Effects of Well Discharges on Hydraulic Heads in and Spring Discharges from the Geothermal Aquifer System in the Bruneau Area, Owyhee County, Southwestern Idaho

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Abstract

Demand for ground water in the 600-square-mile Bruneau study area has increased since 1954 because of agricultural development. Declining flow at Indian Bathtub Spring is adversely affecting a unique species of snail that inhabits the spring.

The Bruneau study area is underlain by sedimentary and volcanic rocks that form a regional geothermal aquifer. Sedimentary rocks range in thickness from zero in the southern part of the study area to more than 3,000 feet in the northeastern corner. Volcanic rocks underlie the entire study and extend southward to the Jarbidge Mountains. In the central part of the study area, the volcanic rocks are probably 2,000 to 3,000 feet thick. For purposes of study, the regional geothermal aquifer system was divided into sedimentary-and volcanic-rock aquifers.

Ground water flows northward through the volcanic-rock aquifer to the sedimentary-rock aquifer, from areas of recharge along the Jarbidge and Owyhee Mountains into the study area, where it is discharged as spring flow or leaves the study area as underflow. Prior to extensive ground-water development, about 10,100 acre-feet was discharged from wells.

Ground-water discharge from wells began in the late 1890's. From the 1890's through 1951, annual discharge was less than 10,000 acre-feet. From 1952 to 1978, annual discharge increased to about 40,600 acre-feet. During 1978-91, well discharge declined from the maximum of 49,900 acre-feet in 1981 to 34,700 acre-feet in 1991. Through 1991, nearly 1,400,000 acre-feet of ground water discharged from wells; about 546,000 acre-feet discharged from 1978 through 1991. Most pumped water is from the volcanic-rock aquifer.

Ground-water development since the mid-1890's locally has modified the direction of water movements in both the sedimentary- and volcanic-rock aquifers. In 1989, ground water moved toward four cones of depression created by pumping—two in the northern part of the study area are in the sedimentary-rock aquifer, two in the southern part are in the volcanic-rock aquifer. Pumping has caused hydraulic heads in the volcanic-rock aquifer to decline more than 30 feet in much of the area and at least 70 feet in one well. About 1 mile from Indian Bathtub Spring, the water level in one well declined about 10 feet during 1979-92, or about 0.7 feet per year.

Within the past 25 years, discharge from monitored springs along Hot Creek and the Bruneau River has declined, most notably from Indian Bathtub Spring. Discharge from Indian Bathtub Spring in 1964 was about 2,400 gallons per minute, and by the summer of 1989, discharge was zero. Discharge began to decline in the mid-1960's when the rate of increase in pumpage accelerated. In contrast, discharge from Pence Hot Spring has ranged from about 700 gallons per minute to about 1,100 gallons per minute.

Changes in discharge from monitored springs corresponded with changes in hydraulic head, which fluctuates seasonally, and are

substantially less in late summer than in the spring. A hydraulic head/spring discharge relation was developed for two sites at Indian Bathtub Spring and a nearby test hole. The relation for Indian Bathtub Spring indicated that a spring discharge of 2,400 gallons per minute would relate to a hydraulic head of about 2,708 feet at the spring, which is about 34 feet higher than the head at zero spring discharge.

INTRODUCTION

Bruneau, Little, and Sugar Valleys, within the 600-mi2 Bruneau study area (fig. 1) in north-central Owyhee County, have undergone extensive agricultural development since the turn of the century. Additional water is needed for irrigation (due to phasing out of "set aside" irrigated lands) in those valleys. A geohydrologic study of the same general area by Littleton and Crosthwaite (1957) indicated that available surface water was inadequate for all irrigable lands. They also noted that the regional geothermal aquifer is perhaps the most promising source for additional water. In 1980, about 25,000 acres in the study area were irrigated with surface water and about 20,000 acres were irrigated with ground water (Lindholm and Goodell, 1986). Young and others (1979, p. 15) estimated that in 1978, about 39,000 acre-ft of ground water was discharged from wells in the study area. Pumping of ground water for irrigation has lowered hydraulic heads throughout the area. Consequently, discharge from monitored geothermal springs along the Bruneau River and Hot Creek is declining, with intermittent flow from Indian Bathtub Spring. Young and others (1990) showed that Indian Bathtub Spring did not flow from July through October 1989 and from July through September 1990.

