WATER QUALITY STATUS REPORT

UPPER SNAKE RIVER, MAIN STEM

(Lake Walcott to Idaho-Wyoming Border)

REPORT NO. WQ-29

September, 1977

Idaho Department of Health and Welfare
Division of Environment
Pocatello, Idaho 83201

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Study Conducted By:

Jim Perry
Mike McSorley
Bob Campbell

Report Prepared By:

Jim Perry

Idaho Department of Health and Welfare
Division of Environment
Statehouse
Boise, Idaho 83720

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ABSTRACT

Samples were collected bi-weekly at 17 water quality stations. The area extended from Heise and Rexburg to the Raft River, a total distance of 273 river kilometers (170 miles). Two point sources (Idaho Falls and Blackfoot STP) and two tributaries (the Blackfoot and Raft Rivers) were sampled.

Point sources and tributaries to this section of the Upper Snake River have insignificant effects on annual loadings. Percentage increases for these four sources, for six parameters, ranged from 0.01% to 7.54%. However, non-point sources are adversely influencing water quality. Percentage increases for selected non-point source areas range from as high as 225%.

Specific non-point source problem areas and pollutants of concern are as follows:

1. Heise and Rexburg to Menan: Total and Suspended Solids.
2. Idaho Falls to below Idaho Falls: Ortho-phosphate Phosphorus and Nitrate Nitrogen.
3. Above Blackfoot to Tilden Bridge: Suspended Solids.
4. Tilden Bridge to Below American Falls Dam: Total Solids, Ortho-phosphate Phosphorus, and Nitrate Nitrogen.
5. American Falls Dam to Massacre Rocks: Total Solids, Suspended Solids, Ortho-phosphate Phosphorus, and Nitrate Nitrogen.

INTRODUCTION

The "Upper Snake River" includes all the Snake River drainage above Minidoka Dam. The dam is at River Kilometer 960 (R.M. 675), and the drainage above that point represents over 400 million square kilometers (15,700 mi^2). The basin is heavily forested along the edges and in the headwaters. The valleys are primarily cleared farmland. Major crops in the river valleys are potatoes, sugar beets, alfalfa hay, and small grains. Mean annual precipitation ranges from 76 cm (30 in.) in the mountains to 33 cm (13 in.) in the lowlands (Minshall and Andrews, 1973). Temperature extremes in the cities of the basin range from 42° C (108° F) to -40° C (-40° F). Land use patterns in the Portneuf River Basin (a tributary to the Snake) are as follows (from Merrell and Onstott, 1965):

Range	- 61%	Timber	- 2.5%
Cropland	- 33%	Meadow Hayland	- 1.0%

Land use is similar in the rest of the Snake River Basin, with perhaps more timber and less range.

Water quality of the Upper Snake River has been investigated by several agencies in recent years. The U.S. EPA conducted an intensive survey of the Henry's Fork Basin in 1973. The U.S. Geological Survey completed a two-year study on the Henry's Fork in 1977. American Falls, Island Park Reservoir, and Palisades Reservoir were part of the National Eutrophication Survey, and were sampled in 1976. American Falls Reservoir was sampled in 1968-69 in an eutrophication investigation (Bushnell, 1968). More recently, American Falls Reservoir was investigated to determine the pollutant levels of pesticides and heavy metals (Johnson et al, 1977). Several state and federal agencies have conducted water quality studies on tributaries of the Upper Snake, and much sporadic water quality data has been collected on the main stem of the Upper Snake since 1967.

However, no previous studies have attempted to investigate water quality of the entire main stem of the river over an entire year. This study was designed to meet that need.

METHODS AND MATERIALS

Seventeen water quality stations were established (Table 1, Figure 1). These included two effluents and two tributaries. The stations were sampled bi-weekly for one year. All samples were grab samples taken from mid-stream at mid-depth. Two chemical samples were taken at each station. One was preserved with 2 ml of concentrated sulfuric acid per liter, the other was stored at 4° C until analysis. Samples for coliform bacteria were taken separately and stored at 4° C. Samples for heavy metals were preserved with 2 ml of concentrated nitric acid per liter. All samples were analyzed by the Idaho Bureau of Laboratories using standard methods. Dissolved oxygen, pH, and temperature were analyzed in the field.

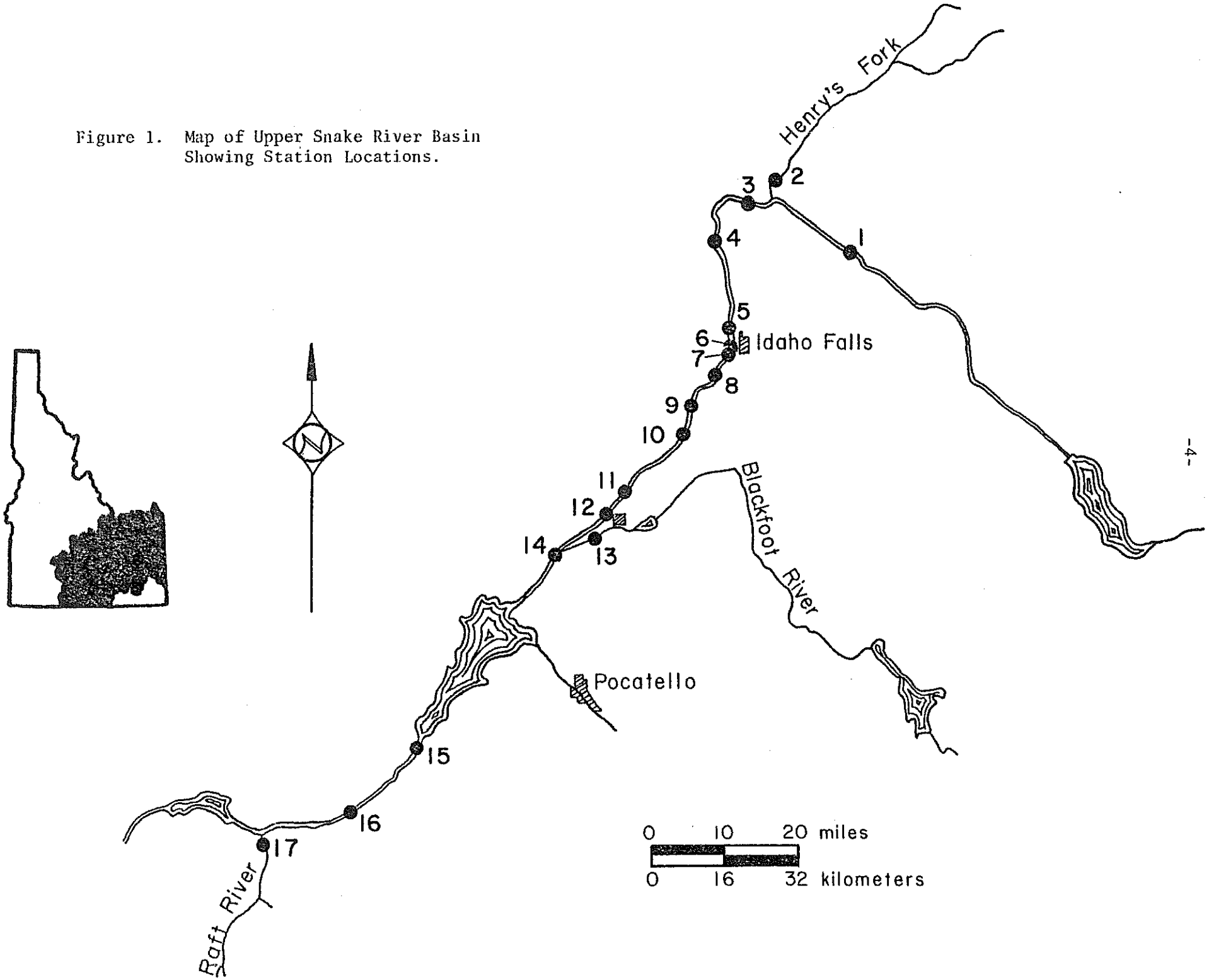
The following 27 parameters were monitored during this study:

Temperature
Turbidity
Conductivity
Dissolved Oxygen
pH
Total Alkalinity
Total Residue
Non-filterable Residue
Settleable Residue
Total Kjeldahl Nitrogen
Total Inorganic Phosphate
Ortho-phosphate
Total Phosphorus
Total Coliform Bacteria
Total Hardness
Calcium
Magnesium
Sodium
Potassium
Chloride
Sulphate
Fluoride
Manganese
Ammonia
Nitrate
Iron
Fecal Coliform Bacteria

TABLE 1. Station Locations

Station No.	Location	River Kilometer	River Mile
1	Snake River at Heise	1360	850.1
2	Henry's Fork of the Snake River near Rexburg (enters Snake River at River Kilometer 1332, R.M. 832.4).	(15)	(9.4)
3	Snake River at Menan	1328	829.8
4	Snake River at Roberts	1305	815.3
5	Snake River above Idaho Falls	1281	800.5
6	Snake River at Idaho Falls	1273	795.9
7	Effluent of Idaho Falls Sewage Treatment Plant	(1269)	(793)
8	Snake River below Idaho Falls	1262	788.5
9	Snake River at Shelley	1252	782.2
10	Snake River at Firth	1243	776.8
11	Snake River above Blackfoot	1225	765.6
12	Effluent of Blackfoot Sewage Treatment Plant	(1216)	(760)
13	Blackfoot River near Blackfoot (enters Snake River at River Kilometer 1201, R.M. 750.6)	(12.8)	(8.0)
14	Snake River below Blackfoot	1200	750.3
15	Snake River below American Falls Reservoir	1143	714.6
16	Snake River at Massacre Rocks	1120	700
17	Raft River near mouth (enters Snake River at River Kilometer 1102, R.M. 688.7)	(2.4)	(1.5)

Figure 1. Map of Upper Snake River Basin Showing Station Locations.



RESULTS

The 1975 mean annual hydrograph for the Upper Snake River is presented in Figure 2. The discharge is closely controlled by irrigation diversions and tributaries seem to contribute insignificant quantities to this portion of the river. The majority of the water in the study area comes from the watershed above Heise and above Rexburg.

Annual mean and extreme loadings for six parameters have been calculated for the study period (Table 2). Only mean loadings were calculated for effluents, tributaries, and all stations for non-filterable residue. Loadings are presented graphically in Figures 3 through 8.

Total solids vary so greatly over the year and loadings are so large that mean and extreme values are best presented logarithmically (Figures 4 and 5). These two figures show that the Snake River at Heise is very high in dissolved solids and that substantial suspended solids loadings enter the river above Shelley and below Blackfoot. They also show that although the Blackfoot River carries a high suspended sediment load, none of the tributaries or point sources effect major changes in the Snake River; i.e., changes are related to non-point source influences.

Phosphorus loadings are quite variable during the year, but do not vary much along the river (Figures 6 and 7). Nitrogen loadings are more variable. Nitrate nitrogen (Figure 8) increases gradually downstream with two major exceptions. Those exceptions are notably low nitrate values at Idaho Falls and from Shelley downstream past Blackfoot. Total Kjeldahl Nitrogen, however, is higher in the upper portions of the river (Menan to Idaho Falls) and below the American Falls Dam (Figure 9). Tributary and effluent contributions are again insignificant.

Many of the distributions just described follow the mean annual hydrograph. Therefore, loading changes may be a fluke of the calculation and not a reflection of a non-point source influence.

Table 2. Mean annual loadings in the Upper Snake River. Means are from 26 samples, collected bi-weekly. All values are in thousands of pounds per day, unless otherwise noted.

Station	Parameter											
	Total Solids (in millions of pounds per day)		Non-filterable Residue		Ortho-phosphate (as P)		Total Phosphorus (as P)		Nitrate Nitrogen (as N)		Total Kjeldahl Nitrogen	
	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range
Heise	11.46	4.7-29.4	137.6		2.0	0.1-36.4	5.0	1.0-37.8	4.7	0.5-11.4	69.7	22.2-221.4
Rexburg	0.26	0.1-6.1	357.9		0.9	0.03-8.8	1.9	1.6-14.0	2.3	1.6-3.7	27.9	8.6-94.4
Menan	14.47	6.1-28.2	1613.8		2.9	0.1-13.2	6.3	0.8-19.0	6.7	3.2-16.3	106.9	15.3-174.2
Roberts	13.80	6.4-32.6	1779.0		2.0	1.3-13.2	5.0	1.4-25.4	6.7	0.9-21.7	102.7	36.8-216.2
above Idaho Falls	13.85	6.5-36.3	2185.3		2.0	0.1-16.2	8.0	2.1-32.3	7.7	9.4-21.7	102.2	24.6-254.1
at Idaho Falls	13.67	5.8-29.7	2086.7		1.6	0.1-9.4	6.2	1.2-40.4	5.8	0.09-19.0	100.8	83.0-265.7
Effluent of Idaho Falls STP	0.027		0.8		0.1		0.1		0.2		0.3	
below Idaho Falls	14.46	6.5-32.2	2083.3		2.6	0.2-16.9	8.2	4.0-37.0	8.4	0.7-24.4	94.4	27.6-207.2
Shelley	10.78	4.3-26.7	1897.5		1.5	0.08-22.5	3.8	0.3-126.5	5.1	0.05-19.8	74.8	16.5-320.2
Firth	12.92	4.7-28.5	1970.5		1.8	0.08-11.2	4.2	1.7-17.8	5.0	0.04-10.8	81.2	26.3-239.5
above Blackfoot	10.39	5.0-23.4	1752.2		1.7	0.08-19.7	4.5	0.5-34.5	4.8	0.04-16.2	78.7	31.4-252.5
Effluent of Blackfoot STP	0.004		0.2		0.03		0.03		0.02		0.08	
Blackfoot River	0.5		132.2		0.06		0.2		0.3		2.2	
below Blackfoot	10.22	2.3-51.0	2550.9		1.4	0.07-14.9	4.4	0.3-24.4	4.6	0.03-26.2	62.9	16.1-219.9
below American Falls	14.67	5.6-32.6	2098.4		2.2	0.06-9.7	6.8	0.7-20.3	8.3	0.1-13.2	98.0	30.1-281.9
Massacre Rocks	17.53	6.3-36.2	2701.4		2.5	0.06-17.6	7.5	0.6-31.3	10.3	0.1-14.1	93.0	38.1-307.2
Raft River	0.09		19.0		0.01		0.05		0.1		0.2	

