UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

GROUND-WATER RECONNAISSANCE IN THE BURNT RIVER VALLEY, BAKER COUNTY, OREGON

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By Don Price 1929-

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Open-file report

Prepared in cooperation with the U.S. Bureau of Reclamation

Portland, Oregon

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GROUND-WATER RECONNAISSANCE IN THE BURNT RIVER

VALLEY, BAKER COUNTY, OREGON

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By Don Price

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ABSTRACT

The Burnt River valley in southern Baker County, Oreg., is underlain by rocks that range in age from pre-Tertiary to Quaternary. The pre-Tertiary rocks consist mainly of argillites, schists, limestones, and intrusive igneous rocks, while the Tertiary rocks consist mainly of felsic and mafic volcanic tuffs, lava flows and breccias, and fluviolacustrine deposits. Quaternary rocks include terrace gravels of Pleistocene and Recent age, and stream-valley alluvium of Recent age. The rock units most widely exposed along the valley are the fluviolacustrine deposits of Miocene and Pliocene(?) age, which extend to depths of as much as a thousand feet below the valley floor, and the pre-Tertiary rocks.

Most of the rocks that underlie the valley are of relatively low permeability and yield only small to moderate quantities of water (generally less than 50 gpm) to wells. The fluviolacustrine deposits contain scattered lenses of relatively permeable sand and gravel, but the unit as a whole is mainly silt and clay of low permeability. Two prospective irrigation wells in the area penetrated these deposits but were abandoned because of insufficient yield.

Perhaps the most permeable rock unit in the area is the Columbia River Basalt of Miocene and Pliocene(?) age. It is exposed extensively west of the main valley, but apparently occurs only as discontinuous lenses beneath the valley floor.

Chemical analyses of water from seven wells in the area indicate that the ground waters have relatively large concentrations of dissolved mineral constituents. Water from two of the wells had excessive concentrations of boron and high sodium and salinity hazards with respect to use for irrigation.

Perhaps the most favorable site for a test irrigation well is about 8 to 10 miles east of Hereford, where the Columbia River Basalt

apparently extends beneath, and is intercalated with, the fluvio-lacustrine deposits.

INTRODUCTION

Purpose and Scope of the Investigation

The purpose of this study was to determine the availability of ground water for irrigation in the Burnt River valley. Most of the land in the valley is irrigated with Burnt River water which is stored in Unity Reservoir. However, according to the U.S. Bureau of Reclamation, there are about 6,000 acres of presently irrigated land in need of additional water, and another 4,000 acres which are suitable for irrigation provided water is available. If a suitable ground-water supply is not available, plans call for augmenting the present surface-water supply by increasing storage facilities on the Burnt River.

Fieldwork, done during the last week of September 1963, consisted of rapid reconnaissance-geologic mapping in the valley and collection of basic well records. Water samples were collected from seven wells and from the Burnt River near Unity Reservoir, Bridgeport, and Durkee. These samples were analyzed for boron and other mineral constituents which might have a bearing on the suitability of the waters for irrigation.

The study was financed by the Bureau of Reclamation and the U.S. Geological Survey and was under the direct supervision of B. L. Foxworthy, district geologist in charge of ground-water studies in Oregon.

Location and Extent of the Area

The general area of this investigation includes the valley of the Burnt River adjacent to, and extending about 64 miles downstream from Unity Reservoir, in southern Baker County, Oreg. It lies between lat 44°20' and 44°35' N., and long 117°15' and 118°15' W. (fig. 1).

The principal areas of interest were four broader segments of the valley where supplemental irrigation water is most likely to be needed. Those segments, which have a total areal extent of about 25 square miles, are the Unity, Hereford, Bridgeport, and Durkee districts. (See figs. 2A and 2B.)

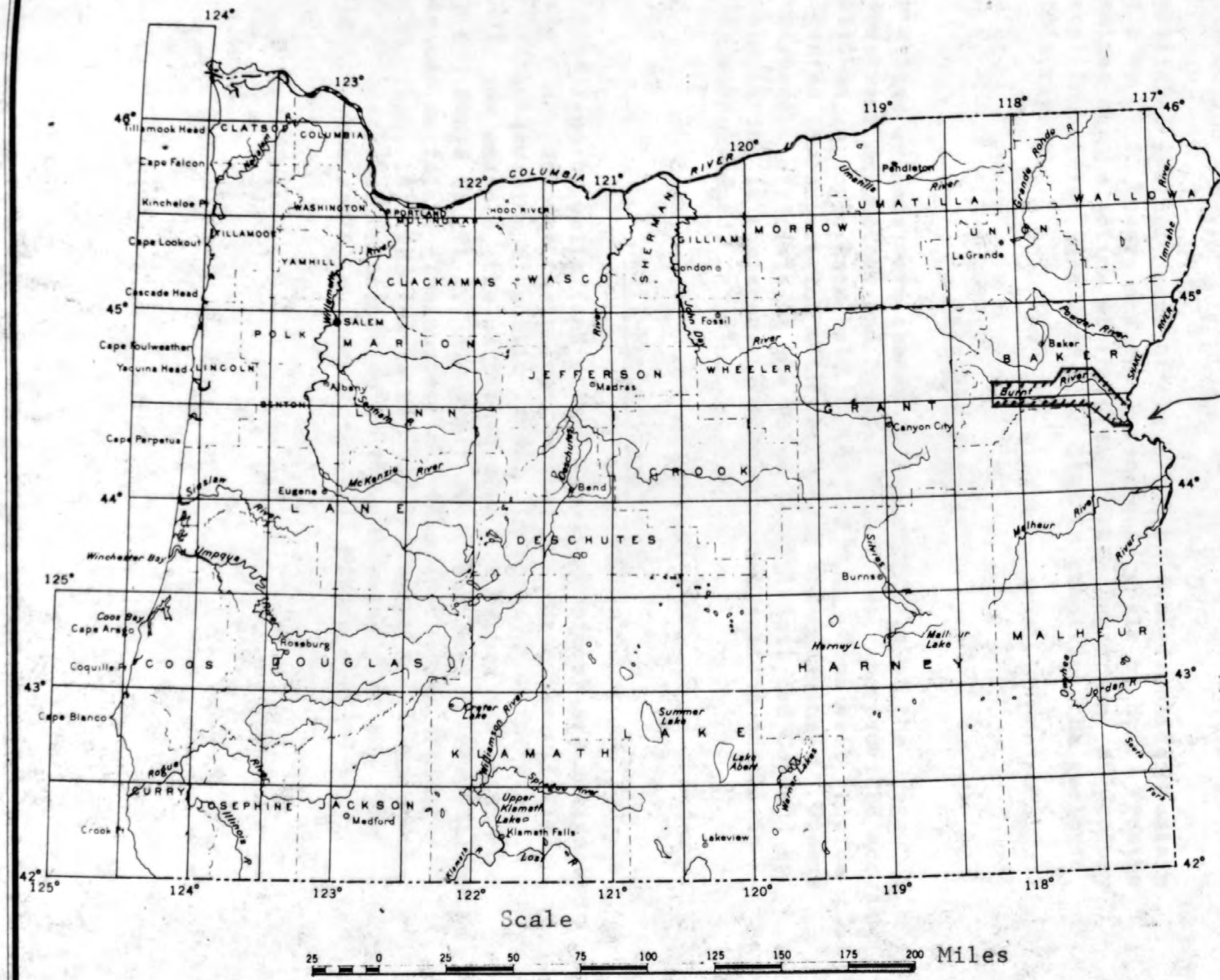


Figure 1.--Map of Oregon showing location of the area of investigation.

Previous Investigations

Geologic investigations of areas adjacent to or encompassing the Burnt River valley include a study of the gold-belt region of the Blue Mountains by Lindgren (1901), a study of the geology and mineral resources of the Baker quadrangle by Gilluly (1937), and a study of the geology of the Sumpter quadrangle by Pardee and others (1941). The latter two reports covered parts of the Burnt River valley, and were extremely useful in the present study.