The Bruneau Hot Springs snail is present in springs along Hot Creek and the Bruneau River in Owyhee County. Within the past 25 years, flows from monitored springs have declined; this decline may have restricted the snail's habitat. Several public agencies, the general public, and Idaho's congressional delegation have become concerned about the continued existence of the snail. The U.S. Fish and Wildlife Service (USFWS) is concerned that declines in spring flow might cause the snail's extinction.

Purpose and Scope

In 1987, the USFWS entered into a cooperative agreement with the U *.S.* Geological Survey (USGS) to develop and implement a three-phase ground-water study of the Bruneau area. This study focused on the hydrology of the regional geothermal system and the hot springs. During the first phase of the study, completed in 1989 (Young and Parliman, 1989), the hydrologic data base was updated and evaluated and a ground-water and spring-monitoring program was implemented in the Indian Bathtub study area, which occupies about 145 mi2 of the larger Bruneau study area. The second phase, completed in 1990 (Young and others, 1990), resulted in the drilling of eight test holes at four sites near the Indian Bathtub Spring (fig. 1). These test holes were designed to provide a better understanding of the relation between hydraulic heads and spring discharge. The purpose of the third phase of the study, described in this report, is to determine the cause or causes of declining flow at Indian Bathtub Spring.

The third phase, completed in 1992, included (1) evaluating all available information about the regional geothermal aquifer system; (2) describing the geohydrology of the Bruneau study area, including ground-water recharge, discharge, movement, and hydraulic head; (3) describing vertical variations in hydraulic head; and (4) determining the effects of discharge from wells on hydraulic heads and spring flows in the study area.

Description of the Study Area

The Bruneau study area is near the southern margin of the western Snake River Plain, about 65 mi southeast of Boise (fig. 1). The study area includes the Indian Bathtub area and extends north from about 42°45' latitude to the Snake River, east from the drainage divide between Shoofly Creek and Little Jacks Creek to the drainage divide between the Bruneau River and Sailor Creek--an area of about 600 mi^2. The study area includes

