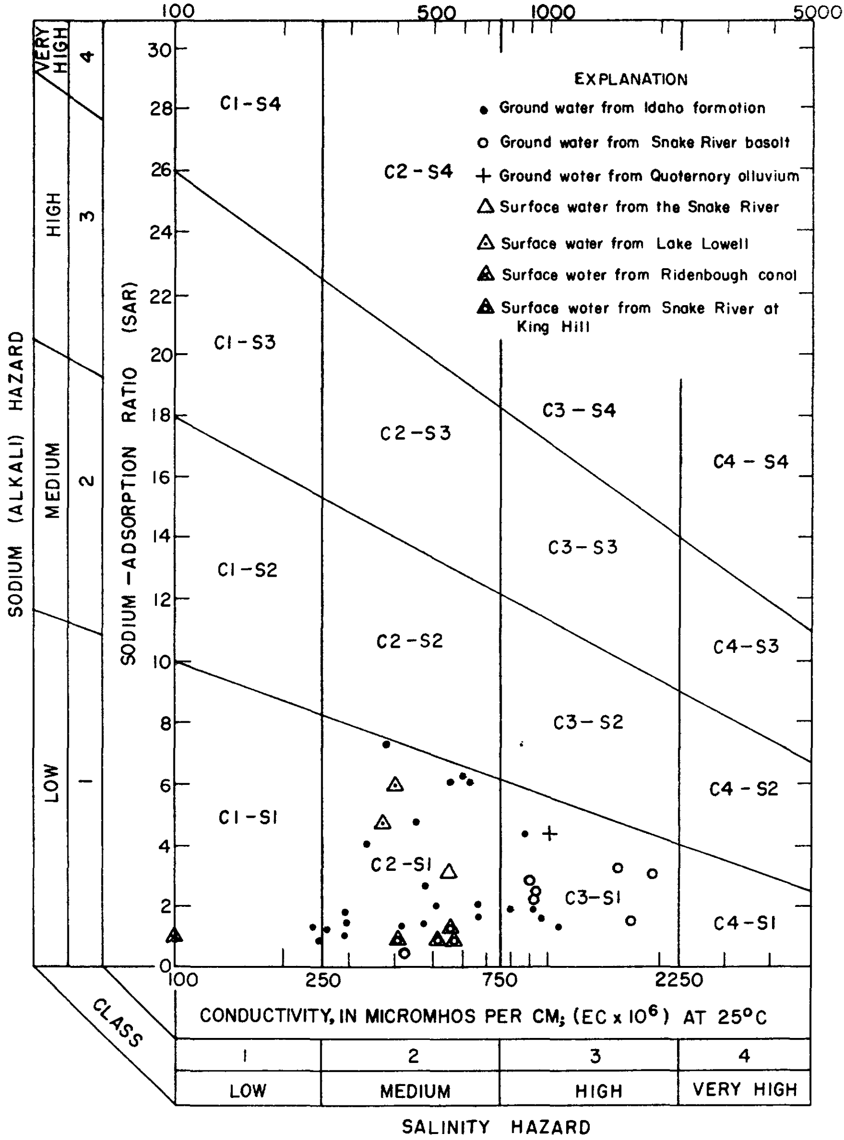

FIGURE 7.—Classification of waters from southern Canyon County. After U.S. Salinity Laboratory Staff (1954, fig. 25).

TABLE 4.—*Suitability of waters of southern Canyon County for irrigation*

[From analyses by the U.S. Geological Survey and U.S. Bureau of Reclamation]

Well No. or location of sampling site	Date of collection	Specific conductance (micromhos at 25° C)	Percent sodium	Class [1]	Sodium-adsorption ratio	Class [2]
2N-3W-5bb1	8-27-56	845	33	GP	1.7	C_3S_1
7aa1	8-27-56	665	31	EG	1.4	C_2S_1
8da1	8-28-56	471	34	EG	1.3	C_2S_1
9bc1	8-27-56	419	35	EG	1.3	C_2S_1
22cb1	5- 6-54	509	44	EG	2.0	C_2S_1
23cc1	8-28-56	476	55	EG	2.7	C_2S_1
34db1	8-27-56	859	64	PD	4.6	C_3S_1
35ca1	8-27-56	388	87	PD	7.5	C_2S_1
1N-3W-12ba1	8-27-56	554	77	PD	6.2	C_2S_1
1N-2W-3cb1	8-28-56	288	37	EG	1.1	C_2S_1
3cb1	5-10-54	258	41	EG	1.2	C_2S_1
4da1	8-27-56	243	46	EG	1.4	C_1S_1
5cb1	8-27-56	295	46	EG	1.5	C_2S_1
6ad1	8-27-56	338	76	EG	4.2	C_2S_1
8ab1	8-27-56	283	52	EG	1.8	C_2S_1
10ba1	8-28-56	248	35	EG	1.0	C_1S_1
16cb1	8-28-56	1,070	28	GP	1.6	C_3S_1
16cb1	5- 6-54	950	32	GP	1.7	C_3S_1
17da1	8-28-56	669	47	EG	2.4	C_2S_1
17dc1	8-28-56	787	34	GP	2.2	C_3S_1
27cc1	8-28-56	1,700	25	GP	1.7	C_3S_1
34ac1	8-28-56	1,910	38	GP	3.2	C_3S_1
36bd1	8-28-56	455	76	PD	5.0	C_2S_1
1S-2W-3dd2	8-28-56	937	39	GP	2.1	C_3S_1
3dd2	10-29-53	995	41	GP	2.4	C_3S_1
14ac2	8-28-56	896	46	GP	2.8	C_3S_1
14ad1	8-29-56	418	16	EG	.5	C_2S_1
15bb1	8-28-56	1,020	59	GP	4.5	C_3S_1
17ab1	8-27-56	620	76	PD	6.2	C_2S_1
17ab1	5- 6-54	595	80	PD	6.3	C_2S_1
1N-2W-34ac1	9- 6-56	1,650	43	GP	3.5	C_3S_1
Snake River [3]	9-25-53	556	26	EG	3.4	C_2S_1
Givens Hot Springs: 1N-3W-16cc	5-18-56	542	96	DU	24	C_2S_4
Lake Lowell: 3N-3W-19da	9-16-53	404	48	EG	6.1	C_2S_1
3N-3W-36bb	9-25-53	389	41	EG	4.7	C_2S_1
Ridenbaugh Canal: 2N-1W-7bc	9-15-53	90.1	26	EG	1.4	C_1S_1
Snake River at King Hill	5/1-5/10/52	405	22	EG	.7	C_2S_1
Do	9/1-9/10/52	546	27	EG	1.1	C_2S_1
Do	9/21-9/30/53	549	28	EG	1.1	C_2S_1
Do	Avg, October 1951 to September 1956	515	25	EG	1.0	C_2S_1

[1] Letter symbols indicate suitability for irrigation as follows: EG, excellent to good; GP, good to permissible; PD, permissible to doubtful.
[2] Salinity hazard: C_1, low; C_2, medium; C_3, high. Sodium or "alkali" hazard; S_1, low.
[3] At Marsing Bridge, T. 3 N., R. 4 W., SE¼ sec. 34 (location shown on pl. 4).

area is 0.63 ppm, which is an amount that is allowable even for boron-sensitive crops.

The temperature of water discharged from 46 wells in and around the Dry Lake area ranged from 58° to 92° F. Water from deep aquifers tends to be warmer than water from shallow aquifers, owing to the natural increase of temperature with increase in depth below the land surface. The average worldwide increase in temperature with depth (thermal gradient) is about 1° F for each 64 feet of depth. In the sediments in the Dry Lake area the thermal gradient differs greatly, and in some wells it is 3° to 4° F for every 100 feet of depth. It is generally believed that upward leakage of warm water from artesian aquifers raises the temperature of the water in the shallower aquifers.

PRESENT DEVELOPMENT

In southern Canyon County ground water is the principal source of domestic and municipal supply, and in recent years it has become an increasingly important source of water for irrigation. Within the Dry Lake area about 3,000 acres is irrigated solely by ground water. Acceleration of the current trend toward increased use of ground water as a supplemental or sole source of irrigation water is probable.

There were about 30 wells in the Dry Lake area in 1956, all of which were drilled wells. Most of them are 10 inches or more in diameter and are used principally for irrigation, though some are used also for domestic supply. A few wells that are less than 10 inches in diameter are used for domestic or stock supply. The reported depths of these 30 wells range from 224 feet to more than 1,200 feet; the average depth is about 500 feet (see table 5).

All the wells in the Dry Lake area have been drilled by the percussion (cable tool) method, but the details of construction differ considerably. Most of the wells are cased into the water-bearing sands and an open hole is drilled to the nominal depth of the well. Most wells are less than 5 years old and produce sand with the water, which indicates that the aquifer contains much unconsolidated sand. Drillers report difficulty in drilling when some sands are penetrated because of caving, which also indicates an unconsolidated sand aquifer. Clogging of the wells with sand or caving of the unstable walls is a very real possibility even while the well is being drilled. A few wells are cased only "deep enough to case out surface seepage" (10 to about 50 ft) and an open hole is drilled into the water-bearing sands. Such wells are likely to cave at any time. A few wells are cased to the bottom, and in some of these the casing is perforated from the water table to the bottom of the hole. Wells cased to their full depth are less likely to cave. If, however, the casing is not perforated opposite the saturated zone, the efficiency of the well is impaired; but, if the casing is perforated, unconsolidated sand may pass through the perforations and fill the hole. Wells that are properly cased and equipped with a gravel envelope or well screen generally have a longer life and are more efficient than less carefully constructed wells. Such wells have a higher initial cost than the other types, but they may prove to be more economical over a long time.