Wagner (1958) compiled a general geologic map of northeastern Oregon (including the Burnt River valley) and described the important rock units of the area.

Unpublished geologic maps of the north half of Ironside Mountain quadrangle by W. D. Lowery and the Durkee quadrangle by H. J. Prostka were examined at the office of the Oregon State Department of Geology and Mineral Industries, and were also used in compiling the geologic map in this report.

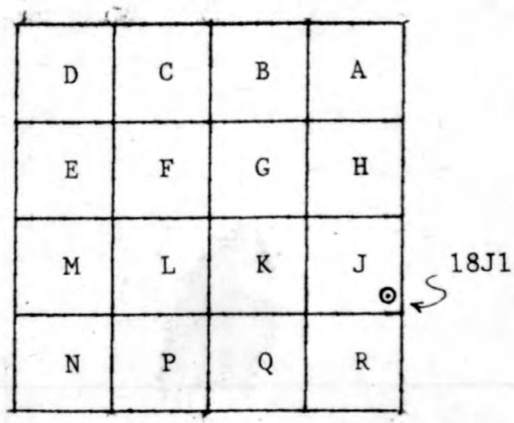
Acknowledgments

The writer extends warm thanks to the officials of the Oregon State Department of Geology and Mineral Industries, who provided access to unpublished geologic data held by that office. Some well records were collected in cooperation with the Oregon State Engineer. Others were furnished by officials of the Union Pacific Railroad Co. and by individuals living in the area. The helpful cooperation of all is gratefully acknowledged.

Well-Numbering System

In this report, wells (and stream-sampling points) are designated by symbols that indicate their locations according to the official rectangular subdivision of public lands. In the symbol for well 11/43-18J1, for example, the part preceding the hyphen indicates the township and range (T. 11 S., R. 43 E.) south and east of the Willamette base line and meridian. The number following the hyphen indicates the section (sec. 18), and the letter (J) indicates the 40-acre subdivision of that section according to the following diagram. The final digit is the serial number of the well within that 40-acre tract.

Section 18



Thus, well 11/43-18J1 is in the NE¼SE¼ sec. 18, T. 11 S., R. 43 E., and was the first well in that tract to be listed. It is identified on the map by that part of its number following the hyphen.

A similar number is used for stream-sampling sites except that the final digit is omitted.

GEOGRAPHY

Climate

The Burnt River valley is semiarid and is characterized by warm, dry summers and cool winters. The average annual precipitation at Unity (altitude 4,031 ft) for the period 1937-62 was about 10.60 inches; the annual precipitation ranged from about 6 inches in 1954 to about 16 inches in 1940 (fig. 3). The average monthly precipitation for the same period, given in the following table, ranged from less than half an inch for the months of August to 1.42 inches for the months of May.

Average monthly precipitation at Unity, Oreg. (1937-62)

/Data from U.S. Weather Bureau/

Month	Precipitation (inches)	Month	Precipitation (inches)
Jan.	1.02	July	0.51
Feb.	.93	Aug.	.42
Mar.	.77	Sept.	.68
Apr.	.60	Oct.	.91
May	1.42	Nov.	.07
June	1.17	Dec.	1.17

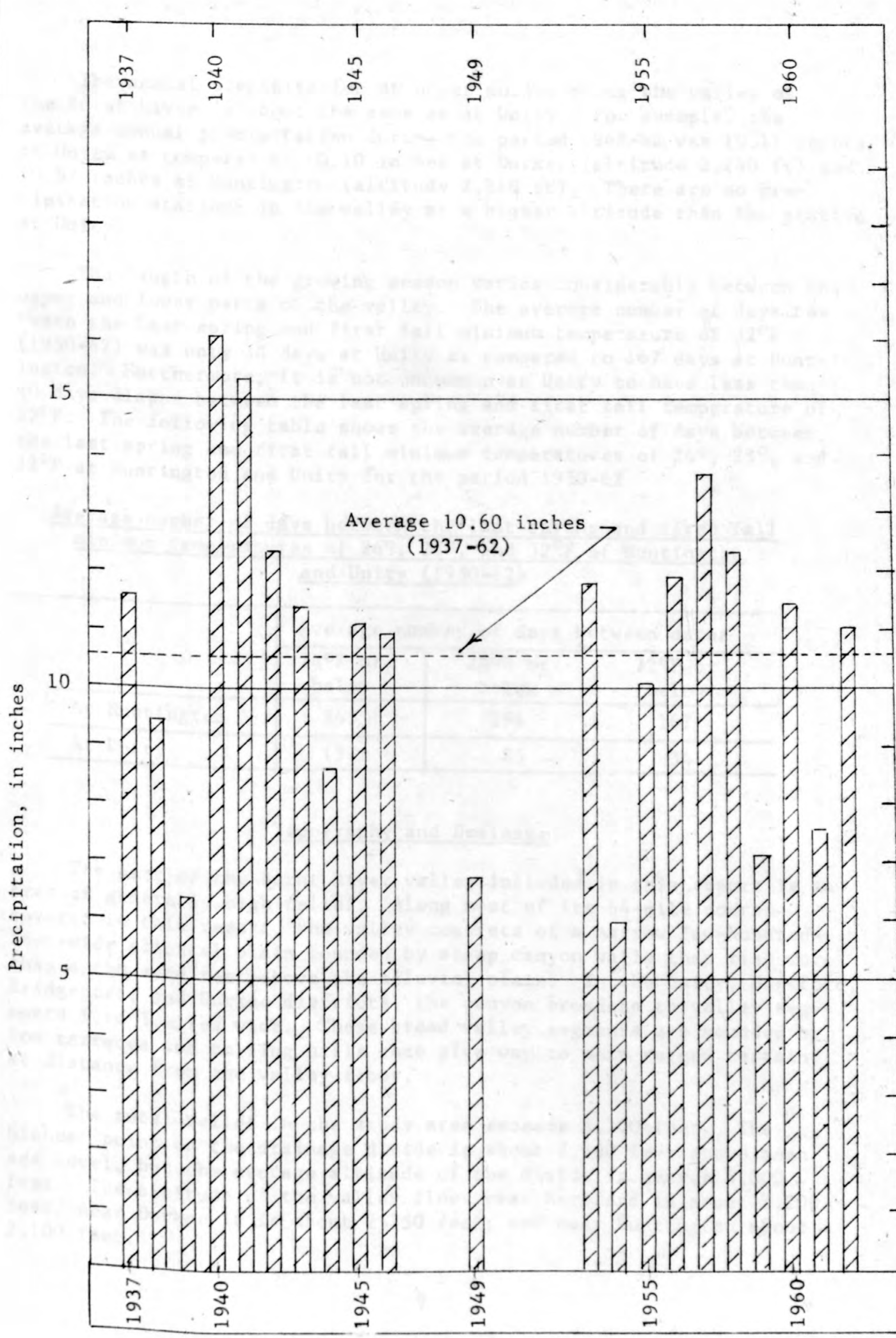


Figure 3.--Annual precipitation at Unity, Oreg., 1937-62.

The annual precipitation at other points along the valley of the Burnt River is about the same as at Unity. For example, the average annual precipitation during the period 1948-62 was 10.11 inches at Unity as compared to 10.10 inches at Durkee (altitude 2,740 ft) and 10.87 inches at Huntington (altitude 2,110 ft). There are no precipitation stations in the valley at a higher altitude than the station at Unity.

The length of the growing season varies considerably between the upper and lower parts of the valley. The average number of days between the last spring and first fall minimum temperature of 32°F (1950-62) was only 34 days at Unity as compared to 167 days at Huntington. Furthermore, it is not uncommon at Unity to have less than 10 days elapse between the last spring and first fall temperature of 32°F. The following table shows the average number of days between the last spring and first fall minimum temperatures of 24°, 28°, and 32°F at Huntington and Unity for the period 1950-62.

