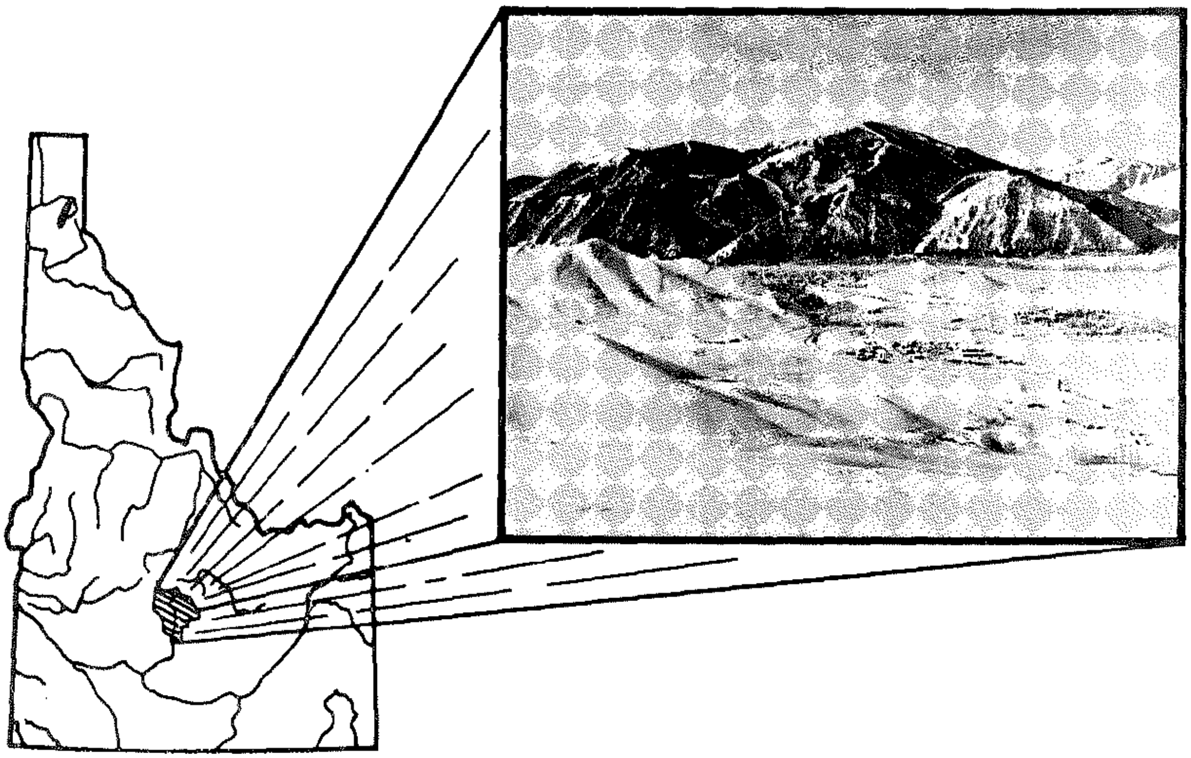
EFFECTS OF URBANIZATION ON THE WATER RESOURCES OF THE SUN VALLEY-KETCHUM AREA BLAINE COUNTY, IDAHO



IDAHO DEPARTMENT OF WATER RESOURCES
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EFFECTS OF URBANIZATION ON THE WATER RESOURCES OF THE SUN VALLEY-KETCHUM AREA, BLAINE COUNTY, IDAHO

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INTRODUCTION

In recent years, parts of Idaho have seen explosive growth, especially in terms of recreational development. The Sun Valley-Ketchum area in south-central Idaho has been subjected to this growth. Increased urbanization has, in many cases caused increased reliance on private wells for water supply and on septic tanks for waste disposal. Where municipal water supplies and waste treatment facilities are inadequate or not available, urbanization may have adverse effects on the water resources.

Purpose and Objectives

The Sun Valley-Ketchum area has high potential for ground and surface water contamination. IDWR began a study of the water resources of the area to:

1) Determine the physical characteristics of aquifers underlying the area.
2) Determine the relation between the ground and surface water resources of the area.
3) Describe the present level of urbanization in terms of water use.
4) Determine the quality of ground and surface waters in the area.
5) Establish a base of hydrologic data for future use, against which future data may be compared.

Location and Extent of Study Area

The study area is located entirely within the northern portion of Blaine County (fig. 1) and includes the upper drainage basin of the Big Wood River as far downstream as Hailey. The area is bounded on the north by the Boulder Mountains, on the west by the Smoky Mountains and on the east by the Pioneer Mountains. The total surface drainage area is approximately 640 square miles.

Previous Investigations

No general water resource studies have been made of the Sun Valley-Ketchum study area; however, a number of studies specifically related to water, land, and sewage programs in the immediate vicinity of Sun Valley and Ketchum have been made by various consulting engineering firms. Some of these include reports by Stevens, Thompson and Runyan (1972); Montgomery Consulting Engineers, Inc., (1973); Cornell, Howland, Hayes & Merryfield (CH_2M), (1967, 1972 and 1974); Keith E. Anderson (1966(a), 1966(b)), Anderson and Kelly (1971); and J-U-B Engineers, Inc., (1963, 1971, 1972).

General discussions of the groundwater resources of the Big Wood River valley are contained as sections in Water Supply Papers 774 and 1654 by Stearns, et al, (1938) and Mundorff, et al, (1964), respectively. In addition, much surface water basic data is contained in U.S. Geological Survey publication series "Water Resources Data for Idaho - Part 1, Surface Water Records."

Well-Numbering System

The well-numbering system used in this study is the same as that used by the U.S. Geological Survey (USGS) in Idaho. This system indicates the locations of wells within the official rectangular subdivisions of public lands, with reference to the Boise base line and meridian. The first two segments of a number designate the township and range. The third segment gives the section number, followed by two letters and a numeral, which indicate, respectively, the quarter section, the 40-acre tract, and the serial number of the well within the tract. If a well has been more accurately located than the nearest 40-acre tract, there will be three letters and a numeral following the section number (fig. 2).

Quarter sections are lettered a, b, c, and d in counterclockwise order, beginning with the northeast quarter of each section. Within the quarter sections, 40-acre and 10-acre tracts are lettered in the same manner. As illustrated in fig. 2, well 4N 17E 11dbd1 is in the SE1/4 of the NW1/4 of the SE1/4 of section 11, Township 4 North, Range 17 East, and is the first well visited in that tract.

Acknowledgments

The authors wish to acknowledge the assistance and cooperation of those groups, agencies, and individuals in the Sun Valley-Ketchum area who allowed free access to their records, facilities, lands, and wells. Special thanks go to those individuals who allowed periodic visits to their wells for the purpose of water-level measurement and water-quality sampling.

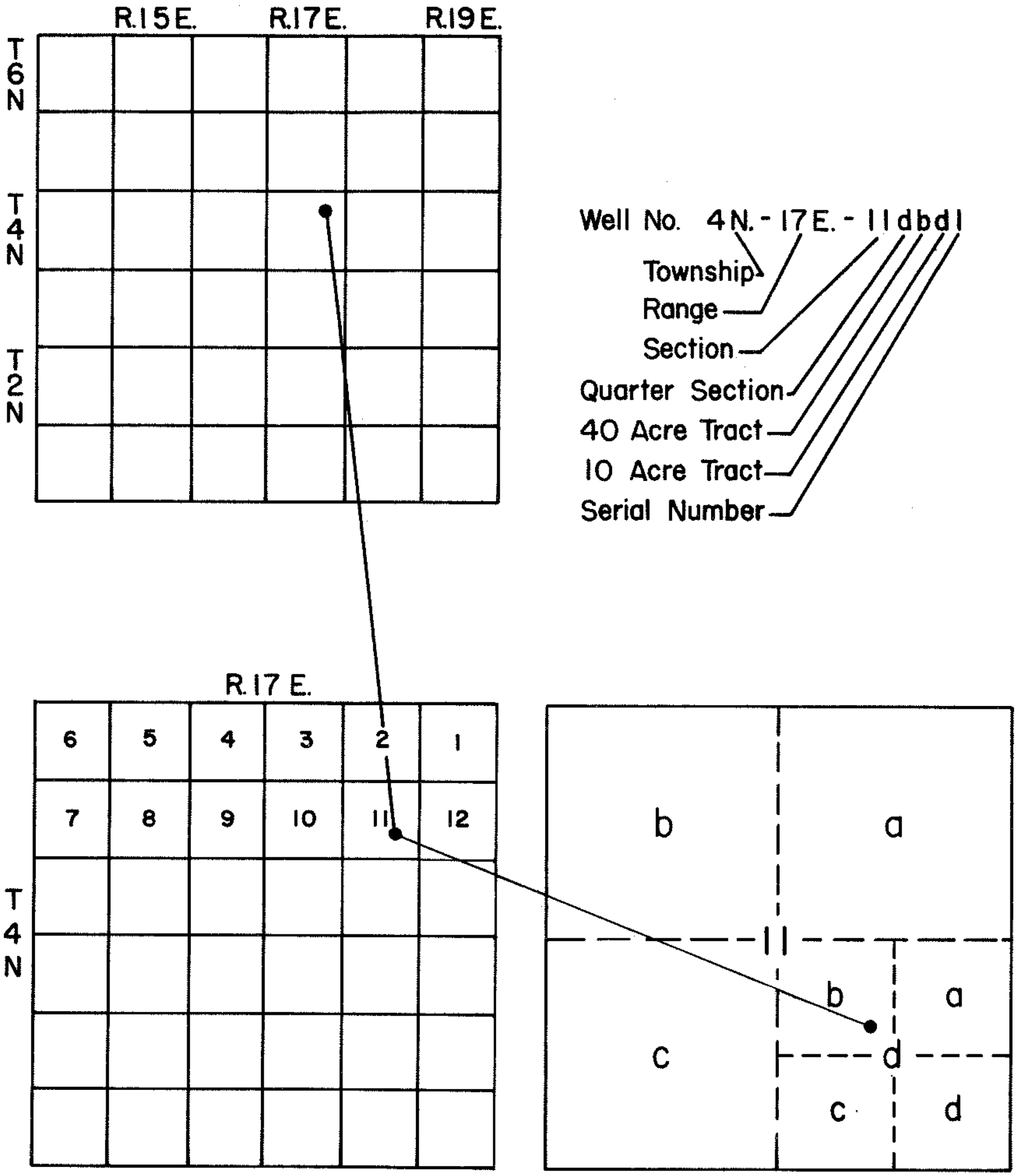


Figure 2. Well Numbering System.

GEOGRAPHIC SETTING

Physically, the study area is one of contrasts. Steep, rugged mountains flank the relatively narrow, flat, alluvium-filled valley on three sides. Hyndman Peak, in the Pioneer Mountains, exceeds 12,000 feet in elevation. Boulder Peak in the Boulder Mountains exceeds 11,000 feet, and many peaks in the Smoky Mountains exceed 10,000 feet in elevation. The valley floor averages approximately one-half mile in width except for an area north of Hailey where the valley exceeds one mile in width (fig. 1). The valley ranges in elevation from about 5300 feet above sea level at Hailey to about 7290 feet at Galena P.O.

The Big Wood River, with its major tributaries the East and North Forks, Trail Creek, Warm Springs Creek and Deer Creek, drains the area. Numerous smaller perennial and intermittent streams also contribute water to these major tributaries.

According to the 1970 census, Ketchum had a resident population of 1,454 and Sun Valley had 180. In the winter of 1972-73 the winter resident population swelled to 2,900 for Ketchum including Big Wood Development, plus 558 for Sun Valley including Elkhorn (CH_2M-Hill, 1974, p. 39). This seasonal population fluctuation of over 200 percent, also did not include the transient population of visitors which further swelled the peak 1972-73 winter population to 4,838 for Ketchum and 3,519 for Sun Valley.

TABLE 1. Climatic Data for Sun Valley-Ketchum Station, Blaine County, Idaho. (Based on 30 years of record.)

Data	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Mean precipitation (inches)	2.41	1.88	1.22	0.98	1.59	1.62	0.63	0.82	0.88	1.06	1.76	2.50	17.35
Percent of total	14.0	10.8	7.0	5.6	9.2	9.4	3.6	4.7	5.1	6.1	10.1	14.4	100.0
Mean snowfall (inches)	31.7	24.2	14.5	4.1	0.9	T	T	T	0.4	1.5	13.1	28.5	118.9
Mean temperature (degrees F.)	14.7	19.5	24.6	37.3	46.0	51.8	59.6	58.3	51.1	43.0	29.2	19.4	37.9
Mean maximum temperature (degrees F.)	30.6	36.4	40.7	52.7	63.7	70.4	82.4	81.3	72.4	60.8	43.5	33.6	55.7

(Note: from U. S. Dept. of Commerce, National Weather Service records.)

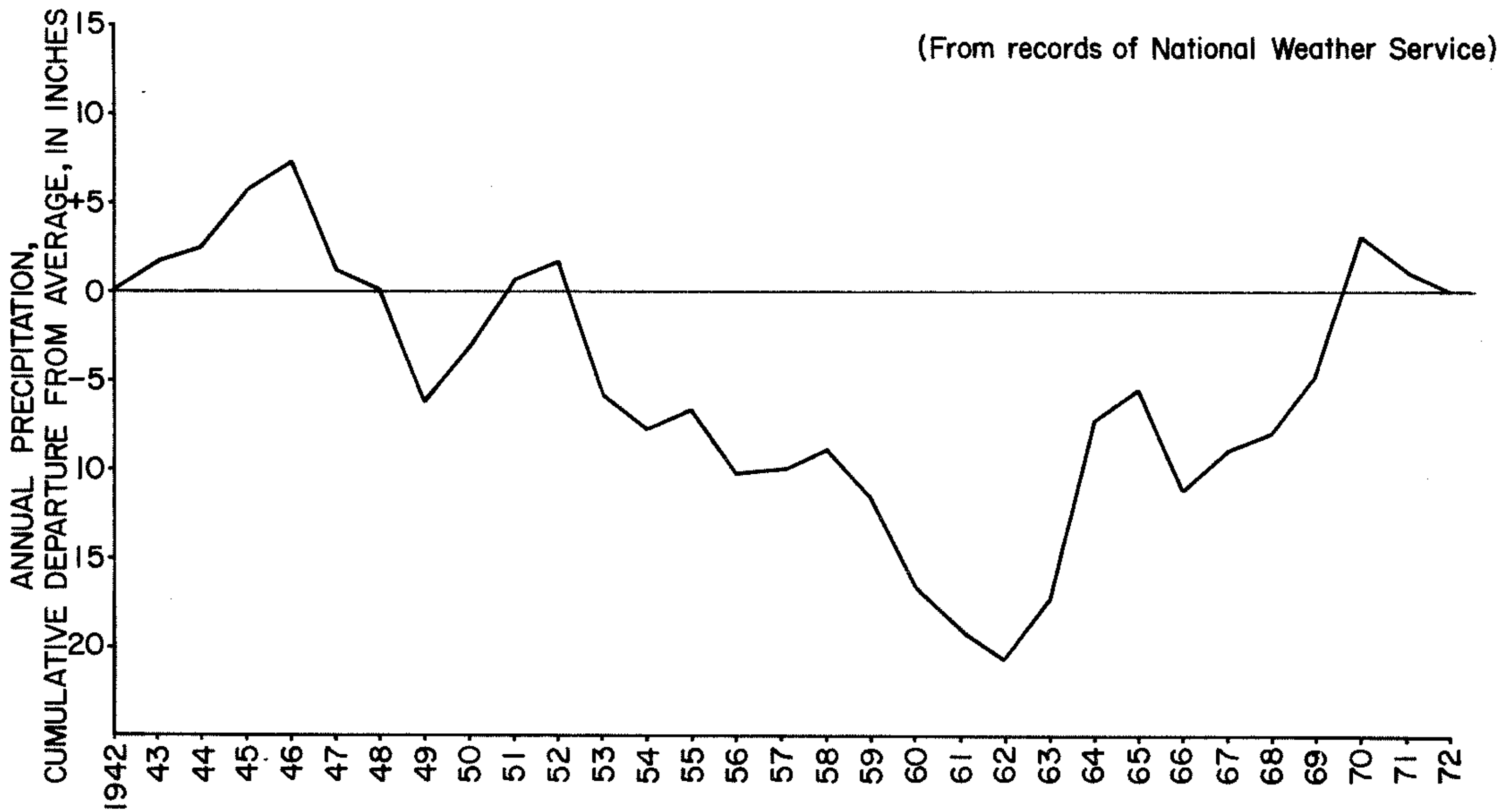
Climate

The climate of the area is characterized by moderately cold winters and warm, dry summers with warm days and cool nights. At Sun Valley, winter temperatures reach the mean minimum temperature of -1.2°F. (degrees Fahrenheit) in January and the summertime mean maximum of 82.4°F. in July (Table 1). The average length of period with freeze-free temperatures is 95 days, occurring between June 11 and September 14. However, on the average there are 126 days between the last 28°F. temperature in the spring and the first in the fall, which is usually considered the growing season for plants.

Precipitation at Sun Valley averages 17.35 inches annually, approximately 50 percent of which falls in the period November through February. An estimated 27 percent (4.7 inches) falls during the growing season.

Figure 3 is a chart showing the departure from normal of annual precipitation values from a long-term average. This chart is useful in visualizing precipitation trends over an extended period of time. It can be seen from the chart that precipitation has averaged above normal from 1962 to 1970, and is beginning a downward trend beginning with 1971. The weather station at Sun Valley was discontinued in 1972 and moved to the Ketchum Ranger Station, where records are currently being kept. Complete precipitation data for 1974 indicates a total annual precipitation of 14.28 inches, also below the long-term average.

Figure 3. Annual precipitation at Sun Valley, cumulative departure from average, 1942-72.



		GEOLOGIC UNIT	LITHOLOGIC DESCRIPTION
Quaternary		Qal Quaternary alluvium undifferentiated	Gravel, sand and silt of flood plains, fans, and terraces; includes fluvioglacial sediments and partially eroded older deposits.
Tertiary	Tcu Challis volcanics undifferentiated	Tcr Rhyolitic rocks	Lava and welded tuff, largely rhyolite and quartz latite.
		Tcb Basaltic rocks	Lava, dominantly basalt or calcic andesite.
		Tcg Germer tuffaceous member and associated rocks	Clastic tuff and some welded tuff, travertine, sandstone, siltstone and conglomerate.
Cretaceous		Ki Idaho batholithic rocks	Granitic rocks with varied composition, but chiefly quartz monzonite.
Pennsylvanian		PPwr Wood River formation	Quartzitic sandstone and siltstone, some limestone and conglomerate.
Mississippian		Mm Milligen formation	Gray and black carbonaceous shale and argillite with some sandy and quartzitic beds and limestone.

(Modified from Ross, 1963)

Associated geologic map on following page.

Figure 4. Lithologic description of geologic units in the Sun Valley-Ketchum area.