In that part of southern Canyon County outside the Dry Lake area many small-diameter wells are used principally for domestic and stock supply, and some large-diameter wells are used for irrigation and public supply. Between Lake Lowell and the Mora Canal some dug wells are used for domestic and stock supply. The reported depths of these dug wells range from less than 25 feet to more than 100 feet. Most of the small-diameter drilled wells are less than 250 feet deep. At Walters (pl. 1), well 1S–2W–17ab1 was drilled to obtain warm water for a natatorium. This well ended in the Idaho formation at a reported depth of 2,300 feet and yielded warm water which flows at the surface, but the depth at which artesian water was found is not known. Between Melba and Warrens (pl. 1) there are many flowing drainage wells ranging in diameter from 6 to 16 inches. The range of reported depths of these drainage wells is from 12 to 80 feet. The wells in southern Canyon County outside the Dry Lake area were drilled by the percussion (cable tool) method, except for the dug wells and well 1S–2W–17ab1, which was drilled by the rotary method. Construction is not uniform, but is similar to the well construction in the Dry Lake area, with one important exception. That is, wells drilled in the Snake River basalt usually are cased only into the basalt and the hole is left uncased opposite the volcanic deposits. Such wells are quite stable because caving does not commonly occur in the basalt.

Irrigation wells in southern Canyon County are equipped with turbine pumps. Most domestic and stock wells are equipped with jet or lift pumps, but a few suction pumps are used where water is obtained at shallow depths. Nearly all the pumps are driven by electric motors. The electric motors used on irrigation wells range from 7½ to 200 horsepower. Gasoline engines are used on two stock wells where electricity is not available.

Pumping lifts in the Dry Lake area in 1956 ranged from less than 170 feet to more than 550 feet and averaged about 315 feet. Pumping lifts in the remainder of southern Canyon County ranged from less than 5 feet near Lake Lowell to more than 500 feet in well 1N–3W–12ba1. Several wells flow in secs. 3, 10, and 14, T. 1 S., R. 2 W.

The reported specific capacities of irrigation wells in southern Canyon County range from 61 gpm per foot of drawdown, 675 gpm with about 11 feet of drawdown (well 3N–3W–29cd1), to 2.5 gpm per foot of drawdown, 378 gpm with about 150 feet of drawdown (well 1N–3W–12ba1). The relative yields of 18 wells in the area for which data were available are compared in the table below which gives yield, drawdown, and specific capacity (yield per foot of drawdown). All these wells obtain water from the Idaho formation except well 1S–2W–14db1, which obtains water from the Snake River basalt. The wide range in reported specific capacities is caused in part by variations in lithology and lenticular bedding of the Idaho formation and in part by variations in well construction which affect the efficiency of the wells. The drawdown in a well can be considered as consisting of two parts: one part is due to loss of head by laminar flow of water through the aquifer; the other part is the head loss caused by turbulent flow in the immediate vicinity of the well and through the screen or perforations in the casing. Improperly constructed wells impede the flow of water from the aquifer into the well, and excessive head loss by turbulent flow in the vicinity of the well may occur. The specific capacity of some wells may increase in time, owing to the removal of some of the finer grained material in the immediate vicinity by pumping; or it may decrease, owing to the clogging of the well with loose sand or the caving of the walls of the well.

Yield, drawdown, and specific capacity of selected wells in southern Canyon County

Well	Yield (gpm)	Drawdown (feet)	Specific capacity (gpm per ft drawdown)
3N-4W-25db2	500	18	28
3N-3W-29cd1	675	11	61
31ad1	450	55	8
32ab1	900	30	30
32ca1	675	15	45
2N-3W- 9cc1	700	57	12
22cb1	780	45	17
23cd1	540	85	6
34db1	470	25	19
2N-2W-34aa1	690	148	5
1N-3W-12ba1	378	150	2.5
1N-2W- 3bb1	520	58	9
4da1	810	305	3
5cb1	800	62	13
8ab1	900	120	7.5
16cb1	1,665	90	19
36bd1	250	24	10
1S-2W-14db1	720	28	26

On the basis of available geologic and hydrologic data, it is estimated that a properly constructed and developed well in the Idaho formation, 16 inches in diameter and from 300 to 500 feet deep, equipped with a commercial screen (120 ft total length) in permeable sand zones would yield about 1,800 gpm with a drawdown of between 50 and 100 feet. Because the drawdown depends in part upon the length of time the well has been pumped, the specific capacities listed above may not be entirely comparable.

EFFECTS OF PROPOSED IRRIGATION DEVELOPMENT

The proposed irrigation of the Dry Lake area (p. 4–5) would cause many changes in the present hydrologic regimen in the area. The configuration of the water table, the depth to water, and seasonal water-level fluctuations would be changed considerably; existing drainage problems in some bordering areas would be further complicated; and the chemical quality of the ground water would change.

CHANGES IN THE GROUND-WATER REGIMEN

Increased ground-water recharge from new irrigation undoubtedly would displace the ground-water divide (pl. 1) to the south or southwest. The amount of the shift would be limited by the Snake River Valley which, acting as a ground-water drain, would keep ground water from building up to high levels that would be necessary for a large shift. Neither the future location of the divide nor the details of the configuration of the water table can be determined from available data.

A significant rise in the water table can be expected subsequent to irrigation of the area with imported water. The amount of the rise cannot be accurately determined at this time However, an indication of the magnitude of the rise can be obtained by analogy with nearby areas that are now irrigated. In these areas water levels have risen many feet since irrigation began some 45 years ago. Records are incomplete but are sufficient to indicate that most of the rise occurred in the first few years of irrigation. The total rise for the period of record amounts to 134 feet in well 2N–3W–8ab1, 129 feet in well 2N–3W–18cb1, and 36 feet in well 2N–2W–22cb1. Figures 8, 9, 10, and 11 show the changes and trends of water levels in wells in the irrigated area. Similar rises in the water levels in wells in the Dry Lake and adjacent areas subsequent to irrigation would not be uniform, but probably would differ from place to place.

The rate of rise of the water table in the observation wells was not uniform, but varied from year to year and from well to well. Similar variations of water level can be expected in the wells in southern Canyon County subsequent to irrigation. Comparison of the hydrographs with precipitation (p. 10) shows that the trend in water levels is not closely related to climatic changes. The hydrograph of well 1N–2W–4bc1 (fig. 11), the only well for which detailed measurements were available, shows a yearly cycle of fluctuations of the water table. In this well, which is typical of wells in the irrigated areas, high water levels occur in October or November and low water levels in May or June. In the nonirrigated area high water levels occur in the spring and low water levels in the autumn. Thus, the time of occurrence of the yearly high and low water levels in the irrigated area is almost opposite to the high and low water levels in the nonirrigated area. This difference in time of high and low water levels is due to recharge of ground water from irrigation which masks the effects of recharge from precipitation. Following project development the time of high and low water levels in the Dry Lake area will probably change to correspond with the time of high and low water table in the currently irrigated area of southern Canyon County.

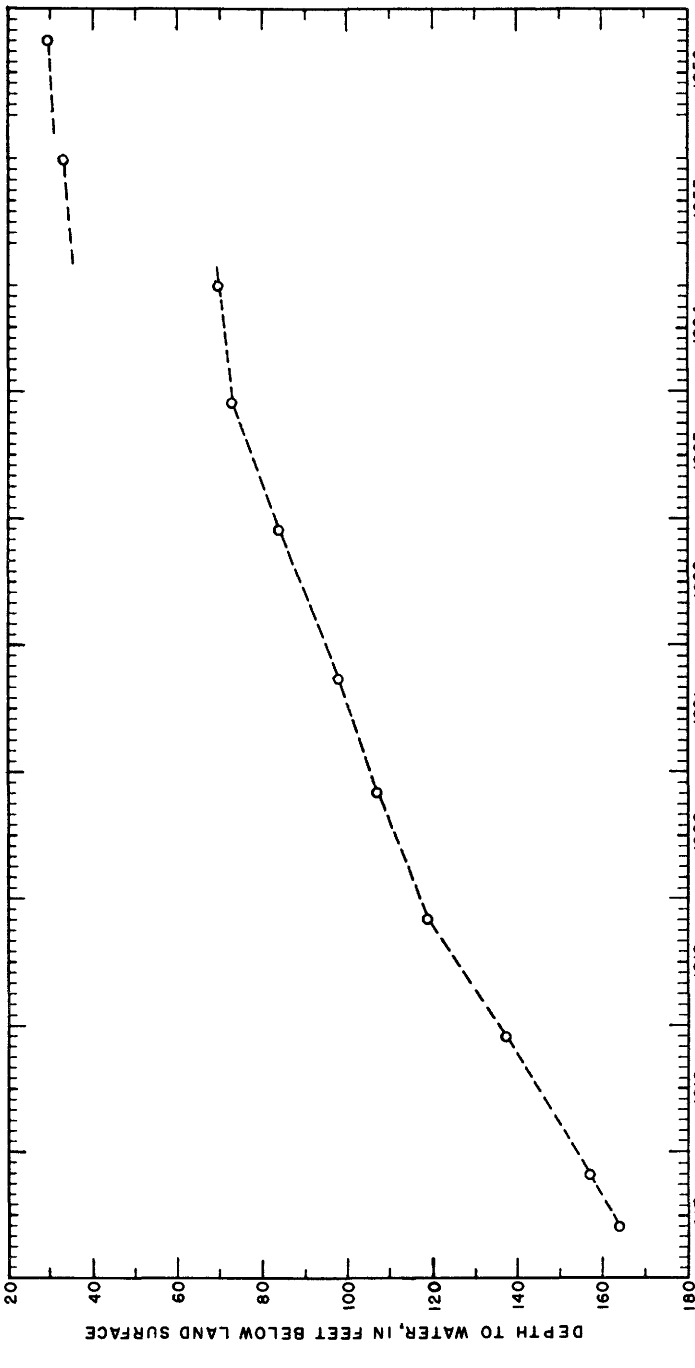

FIGURE 8.—Hydrograph of well 2N-3W-8ab1 for the period 1917-56 showing long-term net rise of water table.