Average number of days between the last spring and first fall minimum temperatures of 24°, 28°, and 32°F at Huntington and Unity (1950-62)

	Average number of days between dates		
	24°F or below	28°F or below	32°F or below
At Huntington	245	194	167
At Unity	137	85	34

Topography and Drainage

The part of the Burnt River valley included in this report is an area of generally high relief. Along most of its 64-mile course covered in this report, the valley consists of a narrow few-hundred-foot-wide alluvial plain bounded by steep canyon walls that rise more than a thousand feet above the alluvial plain. In the Unity, Hereford, Bridgeport, and Durkee districts, the canyon broadens to valley segments 1 to 3 miles wide. These broad valley segments are bounded by low terraces and rolling hills that give way to more rugged terrain at distance from the valley floor.

The total relief in the study area exceeds 5,700 feet. The highest point on the drainage divide is about 7,900 feet above mean sea level, but the average altitude of the divide is nearer 6,000 feet. The altitude of the valley floor near Hereford is about 3,200 feet, near Durkee it is about 2,750 feet, and near Huntington about 2,100 feet.

The Burnt River, including its tributaries outside the study area, drains about 1,100 square miles. The larger tributaries of the river downstream from Unity Reservoir are Camp, Alder, and Dixie Creeks.

Streamflow measurements are made on the Burnt River by the U.S. Geological Survey about half a mile downstream from Unity Reservoir (Hereford gaging station), and near Bridgeport; past measurements have been made at Durkee and at Huntington. Records of the river's discharge are published in the Geological Survey Water-Supply Paper series entitled "Surface-Water Supply of the United States, Part 13, Snake River Basin."

The average annual runoff of the Burnt River at the Hereford gaging station was about 58,350 acre-feet during the past 35 years of record (1928-63). Prior to completion of Unity Reservoir in 1938, the highest monthly runoff of the river at the Hereford gaging station was about 34,000 acre-feet; since 1938, however, the highest monthly runoff at that station has been on the order of about 20,000 acre-feet owing to the annual refilling of Unity Reservoir. Figure 4 shows the monthly runoff of the Burnt River at the Hereford gaging station and at the Huntington station for water year 1932, and the average monthly runoff at those same stations during water years 1957-59. (Water years 1932 and 1957-59 were the only water years in which simultaneous streamflow measurements were made at the Hereford and Huntington gaging stations.) As figure 4 shows, the monthly runoff of the Burnt River at Huntington was negligible in August, September, and October 1932 (prior to completion of Unity Reservoir), but the average monthly runoff for those same months was 4 to 5 thousand acre-feet during water years 1957-59 (after completion of Unity Reservoir). A similarly significant increase in late-summer runoff at the Hereford station following completion of Unity Reservoir is also shown in figure 4.

The principal reason for the greater late-summer flow of the Burnt River at Hereford and Huntington during water years 1957-59 is regulation of flow of the river at Unity Reservoir. However, the increased late-summer flow at Huntington (which is downstream from the main irrigated segments of the valley) is caused partly by irrigation return and more ground-water seepage into the river. The greater amount of ground-water and irrigation-return inflow is indicated by a general increase of dissolved mineral constituents in the river water in a downstream direction (table 4). (Ground water is generally more mineralized than surface water.) For example, on September 25 and 26, 1963, the specific conductance of the river water (a rough index of the total dissolved solids) was found to be 374 micromhos near Unity Reservoir as compared to 477 near Bridgeport and 483 near Durkee. On September 17, 1959, the specific conductance of the river water near Huntington was 677 micromhos. Because the water samples were collected during the irrigation season, some of the increased mineral content was probably due to rather highly mineralized irrigation-return flow.

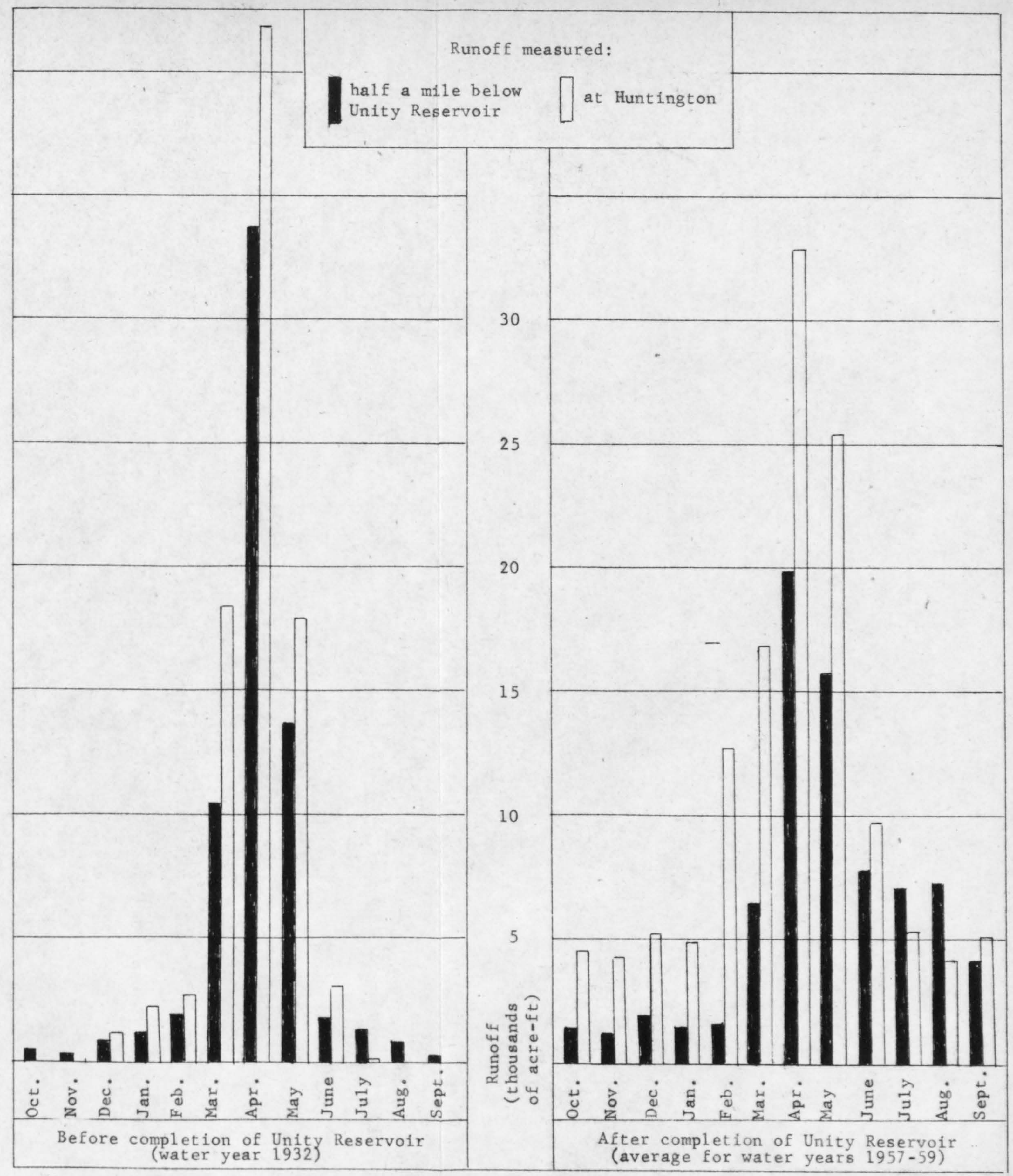


Figure 4.--Graphs showing monthly runoff of the Burnt River before and after Unity Reservoir was completed in 1938.