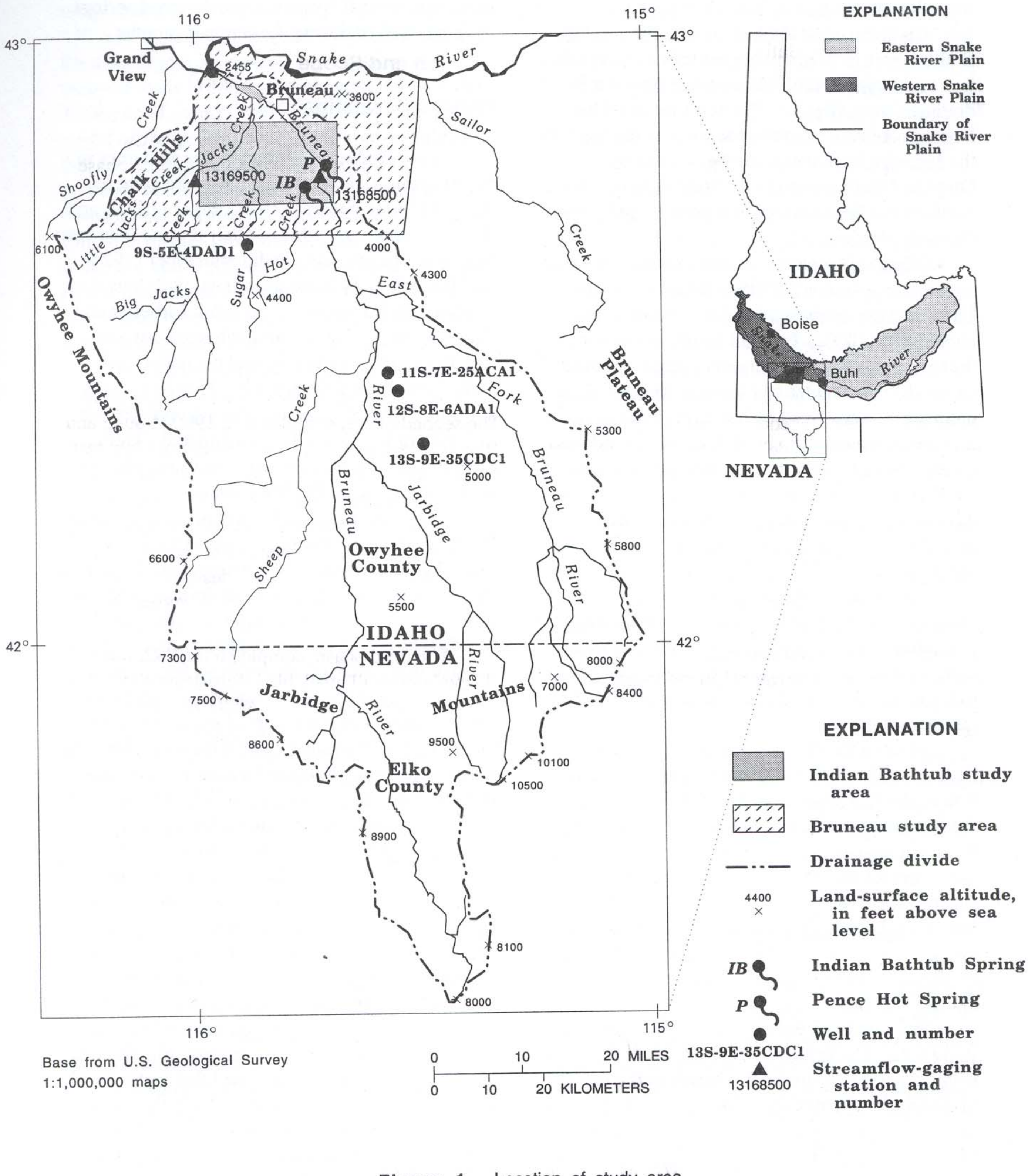


Figure 1. Location of study area.

Bruneau, Little (includes valleys of Little and Big Jacks Creeks), and Sugar Valleys, which are separated by plateaus several hundred feet higher than the valley floors and included streams.

To understand the hydrology of the Indian Bathtub area, it is necessary to determine its relation to a larger hydrologic unit, the Bruneau River drainage basin (fig. 1). The basin includes the Bruneau study area and is bounded on the south by the Jarbidge Mountains, on the west by the Owyhee Mountains and the Chalk Hills, on the north by the Snake River, and on the east by the Bruneau plateau.

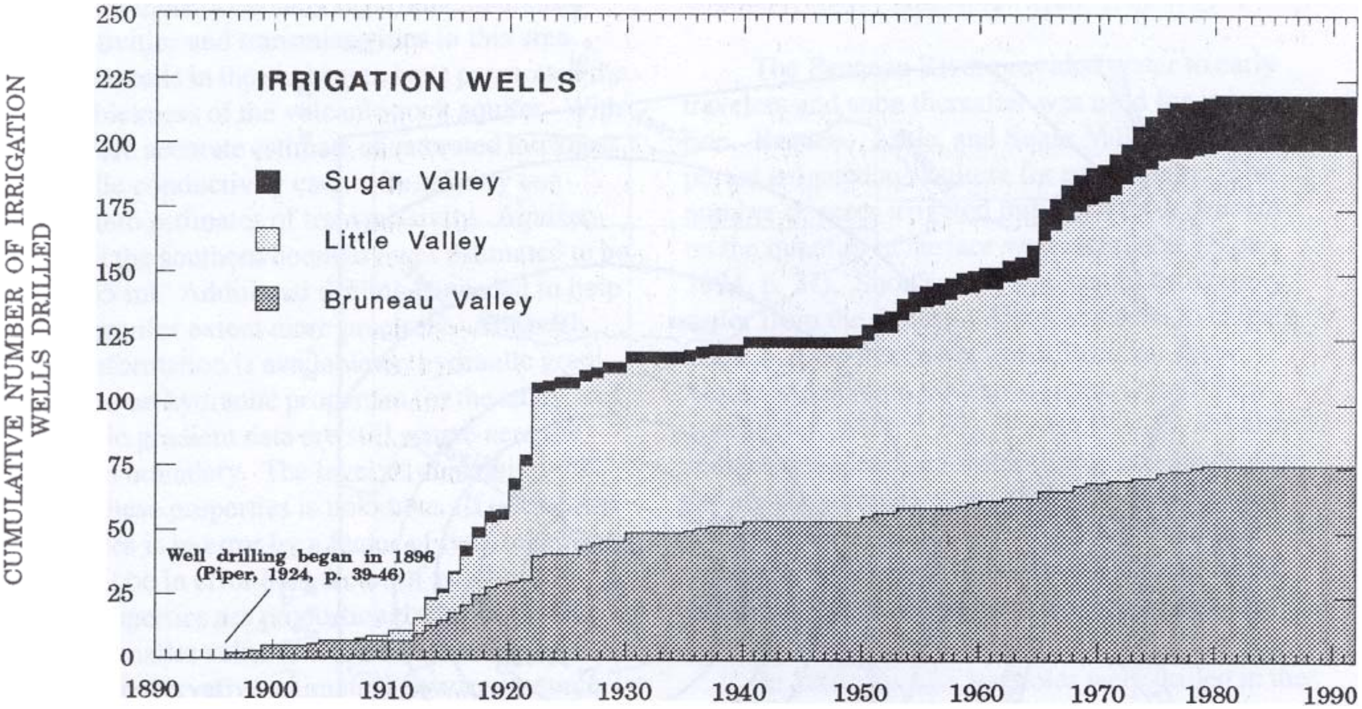
The study area has an arid climate. Average annual precipitation on valley floors is less than 10 in. and the average annual air temperature is about 50°F (10°C). Rainfall is infrequent during the summer; most precipitation (which includes snowfall) is from October through March. Summers are characterized by hot days (average daily maximum temperature is 90°F, or 32°C) and warm nights (average daily minimum temperature is 54°F, or 12°C); winters are characterized by cool days (average daily maximum temperature is 43°F, or 6°C) and cold nights (average daily minimum temperature is 24°F, or -4°C).