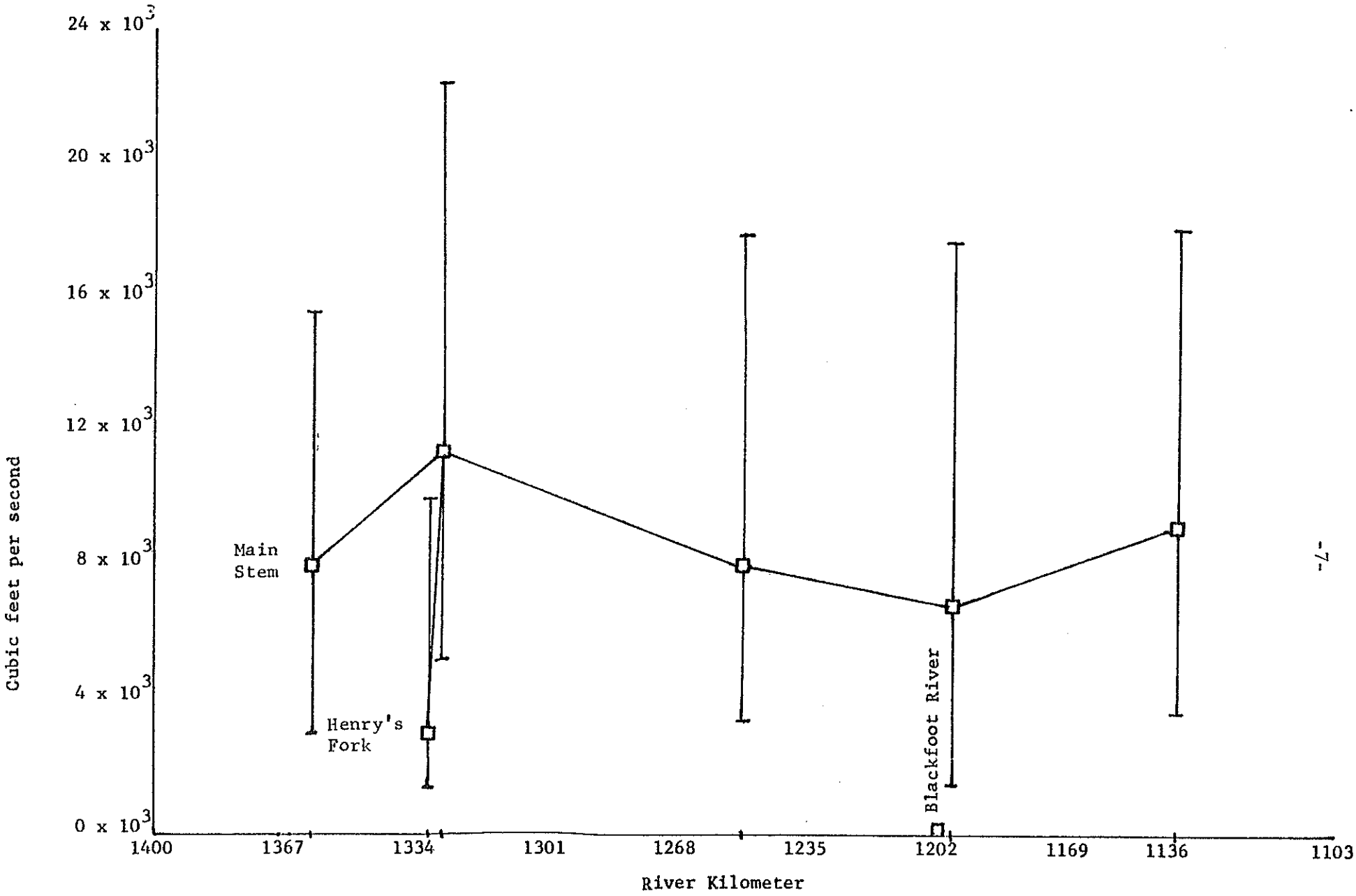


Figure 2. Mean annual discharge, water year 1975, upper Snake River. Vertical Bars are extremes.