Culture and Industry

Except for the small community centers at Unity, Hereford, Bridgeport, Durkee, and Huntington, the valley is sparsely populated; it is utilized mainly for raising of feed for stock. Huntington (population 689 in 1962) is the largest town in the valley and the main railroad station between Weiser, Idaho, and Baker, Oreg. Lumber milling at Unity and cement manufacturing at Lime are the main industries.

GEOLOGIC SETTING

Rocks ranging in age from pre-Tertiary to Quaternary are exposed in the Burnt River valley between the vicinity of Unity Reservoir and Huntington. The rocks of pre-Tertiary age consist mostly of limestone, various metamorphic rocks (schist and argillite), and intrusive igneous rocks (diorite). The rocks of Tertiary age consist mostly of felsic to mafic lava flows, tuff beds, breccias, and fluviolacustrine deposits. The rocks of Quaternary age include stream-valley alluvium and terrace gravels near the streams.

A summary of the geologic units exposed in the study area is given in table 1, along with a generalized geologic column. The areal distribution of these geologic units is shown on figures 2A and 2B.

GROUND WATER

General Features of Occurrence

The igneous and metamorphic rocks, fluviolacustrine deposits, and the valley alluvium that underlie the Burnt River valley are saturated with water below a generally shallow depth. The top of the zone of saturation may be only a few feet below the land surface in the alluvium adjacent to the river; near the margins of the valley, however, the top of the zone of saturation may be 50 feet or more below the land surface. All the water in the zone of saturation is called ground water, and the rock materials that are permeable enough to yield the ground water to wells, seeps, and springs are called aquifers. Ground water is discharged from the aquifers mainly through seeps and springs, by evapotranspiration, and by pumping from wells; the ground water is replenished mainly by infiltration of precipitation that falls within the valley and by infiltration from leaky canals and irrigated land.

Table 1.--Summary of stratigraphy in the Burnt River valley, Baker County, Oreg.

[Based on data from Gilluly (1937) and Pardee and others (1941)]

System	Series	Geologic column	Thickness (feet)	Character of the rocks	Water-bearing properties
QUATERNARY	Pleistocene and Recent	Alluvium	0-50+	Consists largely of well- to poorly sorted clay, silt, sand, and gravel in terraces that border the Burnt River valley along much of its course; consists mainly of silt and sand beneath the present alluvial plain of the river and its tributaries.	Yields small quantities of water to dug and small-diameter domestic and stock wells. No large-yield wells are known to tap the young alluvium.
		Unconformity			
TERTIARY	Miocene and Pliocene(?)	Columbia River Basalt		Crops out extensively west of Unity Reservoir; also exposed locally between Hereford and Huntington, where it interfingers with the fluviolacustrine deposits. Consists mainly of concordantly layered lava flows several tens of feet thick separated by scoriaceous or vesicular zones.	Yields moderate to large quantities of water to wells in other parts of Oregon, but may be too limited in extent within the study area to constitute a major aquifer.
		Fluvio-lacustrine deposits	0-1,000+	Underlie much of the valley between Unity Reservoir and Durkee; also underlie a small area south of Huntington. Consist mainly of tuffaceous clay, silt, and diatomaceous earth, but include mudflow debris and poorly sorted sand and gravel deposits locally.	Mostly of low to moderate permeability; known to yield only small to moderate amounts of water to wells and springs. At places, chemical quality of the water is questionable with respect to use of water for irrigation.
		Unconformity			
	Miocene(?)	Younger rhyolitic rocks	0-200±	Crop out in the valley between Unity Reservoir and Hereford, consist mainly mainly of light-colored lavas and pumaceous and tuffaceous rocks.	Contain some vesicular zones, but for the most part appear to be relatively impermeable.
		Unconformity			
		Dacite	0-200+	Exposed on north side of Burnt River valley between Unity Reservoir and Hereford. Consists of light-gray to pink porphyritic dacite probably of intrusive origin.	Yields small quantities of water to springs; probably does not extend beneath the valley floor.
		Andesite tuffs, flows, and breccias	0-1,800+	Exposed mainly in the vicinity of Unity Reservoir and on the south side of the Burnt River valley between Unity and Hereford. Form smooth slopes and rounded hills, cliffs, and pinnacles. Consist mainly of water-laid fragments of andesite, ranging from sand-size to large boulders.	Wells are not known to tap these rocks; they appear to be relatively impermeable in surface outcrop; yield small amounts of water to springs.
		Unconformity			
		Flow-banded andesite	0-200+	Exposed on the north side of Burnt River canyon between Hereford and Bridgeport. Consists of flow-stretched porphyritic andesite.	Might yield moderate quantities of water to wells if saturated, but may not extend beneath the valley floor.
		Unconformity			
PRE-TERTIARY		Dooley Rhyolite Breccia	0-1,500+	Exposed extensively in Dooley Mountain on the north side of the Burnt River valley between Hereford and Bridgeport. Consists mainly of rhyolite, with subordinate andesitic flows and breccias.	No wells are known to tap the formation. Yields small quantities of water to springs.
		Unconformity			
		Rocks, undifferentiated	0-5,000+	Most extensive exposures between Bridgeport and Durkee and downstream from near Durkee to Huntington. Consists mainly of argillites, schists, limestone, and both extrusive and intrusive igneous rocks.	Rocks are of generally low permeability, but yield small to moderate quantities of water to wells and springs locally. Water quality questionable with respect to use of water for irrigation.

Ground-Water Potential of Selected Rock Units

Little information is available regarding the water-bearing properties of the pre-Tertiary and older Tertiary rocks. In general, those rocks appear to be of low permeability; they yield only small quantities of water to widely separated springs and seeps along the valley walls. The fluviolacustrine deposits, Columbia River Basalt, and the valley alluvium probably contain the best potential aquifers in the Burnt River valley; they are described in more detail below.

Fluviolacustrine Deposits

The fluviolacustrine deposits underlie most of the land in the Unity, Hereford, Bridgeport, and Durkee districts (figs. 2A and 2B). Wells drilled in the respective districts would likely penetrate the fluviolacustrine deposits at depth. These deposits consist mainly of thick layers of tuffaceous clay and silt, but also include mudrock flow debris, poorly sorted alluvial deposits, and intercalated lava flows. The maximum thickness of the fluviolacustrine deposits is believed to be more than a thousand feet in the Durkee district and nearly a thousand feet in the other three districts.

Because the deposits consist predominantly of fine-grained materials, they are, as a whole, of low permeability. The clay and silt strata transmit some water to springs and domestic and stock wells in the area, but the water is yielded much too slowly to sustain a large continual draft such as would be needed for irrigation.

Locally, however, sand and gravel strata interbedded with the thick clay and silt layers transmit the water more readily and could possibly yield moderate quantities (somewhat more than a hundred gpm) to properly constructed and developed wells.

Records of six wells believed to tap the fluviolacustrine deposits are given in table 2 (wells 11/43-28D1, 12/36-24B1, 12/37-28E1, 12/38-27A1, 12/40-25P1, and 12/40-26P1). Drillers' logs of wells 11/43-28D1, 12/37-28E1, and 12/38-27A1 are given in table 3. Of the six wells believed to tap the fluviolacustrine deposits, one (11/43-28D1) reportedly pumped 65 gpm (gallons per minute); the yields of the other five wells ranged from about 5 to 22 gpm, but some of those wells could probably pump more water by increasing the drawdown. For example, the specific capacity[1/] of well 12/38-27A1 is about 4 gpm per foot of drawdown. This indicates that the well could theoretically yield

1/ The specific capacity of a well is the amount of water it will yield with a given drawdown, and is usually expressed in gpm per foot of drawdown.

as much as about 120 gpm with a drawdown of 30 feet. A deeper well of larger diameter tapping the same aquifer might possibly yield even more water.