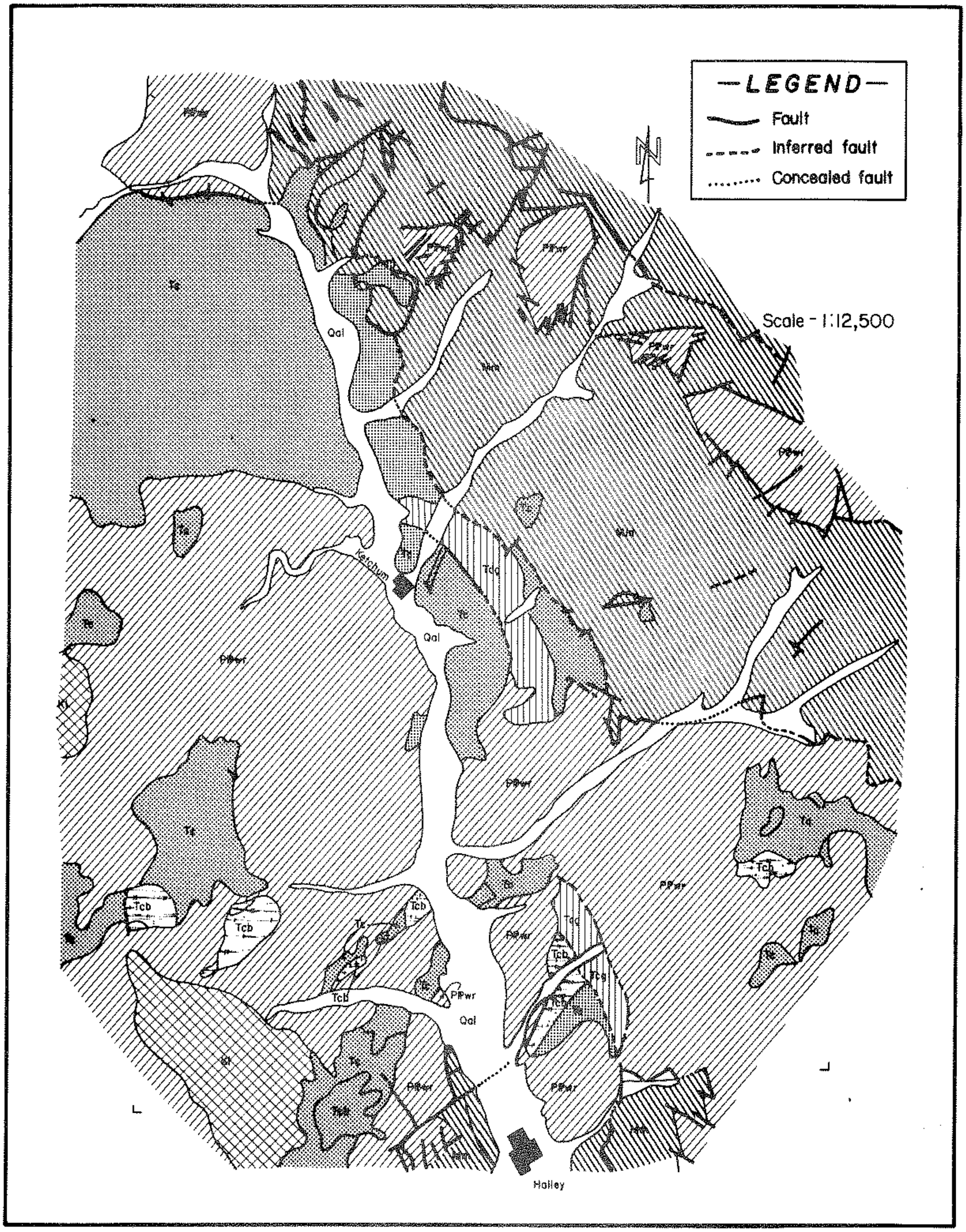


Figure 5. Generalized geologic map of the Sun Valley-Ketchum area. (After Umpleby, Westgate and Ross, 1930, and Ross, 1963.)

Economy

The economy of the area is dependent primarily on tourism and recreation, especially winter sports. In recent years, however, Sun Valley has been striving to also establish itself as a summer resort, with the result that the transient population has further increased. The resident population is generally employed in service-oriented industries such as merchandising, lumbering, mining, construction and agriculture. Recreational pursuits have increased in variety and attendance in recent years also, due primarily to the continued development of Sun Valley as well as the recently established complex of Elkhorn in Elkhorn Gulch south of Sun Valley.

As a result of this accelerated development, many seasonal recreation homes, cabins and condominiums have been built along and near the Big Wood River and its tributaries. Such development offers a potential for serious pollution of ground and surface waters in the area and downstream if sewage facilities are not adequate.

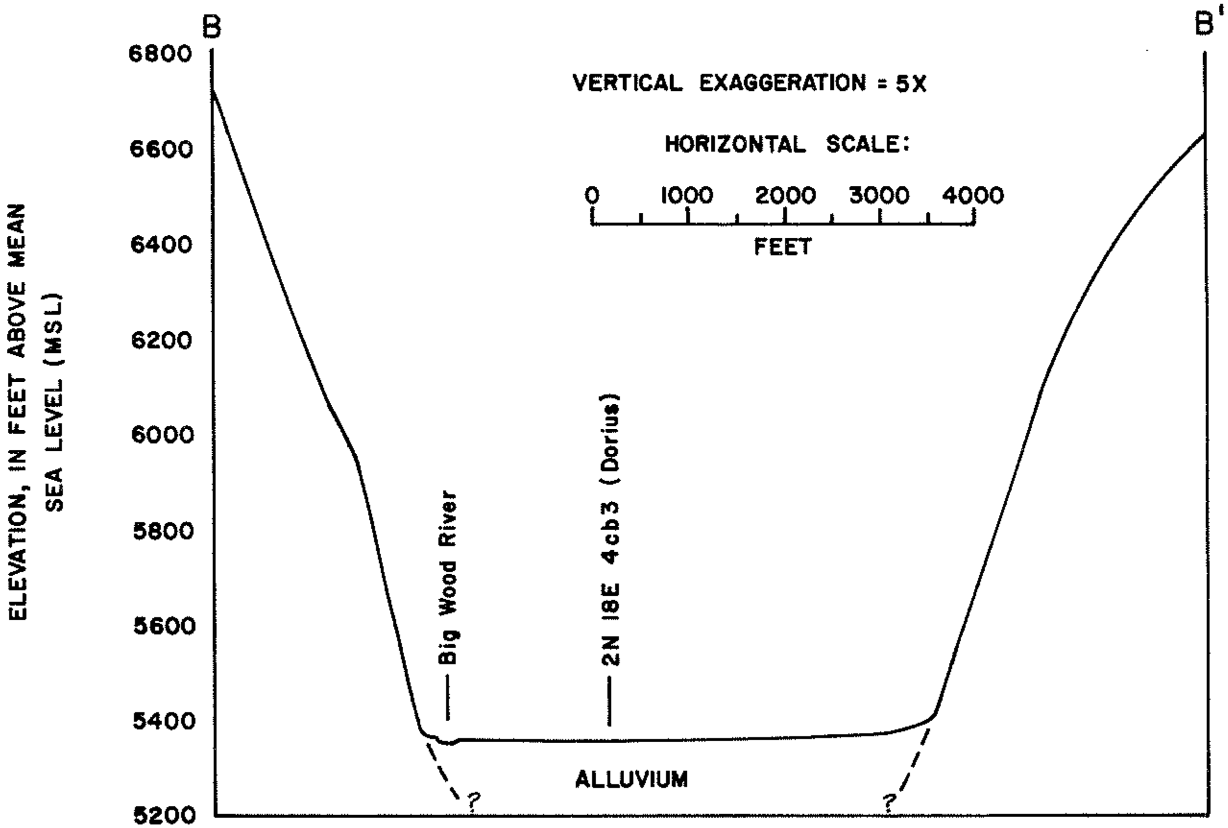
GEOLOGIC FRAMEWORK

The study area is included within the southern extremity of the Northern Rocky Mountain province, an area of unique topography, climate, and geology.

Stratigraphy

Rocks within the study area can be grouped into two broad categories: 1) unconsolidated fluvioglacial, alluvial and colluvial material, and 2) consolidated rocks of sedimentary and igneous origin. Figure 4 lists the

Figure 6. Geologic cross-section of Big Wood River Valley at Hailey.

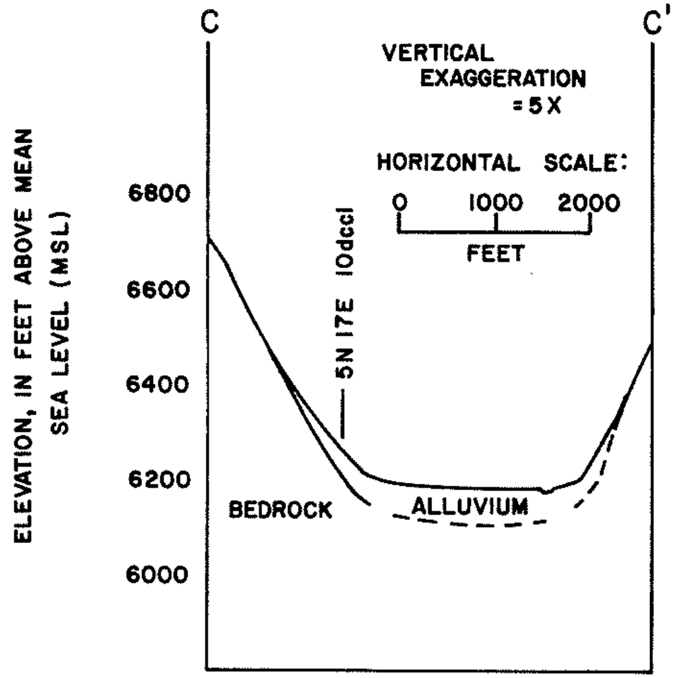


geologic formations present in the area, their lithologic characteristics, and serves as a legend for figure 5, which is a generalized geologic map of the area showing the surface distribution of the various geologic units. The unconsolidated material forms the valley fill and is generally characterized by its coarse-grained, highly permeable nature. An exception to this characterization is indicated in the log of well 4N-18E-8bc1 (Appendix B) belonging to the Ketchum Springs Water Company. This well log indicates predominantly fine-grained, generally poorly permeable sands and clays to a total depth of 586 feet below land surface. Geologic cross-sections of the Big Wood River valley at Hailey, Ketchum and North Fork (figs. 6, 7, and 8), however, indicate coarse alluvial fill bounded by generally impermeable bedrock. Figure 9 is a detailed geologic section based upon drillers' reports for wells in the vicinity of Ketchum which show the relationships more clearly. Locations of the cross-sections are shown on figure 10.

Depth of Alluvial Fill

Only in the vicinity of Ketchum do wells encounter bedrock near the axis of the valley. In an attempt to determine the depth of valley fill in an area where no well logs were available, a site for a seismic survey was chosen about a mile above the confluence of the Big Wood River with its North Fork (fig. 1). At this very narrow section of the valley, rocks of the Wood River formation form both walls of the valley (fig. 5) and are assumed to form the floor of the valley beneath the unconsolidated fill at the site at a relatively shallow depth.

Figure 7. Geologic cross-section of Big Wood River Valley at North Fork.



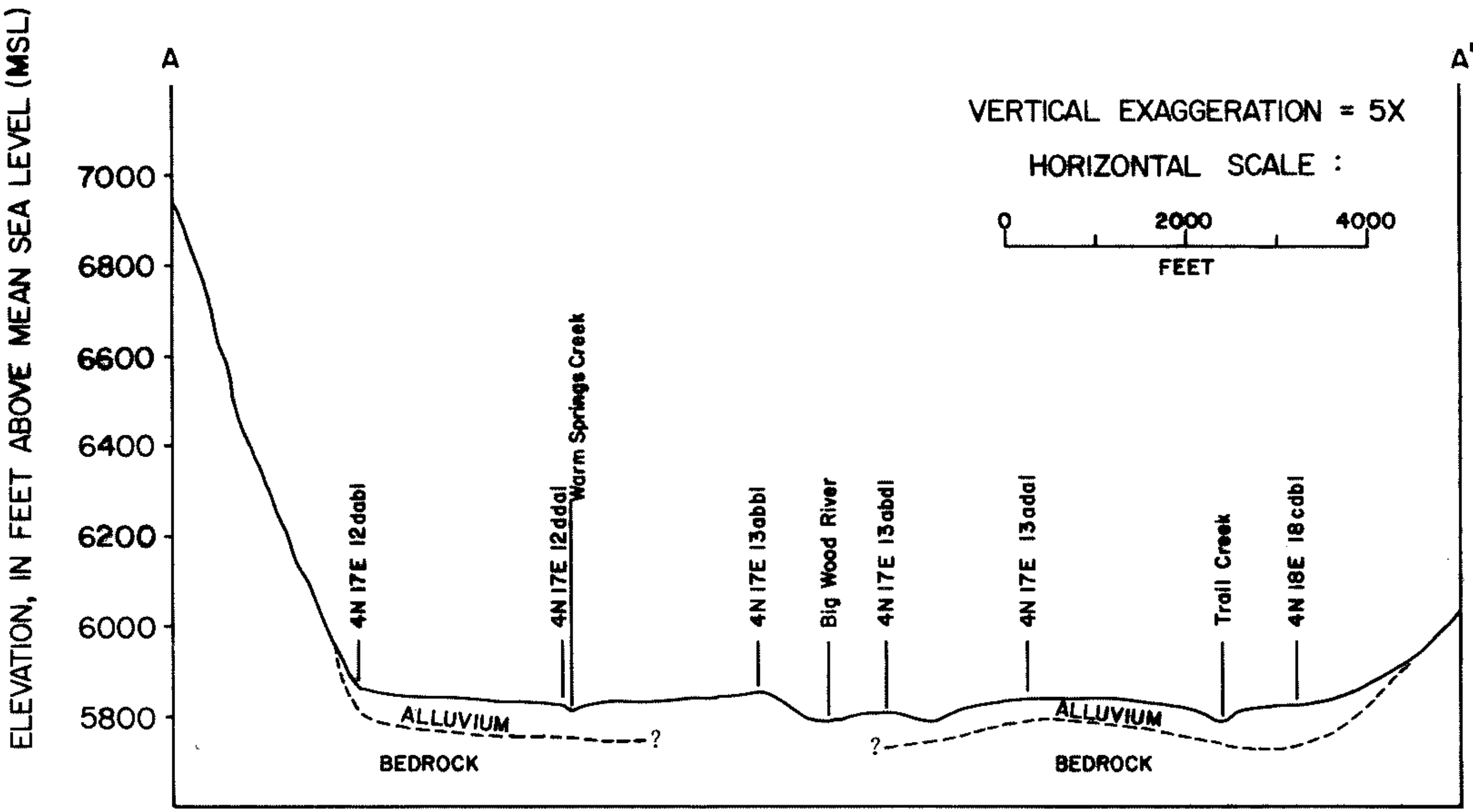
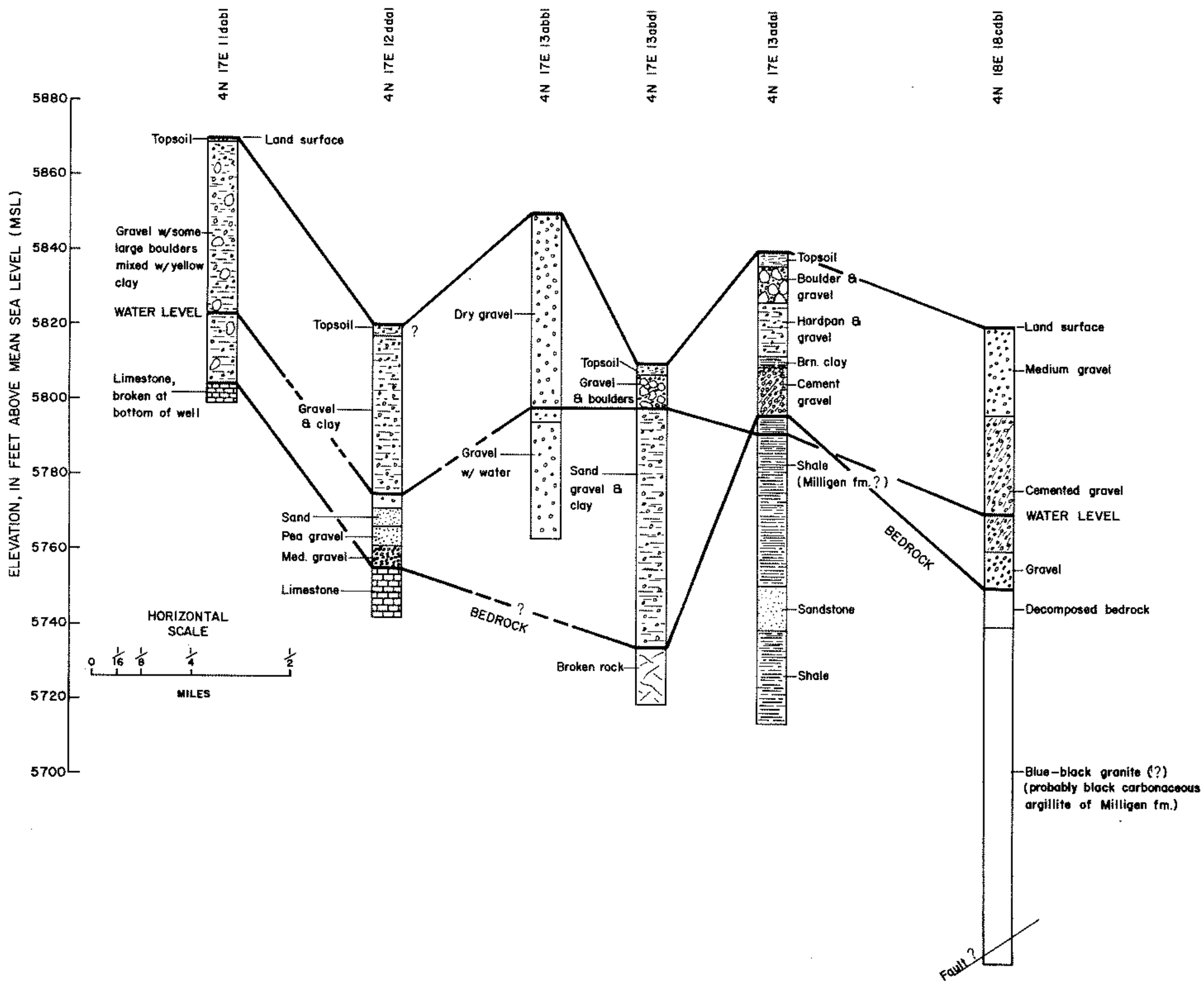


Figure 8. Geologic cross-section of Big Wood River Valley at Ketchum.

Figure 9. Detailed geologic cross-section of Big Wood River Valley at Ketchum.