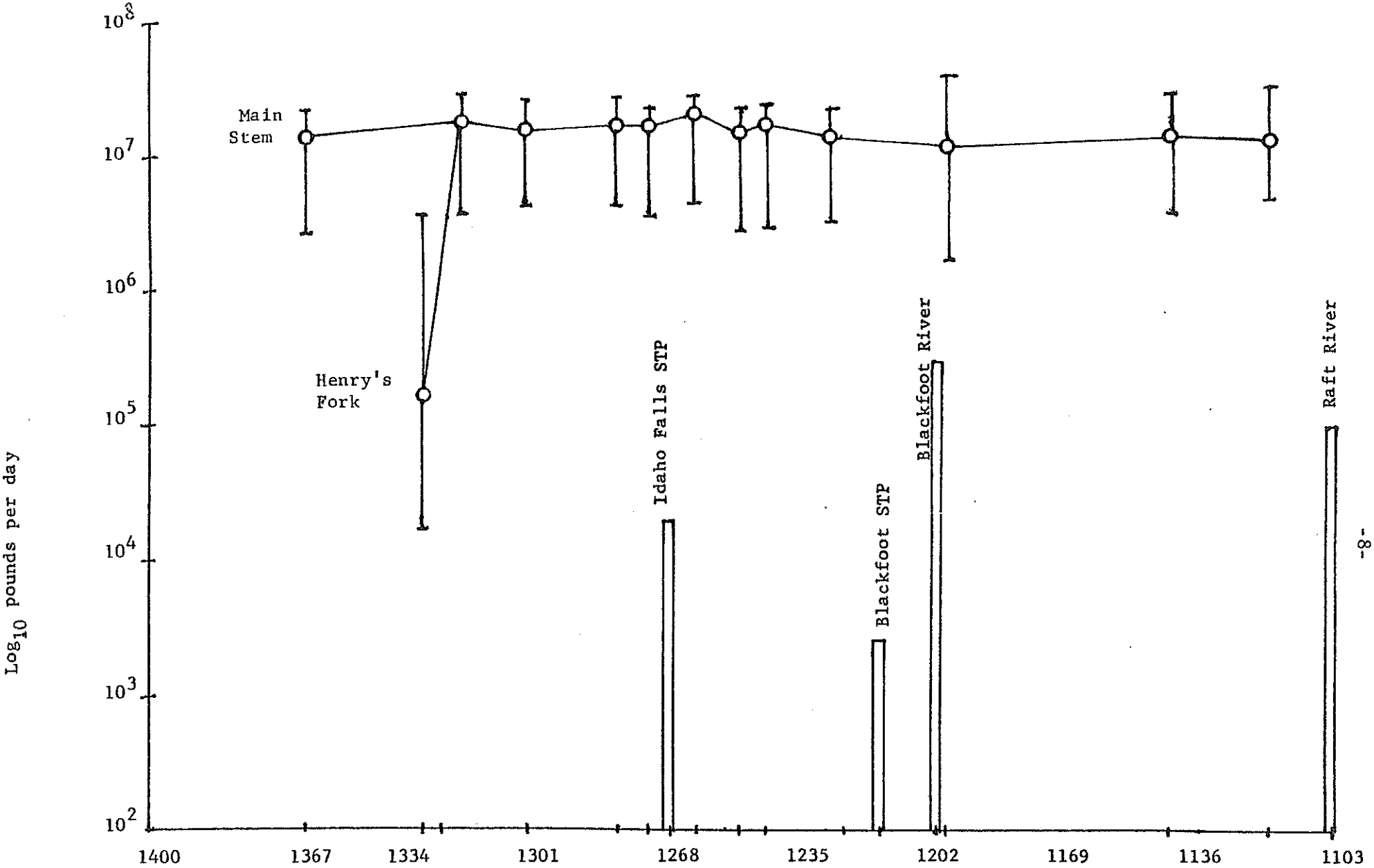


Figure 3. Log_{10} Total Solids loadings in the Upper Snake River. Mean data for 1975.

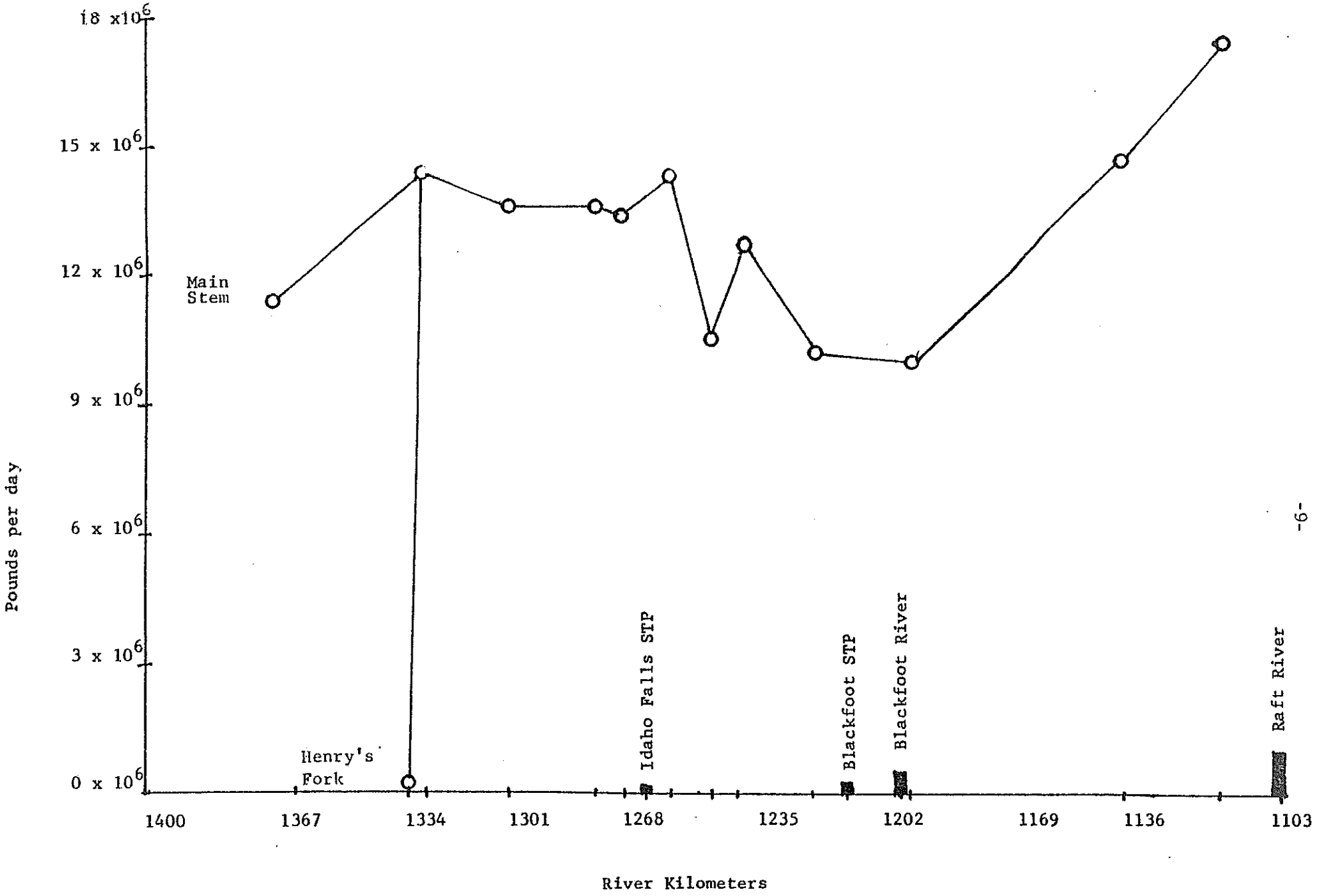


Figure 4. Total Solids loadings in the Upper Snake River, 1975 mean.

