002-21

THE EFFECT OF HYDROELECTRIC DEVELOPMENTS ON THE FISHERY RESOURCES OF SNAKE RIVER

A FINAL REPORT ON PROJECT F-8-R

A FEDERAL AID TO FISH RESTORATION PROJECT

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INTRODUCTION

The Investigation

The purpose of this investigation was to determine the cause(s) of a reported decline in fishing success within certain areas of Snake River and to initiate a management program for the Snake River fishery based on findings.

Fishermen reported a decline in fishing success in the Hagerman Valley and Glenns Ferry areas of Snake River during 1949 and 1950. Since these reports coincided with the initial "peaking" operations of the Idaho Power Company's Lower Salmon Falls hydroelectric installation, the Idaho Wildlife Federation, at its annual meeting in the fall of 1950, requested the Idaho Department of Fish and Game to investigate the effects of hydroelectric installations on the Snake River fishery within the affected areas.

Preliminary investigation of the problem was completed during the early part of 1951 and intensive investigation was begun during November of 1952 and continued until June 30, 1955. Certainly, many of the slow acting but important effects of hydroelectric installations on the fishery would not be measurable during so short a period. In addition, the lack of factual information concerning the Snake River fishery prior to the construction of the several hydroelectric installations has been a definite handicap to the investigation.

The Study Area

Location

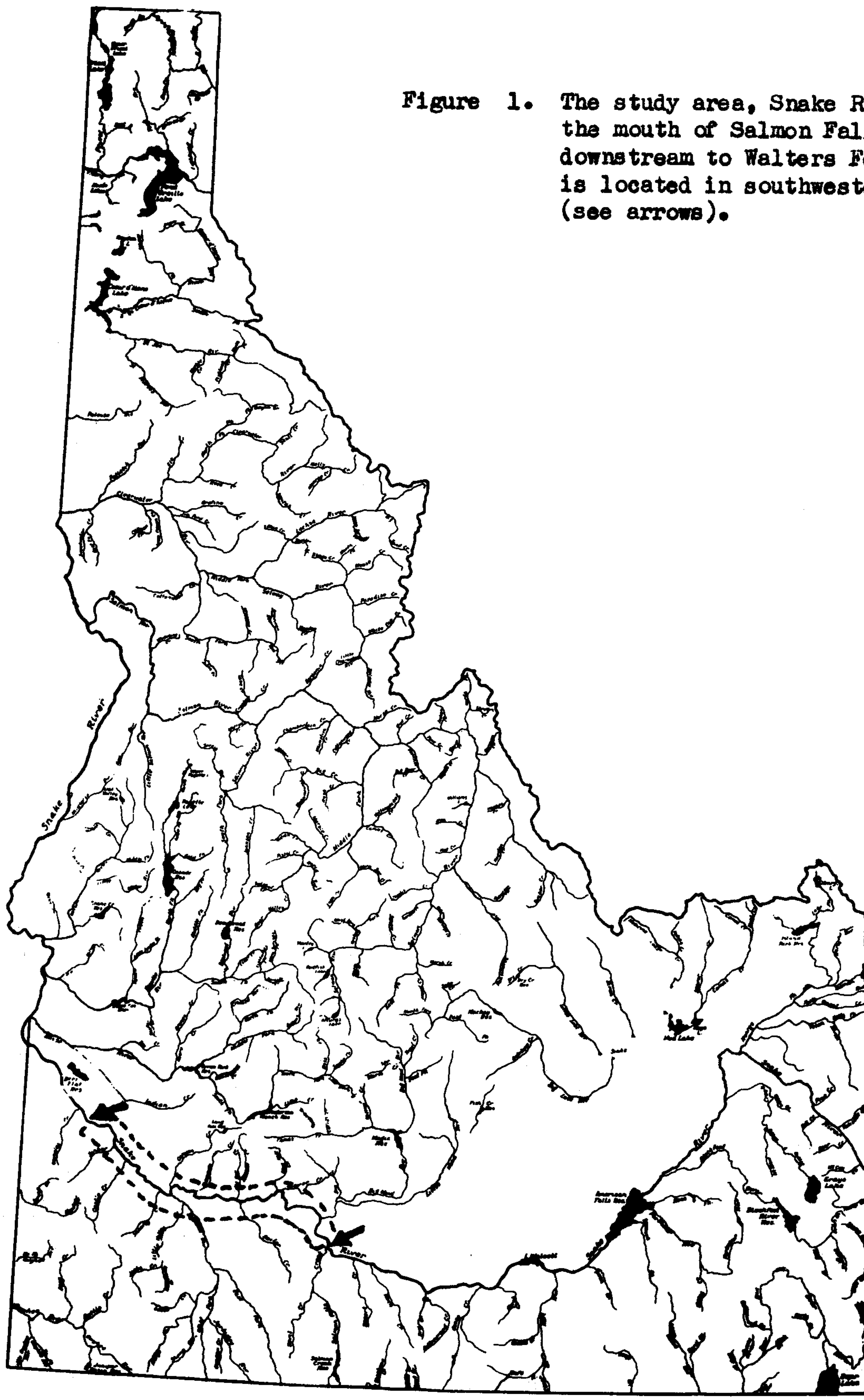
The study area, Snake River from the mouth of Salmon Falls Creek downstream approximately 140 miles to Walters Ferry bridge, is located in southwestern Idaho (Figure 1).

Geology

The study area is located in the west central portion of the Snake River Plains section of the Columbia Plateau physiographic province. Rhodenbaugh (1953) describes the Snake River plain as a broad and shallow "downwarp" 60 to 100 miles wide extending in a crescent shape from the Idaho-Wyoming line to Weiser, a distance of 400 miles. There is a fall in gradient of about 4000 feet from the eastern to the western edges of this area. According to Rhodenbaugh (1953), the Snake River Valley, prior to the Miocene Epoch, was a broad valley some 4000 feet less in elevation than at present. Through this broad valley the Snake River meandered slowly to the Columbia River. The Seven Devils Mountains were non-existent during this period. Since that time, repeated lava flows, both from Oregon and from within the Plains section, plus sediments from adjacent mountains, have filled the Snake River Valley to its present level. Tremendous amounts of sediments were deposited in ancient Lake Payette and Lake Idaho, both of which were formed when the Snake River was impounded by flows of lava in the Hells Canyon area.

At the present time, the Snake River flows across the broad Snake River plain, at times at valley level, but more often in a narrow gorge, 200 to 600 feet deep, which the river has eroded through the numerous layers of lava and sediments.

Figure 1. The study area, Snake River from the mouth of Salmon Falls Creek downstream to Walters Ferry Bridge, is located in southwestern Idaho (see arrows).



Water Supply

Milner dam is located approximately 35 miles up Snake River from the mouth of Salmon Falls Creek, which is the upstream boundary of the study area. During the irrigation season, a leak of less than 10 cubic feet per second of water flows in Snake River below Milner dam. Between Milner dam and the mouth of Salmon Falls Creek, the flow of water in Snake River increases to approximately 7000 cubic feet per second. From the mouth of Salmon Falls Creek to Bliss dam, the flow in Snake River increases to approximately 9000 cubic feet per second and between Bliss and Walters Ferry bridge to approximately 10,000 cubic feet per second.

Exceptionally large springs provide most (approximately 7000 cubic feet per second) of the gain in flow of water within the study area. Most of these large springs are located in coves along the north bank of Snake River in Hagerman Valley. According to Stearns et al (1938), the sources of water that issue from these springs are streams, including Snake River, that arise from the mountains to the north and flow southward to the Snake River plain where many of these streams sink. From the mouth of Henrys Fork to the Malad River, a distance of 250 miles, no stream flows across the surface of this plain to Snake River from the north. Stearns et al (1938) express the theory that the large springs owe their existence to the fact that the modern canyon intercepts a series of roughly parallel former canyons of the river that are now filled with especially permeable lava and hence serve as channels for ground water. The point of greatest interception occurs in the Hagerman Valley which is a north-south trench across the Snake River downwarp.

The sources of the balance of waters that enter Snake River within the study area are surface flows of small streams from the mountains that border the Snake River plain on the south and from mountains west of Malad River that border the plain to the north; small springs that flow into the river from the south bank; and, irrigation waste water from cultivated lands on both sides of the river.

During the spring run-off in June of the years under study, up to 4000 cubic feet per second of water spilled at Milner dam. During non-irrigation periods, water released from American Falls reservoir and Lake Walcott for hydroelectric power production at Minidoka dam are spilled at Milner. These flows are not constant, ranging from 200 to 11,000 and averaging approximately 2000 cubic feet per second. Increased storage facilities under construction in upstream areas will tend to decrease the seasonal fluctuation of river flows downstream from Milner dam.

Gradient

The elevation of Snake River near the mouth of Salmon Falls Creek is 2880 feet and near Walters Ferry bridge is 2260 feet. The length of Snake River within the study area is approximately 140 miles and the gradient, therefore, is approximately 4.5 feet per mile. The gradient, however, is not steady and is greatest in the narrow canyons where lava flows have obstructed the stream. In areas where the river flows through sedimentary formations, particularly upstream from lava flows, the river meanders and the gradient is low.

Hydroelectric Installations

Location

Five major hydroelectric installations that impound waters of the Snake River and three minor installations that produce power from springs adjacent to Snake River are located within the study area (Figure 2).

History of Construction

The major installations range in age from 3 to 54 years. Swan Falls dam, the oldest, was constructed in 1901 at the site of a natural falls (Plate 1). In 1918, the height of this dam was raised from 12 feet to 19 feet. At the present time, Swan Falls dam impounds Snake River for a distance of approximately five miles upstream. The impounded waters have a volume of about 6,900 acre feet and a surface area of 900 acres. A pool-type fishway is provided at the dam and is operative when the impounded waters are at a high level.

The construction of C. J. Strike dam just below the confluence of the Bruneau and Snake Rivers, approximately 35 river miles upstream from Swan Falls dam, was completed in 1952 (Plate 2). It is 115 feet high and impounds water approximately 20 miles up Snake River and 12 miles up Bruneau River. The reservoir has a volume of about 250,000 acre feet and a surface area of 7,500 acres. Since only a small run of anadromous fish, namely the steelhead rainbow trout, ascended Snake River to this installation, a fishway over the dam was not constructed.

Bliss dam, located approximately 62 miles upstream from C. J. Strike dam, was constructed in 1948 (Plate 3). It is 138 feet high and impounds Snake River for a distance of approximately five miles upstream. The impounded waters have a volume of approximately 11,100 acre feet and a surface area of approximately 254 acres. A fishway was not constructed at this installation.

Lower Salmon Falls dam, located approximately 14 miles upstream from Bliss dam, was first built in 1907 at the site of a natural falls. The impoundment depth was then 16 feet immediately above the dam and the impounded water extended one and one-half miles upstream. A new dam, constructed at the site in 1949, increased the impoundment depth to 38.6 feet immediately above the dam and affected water levels seven miles upstream to the tailrace of the lower plant at Upper Salmon Falls (Plate 4). The reservoir capacity is approximately 8,100 acre feet and has a surface area of approximately 840 acres. A pool-type fishway is provided at the Lower Salmon Falls installation and is used by several species of game and non-game fish during their spawning migrations. An efficient automatic gateway system at the upper end of the ladder regulates the amount of water that passes through the fishway and provides an adequate flow during normal fluctuations of the impoundment.

A diversion dam was constructed at Upper Salmon Falls in 1932 (Plate 5). In 1937, a power plant was installed at a site approximately one and one-half miles downstream from the diversion dam and seven miles upstream from the dam at Lower Salmon Falls (Plate 6). A canal and diversion dam (Cavanaugh) were constructed to carry water from this diversion dam to the power plant.

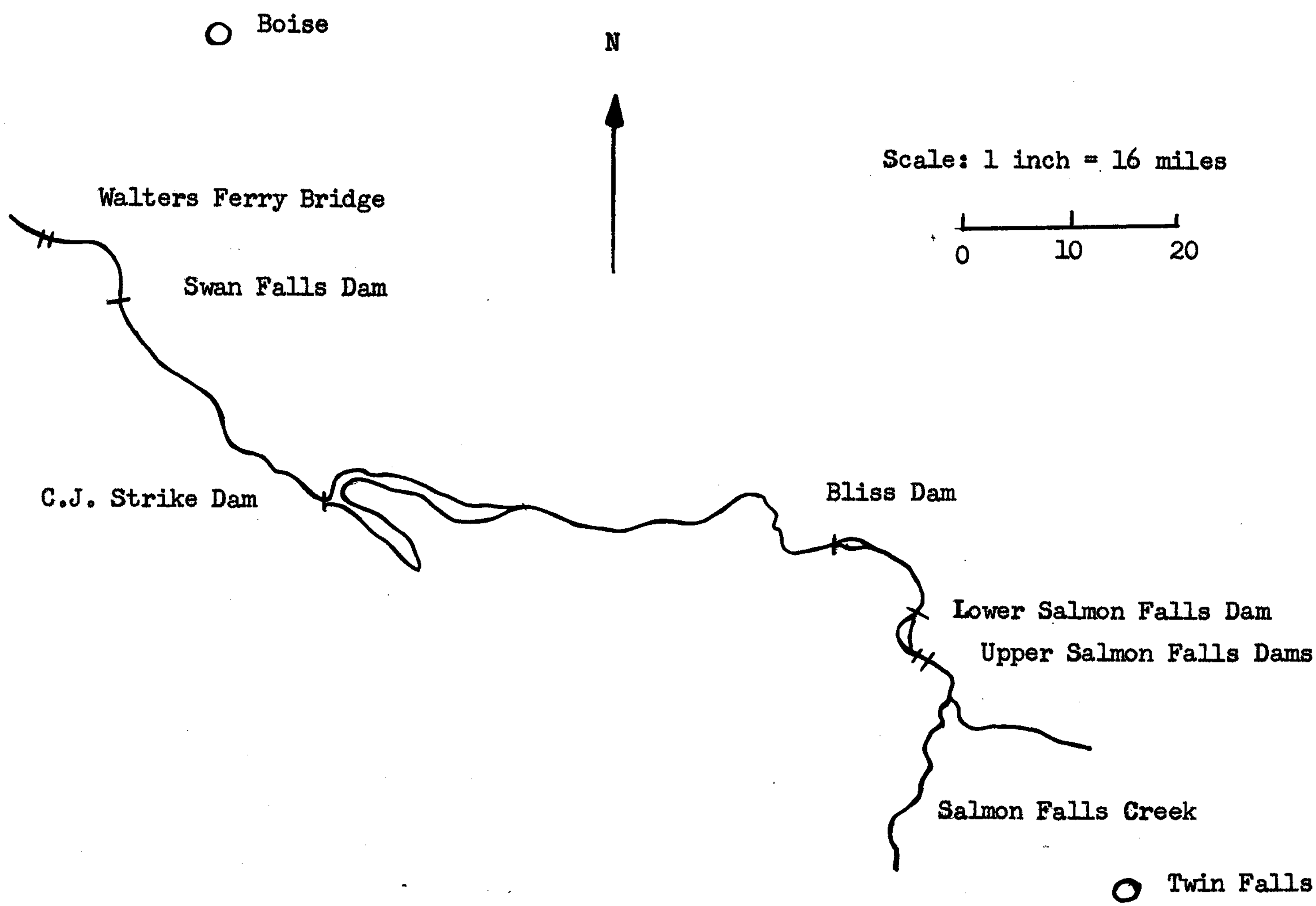


Figure 2. Location of major hydroelectric installations on Snake River within the study area.

Plate 1. Swan Falls Dam. (Idaho Power Company photograph)

Plate 2. C. J. Strike Dam. (Idaho Power Company photograph)

Plate 3. Bliss Dam. (Idaho Power Company photograph)

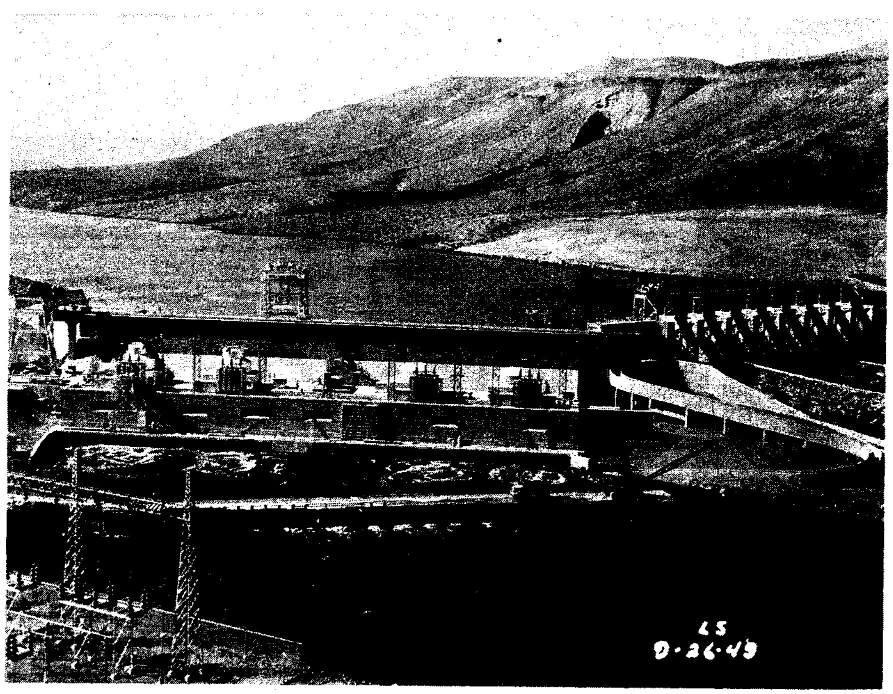


Plate 4. Lower Salmon Falls Dam, fishway at right center. (Idaho Power Company photograph)

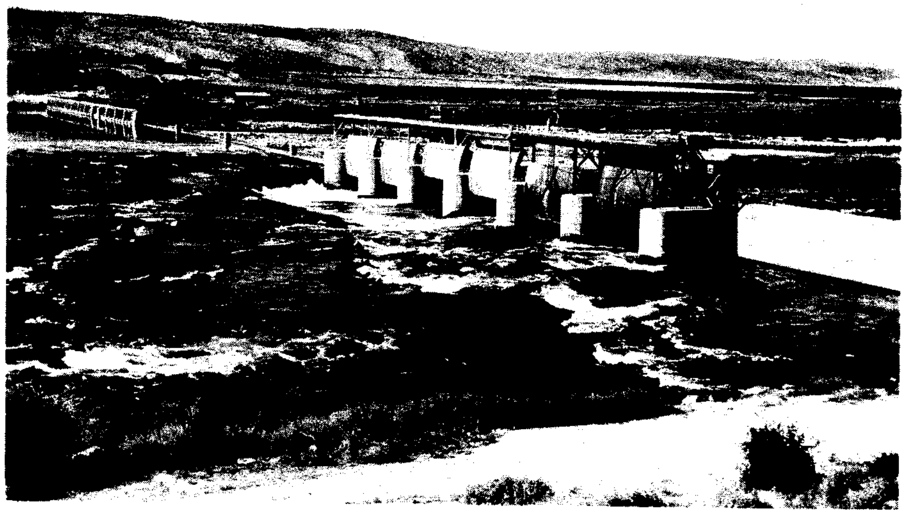


Plate 5. Diversion dam at Upper Salmon Falls.
(Idaho Power Company photograph)

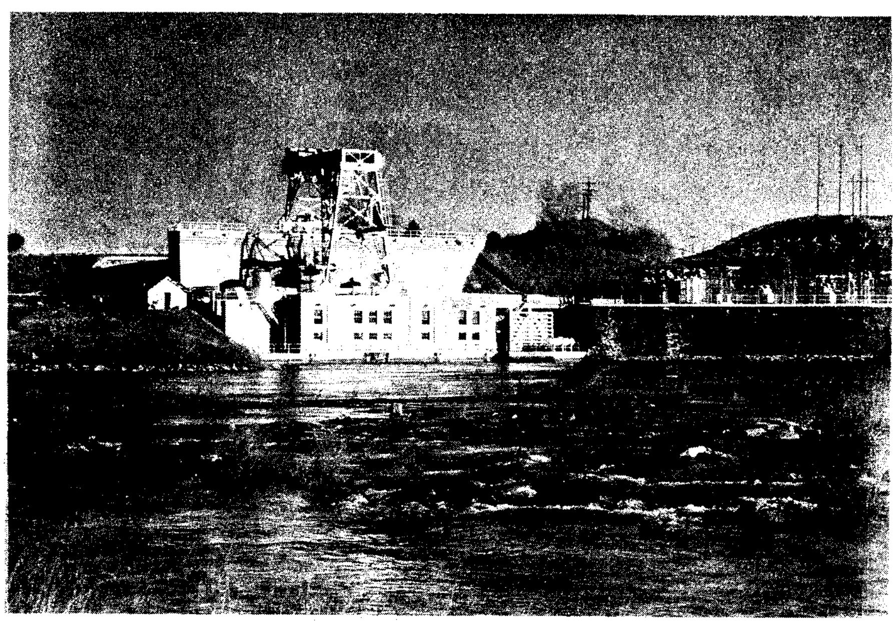


Plate 6. Lower power plant, Upper Salmon Falls.
(Idaho Power Company photograph)

In 1947, the upper diversion dam was modified and a canal constructed to carry water to a new power plant approximately one-half mile downstream from the diversion dam (Plates 7 and 8). The fishway constructed over Cavanaugh dam is effective, but the long fishway over the diversion dam is ineffective because of improper location.

Water levels of Snake River above the diversion dam at Upper Salmon Falls were raised slightly more than one foot in the six-mile section from the dam to the mouth of Salmon Falls Creek, upper boundary of the study area. The impounded waters above the diversion dam have a volume of approximately 1200 acre feet and a surface area of approximately 600 acres.

Operation

The location, type of water flow presented at the power site, demand for electrical power, and other uses of water below the power site are the important criteria that determine the operation of the hydroelectric installations within the study area.

The firm power operation is in effect at the upper and lower plants at Upper Salmon Falls and merely takes advantage of the water flow presented at the power site.

A power-peaking operation is practiced at the Lower Salmon Falls, Bliss and C. J. Strike installations. Water is impounded above these installations during periods of decreased consumption of electrical power (night) and the water thus stored is utilized (peaked) during the periods of increased consumption of electrical power (day). In other words, the flow of water presented at the power site is manipulated to produce electrical power on demand.

The third type of operation, classified as a re-regulation operation, is in use at the Swan Falls installation. The storage space above this installation is moderate, but it is used to level off the fluctuating flows released from the C. J. Strike plant downstream from Swan Falls.

Ecological Environments

Impoundment

An impoundment, for the purpose of this study, is a body of water whose volume and elevation are controlled by a dam and has the following characteristics:

1. The volume of water in an impoundment is not much greater than that of an average river section of equal length.

2. The area of an average cross-section of an impoundment is not much greater than that of an average river section of equal length.

3. As a result of Nos. 1 and 2 above, the exchange of water in an impoundment occurs at a relatively rapid rate.

The bodies of water above the Upper Salmon Falls, Lower Salmon Falls, Bliss and Swan Falls dams are classified as impoundments (Plates 1, 3, 4, 7, 9 and 10).

Plate 7. Diversion dam, canal and upper power plant at Upper Salmon Falls; fish ladder over diversion dam in left center. (Idaho Power Company photograph)

Plate 8. Cavanaugh Dam in foreground; upper power plant at Upper Salmon Falls in background.

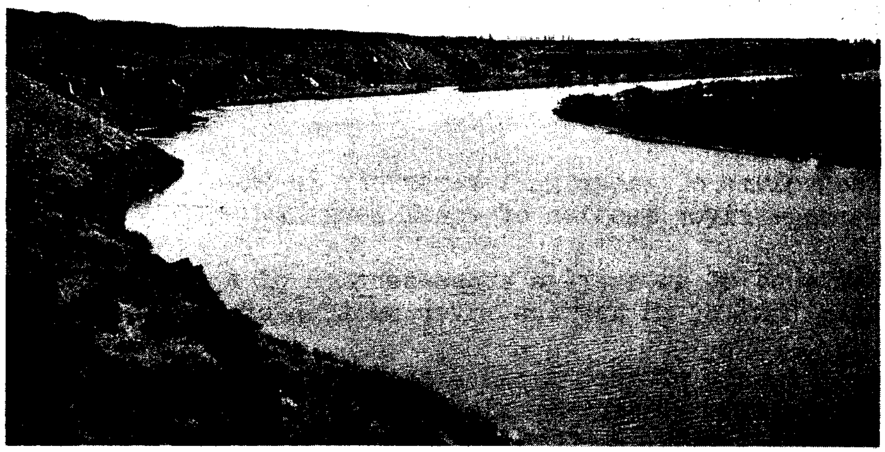


Plate 9. Upper Salmon Falls impoundment; note springs along north (left) bank.