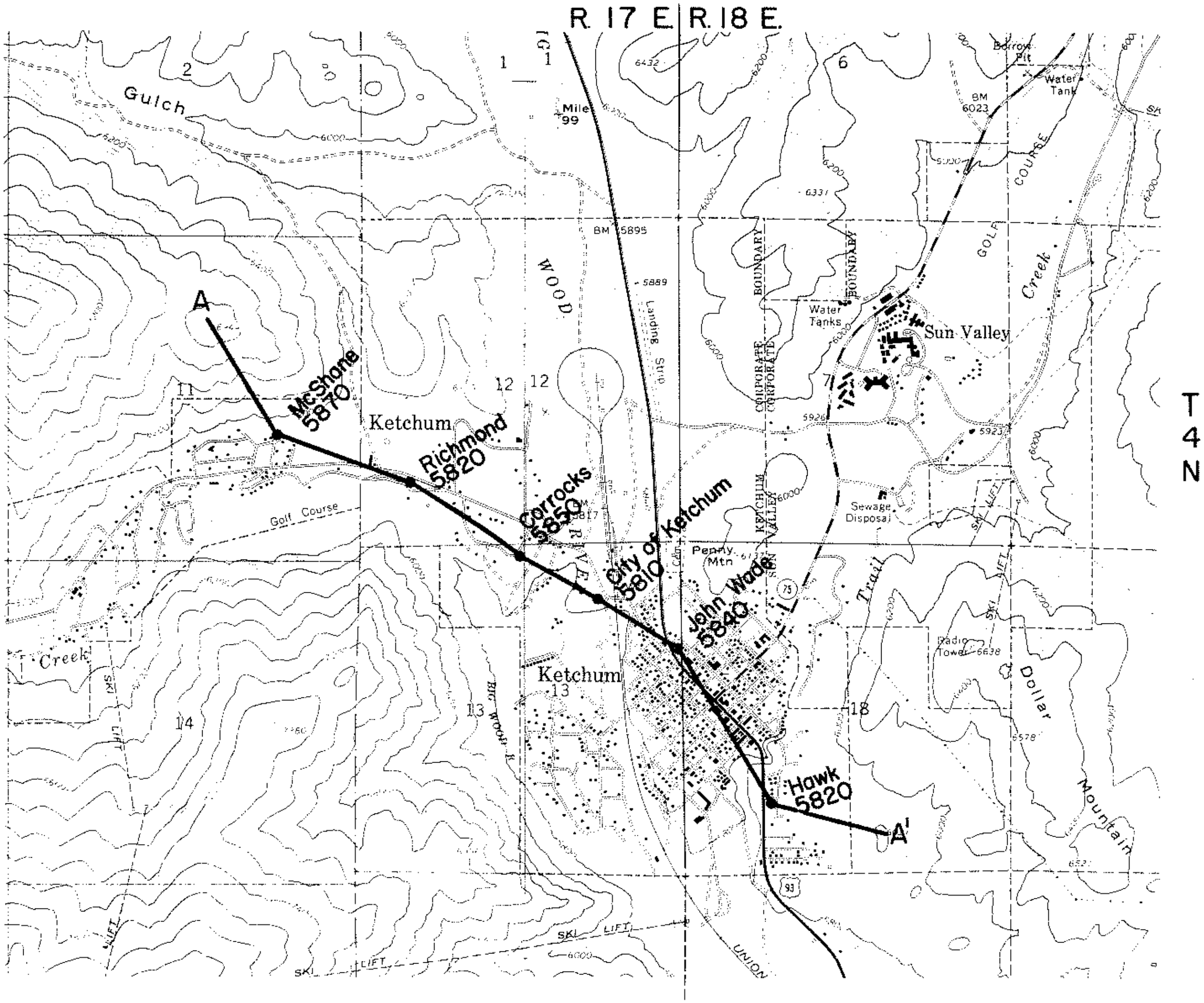
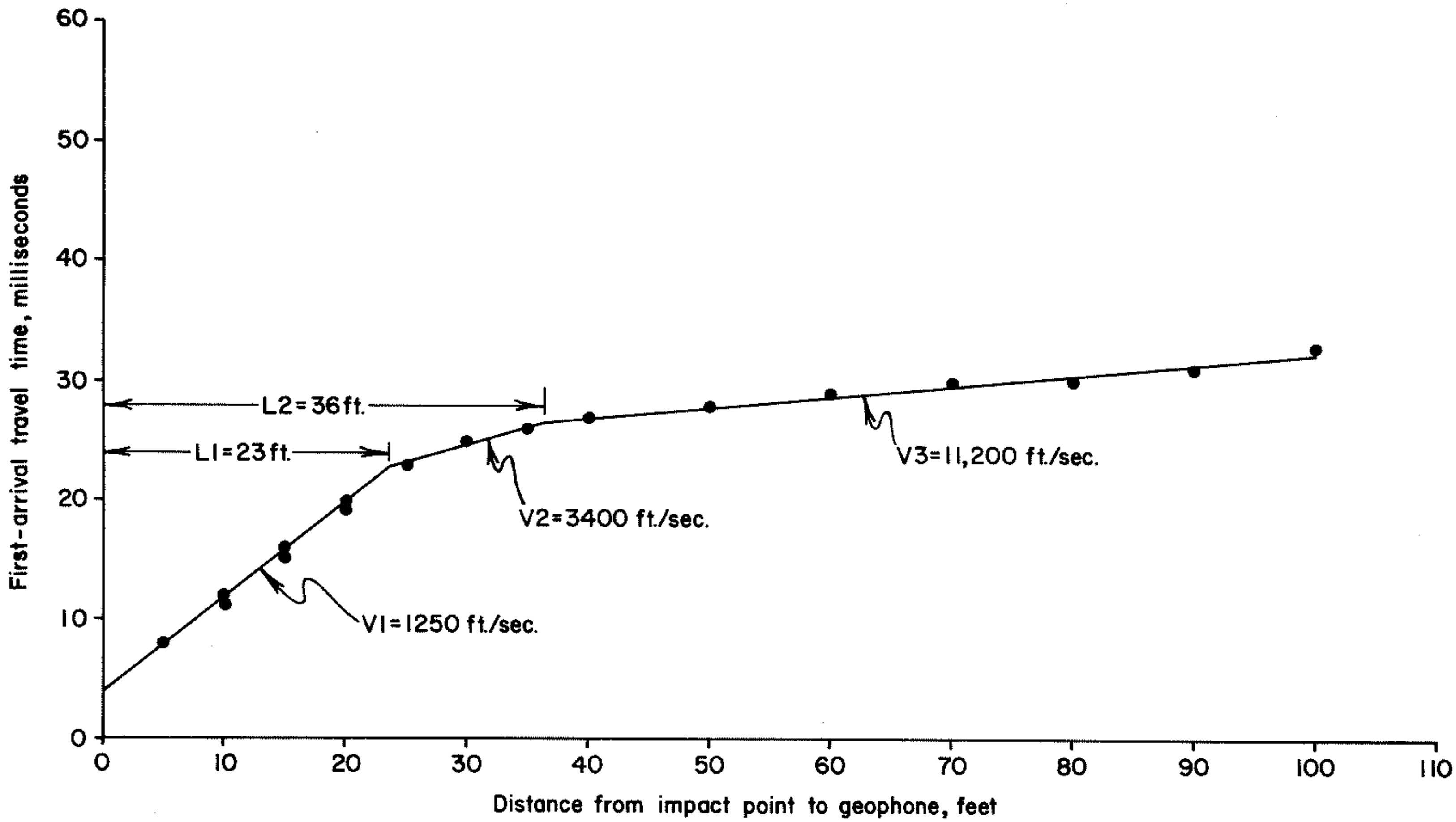


Figure 10. Location of detailed geologic cross-section of Big Wood River Valley at Ketchum.

Figure 11. Travel-time graph of seismic velocities encountered at the seismic survey site. Sun Valley-Ketchum study area.



Using a hammer seismograph, the velocities of sound in various rock or rock materials at depth were obtained. Results indicated two interfaces, or lithologic changes, at depth; one at approximately 9-10 feet, the other between 22-32 feet. The material above the first interface is interpreted to be dry, coarse sand and gravel. Rock material between the two interfaces may be water-saturated sand and gravel, while the high velocities encountered below the lower interface are characteristic of bedrock.

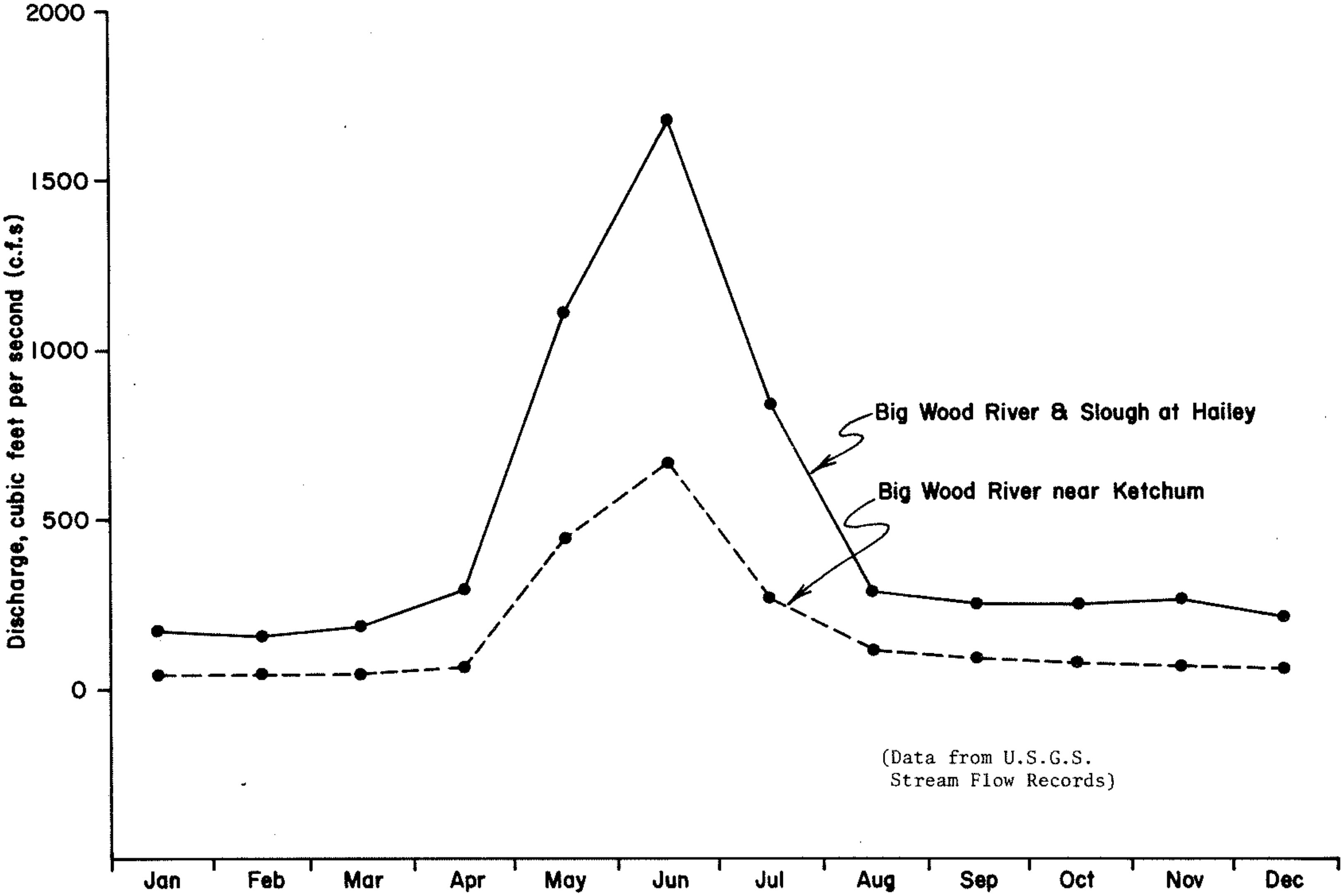
Figure 11 shows the velocities encountered and was used to determine depths to the interfaces. Table 2 is a list of rock materials having particular seismic velocity ranges.

TABLE 2. Materials Characteristic of Certain Seismic Velocity Ranges.

Velocities of Shock Transmission (feet/second)	Typical Materials
500 to 1,700	Topsoils, silts, loams, marshland
1,300 to 2,800	Dry sand, fine gravels
2,700 to 3,500	Medium gravels, gravels with clay
3,000 to 5,000	Wet gravels, compacted tills and gravel banks, clay strata
4,000 to 8,000	Shales, sandstone, cemented gravels, partially decomposed granites
9,000 and above	Sound rock, without weathering or much fracturing

(Note: from Dynametric, Inc., R117B Manual, 1965.)

Figure 12. Monthly mean discharges of Big Wood River at Hailey and near Ketchum, 1970.



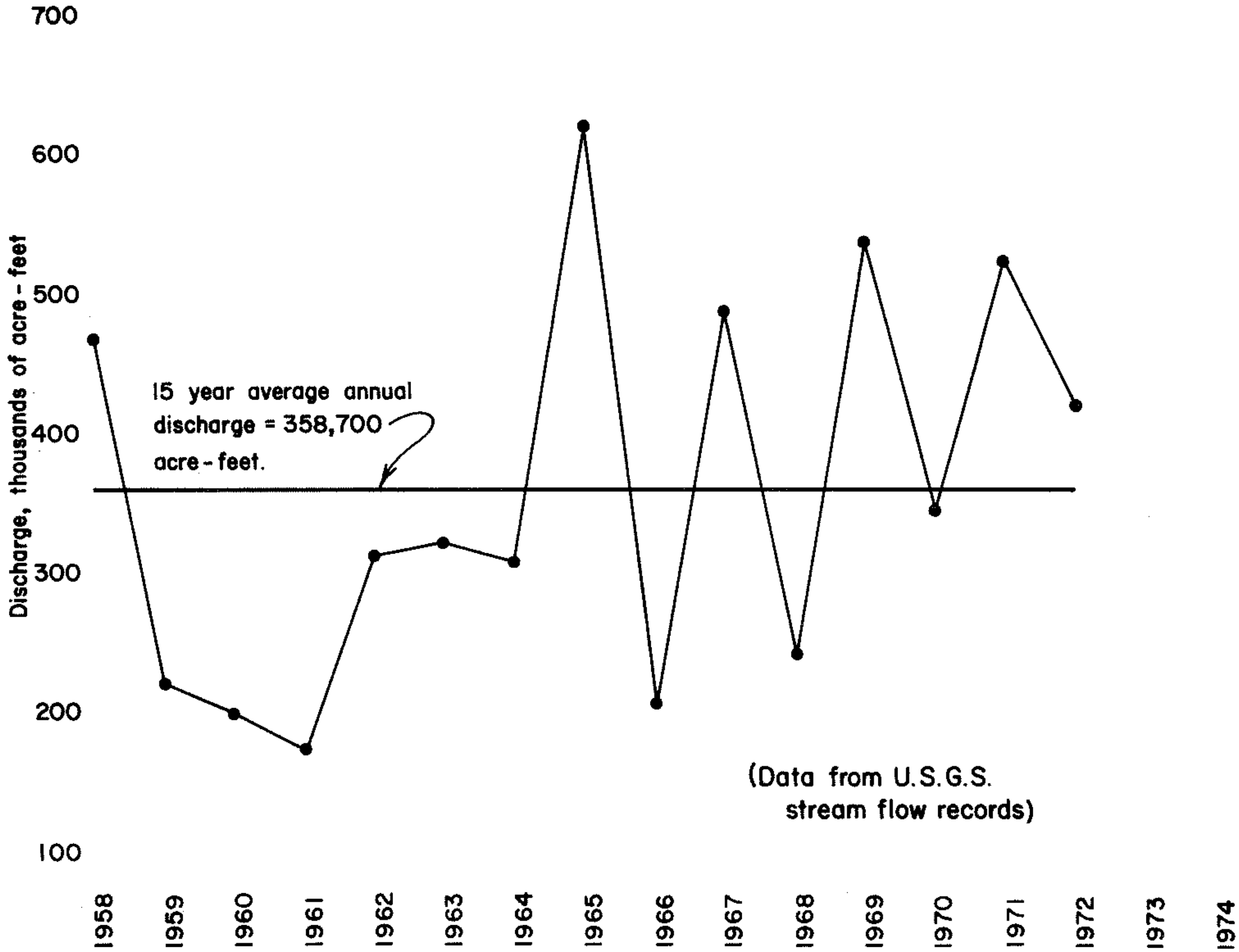
These results are tentative in that they have not been verified by other methods, such as test drilling, therefore, they should not be presumed indicative of bedrock depth anywhere other than the measured section.

Depth to bedrock, inferred from the local geology, was quite shallow at the survey section; however, depth to bedrock is likely to be much greater elsewhere in the valley. Except for wells near the edges of the Big Wood valley and in some tributaries, most wells do not encounter bedrock. This is especially true of wells near the valley axis between Ketchum and Hailey. Drillers' logs of wells in Warm Springs Creek indicate depths to bedrock as shallow as 30 feet below land surface. Conversely, in Trail Creek, well 4N-18E-8bc1, as mentioned previously, was drilled to a depth of 586 feet without penetrating bedrock (see Appendix B). In the absence of sufficiently deep wells to bedrock, surface geophysical methods and/or test drilling would provide valuable information on the total depth of saturated valley fill material available for groundwater development.

Structure

The geologic structure in the area is poorly known, but is believed to be very complex. Extensive folding and faulting makes interpretation difficult. Knowledge of the structure is important, in that it helps determine the depth of alluvial fill, which may be a locally important aquifer, and may also create barriers to ground water accumulation and movement which are not apparent at land surface. Umpleby, Westgate and Ross (1930) also pointed out that faulting, although not evident at the

Figure 13. Annual mean discharges of Big Wood River and Slough at Hailey for 1958-1972.



surface, probably exerts great control on the drainage pattern of the Big Wood River system.

WATER RESOURCES

The ultimate source of water within the study area is precipitation which falls within the drainage area of the basin. Not all precipitation falling on the basin is available for use, however. The water balance equation:

$$\text{Inflow} = \text{Outflow} \pm \text{Storage}$$

must be satisfied. Inflow, in the case of a basin with impermeable boundaries such as the study area, is derived entirely from precipitation. Outflow usually consists of evapotranspiration losses, and streamflow and groundwater flow out of the basin. Storage changes may consist of surface storage (+ or -) in lakes and ponds or fluctuations of groundwater level and soil moisture content (Ward, 1967). The ground and surface water systems in the study area appear to be closely interrelated, based on the geology of the area, and any stress placed on one will have an effect upon the other.

Surface Water

Discharge of Big Wood River

Figure 12 shows the average monthly discharge during 1970 at two points on the Big Wood River; at Hailey and at a point just upstream from the confluence with the North Fork (fig. 1), called the "Big Wood near Ketchum" station. Figure 13 illustrates the total annual mean discharge of the Big Wood River and Slough at Hailey for each year from 1958 to 1972,

TABLE 3. Discharge Measurements at Selected Sites in the Sun Valley-Ketchum Area. (All Values in Cubic Feet Per Second.)

No.	Discharge Measurement Site Description	Site Location	9/14/72	4/9/73	7/10/74	9/18/73	12/19/73	2/6/74
1.	Big Wood River at Easley Hot Springs	SW¼NW¼ sec.10 T.5N R. 16E	85.6	52.4	85.2	54.0	34.4	26.3
2.	North Fork of Big Wood River near confluence with *Main Stem*	NE¼NW¼ sec.10 T.5N R. 17E	39.3	19.3	36.0	31.5	28.4	-----
3.	Big Wood River at Hulen Meadows Bridge	SE¼SW¼ sec.36 T.5N R. 17E	137	104	140	101	42.1	68.2
4.	Upper Trail Creek at Boundary Campground	NW¼SW¼ sec.33 T.5N R. 18E	33.0	15.7	24.6	17.7	15.9	5.36
5.	Lower Trail Creek at Skier's Parking Lot	NW¼NW¼ sec.19 T.4N R. 18E	10.80	9.96	10.4	6.57	5.23	6.65
6.	Upper Warm Springs Creek	NW¼NE¼ sec.21 T.4N R. 17E	44.1	-----	49.5	26.3	-----	-----
7.	Lower Warm Springs Creek	NE¼NW¼ sec.13 T.4N R. 17E	48.2	47.9	56.5	27.4	25.3	22.01
8.	Big Wood River at Ketchum Sewage Treatment Plant	SW¼SE¼ sec.19 T.4N R. 18E	221	189	243	135	107	111
9.	East Fork of Big Wood River near confluence with main stem	NW¼SW¼ sec.8 T.3N R. 18E	26.3	17.4	26.7	19.9	-----	-----
10.	U.S. Geological Survey Gaging Station *at Hailey Bridge west of Hailey*	NE¼SW¼ sec.9 T.2N R. 18E	284	251	327	150	151	159
11.	Big Wood River at Broadford Road Bridge west of Bellevue	NW¼NW¼ sec.36 T.2N R. 18E	263	230	280	128	135	151
12.	Big Wood River at Glendale Bridge	SE¼SW¼ sec.11 T.1N R. 18E	3.96	195	6.32	2.98	83.2	118

and indicates that the 15-year average annual discharge is approximately 358,700 acre-feet, a major portion of the basin yield.