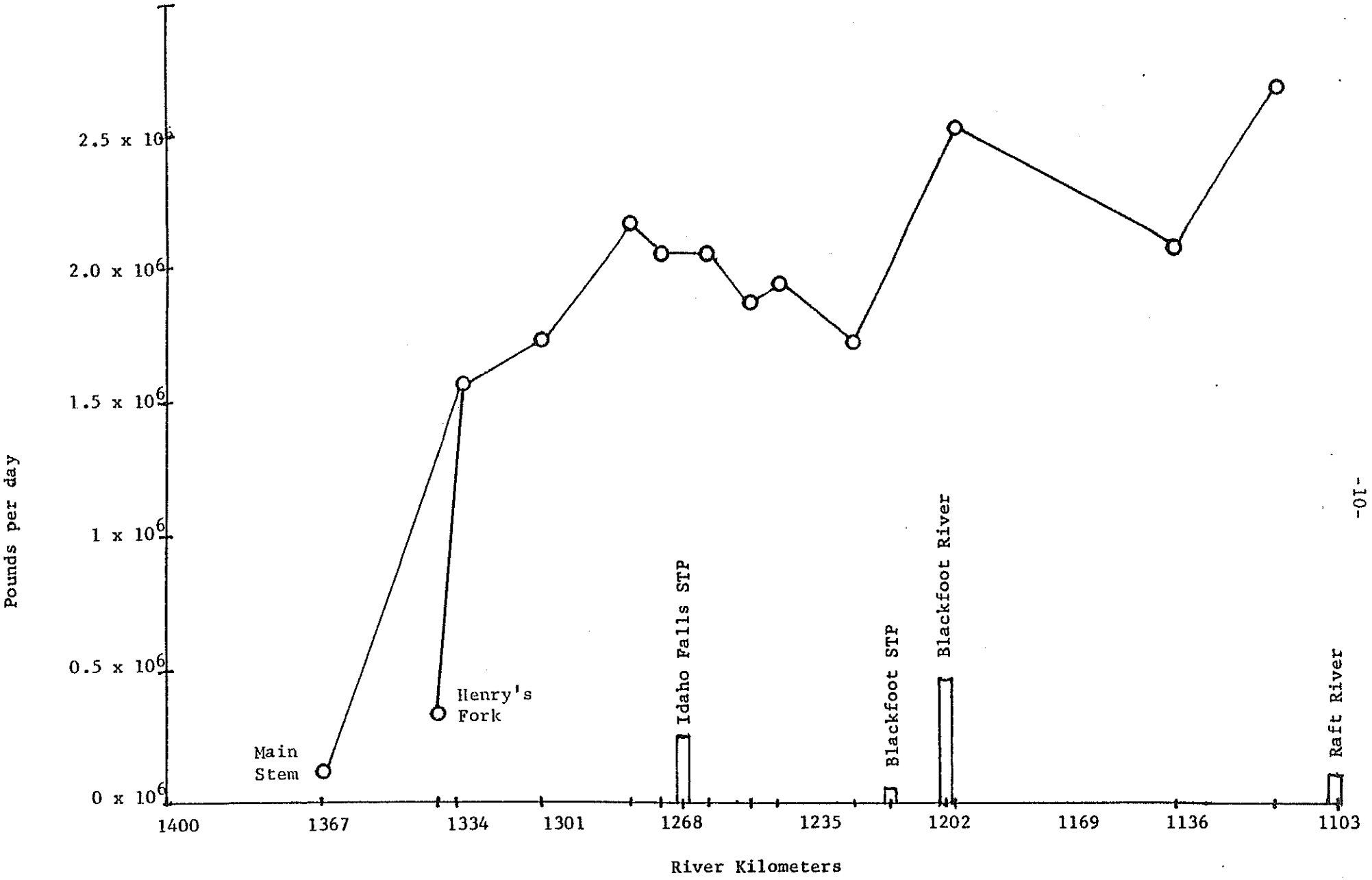


Figure 5. Mean annual non-filterable residue loadings in the Upper Snake River, 1975.

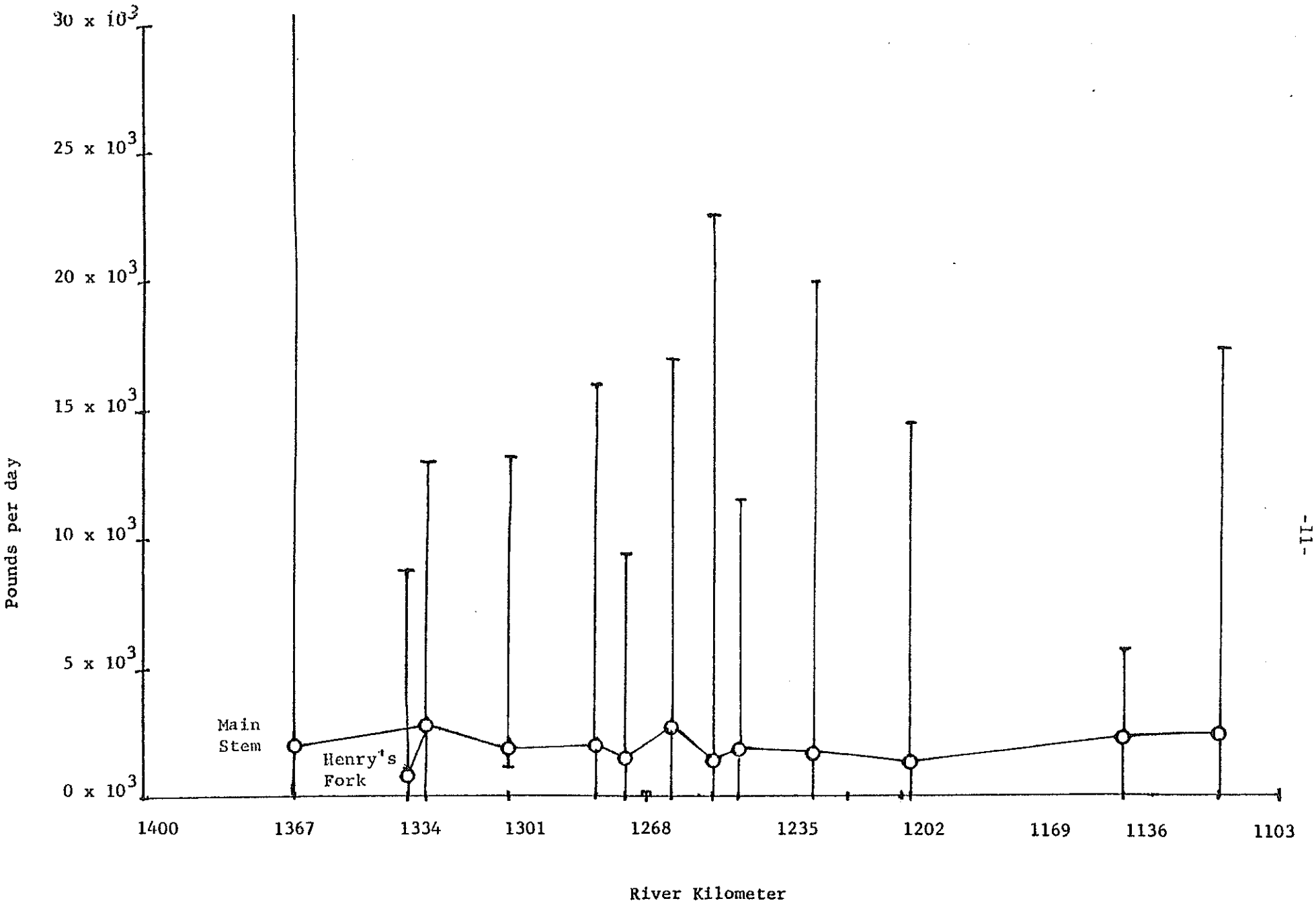


Figure 6. Mean annual ortho-phosphate loading (as P). Upper Snake River. Vertical bars are ranges.