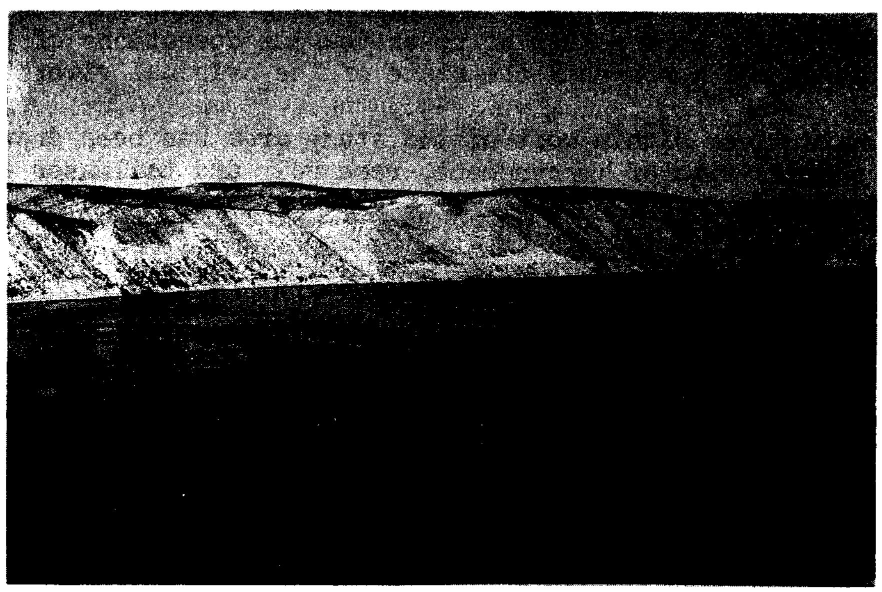


Plate 10. Upper end of Lower Salmon Falls impoundment; hills in background are composed of sediments deposited in ancient Payette Lake.

Reservoir

A reservoir, for the purpose of this study, is a body of water whose volume and elevation are controlled by a dam and has the following characteristics:

1. The volume of water in a reservoir is much greater than that of an average river section of equal length.

2. The area of an average cross-section of a reservoir is much greater than that of an average river section of equal length.

3. As a result of Nos. 1 and 2 above, the exchange of water in a reservoir occurs at a relatively slow rate.

Though the upper section of the Snake River arm of C. J. Strike reservoir approaches the impoundment type of environment, all waters stored above C. J. Strike dam will be considered as a reservoir (Plate 11). The Bruneau River arm of C. J. Strike reservoir approaches the stability of a lake environment.

Tailwater

A tailwater, for the purpose of this study, is a body of water that extends downstream from a hydroelectric installation to the headwaters of an impoundment or reservoir (Plates 12 and 13). The tailwater, except for diurnal fluctuation of its water levels as a result of power-peaking operations of the hydroelectric installation above, approaches the state of the original river environment.

The Snake River within most of the study area has been drawn to scale to show the relative size of impoundment, reservoir and tailwater environments (Figures 3 to 14).

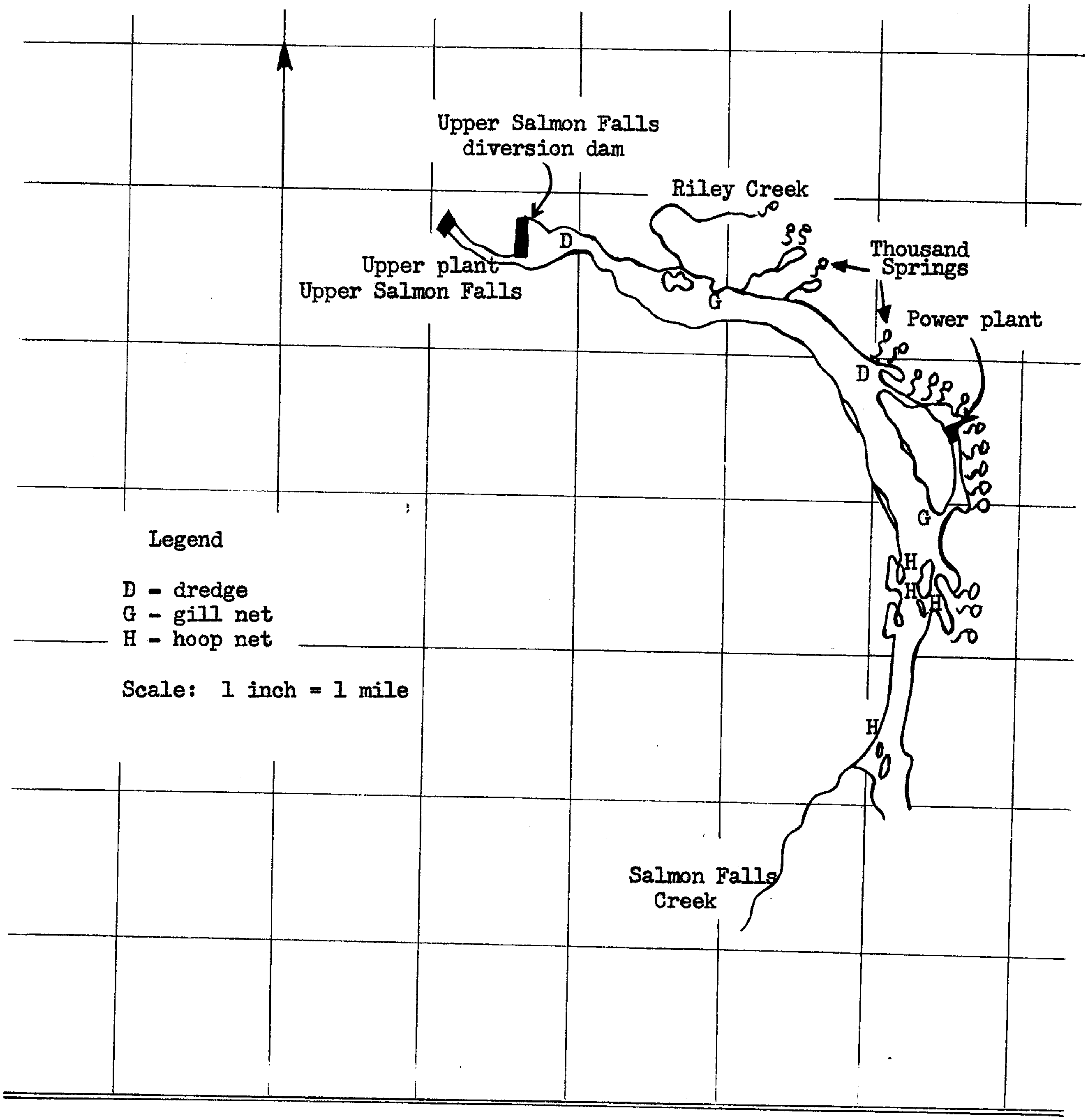


Figure 3. Upper Salmon Falls impoundment: Mouth of Salmon Falls Creek to upper power plant, Upper Salmon Falls.

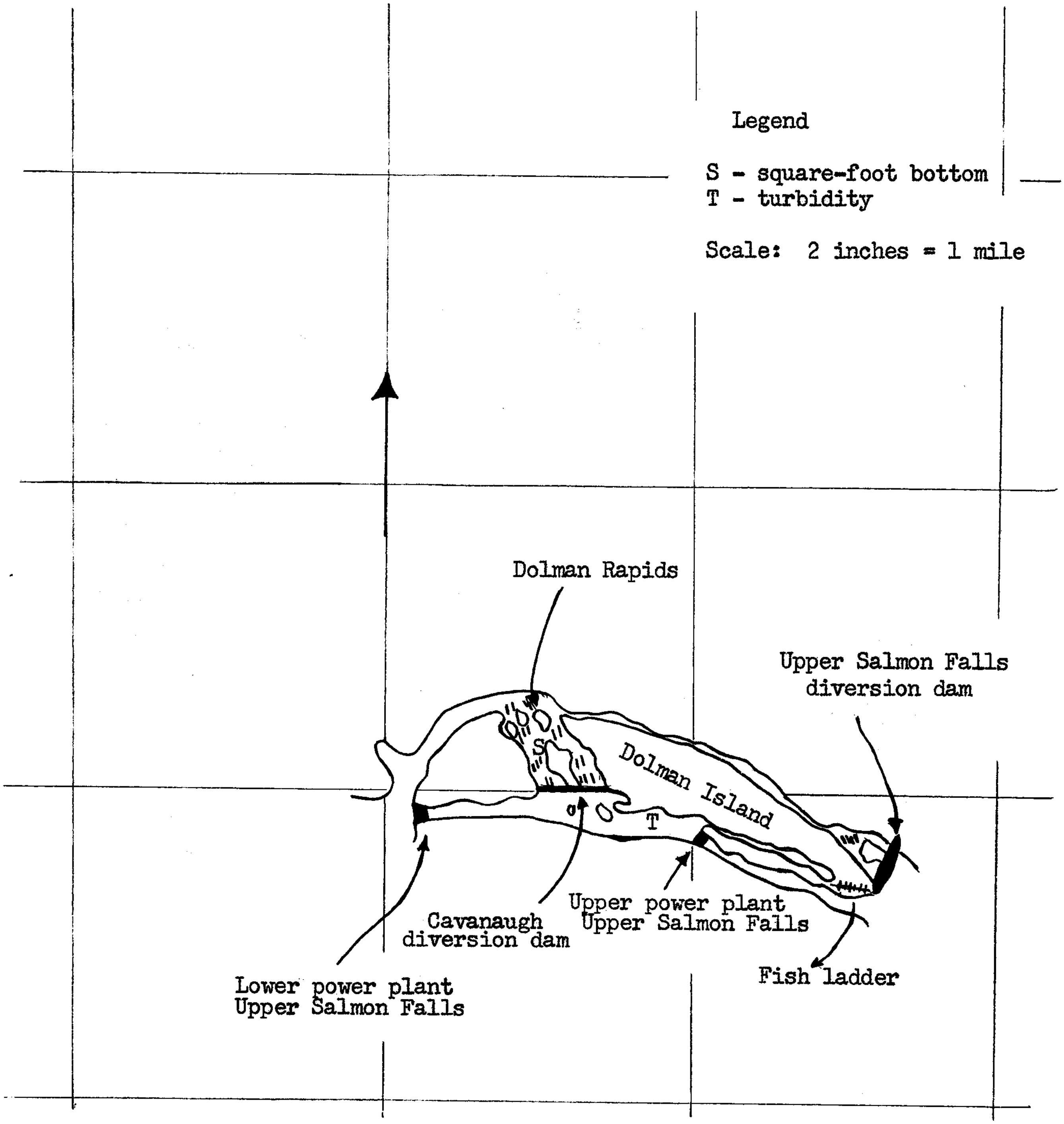


Figure 4. Upper Salmon Falls Dam tailwater:
Upper Salmon Falls diversion dam to Lower Salmon Falls impoundment.

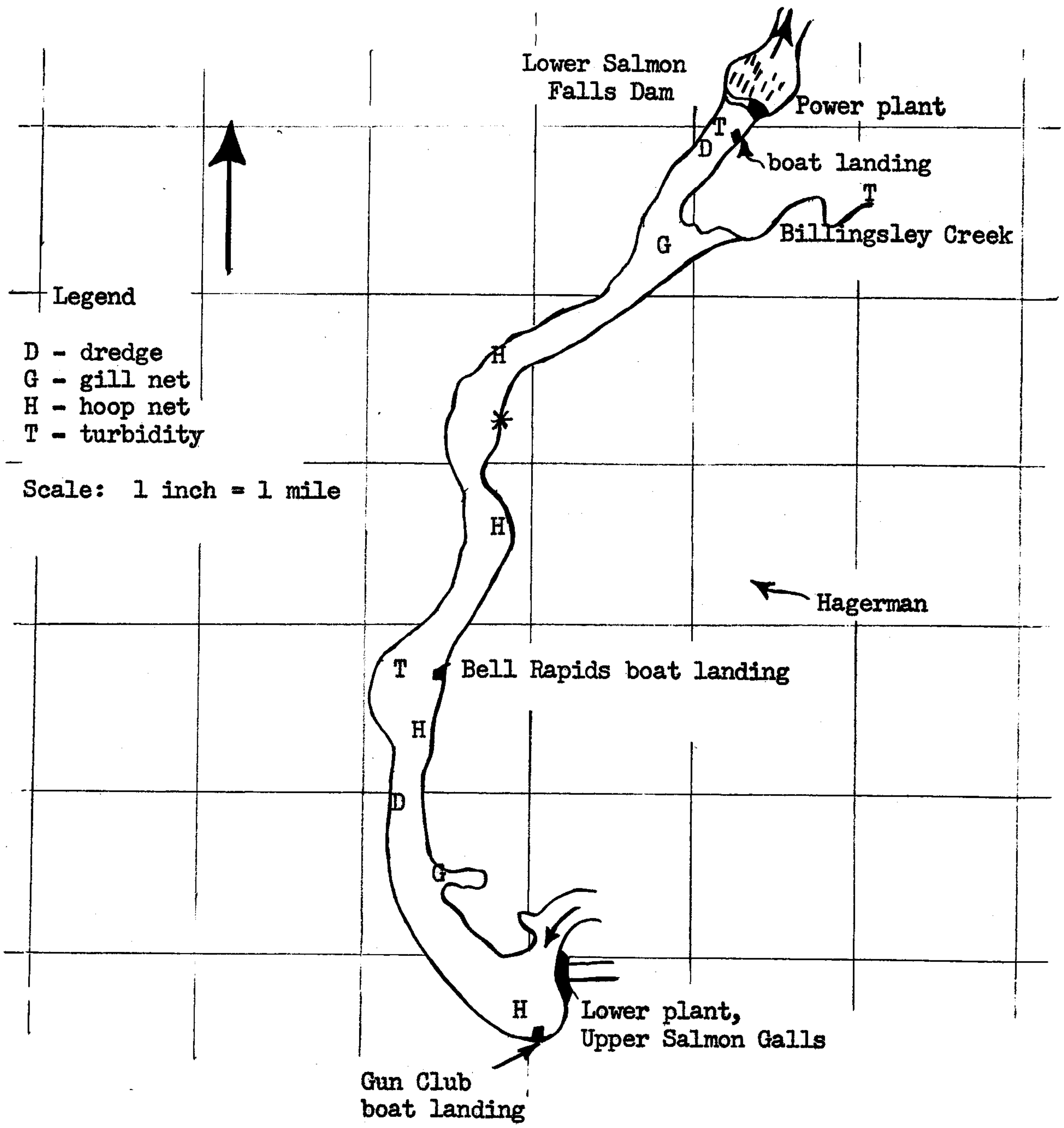


Figure 5. Lower Salmon Falls impoundment:
Upper Salmon Falls tailwater to Lower Salmon Falls dam

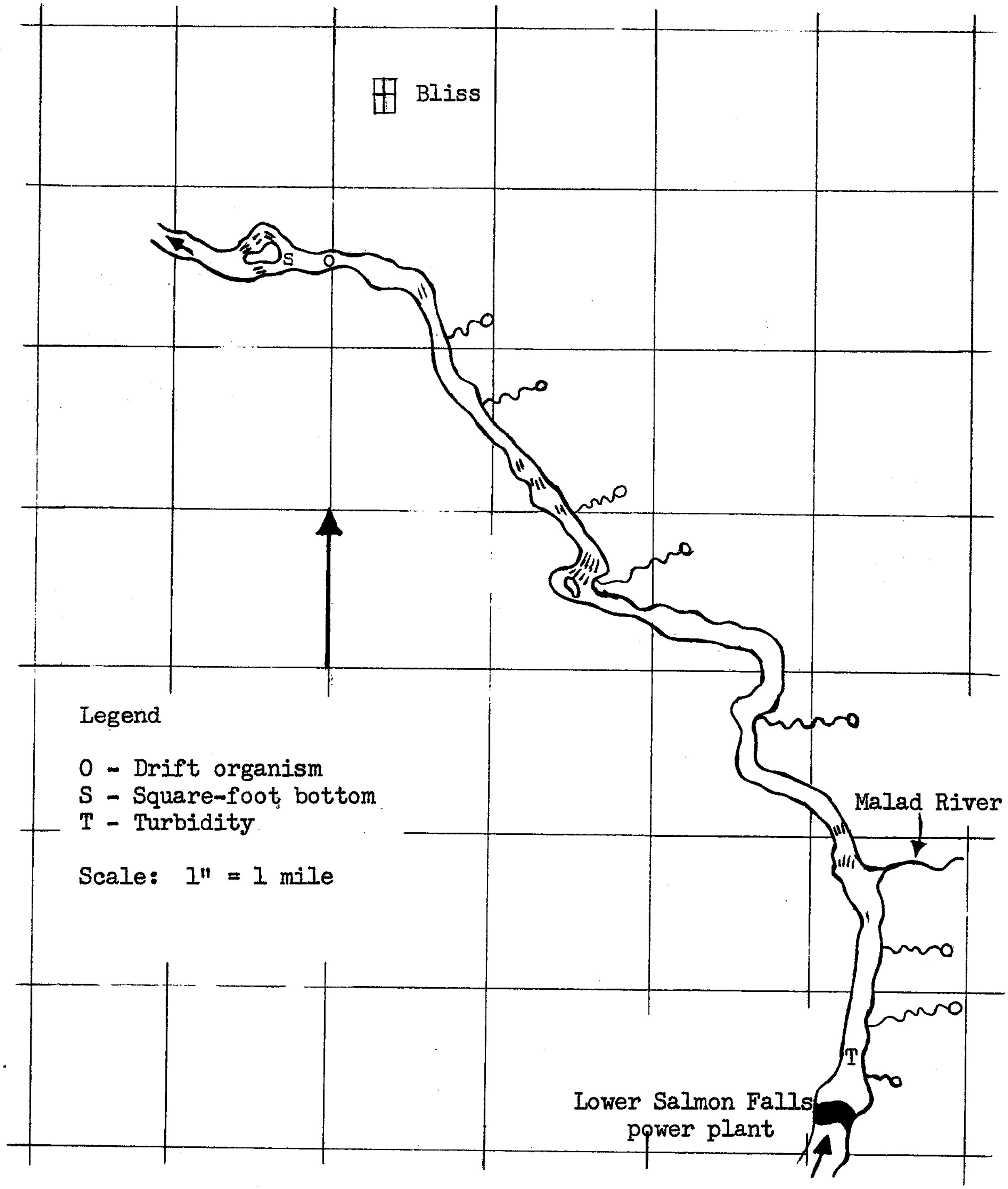


Figure 6. Lower Salmon Falls Dam tailwater:

Lower Salmon Falls Dam to Bliss impoundment.

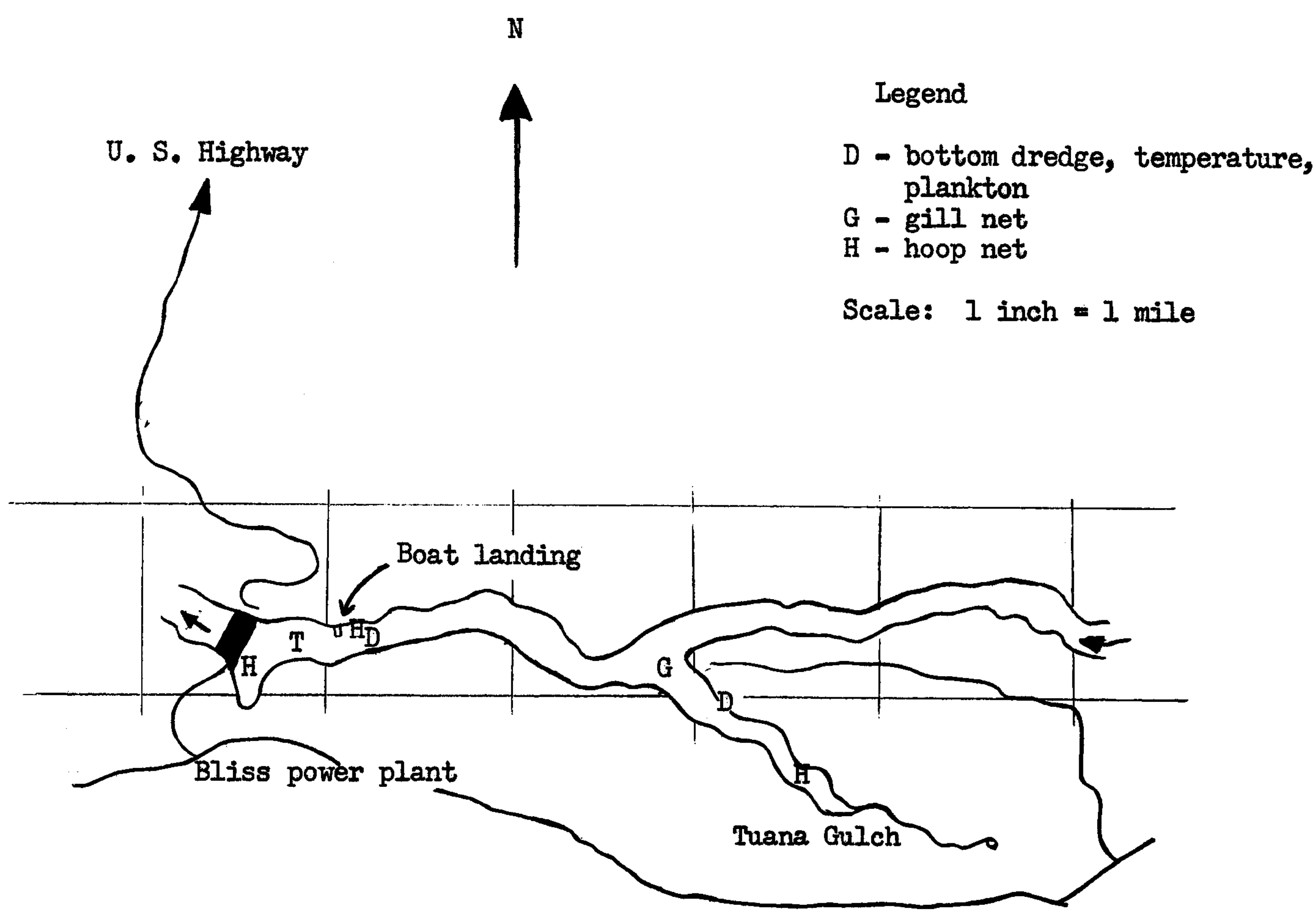


Figure 7. Bliss impoundment:
Lower Salmon Falls tailwater to Bliss Dam.