Because recharge to ground water in the fluviolacustrine deposits is mainly by downward percolation of precipitation that falls within the valley, the semiarid climate of the region may be a major limiting factor in developing ground water for irrigation in the Burnt River valley even if more permeable aquifers are discovered. An example of this limiting factor can be found in Cow Valley (about 15 miles south of Bridgeport), which has climatic conditions similar to the Burnt River valley. In Cow Valley, annual pumpage from about 14 irrigation wells tapping highly permeable aquifers has exceeded natural recharge (which is mainly from precipitation) since about 1950, resulting in serious declines of the ground-water levels. (See Brown and Newcomb, 1962.)

Columbia River Basalt

The Columbia River Basalt crops out extensively west of Unity Reservoir, where it has been mapped by Pardee and others (1941) as older and younger basic lavas, and in scattered areas on the north side of the Burnt River valley between Unity Reservoir and Durkee. Lava flows, believed by the writer to be Columbia River Basalt also, underlie small areas about 1 mile north of Lime and south of Huntington (figs. 2A and 2B).

The Columbia River Basalt consists mainly of a series of concordantly layered lava flows several tens of feet thick, separated by scoriaceous or vesicular (interflow) zones. In most places, the individual flows have a characteristic columnar appearance owing to vertical fractures formed during cooling of the lava; locally, however, horizontal fractures give the flows a platy appearance.

The Columbia River Basalt was apparently extruded during deposition of the fluviolacustrine deposits and is intercalated with those deposits in the Burnt River valley and other parts of eastern Oregon. It probably occurs as thin discontinuous lenses in the fluviolacustrine deposits at depth in the study area.

No wells are known to tap the Columbia River Basalt in the Unity, Hereford, Bridgeport, and Durkee districts, but well 14/45-18M1 at Huntington may have penetrated several lenses of basalt belonging to this geologic unit. (See table 3.) That well reportedly pumped about 75 gpm for 5 days with a drawdown of more than 60 feet (table 2). In other parts of eastern Oregon where the Columbia River Basalt is much thicker and more extensive, the basalt yields large quantities of water to wells (Hampton and Brown, 1964, and Hogenson, 1964).

Alluvium

The alluvium includes the silt, sand, and gravel that underlie the stream-valley plain, and the sand and gravel deposits that underlie the terraces adjacent to the Burnt River and its tributaries. The gravel clasts found in the stream-valley alluvium were derived mainly from the older rocks (schists, limestones, felsic and mafic lava flows, tuffs, and breccias) currently being eroded by the Burnt River and its tributaries; the terrace gravels also include some quartzitic fragments.

Saturated alluvium underlies about 15 square miles in the Unity, Hereford, Bridgeport, and Durkee districts; the deposits probably do not exceed 50 feet in thickness. The principal aquifers include sand and gravel strata underlying the valley plain of the Burnt River and the gravel (where saturated) in the adjacent terrace deposits. Those aquifers may yield small to moderate quantities of water to properly constructed and developed wells.

Well 11/43-18J1 near Durkee is believed to tap alluvium and may be representative of several shallow wells that obtain water from the alluvium for domestic and stock supplies. That well reportedly pumps about 15 gpm (gallons per minute); it supplies sufficient water for domestic and stock supplies and is used to irrigate a small lawn and nursery.

Recharge to the alluvium occurs mainly as downward percolation of precipitation that falls on the valley floor. Some recharge also occurs by downward percolation of water from irrigated land and irrigation canals. Recharge from leaky canals and overirrigated land is reflected in the greater downstream discharge of the Burnt River during the usual low-flow period in late summer and early fall (p. 10). It suggests that more water is reaching the shallow aquifer, which normally provides water for the flow of the river during late summer. Some of the increased flow could be put to beneficial use by pumping from wells tapping the alluvium. Because the valley alluvium is relatively thin, however, any scheme to develop moderate quantities of water from individual wells tapping it would probably have to consider wide spacing of the wells to prevent local overdraft of the aquifers.

Chemical Quality of the Water

In order to determine the chemical quality of the water in the Burnt River valley, samples of water from seven wells and from eight points along the Burnt River were collected and analyzed for mineral content (table 4). Samples were collected two or more times at three points along Burnt River, making 20 in all. (See table 4.)

The few ground-water analyses in table 4 are not intended to represent the chemical quality of all ground water in the Burnt River valley. They do, however, indicate that there is a wide variation in the chemical quality of the ground water. Similarly, the Burnt River water analyses are not intended to be entirely representative of river water, but those analyses show that the quality of the river water varies considerably depending on the sampling site and the date of sample collection.

The analyses of samples from four wells indicate that the waters are of suitable chemical quality for irrigation and most other uses. Analyses of samples from two other wells (11/43-28D1 and 12/40-26P1) indicate that the water from those wells may be undesirable for irrigation owing to relatively high concentrations of boron and sodium; a sample from still another well (12/38-27A1) contained 205 ppm (parts per million) nitrate, which is far in excess of the 45 ppm recommended by the U.S. Public Health Service as the maximum allowable concentration of nitrate in drinking water.

The analyses of samples of Burnt River water show a variation in chemical quality in the river system with respect to high and low flow (as indicated by date of collection) and a general increase in dissolved mineral concentration in a downstream direction. All of the samples of river water were of generally good chemical quality for irrigation and other uses.

Comparison of the analyses of ground and surface water shows that, as is usual, the ground water generally has greater concentrations of dissolved minerals than the surface water. For example, the specific conductance, which is a rough indication of concentration of dissolved minerals, ranged from 433 to 1,590 and averaged about 884 micromhos in the ground-water samples, whereas the specific conductance of the surface-water samples ranged from 89 to 677 and averaged only about 536 micromhos. Relative concentrations of various mineral constituents in the ground and surface waters sampled in the Burnt River valley can be compared by referring to table 4.

Suitability of Water for Irrigation

The characteristics most important in determining suitability of water for irrigation are (a) the total concentration of soluble salts, (b) the concentration of boron or other elements that may be toxic to plants, and (c) the relative proportion of sodium to the principal cations in the water.

Plants are rated as sensitive, semitolerant, and tolerant, according to their ability to withstand boron concentrations (Wilcox, 1948). Irrigation waters containing boron are classified in five categories (from excellent to unsuitable) for each of these classes of plants. Waters having concentrations of boron of less than 0.33 ppm are regarded as excellent for essentially all plants, while waters containing more than 3.75 ppm boron are regarded as unsuitable for even the most boron-tolerant plants.