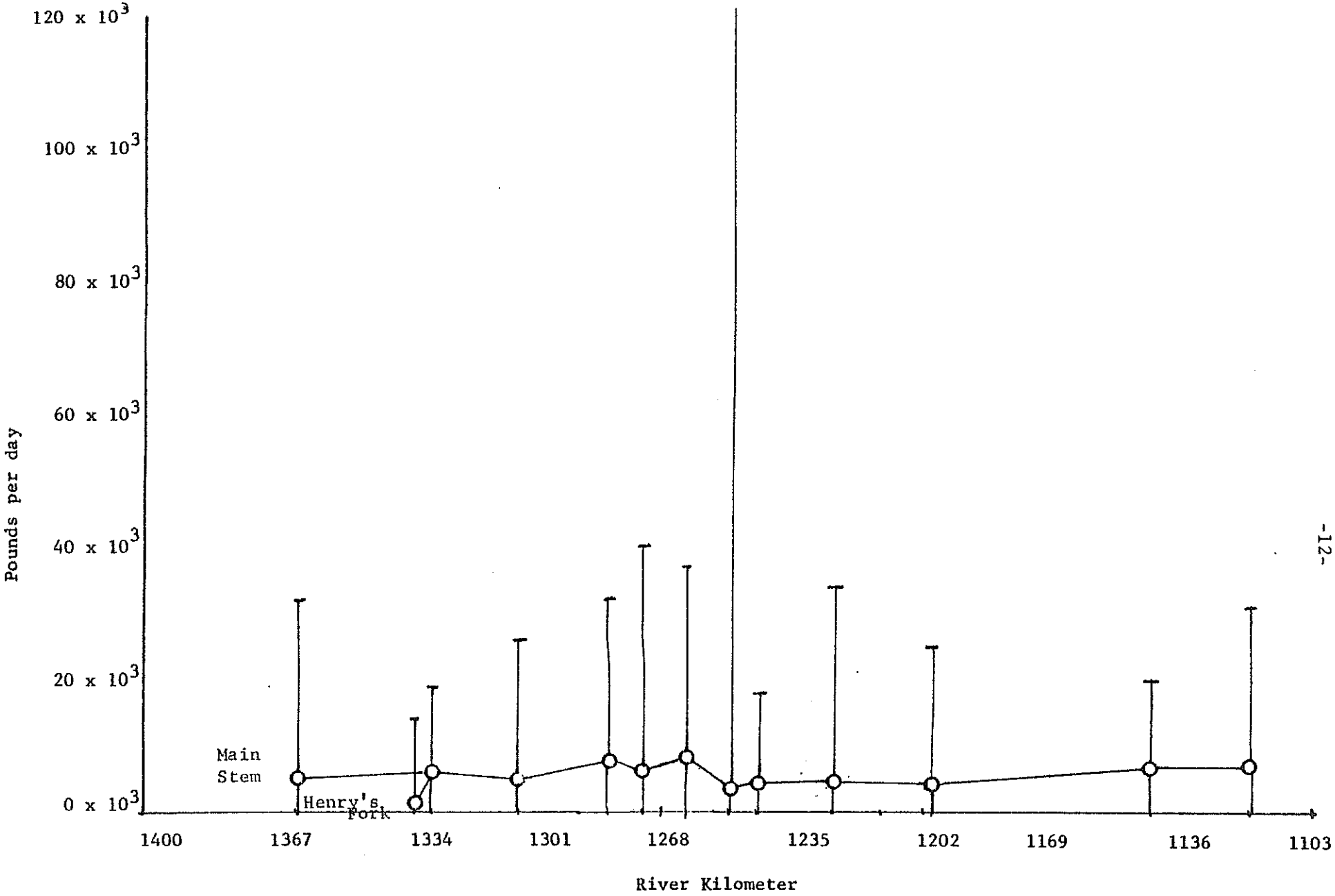


Figure 7. Mean annual total phosphorus loading in the Upper Snake River. Vertical bars are ranges.

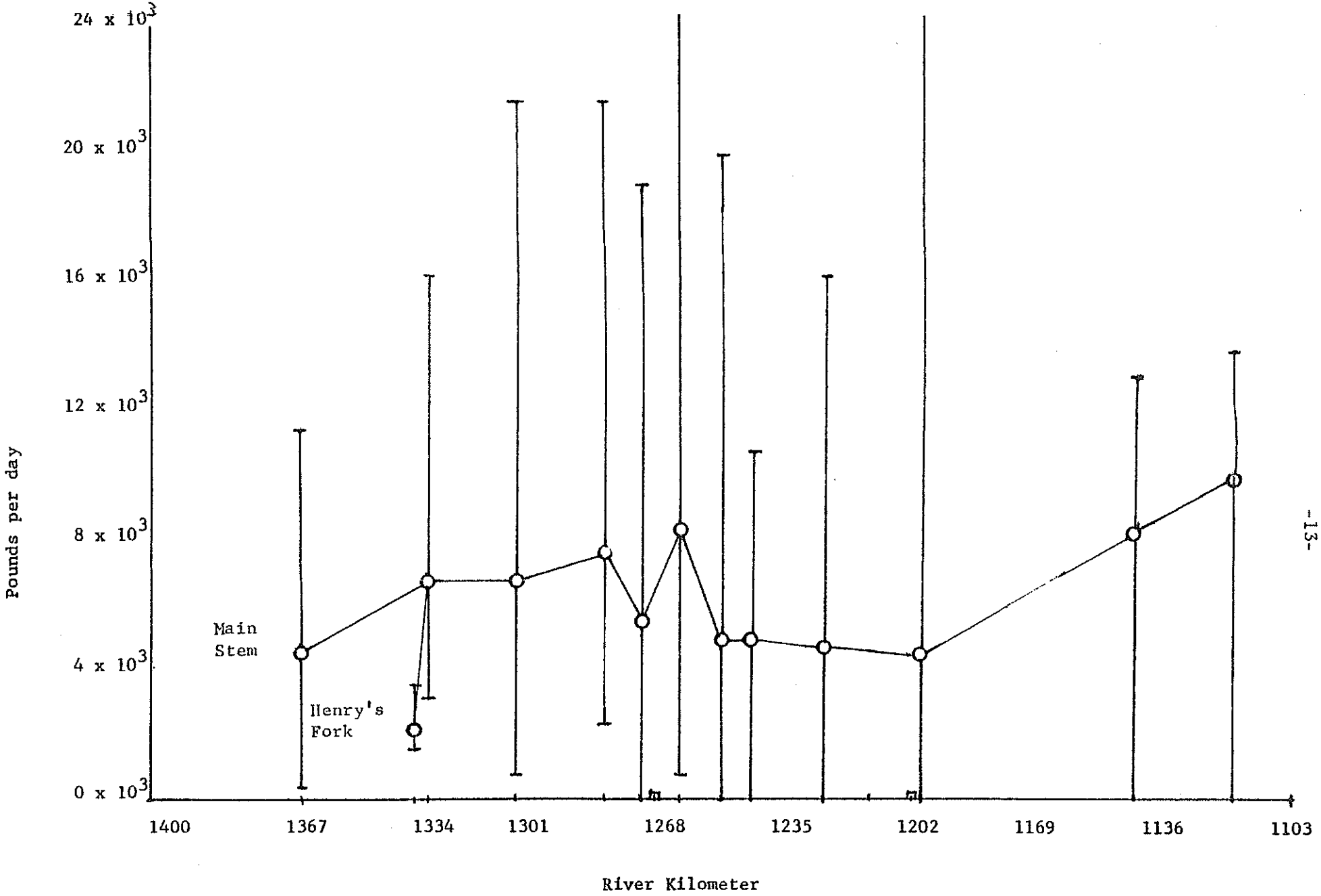


Figure 8. Mean annual Nitrate Nitrogen (as N) loadings in the Upper Snake River. Vertical bars are ranges.