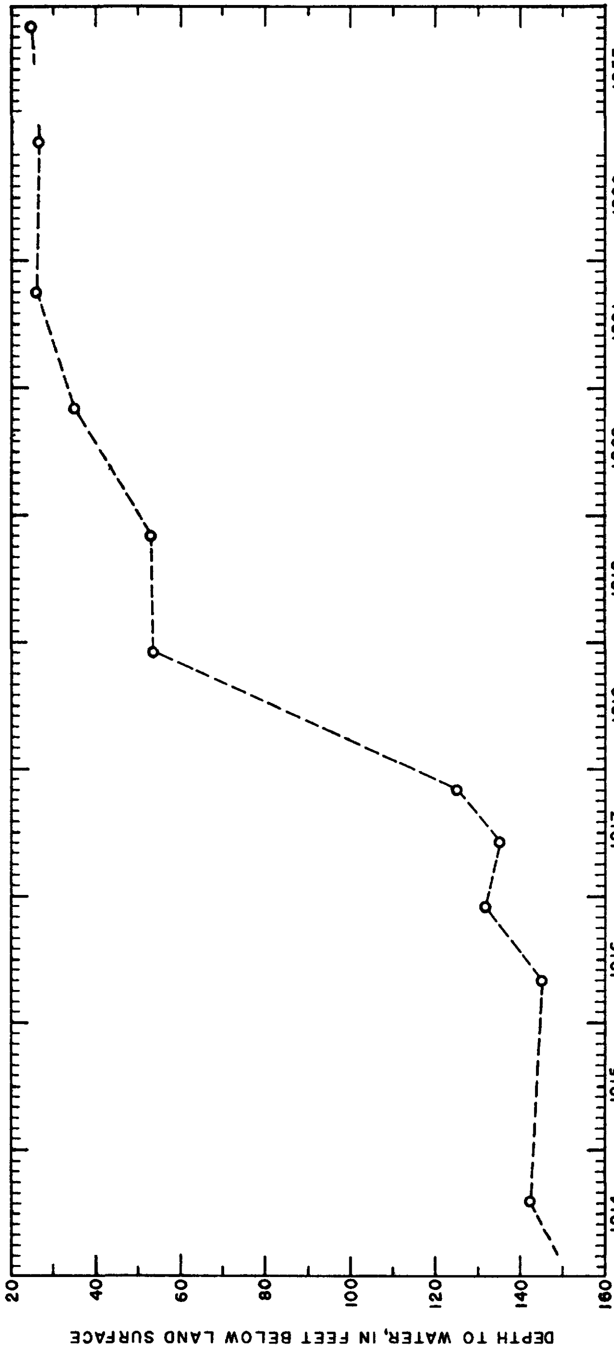

FIGURE 9.—Hydrograph of well 2N-3W-18cb1 for the period 1914–53 showing long-term net rise of water table.

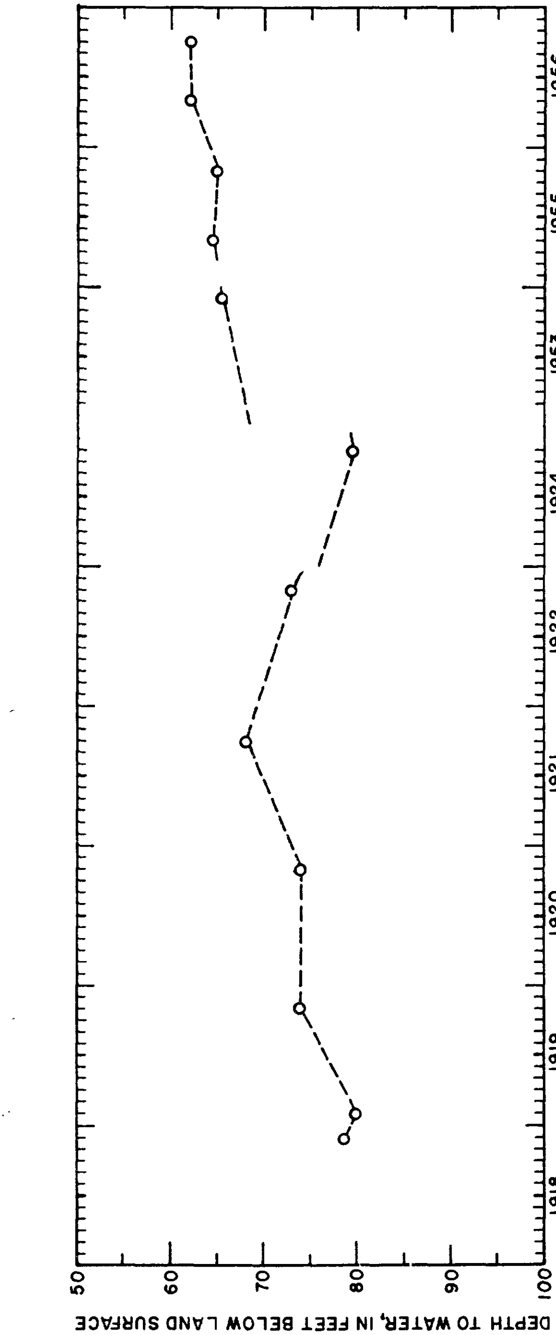

FIGURE 10.—Hydrograph of well 2N-2W-22cb1 for the period 1918–56 showing long-term net rise of water table.

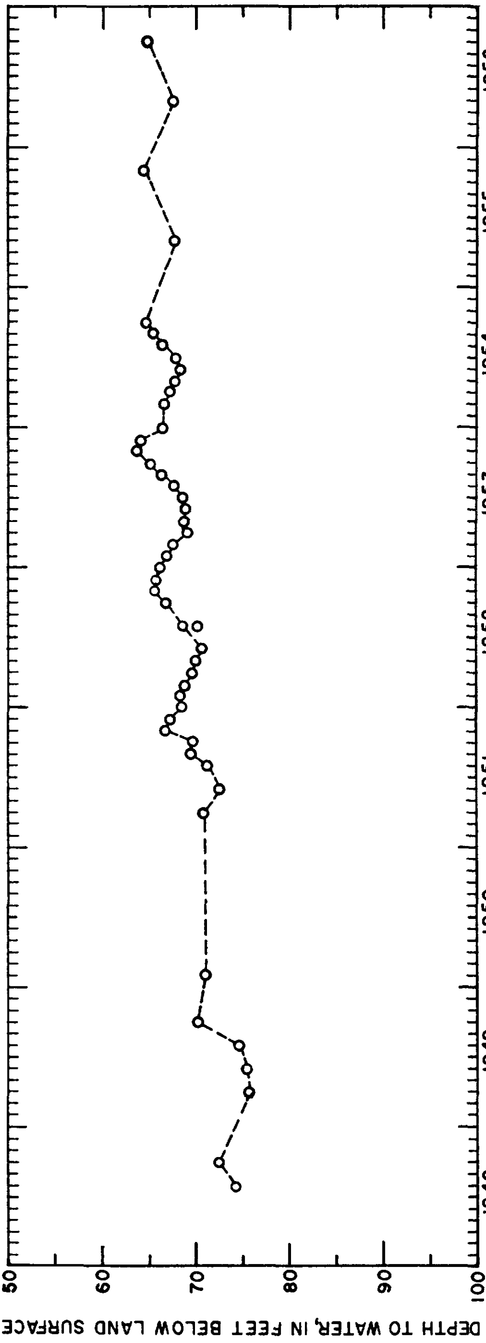

FIGURE 11.—Hydrograph of well 1N-2W-4bc1 for the period 1948–56 showing seasonal and other water-level fluctuations.

The rise of the water table in the irrigated area indicates that the amount of ground water in storage has been increasing for many years. An increase in the amount of ground water in storage following irrigation of the Dry Lake area likewise can be expected.

CHANGE IN RECHARGE

Application of irrigation water will increase ground-water recharge several fold. Although the quantity of recharge cannot be calculated exactly, a rough estimate of the increase in recharge in the Dry Lake area can be made. The net diversion and farm delivery requirements have been estimated by the U.S. Bureau of Reclamation (written communication, March 10, 1958) to be 5.10 and 3.8 acre-feet per irrigable acre, respectively. The difference, 1.30 acre-feet, is conveyance loss, much of which will become ground-water recharge. The water delivered to the area ultimately will be disposed of in one of the following four categories: (a) surface waste, (b) consumptive use by crops, (c) evaporation and transpiration by noncrop vegetation, and (d) recharge by deep penetration to the ground water.

It is estimated by the Bureau of Reclamation on the basis of surface-waste studies in other areas, that surface waste will be 15 to 18 percent of total diversion to the area, or approximately 0.9 acre-feet per irrigated acre.

Consumptive use by irrigated crops has been estimated (U.S. Bureau of Reclamation, 1955, p. 20–21) to average 2.22 acre-feet per acre. The net consumptive use under project operation (allowing for normal precipitation) would average 2.1 acre-feet per acre.

Considerable water will be lost by evaporation from free-water surfaces and by evapotranspiration in areas of seepage. These losses cannot be predicted with any degree of accuracy, but a reasonable estimate might be 25 percent of the consumptive use on irrigated lands, or about 0.50 acre-feet per acre.

The increase in recharge to ground water in the area thus would be the difference between the total diversion to the area and the other uses, which would be about 1.6 acre-foot per acre (5.10—0.9—2.1—0.5). For the area of 23,200 acres, this would represent a gain in annual recharge of about 40,000 acre-feet annually.

POTENTIAL DRAINAGE PROBLEMS

The proposed irrigation of the Dry Lake area and the probable resulting rise of water levels poses potential drainage problems in adjacent areas where a high water table already exists. Drainage problems probably will develop also within the Dry Lake area, owing to the development of local perched water tables.

Drainage problems have existed for some time on the terrace in T. 1 S., R. 2 W. secs. 3, 4, 9, 10, and 14. Numerous open drains have been constructed, and many flowing drainage wells have been drilled to alleviate the problem in that area. Construction of the proposed reservoir on the Snake River would raise the water level of the river about 105 feet to an altitude of about 2,354 feet above mean sea level, and cause the water table to rise. Existing drainage problems on the terrace would be further complicated, and new ones might develop south and southwest of this area where the water table already is near the surface. The rise in the water table would continue until a new equilibrium between recharge and discharge was established. Seepage losses from proposed canals would also complicate the drainage problem by increasing recharge in this area.

Between the Dry Lake area and Lake Lowell the water table is only a few (0 to 20) feet below the land surface. Fluctuations of the water levels in wells in this area correlate with the stage of Lake Lowell. Some of the land already is waterlogged, and a small rise in the water table would increase the size of the waterlogged area. Irrigation of the Dry Lake area and the resulting southward shift of the ground-water divide would increase the quantity of ground water moving northward through this area, and a rise in the water table would occur. However, the southward expansion of the seepage-problem area would be limited by the topography, which rises rather steeply southward from the Mora Canal.