The Bruneau River drainage area has a predominantly rural population dependent on irrigated agriculture. The city of Bruneau, with a 1990 population of about 300 people, covers several square miles in the northern part of the area and is the largest community.

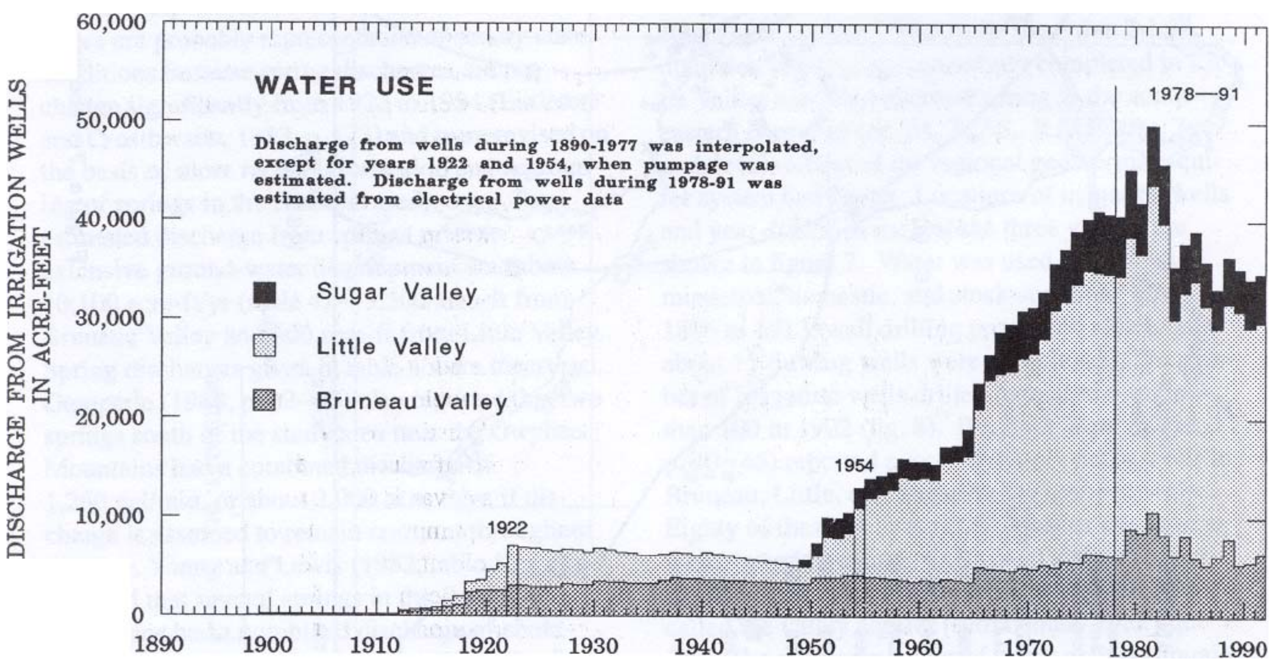
Most of the Bruneau River drainage area is Federal land leased for grazing under the jurisdiction of the U.S. Bureau of Land Management (BLM). Bruneau, Little, and Sugar Valleys have been irrigated extensively since the turn of the century, whereas intervening plateaus are undeveloped desert. The main crops are hay and alfalfa, associated with the raising of cattle; corn and beans are also grown in Little and Sugar Valleys. Water for irrigation is obtained from streams and from flowing and pumped wells.