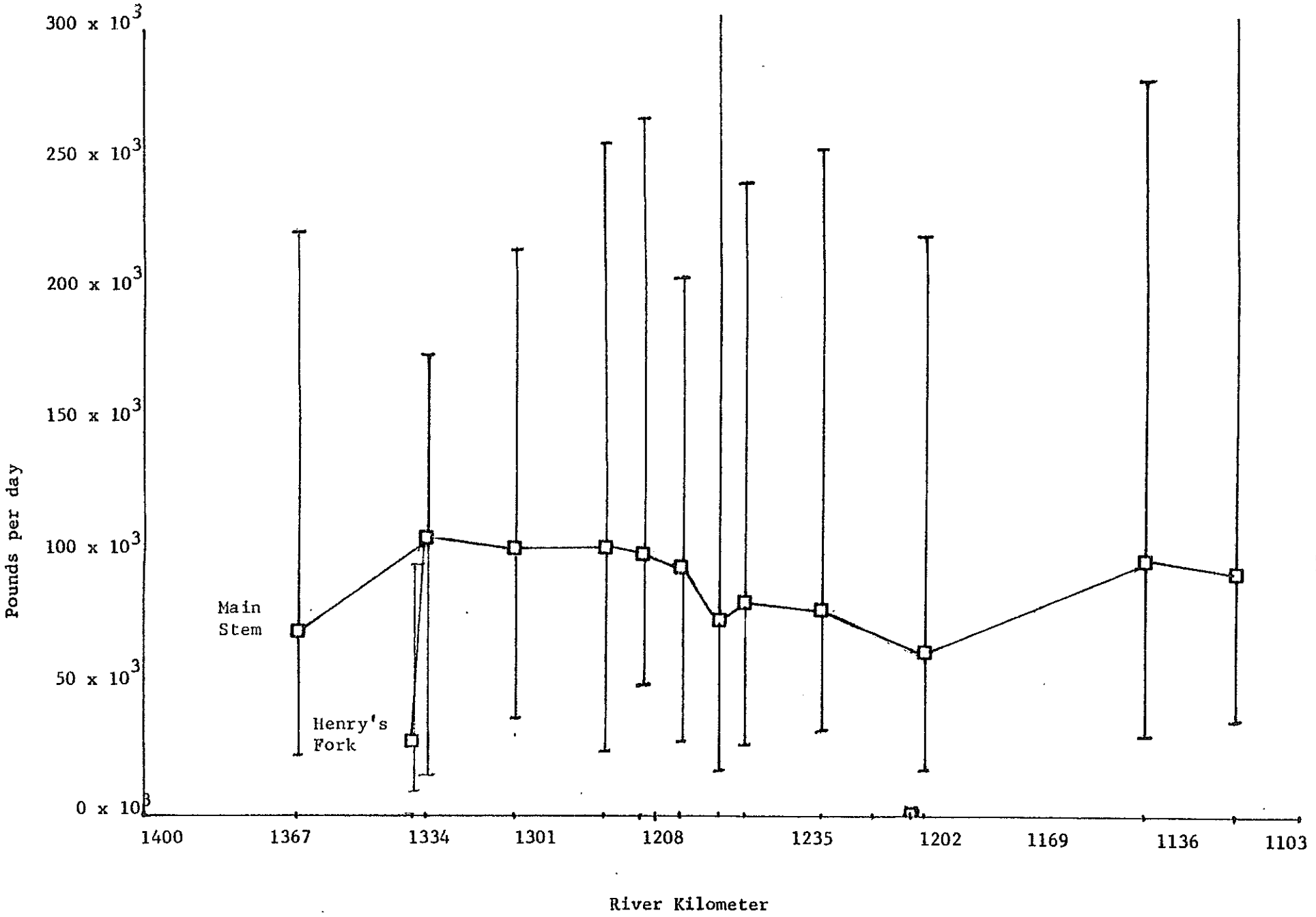


Figure 9. Mean annual Total Kjeldahl Nitrogen loadings in the Upper Snake River. Vertical bars are ranges.

DISCUSSION

Two point sources were sampled during this study. Neither of these has a demonstrable impact upon the water quality of the Snake River, based on this study. Similarly, the tributaries sampled here carry high concentrations of sediment and nutrients. However, flow is so small compared to the Snake River that no loading impacts are seen. It should be noted that the sample stations were located 1-7 kilometers below the sources. Impacts may not be detectable over those distances.

Since no impacts were detected, no "percentage increase" calculations have been made. Similarly no water quality related effluent limitations should be developed.

Non-point sources (NPS) do have a demonstrable effect on the Upper Snake River. Three areas of the Upper Snake River are adversely affected by non-point sources. The South Fork of the Snake River between Heise and Menan is one of these areas. The river at Heise averages 138 pounds per day suspended solids. Only 358 pounds are contributed by the Henry's Fork (as measured at Rexburg). Therefore, the Menan area, near the junction of the two forks, was generating 1108 pounds of suspended solids per day, annual average. That rate of increase is contrived past Roberts to the area above Idaho Falls. The riverine area between Heise and Rexburg and Idaho Falls was generating 29 pounds of suspended solids per river mile per day (40 kilograms per kilometer per day).

The second area affected is near Blackfoot. This 15.5 mile (25 kilometer) stretch of river was generating 799 pounds of non-filterable residue per day, or 51 pounds per mile per day (84 kilograms per kilometer per day). The Blackfoot Sewage Treatment Plant contributes 0.02% of this load, and the Blackfoot River contributes 17% of the loading. Non-filterable residue is decreased dramatically as the Snake River passes through American Falls Reservoir. Then the 23 kilometer stretch of river above Massacre Rocks adds 603 pounds of suspended solids per day, or 42 pounds per mile per day (57 kilograms per kilometer per day).

Phosphorus loadings are most affected by the area below Idaho Falls. That 11 kilometer (17.5 mile) stretch of river adds 1,000 pounds of orthophosphate phosphorus per day (2200 kilograms per day). Only 10% of that loading is attributable to the Idaho Falls Sewage Treatment Plant. That same section of river is markedly influenced by Nitrate Nitrogen additions. Nitrage loadings are increased 210%, or 2600 pounds per day (5720 kilograms per day). Only 8% of that increase is due to the Idaho Falls Sewage Treatment Plant. The most striking increases in Nitrate Nitrogen loadings are in the lower section of the study area. This 80 kilometers (50 miles) of river generates 3700 pounds of Nitrate Nitrogen per day (8140 kilograms per day).