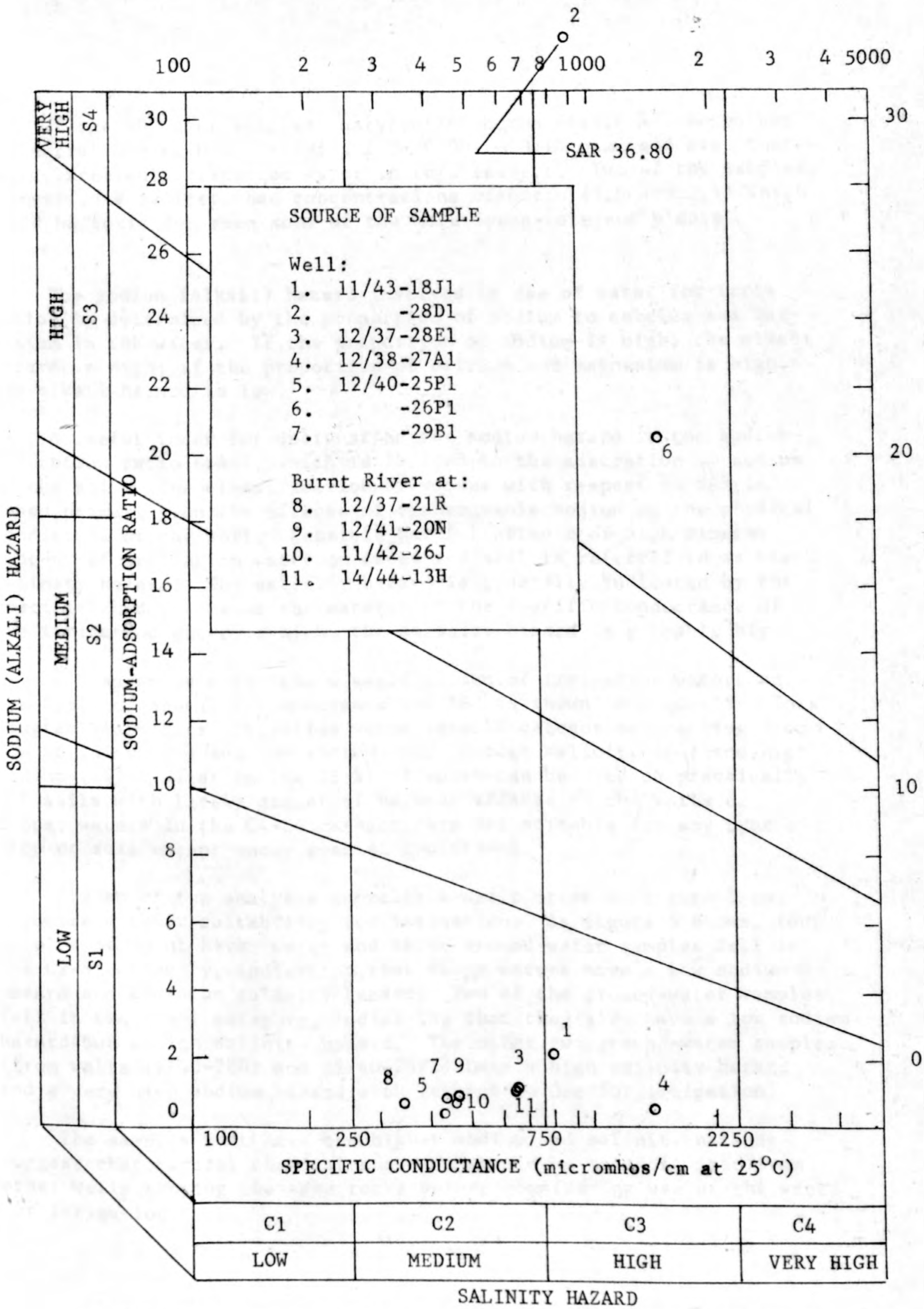


Figure 5.--Diagram for the classification of irrigation waters. (Adapted from U.S. Dept. Agriculture Handb. 60, p. 80.)

Of the 10 water samples analyzed for boron (table 4), seven had concentrations of boron ranging from 0.00 to 0.14 ppm, and are, therefore, excellent irrigation water in this respect. Two of the samples, as mentioned earlier, had concentrations of boron (3.6 and 2.3) which could be toxic for even some of the more boron-tolerant plants.

The sodium (alkali) hazard involved in use of water for irrigation is determined by the proportion of sodium to calcium and magnesium in the water. If the proportion of sodium is high, the alkali hazard is high; if the proportion of calcium and magnesium is high, the alkali hazard is low.

A useful index for designating the sodium hazard is the sodium-adsorption ratio (SAR), which is related to the adsorption of sodium by the soil. The classification of waters with respect to SAR is based primarily on the effects of exchangeable sodium on the physical conditions of the soil. Possible harmful effects of high mineral content of irrigation water on crops and soil is referred to as the salinity hazard. The salinity hazard is generally indicated by the specific conductance of the water. If the specific conductance of the irrigation water is high, the salinity hazard is probably high.

A diagram used for the classification of irrigation waters on the basis of specific conductance and SAR is shown in figure 5. This diagram classifies irrigation water into 16 categories, ranging from low salinity (C1) and low sodium (S1) to high salinity (C4) and high sodium (S4). Water in the C1-S1 category can be used on practically all soils with little danger of harmful effects on the soils or crops; waters in the C4-S4 category are not suitable for any type of crop or soil except under special conditions.

Eleven of the analyses in table 4 are plotted on figure 5 to illustrate their suitability for irrigation. As figure 5 shows, four samples of Burnt River water and three ground-water samples fell in the C2-S1 category, indicating that those waters have a low sodium hazard and a medium salinity hazard. Two of the ground-water samples fell in the C3-S1 category, indicating that they also have a low sodium hazard but a high salinity hazard. The other two ground-water samples (from wells 11/40-28D1 and 12/40-26P1) have a high salinity hazard and a very high sodium hazard with respect to use for irrigation.

The samples that have the higher sodium and salinity hazards suggest that careful chemical analyses should be made of water from other wells tapping the same rocks before considering use of the water for irrigation.

SUMMARY AND CONCLUSIONS

A review of existing geologic literature and a rapid geologic reconnaissance indicate that the Burnt River valley downstream from the vicinity of Unity Reservoir is underlain and bounded largely by relatively impermeable rocks that are capable of yielding only small to moderate amounts of water to wells.

The Columbia River Basalt may constitute a potential aquifer where it apparently extends beneath the Burnt River valley about 8 to 10 miles east of Hereford. There may also be some as yet undiscovered gravel and sand aquifers within the fluviolacustrine deposits that underlie the Hereford and Durkee districts.

Maximum sustained yields of the existing wells in the area are about 75 gpm. The specific capacity of all the wells for which adequate data are available ranged from less than one-half to about 4 gpm per foot of drawdown. Consequently, if an aquifer were found that would sustain a withdrawal of more than a hundred gallons per minute, the pumping lift would very likely be more than a hundred feet.

The chemical quality of the water in the Burnt River valley appears generally good, but the presence of potentially toxic amounts of boron in two of the well-water samples, along with the high SAR value in those samples, indicates that water from wells should be checked for chemical quality before application to crops, especially if the wells tap deep aquifers in the fluviolacustrine deposits.

Considering the low permeability of most of the rocks in the Burnt River valley, it is concluded that most aquifers in the valley would yield water too slowly to sustain a large continuous draft such as is needed for irrigation. Furthermore, the high boron, salinity, and sodium hazards of some of the ground waters sampled indicate that some of the water may not be suitable for irrigation. However, additional drilling may indicate that some of the fluviolacustrine deposits and volcanic rocks will yield moderate to large supplies of good-quality water to wells locally.

The available geologic and hydrologic information suggest that the most favorable site for a test irrigation well is about 8 to 10 miles east of Hereford, where the Columbia River Basalt apparently extends beneath the valley floor and is intercalated with the fluviolacustrine deposits.

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Table 2.--Records of wells in the Burnt River valley, Baker County, Oreg.

Well number: See p. 6 for explanation of well-numbering system.

Type of well: Dg, dug; Dr, drilled.

Altitude: Altitude of land surface at well, in feet above mean sea level, interpolated from topographic maps.

Water level: Depth of water given in feet and decimal fractions are measured; those given in whole feet are reported by the well owner or driller. F, flowing well whose static water level is not known.

Type of pump: C, centrifugal; Cy, cylinder; J, jet, N, none; S, submersible; T, turbine.

Well performance: Yield in gallons per minute and drawdown, in feet, below nondischarging water level reported by owner, operator, or driller. Bailed yields are indicated by a "b."

Use: D, domestic; N, none; PS, public supply; R, formerly supplied water for steam locomotives.

Remarks: Ca, chemical analysis of water in table 4; L, driller's log of well in table 3; temp, temperature of water in °Fahrenheit. Remarks on adequacy and dependability of supply, general quality of water, and materials penetrated are reported by owners, operators, drillers, or others.