Perennial and ephemeral streams drain the study area. The principal drainage is the Bruneau River, a perennial stream that heads in the Jarbidge Mountains and flows northward across the plateaus in deeply incised canyons to the Snake River.

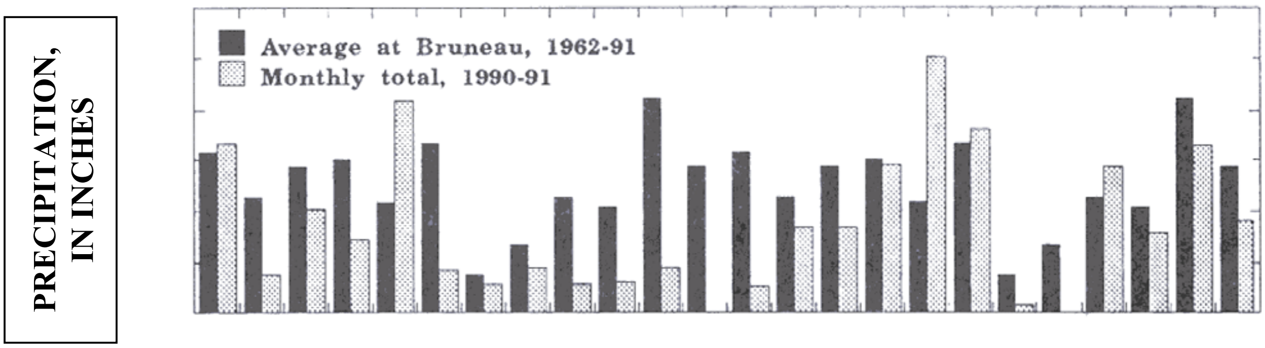
Many streams in the study area are ephemeral and flow only in response to rainstorms or spring runoff; included are Big Jacks, Browns, Deer Heaven, Hot, Little Jacks, and Sugar Creeks. Springs discharge directly to some creeks, like Hot Creek, but in the last several years, some monitored springs have not flowed during the summer months.