West of the Dry Lake area (between that area and the Snake River) in secs. 7, 18, and 19, T. 2 N., R. 3 W., and secs. 12, 13, 23, 24, 25, and 26, T. 2 N., R. 4 W., the water table is at shallow depth. Open ditches intersecting the water table have been constructed and these function as ground-water drains. Irrigation of the Dry Lake area would increase the quantity of ground water moving through the area to the Snake River, and a rise in the water table probably would occur. Complication of existing drainage problems and the spread of such problems are probable.

Within the Dry Lake area drainage problems resulting from a rising water table may be less serious than in the adjoining areas because the Dry Lake area is at a higher altitude. However, the porosity and permeability of the subsurface sediments vary greatly both laterally and vertically, and local drainage problems probably will develop. Drainage problems due to the development and rise of shallow perched water tables are likely to occur. Particularly in secs. 3, 10, 14, and 15, T. 1 N., R. 3 W., on the northern part of the southernmost terrace of the area, perched water may cause a drainage problem. This terrace is capped by relatively permeable basalt which is underlain by less permeable sediments of the Idaho formation. Another place where perched water probably will create drainage problems is the basin in the vicinity of Dry Lake.

WITHDRAWAL CAPACITY AND DRAINAGE EFFECT OF WELLS

It is estimated that 9,000 acre-feet of ground water a year is currently pumped from wells in the Dry Lake area. If the estimate of recharge subsequent to project development is correct, 40,000 acre-feet annually, considerable additional water could be pumped to supplement surface water for irrigation and to help forestall drainage problems in the Dry Lake area. However, the feasibility of using the ground water depends on how efficiently wells can withdraw water from the ground.

In the Dry Lake area the rise in the water table would result in additional strata in the Idaho formation being water bearing. The water-bearing properties of these newly saturated strata would be similar to the existing aquifers in that formation, and yields similar to those now obtained could be expected from new wells in the Dry Lake area. In the areas adjoining the Dry Lake area to the east and north the rise in the water table might be sufficient to saturate some Snake River basalt that is currently dry. Wells drilled into these water-bearing zones could be expected to have yields similar to existing wells in the Snake River basalt which substantially exceed the average yields of wells in the Idaho formation. A rise in the water table sufficient to cause strata in the terrace gravels to become water bearing is not anticipated.

The water-bearing properties of the aquifers in the Dry Lake area differ greatly both vertically and laterally in short distances. The coarse well-sorted strata yield water readily to wells, but the fine-grained strata yield water slowly. Pumping a given amount of water from fine-grained material may lower the water table several times as much as pumping the same amount of water from a coarse material. Although details of the hydraulic characteristics of the aquifers in the Dry Lake area are not now available, a qualitative estimate based on available data indicates that pumping 40,000 acre-feet of ground water per year in the Dry Lake area under project operation would not exceed the perennial yield. However, the drainage benefits to be derived from such pumping would depend upon the degree to which economical pumping of ground water for irrigation could be coupled with effective drainage. Withdrawal of appreciable quantities of ground water would undoubtedly retard the rate of rise of the water table in the Dry Lake area following irrigation and would thereby reduce the spread of the drainage problems in the adjoining areas. However, even a slight rise in the water table in these adjoining areas would cause drainage problems to develop on many acres that are not now affected. Pumping ground water from wells in the Dry Lake area would provide supplemental water for irrigation, but it could not completely prevent aggravation and extension of existing drainage problems by irrigation of the Dry Lake area.

Pumping from wells in the areas afflicted with drainage problems would provide drainage benefits in these areas. However, the location of such wells would require high pumping lifts to deliver irrigation water to the Dry Lake area. Ground water pumped from drainage wells in these areas might be efficiently used for irrigation of nearby land that is currently irrigated with surface water. The combination of pumpage in the Dry Lake area (to supplement surface water for irrigation and retard the rate of rise of the water table) and pumpage in the areas afflicted with drainage problems (principally to provide drainage benefits) might be satisfactory.

CHANGES IN THE QUALITY OF THE GROUND WATER

The concentration of dissolved solids increases, and the chemical quality of water generally deteriorates as it passes through an irrigation cycle. Water from the Snake River contains less dissolved mineral matter than most of the ground water in the Dry Lake area, but considerably more mineral matter than the surface water currently used for irrigation in southern Canyon County. Under project operation, soluble minerals in the soils and sediments would be dissolved by the imported irrigation water, thus increasing the concentration of dissolved solids in the water. Disintegrating organic debris from crops would provide soluble nitrogenous matter and weak acids to the infiltrate. As a result, its solvent power would substantially exceed that of natural-recharge water. Fertilizers and soil amenders that do not occur naturally would be dissolved in the infiltrate. Transpiration of irrigation water by plants would concentrate mineral matter in the water percolating downward to the water table. The concentration of sodium in the Snake River water is considerably less than the concentration of sodium in the ground water in the Idaho formation. Assuming that base exchange would not appreciably raise the concentration of sodium in the infiltrate, it is possible that infiltration of Snake River water could reduce the concentration of sodium of the ground water in the Idaho formation despite an increase in the concentration of dissolved solids.

SUMMARY

The Snake River basalt and the Idaho formation are the most important water-bearing formations in southern Canyon County. The Snake River basalt is above the water table in most of the area, but where saturated it yields water to wells in moderate to large quantities. Confined ground water occurs in the Snake River basalt south of Melba where waterlogging of land is caused by upward leak-

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age of artesian water through imperfectly confining layers of surficial deposits including a calichelike lime layer. The Idaho formation, the most important aquifer in the area, yields as much as 1,600 gpm of unconfined and confined ground water to pumped wells. Small bodies of perched ground water occur in the Snake River basalt and the Idaho formation, but they are not an important source of water.

A high water table is responsible for drainage problems and waterlogged land in the area bodering the south side of Lake Lowell and between the Snake River and the western border of the Dry Lake area.

Recharge to the ground water body in the Dry Lake area is from (a) direct infiltration of precipitation, (b) underflow from outside the area via leaky artesian aquifers, and (c) underflow from adjacent irrigated land. Recharge from precipitation on the Dry Lake area is estimated at about 9,000 acre-feet yearly.

A ground-water divide extends from between the New York and Mora Canals, about a quarter of a mile south of Bowmont, northwestward, paralleling the Mora Canal, to the south side of Lake Lowell. South of this divide the unconfined ground water moves south and west to the Snake River which serves as a ground-water drain. North of the divide the unconfined ground water moves northward to Lake Lowell. Artesian water in the Idaho and underlying formations moves northeastward away from the Owyhee Mountains toward the axis of the Snake River downwarp.

The depths of irrigation wells in the Dry Lake area range from about 230 to 1,200 feet and average about 500 feet. Pumping lifts range from about 170 feet to more than 500 feet. Specific capacities of wells range from less than 2 gpm per foot of drawdown to more than 60 gpm per foot of drawdown; the wide range is due to large variations in the permeability of the Idaho formation and to differences in well construction.

The ground waters in southern Canyon County generally contain calcium or sodium as the predominant cation and bicarbonate or sulfate as the predominant anion. Most of the ground waters are suitable for irrigation. The thermal gradient in wells is 3° to 4° F for every 100 feet in depth. The temperature of the water in well 1N–3W–12ba1, the deepest well (1,265 ft) in the Dry Lake area, was 92° F.

Many changes in the ground-water regimen will occur subsequent to irrigation of the Dry Lake area. Yearly recharge of ground water would increase greatly, and the ground-water divide would shift to the south or southwest. Additional recharge in the Dry Lake area would result in reduced depths to water below land surface and lower pumping lifts and would increase the amount of water in storage. Existing drainage problems in southern Canyon County would be further aggravated and would become more widespread because of a general rise in the water table. Shallow perched water may cause drainage problems within the Dry Lake area, but these could be minimized by adequate drainage of waste water and efficient water-management practices. However, major drainage problems are unlikely within the Dry Lake area. A qualitative estimate based on available data indicates that 40,000 acre-feet of ground water yearly could be pumped from wells in the Dry Lake area subsequent to irrigation without exceeding the perennial yield. Such pumping would retard, but would not completely prevent, a rise in the water table in areas where drainage problems already exist. Pumping ground water in the Dry Lake area to supplement surface water for irrigation and retard the rate of rise of the water table and pumping in the areas afflicted with drainage problems, principally to provide drainage benefits, might prove to be the most satisfactory method of alleviating these problems. Details of the hydraulic properties of the aquifers are not now available, but they would be necessary to determine the optimum number, depth, spacing, pumping lifts, and capacities of wells and to estimate the drainage benefits which might be expected from pumping.

Present data are inadequate for a full answer to questions regarding the ground-water regimen under the proposed irrigation development of the Dry Lake area. Depth-to-water measurements in representative wells in the area should be continued to determine the long- and short-term trends in water-table fluctuations. The frequency of such measurements should be increased and the number of wells should be increased to provide better coverage of the area. Further geologic investigation is needed to determine the position, lithology, thickness, and areal extent of the artesian aquifers in the subsurface. Collection and examination of drill cuttings would be an essential part of such an investigation. Periodic analyses of the chemical quality of the ground water should be made during and after construction of the Guffey Unit to determine the extent and nature of the changes in the chemical quality of the ground water and to determine the effect of such changes upon the suitability of the ground water for irrigation. Carefully controlled pumping tests should be made to provide data on the hydraulic properties of the aquifers. Such data are essential to an adequate appraisal of the ground-water regimen and the effects upon it of irrigation of the Dry Lake area.

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BASIC DATA

TABLE 5.—*Records of wells in southern Canyon County, Idaho*

Altitude: Altitudes expressed in feet, tenths, and hundredths were determined by spirit leveling by the U.S. Bureau of Reclamation. Altitudes followed by the letter "B" were determined by aneroid leveling by the U.S. Geological Survey. All other altitudes were interpolated from topographic maps.
Type of well: Dr, drilled; D, dug.
Depths and water levels: Measured depths of wells are given to the nearest tenth of a foot; reported depths to the nearest whole foot. Measured depths to water are given to the nearest hundredth of a foot; reported depths to the nearest whole foot; an asterisk after depth indicates airline measurement; the letter P following measurement indicates well was being pumped at time measurement was made; date indicates day, month, and year measurement was made; altitude of water is altitude, in feet above mean sea level, at date of measurement.
Type of pump: C, centrifugal; J, jet; L, lift; P, piston; S, submersible; T, turbine.
Use of water: A, abandoned or destroyed; D, domestic; Dr, drainage; I, irrigation; O, observation; PS, public supply; S, stock; U, unused.
Remarks: L, driller's log of well available; LR, driller's log in report; M, depth to water in well could not be measured; MD, accuracy of depth to water measurement doubtful; W, well was being drilled when visited; Dd, drawdown; gpm, gallons per minute.
All yield and drawdown data reported.