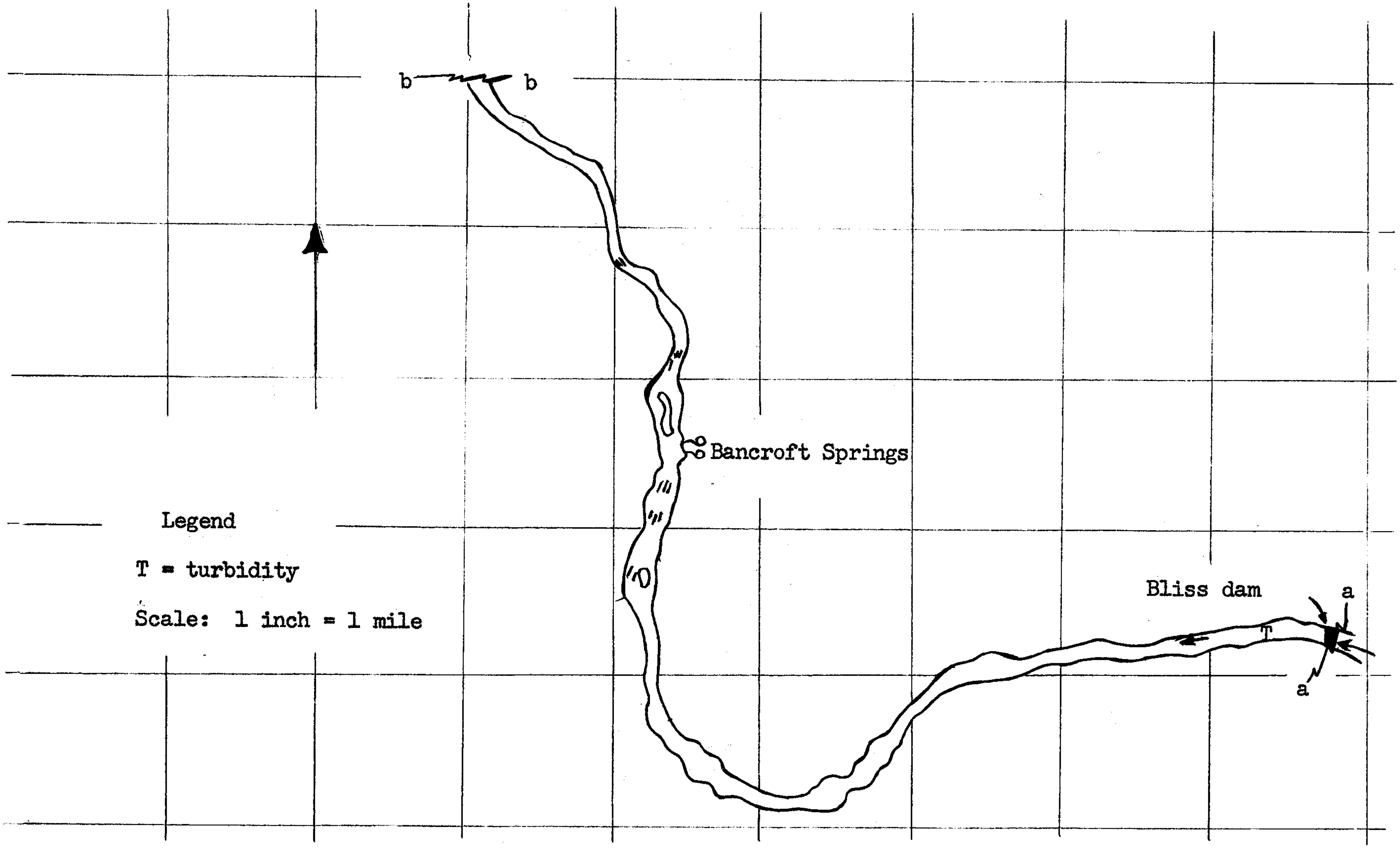


Figure 8. Bliss Dam tailwater: Section a - a to b - b

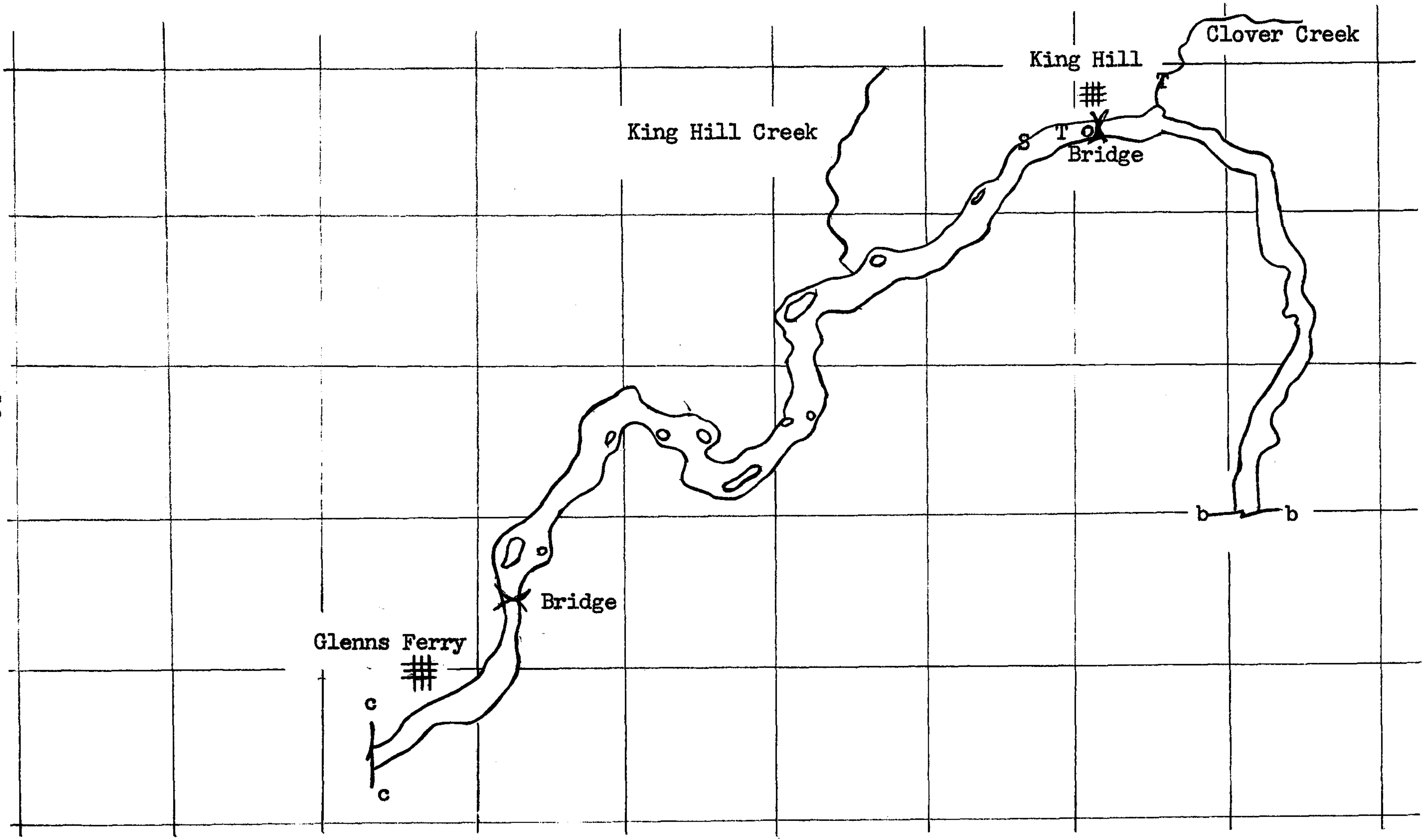


Figure 9. Bliss Dam tailwater: section b - b to c - c.

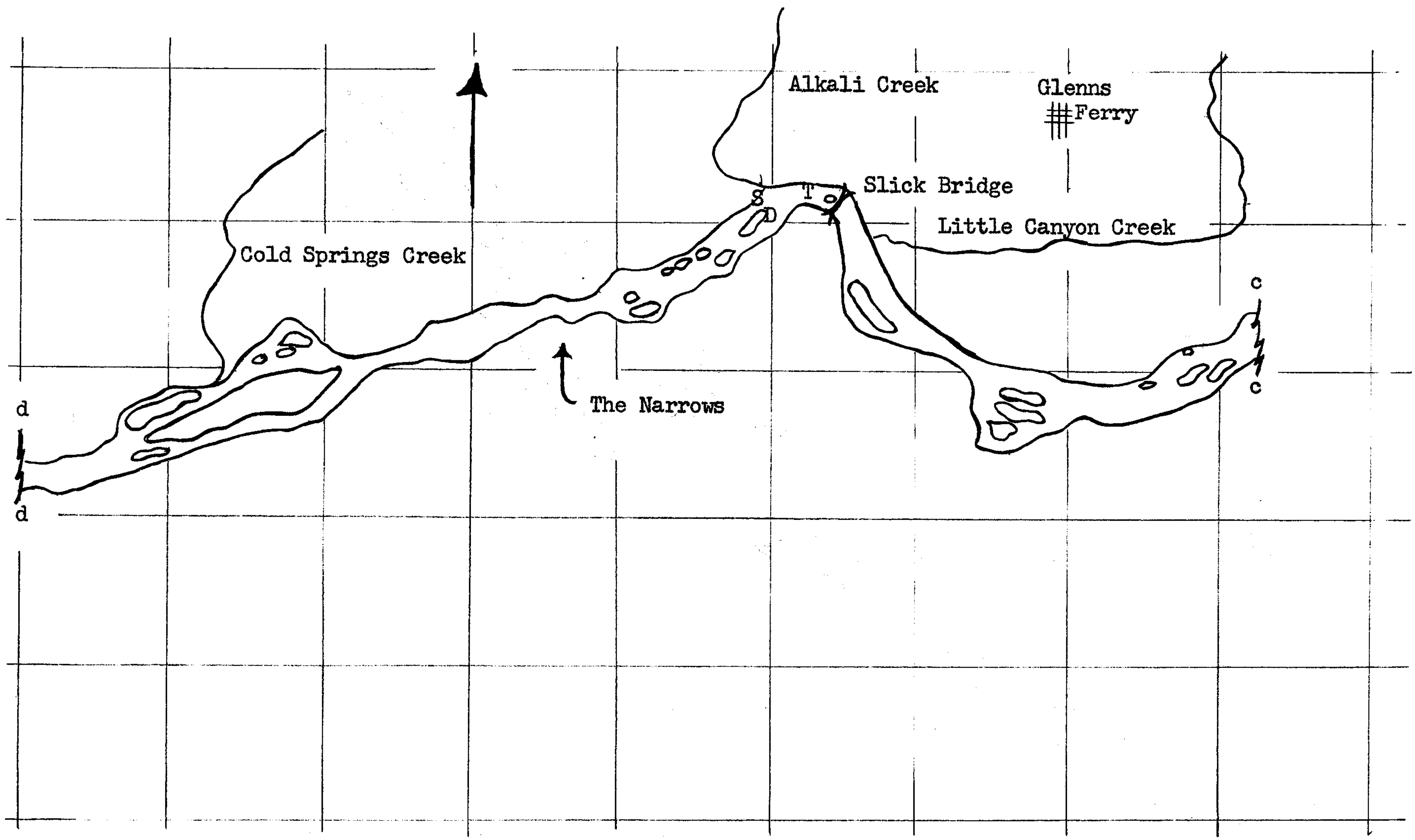


Figure 10. Bliss Dam tailwater: section c - c to d - d.

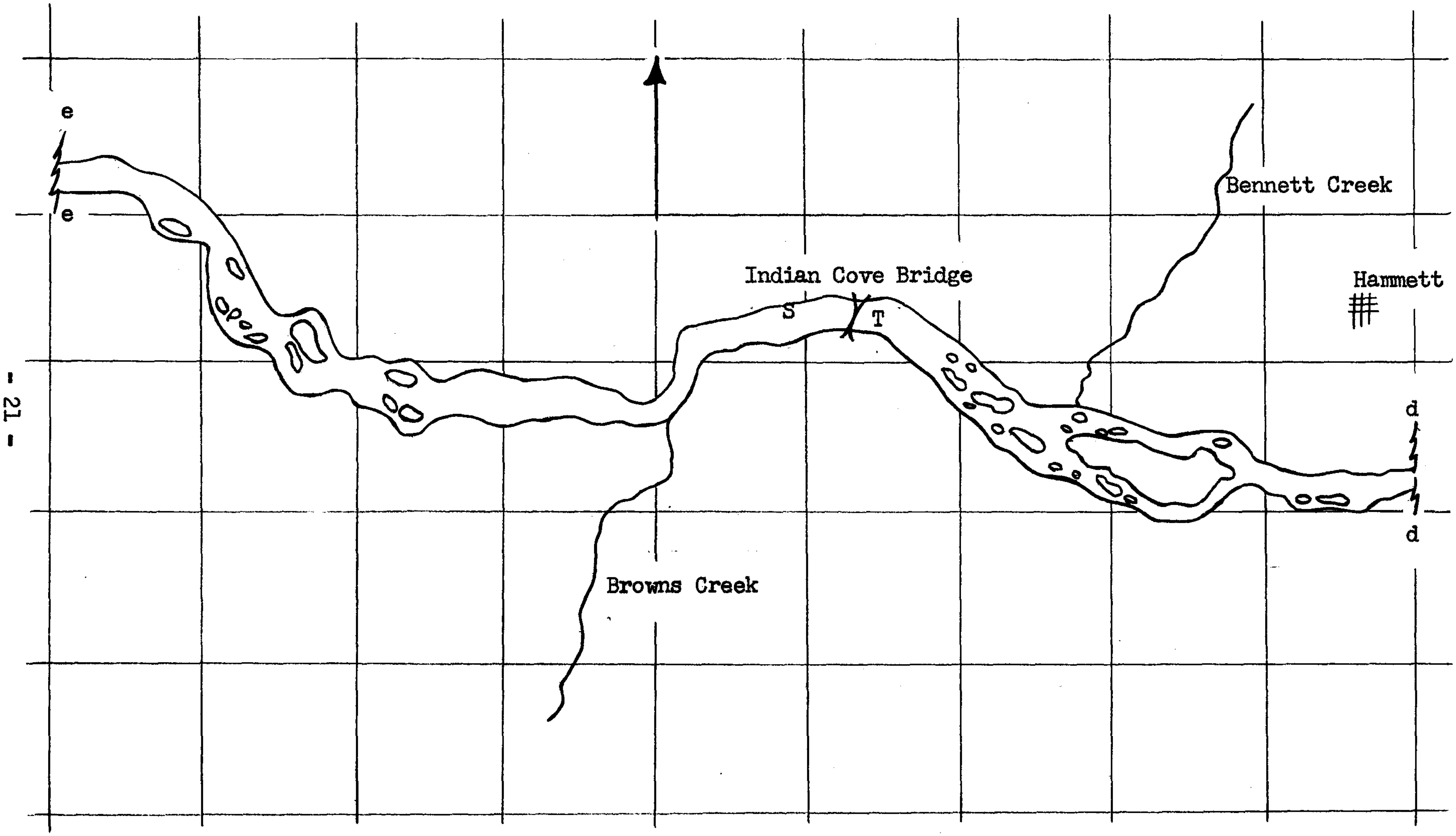


Figure 11. Bliss Dam tailwater: section d - d to e - e.

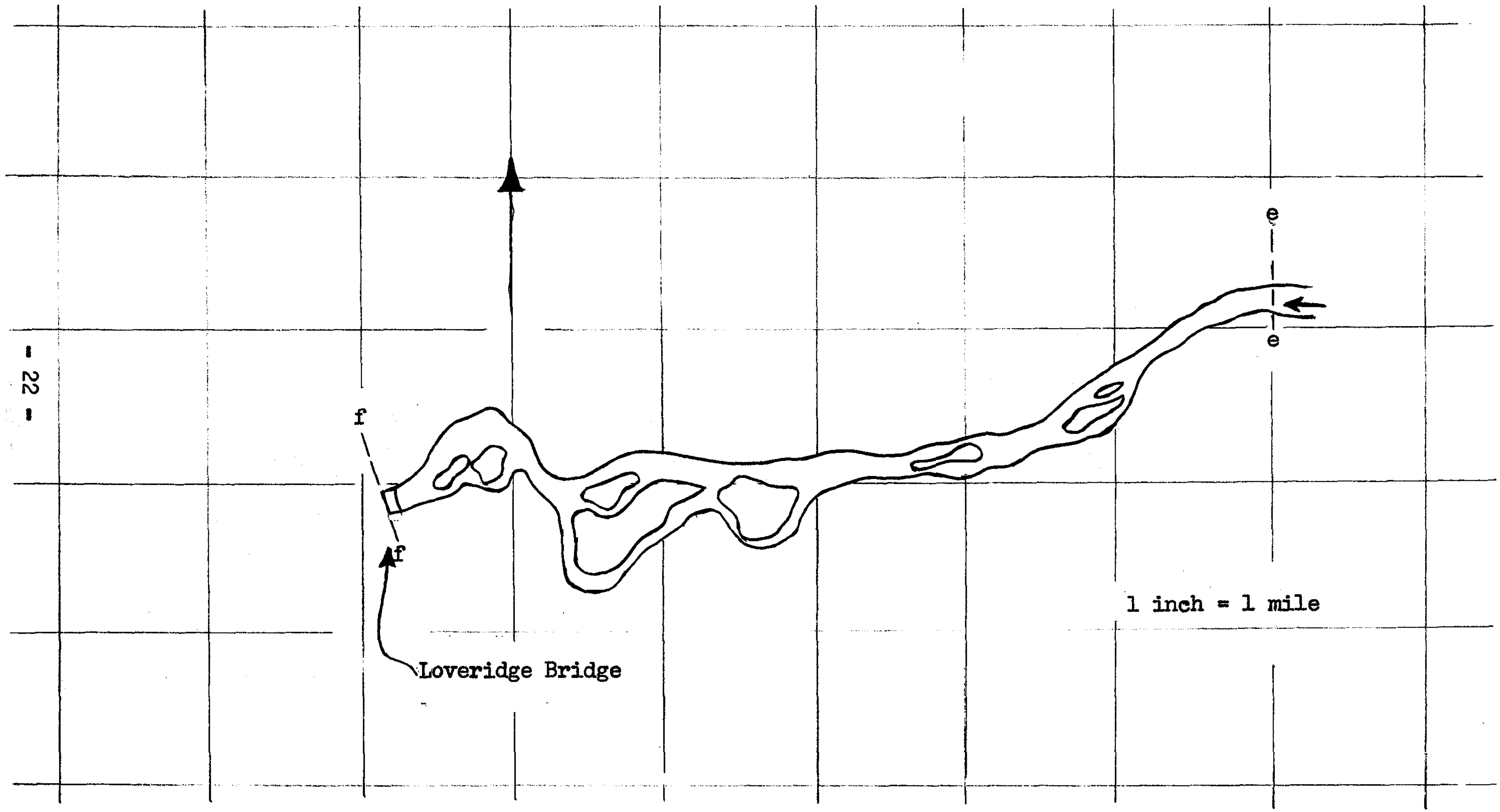


Figure 12. Bliss tailwater: Section e - e to f - f.

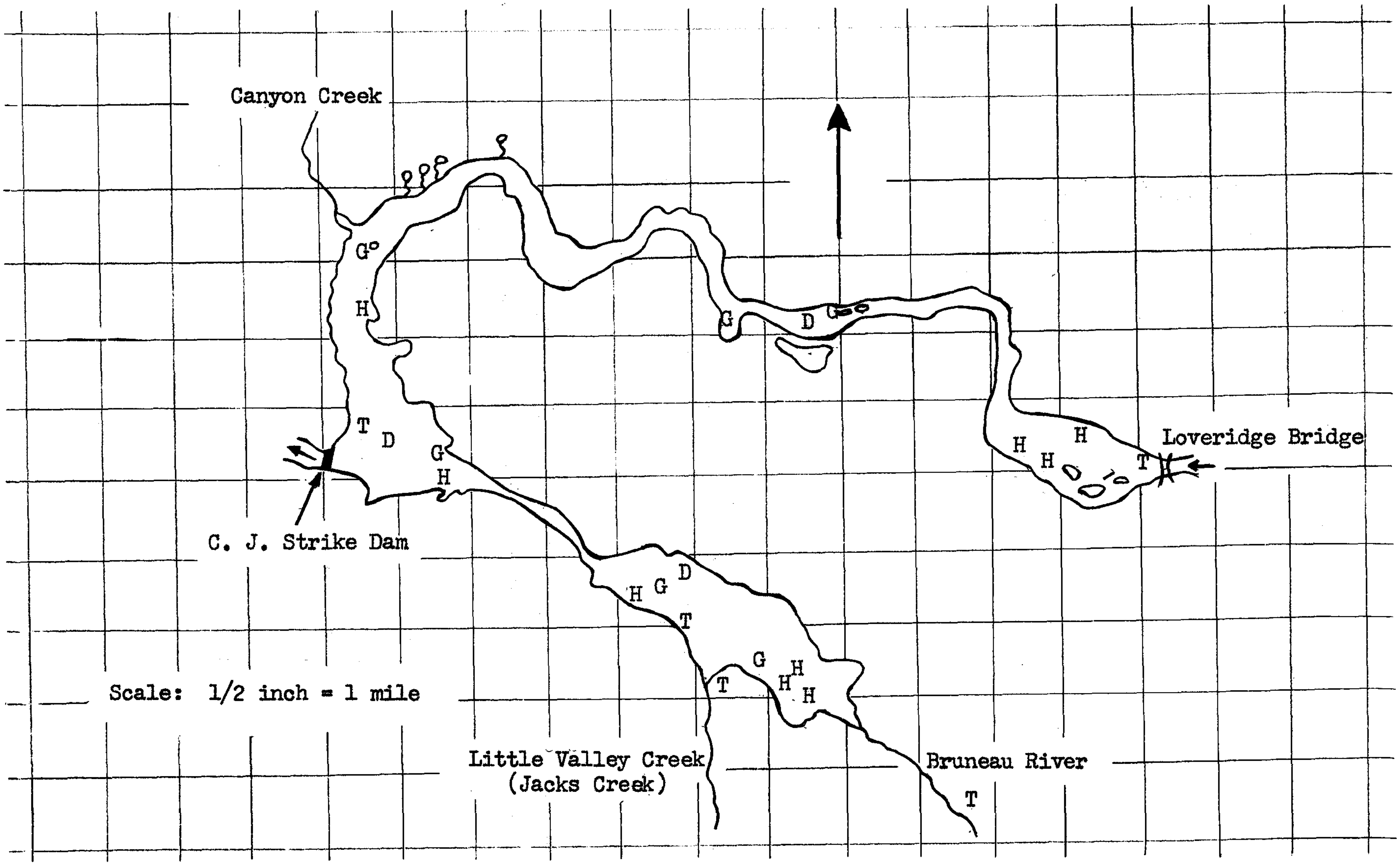


Figure 13. C. J. Strike Reservoir.

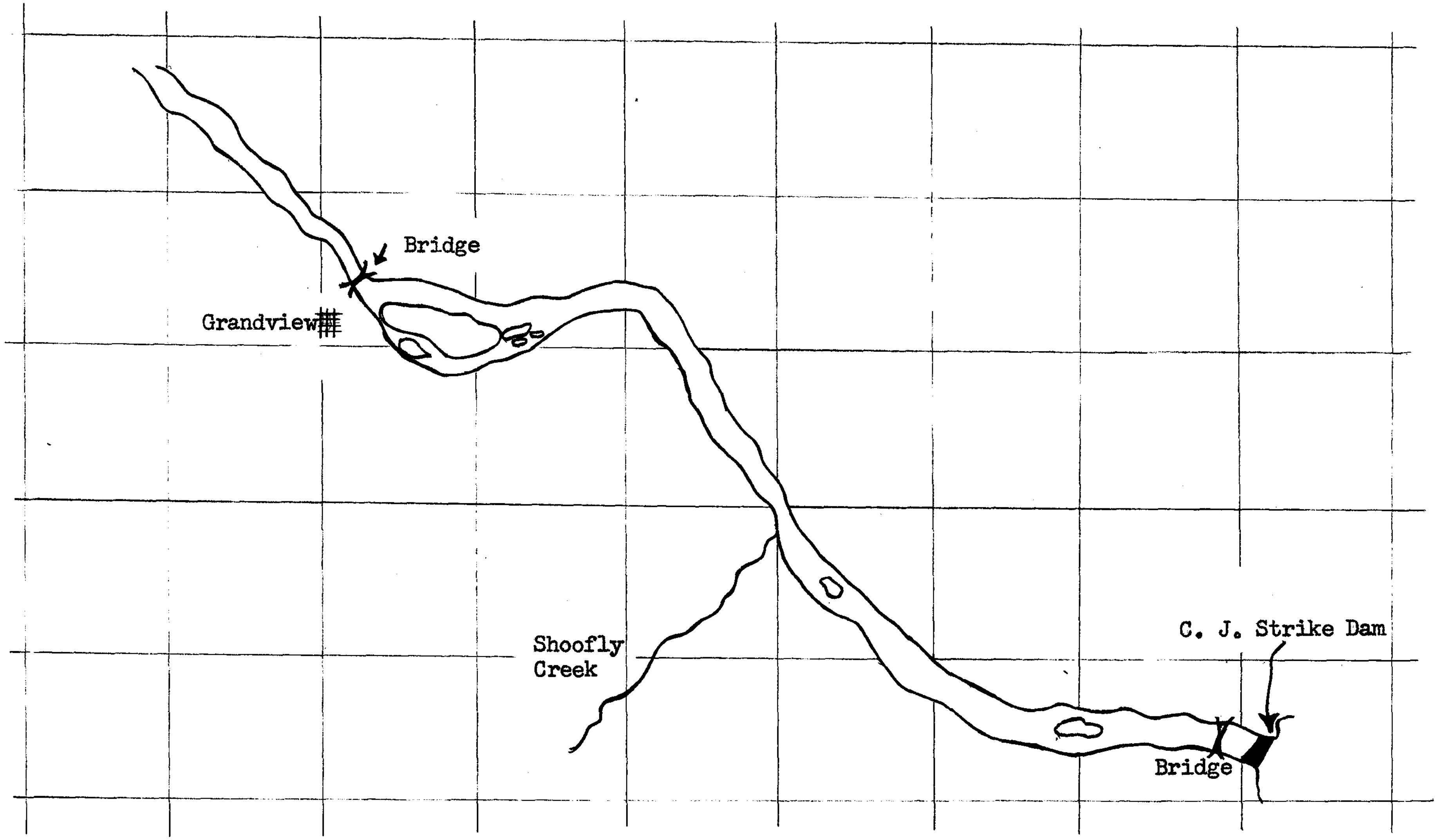


Figure 14. C. J. Strike Dam tailwater.

Plate 11. Lower portion of C. J. Strike Reservoir.

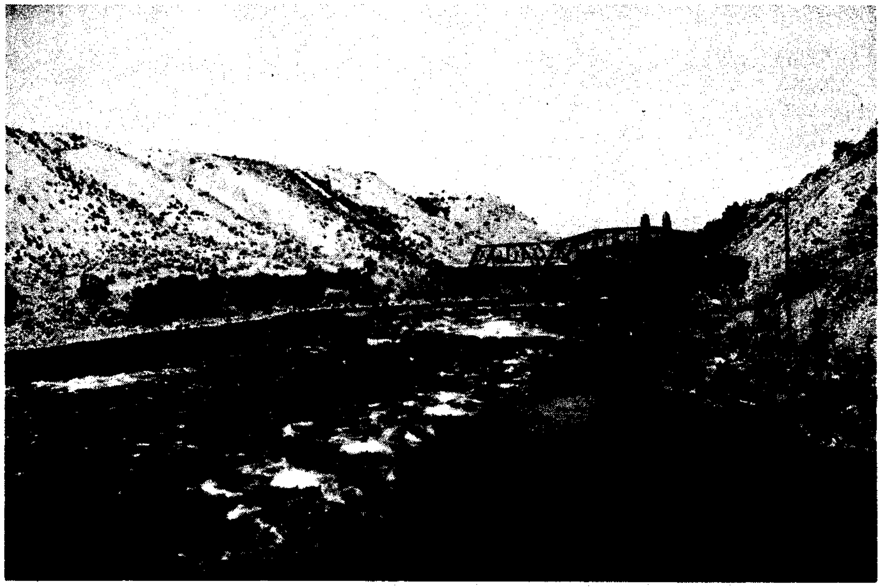


Plate 12. A portion of the Lower Salmon Falls tailwater section of Snake River just below the mouth of Malad River.