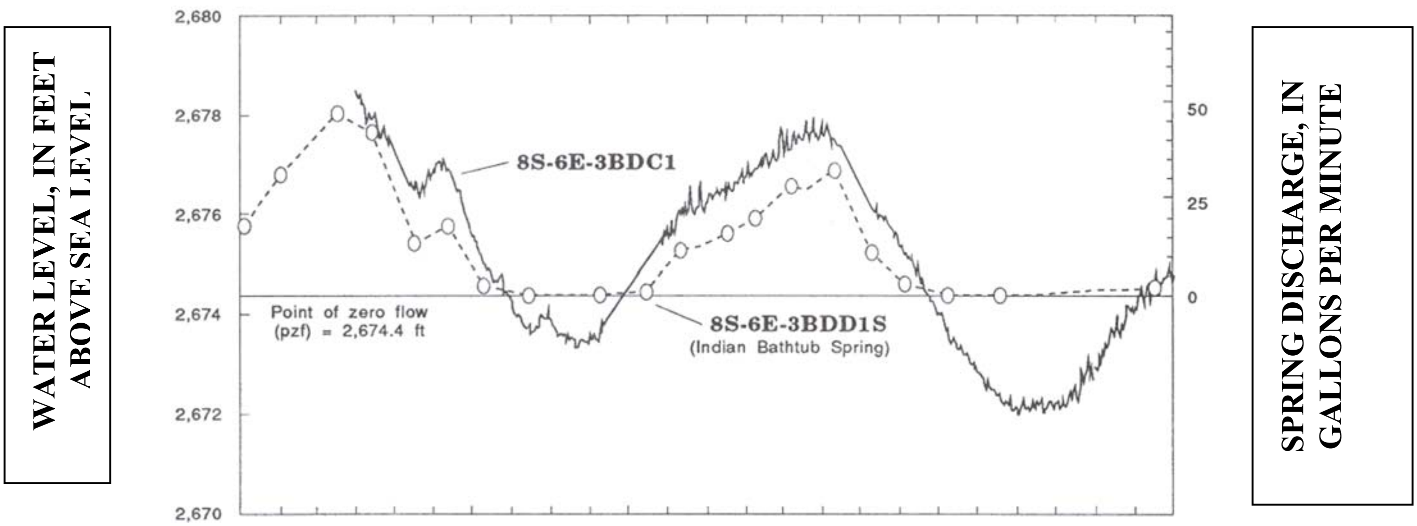


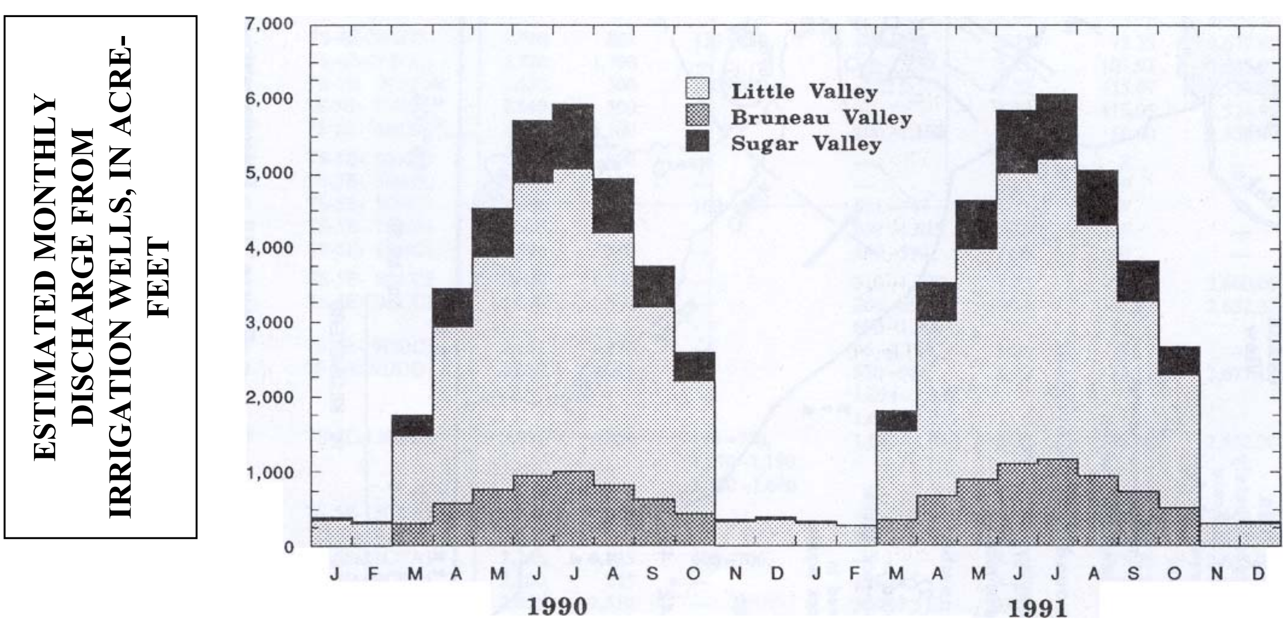
Cumulative number of irrigation wells drilled in the Bruneau area, 1990-1991.