Well	Owner	Altitude of land surface (feet above mean sea level)	Type of well	Year drilled	Depth of well (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Aquifer or water-bearing formation	Water level: Depth of water (feet below land surface)	Water level: Date	Water level: Altitude of water surface (feet below mean sea level)	Pump: Type	Pump: Horsepower	Use of water	Remarks
3N-4W-25db1	John J. Hockberger		Dr	1950	432	12-10	432	Idaho fm sand and gravel.	126.21	8-7-56				U	LR
25db2	do		Dr	1950	170	12	128	do	115*P	8-7-56		T	25	I	LR, Dd 18 ft at 500 gpm.
3N-3W-29cd1	G. A. Saxton		Dr	1953	187	12	156	Idaho fm sand	83*P	8-6-56		T	20	I	LR, Dd 11 ft at 675 gpm.
31aa1	Lester Walker		Dr	1952	155.7	12		Idaho fm	123.94	8-7-56		T	30	I	
31ad1	John E. Walker		Dr	1952	187.5	10	172	do	97.4	8-7-56		T	25	I	LR, Dd 55 ft at 450 gpm.
31dc1	L. C. Peterson		Dr	1920's	120	4		do	96.98	9-5-56		P	3/4	D, S	Original depth 250 ft caved in 1946.
32ab1	G. A. Saxton		Dr	1950	156	12	160	Idaho fm sand	93*P	8-7-56		T	25	I	LR, Dd 30 ft at 900 gpm.
32ca1	Marvin Cuddeback		Dr	1953	278	12	250	do	125.42	9-5-56		T	40	I	LR, Dd 15 ft at 675 gpm.
32dd1	G. A. Saxton		Dr		415	4	200	do	62.32	9-5-56		S	3/4	D, S	
2N-3W-2dc1	Mike Fithian	2,549.02	D	1917	45.9			Terrace gravel and sand.	27.28	9-6-56	2,521.74	J		D, S	
3ca1	John L. Duncan		Dr			6		do	7.65	9-7-56		J		D, S	
3cb1	L. J. Garner		Dr	1911	210	6	210	Idaho fm				P		D	M
3da1	Ralph Clemens		Dr									C	1/3	D, S	M
3dd1	George Keprow		Dr			6		Terrace gravels and Idaho fm.	26.14	9-5-56		J	1	D	
4ba1	Lawrence Cox		D		64.4	32	Concrete	Terrace gravels	3.22	9-7-56		J	1/4	D, S	
4da1	Dave Garner		Dr			4		do				J	1/4	D, S	M

4dd1	Virgil Farner		Dr					Idaho fm (?)				J	½	D, S	M
5bb1	W. J. Lloyd		Dr			4		do				S	¾	D, S	M
6bb1	Ernest Ward		Dr	1929	415	4		Idaho fm	194.48	9- 5-56		P	1	D	
6db1	J. Loyd Harvey	2,609.88	Dr			4		do	208.44	9- 6-56	2,401.44			U, O	
7aa1	Fallon	2,627.52	Dr	1950	191	6	182	do	132.34	9- 6-56	2,495.18	J	1½	D, S	LR
8ab1	Earl Lyons	2,582.70	D					Terrace gravels	33.90	9- 6-56	2,548.80	J	3	D	Irrigates lawn and yard.
8da1	Glenn Knapp	2,702	Dr	1955	280	14-13	268	Idaho fm	191.15	9- 6-56	2,511	T	50	I	LR
9ad1	H. R. Newman	2,626.92	Dr	1910	240			do	5.62	10-22-53	2,621.30	W		S	
9ba1	Glenn Knapp	2,600.91	Dr		246	4		Terrace gravels and Idaho fm.	56.77	9- 6-56	2,544.13	J	½	D, S	
9bc1	do	2,632	Dr		224	12-10	213	Idaho fm	123*P	9- 6-56	2,509	T	30	I	LR
9cc1	George Walker	2,659	Dr	1955	280	14-13	252	do	165*P	8- 1-56	2,494	T	50	I	LR, Dd 57 ft at 700 gpm.
10ab1	do		Dr		250	6		do	37.08	9- 6-56		J	¾	D, S	
10ba1	do	2,584.78	D	1917	105	48		Terrace gravels	26.10	9- 6-56	2,558.68	J	1	D, S	
10bb1	Vivian Liechty		Dr	1937	177	6		do				J	¾	D, S	M
11ad1	George J. Shoemaker.		D					do	8.30	10-18-53				U	
11bb2	Orlin Black		Dr	1944	300			Idaho fm				P	¾	D, S	
12ac1	C. Elmer Allen		D		42							J		D, S	M
12bc1	Douglas Hyslop		Dr					Terrace gravels				C	1	D, S	M
12bd1	C. Elmer Allen		Dr		75	26		do	25.00	9- 7-56		T	2	D, S	
12da1	Ralph Hyslop		Dr	1953	48	4		Basalt	21.35	9- 7-56		P	⅓	S	
13bc1	Ladislev Maglecic	2,710.89	Dr	1953	310	12-11	304	Idaho fm	197.95	9- 7-56	2,512.94	T	70	I	LR
15cb1	Harry Dollarhide	2,718	Dr	1956		12		do				T	50	I	M
15cc1	do	2,726	Dr	1954	307	12-11	284	do	214.58	9- 6-56	2,512	T	50	I	LR
16dc1	George Johnson	2,776	Dr		349	12		Idaho fm	278	8- 7-56	2,498			U	LR, MD
17cc1	Brendell Bros	2,778	Dr		520			do				P	¾	D, S	M
18ca1	R. S. Freeman		Dr	1913	500			do				J	1	D, S	M
18cb1	Albert Mutch		D	1910	163			do	39.79	9- 6-56		P	1	D, S	
20bb1	Elmer Armfield	2,469.40	Dr		750	6	16	do	21.90	9- 6-56	2,447.50	J	1	D, S	
22bd1	R. E. Balley & Son	2,778	Dr	1949	980			do				T	125	I	M
22cb1	do	2,781	Dr	1950	832	12-10-8		do				T	125	I	M, Dd 45 ft at 780 gpm.
23cc1	do	2,721	Dr	1956	300			do					1	D	L, M
23cd1	do	2,721	Dr	1953	360	10	360	do				T	60	I	LR, M, Dd 85 ft at 540 gpm.
27ba1	do	2,842.05	Dr	1952	332	12		do	406.84	10-14-53	2,433.21	T	75	I	LR
34db1	D. W. Frost	2,732.19	Dr	1952	360	12	352	do	340.86 P	10-16-53	2,391.33 P	T	60	I	LR, Dd 25 ft at 470 gpm.
35ca1	Bruce Hoofnaegel	2,758.88	Dr	1953	470	12	420	do	408*P	9- 6-56	2,350	T	100	I	M
35cb1	do	2,743.56	Dr	1953	488	12	300	do	347.26	9- 6-56	2,391.33			U	
2N-2W-13ba1	Jennings	2,585.00	Dr	1945	93.0	6	21	Idaho fm and basalt.	47.80	10-10-56	2,537.2	P		U, O	L
18db1	Masa Nakamura	2,560B	Dr	1943	115	8	9	Basalt	21.81	9- 5-56	2,538.19	T	7½	I	

TABLE 5.—*Records of wells in southern Canyon County, Idaho*—Continued

Well	Owner	Altitude of land surface (feet above sea level)	Type of well	Year drilled	Depth of well (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Aquifer or water-bearing formation	Water level: Depth of water (feet below land surface)	Water level: Date	Water level: Altitude of water surface (feet below mean sea level)	Pump: Type	Pump: Horsepower	Use of water	Remarks
2N-2W-19bb1	Greenway		Dr					Basalt				J	¾	D, S	M
19bd1	Eggers		Dr		190							P	½	D, S	M
20aa1	Beckwith		Dr		58	6						J	½	D, S	M
21aa1	E. C. White		D									J	⅓	D, S	M
22aa1	Frank Stevens		Dr	1917	100	4		Basalt				J	1	D, S	M
22cb1	Mitchell	2,576 B	Dr		152	4		Terrace gravel	62.03	9-5-56	2,533.97			D	
23bb1	F. Exley		Dr		86.6			do				J	1	D, S	M
23cb1	Swartz	2,669 B	Dr		165.0	4		Terrace gravel and Idaho fm.	113.2	11-27-53	2,555.8			U	
23cb2	do		Dr	1951	281	6-4	281	Idaho fm				P	1	D, S	LR, M
24ba1	Roark	2,648 B	Dr		132	4						J	½	D, S	M
24db1	Joseph		D-Dr	1916	131.6	4		Basalt				P	⅓	D, S	M
25ad1	Dewald		Dr	1918	188.5	4		do				J	1	D, S	M
25bb1	H. P. Kloepfer		Dr	1917	119			do				P	¾	D, S	M
25dd1	Davis		Dr		175	4		do				J	1	D, S	M
26dd1	V. Danek	2,648 B	Dr			4			63.2	10-27-53	2,623.8	J	1	D, S	
27ab2	James D. Agenbroad		Dr		450	12		Idaho fm				T	125	I	M
29aa1	Blacksma	2,560.82	Dr		180							J	½	D, S	M
29ac1	Jess Talich		Dr	1946	330	4	330	Idaho fm				J	1	D, S	LR, M
30bb1	Hennis		Dr									P	1	D, S	M
31ad1	George Zap	2,687	Dr	1949	545	8-6	545	Idaho fm				T	30	I	LR, M
34aa1	Dale Grass		Dr		338	14-13-11	303	do				T		I	LR, Dd 148 ft at 690 gpm.
34da1	Boyd	2,658 B	Dr	1913	208	4		do	92.0	11-25-53	2,566	P	1½	D, S	
35ad1	J. T. Eubanks	2,662 B	Dr	1917	158				75.2	11-27-53	2,586.8	J	1	D	
1N-3W-1bd1	John Maglecic	2,751	Dr	1956	415	12		Idaho fm	310.53	10-2-56	2,440.47			U	
2cb1	Rex Jensen	2,751	Dr	1946	1,000	6	500	do	373.63	9-5-56	2,377.37	P		S, O	
12ba1	Elmer Tiegs	2,744	Dr	1956	1,265	12-10-8		do				T	150	I	M, Dd 150 ft at 378 gpm.
1N-2W-1aa1	P. G. Gross		Dr	1937	570	6		Basalt and Idaho fm.				P	¾	D, S	M
2cc1	Stillman Moulton	2,660 B	Dr		224	4			91.04	10-5-53	2,569	J	1	D, S	
2db1	D. L. Dunning		Dr	1945	205	6	30	Basalt				J	1	D, S	LR, M
3ab1	Charles Fiedler		Dr			12		Idaho fm	222*P	7-24-56		T	50	I	M
3bb1	C. E. Ruddick		Dr	1955	295	12-11	290	do				T	40	I	LR, M, Dd 58 ft at 520 gpm.
3cb1	Steve Hennis	2,730 B	Dr	1953	385	12-10	268	do	156.76	11-19-53	2,573.24	T	50	I	LR, M