Miscellaneous Discharge Measurements

Table 3 lists miscellaneous discharge measurements made by the Idaho Department of Water Resources at selected sites in the study area during the period 1972-74. Locations of these sites are shown on Figure 14. Additional sites below Hailey are included for comparison.

Groundwater

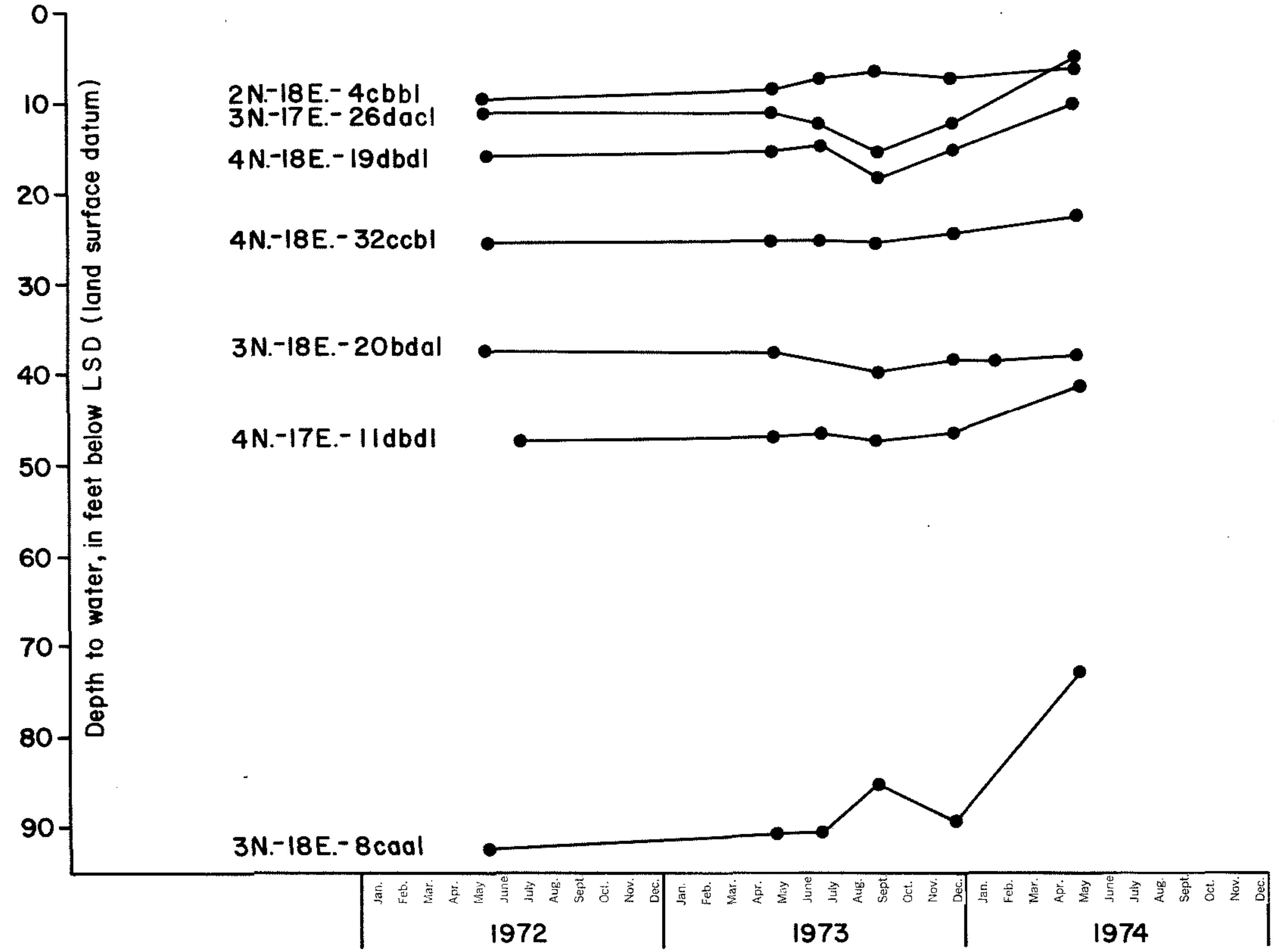
Direction of Movement

The small number and distribution of wells in which water-level measurements were taken precludes any accurate representation of the groundwater flow pattern; however, some generalizations can be made. Groundwater in an alluvial-filled valley with an unconfined, homogeneous aquifer would be expected to move in a downstream direction and toward the topographically low portion of the basin. This is the general flow pattern in the Sun Valley-Ketchum study area, except as locally modified by geologic boundaries such as faults, bedrock, and lateral changes in permeability in the alluvial fill of the valley. The same general pattern may be reflected in confined aquifers that appear at depth in the East Fork and Trail Creek valleys. Large-scale recharge to or discharge from the groundwater system also alters the flow pattern in the vicinity of the recharge or discharge area.

Depths to Water

Depths to water are quite shallow throughout the study area, ranging from as little as 2 feet on the Big Wood River flood plain to

Figure 15. Water-level fluctuations in selected wells in the Sun Valley-Ketchum study area.



110 feet on the river terraces or tributary alluvial fans adjacent to the stream. Water levels, tabulated in Appendix A, are distances in feet from land surface datum (LSD) to the free-standing water surface in the well.

In some cases, water levels are the result of moderate artesian pressures and do not reflect the depth from land surface to the producing aquifer(s). Topography also plays a major part in the differences in the depth to water.

Water Level Fluctuations

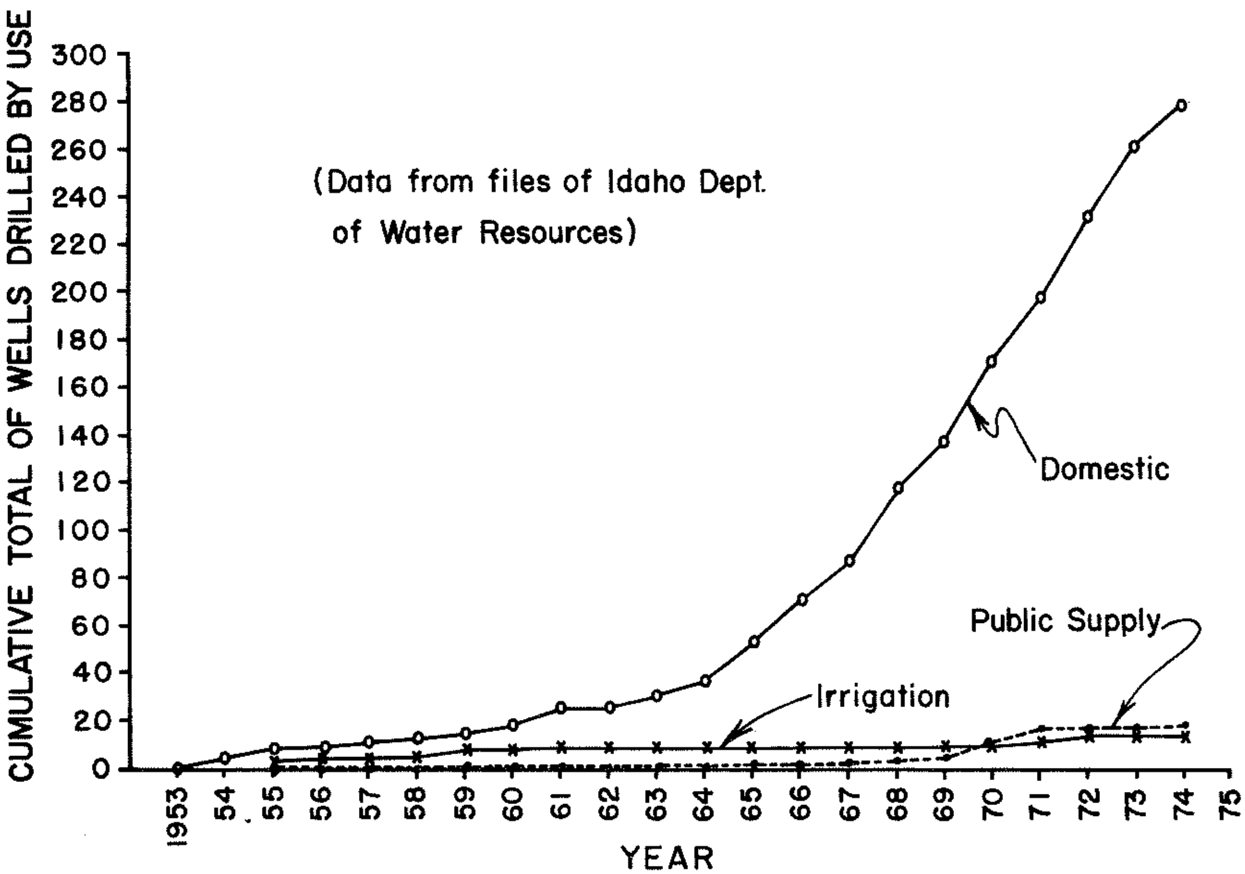
Periodic water level measurements from May, 1972, to May, 1974, indicate that no general water level declines occurred in the area during that period. Modest increases, instead, were noted over the 2-year period (fig. 15), in selected wells throughout the area. This is important to note, since precipitation records for the same period of time (see Climate section) indicate below-normal precipitation.

Because no suitable wells were found for the installation of continuous water level recorders, no data was collected on a continuous basis, which would show seasonal fluctuations of water levels in the groundwater system.

Yield-To-Wells

Yields to wells, expressed in terms of specific capacity (gallons per minute per foot of drawdown), in the area range from 0.3 gpm/ft. to 200 gpm/ft. The very low yields occur in wells perforated in siliceous sandstone of the Wood River formation; the more productive wells are completed in coarse alluvial fill (6-50 gpm/ft.) and in limestone of

Figure 16. Well driller reports filed for wells in the Sun Valley-Ketchum area, 1953-1974.



the Wood River formation (200 gpm/ft.). Additional well yields are tabulated in Appendix A.

Yields are highly dependent upon well construction. Most wells in the area have either open bottom or perforated casings, and would probably have better yields with less drawdown if screens and/or gravel packing were used in the sandier material. In general, however, yields are adequate for the intended uses.

Groundwater Development

An indicator of groundwater development is the number of well driller reports received annually by the Idaho Department of Water Resources. Figure 16 is a chart showing the cumulative totals of well driller reports received on domestic, irrigation and public supply wells in the study area. Public supply wells are those which supply water to several homes, such as a subdivision, condominium complex, or trailer park as well as a city. While the graph is some indication of development, it may also reflect to some degree the drillers' increasing conscientiousness to submit reports on wells drilled. The requirement to submit well driller reports has been in effect only since July 1, 1953.

The groundwater system presently supplies a dependable, constant-quality supply of water for most of the municipal and domestic uses in the basin. Whether this continues to be the case will depend almost entirely upon the degree of groundwater development which will occur in the future. Before any meaningful projections can be made regarding potential for development, better estimates for basin yield will have to obtained.

Basin Yield

Basin yield refers to that outflow from the basin which includes both surface streamflow and groundwater underflow. As was mentioned earlier, the annual discharge of the Big Wood River averages about 358,700 acre-feet. An estimate of groundwater underflow at Hailey has been made previously (Smith, 1959) and amounted to approximately 34,000 acre-feet per year. Summing the two values gives an approximate value for basin yield of 392,700 acre-feet per year. This does not mean that 392,700 acre-feet of water are available for development, however, as any reduction in streamflows will reduce recharge to the groundwater system and any significant reduction in groundwater levels will lead to reduced streamflows. In addition, further development will always have to consider senior water rights downstream from the Sun Valley-Ketchum area.

PRESENT AND FUTURE WATER USE

A rapidly increasing population in the Sun Valley-Ketchum area has created a constant demand for more water. In their report on water and land problems in the area, CH_2M-Hill (1974) indicated that the average daily pumpage of water for municipal use is approximately 2.2 mgd (million gallons per day), exceeding 7 mgd during the peak of the irrigation season. Their report also indicated that the average daily pumpage for municipal use was expected to triple by 1990, reaching 7.3 mgd (CH_2M-Hill, 1974, p. 44). Private domestic uses not served by central systems may also be expected to increase significantly.

Commercial and industrial water use is almost non-existent at present and is not expected to increase in the future, due to the recreation-oriented nature of the area. Diversions of additional water for irrigation is also not expected to increase significantly, since much, if not all, of the suitable soil is presently under cultivation or dedicated to other uses.

The unanswered question with respect to water use is, "How much groundwater exists in storage to meet expected future demands?" This question can be answered only by further study of the hydrology and geology of the region and is one that will demand an answer in the near future.

Land use changes that have occurred in the past are expected to continue into the foreseeable future, although the rate, degree and location of these changes could, and in some cases should, be modified by policies or regulations of agencies having the appropriate jurisdiction. The most notable land use changes that have occurred in the past have involved single-family and high density residences such as condominiums occupying areas along the banks of the Big Wood River, Warm Springs Creek, and Trail Creek. Such development, with private wells and septic tanks, create a potential for contamination of the ground and surface water supplies in the area, as is discussed later. Building on the flood plain of the Big Wood River and its tributaries, especially at the stream's edge, can also create problems with water quality, aquatic life, flood hazard, recreation, and esthetics. These aspects are discussed in succeeding sections of the report.

TABLE 4. Uses of Water in the Sun Valley-Ketchum Area. (From files of the Idaho Department of Water Resources as of December 31, 1974.) All amounts are in cubic feet per second (cfs).

GROUNDWATER			SURFACE WATER	
Licensed	Permits	Uses	Licensed	Permits
-----	-----	Power	253.6	-----
0.44	13.84	Domestic	1.48	11.0
14.25	23.74	Irrigation	15.26	23.16
-----	-----	Mining/ Milling	2.40	3.0
-----	-----	Stock	-----	1.0
-----	0.044	Commercial	-----	9.0
-----	0.7	Recreation	1.0	0.2
-----	0.49	Fire Protection	-----	5.6
6.09	5.0	Municipal	-----	-----
20.78	43.81	Totals	273.74	52.96

WATER RIGHTS

Table 4 lists all uses of water appearing on valid licenses and applications for permit on file with the Idaho Department of Water Resources as of December 31, 1974. Both surface and groundwater sources are tabulated. It should be emphasized that these figures represent only those rights in the area. To establish a water right prior to May 20, 1971, for surface water or March 24, 1973, for ground water, it was necessary only to divert the water and apply it to a beneficial use, which required no written account of such diversion and use. Effective on and after the above dates, however, the Idaho Legislature enacted laws which made it necessary to follow a mandatory permit procedure in order to develop a water right. Exceptions to these laws apply to domestic and stockwater diversions from a groundwater source. Further details are available from any Department of Water Resources office in Boise, Coeur d'Alene, Idaho Falls or Twin Falls.

FISHERY

Game Species

The Big Wood River contained an abundant fishery when white settlers first arrived. In West to the Big Wood I. I. Lewis (Irvin 1967) told of catching about 40 pounds of "nice large fish" in 1877 while camping below the present-day location of Bellevue.

According to Dr. R. Wallace at the University of Idaho (personal communications), mountain whitefish and cutthroat were the native game fish in the Big Wood River. Although not described, the species Mr. Lewis spoke of catching was probably this trout. Later, eastern brook trout were introduced to the Big Wood drainage and throughout the state.

Planting Program

Large numbers of rainbow and eastern brook trout were raised at the Hay Spur Fish Hatchery and planted in the Big Wood area as early as 1912 (French 1914).

In 1972 Hay Spur Fish Hatchery produced 75,100 pounds of catchable rainbow trout. Table 5 lists the number and weight of these fish planted in the Upper Big Wood River area.

TABLE 5. Catchable Rainbow Trout Planted in the Big Wood River and Tributaries in the Sun Valley-Ketchum Area in 1972. (Unpublished Idaho Fish and Game Department Records.)

Location	Pounds	Number
Big Wood River	17,475	47,488
North Fork Big Wood River	1,600	3,725
Warm Springs Creek	6,750	20,535
Penny Lake	1,850	5,823
Dollar Lake	100	320
Trail Creek	6,475	17,508
East Fork Wood River	600	1,655
Deer Creek	725	2,050
Lake Creek	1,325	4,656
Total	36,900	103,760

The number of fish planted in each stream varies from year to year according to fishing pressure and the availability of fish. A general decrease in the number planted in 1974 was necessitated by an increase in fish food costs.

Cutthroat, California golden trout, and greyling are also found in the drainage but are restricted to the head waters and mountain lakes. Mountain Lakes of Idaho, an information bulletin published by the Idaho Fish and Game Department (1973), lists nine mountain lakes in the upper Big Wood area, although others exist. Some offer fine fishing for small trout, and most are less than 6 miles by trail from an improved road.

WATER QUALITY

Pollutant Sources

Rapid population growth in the Sun Valley-Ketchum area has led to considerable concern about the quality and quantity of the water. Water pollutants may be attributed to four primary sources:

Sewage

Sewage, the most significant source of pollution in the Big Wood River, may contribute to unaesthetic growths in the stream, cause unpleasant odors, eliminate fish habitat, and, most important, represent a public health hazard. A large number of homes in the study area are served by septic tanks. In areas with shallow water tables or permeable surface soils, waste from the septic tanks can reach the ground water without sufficient filtration. Sewage treatment facilities are located at Ketchum. A long-range plan for upgrading the Ketchum facilities exists but rapid population expansion has taxed the treatment plant in the past. Table 6 lists data on the sewage treatment plant. Although it is not in the study area, the information on the sewage treatment facilities at Hailey is added for comparison.

Mining

Considerable mining within the study area has occurred in the past and one mine is still operating. Others could resume operation if economic conditions change. Although few problems from mining have occurred in the past, the potential for severe and chronic water problems exist. Zinc has caused serious problems in other streams of the state and is one of the minerals mined in the Big Wood River drainage.

TABLE 6. Data on the Sun Valley-Ketchum and Hailey Sewage Facilities. (From Idaho Department of Health and Welfare records.)

	Sun Valley-Ketchum	Hailey
Type	Activated Sludge	Activated Sludge
Design capacity Million gallons per day (MGD)	2.25	0.375
Design population	24,000	3,000
Population served	9,000	1,400
Load Average	1.45	
MGD	0.9 (Estimate)	0.213
Effluent Standards* BOD Monthly average	30 mg/1	30 mg/1
Suspended Solids	30 mg/1	30 mg/1
Fecal Coliform Bacteria	200/100 ml	200/100 ml
Efficiency BOD Removal	88-95%	80-86%

*National Pollution Discharge Elimination System Discharge Permit.

Construction

Construction continues to add silt to the river and encroach on the flood plain. Building construction may cause short-term siltation while road construction may add silt to the streams for many years. The U.S. Environmental Protection Agency (1975) and the U.S. Forest Service (1975) have published reports containing information on ways to reduce erosion from road construction.