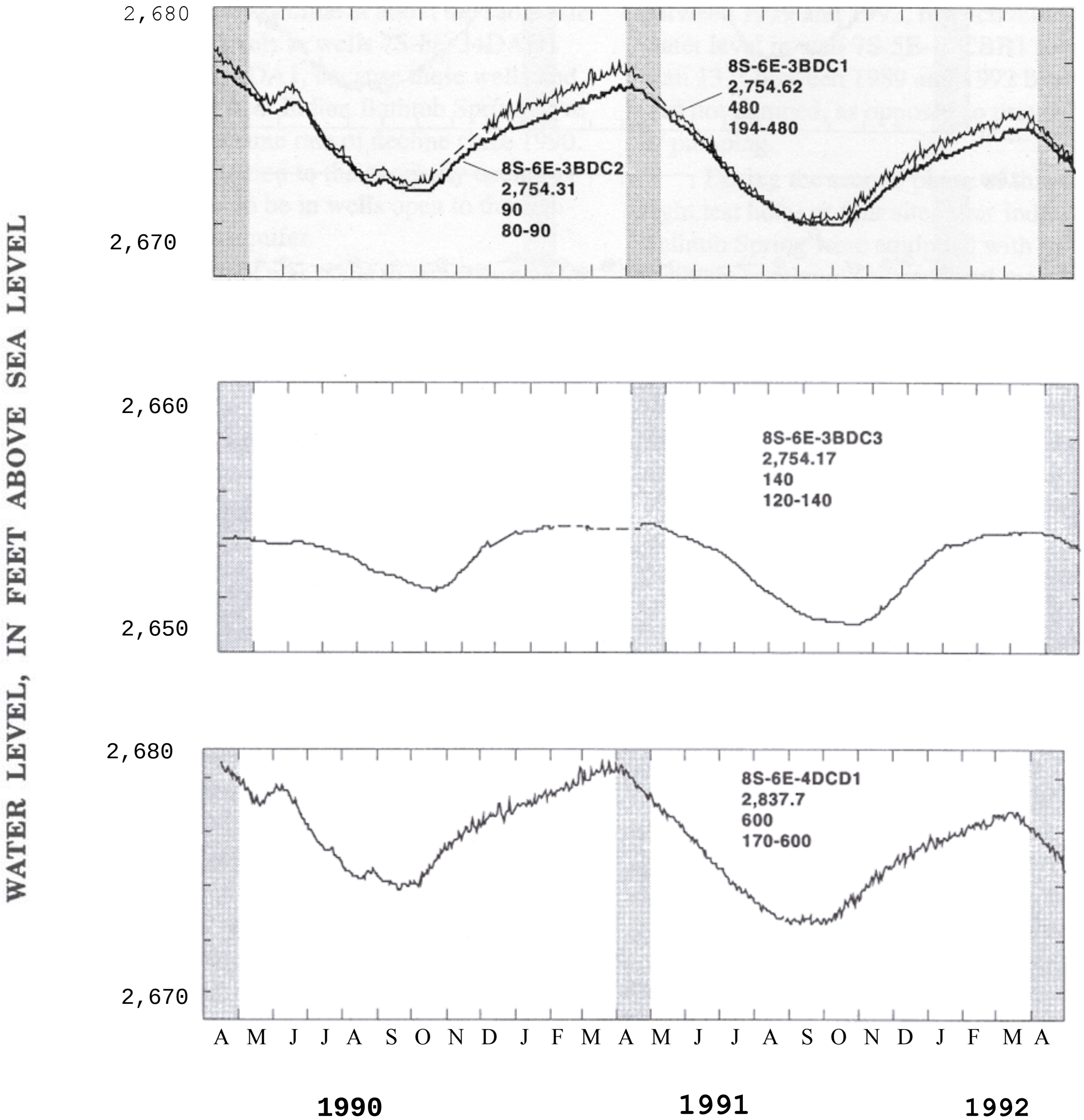


Distribution of annual discharge from irrigation wells in the Bruneau area, 1890-1991.


PRECIPITATION, IN INCHES
Average at Bruneau, 1962-91
Monthly total, 1990-91


WATER LEVEL, IN FEET ABOVE SEA LEVEL
SPRING DISCHARGE, IN GALLONS PER MINUTE
2,680
2,678
2,676
2,674
2,672
2,670
50
25
0
8S-6E-3BDC1
8S-6E-3BDD1S
(Indian Bathtub Spring)
Point of zero flow
(pzf) = 2,674.4 ft


ESTIMATED MONTHLY DISCHARGE FROM IRRIGATION WELLS, IN ACRE-FEET
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Little Valley
Bruneau Valley
Sugar Valley
J F M A M J J A S O N D J F M A M J J A S O N D
1990
1991



Hydrographs for test holes near Indian Bathtub Spring, April 1990 through April 1992-Continued.

SUMMARY

This report describes results of a study to determine the cause or causes of declining flow at Indian Bathtub Spring that is adversely affecting a unique species of snail that inhabits the spring.

The Bruneau study area of about 600 mi2 includes the northern part of the Bruneau River drainage basin and Indian Bathtub area. The study area includes Bruneau, Little, and Sugar Valleys, which are separated by plateaus several hundred feet higher than the valley floors and included streams. Many faults cross the study area. They enhance and provide conduits for ground-water flow, horizontally and vertically.