Plate 13. A portion of the Bliss tailwater section of Snake River near Hammett; Indian Cove Bridge in foreground.

Check List of Fishes

Game Fish

The common and scientific names of game fishes in Snake River within the study area are as follows:

Family	Common Name	Scientific Name
Catfish	brown bullhead	Ameiurus nebulosus
	channel catfish	Ictalurus punctatus
Perch	yellow perch	Perca flavescens
Salmon and trout	kokanee	Oncorhynchus nerka kennerlyi
	chinook salmon	Oncorhynchus tshawytscha
	steelhead	Salmo gairdneri gairdneri
	brown trout	Salmo trutta
	cutthroat trout	Salmo clarki
	eastern brook trout	Salvelinus fontinalis
	rainbow trout	Salmo gairdneri
Sturgeon	white sturgeon	Acipenser transmontanus
Sunfish	largemouth bass	Micropterus salmoides
	smallmouth bass	Micropterus dolomieu
	black crappie	Pomaxis migro-maculatus
	bluegill sunfish	Lepomis macrochirus
	pumpkinseed sunfish	Lepomis gibbosus
	redear sunfish	Lepomis microlophus
	green sunfish	Lepomis cyanellus
Whitefish	Rocky Mountain whitefish	Prosopium williamsoni

Though no chinook salmon and only a few steelhead were caught within the study area during the 1953-54 period, chinook salmon spawn in the vicinity of Walters Ferry bridge. The following comments of Evermann (1895) concerning the chinook and steelhead are interesting: "From September 29 to November 1, 1894, Liberty Millet landed 902 chinook salmon in his salmon seining operations at Millet Island below Upper Salmon Falls.....Mr. Millet reports that he catches salmon trout (steelhead) at the same time with the chinook salmon, but they are not common. They (steelhead) seem to be here all year. People catch them (steelhead) with hook and line sometimes. They (steelhead) weigh as much as 15 pounds, and probably spawn in the spring. During the entire fishing season of 1894 caught only 10 salmon trout (steelhead).....One man with whom I talked at Shoshone Falls (approximately 30 miles upstream from mouth of Salmon Falls Creek) tells of fishermen who claim to have seen some salmon at the foot of Shoshone Falls....."

Non-game Fish

The common and scientific names of non-game fishes in Snake River within the study area are as follows:

Family	Common Name	Scientific Name
Minnow	carp	Cyprinus carpio
	chiselmouth	Acrocheilus alutaceus
	Columbia River chub	Mylocheilus caurinus
	Snake River chub	Gila sp.
	long-nosed dace	Rhynichthys cataractae
	speckled dace	Rhynichthys nubilus
	redside shiner	Richardsonius balteatus balteatus
	squawfish	Ptychocheilus oregonensis
Sculpin	sculpin	Cottus sp.
Sucker	coarse scale sucker	Catostomus machrocheilus
	fine scale sucker	Catostomus columbianus

METHODS AND PRESENTATION OF DATA

Physical and Chemical

Water Flow

The daily flow of water in Snake River past each of the five major hydroelectric installations within the study area was recorded by the Idaho Power Company during the 1953-54 period. The differences between the average daily flows per month during 1953 were greater than in 1954 due to a greater spring run-off in 1953 (Table 1). Although average daily flows are quite stable, the power-peaking operations at the Lower Salmon Falls and C. J. Strike installations cause considerable fluctuation in the tailwater flows below Lower Salmon Falls, Bliss and C. J. Strike within the daily period. For example, the river flow in the Lower Salmon Falls tailwater averages approximately 2,500 cubic feet per second for the daily period from 10 P. M. to 6 A. M., whereas the flow during the daily period from 6 A. M. to 10 P. M. averages 12,000 cubic feet per second. Thus the daily high flows are nearly five times greater than the daily low flows.

Water-level Fluctuation

The fluctuation of water levels of impoundments, reservoirs and tailwaters are both seasonal and diurnal in nature. Seasonal fluctuations are determined by the amount of precipitation and operation of flood control and irrigation installations in the Snake River drainage upstream from the study area.

The diurnal fluctuation of water levels both above and below hydroelectric installations results from the manipulation of stored water to meet the variable demand for electricity during the daily 24-hour period.

The daily fluctuation of tailwater levels was collected from records of the U. S. Geological Survey and Idaho Power Company during 1953 and 1954. The daily fluctuation of impoundment and reservoir water levels was recorded by the Idaho Power Company during 1953 and 1954.

The average daily maximum and minimum depth of water immediately above the dam each month and the average and maximum daily fluctuation of water levels each month of Lower Salmon Falls, Bliss and Swan Falls impoundments and C. J. Strike reservoir for 1953 and 1954 are shown in Tables 2 to 5. The average daily fluctuation of water levels of the Lower Salmon Falls, Bliss, C. J. Strike and Swan Falls tailwaters has been tabulated for the winter (November, December, January, February), spring (March, April, May, June), and summer-fall (July, August, September, October) water-flow periods of 1953 and 1954 (Table 6).

Water levels of Upper Salmon Falls impoundment and tailwater are not subject to diurnal fluctuations.

Water Temperature

The daily maximum and minimum water temperatures of Snake River were measured at the intake to hydroelectric installations within the study area and recorded by the Idaho Power Company during 1953 and 1954. The monthly average of daily maximum and minimum water temperatures, as measured at the intake to hydroelectric installations for 1953-54 are given in Tables 7 and 8.

Table 1. The average daily flow of water in Snake River per month during 1953 and 1954, as measured in cubic feet per second at hydroelectric installations by the Idaho Power Company.

Month	Upper Salmon Falls (upper plant)		Lower Salmon Falls		Bliss		C. J. Strike		Swan Falls	
	1953	1954	1953	1954	1953	1954	1953	1954	1953	1954
January	8071	7751	8664	8352	9952	9597	10983	10121	11360	10259
February	9240	6875	9840	8308	10853	9575	11688	10236	12051	10632
March	10152	6902	10897	8666	11150	9561	12318	10083	13299	10550
April	7691	6786	8328	9120	9696	9975	10461	10429	10129	10945
May	6324	6003	7011	7780	8047	8530	8234	8175	8163	8528
June	10740	6789	11925	7592	13081	8497	14333	8755	15029	9469
July	6433	6445	6822	6987	7646	7869	7491	7380	7827	7827
August	6754	6641	7137	7139	8008	8028	7521	7587	7861	7649
September	6856	6803	7608	7597	8525	8585	8131	8341	8791	8762
October	6917	6923	7691	8790	8808	9975	8689	9980	9092	10782
November	6913	6914	7552	9051	8796	10054	9044	10382	8915	11116
December	7806	6963	8406	8435	9585	9292	10014	9660	9757	10375
Annual average	7825	6816	8490	8151	9512	9128	9909	9261	10190	9741

Table 2. Average daily maximum and minimum depth of water immediately above dam, per month, and average and maximum daily fluctuation of water levels, per month, of Lower Salmon Falls impoundment as measured in feet by the Idaho Power Company during 1953 and 1954.

Month	Average daily maximum depth		Average daily minimum depth		Average daily fluctuation		Maximum daily fluctuation	
	1953	1954	1953	1954	1953	1954	1953	1954
January	38.6	38.7	33.2	32.5	5.4	6.2	6.4	8.6
February	38.6	38.6	32.2	32.6	6.4	6.0	8.9	6.4
March	38.7	38.6	35.8	34.3	2.9	4.3	6.8	7.0
April	38.5	38.7	35.1	35.5	3.4	3.2	5.5	5.0
May	38.6	38.6	36.0	35.5	2.6	3.1	3.6	4.9
June	38.7	38.6	36.2	35.0	2.5	3.6	5.5	4.8
July	38.7	38.6	35.7	35.4	3.0	3.2	4.1	5.6
August	38.7	38.7	35.2	35.4	3.5	3.3	3.8	4.0
September	38.7	38.6	35.0	35.2	3.7	3.4	4.5	4.6
October	38.7	38.6	34.6	34.5	4.1	4.1	6.1	6.5
November	38.6	38.5	33.7	34.6	4.9	3.9	7.5	4.9
December	38.7	38.6	33.3	34.4	5.4	4.2	6.8	4.8

Table 3. Average daily maximum and minimum depth of water immediately above dam, per month, and average and maximum daily fluctuation of water levels, per month, of Bliss impoundment as measured in feet by the Idaho Power Company during 1953 and 1954.

Month	Average daily maximum depth		Average daily minimum depth		Average daily fluctuation		Maximum daily fluctuation	
	1953	1954	1953	1954	1953	1954	1953	1954
January	79.0	79.0	78.1	77.3	0.9	1.7	2.0	3.4
February	79.0	79.0	77.5	78.1	1.5	0.9	2.5	1.5
March	79.0	78.9	77.3	77.0	1.7	1.9	5.4	5.5
April	79.0	78.0	77.7	78.3	1.3	0.7	3.8	2.0
May	79.0	79.0	78.6	78.0	0.4	1.0	0.8	2.7
June	79.0	79.0	78.0	78.1	1.0	0.9	5.9	1.9
July	79.0	79.0	78.3	78.5	0.7	0.5	2.0	1.0
August	78.7	79.0	78.2	78.7	0.5	0.3	1.7	1.9
September	78.9	79.0	78.3	78.4	0.6	0.6	1.1	1.7
October	79.0	79.0	78.1	77.8	0.9	1.2	2.5	2.3
November	79.0	79.0	77.6	75.7	1.4	3.3	3.2	11.0
December	79.0	78.9	78.1	77.2	0.9	1.7	1.6	3.7

Table 4. Average daily maximum and minimum depth of water immediately above dam, per month, and average and maximum daily fluctuation of water levels, per month, of C. J. Strike reservoir as measured in feet by the Idaho Power Company during 1953 and 1954.

Month	Average daily maximum depth		Average daily minimum depth		Average daily fluctuation		Maximum daily fluctuation	
	1953	1954	1953	1954	1953	1954	1953	1954
January	114.4	114.9	113.7	114.1	0.7	0.8	1.1	1.0
February	114.8	114.8	114.3	114.0	0.5	0.8	0.9	1.0
March	115.1	114.4	114.8	113.8	0.3	0.6	0.7	1.0
April	114.8	115.0	114.4	114.4	0.4	0.6	0.9	0.9
May	115.1	114.8	114.7	114.2	0.4	0.6	0.7	1.0
June	115.4	115.1	115.0	114.4	0.4	0.7	0.9	0.7
July	115.1	114.7	114.6	114.1	0.5	0.6	0.6	1.2
August	115.0	115.0	114.4	114.4	0.6	0.6	0.7	0.8
September	115.0	114.8	114.4	114.2	0.6	0.6	0.9	1.1
October	115.1	115.0	114.5	114.3	0.6	0.7	0.9	1.0
November	114.9	115.1	114.1	114.7	0.8	0.4	1.1	0.7
December	115.0	115.0	114.3	114.4	0.7	0.6	1.0	0.8

Table 5. Average daily maximum and minimum depth of water immediately above dam, per month, and average and maximum daily fluctuation of water levels, per month, of Swan Falls impoundment as measured in feet by the Idaho Power Company during 1953 and 1954.

Month	Average daily maximum depth		Average daily minimum depth		Average daily fluctuation		Maximum daily fluctuation	
	1953	1954	1953	1954	1953	1954	1953	1954
January	18.2	17.6	16.9	13.6	1.3	4.0	3.1	5.6
February	18.2	17.9	17.3	13.9	0.9	4.0	1.6	7.2
March	17.6	16.7	15.6	13.5	2.0	3.2	2.9	5.5
April	17.6	17.9	15.8	14.7	1.8	3.2	3.8	6.0
May	18.4	17.2	16.3	13.8	2.1	3.4	4.8	6.9
June	17.7	18.1	16.0	14.5	1.7	3.6	4.4	7.1
July	18.1	17.9	15.4	15.0	2.7	2.9	4.0	4.2
August	18.1	17.9	14.9	14.6	3.2	3.3	4.5	4.7
September	17.9	18.1	15.2	14.6	2.7	3.5	4.1	6.2
October	17.7	18.0	14.9	15.1	2.8	2.9	4.6	4.9
November	17.3	18.3	13.2	16.7	4.1	1.6	5.8	4.1
December	17.7	18.5	14.1	16.8	3.6	1.7	5.5	4.0

Table 6. Average daily fluctuation, in feet, of tailwater levels below Lower Salmon Falls, Bliss, C. J. Strike and Swan Falls hydroelectric installations for the Winter, Spring and Summer-Fall periods of 1953 and 1954.

Year and period	Lower Salmon Falls tailwater[1]	Bliss tailwater[2]	Bliss tailwater[3]	C. J. Strike tailwater[4]	Swan Falls tailwater[5]
1953					
Winter	6.7	4.3	3.3	2.4	2.0
Spring	5.0	3.8	1.8	1.8	0.9
Summer-Fall	4.8	3.7	2.5	3.4	0.4
1954					
Winter	7.0	5.0	3.5	3.8	0.5
Spring	5.0	4.0	2.1	3.4	0.5
Summer-Fall	4.8	4.0	2.6	3.6	0.5

1 U. S. Geological Survey gaging station located one mile below Lower Salmon Falls Dam.

2 U. S. Geological Survey gaging station located 14 miles below Bliss Dam near King Hill.

3 Idaho Power Company gaging station located 35 miles below Bliss Dam near Hammett.

4 Idaho Power Company gaging station located four miles below C. J. Strike Dam near Grandview.

5 U. S. Geological Survey gaging station located four miles below Swan Falls Dam near Murphy.

Table 7. Daily maximum and minimum temperature of water (monthly averages), as measured in degrees Fahrenheit at the intake to the hydroelectric installations within the study area by the Idaho Power Company during 1953.

Month	Upper Salmon Falls		Lower Salmon Falls		Bliss		C. J. Strike		Swan Falls	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
January	50.4	49.6	46.9	46.8	50.5	49.5	45.5	45.0	46.0	44.8
February	47.8	46.6	45.0	43.9	49.6	48.0	44.4	44.1	44.8	42.8
March	49.3	48.0	46.4	45.7	50.7	49.6	47.1	46.6	46.8	44.4
April	54.5	52.9	52.0	50.9	54.3	54.0	52.2	52.0	51.8	49.5
May	58.6	56.1	55.9	55.0	58.6	58.1	58.1	57.9	58.1	56.1
June	62.6	60.4	59.9	59.4	62.2	61.7	63.3	63.0	63.7	61.5
July	65.1	64.0	63.1	62.6	66.0	65.3	70.9	69.1	71.2	69.4
August	63.9	62.1	61.9	61.5	65.5	64.2	70.3	70.0	70.3	67.6
September	61.3	59.7	59.2	58.5	61.7	61.0	64.8	64.2	65.7	64.4
October	57.0	55.8	53.8	52.9	57.4	56.8	57.4	57.0	56.5	55.0
November	54.0	53.1	50.7	50.4	54.9	53.6	51.1	50.7	50.0	48.6
December	48.9	48.0	45.7	45.0	49.8	48.9	45.3	45.1	43.5	42.8

Table 8. Daily maximum and minimum temperatures of water (monthly averages), as measured in degrees Fahrenheit at the intake to the hydroelectric installations within the study area by the Idaho Power Company during 1954.

Month	Upper Salmon Falls		Lower Salmon Falls		Bliss		C. J. Strike		Swan Falls	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minin
January	48.0	47.3	45.0	44.4	49.5	48.2	43.2	42.8	41.9	41.2
February	50.4	48.9	47.3	46.8	51.3	50.2	46.6	46.0	44.4	43.9
March	50.0	48.8	47.3	46.4	51.3	51.1	47.3	46.8	45.0	44.2
April	55.0	53.2	52.3	51.6	55.8	54.9	53.8	53.1	52.3	51.4
May	60.8	58.5	58.3	57.2	61.2	60.3	61.3	60.4	60.6	59.9
June	61.3	69.2	58.8	57.9	61.3	60.8	62.4	61.7	62.4	61.2
July	65.3	63.0	63.3	62.2	65.7	65.1	72.0	70.5	71.6	70.0
August	63.1	61.2	61.0	60.4	63.5	62.6	68.7	67.8	68.5	67.4
September	60.6	58.8	58.5	57.4	61.0	60.3	64.4	63.5	64.2	62.8
October	55.9	54.3	52.7	52.3	56.1	55.6	56.5	56.1	56.7	55.9
November	52.2	51.3	49.5	48.9	52.9	52.2	51.1	50.5	49.3	48.9
December	47.7	46.8	44.4	43.7	48.4	47.5	44.4	43.9	41.7	41.2

Temperatures of impounded waters at various depths were measured with a reversing thermometer at selected stations (Figures 3, 5, 7, and 13) and recorded on special forms. Surface and bottom water temperatures of impoundment and reservoir areas have been tabulated for 1953 (Table 9). Temperatures of water at selected depths in C. J. Strike reservoir have been tabulated for 1954 (Table 10).

Water Turbidity

Water samples were collected according to the water-flow seasons at each of 18 stations established at appropriate locations on Snake River and tributaries during 1954 (Figures 3 to 14). Turbidity in each water sample as measured in parts per million by use of a Jackson turbidimeter is shown in Table 11.

Water Chemistry

Water samples were collected from the Upper Salmon Falls impoundment near the Owsley bridge and from the Swan Falls tailwater near the Walters Ferry bridge during the irrigation and non-irrigation periods of 1953. A quantitative analysis of the more common substances in these samples was made by the Idaho Department of Public Health and is shown in Table 12.

Biological

Production of Aquatic Organisms

Tailwaters

Bottom organisms. The production of aquatic bottom organisms in tailwater areas was determined by sampling the organisms at selected stations with a Surber, square-foot bottom sampler during each of the Winter, Spring and Summer-Fall water-flow periods of 1953 and 1954.

All samples were collected from the river bottom at a depth of one foot below the prevailing water level. Aquatic organisms were dislodged from rocks and detritus to a depth of two inches in the firm substratum within the square-foot base of the sampler. Samples were transferred to jars, the contents labeled to correspond with information on the data sheet, and formalin added to preserve the sample. The special data form included river conditions at the time sample was taken; i.e., high, low and rising or falling. Organisms of each sample were identified, counted and volumes measured to nearest 0.1 cubic centimeter by water displacement. Volumes less than 0.1 cubic centimeter were recorded as traces (tr.).

Freshwater mussels (Pelecypoda) in the samples were counted; but, due to their large size, volumes were not measured.

Six square-foot samples of aquatic organisms were collected at the station established in the Dolman Rapids section of the Upper Salmon Falls tailwater during 1954 (Table 13). The water levels of this tailwater are not subject to diurnal fluctuation. The river bottom at this station is composed of approximately 70 per cent rubble and 30 per cent bedrock.

The aquatic organism sampling station for the Lower Salmon Falls tailwater was established approximately one-fourth mile below the Bliss bridge (Figure 6).

Table 9. Surface and bottom temperatures of impoundment and reservoir areas as measured in degrees Fahrenheit with a reversing thermometer during 1953.

Area and date	Surface	Bottom
Upper Salmon Falls impoundment		
January 16	48.9	48.9
August 4	63.7	63.7
Lower Salmon Falls impoundment		
January 6	47.3	47.3
May 22	56.8	56.5
Bliss impoundment		
January 22	49.6	49.6
August 7	64.6	63.5
C. J. Strike reservoir		
Snake River arm, upper section		
February 14	46.0	45.9
May 27	57.6	57.4
Bruneau River arm		
February 12	41.2	40.3
May 25	60.8	55.4
Swan Falls impoundment		
February 10	45.0	45.0
June 24	62.8	62.8

Table 10. Temperature of water at selected depths in C. J. Strike reservoir in degrees Fahrenheit, 1954.

Area and date	Depth of water in feet					
	0	10	20	40	60	80
Snake River arm, lower section						
March 4	46.8	46.4	46.4	46.4	46.4	45.0
June 2	59.9					54.7
August 8	73.0	69.4	67.8	66.6	65.5	60.3
November 18	52.4					48.7
Bruneau River arm						
March 1	44.6			44.6		
June 2	60.1			59.4		
August 12	71.8			67.3		
December 15	38.8			38.8		

Table 11. Turbidity of water in Snake River and some tributary streams in parts per million during Winter, Spring and Summer-Fall periods, 1954.

Area and site	Winter	Spring	Summer-Fall
	March 9	June 28	October 21
Upper Salmon Falls impoundment, Owsley bridge	-25*	-25	-25
Upper Salmon Falls tailwater, below upper plant	-25	-25	-25
Lower Salmon Falls impoundment, Bell Rapids	30	-25	-25
Lower Salmon Falls impoundment, boat landing	-25	-25	-25
Billingsley Creek, highway bridge	-25	-25	-25
Lower Salmon Falls tailwater, 1000 feet below dam	-25	-25	-25
Bliss impoundment, boat landing	-25	-25	-25
Bliss tailwater, 1500 feet below dam	-25	-25	-25
Clover Creek, railroad bridge	650	-25	28
Bliss tailwater, King Hill bridge	110	-25	-25
Bliss tailwater, Slick bridge	38	-25	-25
Bliss tailwater, Indian Cove bridge	25	-25	-25
C. J. Strike reservoir, Snake River arm	-25	-25	-25
C. J. Strike reservoir, boat landing above dam	28	-25	-25
Bruneau River, highway bridge	-25	-25	-25
Little Valley Creek, highway bridge	150	34	-25
C. J. Strike reservoir, Bruneau River arm	95	-25	42
C. J. Strike tailwater, bridge below dam	-25	-25	-25

* -25 is a turbidity of less than 25 parts per million

Table 12. Chemical analyses of water samples from Snake River during the irrigation (Summer) and non-irrigation (Winter) periods of 1953. With exception of pH, values are expressed in parts per million.

Item	Upper Salmon Falls impoundment		Swan Falls tailwater	
	Irrigation	Non-irrigation	Irrigation	Non-irrigation
Hydrogen ion concentration (pH)	7.7	8.1	7.5	8.4
Alkalinity (bicarbonate)	160	190	160	162
Hardness (as $CaCO_3$)	164	198	170	200
Calcium (as Ca)	33	48	34	47
Magnesium (as Mg)	20	19	21	20
Ammonia (as N)	0.0	0.1	0.0	0.6
Fluoride (as F)	0.85	0.60	0.75	0.60
Chloride (as Cl)	30	29	30	no analysis
Sulfate (as SO_4)	58	47	85	51
Nitrate (as N)	0.7	0.6	1.2	0.4
Phosphate (as PO_4)	0.03	0.18	0.05	0.40

Table 13. Frequency of occurrence, number and volume (cubic centimeters) of aquatic organisms from six square-foot samples of the bottom area within the stable, daily flow of Upper Salmon tailwater during 1954.

Organisms	Occurrence	Number	Volume
Animals	6	1242	31.7
Insecta	6	375	10.3
Coleoptera	3	9	tr.
Diptera	3	9	tr.
Ephemerida	2	15	0.1
Trichoptera	4	342	10.2
Amphipoda	6	492	3.0
Hirudinea	4	72	6.0
Tubificidae	3	48	0.1
Pulmonata	5	255	12.3

The water levels (elevations) of this tailwater are subject to severe diurnal fluctuation (Table 6, Plates 14 to 17). Six square-foot samples of aquatic organisms were collected from the bottom within the low and within the high water flows at this station during 1953 and 1954 (Table 14).

The low and high flows of the Lower Salmon Falls tailwater adjacent to the aquatic organism collection station below Bliss bridge were surveyed and plotted (Figure 15). The surface areas of the low and high flows and fluctuation zone, within the surveyed area, were computed as follows:

Area within high flow - - - 252,200 square feet - - 100 per cent

Area within low flow - - - - 199,700 square feet - - 79 per cent

Area of fluctuation zone - - 52,500 square feet - - 21 per cent

The river bottom at the above station is composed of 90 per cent rubble and 10 per cent sand, soil and detritus.

Three aquatic organism sampling stations were established at locations typical of the Bliss tailwater environment. The upper station was located approximately one-half mile below the King Hill bridge (Figure 9). The water levels of the Bliss tailwater at this station are subject to rather severe diurnal fluctuation (Table 6, Plates 18 to 21). Six square-foot samples of aquatic organisms were collected from the bottom within each the low and within the high water flows at this station during 1953 and 1954 (Table 15).