4bc1	Edwin Tiegs	2,638.20	Dr	1914	213	4		Basalt and terrace gravel.	62.44	9-5-56	2,575.76	J	½	D, S, O	LR
4bc2	do		Dr	1955	319	6	305	Idaho fm				J	1	D, S	M
4da1	do	2,747	Dr	1955	800	12-10-8-6	800	do	171.88	9-6-56		T	75	I	Dd 305 ft at 810 gpm.
5cb1	Leonard Tiegs	2,687	Dr	1952	437	10	415	do	166.02	9-30-53	2,529	T	50	I	LR, M, Dd 62 ft at 800 gpm.
6ad1	do	2,728	Dr	1956	720	12		do	276*P	7-24-56	2,452	T	75	I	M
8ab1	Donald Tiegs	2,697	Dr	1954	600	16-10-8		do				T	125	I	M, Dd 120 ft at 900 gpm.
9ad1	H. J. Yoder		Dr	1921	360							P	1½	D, S	M
9dd1	G. H. Ruggles	2,658	Dr	1949	144	6	144	Idaho fm	109.28	9-6-56	2,548.72	J		D, S	
10ba1	Sam Porter		Dr	1955	444	12	344	do				T	30	I	
10bb1	Walton Brown		Dr		400	5						J	1	D, S	M
10cb1	W. J. Lloyd		Dr		128	6			87.87	9-7-56		J	1	D, S	
10dd1	J. E. Grantham		Dr	1946	204	6		Basalt				P	½	D, S	LR
14da1	Belky	2,673 B	Dr	1918	325	6		Basalt and Idaho fm.	109.29	9-7-56	2,563.71	J	1	D, S	
14dc1	Don Mullen		Dr	1917	260							P		U	M
15bd1	G. H. Poppow		Dr	1945	165	6	6					J	2	D, S	M
15dc1	Stanley Hall		Dr		110	6			98.45	9-7-56		S	½	D, S	
16bc1	Herbert Tiegs	2,730	Dr	1956										I	W
16cb1	do	2,742	Dr	1952	475	16	376	Idaho				T	200	I	M, Dd 90 ft at 1,665 gpm.
17da1	Kenneth Tiegs	2,718	Dr		425	16	200	do				T	200	I	M
17dc1	do	2,748	Dr		680	12-8	680	do				T	100	I	LR, M
18cd1	Rex Jensen	2,697	Dr	1946	285							P		S	M
22bc1	H. C. Stewart		Dr									T	3	D, S	M
22cc1	J. W. Miller		Dr	1930	220	6	20					P	1½	D, S	M
22cd1	Harry Pitman		Dr			6						P	¾	D, S	M
22db1	Peter Ward		Dr	1941	225	6	6					P	1½	D, S	M
23bb1	Nate Clark		Dr	1949	165	8	4	Basalt	111.78	9-6-56		S	2	D, S	
23cc1	D. P. Montgomery and D. E. Parsons		Dr	1946	195	6	2	do				P	2	D, S	
24dc1	Owen Furiman		Dr	1947	177	6		do				J	2	D, S	LR, M
25ad1	Blanksman		Dr	1947	220			Basalt				P	1½	D, S	L
26ad1	Robert Morris		Dr	1951	375	6		do				J	2	D, S	L
26cc1	L. I. Robinson		Dr			6		do	145.86	9-6-56		P	¾	D, S	
26dc1	Myrna Ferris		Dr			4						P	2	D, S	
27cb1	Charles Flahiff		Dr	1916	286	4		Basalt				P	3	D, S	LR, M
27cc1	John Farner	2,722 B	Dr	1917	269	4		do	172.82	10-6-53		P	2	D, S	L
28aa1	Winnie Johnson	2,260	Dr	1920		6			193.20	8-29-56	2,067.30	J	2	D, S	
34aa1	Ray McClaran		Dr	1925	234	6	30	Basalt				P	1½	D, S	M
34ac1	George Smith		Dr	1948	230	6		do				P	¾	D, S	LR, M
35aa1	Al Barr	2,640 B	Dr	1948	255	6	20.5	do	211.74	8-7-53	2,428.26	P	1	D, S	LR
35ba1	Ray McClaran		Dr	1925	234	6	20					S	¾	D, S	M
35cc1	Russel Harpster	2,583 B	Dr	1952	177	6	20	Basalt	148.49	9-6-56	2,434.51	J	1½	D, S	LR
36ba1	Brown	2,686 B	Dr	1949	255	4		do	226.5	10-6-53	2,459.50	P	2½	D, S	LR
36bc1	Alfred Sayrock		Dr	1930	510	4	468	do						A	L
36bd1	Town of Melba		Dr	1956	617	8-6	617	Idaho fm	256*	7-25-56		T	25	PS	LR, M, Dd 24 ft at 250 gpm.

TABLE 5.—*Records of wells in southern Canyon County, Idaho*—Continued

Well	Owner	Altitude of land surface (feet above sea level)	Type of well	Year drilled	Depth of well (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Aquifer or water-bearing formation	Water level: Depth of water (feet below land surface)	Water level: Date	Water level: Altitude of water surface (feet below mean sea level)	Pump: Type	Pump: Horsepower	Use of water	Remarks
1S-2W- 2bb1	W. E. Fine		Dr	1913	249	6						J	1	D, S	
2cd1	G. C. Miller		Dr		102	4								D, S	M
3dc1	B. W. Kauffman		Dr	1950	76	8		Basalt	Flows					D, S, Dr	
3dc2	do		Dr	1953	73	12		do	Flows					I	
3dc3	do		Dr					do	Flows					I	
3dc4	Boise-Kuna Irrigation Dist.		Dr	1948	24	16	8	do	Flows					I	LR
3dc5	B. W. Kauffman		Dr		28	16	12	do	Flows					I	L
3dd2	Reynolds Irrigation Dist.		Dr	1950	71	12¾	45	do	Flows					I	L
3dd3	do		Dr	1950	71	12¾	45	do	Flows					I	L
3dd4	do	2,377 B	Dr					do	Flows					I	
3dd5	do		Dr	1949	26			do	Flows					I	
4dd1	Carl E. Nicholson		Dr		73	12	44	do	Flows			C	30	I	LR
10ab1	Carl Nicholson		Dr	1953	80	14		do	Flows					I	
11ad1	J. M. Brown		Dr	1919	147	6						J	1	D, S	M
12bb1	A. L. Seeger	2,497 B	Dr	1948	220	6		Basalt	124.30	9-7-56	2,372.7	J	1	D, S	LR
12bc1	Russell Knapp		Dr	1948	138	6	11	do	102.09	10-8-53		J	1	D, S	L
14ac2	Boise-Kuna Irrigation Dist.		Dr	1948		16	12	do	Flows					I	LR
14ac3	U.S. Bureau of Reclamation.		Dr	1948	26			do	Flows					I	L
14ac4	do		Dr			16		do	Flows					I	
14ac5	do		Dr			16		do	Flows					I	
14ac6	do		Dr			12		do	Flows					I	
14ac7	do		Dr			12		do	Flows					I	
14ad1	Bird Hawley		Dr	1925	98	6		do	65.16	8-10-56		J	1	D	L
14db1	Rex Jensen		Dr	1953	80	12	40					C	15	I	Dd 28 ft at 720 gpm.
14db2	Boise-Kuna Irrigation Dist.		Dr	1948	54	6	22.5	Basalt and alluvium.	Flows					I	L
14db3	do		Dr	1948	43	6	21.3	do	Flows					I	L
15bb1	A. C. Simpson		Dr		69	6			40.53	8-10-56		J	1	D, S	
17ab1	Dr. Swayne		Dr	1953	2,300	8	62	Idaha fm	Flows					D, S	L
22aa1	Rex Jensen		D		39	24		Alluvium	29.49	9-7-56		P	½	D	
24bd1	R. M. Peckham		Dr			6			92.28	9-6-56		J	1	D, S	
25bd1	Rex Jensen		Dr	1951	800	12-10-8	800	Idaho fm				T	30	D, I	L

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*

[The well logs contained herein were obtained from the owners and drillers of wells. The terminology of the logs has been slightly modified to achieve uniformity and clarity]

Material	Thickness (feet)	Depth (feet)
3N-4W-25db1. John J. Hockberger		
Soil	4	4
Hardpan	2	6
Cinders, red, and shale	43	49
Basalt	2	51
Cinders, red, and shale	23	74
Clay, blue, hard	12	86
Cinders, red, and shale	10	96
Clay	8	104
Clay, sandy	32	136
Gravel, pea	16	152
Clay, hard	54	206
Clay, sandy	5	211
Clay	25	236
Shale	10	246
Clay, sandy	45	291
Clay, hard	4	295
Clay	20	315
Clay, hard	24	339
Clay, blue-black, hard	50	389
Clay, yellow	4	393
Clay, blue, hard	12	405
Clay, blue, sandy	32	437
Clay, blue, sandy	6	443
3N-4W-25db2. John J. Hockberger		
Soil	4	4
Clay, sandy	30	34
Cinders, red, and gravel	46	80
Basalt	2	82
Sand	28	110
Clay, hard	6	116
Gravel	12	128
Clay	20	148
Shale	22	170