Agriculture

Agriculture in the Big Wood River Basin does not cause serious pollution problems above Bellevue. The small area of farmland is used primarily for pasture and hay. Also, sprinkler irrigation is frequently used, which results in less silt and fewer nutrients reaching the river. There are no large feedlot operations on the river in the study area although many small livestock enclosures are located close to the river or its tributaries and they undoubtedly contribute silt, nutrients, and bacteria to the water. In the past, large amounts of soil were lost from overgrazing (Holte and others 1970). Land management practices have improved the range, and reseeding has stabilized most areas.

Water Quality Parameters

Water Temperature

Temperature, an important parameter in water quality, determines dissolved oxygen, carbon dioxide and other gas concentrations in water; growth rates of aquatic plants and animals; and species composition.

Limiting maximum temperatures for brook, brown and rainbow trout are 75°F. (24°C), 81°F. (27°C), and 83°F. (28°C) respectively (Needham, 1969). Optimal temperatures would be 5-10°F. (3-6°C) lower than these.

Water temperature in the study area ranged from 32°F. (0°C) to 60.6°F. (15.9°C) in the upper parts of the drainage and 33.8°F. (1°C) to 68°F. (20°C) near Bellevue. Even the summer temperature at the lower stations were low enough for all indigenous aquatic life. Additional sewage outfalls and irrigation return flows could result in increased water temperatures. Removal of bank vegetation can also raise water temperatures by exposing the stream substrate and water to the sun's rays.

Phosphate

Phosphorous is a primary nutrient in water which commonly limits plant growth. Nuisance algal growth or "blooms" can occur with dissolved phosphate concentrations as low as 0.01 mg/l. The natural sources of phosphate in streams are from soil and from the weathering of phosphatic rocks. Some phosphatic rocks do occur in the area but they are small deposits and probably add little phosphate to the water (Umpleby, Westgate and Ross, 1930). Sewage and runoff from fertilized farmland may also add phosphate to streams. Phosphates are relatively insoluble and are usually washed into the stream attached to soil particles. The low concentrations in unpolluted water are rapidly taken up by algae. Phosphate concentrations were below 0.03 mg/l at all stations in the Big Wood River and its tributaries, and usually below the detection limits of the methods used.

Nitrates

Nitrogen is important to the life processes of all plants and animals. High concentrations of nitrate nitrogen in water can cause excessive growths of algae, which in extreme cases, can kill fish by removing oxygen from the water and cause obnoxious odors. The nitrate concentrations in the Big Wood River and its tributaries are low compared to other streams in Idaho. According to Sawyer (1948) the critical concentration of nitrogen below which algal growths were not troublesome was 0.30 mg/l, providing that phosphorous was below 0.015 mg/l. Falter (1973) observed algae blooms in Magic Reservoir (on the Big Wood River 20 miles south of Bellevue) during midsummer of 1972 and suggested the lack of nitrate nitrogen limited further algal growths. The U.S. Public Health Service Drinking Water Standards (1962) recommended a limit of 45 mg/l nitrate. Concentrations measured in the Big Wood drainage were far below this figure, never exceeding 0.26 mg/l.

Zinc

To determine the extent of contamination of surface water by zinc, samples from five locations were collected and analyzed at Regional Lab of the U.S. Bureau of Reclamation in Boise, Idaho. Results of analyses and supplemental data obtained from the Idaho Department of Health and Welfare are shown in figure 17. U.S. Public Health Standards (1962) have established a limit of 15 mg/l zinc in drinking water. Concentrations of zinc in each sample were less than 0.01 mg/l (milligrams per liter).

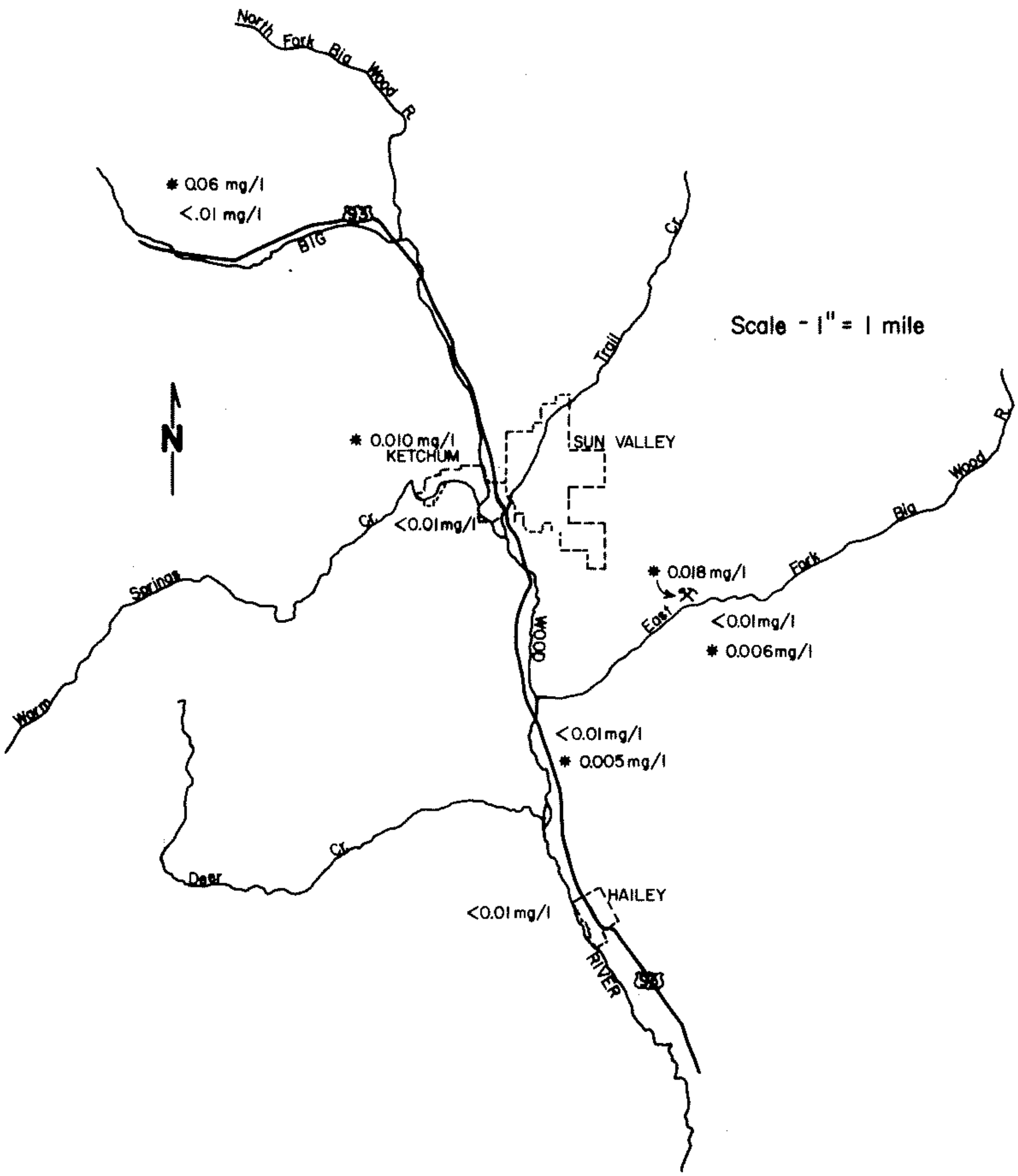


Figure 17. Zinc (dissolved) concentrations in the Big Wood River, Sun Valley-Ketchum area.

Specific Conductance

Specific conductance is a measure of the capacity of water to conduct an electrical current, and is an indicator of total dissolved solids. The conductivity is usually expressed as micromhos (the reciprocal of megohms) per square centimeter at 25°C (Reid 1961).

Specific conductance values for water samples taken in the Big Wood River drainage range from 156 to 380 umhos on September 20-21, 1973 and from 195 to 412 umhos on February 5-6, 1974. The generally lower specific conductance on the latter date is due to the diluting effect of a higher flow. Values increase downstream on the Big Wood River. This is partly because water naturally dissolves minerals as it flows downstream. Urban run-off, sewage-plant effluent, and irrigation return flows also contribute to increased specific conductance.

Water quality data collected during this study are listed in Table 7 and in Appendix C. Locations of all ground and surface water sampling sites are shown on figure 18.

Bacteria

Indicator bacteria are used to detect and measure recent contamination of water by sewage. The three groups of indicator bacteria commonly used are total (immediate) coliform, fecal coliform, and fecal streptococci. The coliform group of bacteria are widely distributed in nature and considered harmless. However, the presence of total coliform bacteria in water indicates possible fecal contamination; the presence of fecal coliforms and fecal streptococci specifically indicates fecal waste contamination by warm-blooded animals.

TABLE 7. Water Quality Data for the Big Wood River and Tributaries in the Sun Valley-Ketchum Area.

Location	Date	Nitrate	Orthophosphate	Sodium	Specific Conductance
		milligrams per liter			umhos
Big Wood River					
Easley Hot Springs	9-20-73	0.03	0.00	2.8	156
	2-05-74	0.22	0.00	3.0	237
Hulan Meadows	9-20-73	0.08	0.00	2.8	204
	2-05-74	0.16	0.00	2.8	195
Ketchum	9-20-73	0.15	0.00	4.6	232
	2-05-74	0.11	0.00	4.8	238
Hailey	9-20-73	0.17	0.00	4.4	247
	2-05-74	0.19	0.02	5.5	275
Above Bellevue	9-20-73	-	-	-	-
	2-05-74	0.26	0.03	4.8	280
Below Bellevue	9-20-73	-	-	-	-
	2-05-74	0.26	0.03	4.6	286
Tributaries					
North Fork	9-20-73	0.03	-	1.4	233
	2-05-74	0.02	-	1.1	237
Upper Warm Springs	9-20-73	0.06	0.02	6.7	202
	2-05-74	-	-	-	-
Lower Warm Springs	9-20-73	0.05	0.00	9.2	229
	2-05-74	0.18	0.00	9.2	235
Upper Trail Creek	9-20-73	0.03	0.01	2.1	337
	2-05-74	0.15	0.00	2.3	409
Lower Trail Creek	9-20-73	0.18	0.00	8.0	380
	2-05-74	0.11	0.00	6.0	412
Upper East Fork	9-20-73	0.02	0.01	1.8	294
	2-05-74	0.18	0.01	1.8	327
Lower East Fork	9-20-73	0.02	0.00	2.3	297
	2-05-74	0.18	0.01	2.8	385

of sewage. Further tests narrowed the source of the effluent to an area near the bridge on US Highway 93, but the precise source was not located. Moderate bacteria concentrations, 0-156/100 ml., were also detected in Warm Springs Creek. Bacteria counts do not differ greatly between upper and lower stations on Warm Springs Creek. Apparently the major source(s) of bacteria is (are) above the upper sampling station. Bacteria concentrations in the Big Wood River increased below Bellevue. Seepage or direct discharge from septic tanks and livestock are possible sources of contamination. As expected, the lowest bacteria counts occurred May 15, 1974, when high spring runoff diluted the streams. Highest concentrations occurred during low flows and at warm water temperatures. Counts were generally lower than those obtained by the Idaho Department of Health and Welfare in 1972. Bacteria data are listed in Table 8.

Benthos

The community of plants and animals that live on the bottom of lakes and streams are collectively called benthos. Most streams contain a great variety of benthic organisms that form an important link in the food chain.

Water quality of a stream can be estimated by enumerating and identifying the macrobenthic organisms and calculating a diversity index. A stream with good water quality will contain many different organisms but with a low number of each species, resulting in a high diversity index. A polluted stream will contain few species, but one or two will be present in large numbers resulting in a low diversity index.

TABLE 8. Bacteria concentrations per 100 ml. in the Big Wood River and its tributaries. Counts are reported in number/100 ml. Counts less than 20/100 ml. should be considered estimates. Data for July 17-18, and September 11, 1972 was supplied by the Idaho Department of Health and Welfare.

Station	Test	July 17-18, 1972	Sept. 11, 1972	Apr. 9-11, 1973	July 10, 1973	Feb. 2, 1974	May 15, 1974
Easley Hot Springs	Total	24	120	0	1	0	0
	Fecal	4	4	0	1	1	0
	F. Strep	--	--	0	--	3	0
Hulen Meadows	Total	80	140	0	6	7	0
	Fecal	4	4	0	3	5	0
	F. Strep	--	--	3	35	1	1
Below Ketchum	Total	88	160	6	1	0	0
	Fecal	4	2	0	9	1	2
	F. Strep	--	--	2	36	1	7
Hailey	Total	--	36	5	9	0	0
	Fecal	--	2	1	--	0	3
	F. Strep	--	--	6	14	0	1
Above Bellevue	Total	20	44	10	2	0	0
	Fecal	4	2	0	2	0	3
	F. Strep	--	--	4	20	1	2

Below Bellevue	Total	20	52	13	74	0	0
	Fecal	4	2	0	51	0	0
	F. Strep	--	--	7	71	1	3
North Fork B.W.R.	Total	16	28	0	10	0	0
	Fecal	4	2	0	0	0	1
	F. Strep	--	--	0	8	0	0
Upper Warm Springs	Total	110	156	--	64	--	0
	Fecal	4	6	--	24	--	1
	F. Strep	--	--	--	38	--	0
Lower Warm Springs	Total	140	116	27	58	11	0
	Fecal	4	10	--	15	6	0
	F. Strep	--	--	1	56	1	0
Upper Trail Creek	Total	36	68	0	2	0	0
	Fecal	4	6	0	3	0	0
	F. Strep	--	--	0	18	0	2
Lower Trail Creek	Total	860	1,560	78	*TNTC	TNTC	0
	Fecal	200	132	--	450	TNTC	2
	F. Strep	--	--	270	350	TNTC	64
East Fork B.W.R.	Total	60	100	3	7	0	0
	Fecal	20	20	0	15	1	0
	F. Strep	--	--	2	42	TNTC	1

*TNTC: too numerous to count.

The Millipore Filter method (1972) was used to analyze samples for bacteria from 12 stations four times during a one-year period. Samples were collected in sterile 500 milliliter bottles and stored at a near 4°C for less than six hours. Water-quality standards set by the Idaho Department of Environmental and Community Services (DECS) (1964) state:

> *No wastewaters shall be discharged and/or no activity shall* be conducted in waters of the State which either alone or in combination with other wastewaters or activities will cause in waters of any specified reach, lake or impoundment, or in general surface waters of the State.
>
> A. The organism concentrations of the coliform group
>
> 2. In waters protected for primary contact recreation (A_2)
>
> a. Total coliform concentrations where associated with a fecal source(s) to exceed a geometric mean of 240/100 ml., nor shall more than 20 percent of total samples during any 30-day period exceed 1000/100 ml. (as determined by multiple-tube fermentation or membrane filter procedures and based on not less than 5 samples for any 30-day period).
>
> b. Fecal coliform concentrations to exceed a geometric mean of 50/100 ml., nor shall more than 10 percent of total samples during any 30-day period exceed 200/100 ml.; or greater than 500/100 ml. for any single sample.

Fecal streptococci are not used by the Idaho Department of Health and Welfare in setting state standards. Fecal streptococci have longer survival rates than fecal coliform and, therefore, may still be detected in water after the total and fecal coliform bacteria have died off (Gordon, 1972, Geldreich and Kenner, 1969).

Only the station on lower Trail Creek consistently contained high bacteria concentrations. On July 10, 1973, the creek actually smelled

Four random square-foot samples were collected from 12 stations on the Big Wood River and its tributaries on April 9-11, 1973. All benthic macroinvertebrates were identified and are listed in Appendix D.

The formula,

$$\bar{H} = 3.3219\ (\mathrm{Log}N \qquad \frac{n_i \log_{10} n_i)}{N}$$

where: N = the total number of organisms in a sample and

n_i = the number of organisms of the ith species.

(Margolef, 1957) was used to calculate the diversity indices illustrated in figure 19. The diversity was high at all stations above the Sun Valley-Ketchum area, indicating good water quality. Platts (1974) also found diverse benthic populations in a study of the upper reaches of the Big Wood River and the North Fork of the Big Wood River, although he did not calculate diversity indices for his data. Downstream from Ketchum, the diversity decreases, reaching its lowest point below Bellevue.

Several factors probably contribute to the decline in diversity of benthic macroinvertebrates. As the river gradient decreases from the headwaters to the lower end of the study area, the streambed is composed of a greater percentage of fine-grained material. Generally, the diversity and the total biomass is greatest in a cobble substrate and decreases with an increase in sand. Several outfalls, including the Ketchum and Hailey sewage treatment plants, increase the total dissolved solids and BOD (biochemical oxygen demand) in the river. Agriculture and irrigation is greater in the lower end of the area. The low diversity at the station below Bellevue was caused by low summer flows. All but a small

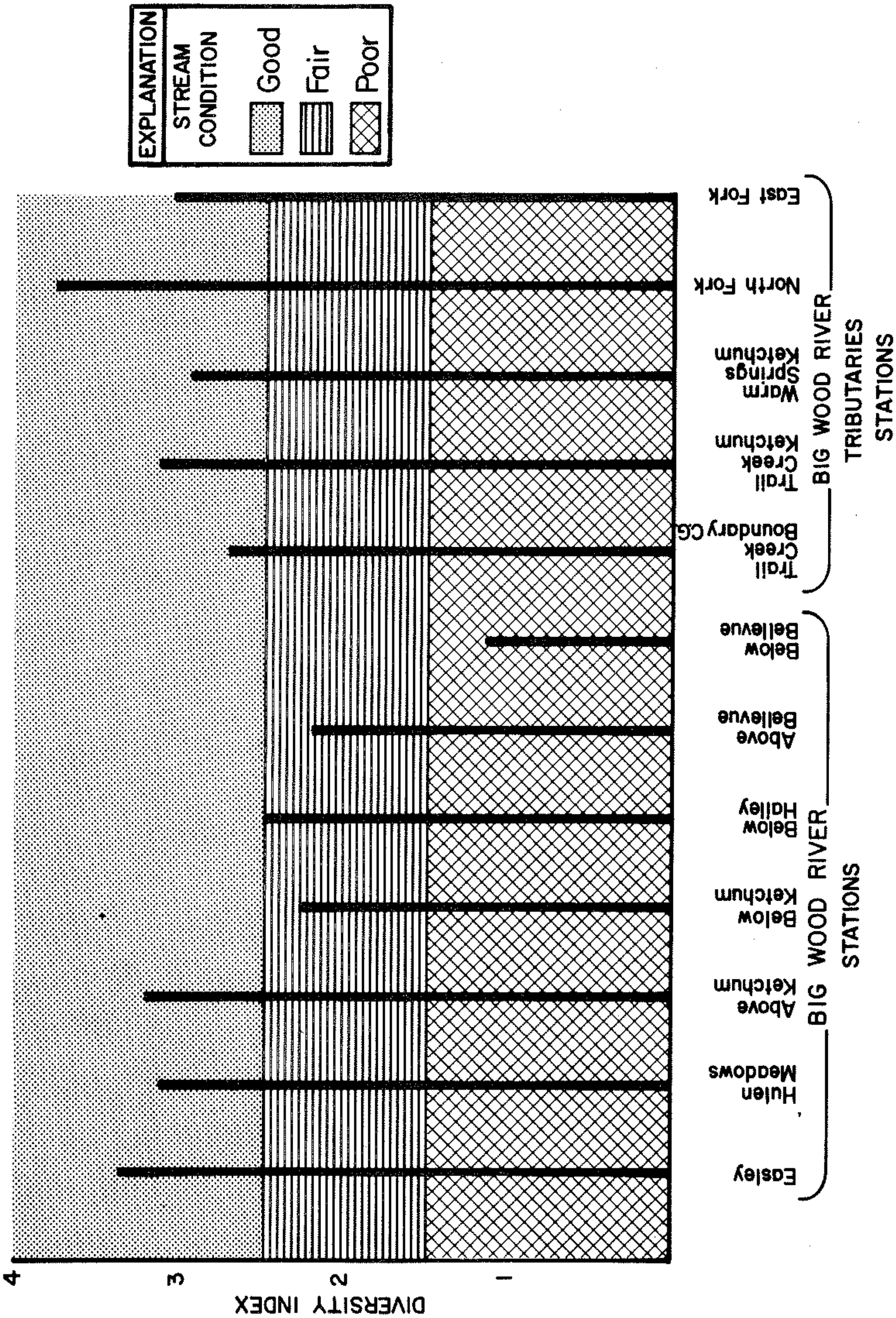


Figure 19. Diversity indices for 12 locations in the Big Wood River Drainage, Sun Valley-Ketchum area, April 1973.

amount of water is diverted into the Bypass Canal a short distance upstream. Large numbers of black fly larvae reduced the diversity index at some stations.