The low and high flows of the Bliss tailwater adjacent to the aquatic organism collection station below King Hill bridge were surveyed and plotted. The surface areas of the low and high flows and fluctuation zone within the mapped area were measured, as follows:

Area within high flow - - - - - 360,100 square feet - - 100 per cent

Area within low flow - - - - - - 312,200 square feet - - 87 per cent

Area within fluctuation zone - - 47,900 square feet - - 13 per cent

The river bottom at the above station is composed of 70 per cent rubble and 30 per cent sand, soil and detritus.

The middle station for collection of aquatic organisms on the Bliss tailwater was established approximately 100 feet below the mouth of Alkali Creek (Figure 10). The water levels of Bliss tailwater at this station are subject to moderate diurnal fluctuation (Table 6, Plates 22 to 25). Six square-foot samples of aquatic organisms were collected from the bottom within the low and within the high water flows at this station during 1953 and 1954 (Table 16).

The low and high flows of the Bliss tailwater adjacent to the aquatic organism collection station below the mouth of Alkali Creek were surveyed and plotted (Figure 17). The surface areas of the low and high flows and fluctuation zone within the mapped area were measured, as follows:

Table 14. Frequency of occurrence, number and volume (cubic centimeters) of aquatic organisms from six square-foot samples of the bottom area, each within the low and within the high daily flows of Lower Salmon Falls tailwater during 1953-54.

Organisms	Low			High		
	Occurrence	Number	Volume	Occurrence	Number	Volume
Animals	6	1356	22.8	5	252	1.6
Insecta	6	566	7.8	5	83	0.6
Coleoptera	3	12	tr.	...	...	...
Diptera	4	69	0.1	4	78	0.6
Ephemerida	5	42	0.2	...	...	...
Trichoptera	6	443	7.5	2	5	tr.
Hydrachnidae	2	7	tr.	...	...	...
Amphipoda	6	169	0.5	5	52	0.2
Decapoda	1	1	1.5	...	...	...
Hirudinea	1	1	0.1	1	1	tr.
Tubificidae	4	13	0.1	4	30	0.2
Pulmonata	6	597	12.8	4	86	0.6
Pelecypoda	2	2	----	...	...	...

Table 15. Frequency of occurrence, number and volume (cubic centimeters) of aquatic organisms from six square-foot bottom samples each within the low and within the high daily flows of Bliss tailwater in the King Hill area during 1953-54.

Organisms	Low			High		
	Occurrence	Number	Volume	Occurrence	Number	Volume
Animals	6	1032	5.4	5	223	1.2
Insecta	6	371	1.2	3	33	tr.
Coleoptera	3	35	0.1	1	3	tr.
Diptera	6	319	1.0	3	27	tr.
Ephemerida	2	3	tr.	...	...	...
Trichoptera	2	14	0.1	1	3	tr.
Hydrachnidae	3	42	tr.	1	1	tr.
Amphipoda	6	514	2.1	1	157	0.9
Decapoda	1	1	0.3	...	...	...
Hirudinea	...	....	...	1	1	tr.
Tubificidae	4	14	0.1	4	26	0.2
Pulmonata	5	89	1.7	1	5	0.1
Pelecypoda	1	1	---	...	...	...

Table 16. Frequency of occurrence, number and volume (cubic centimeters) of aquatic organisms from six square-foot bottom samples each within the low and the high daily flows of the Bliss tailwater in the Alkali Creek area during 1953-54.

Organisms	Low			High		
	Occurrence	Number	Volume	Occurrence	Number	Volume
Animals	6	526	4.6	6	55	0.1
Insecta	6	432	3.6	3	44	0.1
Coleoptera	4	13	tr.	1	1	tr.
Diptera	5	40	tr.	1	5	tr.
Ephemerida	6	116	0.5	3	22	0.1
Odonata	1	1	0.1	...	...	...
Trichoptera	6	262	3.0	3	16	tr.
Amphipoda	3	21	tr.	1	9	tr.
Hirudinea	1	1	tr.	...	...	...
Tubificidae	2	3	tr.	1	2	tr.
Pulmonata	6	68	1.0	...	...	...
Pelecypoda	1	1	---	...	...	...

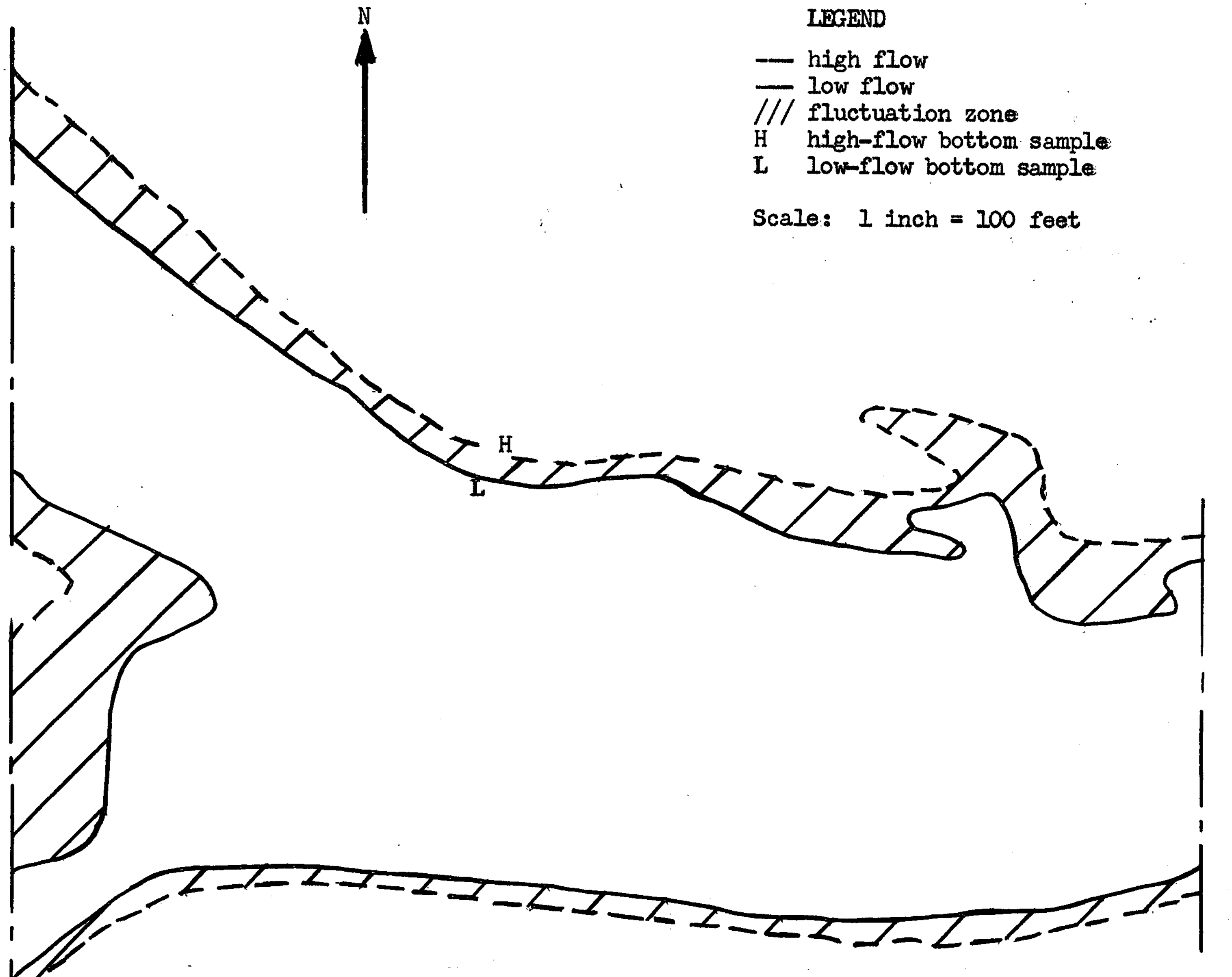


Figure 15. Fluctuation zone of Lower Salmon Falls tailwater in vicinity of bottom sample collections near Bliss Bridge.

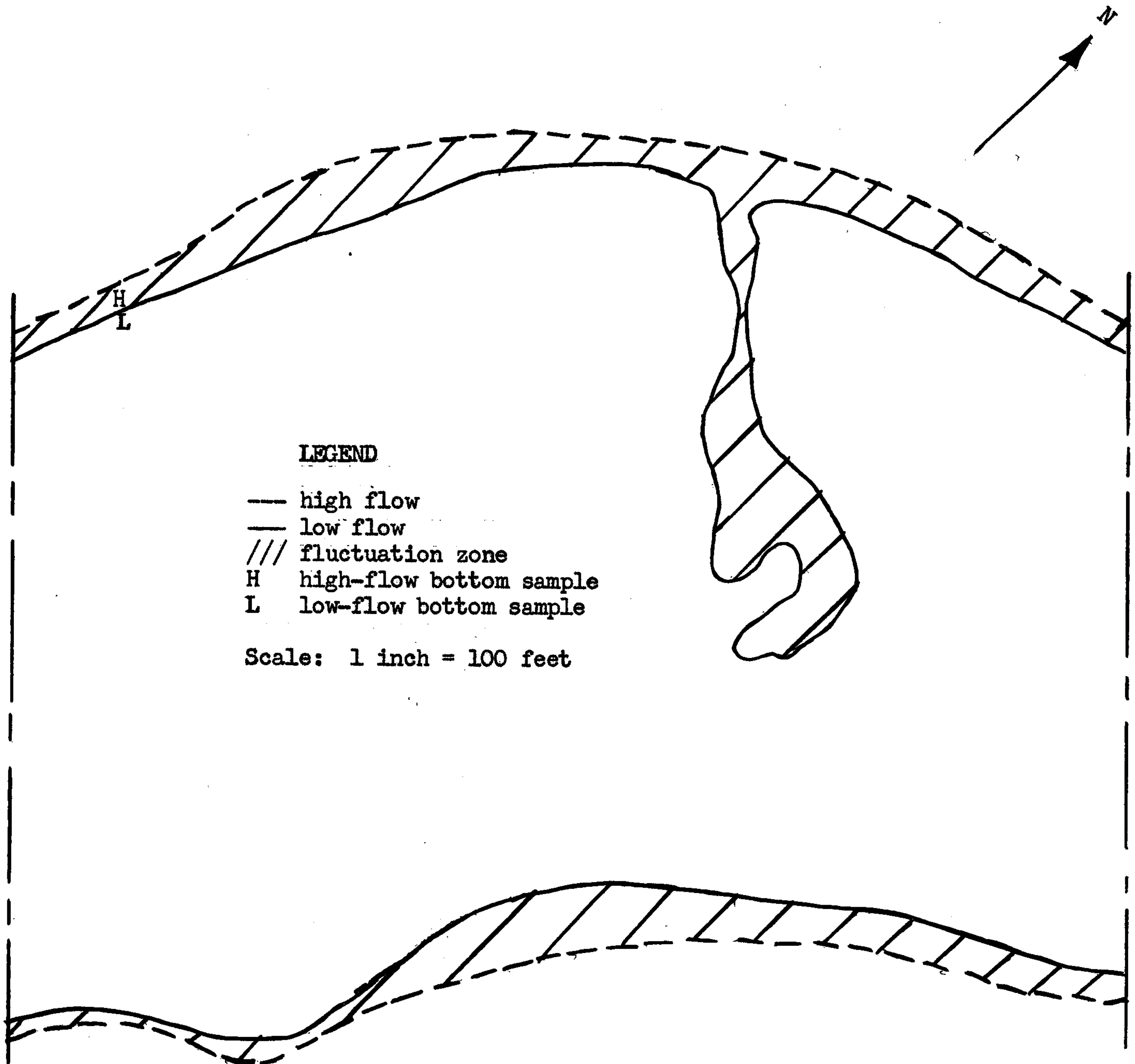


Figure 16. Fluctuation zone of Bliss tailwater in vicinity of bottom sample collections near King Hill.

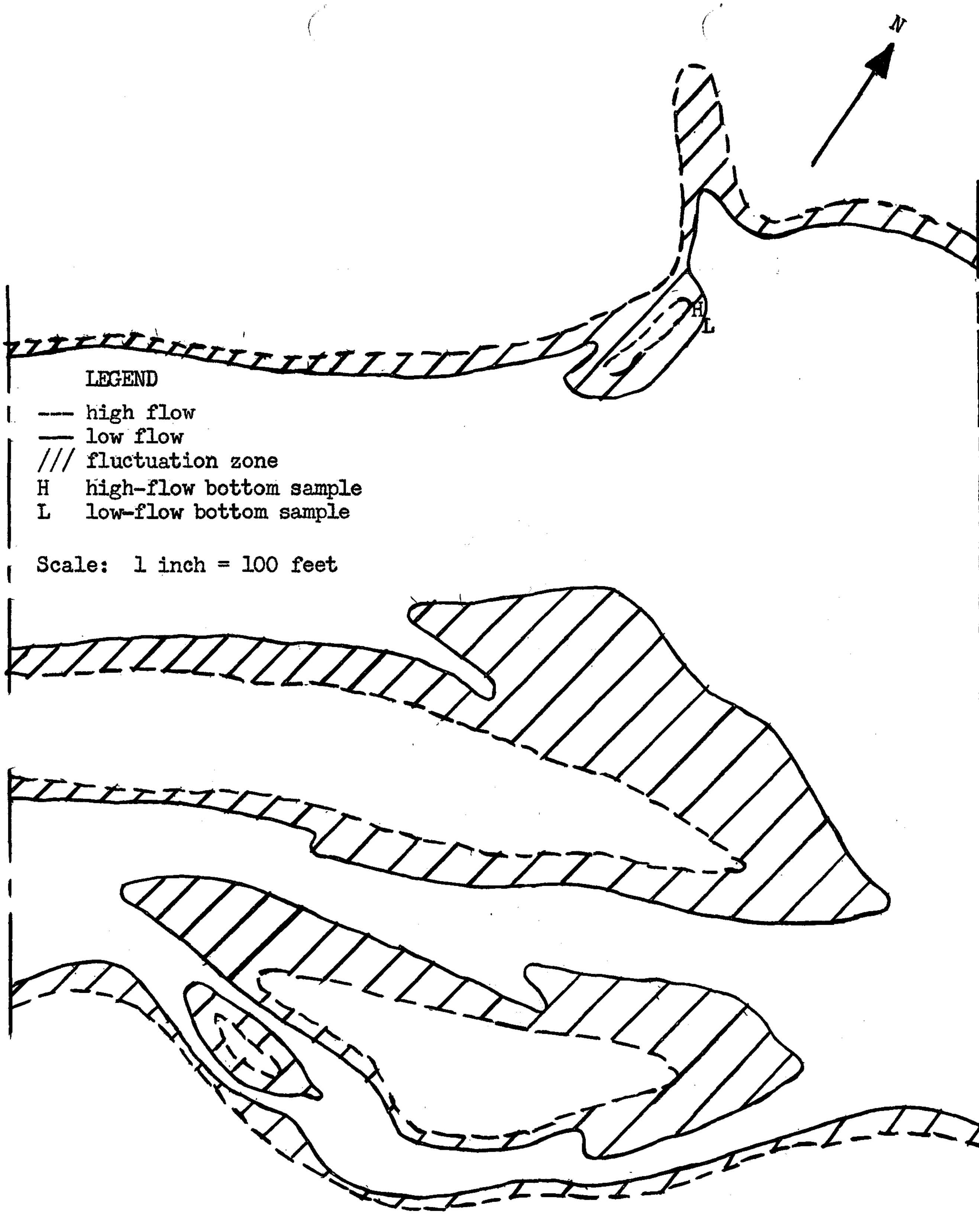


Figure 17. Fluctuation zone of Bliss tailwater in vicinity of bottom sample collections near mouth of Alkali Creek.

Plate 14. Low water flow of Lower Salmon Falls tailwater below Bliss Bridge.

Plate 15. High water flow of Lower Salmon Falls tailwater below Bliss Bridge.
(Picture taken same day as Plate 14.)

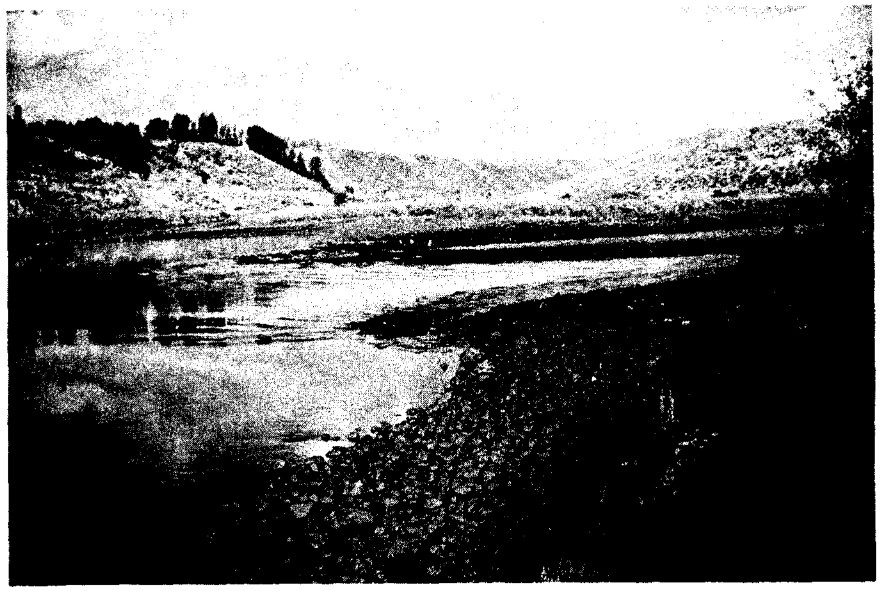


Plate 16. Low water flow of Lower Salmon Falls tailwater at aquatic organism collection station 1/4 mile below Bliss Bridge.

Plate 17. High water flow of Lower Salmon Falls tailwater at aquatic organism collection station 1/4 mile below Bliss Bridge.
(Same day as above.)

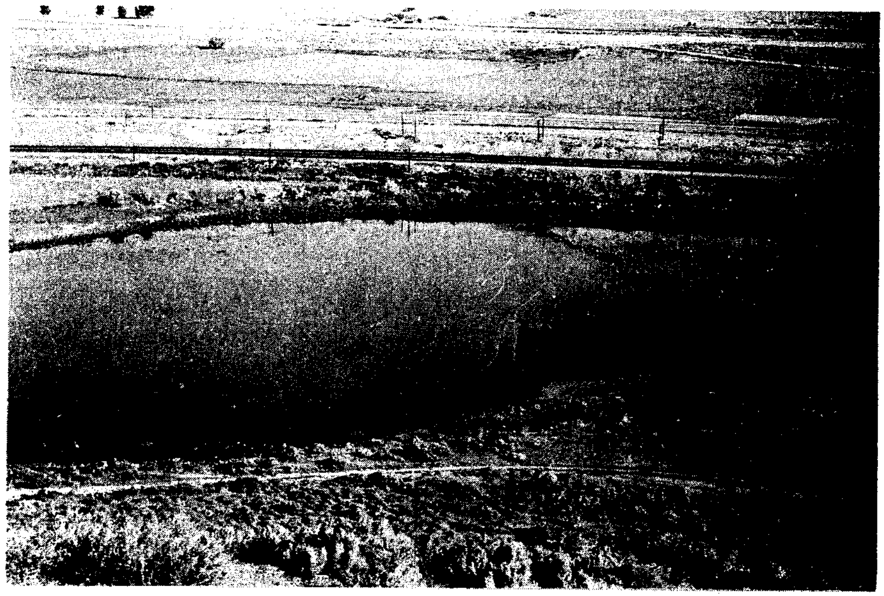


Plate 18. Low water flow of Bliss tailwater below King Hill Bridge.

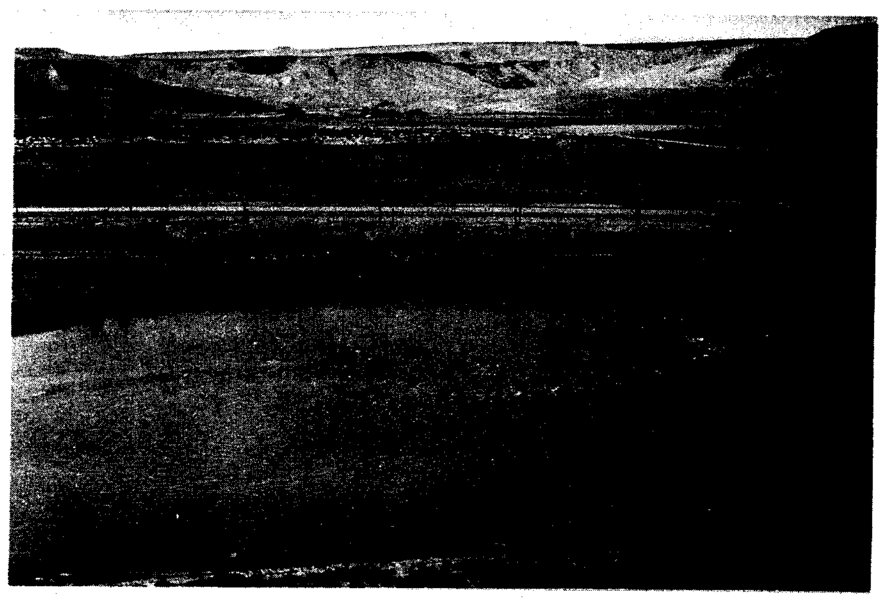


Plate 19. High water flow of Bliss tailwater below King Hill Bridge.
(Same day as Plate 18.)

Plate 20. Low water flow of Bliss tailwater near aquatic organism collection station 1/2 mile below King Hill Bridge.

Plate 21. High water flow of Bliss tailwater near aquatic organism collection station 1/2 mile below King Hill Bridge.
(Same day as Plate 20.)

Plate 22. Low water flow of Bliss tailwater near mouth of Alkali Creek.

Plate 23. High water flow of Bliss tailwater near mouth of Alkali Creek.
(Same day as Plate 22.)

Area within high flow - - - 343,000 square feet - - 100 per cent

Area within low flow - - - - 244,600 square feet - - 71 per cent

Area of fluctuation zone - - 98,400 square feet - - 29 per cent

The river bottom at the above station is composed of 50 per cent rubble, 40 per cent gravel and 10 per cent sand, soil and detritus.

The lower station for collection of aquatic organisms on the Bliss tailwater was located approximately one-third mile below Indian Cove bridge (Figure 11). The water levels of Bliss tailwater at this station are subject to moderate diurnal fluctuation (Table 6, Plates 26 to 29). Six square-foot bottom samples of aquatic organisms were collected each within the low and within the high water flows at this station during 1953 and 1954 (Table 17).

The low and high flows of the Bliss tailwater adjacent to the aquatic organism collection station below Indian Cove bridge were surveyed and plotted (Figure 18). The surface areas of the low and high flows and fluctuation zone within the mapped area were measured, as follows:

Area within high flow - - - 489,200 square feet - - 100 per cent

Area within low flow - - - - 451,700 square feet - - 92 per cent

Area of fluctuation zone - - 37,500 square feet - - 8 per cent

The bottom of the river at the above station was composed of 80 per cent rubble and 20 per cent sand, soil and detritus.

Drift organisms. In order to determine whether the fluctuation of tailwater flows had an effect on production of aquatic organisms by dislocation or movement of organisms due to changes in velocity and volume of flow, organisms drifting in the low and high flows of the Lower Salmon Falls and Bliss tailwaters were sampled.

Two drift organism nets were constructed of 24-gage galvanized iron. The mouth of each net has an area of one foot square (Plate 30) and screened spaces were provided along the rear sides of each net to decrease back pressure at the mouth (Plate 31). A detachable cup at the rear of the net allowed easy removal of the sample (Plate 32). A rope, chain and anchor facilitated the setting and recovery of the net (Plate 33).

The drift-organism nets would have been more efficient and less back pressure developed if the nets had been constructed more in the shape of a Wisconsin plankton net; that is, with an enlarged screened section immediately to the rear of the mouth.

Stations were established for the collection of drift organisms, as follows: Lower Salmon Falls tailwater: approximately one-half mile below Bliss bridge (Figure 6); Bliss tailwater: King Hill bridge (Figure 9), Slick bridge (Figure 10) and Indian Cove bridge (Figure 11). Two nets were set at each station during the high and during the low flow on the collection date of the Winter, Spring and Summer-Fall periods of 1953 and 1954. Sets were accomplished by lowering the two nets simultaneously into the water at each station until the anchors touched the bottom at which time the ropes were secured to the bank or bridge to hold the nets in

Table 17. Frequency of occurrence, number and volume (cubic centimeters) of aquatic organisms from six square-foot bottom samples each within the low and the high daily flows of the Bliss tailwater in the Indian Cove area during 1953-54.