Well number	Owner	Type of well	Year completed	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Water-bearing zone(s): Depth to top (feet)	Water-bearing zone(s): Thickness (feet)	Water-bearing zone(s): Character of material	Altitude (feet)	Water level: Feet below datum	Water level: Date	Type of pump and hp	Well performance: Yield (gpm)	Well performance: Drawdown (feet)	Use	Acres irrigated	Remarks
11/43-18J1	D. S. Kirby	Dg	--	30±	48	30	--	--	--	--	2,720	18.40	9-24-63	C	15	--	D	--	Temp 60, Ca.
28/D1	Union Pacific Railroad Co.	Dr	1921	1,082	12-6	941.4	Open bottom	921 973	42 10	Quartz sand Quartz sand and gravel	2,650	F	1921	T, 10	65	162+	R,D	--	Currently supplies several homes; temp on completion of well 96; Ca, L.
12/36-24B1	John Rice	Dr	1955	212	12	--	--	--	--	"Blue shale"	3,950	8-10	1955	N	5-10	--	N	--	Well originally planned for irrigation; reportedly penetrated only "blue shale" to 212 ft and was abandoned owing to insufficient yield.
12/37-28E1	Oregon State Highway Dept.	Dr	1959	300	6	60	Open bottom	220 280	12 2	Shale and sand do	3,900	220	1959	--	150(?)	200(?)	D	--	Well supplies water for camping and picnic area; temp 58, Ca, L.
12/38-27A1	Hereford Community Church	Dr	1959	81	6	81	do	74	7	Clay and gravel; some sand	3,660	48.83	4-10-59	J, 1/2	22b	5	D	--	Temp 54, Ca, L.
12/40-25P1	Harry Elliott	Dr	1930±	98	6	--	do	--	--	--	3,550	5	1962	J, 3/4	--	--	D	--	Ca.
26P1	Virgil Elliott	Dr	1914	165	8	--	--	--	--	Gray clay	3,550	--	--	Cy	--	--	D	--	Water from well reportedly contains some gas; temp 54, Ca.
36N1	J. A. Andersen	Dr	1958±	300	12	300	Casing perforated at unknown depth	--	--	Shale and volcanic wash	3,600	--	--	N	--	--	N	--	Well originally planned for irrigation; reportedly penetrated shale and "volcanic wash" to 300 ft; Abandoned owing to insufficient yield.

Table 2.--Records of wells in the Burnt River valley, Baker County, Oreg.--Continued

Well number	Owner	Type of well	Year completed	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Water-bearing zone(s): Depth to top (feet)	Water-bearing zone(s): Thickness (feet)	Water-bearing zone(s): Character of material	Altitude (feet)	Water level: Feet below datum	Water level: Date	Type of pump and hp	Well performance: Yield (gpm)	Well performance: Drawdown (feet)	Use	Acres irrigated	Remarks
12/40-29B1	J. R. Mitchell	Dr	1952	80	6	--	Open bottom	--	--	--	3,600	22.00	9-25-63	S	--	--	D	--	Water reportedly contains soft, chalky-white sediment that coats fixtures; temp 53, Ca.
12/41-31C1	Wendt Bros.	Dr	1900±	145	6	145(?)	do	145	--	Granite rock	3,440	10-15	1963	N	10	--	N	--	Pumps dry when equipped with gasoline-driven motor.
12/44-6E1	Hite Bros.	Dr	1961	101	6	64	Casing perforated 60-64 ft	61	40	Black and light-green rock	3,040	4.36	9-24-63	N	18b	80	N	--	Well planned for limited irrigation of small plot; temp 50, L.
13/37-9M1	Ellingson Lumber Co.	Dr	1960	285	6	167	Casing perforated 35-167 ft	130 257	80 3	Clay and gravel do	3,950	9	4-20-60	--	40b	22	D	--	L.
13/44-27A1	Union Pacific Railroad Co.	Dr	--	184	8-6	171	Open bottom	167	17	Sandstone and coarse sand	2,530	2	--	N	30	41	R	--	Formerly equipped with a turbine pump having a capacity of 120 gpm; capped and abandoned; L.
14/44-13H1	do	Dr	1907	391	10-8	228	--	--	--	--	1,920	--	--	--	--	--	R	--	Owner's well 1 at Huntington; formerly equipped with a turbine pump having a capacity of 165 gpm; reportedly capped and abandoned.
13H2	do	Dr	1920	240	12-10	61	--	--	--	--	1,920	--	--	--	--	--	R	--	Owners' well 2; formerly equipped with a turbine pump having a capacity of 200 gpm.
14/45-18M1	City of Huntington	Dr	1932	583	10-8	523	Casing perforated 325-523 ft	460 523	45 30	Red rock "Lime rock"	2,115	465	5- -44	T, 50	75±	60+	PS	--	Temp 76; soap hardness of water 40-45 parts per million.
18N1	do	Dr	1944	870±	8-4	--	Open bottom	--	--	--	2,150	--	--	--	--	--	--	--	Test well; no yield reported.

Table 3.--Drillers' logs of wells in the Burnt River valley, Baker County, Oreg.

11/43-28D1. Union Pacific Railroad Co. Altitude 2,650 ft. Drilled by G. E. Scott, 1921

Materials	Thickness (feet)	Depth (feet)
Clay and boulders	25	25
Soapstone	10	35
Clay, dense, blue	165	200
Clay, dense, brown	45	245
Clay, dense, blue	285	530
Rock; yields some water	8	538
Clay, dense, blue	70	608
Clay, dense, white; yields some water	8	616
Clay, dense, blue	79	695
Clay, dense, brown	5	700
Clay, dense, blue	72	772
Rock, "lava"	3	775
Clay, dense, blue	3	778
(Clay), sandy, grayish	56	834
Clay, dense, blue; water level 40 ft below land surface	43	877
Clay, sandy, blue, water-bearing; well began to flow at a rate of 1 gpm	23	900
Clay, dense, blue	31	931
Sand, "quartz"	42	973
Sand and gravel, "quartz"; artesian flow measured to 20 gpm	10	983
Granite or syenite, "secondary," hard to medium-hard	48	1,031
Rock, hard, mineral-bearing; contains considerable pyrite	5	1,036
Granite or syenite, "secondary," hard to medium-hard	27	1,063
Clay, dense, blue	19	1,082

Casing: 12-in. 0-193.4 ft, 10-in. 0-621.6 ft, and 8-in. 576.6-941.4 ft; unperforated.

Table 3.--Drillers' logs of wells in the Burnt River valley, Baker County, Oreg.--Continued

12/37-28E1. Oregon State Highway Dept. Altitude 3,900 ft. Drilled by Holloway Drilling Co., 1959

Materials	Thickness (feet)	Depth (feet)
Topsoil ----------------------------------	3	3
(Hardpan) --------------------------------	3	6
Gravel and sand, dry ---------------------	16	22
Clay, sandy ------------------------------	30	52
Shale, blue ------------------------------	98	150
Shale, brown -----------------------------	20	170
Shale, white -----------------------------	20	190
Shale, blue ------------------------------	30	220
Shale, sandy; yields some water ----------	12	232
Shale, blue ------------------------------	40	272
Shale, black -----------------------------	8	280
Sand, water-bearing ----------------------	2	282
Shale, blue ------------------------------	18	300

Casing: 6-in. to 60 ft; unperforated.

Table 3.--Drillers' logs of wells in the Burnt River valley, Baker County, Oreg.--Continued

12/38-27A1. Hereford Community Church. Altitude 3,660 ft. Drilled by R. W. Davis, 1959

Materials	Thickness (feet)	Depth (feet)
Topsoil	5	5
Clay, light-brown	15	20
Clay, yellow; sand and gravel	5	25
Clay, light-brown, some gravel	12	37
Clay, hard, brown, and gravel	2	39
Sand, gravel, and clay, tan	11	50
Clay and gravel, dark-brown	7	57
Hardpan	1	58
Sand, brown; yields some water	3	61
Clay, packed, hard, and gravel, water-bearing	7	68
Clay and gravel	6	74
Clay, soft; gravel and sand	7	81

Casing: 6-in. to 81 ft; unperforated.