Physical Condition of the Channels of the Big Wood River and Tributaries

Stream Channel Alterations

Since the Stream Channel Protection Act was passed on July 7, 1972, 108 physical alterations have occurred on the Big Wood River and its tributaries above Bellevue. The approximate locations of these alterations are shown in figure 20.

The effects and benefits of altering a river are emotional issues and almost always debated. Some effects that can occur are:

1. The reduction or elimination of fish habitat by eliminating undercut banks, streambank vegetation, riffles, and other stream irregularities.
2. The loss of fish and eggs that may be in the stream at the time of the alteration.
3. The elimination of waterfowl nesting and feeding areas.
4. The reduction of wildlife habitat by reducing vegetation, beaver dams, and gravel bars.
5. The creation of unstable channel conditions resulting in increased erosion.
6. The loss of natural aesthetic values.

Benefits include:

1. Reduced erosion at specific locations.

2. Protection of life and property.

3. Increased property values.

The exact effects depend upon the location and type of alteration. In the upper Big Wood area the majority of alterations are for bank protection and flood control. These streambank alterations have been made necessary by encroachment of recreation home developments on the river.

Irizarry (1969) reported 22 miles of the Big Wood River to be altered in some manner. The lower part of Warm Springs Creek is nearly 100 percent altered and lower Trail Creek is about 80 percent altered. Studies in Idaho and Montana (Peters and Alvord, 1965) indicate that an altered stream will contain only 20-30 percent as many fish as a natural, unaltered stream.

Several methods can be used to avoid alterations or to reduce their impact. Flood-plain zoning can reduce flood damage by eliminating encroachment on the streams. The recurrence interval for flooding in most streams appears to be in the range of one to two years, although some localities diverge greatly from this value (Leopold, Wolman, and Miller, 1964). When rivers exceed their banks so frequently, it seems logical to avoid construction in the flood plain. Since buildings may impede the flow of flood waters and increase flooding, it also seems logical to avoid all construction in the lower parts of the flood plain. The Corps of Engineers have conducted studies on the Big Wood River in the Bellevue-Hailey, and Ketchum vicinities, Warm Springs Creek in the Ketchum area, and East Fork Big Wood River in the Gimlet-Triumph area. These studies were done to acquaint local people and public agencies with flood problems of the area, to record pertinent information in concise form for reference, and to furnish data needed for planning best use of the areas subject to flooding (Corps of Engineers 1970, 1971, 1972, 1973). Blaine County has a flood plain zoning ordinance that is designed to regulate construction in the flood plain and to reduce flooding.

Potential Dam Sites

Four multipurpose reservoir sites have been studied in the upper Big Wood area; one each on Trail Creek, Warm Springs Creek, East Fork, and the Big Wood River at Boulder Flats (Corps of Engineers 1972). The purpose of these dams would be to control flooding immediately below the dam site, supplement irrigation needs, and supply recreation. A reservoir would eliminate a reach of free-flowing stream but could benefit the fishery by supplementing flows in the lower reaches of the Big Wood River that are usually dry during irrigation season. The full benefits of flood control may not be realized because of the tendency to encroach on the river after a dam controls the flow. Furthermore, the lack of high flows often cause a decrease in channel capacity. Some areas would then flood even with the controlled flows; dredging and/or levees may still be necessary. Bureau of Reclamation studies in the 1950's indicated that the cost/benefit ratio of dams on the Big Wood or its tributaries made their construction unfeasible. With increased property values, recreation potential or other identified surface water needs at present or in the future, perhaps this conclusion is no longer valid.

CONCLUSIONS

1. Aquifers underlying the study area have an unknown potential, as yet, for further development.
2. The ground and surface water systems are highly interconnected; any stress imposed upon one will affect the other.
3. Present groundwater use (average daily pumpage) in the Sun Valley-Ketchum area is approximately 2.2 mgd; during the peak of irrigation season, the pumpage increases to over 7 mgd. Projections of population growth indicate that population may triple before 1990, with an obvious increased demand for water.
4. Groundwater quality at present is adequate for all current uses. Surface water quality in streams above developed areas presently meets standards set by the Idaho Department of Health and Welfare. Bacteria concentrations in the lower portions of Trail Creek exceeded these standards on four out of six occasions. Bacteria present in portions of Warm Springs Creek on all occasions sampled, except during high spring flows, indicate continuous contamination from fecal sources. The Big Wood River and its major tributaries are generally free of chemical pollutants.
5. The observation well network used for this study provided a base of hydrologic data for future water-level comparisons. Water-quality samples taken during the course of this study provide some basis for future comparisons.
6. Approximately 22 miles of the Big Wood River has been altered from the natural state. Continued encroachment on the river and flood plain will require additional work in the river, which will further reduce the aquatic habitat for fish and wildlife.

RECOMMENDATIONS

1. A number of observation wells should be established in the vicinity of the Sun Valley-Ketchum area, both for groundwater level and water quality monitoring. All wells used during this study were used for domestic or irrigation purposes; consequently, water level measurements were questionable at times. Wells established solely for observation purposes should be placed throughout the area.
2. Aquifer tests should be performed in a number of wells in the area, to determine aquifer characteristics. With this and other data, water level declines due to withdrawals can be computed for projected pumpage figures. This should be done so that the results can be incorporated into planning efforts for future development.
3. Existing sources of fecal contamination in Trail and Warm Springs creeks should be located and eliminated. In addition, existing proposals for construction of community water and sewage collection facilities should be implemented, with a corresponding denial of permits allowing septic tank construction in new high-density developments. These statements are especially true of Warm Springs Creek as well as near the Big Wood River, since development in Warm Springs Creek may eventually extend far up the drainage.
4. Most stream channel alterations on the study reach of the Big Wood River are for protection of homes immediately adjacent to the stream. By restricting development within a particular distance from the stream, the necessity for many alterations could be eliminated. This "green-belt" approach would enhance the natural recreational value

of the riverbanks and improve the quality of the fish and wildlife habitat.

5. Further work is necessary to determine values for factors used in estimating the basin yield. Estimates of evapotranspiration, groundwater underflow, precipitation, and consumptive uses or diversions out of the basin need to be quantified.

6. Further surface geophysical work including resistivity and/or seismic refraction define the physical boundaries of the saturated valley-fill material, especially in the Hailey-North Fork reach where future groundwater development is likely to be concentrated.

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APPENDICES

APPENDIX A

Table of Wells in Which Water Level Measurements Were Made During the Course of the Sun Valley-Ketchum Study, Blaine County, Idaho

WELL NUMBER	OWNERSHIP	ALTITUDE OF L.S.D. (FEET)	YEAR DRILLED	USE OF WELL	DEPTH OF WELL (FEET)	DEPTH CASED (FEET)	WELL DIAMETER (INCHES)	WATER LEVEL (FEET)	DATE MEASURED	WELL LOG YES	WELL LOG NO	WELL YIELD (GPM)	DRAWDOWN (FEET)	REMARKS
2N-18E- 4cb1	Floyd Dorius	5350	1972	Dom.	50		6	10.86	5/31/72		X			
4cbb1	Zenonea	5350	1966	Dom.	36	36	6	6.08	5/16/74	X		30	8	I.D.W.R.[1] OBS.
4cb3	W. McKenzie	5350	1972	Dom.	48		6	10.32	6/01/72		X			
4cc1	P. Pouley	5350	1967	Dom.	48		6	10.51	5/31/72		X			
4cdc1	Sahaka	5335	1961	Dom.	48	48	6	7.77	5/16/74	X		30	2	I.D.W.R. OBS.
4cd2	J. Savaria	5360	1968	Dom.	63	63	6	42.23	5/30/72	X		40	0	Open End
5aa1	Schlunegger	5370		Irr.			6	8.97	7/11/73		X			I.D.W.R. OBS.
9ba1	Sahaka	5340		Dom.	30		6	11.31	5/31/72		X			
3N-17E-25acd1	Potter/Marsh	5522	1956	Irr.	95	95	16	3.25	5/16/74	X				I.D.W.R. OBS. Perfs.[2] Unknown
26dac1	W. Burt	5562	1961	Irr.	178	170	20	5.04	5/16/74	X		635	100	I.D.W.R. OBS. Perf. 45-160'
3N-18E- 6ab1	E.V. McHans	5640		Dom.	41		6	5.22	5/16/74		X			I.D.W.R. OBS.
6ad1	John Adams	5600	1971	Dom.	61	61	6	5.10	5/16/74	X		26	0	I.D.W.R. OBS.
7da1	Kreilkamp	5560		Dom.	36		6	2.6	6/06/72		X			
7da2	J. Hogg	5565		Dom.	35		6	14.9	6/05/72		X			
7dd1	C. Fowler	5555	1970	Dom.	44	44	6	14.70	6/05/72	X		35	3	Open End
8ca1	Bagley	5620		Dom.	138		6	73.08	5/16/74		X			I.D.W.R. OBS.
8cb1	Larry Wilde	5570	1971	Dom.	45	45	6	13.57	6/05/72	X		20	15	Open End
8cb2	Bob Ratto	5600	1968	Dom.	39	39	6	30.4	6/02/72	X				Open End
8da1	G.A. Kriver	5560	1970	Dom.	155	134	6	110.6	6/05/72	X				Open Hole
9cba1	K. Taylor	5700	1971	Dom.	190	43	6	68.37	5/16/74	X				I.D.W.R. OBS.
17cb1	D. Farmer	5560	1969	Dom.	91	91	6	39.27	5/16/74	X		20	12	I.D.W.R. OBS.
17cb2	Thornly	5520		Dom.			6	17.34	6/02/72		X			
18ac1	Private	5540	1955	Irr.	113	90	16	58.	1/14/55	X				I.D.W.R. OBS. Perf. 36-86'
20bd1	H. Murphy	5550	1965	Irr.	60	60	6	34.80	6/02/72	X				Open End
20bda1	Mizer Bros.	5520	1959	Irr.	180	174	20	37.98	5/16/74	X		1800	88	I.D.W.R. OBS. Perf. 41-170'
29ab1	J. Clemons	5452		Dom.	71		6	9.59	6/02/72		X			
29cd1	Balis	5415		Dom.	68		6	6.6	6/01/72		X			
29dc1	Shaw	5420		Dom.	43		6	10.71	6/01/72		X			
30ad1	W. Burt	5525	1963	Dom.	270		6	88.69	5/16/74		X			I.D.W.R. OBS.
32ab1	R. Giddings	5410	1970	Dom.	45	45	6	4.69	5/16/74	X				I.D.W.R. OBS.
32ab2	Bill Butler	5420	1971	Mun.	77	77	10	12.12	6/01/72	X				Perf. 48-72'
32dca1	J. Mallea	5382		Dom.	52		6	8.93	6/01/72		X			
4N-16E-36ada2	Dee Pace	6240	1967	Dom.	19	18	6	4.04	9/19/73	X				I.D.W.R. OBS. Open End
4N-17E-11ccd1	Hammond	5910		Dom.			6	35.85	5/16/74		X			I.D.W.R. OBS.
11ccd2	Gary Rogers	5910	1966	Dom.	200+		6	40.9	7/13/72		X			
11cda1	Katsilometes	5850		Dom.	40+			16.97	5/16/74		X			
11cdb1	Ricker	5900		Dom.			6	51.32	7/13/72		X			
11cdc	John Koby	5900	1966	Dom.			6	49.47	7/13/72		X			
11cdd1	R. Roberts	5870		Dom.			6	32.13	7/13/72		X			
11cdd2	Bill Prosch	5870		Dom.			6	22.28	7/13/72		X			
11dac1	H. Turner	5865			60		6	44.84	7/13/72		X			

WELL NUMBER	OWNERSHIP	ALTITUDE OF L.S.D. (FEET)	YEAR DRILLED	USE OF WELL	DEPTH OF WELL (FEET)	DEPTH CASED (FEET)	WELL DIAMETER (INCHES)	WATER LEVEL (FEET)	DATE MEASURED	WELL LOG YES	WELL LOG NO	WELL YIELD (GPM)	DRAWDOWN (FEET)	REMARKS
11dad1	Bob Reese	5835	1972	Dom.			6	11.23	7/14/72		X			
11dbc1	Huffman	5870	1968	Dom.	70		6	48.86	7/13/72		X			
11dbd1	R. S. McShane	5870	1968	Dom.	71	66	6	41.26	5/16/74	X				I.D.W.R. OBS.
12bd1	R. Shay	5870	1968	Dom.	30		6	6.85	7/15/72		X			
12ca1	T. Grunner	5860	1950's	Dom.	80		6	68.4	7/14/72		X			
12cad1	C. Pugmire	5850		Dom.			6	54.86	7/15/72		X			
12cbc1	Private	5842		P.S.				40.95	5/16/74		X			I.D.W.R. OBS.
12cdb1	T. Grunner	5845	1950's	Irr.	70+			42.2	7/14/72		X			
12cdc1	Walford	5815		Dom.			6	40.58	5/16/74		X			I.D.W.R. OBS.
12dcc1	J. McDonald	5850		Dom.			6	47.83	5/16/74		X			I.D.W.R. OBS.
12dc1	Corporation	5817		Dom.	54			5.74	5/14/74		X			I.D.W.R. OBS.
12dcd1	Corporation	5845		P.S.	270			17.12	2/06/74		X			I.D.W.R. OBS.
13ab1	O. Simpson	5815		Dom.	46		6	12.58	7/14/72		X			
13abb1	J. Corrock	5842	1971	Dom.	84		6	46.4	7/14/72		X			
13abc1	Ritzau	5795	1971	Dom.	40		6	2.85	7/14/72		X			
13acc1	Private	5790		Dom.			6	2.17	7/11/73		X			I.D.W.R. OBS.
13db1	C. V. Wayland	5780		Dom.	22			1.88	7/14/72		X			
13dba1	Private	5780		Dom.			6	10.02	7/14/72		X			I.D.W.R. OBS.
13dca1	Rupert	5770		Dom.			6	1.85	5/16/74		X			I.D.W.R. OBS.
13dd1	R. Reagen	5772	1971	Dom.	38		6	7.67	7/14/72		X			
14bab1	Private	5880	1971	Dom.	55		6	19.78	7/13/72		X			
14bba1	N. Wood	5900		Dom.			6	14.7	7/12/72		X			
14bca1	Puchner	5920		Dom.			6	6.88	5/16/74		X			
14bca2	Puchner	5880	1970	Dom.			6	3.97	7/13/72		X			I.D.W.R. OBS.
15ca1	Gary Dauven	5950	1967	Dom.			6	4.84	7/13/72		X			
15cac1	Ken Chermak	5960	1969	Dom.	40	40	6	13.65	5/15/74	X		30	5	I.D.W.R. OBS. Open End
15cad1	Scheldahl	5972	1971	Dom.	52		6	16.8	7/12/72	X		20	0	
15ccb1	C. Huxley	5965	1970	Dom.	31	31	6	3.61	5/16/74	X		33	3	I.D.W.R. OBS. Open End
15cc1	Max Fife	5985	1970	Dom.	53	44	6	11.76	7/12/72	X		30	4	Open Hole
15cc2	A. Higley	5945	1971	Dom.	30	30	6	4.1	7/12/72	X		30	5	Open End
15cc3	D. Johnson	5962	1968	Dom.	34	32	6	6.05	7/12/72	X		20	7	Open Hole
15ccc1	Inadomi	5970		Dom.			6	3.1	7/12/72		X			
4N-18E-19dbb1	John Wade	5735	1968	Dom.	126	46	6	24.07	5/16/74	X		18	40	I.D.W.R. OBS. Open Hole
19dbd1	C. Pothier	5738	1970	P.S.	70	70	10	10.01	5/16/74	X		495	5	I.D.W.R. OBS. Perf. 48-52'
25dcb1	Karst	6100	1964	P.S.	40		6	18.20	5/16/74		X			I.D.W.R. OBS.
30daa1	B. Caskey	5700		Dom.			14	8.04	5/16/74		X			I.D.W.R. OBS.
31aab1	Bramble	5670		Dom.			6	4.80	5/16/74		X			I.D.W.R. OBS.
32ccb1	D. Knotts	5630	1971	Dom.	176	44	6	22.58	5/16/74	X		20	135	I.D.W.R. OBS. Artesian, Open Hole
5N-16E-10db1	Church Camp	6560	1968	Dom.	38	38	6	4.10	7/11/72	X		40	2	Perf. 32-36'

WELL NUMBER	OWNERSHIP	ALTITUDE OF L.S.D. (FEET)	YEAR DRILLED	USE OF WELL	DEPTH OF WELL (FEET)	DEPTH CASED (FEET)	WELL DIAMETER (INCHES)	WATER LEVEL (FEET)	DATE MEASURED	WELL LOG YES	WELL LOG NO	WELL YIELD (GPM)	DRAWDOWN (FEET)	REMARKS
5N-17E-10ccc1	G. Mueller	6180		Dom.	44			13.44	7/11/72		X			
10dad1	F. R. Insinger	6180		Dom.			6	15.70	7/11/72		X			I.D.W.R. OBS.
10db1	Ron Silvara	6200		Dom.			6	4.03	7/12/72					
10dc1	Jensen/Hall	6200	1968	Dom.	50	50	6	21.82	7/11/72	X		26	4	Open End
10dcd1	M. Marin	6200	1961	Dom.	47	47	6	19.57	5/14/74	X		20	12	I.D.W.R. OBS.
14aca1	Ken Brown	6225	1969	Dom.	79	80	6	25.30	5/14/74	X		20	0	I.D.W.R. OBS. Perf. 51-79'
14acc1	M. Browning	6170	1971	Dom.	76	76	6	29.76	7/11/72			20	0	Perf. 44-65'
14acc2	Don Aslett	6190	1969	Dom.	73	73	6	40.52	7/11/72	X		26	0	Open End
14bbc1	Gustafson	6155		Dom.	60		6	20.22	7/11/72		X			
14ca1	Connelly	6150		Dom.	40		6	16.36	6/08/72		X			
14caa1	N. Cantor	6160	1970	Dom.	80+	70	6	24.60	7/11/72	X		20	0	Perf. 43-58'
14caa2	R. S. Wright	6200	1971	Dom.	150	23	6	30.47	5/14/74	X				I.D.W.R. OBS.
14cba1	Jack Colven	6135	1972	Dom.	42		6	3.24	5/14/74			15	10	I.D.W.R. OBS.
14cb1	C. Forgnone	6125	1965	Dom.	39	39	6	2.46	6/08/72	X		50		Open End
23ac1	J. Monroe	6075	1968	Irr.	51	51	8	4.32	6/08/72	X		50	0	Perf. 30-48'
23bad1	Bleckman	6110	1969	Dom.	42	44	6	11.4	6/08/72	X		50	2	Perf. 37-42'
23bda1	J. Hemingway	6095	1972	Dom.	41	41	6	5.64	5/14/74	X		30	3	I.D.W.R. OBS.
23da1	Arnold	6060	1965	Dom.	38	38	6	8.43	6/08/72	X		1800	0	Open End
23dd1	C. Shriber	6050	1969	Dom.	46	46	6	3.85	6/08/72	X		50	1	Perf. 38-44'
23dd2	B. Fletcher	6045	1968	Irr.	46		6	4.04	5/14/74	X		52	0.5	I.D.W.R. OBS. Perf. 38-45'
25bc1	Don Wilson	6020		Dom.			6	14.68	6/08/72		X			
25bc2	Butterfield	6030	1968	Dom.	91	62	6	19.68	7/10/73	X		26	34	I.D.W.R. OBS.
25bc3	Monk	6045		Dom.	45	45	6	21.35	6/08/72	X		20	1	
36ba1	Walker	5695		Dom.	30		6	1.6	6/07/72		X			
36ba2	Jack Ward	6180	1971	Dom.	70	70		19.93	7/10/73	X				I.D.W.R. OBS.
36cbd1	Corporation	5965	1968	P.S.	117		16	31.49	5/14/74	X		300	60	I.D.W.R. OBS.
36cc1	Corporation	5970	1966	Dom.	101		12	22.3	6/08/72	X		110	36	Perf. 47-97'
6N-16E-31dd1	Dist. 4-H Camp	7090	1965	Dom.	140	56	8	14.03	7/11/72	X				Perf. 48-54'
33cd1	U.S. Forest Service	-	1966	Dom.	50	50	6	+1.	5/ /66	X				

(Owner's names are from driller's reports and may not reflect current ownership.)