Organisms	Low			High		
	Occurrence	Number	Volume	Occurrence	Number	Volume
Animals	6	826	13.4	5	63	0.5
Insecta	6	252	5.3	3	10	0.1
Coleoptera	5	35	0.5	...	...	...
Diptera	5	18	tr.	2	2	tr.
Ephemerida	6	59	0.5	2	5	tr.
Odonata	3	8	2.5	...	...	...
Trichoptera	6	132	1.8	2	3	0.1
Hydrachnidae	2	3	tr.	...	...	...
Amphipoda	6	351	1.2	3	20	0.2
Decapoda	1	1	1.5	...	...	...
Hirudinea	2	6	0.2	...	...	...
Tubificidae	2	9	tr.	4	8	0.1
Pulmonata	4	204	5.2	2	20	0.1
Pelecypoda	...	...	...	1	5	---

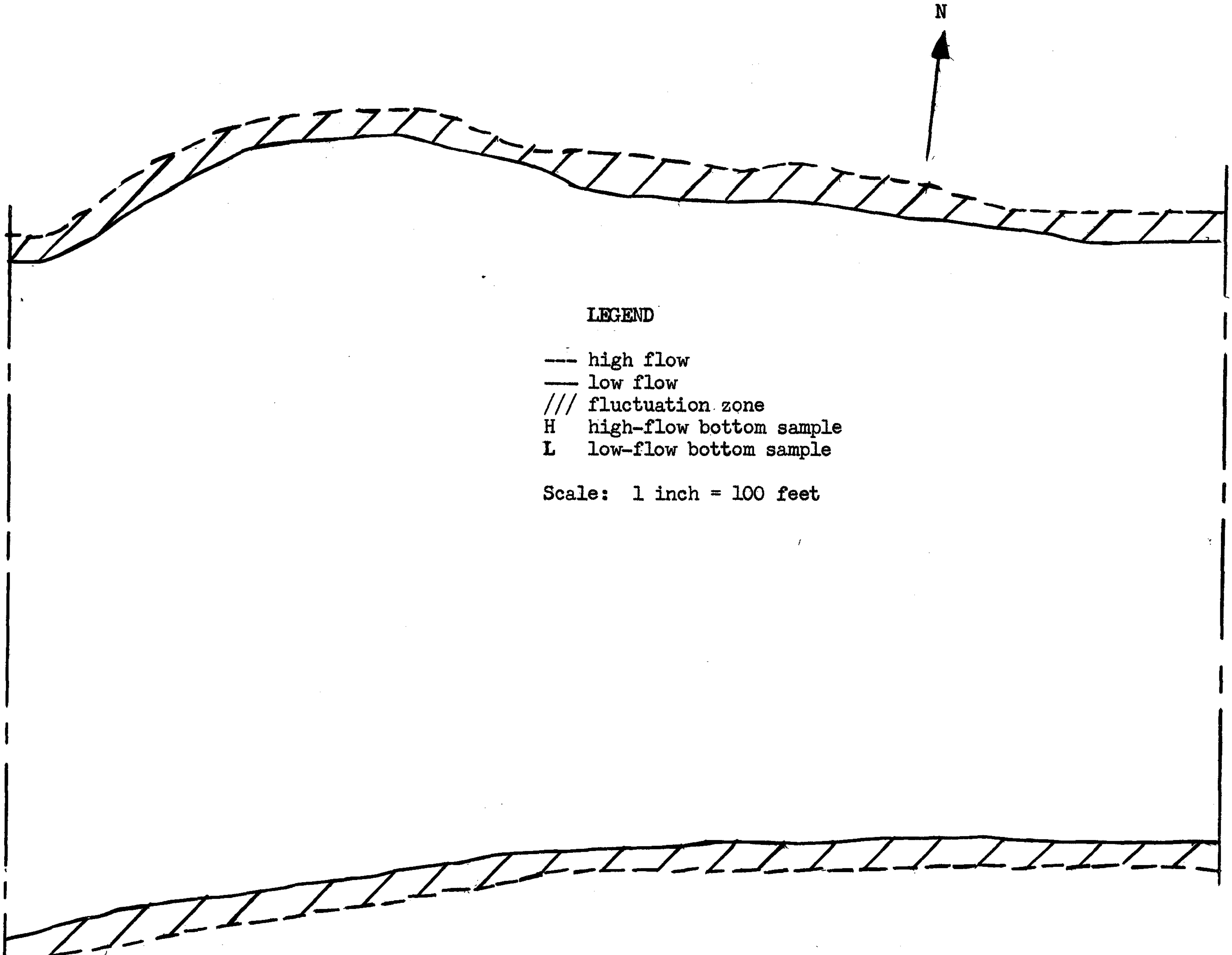


Figure 18. Fluctuation zone of Bliss tailwater in vicinity of bottom sample collections near Indian Cove Bridge.

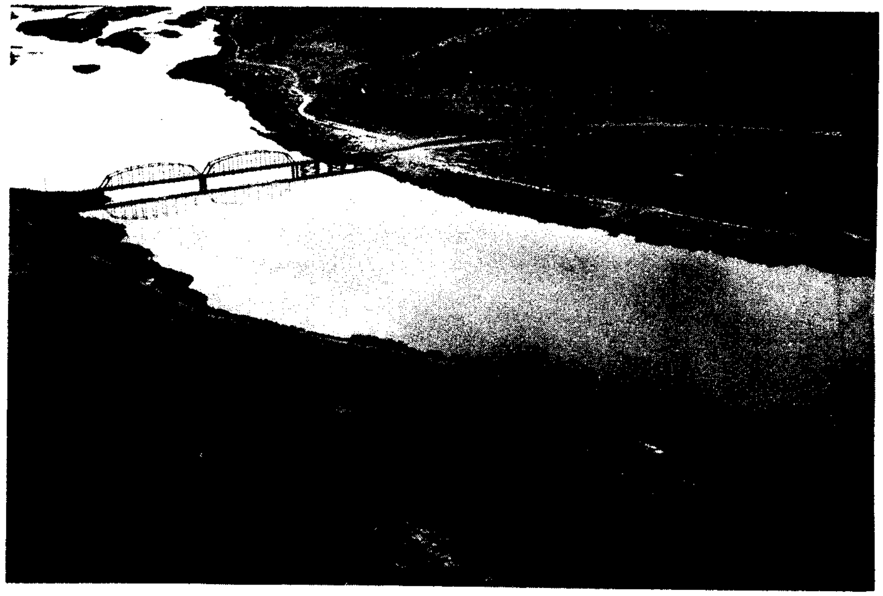


Plate 26. Low water flow of Bliss tailwater below Indian Cove Bridge.

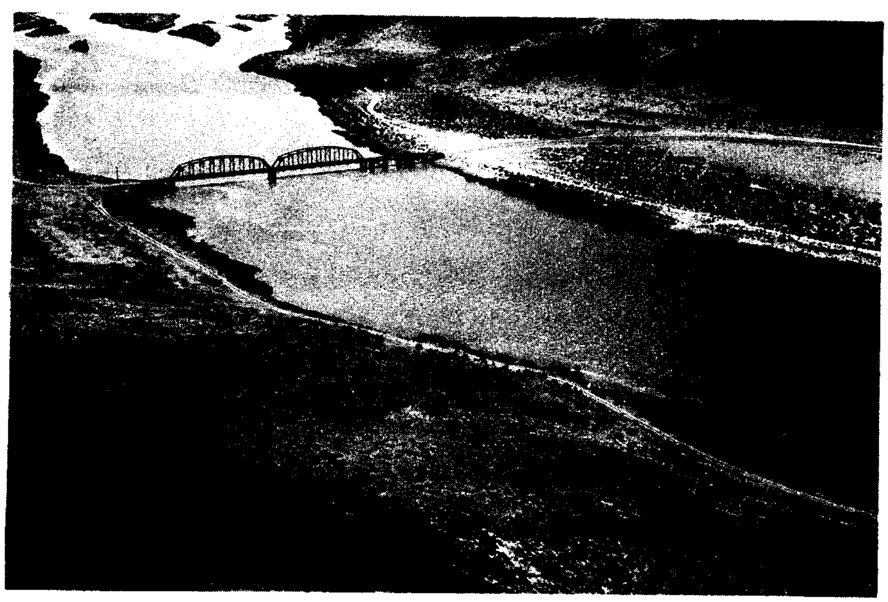


Plate 27. High water flow of Bliss tailwater below Indian Cove Bridge.
(Plates 26-27 taken same day.)

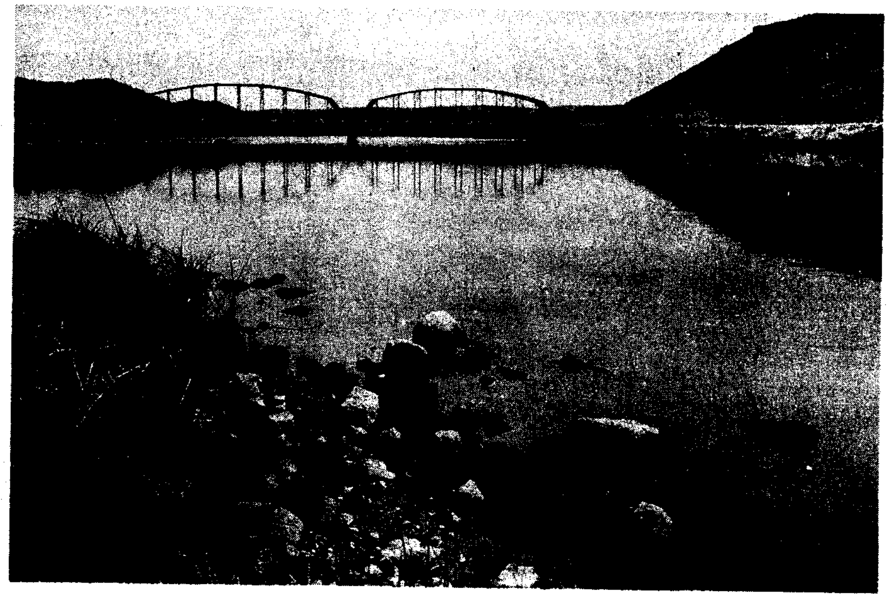


Plate 28. Low water flow of Bliss tailwater at aquatic organism collection station 1/3 mile below Indian Cove Bridge.

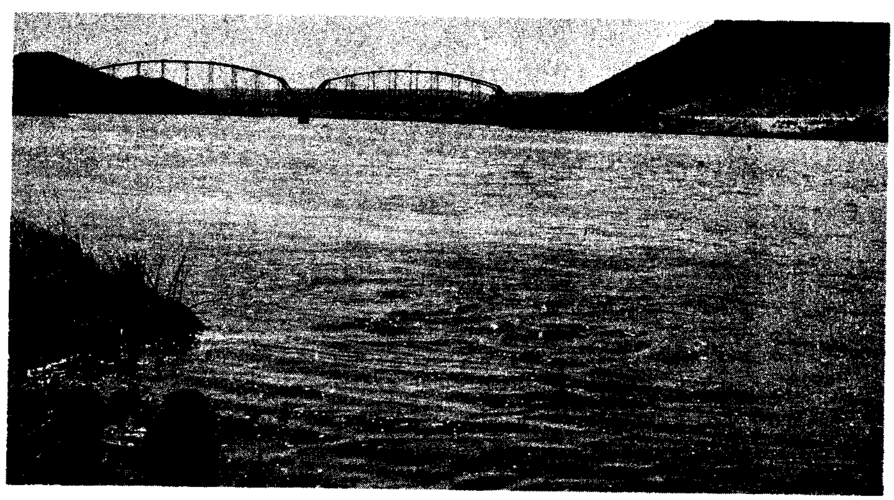


Plate 29. High water flow of Bliss tailwater at aquatic organism collection station 1/3 mile below Indian Cove Bridge. (Same day as Plate 28.)

Plate 32. Collection cup and method of its attachment to drift organism net.

Plate 33. Rope, chain and anchor are accessory equipment for operation of drift organism net.

position. As the nets were lowered into the water, the current forced the nets to swivel on their chains to a position with the mouths of the nets upstream. The nets were set side by side, as a unit, to eliminate some of the errors due to sampling. Nets were set in approximately the same location at each station during both high and low flow periods and, thus, drift-organism samples were collected from low flows at water depths of one to six feet and from high flows at water depths of four to ten feet.

The surface velocity of the tailwater current at each station during the set of drift nets in both low and high flows was measured by timing the movement of a float for a measured distance. The velocity of the current at the net site near the bottom was assumed to be the same as at the surface. During trial sets the net screens did not become clogged with debris enough to affect the sampling, if the sets were for a period of less than 30 minutes. For the purpose of this report and for standardization, it is assumed that at a surface current velocity of one foot a second, each net strained a cubic foot of water for each second of the period the net was set.

Samples were transferred from the nets to jars and labeled to correspond with information on the data card, which indicated river flow and elevation conditions at the time sample was taken. The samples were analyzed while fresh. Organisms in each sample were identified, counted, and volumes measured to the nearest 0.1 cubic centimeter by water displacement. Volumes less than 0.1 cubic centimeter were considered as traces (tr.).

In order that drift-net samples be more readily compared, the numbers and volumes of organisms sampled in each net were adjusted to the numbers and volumes that would have been strained from 5,000 cubic feet of water. A total of 48 drift-organism net samples of the low and of the high flows of tailwaters were collected during 1953 and 1954 and are tabulated in Tables 18 to 21.

Vegetative material from each drift-net sample collected during 1954 was placed between paper towels to remove as much moisture as possible, put in a tin cup and placed in a preheated oven which was maintained at 180° Fahrenheit for a period of 4-1/2 hours. The oven-dry samples were then weighed on a laboratory balance to the nearest 0.005 gram. In order that weights of samples be more comparable, all were adjusted to weights that would have been strained from 5,000 cubic feet of water (Table 22).

Impoundments and Reservoirs

Bottom organisms. The production of aquatic organisms on the bottoms of impoundments and reservoirs was determined by sampling the bottom at selected stations with an Ekman dredge during each of the Winter, Spring and Summer-Fall periods of 1953 and 1954 (Figures 3, 5, 7 and 13).

Each collection at each station consisted of three samples; one from the shallow area near the shore, one from the deeper area, and one from an intermediate depth area. The three samples were mixed together and strained through a 14-mesh screen, transferred to a bottle, formalin added to preserve the sample and the contents labeled to correspond with information on the data card.

Organisms of each dredge sample were identified, counted and volumes measured to the nearest 0.1 cubic centimeter by water displacement. Volumes less than 0.1 cubic centimeter and percentages less than 0.5 were considered as traces. Fresh-

Table 18. Frequency of occurrence, number and volume (cubic centimeters) of aquatic organisms from 12 drift-organism net samples each of the low and of the high flows of Lower Salmon Falls tailwater below the Bliss bridge during the 1953-54 period.

Organisms	Low			High		
	Occurrence	Number	Volume	Occurrence	Number	Volume
Animals	8	83	0.9	8	56	0.8
Insecta	7	43	0.4	5	18	0.2
Coleoptera	1	4	tr.	...	...	...
Diptera	3	6	tr.	...	...	...
Ephemerida	1	2	tr.	2	4	tr.
Trichoptera	5	31	0.4	5	14	0.2
Amphipoda	3	5	tr.	2	3	tr.
Hydrachnidae	1	2	tr.	...	...	...
Pulmonata	4	25	0.4	3	34	0.6
Tubificidae	1	8	0.1	2	2	tr.
Pisces	...	...	...	1	1	tr.

Table 19. Frequency of occurrence, number and volume (cubic centimeters) of aquatic organisms from 12 drift-organism net samples each of the low and of the high flows of Bliss tailwater below the King Hill bridge during the 1953-54 period.

Organisms	Low			High		
	Occurrence	Number	Volume	Occurrence	Number	Volume
Animals	4	25	0.1	8	17	tr.
Insecta	2	12	0.1	6	12	tr.
Coleoptera	...	...	...	3	5	tr.
Diptera	...	...	...	1	4	tr.
Ephemerida	2	12	0.1	3	3	tr.
Amphipoda	1	3	tr.	2	2	tr.
Hydrachnidae	...	...	...	1	1	tr.
Pulmonata	1	3	tr.	...	...	...
Tubificidae	2	7	tr.	...	...	...
Pisces	...	...	...	1	1	tr.

Table 20. Frequency of occurrence, number and volume (cubic centimeters) of aquatic organisms from 12 drift-organism net samples each of the low and of the high flows of Bliss tailwater below the Slick bridge during the 1953-54 period.

Organisms	Low			High		
	Occurrence	Number	Volume	Occurrence	Number	Volume
Animals	3	127	1.1	10	116	0.7
Insecta	2	126	1.1	9	95	0.6
Coleoptera	...	...	...	2	4	tr.
Diptera	1	13	tr.	5	48	0.1
Ephemerida	2	75	0.6	3	7	tr.
Plecoptera	...	...	...	1	1	tr.
Trichoptera	2	38	0.5	8	35	0.5
Amphipoda	...	...	...	3	7	tr.
Tubificidae	1	1	tr.	3	14	0.1

Table 21. Frequency of occurrence, number and volume (cubic centimeters) of aquatic organisms from 12 drift-organism net samples each of the low and of the high flows of Bliss tailwater below the Indian Cove bridge during the 1953-54 period.

Organisms	Low			High		
	Occurrence	Number	Volume	Occurrence	Number	Volume
Animals	6	26	0.2	3	23	0.1
Insecta	4	12	0.1	3	15	0.1
Diptera	3	5	tr.	2	6	tr.
Ephemerida	1	1	tr.	1	1	tr.
Trichoptera	1	6	0.1	2	8	0.1
Amphipoda	1	2	tr.	2	6	tr.
Hydrachnidae	...	...	...	1	2	tr.
Pulmonata	2	4	tr.	...	...	...
Tubificidae	2	8	0.1	...	...	...

Table 22. Mean oven-dry weight (grams) of vegetation collected of two drift-net samples each of the low and of the high flows of Lower Salmon Falls and Bliss tailwaters during the Winter, Spring and Summer-Fall periods of 1954.

Area and period	Low	High
Lower Salmon Falls tailwater		
Bliss bridge		
Winter	0.04	0.42
Spring	0.24	0.07
Summer-Fall	0.27	0.52
Bliss tailwater		
King Hill bridge		
Winter	0.01	0.12
Spring	0.04	0.35
Summer-Fall	0.29	0.89
Slick bridge		
Winter	0.13	1.56
Spring	0.35	0.58
Summer-Fall	0.27	1.98
Indian Cove bridge		
Winter	0.49	3.50
Spring	0.67	2.92
Summer-Fall	0.17	0.72
Total	2.97	13.63

water mussels (Pelecypoda) were counted; but the volumes were not measured. A total of 141 dredge samples were collected from the bottom areas of impoundment and reservoir environments during the 1953-54 period and are shown in tabular form in Tables 23 to 27.

In general, the bottoms of impoundments and reservoirs are composed of sand, soil and detritus with gravel and rubble present in areas of high water velocities. Small rubble composes 50 per cent of the bottom of Upper Salmon Falls impoundment. Portions of the bottom of the Bruneau arm of C. J. Strike reservoir, hayfields prior to inundation in 1952, were quite hard and habitat for aquatic bottom organisms was thought to be limited.

Plankton. The production of plankton in impoundment and reservoir areas was sampled at selected stations with a 200-mesh Wisconsin plankton net during the Winter, Spring and Summer-Fall periods of 1953 and 1954 (Figures 3, 5, 7 and 13). Each sample was collected by towing the plankton net at a rate of one meter per second for a period of 100 seconds through the upper 10-foot stratum of water. The plankton samples were transferred to a vial, preserved in a five per cent solution of formalin and the contents labeled to correspond with information on the data card. The volume of plankton in each sample was measured according to methods described by Reighard (Ward and Whipple, 1918). A total of 33 plankton samples was collected from impoundment and reservoir areas during the 1953-54 period.

Diatoms and green algae were abundant and copepods and cladocerans virtually absent from plankton samples collected from impoundments and the upper section of the Snake River arm of C. J. Strike reservoir. Diatoms and green algae were abundant, copepods common and cladocerans scarce in the lower section of the Snake River arm of C. J. Strike reservoir. Diatoms and green algae were abundant in the Bruneau River arm of C. J. Strike reservoir during the Winter and Spring periods of 1953, but blue-green algae, copepods and cladocerans were common to abundant during the Summer-Fall period of 1953. In the Bruneau River arm of C. J. Strike reservoir during 1954, diatoms, green algae and copepods were common during the Winter period and blue-green algae, copepods and cladocerans common to abundant during the Spring and Summer-Fall periods (Table 28).

Utilization of Aquatic Organisms

Tailwaters

Utilization of aquatic organisms produced in tailwater environments was determined by analysis of the stomach contents of 120 rainbow trout and 6 Rocky Mountain whitefish caught from tailwater environments of Snake River during the 1953-54 period (Tables 29 and 30).

One sturgeon stomach contained approximately a quart of snails, but the remainder of the few sturgeon stomachs collected were empty.

Impoundments and Reservoirs

Utilization of aquatic organisms produced in impoundment and reservoir environments was determined by analysis of the stomach contents of 146 rainbow trout and 32 Rocky Mountain whitefish caught from the impoundments and reservoirs of Snake River during the 1953-54 period (Tables 30 and 31). Since most large-

Table 23. Frequency of occurrence, number and volume (cubic centimeters) of aquatic organisms sampled with a 6- by 6-inch Ekman dredge from 10 square feet of bottom of Upper Salmon Falls impoundment during the 1953-54 period.

Organisms	Total			Per cent		
	Occurrence	Number	Volume	Occurrence	Number	Volume
Animals	10	2404	33.5	100	100	100
Insecta	10	501	2.0	100	21	6
Coleoptera	2	2	tr.	20	tr.	tr.
Diptera	7	482	1.8	70	20	5
Ephemerida	6	15	0.2	60	tr.	1
Trichoptera	2	2	tr.	20	tr.	tr.
Amphipoda	6	260	0.9	60	11	3
Hirudinea	7	33	0.3	70	1	1
Tubificidae	8	1225	6.4	80	51	19
Pulmonata	5	378	23.9	50	16	71
Pelecypoda	5	7	----	50	tr.	---

Table 24. Frequency of occurrence, number and volume (cubic centimeters) of aquatic organisms sampled with a 6- by 6-inch Ekman dredge from 12 square feet of bottom of Lower Salmon Falls impoundment during the 1953-54 period.

Organisms	Total			Per cent		
	Occurrence	Number	Volume	Occurrence	Number	Volume
Animals	12	3754	17.5	100	100	100
Insecta	12	349	2.5	100	9	14
Diptera	12	348	2.5	100	9	14
Trichoptera	1	1	tr.	9	tr.	tr.
Hydrachnidae	2	9	tr.	17	tr.	tr.
Amphipoda	2	11	tr.	17	tr.	tr.
Hirudinea	5	43	2.2	42	1	13
Tubificidae	12	3320	12.6	100	88	72
Pulmonata	2	17	0.2	17	tr.	1
Pelecypoda	2	5	----	17	tr.	---

Table 25. Frequency of occurrence, number and volume (cubic centimeters) of aquatic organisms sampled with a 6- by 6-inch Ekman dredge from 10 square feet of bottom of Bliss impoundment during the 1953-54 period.

Organisms	Total			Per cent		
	Occurrence	Number	Volume	Occurrence	Number	Volume
Animals	10	4578	13.4	100	100	100
Insecta	10	645	3.3	100	14	25
Coleoptera	1	1	0.1	10	tr.	tr.
Diptera	10	628	3.2	100	14	25
Ephemerida	2	5	tr.	20	tr.	tr.
Odonata	4	11	tr.	40	tr.	tr.
Hydrachnidae	2	4	tr.	20	tr.	tr.
Amphipoda	4	29	tr.	40	1	tr.
Hirudinea	7	103	1.1	70	2	8
Tubificidae	9	3754	8.2	90	82	61
Pulmonata	6	40	0.8	60	1	6
Pelecypoda	3	3	----	30	tr.	---

Table 26. Frequency of occurrence, number and volume (cubic centimeters) of aquatic organisms sampled with a 6- by 6-inch Ekman dredge from 11 square feet of bottom of the upper section of the Snake River arm of C. J. Strike reservoir during the 1953-54 period.

Organisms	Total			Per cent		
	Occurrence	Number	Volume	Occurrence	Number	Volume
Animals	11	347	1.7	100	100	100
Insecta	5	59	0.5	45	17	29
Diptera	4	57	0.5	36	17	29
Odonata	1	1	tr.	9	tr.	tr.
Trichoptera	1	1	tr.	9	tr.	tr.
Hydrachnidae	1	1	tr.	9	tr.	tr.
Hirudinea	1	1	tr.	9	tr.	tr.
Tubificidae	4	278	1.1	36	80	65
Pulmonata	2	8	0.1	18	3	6

Table 27. Frequency of occurrence, number and volume (cubic centimeters) of aquatic organisms sampled with a 6- by 6-inch Ekman dredge from 6 square feet of bottom of the Bruneau River arm of C. J. Strike reservoir during the 1953-54 period.