It is apparent from the data that point sources and tributaries to the Upper Snake River contribute less than 10% of the annual loadings. Those annual loadings have been tabulated, and are available for reference (Table 3).

Table 3. Point Source and Tributary Laodings to the Upper Snake River. Data are in tons per year, based on 1975 samples.

Source	Parameter (tons per year)					
	Total Solids	Non-filterable Residue	Nitrate Nitrogen	Total Kjeldahl Nitrogen	Ortho-Phosphate (as P)	Total Phosphorus (as P)
Idaho Falls Sewage Treatment Plant	4,930	146	36	55	18	18
Blackfoot STP	730	36	4	15	6	6
Blackfoot River	83,712	24,126	55	402	256	55
Raft River	16,425	3,468	18	36	2	9

CONCLUSIONS

A. Point Sources

1. Two point sources and two tributaries to the Upper Snake River were sampled in this study. They do not adversely affect water quality of the Snake River at the stations sampled.

2. The yearly contributions (in pounds per day) and the percentage increase attributable to each point source and each tributary are presented in Table 4.

3. The point source discharges to the Snake River above Lake Walcott have little effect on the water quality of the river.

B. Non-point Sources

1. The Upper Snake River is adversely affected by non-point sources. The primary areas and parameters of concern are:

   a. Non-filterable Residue. Rexburg and Heise to Menan; above Blackfoot to Tilden Bridge; and American Falls Dam to Massacre Rocks. The former two are probably related to farming practices along the river. No explanation for the latter is apparent.

   b. Ortho-phosphate phosphorus. The area just below Idaho Falls shows a marked increase in phosphate loadings. Very little of this (6.25%) is due to the Idaho Falls STP. The remainder of the loading comes from irrigation return water.

   c. Nitrate Nitrogen. Rexburg and Heise to Menan; just below Idaho Falls; and the head of American Falls Reservoir to Massacre Rocks. The first two are primarily related to farming practices. Eutrophication, algal growth, and the Portneuf River all contribute to nutrient exports below American Falls Dam. No apparent cause is seen for the increase between the Dam and Massacre Rocks.

2. The specific pounds/day and percentage increases for the items discussed above (1, a-c) are presented in Table 5.

3. The most probable cause or derivation of the pollutants described is included in the discussion in Number 1.

Table 4. Yearly contribution and percentage increase attributable to each point source and each tributary sampled in this study. Percentages are calculated as percent of upstream loading.

Source	Parameter (in pounds per day)											
	Total Solids		Non-filterable Residue		Nitrate		Total Kjeldahl N		Ortho-Phosphate		Total Phosphrous	
	Loading	% increase	Loading	% increase	Loading	% increase	Loading	% increase	Loading	% increase	Loading	% increase
Idaho Falls STP	27,000	0.20%	800	0.04%	200	3.45%	300	0.30%	100	6.25%	100	1.61%
Blackfoot STP	4,000	0.04%	200	0.01%	20	0.42%	80	0.10%	30	1.76%	30	0.67%
Blackfoot River	500,000	4.81%	132,200	7.54%	300	6.25%	2,200	2.79%	60	3.53%	200	4.44%
Raft River	90,000	0.51%	19,000	0.70%	100	0.97%	200	0.22%	10	0.40%	50	0.67%

Table 5. Yearly contribution and percentage increase attributable to selected problem non-point source areas. Percentages are calculated as percent of upstream loadings.

Area	Parameter							
	Total Solids		Non-filterable Residue		Ortho-Phosphate Phosphorus (as P)		Nitrate Nitrogen (as N)	
	ppd inc.	%	ppd inc.	%	ppd	%	ppd	%
Heise and Rexburg to Menan	2,750,000	23.46%	1,118,300	225,69%	0	0	-300	-4.28%
Idaho Falls to below Idaho Falls	763,000	5.57%	-4,200	-0.20%	900	52.94%	2,400	40%
above Blackfoot to Tilden Bridge	-674,000	-6.19%	666,300	35.35%	-390	-21.78%	-520	-10.16%
Tilden Bridge to below American Falls Dam	4,450,000	43.54%	-452,500	-17.74%	800	57.14%	3,700	80.43%
American Falls Dam to Massacre Rocks	2,860,000	19.49%	603,000	28.74%	300	13.64%	2,000	24.10%

RECOMMENDATIONS

1. Since point sources have little effect on the water quality of the Snake River above Lake Walcott, the effluent limitations for these sources should be based on EPA effluent guidelines and/or the wastewater treatment requirements contained in the State of Idaho Water Quality Standards. The development of water quality related effluent limits are not justifiable based on the survey data.

2. For nonpoint sources, the Statewide 208 planning program is developing "Best Management Practices" to help control these sources. These management practices should be applied to land uses along the Snake River and its tributaries. Of priority importance are the following river reaches:

   --Heise to Menan
   --The area directly below Idaho Falls
   --From directly above Blackfoot to Tilden Bridge
   --From the head of American Falls Reservoir to Massacre Rocks

   In addition to the mainstem sections, the Henry's Fork, the lower Blackfoot River, and the Raft River are also high priority areas for application of management practices.

LITERATURE CITED

Merrell, J.E. & O.L. Onstott. 1965. Reconnaissance Report of Erosion and Sedimentation in the Portneuf River Basin, Idaho. U.S. Dept. of Agriculture, Soil Conservation Service, Boise, Idaho.

Minshall, G. W. & D.A. Andrews. 1973. An Ecological Investigation of the Portneuf River, Idaho, a Semi-arid - Land Stream Subjected to Pollution. Freshwater Biology 3:1-30.

Location	Parameters
15. Main stem of the Snake River below American Falls Reservoir at river mile 713.9. USGS gaging station number 0765 is located on American Falls Reservoir. The Snake River drains 13,580 square miles to this point. Bannock Creek, draining 430 square miles, enters the American Falls Reservoir at river mile 727.0. The Portneuf River, draining 1400 square miles and including the 12 million gallon per day Pocatello sewage treatment plant, enters the reservoir at river mile 736.0. The Portneuf River is the subject of a separate intensive sruvey currently being conducted by this Department.	CA, B (BS, A)
16. Main stem of the Snake River at Massacre Rocks State Park. This station presents access problems and will necessitate a bank sample. If access is restricted during winter, the station may be discontinued.	CA, B
17. Raft River from the U.S. Interstate 15 W bridge at river mile 1.4. Raft River drains 1,300 square miles of important agricultural land.	CA, B (BS, A)
18. Main stem of the Snake River below Minidoka Dam at mile 675.0. USGS gaging station number 0810 is on Minidoka Reservoir and station number 0815 is on the river at mile 673.7. The Snake River Basin above Minidoka Dam represents 15,700 square miles.	CA, B (BS, A)