(Altitudes interpolated from U.S.G.S. 7.5' Quad sheets.)

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1 I.D.W.R. OBS. - Idaho Department Water Resources Observation Well

2 Perfs. - Perforated intervals in the well casing

APPENDIX B

Chemical Analyses of Water at
Selected Surface and Groundwater
Sites, Sun Valley-Ketchum Area

NO.	SOURCE LOCATION	DATE OF COLLECTION	SILICA (SiO_2)	IRON (Fe)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	BICARBONATE (HCO_3)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	BORON (B)	DISSOLVED SOLIDS	PERCENT SODIUM	SODIUM ADSORPTION RATIO	pH	SPECIFIC ELECTRICAL CONDUCTANCE (umhos at 25° C.)
	SURFACE WATER																		
1.	Big Wood River at Easley Bridge	8/15/73	11.4	0.12	23.8	2.3	2.8	0.0	84.2	4.3	0.0	0.20	0.03	0.02	101	8.2	0.14	7.9	156
		2/ 5/74	11.5	0.11	23.6	2.7	3.0	0.4	82.4	6.7	3.5	0.24	0.22	0.00				7.8	151
		5/15/74	12.8	0.16	17.2	1.8	2.1	0.4	60.4	4.8	0.7	0.10	0.12	0.01				7.7	104
2.	N. Fk. Big Wood at confluence with Big Wood	8/15/73	7.0	0.01	36.5	6.4	1.4	0.4	131.8	14.9	0.0	0.03	0.03	0.02	151	2.5	0.06	8.1	233
		2/ 5/74	7.0	0.11	38.9	7.9	1.1	0.8	134.2	17.8	1.4	0.19	0.18	0.02				8.1	237
		5/15/74	7.0	0.01	36.7	5.4	1.1	0.4	130.0	8.6	0.7	0.10	0.18	0.00				7.6	207
3.	Big Wood River at Hulen Meadows	8/15/73	10.0	0.03	32.3	5.2	2.8	0.0	120.2	9.6	0.0	0.21	0.08	0.04	133	5.6	0.12	8.1	204
		2/ 5/74	10.4	0.10	29.9	5.4	2.8	0.8	112.3	10.1	2.5	0.23	0.16	0.01				8.0	195
		5/15/74	12.2	0.11	24.0	3.5	2.1	0.8	88.5	5.8	0.7	0.11	0.18	0.01				7.4	145
4.	Warm Springs Creek NW¼ SE¼ NW¼ Sec.21 T4N R17E B.M.	8/15/73	19.0	0.02	30.1	5.0	6.7	0.4	121.4	9.6	0.0	0.78	0.06	0.03	131	13.1	0.30	8.1	202
		5/15/74	19.0	0.12	19.2	2.1	3.2	0.08	67.7	6.2	1.4	0.15	0.17	0.00				7.8	119
5.	Warm Springs Creek SE¼ NE¼ SW¼ Sec.13 T4N R17E B.M.	8/15/73	19.6	0.05	33.5	5.4	9.2	0.8	130.0	11.5	0.4	1.26	0.05	0.04	149	15.8	0.39	8.3	229
		2/ 5/74	20.0	0.09	30.1	5.8	9.2	1.2	123.3	13.9	3.5	1.24	0.18	0.01				8.0	235
		5/15/74	18.8	0.15	20.0	2.6	3.7	0.4	73.8	7.2	1.4	0.26	0.19	0.00				7.9	129
6.	Trail Creek at Boundary Campground	8/15/73	6.2	0.02	46.5	17.8	2.1	0.8	202.6	31.7	0.0	0.08	0.03	0.03	219	2.3	0.07	8.3	219
		* 2/ 5/74	7.0	0.12	54.1	22.1	2.3	1.2	222.1	48.0	3.9	0.16	0.15	0.01				8.1	409
		5/15/74	6.8	0.02	40.1	15.4	1.4	0.8	170.9	28.8	0.7	0.12	0.12	0.00				7.5	294
7.	Trail Creek near its confluence with Big Wood River	8/15/73	13.6	0.01	48.1	17.0	8.0	1.2	204.4	37.9	1.1	1.35	0.18	0.04	247	8.4	0.25	8.4	247
		2/ 5/74	10.0	0.10	50.9	21.2	6.0	1.6	203.2	48.5	3.5	0.88	0.11	0.00				8.6	412
		5/15/74	7.2	0.03	42.7	15.8	1.8	1.2	177.0	32.2	1.1	0.16	0.19	0.01				7.2	317

* Sampled at Trail Creek Cabins rather than Boundary Campground because of snow depths.

NOTE: Chemical constituents expressed in milligrams per liter.
All analyses performed by U. S. Bureau of Reclamation.

SURFACE WATER (continued)

NO.	SOURCE LOCATION	DATE OF COLLECTION	SILICA (SiO_2)	IRON (Fe)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	BICARBONATE (HCO_3)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	BORON (B)	DISSOLVED SOLIDS	PERCENT SODIUM	SODIUM ADSORPTION RATIO	pH	SPECIFIC ELECTRICAL CONDUCTANCE (umhos at 25° C.)
8.	Ketchum Sewage Treatment Plant Outfall	8/15/73	14.4	0.03	47.3	14.3	43.7	7.8	202.6	45.1	0.0	0.81	13.10	0.13	333	33.7	1.43	7.6	513
9.	Big Wood River above Ketchum Sewage Treatment Plant	8/15/73	12.0	0.01	35.1	6.8	4.6	0.8	137.9	11.0	0.0	0.52	0.15	0.01	151	7.9	0.19	8.2	232
10.	East Fork Big Wood below Triumph SE¼ SE¼ SW¼ Sec. 35 T4N R18E B.M.	8/15/73	8.6	0.01	41.1	11.9	1.8	2.3	166.6	25.5	0.0	0.03	0.02	0.02	191	2.5	0.06	8.3	294
		2/ 5/74	7.6	0.13	51.9	17.4	2.8	2.0	186.6	50.0	4.6	0.10	0.18	0.00				8.1	385
		5/15/74	9.6	0.05	39.3	11.6	2.1	1.2	154.4	25.5	1.1	0.10	0.17	0.02				7.9	269
11.	East Fork Big Wood above Triumph SW¼ SW¼ SE¼ Sec. 30 T4N R19E B.M.	8/15/73	10.0	0.20	42.3	11.7	2.3	0.8	176.3	16.3	0.0	0.02	0.08	0.02	193	3.1	0.08	8.0	297
		2/ 6/74	7.4	0.09	45.3	14.8	1.8	0.8	177.6	28.8	2.8	0.10	0.18	0.01				8.0	327
12.	Big Wood River at Deer Creek Bridge SE¼ SW¼ SW¼ Sec.29 T3N R18E B.M.	8/15/73	11.8	0.02	38.5	8.3	4.4	0.8	153.8	14.9	0.0	0.40	0.17	0.02	161	6.8	0.17	8.3	247

NO.	SOURCE LOCATION	DATE OF COLLECTION	SILICA (SiO_2)	IRON (Fe)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	BICARBONATE (HCO_3)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	BORON (B)	DISSOLVED SOLIDS	PERCENT SODIUM	SODIUM ADSORPTION RATIO	pH	SPECIFIC ELECTRICAL CONDUCTANCE (umhos at 25° C.)
							GROUND WATER												
1.	2N 18E 4cdc1	9/20/73	15.6	0.01	55.3	10.9	3.7	1.2	214.8	15.4	2.1	0.29	0.57	0.03	241	4.2	0.12	7.70	371
	(Sahaka)	2/ 6/74	11.7	0.10	56.1	11.6	3.4	1.2	212.3	16.8	2.8	0.31	0.37	0.02				7.68	362
2.	3N 17E 25acd1	9/20/73	21.4	3.12	46.7	5.4	6.4	1.2	163.5	17.3	2.8	0.57	0.67	0.03	198	4.0	0.24	7.84	305
	(Potter/Marsh)	5/16/74	18.0	0.03	47.7	6.0	6.7	1.2	167.2	18.3	2.5	0.62	0.62	0.03				7.70	276
3.	3N 18E 9cba1	9/20/73	14.6	0.00	58.1	12.8	3.9	2.0	209.3	33.6	3.2	0.28	0.80	0.03	247	4.1	0.12	7.64	380
	(Taylor)	2/ 6/74	11.0	0.10	55.5	13.9	4.1	2.3	204.4	33.6	5.0	0.31	0.79	0.02				7.60	380
		5/16/74	12.6	0.02	56.9	13.5	3.9	2.0	208.7	35.1	2.5	0.27	0.76	0.02				7.51	354
4.	4N 16E 36ada2	9/20/73	28.4	0.00	23.4	3.0	9.7	0.8	97.6	10.1	1.1	1.33	0.10	0.04	112	22.6	0.50	7.38	173
	(Pace)																		
5.	4N 17E 11dbd1	9/20/73	14.8	0.00	44.3	22.4	10.6	2.0	237.4	30.3	5.0	0.53	0.19	0.02	250	10.1	0.32	7.72	385
	(McShane)	2 6/74	11.7	0.06	46.3	21.6	10.8	2.0	230.7	33.6	6.4	0.54	0.35	0.03				7.76	414
6.	4N 17E 12dab1	9/20/73	27.6	0.00	33.5	5.6	4.4	1.2	130.6	8.2	1.1	0.43	0.82	0.01	148	8.1	0.18	7.70	227
	(Big Wood Development)	2/ 6/74	23.4	0.09	35.7	6.2	4.4	1.2	133.6	9.6	3.5	0.18	0.92	0.03				7.84	251
		5/16/74	28.2	0.73	28.3	3.9	3.9	0.8	106.8	7.2	1.4	0.11	1.20	0.00				7.73	174
7.	4N 17E 13dca1	9/20/73	13.8	0.07	40.9	7.3	4.4	1.2	159.3	10.6	1.8	0.31	0.31	0.00	172	6.6	0.17	7.86	265
	(Rupert)	2/ 6/74	11.6	0.10	40.3	7.5	4.1	0.8	150.1	13.4	2.8	0.33	0.40	0.02				7.78	266
		5/16/74	12.2	0.01	45.1	6.0	4.4	0.8	155.6	16.8	3.9	0.32	1.40	0.04				7.76	273
8.	4N 17E 15cac1	9/20/73	16.2	0.00	41.5	6.0	4.1	1.2	158.7	7.7	2.5	0.38	0.30	0.00	170	6.5	0.16	7.80	262
	(Chermak)	2/ 6/74	13.6	0.09	42.5	6.2	4.4	1.6	158.0	8.6	3.9	0.40	0.23	0.02				7.78	263
		5/16/74	14.2	0.02	41.1	5.6	4.1	1.2	153.2	8.6	0.7	0.36	0.29	0.01				7.40	246
9.	4N 18E 7dab1 (Sun Valley	9/21/73	11.0	0.00	50.9	18.2	1.8	1.6	212.9	32.7	1.4	0.13	0.19	0.04	252	1.9	0.06	7.82	388
	#5)	5/16-74	7.6	0.02	55.7	20.9	2.1	1.2	232.5	41.8	2.8	0.18	0.88	0.03				7.72	384
10.	4N 18E 8bbc1 (Sun Valley	9/21/73	10.6	0.02	60.1	20.9	2.1	1.6	249.6	37.5	2.1	0.12	0.31	0.00	294	1.8	0.06	7.50	452
	#4a)	5/16/74	7.0	0.00	60.5	19.2	1.8	1.2	238.0	41.3	3.5	0.11	0.78	0.02				7.59	389
11.	4N 18E 19dbd1	9/20/73	11.4	0.00	54.7	18.8	2.8	2.0	228.2	34.1	1.8	0.17	0.37	0.00	262	2.7	0.08	7.70	403
	(Pothier)	2/ 6/74	11.0	0.09	55.9	19.1	3.9	1.6	226.4	38.9	3.9	0.24	0.39	0.03				7.64	418

NO.	SOURCE LOCATION	DATE OF COLLECTION	SILICA (SiO_2)	IRON (Fe)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	BICARBONATE (HCO_3)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (NO_3)	BORON (B)	DISSOLVED SOLIDS	PERCENT SODIUM	SODIUM ADSORPTION RATIO	pH	SPECIFIC ELECTRICAL CONDUCTANCE (umhos at 25° C.)
						GROUND WATER (continued)													
12.	4N 18E 19dcc1 (Sun Valley #8-Elkhorn)	9/21/73	14.6	0.16	43.9	11.7	3.7	1.6	180.0	22.1	1.4	0.31	0.18	0.04	201	4.8	0.13	7.74	309
13.	5N 17E 10dcd1 (Marin)	9/20/73	22.4	0.00	26.1	2.7	16.8	0.8	136.1	3.4	2.1	0.10	0.41	0.00	141	32.2	0.84	8.00	217
		2/ 6/74	20.4	0.07	25.9	2.8	17.2	0.8	131.8	3.4	2.1	0.10	0.32	0.02				8.00	210
		5/16/74	21.6	0.03	28.5	2.3	17.0	0.8	140.3	3.4	0.7	0.07	0.33	0.00				7.63	208
14.	5N 17E 23bda1 (Hemingway)	9/20/73	8.6	0.00	42.5	11.3	1.6	0.8	177.6	10.6	1.1	0.10	0.42	0.00	190	2.2	0.06	7.80	293
		2/ 4/74	8.0	0.06	40.1	11.1	1.8	0.8	161.7	11.0	2.5	0.10	0.32	0.01				7.90	266
		5/16/74	7.4	0.04	44.5	12.0	1.4	0.4	181.8	13.0	0.7	0.07	1.07	0.06				7.60	298

APPENDIX C

Selected Well Logs,

Sun Valley-Ketchum Area

SELECTED WELL LOGS - SUN VALLEY-KETCHUM AREA

(From files of Idaho Dept. of Water Resources)

Well: 2N-18E-4cd2 Owner: J. Savaria

Feet	Lithology	Water-Bearing Yes/No
0-3	Topsoil & gravel	No
3-21	Cemented medium gravel	No
21-37	Gravel & clay	No
37-44	Clay & course sand	No
44-63	Washed river gravel	Yes

Water level - 42 feet below LSD (land surface datum) 5/13/68

Well: 2N-18E-9cc Owner: W.A. Lewis

Feet	Lithology	Water-Bearing Yes/No
0-1	Topsoil	No
1-10	Gravel	No
10-13	Gravel	Yes
13-27	Gravel & clay, little water	
27-28 1/2	Yellow clay	No
28 1/2-40	Broken shale & clay	No
40-42	Shale bed rock	Yes

Water level - 10 feet below LSD 8/8/68

Well No.: 3N-18E-6ad1 Owner: John Adams

Feet	Lithology	Water-Bearing Yes/No
1-3	Rocky topsoil	No
3-15	Cemented gravel	No
15-42	Clay & sand	Yes
42-49	Solid rock)	No
	) Wood	
49-51	Scoria) River	Yes
	) Formation	
51-61	Solid rock)	No

Well No.: 3N-18E-9cba1 Owner: K. F. Hellyer, (now Mr. Kip Taylor)

0-3	Topsoil	No
3-44	Boulders, gravel & clay	No
44-171	Limestone, alternating hard and soft, massive and fractured	Water in fractured zones between 100 & 145 feet.

Water level - 97 feet below LSD 10/13/68

Well No.: 3N-18E-32ab1 Owner: Robert Giddings

0-1	Black soil & sand	No
1-14	Boulders & gravel	Yes
14-18	Gravel & sand	Yes
18-39	Clay & sand	No
39-45	Gravel & sand	Yes

Water level - 7 feet below LSD 5/23/70

Well No.: 4N-17E-12 cb Owner: Jack Simpson

Feet	Lithology	Water-Bearing Yes/No
0-3	Topsoil	No
3-17	Boulders	No
17-44	Gravel	Yes
44-57	Gravel w/some clay	Yes
57-69	Clean gravel	Yes
69+	Bedrock (no description)	No

Water level - 22 feet below LSD 10/6/67

Well No.: 4N-17E-15db Owner: Carl Rixon

0-2	Topsoil	No
2-28	Coarse gravel w/clay	No
28-37	Gravel & clay	No
37-44	Yellow limestone (?)	No
44-45	Fractured limestone (?)	Yes

Water level - 14 feet below LSD 5/10/69

Well No.: 4N-18E-12dc Owner: A. L. Arnold

0-5	Soil & fine gravel	No
5-20	Cement gravel	No
20-66	Clay & sand	No
66-68	Coarse sand & gravel	Yes

Water level - 50 feet below LSD 8/30/70

Well No.: 4N-18E-8bc Owner: Ketchum Spring Water Co.