Organisms	Total			Per cent		
	Occurrence	Number	Volume	Occurrence	Number	Volume
Animals	6	313	0.5	100	100	100
Insecta	4	257	0.4	67	82	80
Diptera	4	255	0.4	67	81	80
Ephemerida	1	2	tr.	17	1	tr.
Amphipoda	1	2	tr.	17	1	tr.
Hirudinea	2	3	tr.	34	1	tr.
Tubificidae	4	51	0.1	67	16	20

Table 28. Volumes of plankton sampled from upper 10-foot strata of impoundment and reservoir waters of Snake River during 1953 and 1954 (expressed in cubic centimeters per cubic meter).

Areas	1953			1954		
	Winter	Spring	Summer-Fall	Winter	Spring	Summer-Fall
Upper Salmon Falls impoundment	1.0	...	0.6	...	...	...
Lower Salmon Falls impoundment	0.1	4.6	0.1	...	...	...
Bliss impoundment	0.3	...	0.8	...	...	...
C. J. Strike reservoir						
Snake River arm						
Upper section	1.3	4.4	0.4	0.8	...	...
Lower section	...	...	...	3.5	3.5	15.5
Bruneau River arm	3.0	9.5	4.8	4.5	10.0	21.0
Swan Falls impoundment	0.1	0.2	0.1	...	...	...

Table 29. Frequency of occurrence and number of aquatic organisms from stomachs of 120 rainbow trout sampled from Upper Salmon Falls, Lower Salmon Falls, Bliss and C. J. Strike tailwaters during the 1953-54 period. Data presented on the basis of 100 stomachs per area.

Organisms	Upper Salmon Falls tailwater (n=33)		Lower Salmon Falls tailwater (n=18)		Bliss tailwater (n=32)		C. J. Strike tailwater (n=37)	
	Occurrence	Number	Occurrence	Number	Occurrence	Number	Occurrence	Number
Animals	100	2366	96	3038	84	2336	84	2690
Insecta	100	1699	96	2573	69	2036	76	2233
Coleoptera	61	182	22	17	34	225	5	8
Diptera	76	688	96	758	56	888	54	1357
Ephemerida	39	103	44	653	41	494	..	....
Hemiptera	21	48	4	17	3	3	..	....
Hymenoptera	18	24	..	....	6	16	3	3
Odonata	36	48	22	28	..	....	..	....
Plecoptera	...	....	..	....	6	41	..	....
Trichoptera	79	606	89	1100	50	369	43	865
Hydrachnidae	...	....	..	....	6	6	3	3
Amphipoda	45	567	11	55	19	22	22	111
Decapoda	3	3	6	6	..	....	..	....
Hirudinea	6	6	..	....	19	38	..	....
Oligochaeta[1]	...	....	..	....	6	6	..	....
Pulmonata	21	73	7	394	25	128	14	57
Pisces	3	3	10	10	6	6	5	6
Trout eggs	3	15	..	....	3	94	14	280
Plants	15	----	30	----	41	----	65	----

[1] Not Tubificidae

Table 30. Frequency of occurrence and number of aquatic organisms from stomachs of the 38 Rocky Mountain whitefish sampled from Upper Salmon Falls and Lower Salmon Falls impoundments and the Bliss tailwater during the 1953-54 period. Data presented on the basis of 100 stomachs per area.

Organisms	Upper Salmon Falls impoundment (n=11)		Lower Salmon Falls impoundment (n=21)		Bliss tailwater (n=6)	
	Occurrence	Number	Occurrence	Number	Occurrence	Number
Animals	100	12326	86	10123	100	6067
Insecta	82	472	81	1242	100	5584
Coleoptera	18	45	10	14	100	2700
Diptera	55	155	67	976	50	850
Ephemerida	18	82	14	19	83	567
Hemiptera	9	9	..	.....	...	....
Odonata	9	36	38	233	...	....
Trichoptera	18	145	..	.....	83	1467
Hydrachnidae	9	9	5	10	...	....
Amphipoda	73	10782	62	7871	33	450
Pulmonata	45	745	38	1000	17	33
Hirudinea	18	318	..	.....	...	....

Table 31. Frequency of occurrence and number of aquatic organisms from stomachs of 146 rainbow trout sampled from Upper Salmon Falls, Lower Salmon Falls and Bliss impoundments and the Snake River arm of C. J. Strike reservoir during the 1953-54 period. Data presented on the basis of 100 stomachs per area.

Organisms	Upper Salmon Falls impoundment (n=42)		Lower Salmon Falls impoundment (n=19)		Bliss impoundment (n=30)		Snake River arm C.J.Strike reservoir (n=55)	
	Occurrence	Number	Occurrence	Number	Occurrence	Number	Occurrence	Number
Animals	95	8938	89	915	90	1168	87	2710
Insecta	69	613	84	732	63	416	87	2706
Coleoptera	..	....	..	...	3	3	2	2
Diptera	26	260	84	732	53	267	87	2689
Ephemerida	10	10	..	...	13	133	2	2
Hemiptera	40	276	..	...	3	3	2	13
Odonata	26	48	..	...	9	10	..	....
Trichoptera	10	19	..	...	..	....	..	....
Hydrachnidae	2	176	..	...	..	....	..	....
Amphipoda	81	7855	32	84	3	3	2	2
Decapoda	2	2	..	...	..	....	..	....
Hirudinea	10	10	5	5	12	33	..	....
Oligochaeta[1]	..	....	..	...	9	13	..	....
Pulmonata	52	276	26	89	60	693	..	....
Pisces	6	6	5	5	9	10	2	2
Plants	10	----	37	---	27	----	76	----

[1] Not Tubificidae

mouth bass were caught during the Winter period, their stomachs were practically empty or the contents difficult to identify.

Stomachs of fish sampled from all environments were removed from the fish while fresh, transferred to a jar, preserved in 10 per cent formalin and labeled to correspond with information on the data card. The organisms from each stomach were identified and their numbers and frequency of occurrence noted. Plant material was not identified, but its presence in a stomach was listed as an occurrence.

Fish Movement

Migration

The word migration implies voluntary movement. The movement may be periodic or permanent. Migration of fish in Snake River usually concerns movement of adults to spawning areas for the purpose of reproduction and the drift of immature fish from nursery streams to other habitat areas. Sunfish, perch and carp, for example, move from deep to shallower water in localized areas for the purpose of reproduction. Trout, salmon, steelhead and whitefish, on the other hand, may travel from a few to several hundred miles for the purpose of reproduction.

Fishways have been provided at Swan Falls, Lower Salmon Falls (Plate 34), and Upper Salmon Falls (Plate 35) dams to permit the upstream passage of migrating fish. The fishway at Swan Falls dam is operative only during period when the water elevation of the forebay is at or near maximum.

Fish collected from the Upper Salmon Falls and the Lower Salmon Falls fishways, using a 2,500 watt direct current shocker, are tabulated in Tables 32 and 33. Equipment used and fish sampled from the Lower Salmon Falls fishway on April 28, 1955, are shown in Plates 36 and 37.

Dispersal

Dispersal implies involuntary movement, but includes voluntary action. In order to determine the effects of hydroelectric installations on the movement of legal-size, hatchery-reared rainbow trout, 5,000 rainbow trout that averaged 3.5 per pound and nine inches in length were marked with numbered metal strap tags locked around the lower jaw. One thousand of the tagged trout were released at the upper end of the Dolman Rapids area of Upper Salmon Falls tailwater. Four thousand tagged trout were released in Lower Salmon Falls impoundment, as follows: 2,000 at the Rod and Gun boat landing in the upper end of the impoundment; 1,000 at the Bell Rapids boat landing in the central portion of the impoundment; and, 1,000 at the boat landing in the lower end of the impoundment near the dam (Figure 5).

The tags from fish were recovered during creel checks and through voluntary return by anglers. The location and date was recorded for each tag recovered. From these records, the number of tags returned has been tabulated by area and date of recovery (Tables 34 and 35).

Rate of Growth

Age and growth in length. Scale samples were collected from wild and hatchery-reared rainbow trout, whitefish, squawfish and largemouth bass selected at random

Table 32. Fish collected from the upper 10 pools of the fishway over the Upper Salmon Falls diversion dam by use of a 2500 watt electrical shocker.

Collection date	Numbers of fish collected			
	Immature Rainbow trout	Whitefish	Sculpin	Dace
May 12, 1954	2	..	..	..
October 16, 1954	3	..	..	3
November 30, 1954	2	..	2	..
March 3, 1955[1]	3	1	..	..

[1] Water drained from fishway pools. Fish observed, but not collected with shocker.

Table 33. Fish collected from the lower 13 pools of the fishway over Lower Salmon Falls dam by use of a 2500 watt electrical shocker.

Collection date	Number of fish collected						Remarks
	Rainbow trout[1]	White-fish	Sucker	Squaw-fish	Chisel-mouth	Dace	
January 6, 1954	2	..	..	..	...	..	
May 13, 1954	13	..	35	1	130	..	4 tagged rainbow
October 25, 1954	6	41	..	..	...	..	1 tagged rainbow
November 30, 1954	2	..	..	..	...	..	
January 27, 1955	3	..	3	..	...	..	
March 3, 1955	4	..	5	..	...	..	
April 28, 1955	4	..	5	1	...	1	

[1] All rainbow trout collected were immature. Analysis of organisms from stomachs of these trout indicated many of the trout had spent considerable time in the fishway.

Table 34. Return of 228 tags from 1000 tagged rainbow trout planted in Upper Salmon Falls tailwater on March 24, 1954.

Period tags recovered	Number of tags returned, by area of recovery			
	Upper Salmon Falls tailwater	Lower Salmon Falls impoundment	Lower Salmon Falls tailwater	Bliss impoundment
April 1954	169	..	2	1
May	37	2	1	1
June	1	..	1	..
July	1	2	..	..
August	..	1	..	..
September	1	..	..	..
October	..	1	3	..
November	..	2	..	..
December	..	..	..	..
January 1955	1	..	..	..
February	1	..	..	..
Total	211	8	7	2

Table 35. Return of 405 tags from 4000 tagged rainbow trout planted in Lower Salmon Falls impoundment on March 25, 1954.

Period tags recovered	Number of tags returned, by area of recovery						
	Upper Salmon Falls		Lower Salmon Falls		Bliss		C. J. Strike
	Impoundment	Tailwater	Impoundment	Tailwater	Impoundment	Tailwater	Tailwater
March 1954	..	..	6	..	..	..	..
April	..	15	51	49	11	..	..
May	..	4	19	33	11	..	..
June	..	..	18	18	3	..	..
July	..	..	28	1	..	..	..
August	..	..	5	12	..	..	..
September	..	4	4	20	1	1	1
October	..	..	12	21	..	..	..
November	..	4	23	5	..	..	..
December	..	1	4	..	..	..	..
January 1955	1	2	1	7	..	..	..
February	..	2	1	1	..	..	..
March	..	..	1	4	..	..	..
Total	1	32	173	171	26	1	1

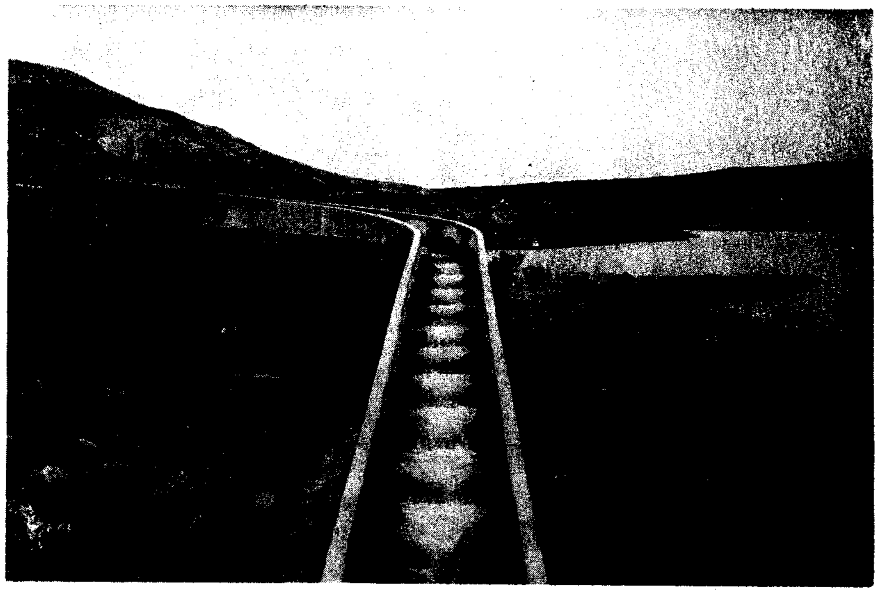


Plate 34. Normal water flow through fishway over Lower Salmon Falls Dam.

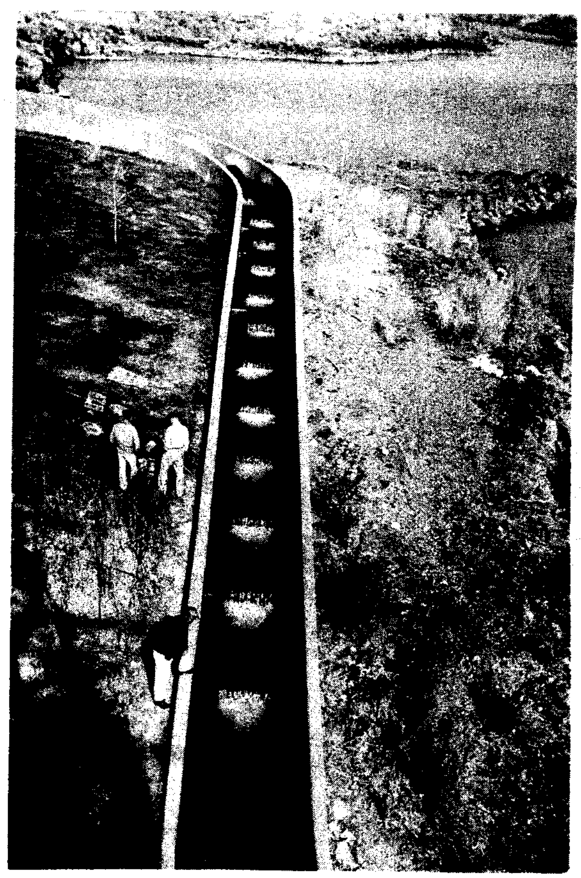


Plate 35. Reduced water flow in fishway over Lower Salmon Falls Dam in preparation for the collection of fish from pools with electrical shocker equipment.

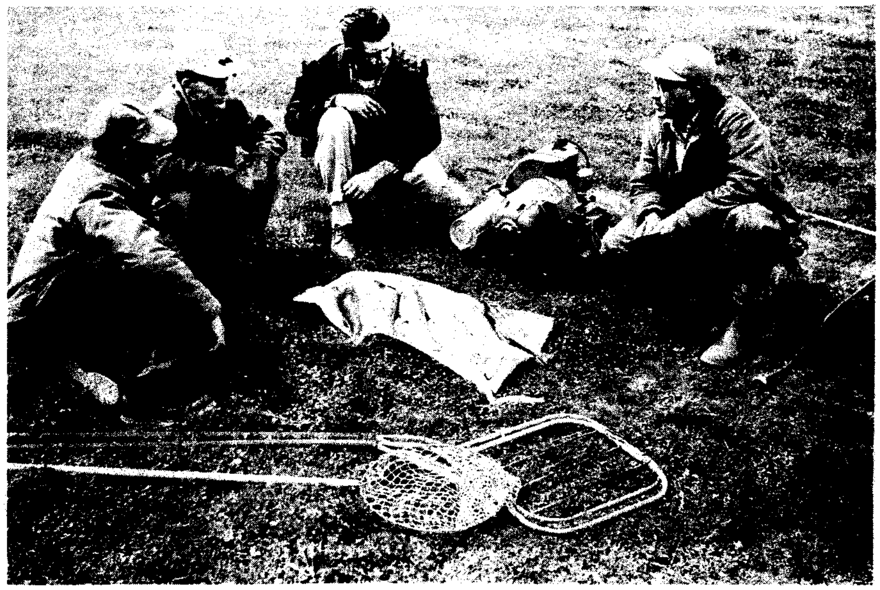


Plate 36. Dip net, electrodes and 2500 watt direct current electrical shocker used to collect fish from fishways.

Plate 37. Fish collected from lower 13 pools of fishway over Lower Salmon Falls Dam on April 28, 1955. Mature squawfish at left, ripe suckers in background and immature rainbow trout in foreground.

from the anglers' creels and gill-net, hoop-net, seine-haul and fishway collections. In addition to the scale samples from each fish, the date, location and method of capture, sex and total length were recorded.

Age and rate of growth in length of 80 wild and 40 hatchery-reared rainbow trout and 28 largemouth bass were determined by the conventional method of scale analysis (Tables 36 to 40). Wild rainbow trout were differentiated from hatchery-reared rainbow trout by the completeness of the fins, especially the dorsal. Since a few hatchery-reared rainbow trout had fins that were nearly complete at the time of stocking, it is possible that age and growth in length determinations for wild rainbow trout include some hatchery-reared rainbow trout. However, several thousand rainbow trout were examined in obtaining the samples of 80 wild trout.

Ages of sturgeon were determined by analysis of the growth rings in a thin cross-section of the bony part of the pectoral fin (Table 41).

Fish Populations

The species composition and numbers of fish in any body of water tend to fluctuate under natural conditions. Most of man's activities tend to accelerate these changes in fish populations; usually in the direction of reduced numbers of game fish. However, man's fish cultural activities tend to increase game fish numbers. The numbers of fish, by species, planted in Snake River within the study area during recent years have been tabulated in Tables 42 and 43.

Gill-net catches. Stations for sampling fish populations with gill nets were established in each impoundment and reservoir so that comparable sets could be made during 1953 and 1954 (Figures 3, 5, 7 and 13). Water depths at stations ranged from 15 to 40 feet. Gill nets were set periodically at each station during water-flow seasons designated as Winter, Spring and Summer-Fall.

The experimental linen gill nets used in these collections consisted of 35 feet each of 1-inch, 1-1/2-inch, and 2-inch mesh, bar measure. Gill nets were set for approximately 24 hours and the catch of each set adjusted to the 24-hour period. Catch figures and other pertinent data were recorded on a special form. A total of 64 gill-net sets were made in impoundment and reservoir areas during the 1953-54 period. The catch of fish, by species, in gill nets in each ecological area has been tabulated (Tables 44 to 49). Trace (Tr.) refers to less than 0.5 per cent in the sample.

A simple gill-net setting device was constructed to save time and thus increase efficiency in netting operations. The device was constructed of 3/8 inch iron pipe and consisted of two main parts: two arms to hold the gill net and a cradle to attach the arms into position on the boat. Each of the two arms is a pipe 18 inches in length. A 3-inch nipple, T-fitting and coupling are firmly screwed to one end of each arm (Plate 38) and a 3-inch nipple and elbow are attached, finger tight, to the other end of each arm (Plate 39). Keepers made of wood, lined with web strapping and with 3/4-inch holes drilled near the ends, are held in position on the arms by T-fittings screwed to the 3-inch nipples (Plate 40).

The lead line is looped onto one arm and the float line looped onto the other and both lines held firmly in place by the wooden keepers (Plate 41).

Table 36. Age and calculated total lengths and annual increments, in inches, of wild rainbow trout collected from tailwater environments of Snake River during 1953 and 1954.

Age group	Number of fish	Total length at capture	Calculated length at end of year of life 1	2	3	4	5
I	2	7.8	5.5	....	....	....	....
II	14	12.1	5.7	11.2	....	....	....
III	25	13.7	4.5	9.6	13.4	....	....
IV	2	19.9	5.3	11.8	18.5	19.9	....
V	2	20.2	6.7	11.1	13.9	17.0	19.2
Grand average			5.1	10.3	13.8	18.4	19.2
Increment			5.1	5.2	3.9	2.2	2.1
Number of fish			45	43	29	4	2

Table 37. Age and calculated total lengths and annual increments, in inches, of wild rainbow trout collected from impoundment-reservoir environment of Snake River area during 1953 and 1954.

Age group	Number of fish	Total length at capture	Calculated length at end of year of life 1	2	3	4	5
I	2	8.8	7.0	....	....	....	....
II	22	10.5	5.0	9.8	....	....	....
III	7	14.3	4.6	9.2	13.5	....	....
IV	2	17.8	6.5	11.3	15.3	16.8	....
V	2	19.9	5.5	12.3	15.6	19.0	19.9
Grand average			5.1	9.9	14.2	17.9	19.9
Increment			5.1	4.9	4.1	2.5	0.9
Number of fish			35	33	11	4	2

Table 38. Age and calculated total lengths and annual increments, in inches, of wild rainbow trout collected from tailwater, impoundment and reservoir environments of Snake River during 1953 and 1954.

Age group	Number of fish	Total length at capture	Calculated length at end of year of life				
			1	2	3	4	5
I	4	8.0	6.3	....	....	....	....
II	36	11.1	5.3	10.3	....	....	....
III	32	13.9	4.6	9.5	13.5	....	....
IV	4	18.8	5.9	11.5	16.9	18.3	....
V	4	20.0	6.1	11.7	14.8	18.0	19.5
Grand average			5.1	10.1	13.9	18.2	19.5
Increment			5.1	5.1	4.0	2.3	1.5
Number of fish			80	76	40	8	4

Table 39. Age and calculated total lengths and annual increments, in inches, of hatchery-reared rainbow trout collected from tailwater, impoundment and reservoir environments of Snake River during 1953 and 1954.

Age group	Number of fish	Total length at capture	Calculated length at end of year of life			
			1	2	3	4
I	3	8.3	6.2	....	....	....
II	26	10.6	5.1	10.0	....	....
III	9	13.4	4.7	9.2	13.1	....
IV	2	17.5	3.3	6.3	13.0	17.5
Grand average			5.0	9.6	13.1	17.5
Increment			5.0	4.7	4.4	4.5
Number of fish			40	37	11	2

Table 40. Age and calculated total lengths and annual increments, in inches, of largemouth bass collected from the Bruneau arm of C. J. Strike reservoir during 1953-54-55.

Age group	Number of fish	Total length at capture	Calculated length at end of year of life			
			1	2	3	4
II	16	10.9	6.2	10.9	....	....
III	9	13.2	5.6	10.4	13.2	....
IV	3	16.0	6.2	9.8	13.5	16.0
Grand average			6.0	10.6	13.3	16.0
Increment			6.0	4.6	3.0	2.5
Number of fish			28	28	12	3

Table 41. Age and total length at capture of seven white sturgeon from the Bliss tailwater of Snake River.

Date captured	Age	Sex	Total length (inches)
September 15, 1953	III	Undetermined	15
May 15, 1954	XI	Undetermined	45
September 8, 1953	XI	Undetermined	46
June 28, 1953	VII	Female	55
August 22, 1953	XXVIII	Male	75
September 5, 1953	XXIII	Female	90
July 18, 1953	XXX	Female	98

Table 42. Numbers of legal-size (12 per pound or larger) and fingerling (smaller than 12 per pound) rainbow trout planted in Snake River during years 1950 to 1954 inclusive, by ecological area.

Ecological area	1950		1951		1952		1953		1954	
	Legal-size	Finger-ling	Legal-size	Finger-ling	Legal-size	Finger-ling	Legal-size	Finger-ling	Legal-size	Finger-ling
Upper Salmon Falls impoundment	24,000	20,566	......	127,112	2,279	98,876	48,592	111,352	53,390	6,650
Upper Salmon Falls tailwater	3,960	40,000	165	....	.....	......	......	....	2,600	....
Lower Salmon Falls impoundment	6,645	10,000	......	11,224	.....	65,518	13,000	12,710	34,971	....
Lower Salmon Falls tailwater	10,034	35,000	......	....	.....	12,000	18,700	....	25,228	....
Bliss impoundment	......	......	......	....	.....	......	6,000	12,000	5,530	....
Bliss tailwater	9,920	14,688	......	57,880	2,750	400	22,600	....	18,820	....
C. J. Strike reservoir										
Snake River arm	......	5,400*	......	....	.....	......	......	218,000	23,400	115,361
C. J. Strike tailwater	......	......	......	....	.....	......	......	....	2,472	....
Swan Falls tailwater	......	......	......	....	.....	......	......	....	2,490	....
Totals	54,559	125,654	165	196,216	5,029	176,794	108,892	354,062	168,901	122,011

* Pre-impoundment plant.

Table 44. Species composition of the fish catch in Upper Salmon Falls impoundment in two gill-net sets in each Winter and Summer-Fall period of 1953 and 1954.

Species	Number		Per cent of total fish	
	1953	1954	1953	1954
Game fish				
Rainbow trout	4	6	1	2
Rocky Mountain whitefish	68	25	18	6
Yellow perch	...	2	...	1
Total game fish	72	33	19	9
Non-game fish				
Chiselmouth	42	31	11	8
Chub	107	129	28	35
Squawfish	55	41	15	11
Sucker	101	137	27	37
Total non-game fish	305	338	81	91
Total fish	377	371	100	100

Table 45. Species composition of the fish catch in Lower Salmon Falls impoundment in two gill-net sets in each Winter, Spring and Summer-Fall period of 1953 and of 1954.