The Bruneau area is underlain by sedimentary and volcanic rocks. The sedimentary rocks consist predominantly of fine sand, silt, and clay of low permeability with some included gravel and volcanic rocks. The sedimentary rocks range in thickness from zero in the southern part of the study area to more than 3,000 ft in the northeastern part and underlie about 500 mi2 of the study area. The volcanic rocks consist of basalt and silicic rocks with some interbedded sedimentary rocks. The thickness of the volcanic rocks is largely unknown but is probably 2,000 to 3,000 ft. For this study, the regional geothermal aquifer system was divided into sedimentary- and volcanic-rock aquifers. The sedimentary rocks are part of a more extensive aquifer in the western Snake River Plain. Volcanic rocks are present throughout the study area and extend southward to the Jarbidge Mountains. In the northern part of the study area, the volcanic-rock aquifer underlies the sedimentary- rock aquifer and water is confined in both.

Transmissivity of the volcanic rocks, as estimated from aquifer and slug tests, ranged from about 25 to 100,000 fr^2/d. Low values were obtained from tests in two wells about 23 mi south of Indian Bathtub and are indicative of massive, unfractured silicic volcanic rocks as compared with the highly fractured volcanic rocks in the Bruneau study area. Transmissivity and hydraulic conductivity, estimated from specific-capacity tests, ranged from 1,700 ft2/d and 0.7 ft/d for the sedimentary-rock aquifer to 980,000 ft2/d and 390 ft/d for the volcanic-rock aquifer. In general, transmissivities in the sedimentary-rock aquifer decrease from south to north because of the increase in fine-grained rocks toward the Snake River.

Generally, ground water moves northward from areas of recharge along the Jarbidge and Owyhee Mountains toward the study area, where it is discharged as spring flow or leaves the study area as underflow. Natural recharge to the study area was estimated by the basin yield method for the period 1934-80 to be about 57,000 acre-ft/yr.

Ground water for irrigation in the late 1890's was first obtained from flowing wells. From 1890 to 1981, discharge from flowing or pumped irrigation wells increased from 0 to about 49,900 acre-ft/yr. After 1981, discharge decreased and was about 34,700 acre-ft in 1991. Through 1991, nearly 1,400,000 acre-ft of ground water discharged from wells in the study area. Of that quantity, about 546,000 acre-ft discharged from 1978 through 1991. Most pumped water is from wells completed in the volcanic-rock aquifer and farther than 5 mi from Indian Bathtub Spring.

Ground-water movement in the sedimentary- and volcanic-rock aquifers in spring 1989 generally was from south to north toward the Snake River. Four depressions, created by heavy pumping for irrigation, were evident on the potentiometric surface in the study area. Two depressions were in the northern part of the study area in the sedimentary-rock aquifer. The other two depressions were near the southern end of Bruneau and Little Valleys, where most of the wells are completed in volcanic rocks. Hydraulic head in the volcanic-rock aquifer is about 25 ft higher than head in the sedimentary-rock aquifer and, in places, is as much as 50 ft higher.

Long-term hydraulic heads in the sedimentary-rock aquifer have not changed significantly since the mid-1950's, but in the volcanic-rock aquifer, heads have declined several tens of feet. Water levels in three wells in the volcanic-rock aquifer in Little Valley have declined about 70, 45, and 30 ft since the mid-1950's. Seasonally, hydraulic heads fluctuate in

response to pumping and natural recharge; heads are generally highest in March-April and lowest in September-October.

Within the past 25 years, discharge from monitored springs along Hot Creek and the Bruneau River has declined, most notably from Indian Bathtub Spring. From the late 1890's through 1991, nearly 275,000 acre-ft of water discharged from Indian Bathtub Spring. Of this quantity, about 1,400acre-ft was discharged during 1982-91. Discharge from Indian Bathtub Spring began to decline in the mid-1960's when well discharge accelerated. Discharge from Pence Hot Spring has ranged from about 700 to 1,100 ga1/min since 1922.

Changes in discharge from monitored springs are similar to changes in hydraulic head, which fluctuates seasonally and is substantially less in late summer than in the spring. A hydraulic head/spring discharge relation was developed for two sites at Indian Bathtub Spring and a nearby test hole. The relation for Indian Bathtub Spring indicated that a spring discharge of 2,400 ga1/min, as in 1964, would relate to a hydraulic head of about 2,708 ft, or about 34 ft higher than the head at zero discharge. Hydraulic head declines of 34 ft at the Indian Bathtub area are probably reasonable because a similar magnitude of decline has been measured elsewhere in the area.