Feet	Lithology	Water-Bearing Yes/No
0-20	Topsoil	No
20-40	Clay & gravel	No
40-55	Clay w/sand stringer	Yes
55-90	Clay	No
90-91	Sand	Yes
91-100	Clay w/sand stringers	Yes
100-120	Clay w/fine gravel	No
120-140	Clay, blue	No
140-150	Clay w/fine gravel	No
150-151	Sand	Yes
151-170	Sandy clay	No
170-175	Clay w/gravel stringers	Yes
175-195	Sandy clay, sticky	No
195-281	Clay, blue	No
281-287	Sand, blue-gray	No
287-303	Clay, blue	No
303-310	Sand or soft sandstone	No
310-345	Clay	No
345-360	Sand or sandstone	No
360-400	Clay	No
400-435	Sand or sandstone	No
435-475	Clay	No

Well No.: 4N-18E-8bc (continued)

Feet	Lithology	Water-Bearing Yes/No
475-490	Sand or sandstone	No
490-540	Clay	No
450-550	Sand or sandstone	No
550-586	Clay	No

Water level - 24 feet below LSD 7/31/52

Well No.: 4N-18E-18cd Owner: Jess Zimmerman

0-23	Boulders	No
23-46	Medium gravel	No
46-74	Cemented gravel	No
74-85	Medium gravel	Yes
85-97	(Rhyolite	No
97-98	Challis Volcanics ?(Fractured rhyolite (?)	Yes
98-107	(Rhyolite	No
107-108	(Fractured rhyolite (?)	Yes

Water level - 74 feet below LSD 8/17/58

Well No.: 4N-18E-19dc Owner: City of Ketchum

0-19	Soil & large boulders	No
19-54	Loose gravel & silt	No
54-59	Dry silt and gravel	Yes
59-68	Coarse sand & gravel	Yes
68-70	Firm gray rock	Yes

Water level - 59 feet below LSD 8/7/69

C-6

Well No.: 5N-17E-14cb   Owner: Norm Cantor

Feet	Lithology	Water-Bearing Yes/No
0-3	Topsoil	No
0-25	Clay & gravel	No
25-32	Gravel w/some clay	Yes
32-43	Gravel & clay	No
43-60	Gravel, sand, some clay	Yes
60-70	Clay & gravel	No
70-80	Bedrock (limestone?)	No

Water level - 25 feet below LSD 6/26/70

Well No: 5N-17E-36cc1   Owner: Hulen Meadows, Inc.

0-17	Gravel, boulders, clay	No
17-19	Loose gravel & sand	No
19-47	Gravel & sandy clay	No
47-56	Loose gravel	Yes
56-59	Gravel set in clay	No
59-61	Loose medium gravel	Yes
61-69	Clay & gravel	No
69-92	Loose medium gravel	Yes
92-101	Gravel & clay	No

Water level - 44 feet below LSD 6/10/66

Well No.: 6N-16E-31dd1 Owner: District 4-H Camp

Feet	Lithology	Water-Bearing Yes/No
0-48	Gravel with clay	?
48-56	Clay and gravel	?
56-92	Sedimentary type rock (Challis Volcanics?)	?
92-140	Granite (Idaho batholith)	?

Water level - 24 feet below LSD 10/24/65

APPENDIX D

Benthic Macroinvertebrates Identified
in the Big Wood River and Tributaries,
April 1973, Sun Valley-Ketchum Area

APPENDIX D List of benthic invertebrates collected in April, 1973, from the Big Wood River and tributaries.

Order	Family	Genus and Species
Diptera		
	Blephariceridae	
	Chironomidae	
	Empidae	
	Psychodidae	
	Rhagionidae	*Atherix variegata*
	Simuliidae	*Simulium*
	Tabanidae	
	Tipulidae	
Plecoptera		
	Chloroperlidae	*Alloperla*
		Chloroperla
		Paraperla
	Nemouridae	*Allocapnia*
		Brachyptera
		Isocapnia
		Nemoura
		Capnia
	Perlidae	*Acronuria ruralis*
		Claassenia
	Perlodidae	
		Arcynopteryx
		Isogenus
		Isoperla
		Perlesta
	Pteronarcidae	*Pteronarcella regularis*
		Taenioptryx
Trichoptera		
	Brachycentridae	*Brachycentrus*
	Hydropsychidae	*Arctopsyche*
		Hydropsyche
		Potomyia
	Lepidostomatidae	
	Limnephilidae	*Limnephilus*
	Rhyacophilidae	*Glossosoma*
		Rhyacophyla

D-2

Order	Family	Genus and Species
Ephemeroptera		
	Baetidae	*Baetis*
		E. doddsi
		E. levis
		E. tibialis
		E. (walkeri) carsona
		E. (walkeri) coloradensis
		E. (walkeri) flavilinea
		E. (walkeri) spinefera
		Paraleptophlebia
	Heptageniidae	*Arthroplea*
		Epeorus (Iron)
		Rhithrogena
Coleoptera		
	Elmidae	
	Staphylinidae	
Hemiptera		
	Saldidae	
Turbellaria		
Oligochaeta		
Hydracarina		
Hirudinea		

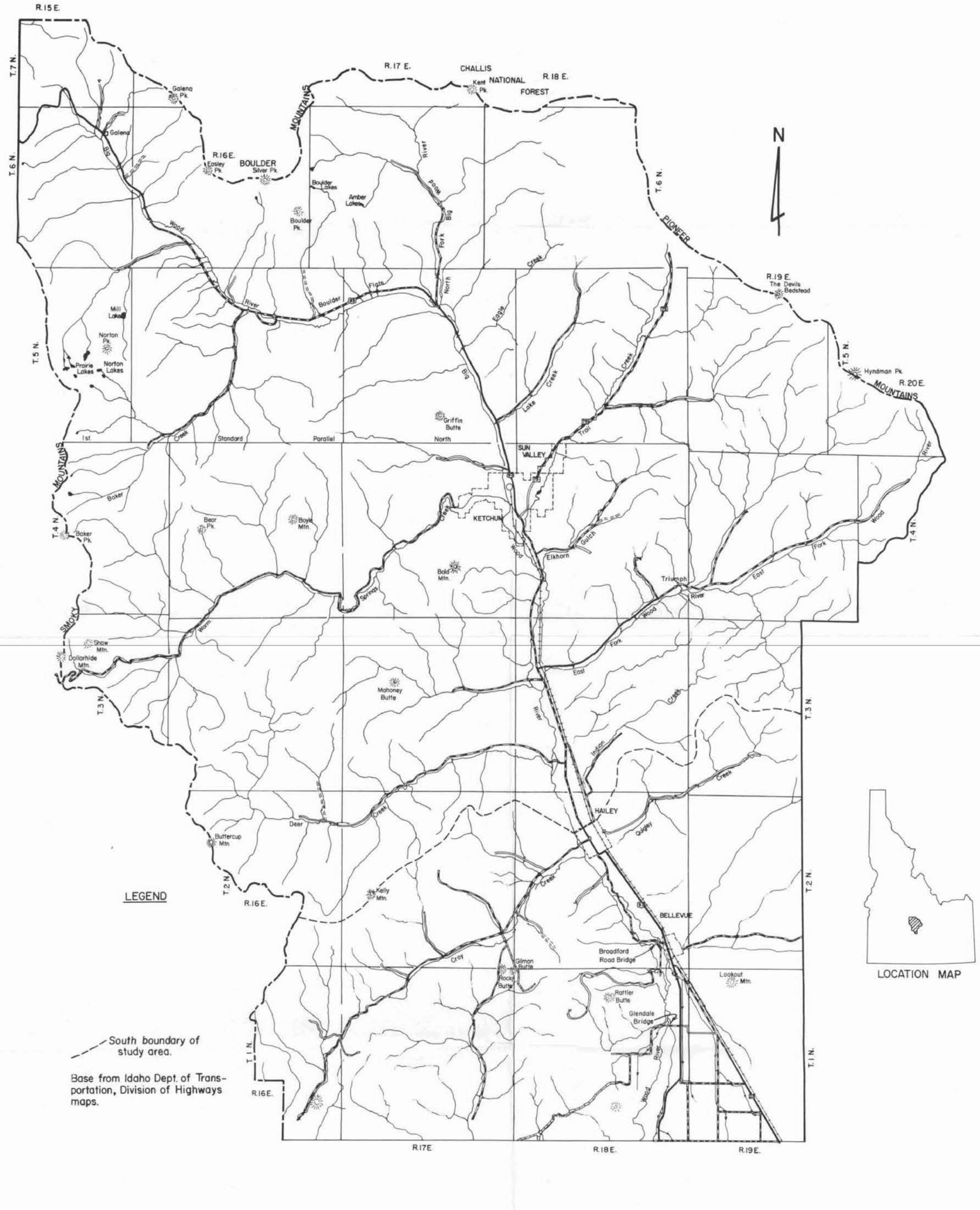

FIGURE 1.--Location and Extent of Sun Valley-Ketchum Study Area, Blaine County, Idaho

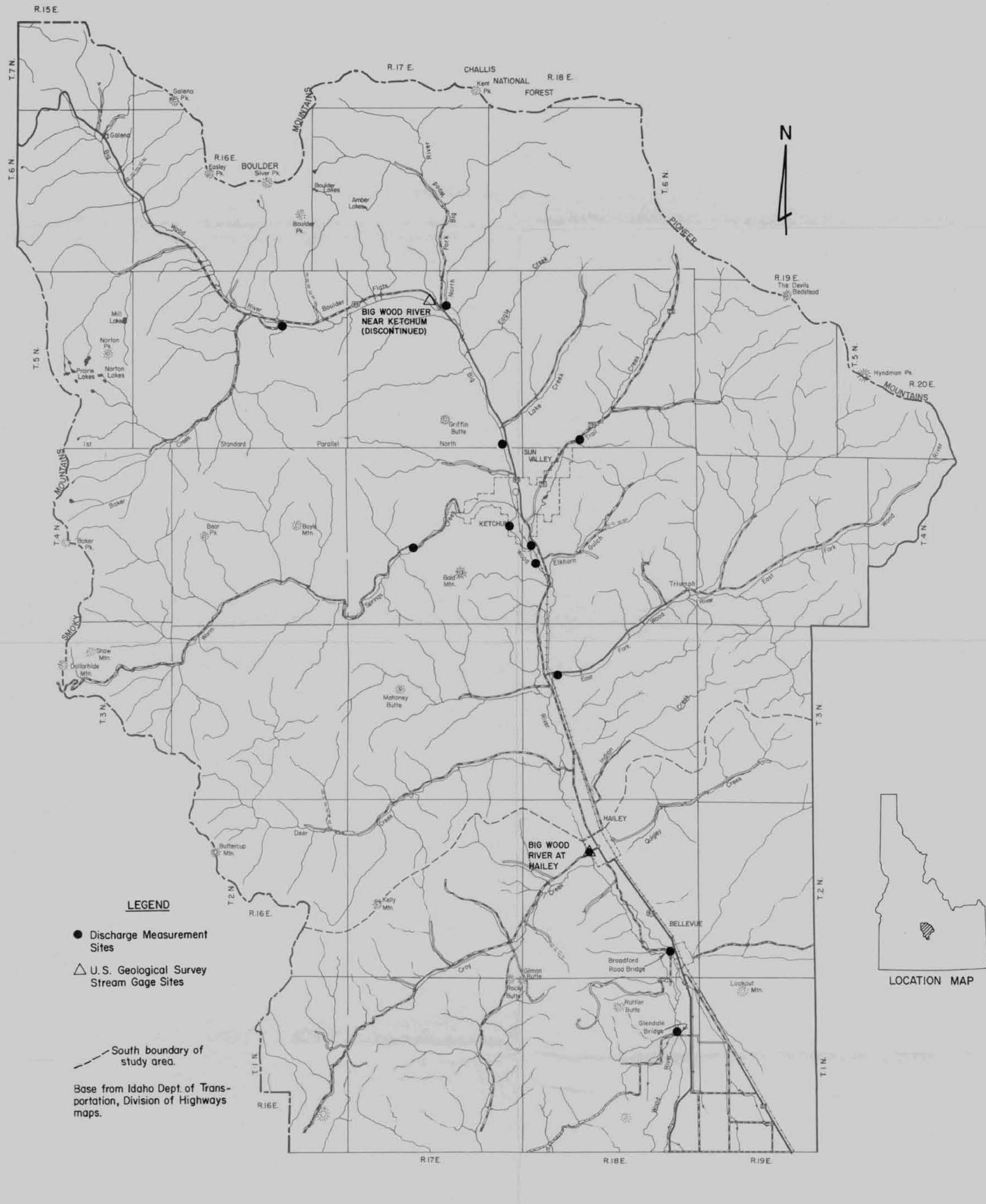

FIGURE 14.--Location Map of Discharge Measurement Sites in the Sun Valley-Ketchum Study Area

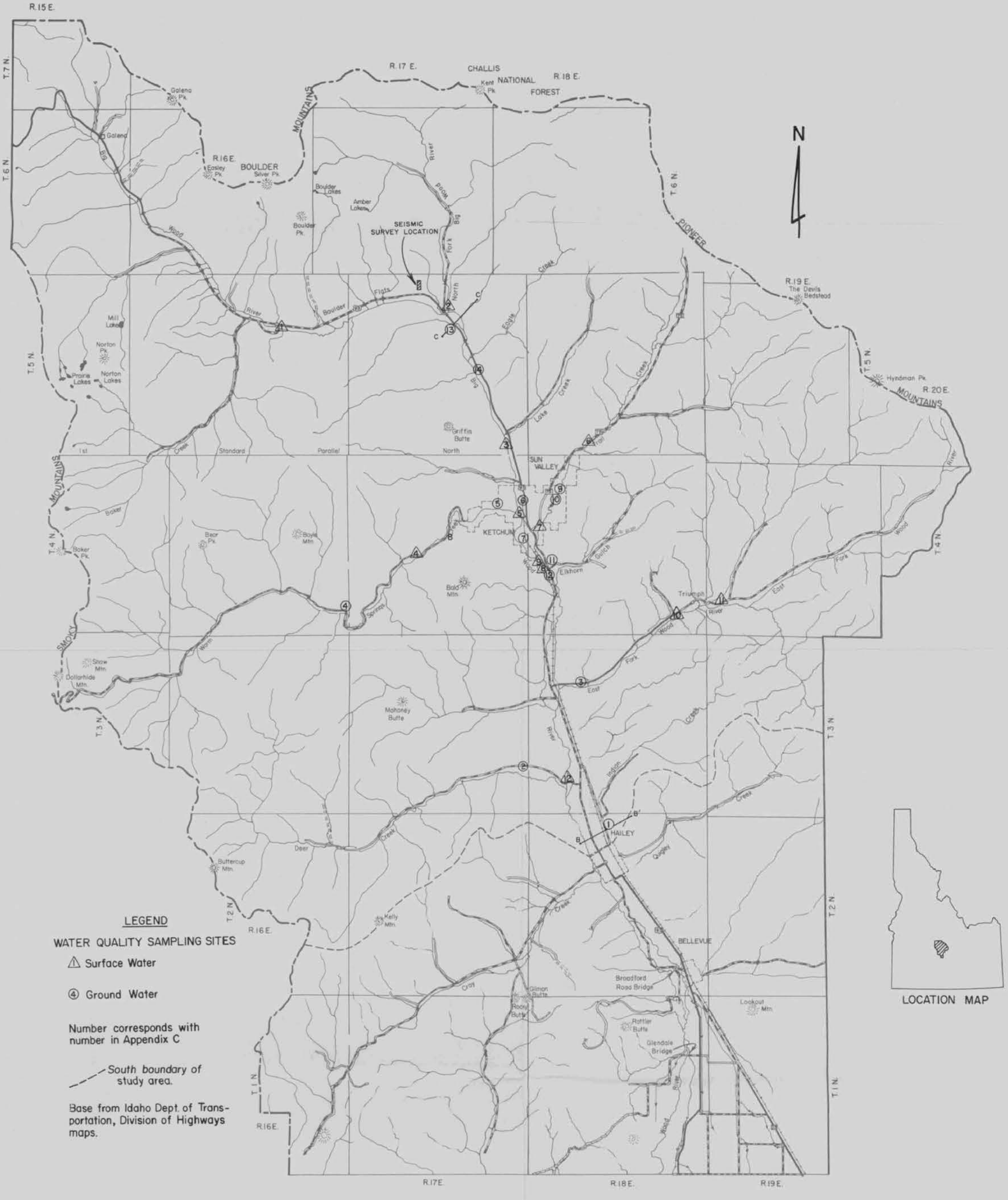

FIGURE 18.--Locations of Ground and Surface Water Sampling Sites, Sun Valley-Ketchum Area

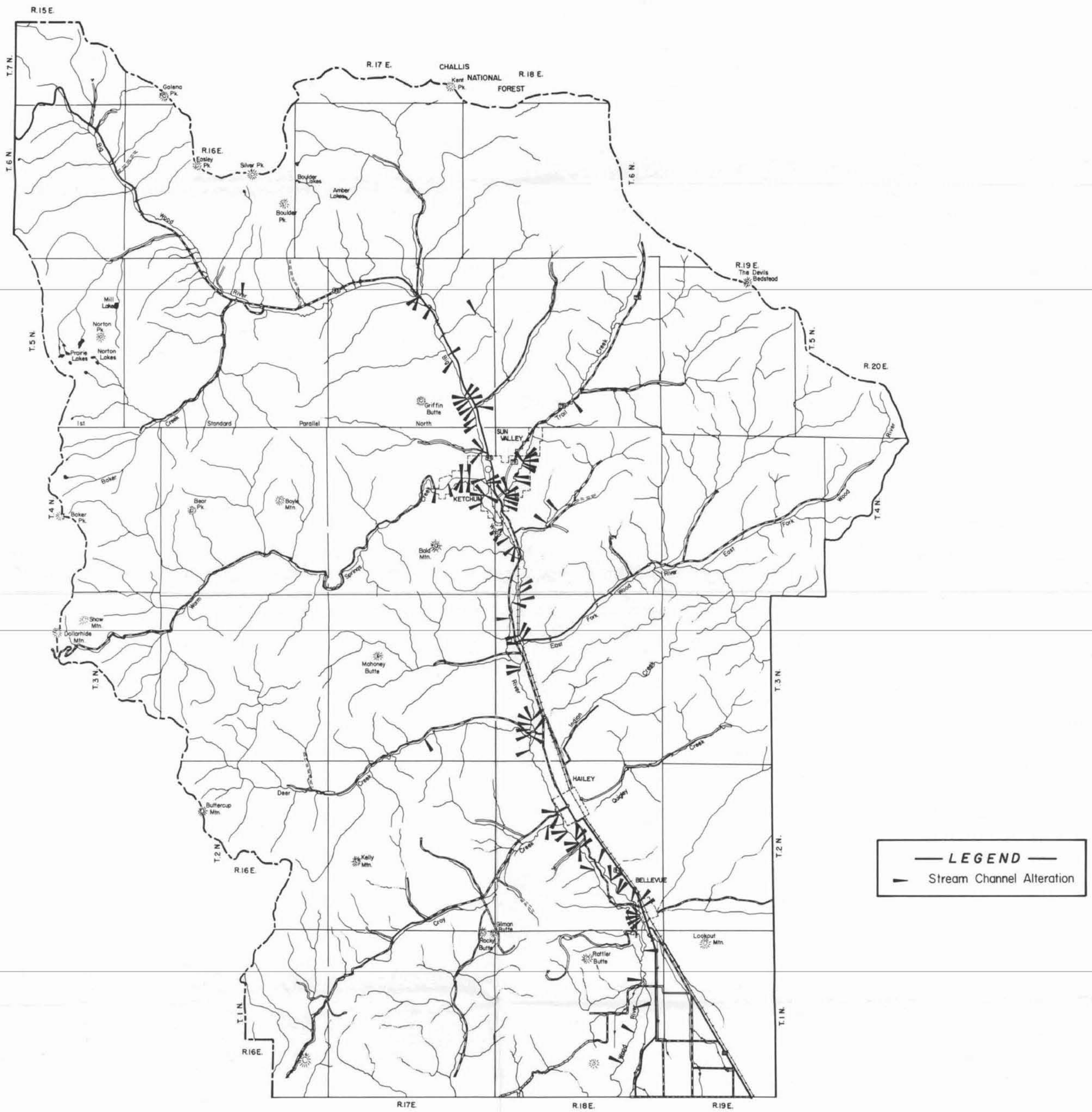

FIGURE 20.--Stream Channel Alterations on the Big Wood River and Tributaries in the Sun Valley-Ketchum Area According to Permits Filed with IDWR Since July 1, 1971