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
3N-3W-29cd1. G. A. Saxton		
[Casing, 12-in., 0-156 ft. Perforated, 80-156 ft. Well filled in to 115 ft]		
Soil	3	3
Boulders	8	11
Clay, yellow	46	57
Sand, fine, caving; water	33	90
Clay, sandy	6	96
Sand and water	32	128
Clay, yellow	19	147
Clay, blue	14	161
Clay, yellow	4	165
Sand	22	187
3N-3W-31ad1. John E. Walker		
[Casing, 10 in., 0-172 ft. Perforated, 105-113 ft and 152-162 ft]		
Soil	1½	1½
Gravel	6	7½
Clay	2	9½
Clay, hard, sandy	10	19½
Sand	17	36½
Clay, hard	4	40½
Sand	18	58½
Clay, sandy	20	78½
Sand	15	93½
Sand, hard	12	105½
Sand	8	113½
Sand and clay	29	142½
Clay, hard	10	152½
Sand and shale	10	162½
Sand and clay, hard	15	177½
3N-3W-31bd1. John E. Walker		
[Casing, 6 in., 0-276 ft]		
Clay, sandy	10	10
Clay	30	40
Cinders	40	80
Clay, hard	10	90
Sand	2	92
Clay, sandy	20	112
Sand	79	191

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
3N-3W-31bd1. John E. Walker—Continued		
Clay, hard	24	215
Sand	20	235
Clay, hard	30	265
Sand and shale	7	272
Clay, hard	21	293
Shale and sand	4	297
3N-3W-32ab1. G. A. Saxton		
[Casing, 12 in., 0-160 ft]		
Soil	3	3
Gravel	2	5
Clay, yellow	80	85
Clay and sand	25	110
Sand, brown, very fine; water	38	148
Clay, blue	28	176
3N-3W-32ca1. Marvin Cuddeback		
[Casing, 12 in., 0-250 ft]		
Soil	4	4
Gravel and cobbles	26	30
Sand	20	50
Clay, yellow, sticky	73	123
Clay, brown, soft, and sand; water	35	158
Sand, brown	4	162
Clay, yellow	10	172
Sand, brown, soft	21	193
Clay	4	197
Sand, brown	3	200
Sand and clay	15	215
Sand, brown, soft; water	3	218
Sand, brown, hard	8	226
Sand, brown, soft, and clay	17	243
Clay, blue	12	255
Sand, brown, hard; water	10	265
Sand, brown, fine	4	269
Sand, very soft and clay	9	278

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
2N-3W-7aa1. Fallon		
[Casing: 6 in., 0-182 ft]		
Soil	2	2
Gravel, coarse	30	32
Clay and sand	53	85
Sand, coarse	20	105
Clay, sandy	10	115
Sand	76	191
2N-3W-8da1. Glenn Knapp		
Soil	3	3
Gravel	21	24
Clay and sand	8	32
Sand	52	84
Clay and sand	8	92
Sand, coarse	20	112
Sand, hard	5	117
Clay and sand	6	123
Sand	89	212
Sand and clay	13	225
Sand, coarse	7	232
Clay, hard	4	236
Shale, sand, and clay	24	260
Clay, hard, and sand	20	280
2N-3W-9bc1. Glenn Knapp		
[Casing: 12 in., 0-153 ft; 10 in., 153-213 ft. Perforated, 170-210 ft. Liner 10 in. ,0-104 ft]		
Soil	4	4
Gravel	18	22
Gravel and clay	10	32
Sand and clay	41	73
Sand and clay	114	187
Clay, hard	6	193
Sand	17	210
Clay, hard	12	222
Sand	2	224

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
2N-3W-9cc1. George Walker		
[Casing: 14 in., 0–200 ft; 13 in., 200–252 ft. Perforated, 132–140 ft, 194–199 ft, and 201–241 ft]		
Hardpan	2	2
Gravel	22	24
Sand	8	32
Clay, hard, and sand	35	67
Sand, fine	65	132
Clay, sandy	4	136
Sand, fine	62	198
Clay, sandy	4	202
Sand and clay, hard	8	210
Sand, clay, and shale	21	231
Shale and clay, hard	18	249
Clay, blue	20	269
Shale	10	279
Clay, hard	5	284
2N-3W-13bc1. Ladislev Maglecic		
[Well deepened later to 310 ft. Casing: 12 in., 0–280 ft.; 11 in., 280–304 ft. Perforated, 211–227 ft]		
Soil	3	3
Gravel	6	9
Gravel, sandy	7	16
Clay, sandy	12	28
Sand	8	36
Sand and clay, hard	55	91
Sand	10	101
Clay, sandy	12	113
Sand	11	124
Clay, hard	9	133
Sand	16	149
Sand and clay	62	211
Clay and sand	5	216
Clay	11	227
Sand	18	245
Clay	3	248
Sand, hard	20	268
Sand, coarse, and clay	12	280

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
2N-3W-15cc1. Harold Dollarhide		
Soil	4	4
Gravel and sand	42	46
Sand	4	50
Clay, sandy, hard	30	80
Clay	40	120
Sand, fine	108	228
Shale and clay	28	256
Sand and shale	14	270
Sand, fine	15	285
Clay and sand	5	290
Shale and clay	9	299
Clay, blue, hard	8	307
2N-3W-16dc1. George Johnson		
Soil	8	8
Gravel and clay	8	16
Sand	3	19
Gravel and sand	42	61
Sand	36	97
Clay, sandy, hard	10	107
Sand	30	137
Clay, hard	11	148
Sand	37	185
Clay, sandy, hard	4	189
Clay, hard	15	204
Sand	3	207
Clay, sandy, hard	22	229
Sand	95	324
Clay, hard	10	334
Shale and clay	15	349
2N-3W-23cd1. R. E. Bailey & Son [Casing, 10 in., 0-360 ft]		
Soil	4	4
Hardpan	5	9
Soil and clay, greasy	51	60
Basalt, hard	2	62
Cinders, black	60	122
Gravel	22	144
Sand, white, with clay stringers	115	259

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Materia	Thickness (feet)	Depth (feet)
2N-3W-23cdl. R. E. Balley & Son—Continued		
Clay	2	261
Sand, coarse; water	3	264
Clay, blue	12	276
Sand, light-blue; water	40	316
Clay, brown	8	324
Sand, blue	8	332
Clay, blue	14	346
Sand, blue	22	368
2N-3W-27bal. R. E. Balley & Son		
Soil	2	2
Gravel, coarse	3	5
Sand, coarse	10	15
Sand, fine, and clay	8	23
Sand and clay	8	31
Sand and gravel	18	49
Sand	6	55
Sand and gravel	8	63
Sand, gravel, and clay	8	71
Clay	27	98
Sand and clay	12	110
Sand and gravel	2	112
Clay	16	128
Clay and sand	12	140
Sand and gravel	20	160
Sand and clay	10	170
Clay	14	184
Sand and clay	12	196
Sand, coarse	57	253
Clay	21	274
Sand	10	284
Clay	12	296
Sand, fine, silty	2	298
Sand	18	316
Gravel, coarse	4	320
Clay, dark, hard	12	332

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TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
2N-3W-34db1. D. W. Frost		
[Casing, 12 in., 0-352 ft. Perforated, 287-352 ft.]		
Soil	4	4
Basalt	2	6
Gravel, clay, and sand	132	138
Sand, hard	10	148
Gravel and cinders	30	178
Sand	20	198
Basalt and cinders	40	238
Clay, hard	6	244
Basalt and cinders, loose	38	282
Cinders and sand	30	312
Cinders, sand, and gravel	42	354
Basalt and shale	9	363
2N-2W-23cb2. Swartz		
Sand	10	10
Silt	20	30
Sand	15	45
Silt	65	110
Sand	30	140
Sand, muddy	30	170
Silt	20	190
Sand	40	230
Clay, blue, sandy	2	232
Sand	12	244
Sand and clay stringers	10	254
Sand, blue	10	264
Sand with clay stringers	3	267
Sand	14	281
2N-2W-29ac1. Jess Talich		
[Casing, 4 in., 0-330 ft.]		
Soil and boulders	4	4
Basalt	54	58
Clay, red	9	67
Sand, coarse, and coarse gravel; dry	3	70
Sand, dry; water at 86 ft	16	86
Sand, white, fine, unconsolidated; and clay	12	98
Clay and sand, fine	102	200
Clay and sand, blue	38	238
Sand, blue	3	241
Clay, blue	17	258

TABLE 6.—*Driller's logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
2N-2W-29ac1. Jess Talich—Continued		
Clay, sandy	24	282
Clay, sandy, blue	14	296
Clay, blue	24	320
Shale and sand	10	330
2N-2W-31ad1. George Zap		
Soil and hardpan	10	10
Sand, coarse, and coarse gravel	23	33
Sand and gravel	10	43
Gravel, coarse	6	49
Sand, coarse, and coarse gravel	11	60
Silt, yellow	4	64
Clay and silt	6	70
Sand, brown, muddy	35	105
Sand, brown, and silt	22	127
Sand, brown and gray; water	5	132
Sand, gray	15	147
Silt and sand, muddy	13	160
Sand, gray and brown, with clay	11	171
Clay, yellow, sandy	3	174
Sand and clay stringers	5	179
Clay, yellow, silty, sticky	13	192
Sand, gray, fine; water	8	200
Sand, coarse	15	215
Clay, yellow, sandy	9	224
Sand, muddy	11	235
Clay, blue, sandy	5	240
Clay, blue	11	251
Sand, blue, coarse	15	266
Sand, blue	13	279
Clay, blue	3	282
Sand, blue, fine	15	297
Clay, blue and black	48	345
Shale, blue and black	13	358
Sand, gray; water	15	373
Shale, gray, sticky	3	376
Sand, gray	5	381
Shale, light-gray, sandy	14	395
Clay, gray	2	397
Sand, light-gray, clay and silt	4	401
Clay, light-gray, sticky	24	425
Sand, gray, fine, muddy	25	450
Sand, gray, coarse	38	488