Table 3.--Drillers' logs of wells in the Burnt River valley, Baker County, Oreg.--Continued

12/44-6E1. Hite Bros. Altitude 3,040 ft. Drilled by O. C. Tandy, 1961

Materials	Thickness (feet)	Depth (feet)
Topsoil	4	4
Clay, blue-black	38	42
Clay, yellow	19	61
Rock, solid, light-green	17	78
Rock, solid, black	23	101

Casing: 6-in. to 64 ft; perforated 60-64 ft.

Table 3.--Drillers' logs of wells in the Burnt River valley, Baker County, Oreg.--Continued

13/37-9M1. Ellingson Lumber Co. Altitude 3,950 ft. Drilled by R. W. Davis, 1960

Materials	Thickness (feet)	Depth (feet)
Soil, dark-brown	5	5
Clay, blue; some gravel	15	20
Clay, light-brown; gravel	15	35
Clay, light-brown, and coarser gravel	15	50
Clay, blue, and greenish sand	40	90
Clay, crumbly, blue	30	120
Clay, grayish, and gravel	10	130
Clay, blue and brown, with gravel; yields some water	80	210
Clay, brown, with lots of gravel	35	245
Clay, green, and gravel; water-bearing	15	260
Rock, gray, interbedded with gray and greenish-tan clay	25	285

Casing: 6-in. to 167 ft; perforated 135-167 ft.

Table 3.--Drillers' logs of wells in the Burnt River valley, Baker County, Oreg.--Continued

13/44-23J1. Union Pacific Railroad Co. Altitude 2,530 ft. Drilled by A. A. Durand

Materials	Thickness (feet)	Depth (feet)
Topsoil and clay	14	14
Gravel; some clay	9	23
Limestone, white	29	52
Shale, hard	3	55
Basalt, hard, red	10	65
Shale, broken; streaks of clay	9	74
Clay and shale, with quartz	13	87
Shale, hard, red	16	103
Rock, hard, red; some quartz	9	112
Rock, red; quartz abundant	15	127
Sand, fine, brown	5	132
Rock, broken	4	136
Quartz, hard, white	5	141
Rock, brokwn; quartz	21	162
Rock, hard, and quartz	5	167
Sand, coarse	6	173
Sand, cemented, and rock	11	184

Casing: 8-in. from land surface to 43 ft below, 6-in. from 1½ ft ft above land surface to 171 ft below; unperforated.

Table 3.--Drillers' logs of wells in the Burnt River valley, Baker County, Oreg.

14/45-18M1. City of Huntington. Altitude 2,115 ft. Drilled by A. A. Durand, 1932

Materials	Thickness (feet)	Depth (feet)
Soil	15	15
Gravel	7	22
Clay and gravel	18	40
Shale and soapstone	45	85
Shale and blue mud	115	200
Boulders	10	210
Clay, blue	54	264
Shale	41	305
Basalt, hard	17	322
Shale, green	58	380
Boulders	20	400
Mud, blue	5	405
Basalt	15	420
Rock, black	38	458
Clay, sticky	2	460
Rock, red	45	505
Shale, crumbly	18	523
Limerock	30	553
Basalt, gray	12	565
Rock, black	18	583

Casing: 10-in. 0-264 ft and 8-in. unknown depth to 523 ft; perforated 325-523 ft.

Table 4.--Chemical analyses of waters in the Burnt River valley, Baker County, Oreg.

Number[1]	Source	Date of collection	Temperature (°F)	Parts per million: Silica (SiO_2)	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[2]	Hardness: As $CaCO_3$	Hardness: Noncarbonate	Sodium adsorption ratio (SAR)	Residual sodium carbonate (Me./l.)	Specific conductance (micromhos at 25°C)	pH	Laboratory[3]
	Ground water [Water-bearing zone(s) ft]																						
11/43-18J1	30±	9-24-63	60	--	67	19	80	18	410	0	88	7.1	--	6.2	0.56	--	243	0	2.2	1.86	774	7.3	BR
28D1	877-900, 973-983	do	68	--	.8	1.0	212	1.6	372	82	12	12	--	.0	3.60	--	6	0	36.8	8.72	871	9.4	BR
12/37-28E1	220-232, 280-282	9-25-63	57	--	44	24	49	21	225	0	135	19	--	4.3	.00	--	209	26	1.5	0.00	683	7.0	BR
12/38-27A1	74-81	do	54	--	109	109	38	7.8	626	0	91	49	--	205	.00	--	720	2.07	.6	.00	1,400	7.6	BR
12/40-25P1	--	do	54	--	72	5.1	14	5.5	212	0	59	2.8	--	.0	.06	--	200	26	.4	.00	436	7.5	BR
26P1	--	do	54	--	18	6.7	397	15	1,150	0	1.4	24	--	.0	2.3	--	72	0	20.3	17.38	1,590	7.8	BR
29B1	--	do	53	--	21	8.5	23	4.7	95	0	50	9.9	--	.0	.00	--	86	9	1.1	.00	433	7.2	BR
	Surface water [Burnt River, in downstream order]																						
11/36-3G	North Fork near Whitney	4- 6-60	50	28	8.0	3.9	3.6	1.1	52	0	2.2	.0	0.1	.3	--	86	36	0	.3	-.13	89	7.4	GS
13/37-6B	South Fork 2 miles above Unity Reservoir	6-27-57	--	--	32	10	23	5.5	164	2	--	--	--	--	--	--	121	0	.9	-.33	327	8.3	
12/37-32C	South Fork 1 mile above Unity Reservoir	4- 6-60	54	33	11	4.1	6.3	2.6	65	0	6.2	.0	.1	.3	--	103	44	0	.4	-.18	119	7.5	GS
-21R	Main stem 1/2 mile below Unity Reservoir	6-27-57	--	--	19	6.7	11	2.6	88	4	--	--	--	--	--	--	75	0	.5	.07	194	8.6	GS
Do	do	9- 2-60	63	36	23	9.0	16	4.0	112	0	33	2.0	.3	1.0	--	191	94	2	.7	.00	255	7.5	GS
Do	do	9-25-63	60	--	32	13	23	5.1	152	0	62	2.1	--	.0	.04	--	135	10	.9	.00	347	7.9	BR
12/41-20N	Main stem near Bridgeport	do	60	--	46	18	34	7.4	242	0	64	3.5	--	.0	.00	--	188		1.1	.20	477	8.2	BR
11/42-26J	Main stem above Durkee	9-24-63	64	--	50	17	36	8.6	198	27	63	2.8	--	.0	.14	--	196		1.1	.24	483	8.8	BR
11/43-29J	Main stem at Durkee	4- 6-60	61	32	28	8.1	16	3.6	125	0	31	2.2	.3	1.3	--	188	103	0	.7	.00	274	7.6	GS
Do	do	9-29-60	65	43	55	20	39	8.0	263	7	74	4.8	.4	.3	--	386	218	0	1.1	.17	558	8.4	GS
14/44-13H	Main stem at Huntington	7-25-58	--	42	60	17	38	7.0	251	0	87	4.5	.4	1.1	--	384	220	14	1.2	.00	548	8.0	GS
Do	do	9-17-59	65	42	75	16	50	8.9	282	14	110	6.0	.5	.5	--	471	252	0	1.4	.04	677	8.5	GS
Do	do	4- 6-60	59	32	32	7.8	16	3.8	131	0	34	2.0	.3	1.6	--	200	112	4	.7	.00	289	7.6	GS

1/ See p. 7 for explanation of numbering system.
2/ Residue on evaporation at 180°C.
3/ BR, U.S. Bureau of Reclamation; GS, U.S. Geological Survey.

Pocket contains
2 maps