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
2N-2W-31ad1. George Zap—Continued		
Shale, gray, sticky	12	500
Sand, fine, salt-and-pepper appearance	15	515
Shale, gray, sticky	30	545
2N-2W-34aa1. Dale Grass		
[Casing: 14 in., 0-184 ft; 13 in., 184-275 ft; 11 in., 275-303 ft. Perforated 242-276 ft with 1- by 1¼-in. slots]		
Soil	1	1
Clay and hardpan	8	9
Clay, sandy	7	16
Cinders	5	21
Clay, sandy	11	32
Gravel and sand	32	64
Clay, sandy	28	92
Sand, coarse	4	96
Clay, sandy	34	130
Sand, coarse	10	140
Sand, fine and coarse	65	205
Clay, sandy, soft	37	242
Sand, coarse	61	303
Sand, coarse and fine	35	338
1N-2W-2db1. D. L. Gunning		
[Casing, 6-in., 0-30 ft]		
Basalt, jointed	45	45
Basalt, solid; small amount of water at 100 ft	65	110
Basalt, black, solid	10	120
Basalt, black, very hard	60	180
Clay	25	205
1N-2W-3bb1. C. E. Ruddick		
[Casing, 12 in., 0-186 ft. Liner, 11 in., 186-290 ft. Perforated 186-290 ft.]		
Soil	12	12
Sand	4	16
Clay, yellow, sandy	30	46
Sand	7	53
Clay, hard	11	64
Sand	18	82

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
1N-2W-3bb1. C. E. Ruddick—Continued		
Sand and clay, yellow	26	108
Sand	23	131
Clay, yellow	10	141
Sand	7	148
Clay, yellow	16	164
Sand	4	168
Clay, yellow; water	20	188
Shale and sand, coarse; water	12	200
Clay, yellow	6	206
Sand, coarse; water	4	210
Clay, yellow, sandy; water	32	242
Sand, coarse; water	13	255
Clay, yellow	40	295
1N-2W-3cb1. Steve Hennis		
Soil	4	4
Gravel, coarse	2	6
Clay, hard	24	30
Sand	22	52
Clay, sandy, hard	36	88
Sand	40	128
Clay, hard, and sand	28	156
Clay, hard	7	163
Sand	8	171
Clay	3	174
Clay, sandy, hard	6	180
Clay, hard	12	192
Sand and shale	35	227
Clay, hard	8	235
Sand	16	251
Clay, hard	3	254
Sand	13	267
Clay, hard	17	284
Clay, sandy, hard	45	329
Clay, sandy	28	357
Clay, blue, hard	12	369
Clay, yellow, hard	5	374
Sand, coarse	15	389
Clay, sandy, hard	5	394

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
1N-2W-4bc1. Edwin Tiegs		
Soil	6	6
Basalt	49	55
Clay, brown	21	76
Basalt	89	165
Gravel	25	190
Gravel, loose	4	194
1N-2W-5cb1. Leonard Tiegs [Casing: 10 in., 0-415 ft]		
Soil	4	4
Sand, loose; runs into hole	9	13
Sand, loose, dry, muddy	15	28
Basalt	3	31
Gravel and sand	12	43
Gravel	4	47
Gravel, coarse, dry	33	80
Clay, yellow	5	85
Clay, yellow, gritty	25	110
Mud, gray	20	130
Mud, yellow	5	135
Sand, yellow; some water 144–150 ft	15	150
Clay, bluish-yellow	7	157
Sand, gray; some water	10	167
Clay, gray, with sand and silt stringers	28	195
Mud, silty	10	205
Mud, gray, sticky	13	218
Crevice	2	220
Silt and gravel, dark brown	14	234
Silt and clay stringers	6	240
Sand, fine, and silt	40	280
Clay, gray	3	283
Sand, muddy	12	295
Clay, gray, sticky	8	303
Mud, sticky, and sand stringers	41	344
Sand, muddy	11	355
Sand, brown	5	360
Sand, brownish-gray, and boulders	4	364
Clay, grayish-brown	4	368
Clay, grayish-blue	3	371
Sand, blue, muddy	6	377
Clay, blue, and sand stringers	3	380
Clay, blue, sticky	5	385
Sand, blue, very fine	23	408
Clay, blue, sticky	9	417
Sand, dark-gray, fine, silty	20	437

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
1N-2W-10dd1. J. E. Grantham		
Soil and silt	20	20
Basalt	25	45
Basalt and cinders	30	75
Basalt; water at 120 ft	72	147
Basalt and clay	57	204
1N-2W-17dc1. Kenneth Tiegs		
Soil	4	4
Basalt	69	73
Basalt, hard	3	76
Basalt, broken	7	83
Basalt; lost drilling water 140–143 ft	62	145
Basalt	20	165
Basalt; lost drilling water	2	167
Basalt, hard	10	177
Basalt; some layers hard	24	201
Cinders, gravel, and streaks of basalt	16	217
Basalt, broken, and cinders	3	220
Clay, red, and silt	20	240
Basalt, broken, and cinders	3	243
Basalt, broken	18	261
Basalt	19	280
Sand, red, coarse	6	286
Gravel, cemented, and clay	14	300
Clay, yellow	7	307
Shale, blue	36	343
Clay, brown	8	351
Sand, gray	11	362
Sand, brown	36	398
Clay, blue	1	399
Sand, brownish-gray	11	410
Clay, gray, and sand stringers	10	420
Sand, brown, coarse	8	428
Clay, blue, and sand stringers	17	445
Clay	10	455
Clay, gray-blue	20	475
Clay, gray-blue, sticky	60	535
Mud, gray-blue	35	570
Mud, gray, sticky	25	595
Clay, gray, and some gravel	16	611
Mud, gray-blue	26	637
Sand; hole caving badly	8	645
Sand, gray, coarse; hole caving badly	10	655
Sand	7	662
Clay, blue	18	680

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
1N-2W-24dc1. Owen Fuhriman		
Soil and silt	10	10
Basalt, hard	21	31
Basalt	14	45
Basalt, hard; crevices	10	55
Basalt, hard	16	71
Basalt	44	115
Basalt, red mud, and cinders	10	125
Basalt, broken	15	140
Basalt, hard	16	156
Basalt, broken	8	164
Basalt; water	7	171
Basalt	3	174
Sand, brown	3	177
1N-2W-26ad1. Robert Morris		
Soil and hardpan	20	20
Basalt	55	75
Clay, red	20	95
Basalt	233	328
Clay, red	30	358
Gravel	4	362
Silt, red	13	375
1N-2W-27cb1. Charles Flahiff		
Soil and silt	24	24
Basalt	210	234
Sand	6	240
Clay	15	255
Basalt, vesicular	9	264
1N-2W-34ac1. George Smith		
Soil	4	4
Basalt	41	45
Basalt, hard	6	51
Basalt; crevices; water	14	65
Basalt, broken; crevices	20	85
Basalt	20	105
Cinders and basalt	5	110
Basalt, broken; crevices	15	125

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
1N-2W-34ac1. George Smith—Continued		
Basalt	20	145
Basalt; crevices	15	160
Basalt	50	210
Clay, red	20	230
1N-2W-35aa1. Albert Barr		
[Casing, 6 in., 0-20.5 ft]		
Soil and silt	20	20
Basalt	18	38
Silt, muddy	11	49
Basalt	21	70
Cinders	5	75
Clay, yellow, sandy	20	95
Basalt	35	130
Basalt, broken	10	140
Basalt, brown	31	171
Cinders, red	4	175
Basalt, brown	10	185
Basalt, gray	10	195
Cinders, black	3	198
Basalt, gray	32	230
Basalt, black	15	245
Basalt, black, broken	10	255
1N-2W-35cc1. Russel Harpster		
[Casing, 6 in., 0-20 ft]		
Soil	2	2
Basalt	14	16
Basalt, broken	36	52
Basalt	15	67
Basalt, broken	11	78
Basalt	62	140
Basalt, broken, and red mud	15	155
Basalt, broken; gravel; red mud	22	177

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
1N-2W-36ba1. Brown		
Soil and hardpan	5	5
Basalt	125	130
Basalt, broken, and black cinders	5	135
Mud, red	12	147
Basalt, broken, and cinders; black	3	150
Basalt	30	180
Not recorded	5	185
Basalt	30	215
Clay, brown	20	235
1N-2W-36bd1. Town of Melba [Casing: 8 in., 0–432 ft.; 6 in., 405–620 ft. Torch perforated 538–618 ft]		
Soil	1	1
Basalt, broken	13	14
Basalt	71	85
Cinders, red, and mud	3	88
Basalt	19	107
Clay, red	5	112
Basalt	13	125
Silt	17	142
Basalt	53	195
Cinders, red, and broken basalt	10	205
Basalt	50	255
Basalt and cinders	20	275
Basalt	45	320
Cinders	8	328
Basalt	12	340
Cinders	8	348
Basalt	30	378
Cinders	8	386
Basalt	17	403
Basalt and gravel	19	422
Clay	15	437
Basalt	73	510
Clay, blue	45	555
Sand and gravel	3	558
Clay, blue	11	569
Sand and gravel	3	572
Clay, blue	41	613
Sand, coarse, and gravel	6	619
Clay, blue	1	620

TABLE 6.—*Drillers' logs of selected water wells in southern Canyon County, Idaho*—Continued

Material	Thickness (feet)	Depth (feet)
1S-2W-3dc5. B. W. Kauffman		
[Casing, 16 in., 0-12 ft]		
Soil	6	6
Basalt, broken	3	9
Basalt	19	28
1S-2W-4dd1. Carl E. Nicholson		
[Casing, 12 in., 0-44 ft]		
Soil	5	5
Shale, sandy	27	32
Sand	12	44
Basalt	29	73
1S-2W-12bb1. A. L. Seeger		
Basalt, black	32	32
Basalt, gray	50	82
Basalt, red	8	90
Mud, gray	8	98
Basalt, black	26	124
Basalt, gray	11	135
Clay	30	165
Basalt	55	220
1S-2W-14ac2. Boise-Kuna Irrigation District		
[Casing, 16 in., 0-12 ft]		
Soil	5	5
Basalt; water	13	18

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