Species	Number		Per cent of total fish	
	1953	1954	1953	1954
Game fish				
Rainbow trout	3	13	1	2
Rocky Mountain whitefish	68	89	14	17
Bluegill sunfish	1	...	tr.	...
Yellow perch	22	...	5	...
Total game fish	94	102	20	19
Non-game fish				
Carp	1	...	tr.	...
Chiselmouth	9	11	2	2
Chub	100	63	21	12
Squawfish	69	38	15	7
Sucker	199	322	42	60
Total non-game fish	378	434	80	81
Total fish	472	536	100	100

Table 46. Species composition of the fish catch in Bliss impoundment in two gill-net sets in each Winter and Summer-Fall period of 1953 and of 1954.

Species	Number		Per cent of total fish	
	1953	1954	1953	1954
Game fish				
Rainbow trout	17	18	3	10
Rocky Mountain whitefish	4	...	1	...
Brown bullhead	2	1	tr.	1
Bluegill sunfish	4	...	1	...
Yellow perch	18	1	4	1
Total game fish	45	20	9	12
Non-game fish				
Carp	1	...	tr.	...
Chiselmouth	22	1	5	1
Chub	25	11	5	6
Squawfish	11	3	2	2
Sucker	399	145	79	79
Total non-game fish	458	160	91	88
Total fish	503	180	100	100

Table 47. Species composition of the fish catch in the upper section of the Snake River arm of C. J. Strike reservoir in two gill-net sets in each Winter, Spring and Summer-Fall period of 1953 and of 1954.

Species	Number		Per cent of total fish	
	1953	1954	1953	1954
Game fish				
Brown bullhead	1	1	1	1
Black crappie	...	1	...	1
Yellow perch	...	1	...	1
Total game fish	1	3	1	3
Non-game fish				
Carp	4	18	3	10
Chiselmouth	2	2	2	1
Chub	11	12	10	7
Squawfish	79	31	68	18
Sucker	18	102	16	61
Total non-game fish	114	165	99	97
Total fish	115	168	100	100

Table 48. Species composition of the fish catch in the lower section of the Snake River arm of C. J. Strike reservoir in two gill-net sets in each Winter, Spring and Summer-Fall period of 1953 and 1954.

Species	Number		Per cent of total fish	
	1953	1954	1953	1954
Game fish				
Rocky Mountain whitefish	4	1	1	tr.
White sturgeon	2	...	1	...
Brown bullhead	32	57	11	9
Black crappie	...	1	...	tr.
Largemouth bass	14	...	5	...
Total game fish	52	59	18	10
Non-game fish				
Carp	72	125	24	21
Chiselmouth	...	10	...	2
Chub	...	24	...	4
Squawfish	82	148	28	24
Sucker	90	237	30	39
Total non-game fish	244	544	82	90
Total fish	296	603	100	100

Table 49. Species composition of the fish catch in the Bruneau River arm of C. J. Strike reservoir in two gill-net sets in each Winter, Spring and Summer-Fall period of 1953 and of 1954.

Species	Number		Per cent of total fish	
	1953	1954	1953	1954
Game fish				
Brown bullhead	26	42	13	10
Yellow perch	2	1	1	tr.
Total game fish	28	43	14	10
Non-game fish				
Carp	10	139	5	33
Chiselmouth	...	1	...	tr.
Chub	32	53	16	12
Squawfish	50	29	25	7
Sucker	80	163	40	38
Total non-game fish	172	385	86	90
Total fish	200	428	100	100

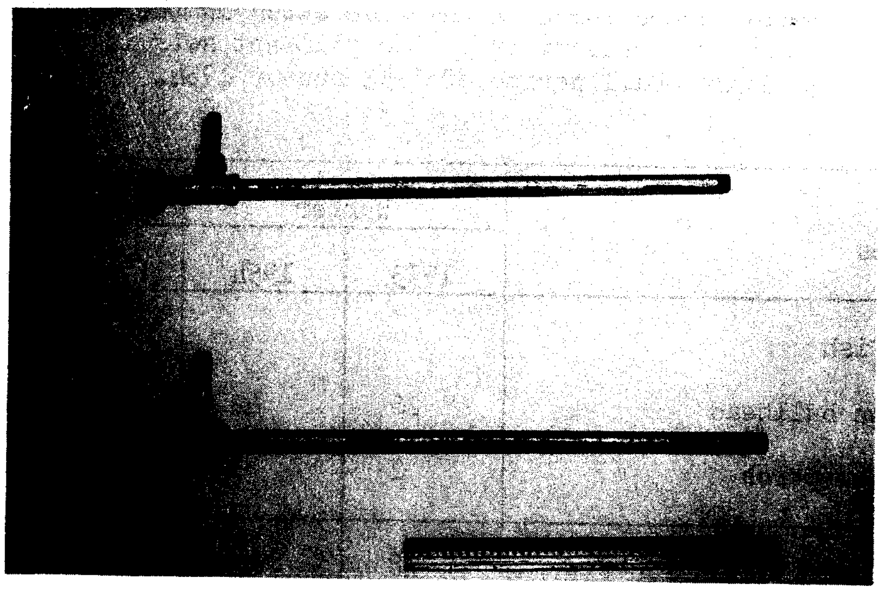


Plate 38. Horizontal arms of gill net setting device.

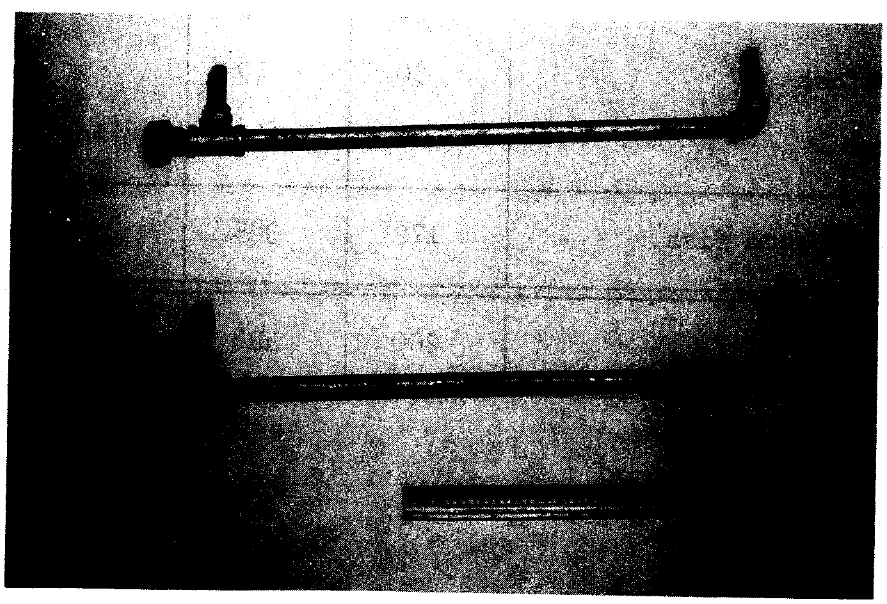


Plate 39. Horizontal arms of gill net setting device with removable vertical arms attached.

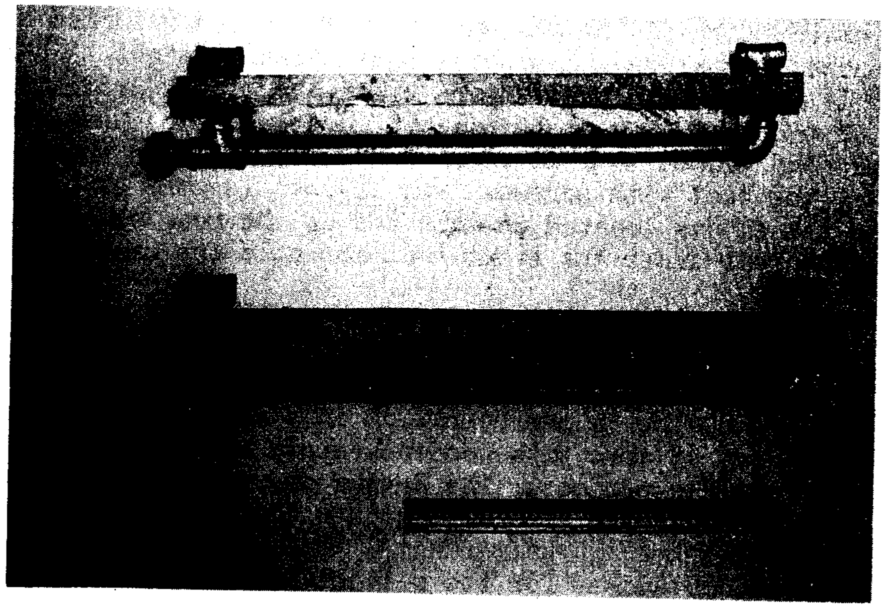


Plate 40. Horizontal arms of gill net setting device with wooden keepers held in place with T-fittings.

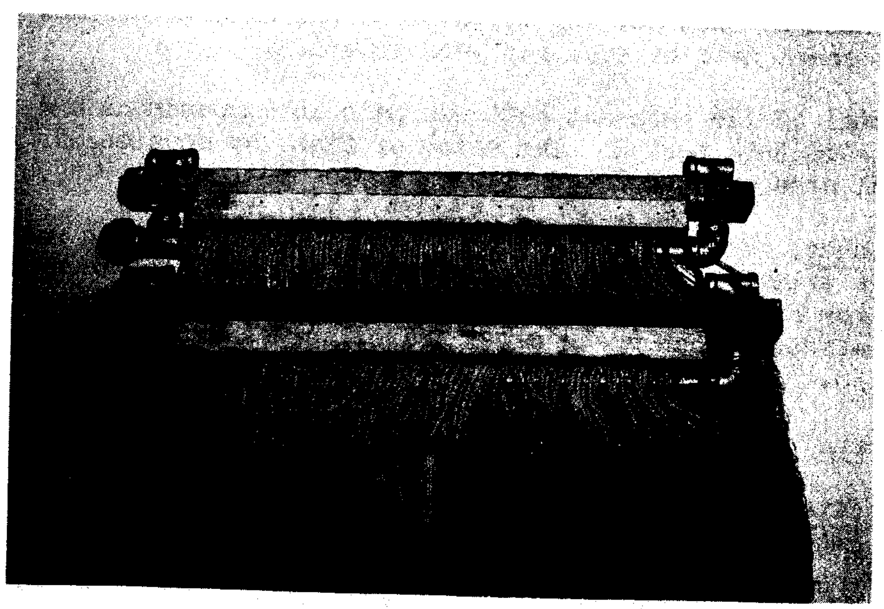


Plate 41. Lead and float lines of gill net looped on horizontal arms and held firmly in place by wooden keepers.

The cradle part of the gill-net setting device was also constructed of 3/8-inch pipe, but since it supports considerable weight, 3/4-inch pipe would provide better support. The forward cross-arm of the cradle is supported at the prow of the boat by a short piece of one-inch pipe that was cut in half, lengthwise, and welded to a 12-inch strip of strap iron which was attached to the prow of the boat with screws. Two 12-inch lengths of pipe, screwed finger tight into the elbows located on each end of the rear cross-arm of the cradle, extend to the rear under the front seat and hold the cradle in position (Plate 42).

One man is able to set a gill net with ease by use of this device (Plates 43 and 44) and fish can be removed from the gill net and the gill net restrung onto the setting device in one operation in a minimum of time and space (Plate 45). A set of arms with wooden keepers was constructed for each of the two nets used on this project. The drying and transport of gill nets were facilitated by keeping the nets strung onto the arms during periods of nonuse.

Hoop-net catches. Stations for the collection of hoop-net samples of the fish populations in shallow waters were established in each impoundment and reservoir (Figures 3, 5, 7 and 13). Hoop nets were set at each station according to the water flow seasons.

Hoop nets of one-inch mesh, bar measure, were set in waters four to eight feet in depth. A hoop net of 1/4-inch mesh, bar measure, was set in waters three to six feet in depth. They were set for periods of approximately 24 hours and the catch of each set was adjusted to the 24-hour period. Catch figures and other pertinent data of each set were recorded.

A total of 116 hoop-net sets was made in impoundment and reservoir areas during the 1953-54 period. The catch of fish, by species, in hoop nets in each ecological area was tabulated (Tables 50 to 55).

Seine catches. Several hauls with a 5 x 60-foot, 1/4 inch mesh, bar measure, seine were attempted. The seine proved to be too small to collect adequate samples from Snake River. Catches from seine hauls by commercial fishermen using 200-foot, 2-inch mesh, bar measure, seines were recorded and are shown in Table 56.

Creel Census

Types of data collected. Creel census data were collected from fishermen by personal interview. The kinds of data collected were:

1. Number of fishermen for each ecological area each census date.

2. Number of fish caught, by species, for each fisherman checked.

3. Number of hours fished by each fisherman at time checked.

Table 50. Species composition of the fish catch in 16 hoop-net sets in Upper Salmon Falls impoundment during the 1953-54 period.

Species	Number	Per cent of total fish
Game fish		
Rocky Mountain whitefish	26	2
Bluegill sunfish	5	tr.
Largemouth bass	1	tr.
Total game fish	32	2
Non-game fish		
Carp	23	2
Chiselmouth	20	2
Chub	667	49
Shiner	359	26
Squawfish	43	3
Sucker	223	16
Total non-game fish	1335	98

Table 51. Species composition of the fish catch in 21 hoop-net sets in Lower Salmon Falls impoundment during the 1953-54 period.

Species	Number	Per cent of total fish
Game fish		
Rocky Mountain whitefish	4	2
Total game fish	4	2
Non-game fish		
Chiselmouth	7	4
Chub	16	8
Shiner	131	66
Squawfish	1	tr.
Sucker	40	20
Total non-game fish	195	98

Table 52. Species composition of the fish catch in 25 hoop-net sets in Bliss impoundment during the 1953-54 period.

Species	Number	Per cent of total fish
Game fish		
Rainbow trout	6	2
Brown bullhead	6	2
Channel catfish	1	tr.
Bluegill sunfish	8	2
Green sunfish	2	tr.
Redear sunfish	1	tr.
Largemouth bass	1	tr.
Yellow perch	6	2
Total game fish	31	8
Non-game fish		
Carp	4	1
Chiselmouth	11	3
Chub	6	2
Dace	2	tr.
Shiner	54	14
Squawfish	75	19
Sculpin	3	1
Sucker	204	52
Total non-game fish	359	92

Table 53. Species composition of the fish catch in 19 hoop-net sets in the upper section of the Snake River arm of C. J. Strike reservoir during the 1953-54 period.

Species	Number	Per cent of total fish
Game fish		
Brown bullhead	5	4
Total game fish	5	4
Non-game fish		
Carp	31	23
Chiselmouth	36	27
Chub	1	1
Dace	5	4
Shiner	1	1
Squawfish	3	2
Sucker	50	38
Total non-game fish	127	96

Table 54. Species composition of the fish catch in 10 hoop-net sets in the lower section of the Snake River arm of C. J. Strike reservoir during the 1954 period.

Species	Number	Per cent of total fish
Game fish		
Brown bullhead	25	43
Black crappie	1	2
Total game fish	26	45
Non-game fish		
Carp	24	41
Sucker	8	14
Total non-game fish	32	55

Table 55. Species composition of the fish catch in 25 hoop-net sets in the Bruneau River arm of C. J. Strike reservoir during the 1953-54 period.

Species	Number	Per cent of total fish
Game fish		
Brown bullhead	737	67
Black crappie	8	1
Green sunfish	4	tr.
Pumpkinseed sunfish	9	1
Redear sunfish	3	tr.
Largemouth bass	4	tr.
Total game fish	765	70
Non-game fish		
Carp	299	27
Chub	5	tr.
Shiner	6	1
Squawfish	12	1
Sucker	5	tr.
Total non-game fish	327	30

Table 56. Species composition of the fish catch in six seine hauls in Upper Salmon Falls impoundment, thirty seine hauls from Lower Salmon Falls impoundment, and two seine hauls from Bliss tailwater during 1953.

Species	Upper Salmon Falls impoundment		Lower Salmon Falls impoundment		Bliss tailwater	
	Number	Per cent	Number	Per cent	Number	Per cent
Game fish						
Rainbow trout	42	1	39	tr.	14	5
Rocky Mountain whitefish	48	1	36	tr.	99	35
Largemouth bass	1	tr.	39	tr.	...	..
Yellow perch	1	tr.	50	tr.	...	..
Total game fish	92	2	164	2	113	40
Non-game fish						
Carp	310	6	62	1	...	..
Chiselmouth	168	3	51	tr.	1	tr.
Chub	1470	28	2617	24	2	1
Squawfish	155	3	277	3	1	tr.
Sucker	3120	58	7637	70	162	58
Total non-game fish	5223	98	10644	98	166	60

Plate 42. Horizontal arms coupled to cradle of gill net setting device and gill net in position to be set.

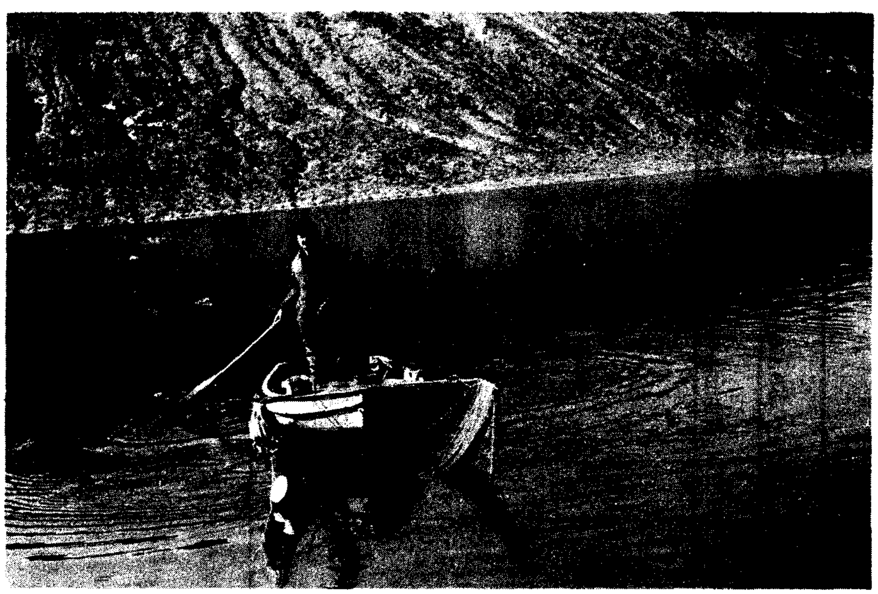


Plate 43. Maneuvering boat into position to set gill net. Fine-mesh end of gill net has been tied to shore anchor and other anchors and marker floats have been attached to gill net.

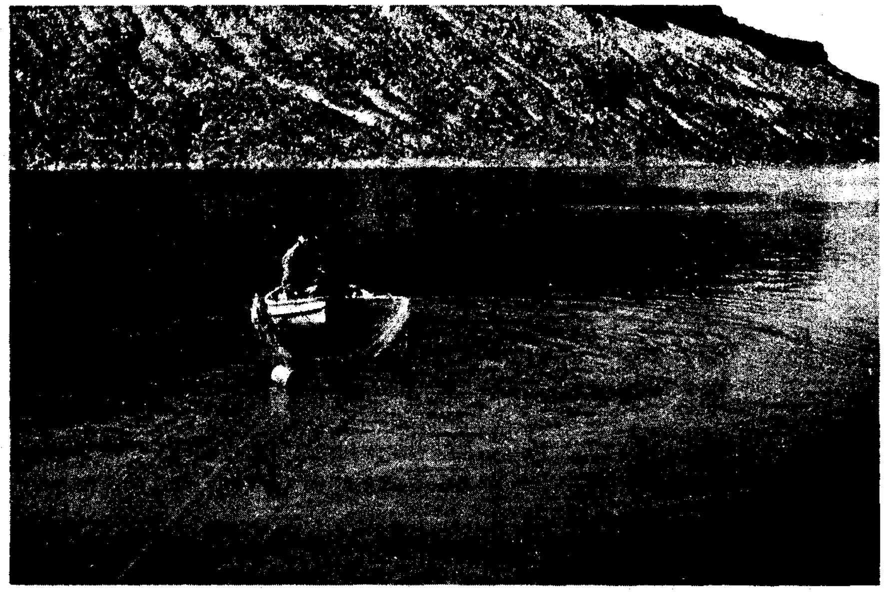


Plate 44. Gill net is set by backing boat in a direction in-line with the desired set.

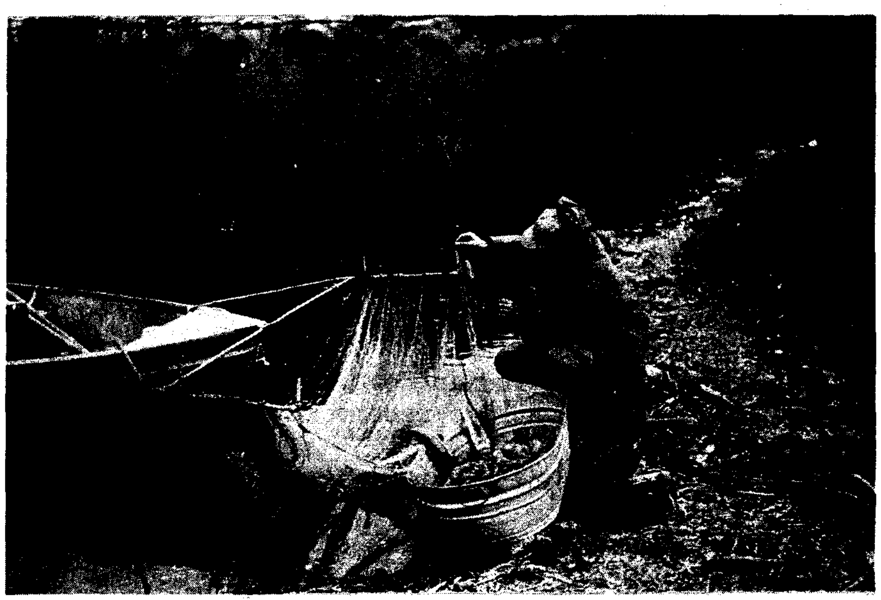


Plate 45. Fish may be removed from gill net and net re-strung on setting device in a minimum of space and time.

Census periods. For the purpose of collection and compilation of the creel census data, the 1953 and 1954 census years were divided into quarter periods, as follows:

1. Winter: November 17, 1952 to February 15, 1953 --- 91-day period
   November 17, 1953 to February 15, 1954 --- 91-day period

2. Spring: February 16, 1953 to May 17, 1953 --- 91-day period
   February 16, 1954 to May 17, 1954 --- 91-day period

3. Summer: May 18, 1953 to August 16, 1953 --- 91-day period
   May 18, 1954 to August 16, 1954 --- 91-day period

4. Fall: August 17, 1953 to November 16, 1953 --- 92-day period
   August 17, 1954 to November 16, 1954 --- 92-day period

Each seasonal quarter-period was further divided into six sub-periods, each composed of 15 or 16 days depending on the number of days in the seasonal quarter-period. One Saturday, one Sunday and one weekday were selected at random from each 15 or 16-day sub-period as the census dates for that period.

Thus, a census of the creels of Snake River fishermen occurred three days in each 15 or 16-day sub-period, 18 days in each seasonal quarter-period, and 72 days in each census year for a sample of the fishermen during 20 per cent of the daily fishing periods.

Census areas. During the Winter and Spring periods of the 1953 census year, the study area was divided into four sub-areas for the purpose of collecting creel census data, as follows:

1. Upper Salmon Falls impoundment and tailwater and Lower Salmon Falls impoundment and tailwater.

2. Bliss impoundment and that portion of the Bliss tailwater from Bliss dam downstream to Indian Cove bridge.

3. Bliss tailwater from Indian Cove bridge downstream to C. J. Strike reservoir and C. J. Strike reservoir and tailwater.

4. Swan Falls impoundment and tailwater.

A census taker was assigned to each of the four sub-areas and creel census data were collected from all sub-areas on the same census days. Due to the lack of fishing pressure, no census was made in the Swan Falls impoundment and tailwater areas during the Winter period of the 1953 census year.

During the Summer and Fall periods of the 1953 census year and the entire 1954 census year, the study area was divided into two sub-areas for the purpose of collecting creel census data, as follows:

1. Upper Salmon Falls impoundment and tailwater, Lower Salmon Falls impoundment and tailwater and Bliss impoundment.

2. Bliss tailwater, C. J. Strike reservoir and tailwater and Swan Falls impoundment and tailwater.

Different census days were selected at random for each of the two sub-areas and one census-taker collected the creel census data from both sub-areas. Due to the low fishing pressure, a voluntary creel census program was initiated for the Swan Falls impoundment and tailwater areas from June 23, 1953 to May 18, 1954. This voluntary creel census program was accomplished by installation of a creel-census card and box station on the only road leading into the Swan Falls impoundment and tailwater areas. Creel census of the Swan Falls impoundment and tailwater areas was discontinued at the end of the Spring census period of 1954.

Fishing pressure. In order to establish a reliable estimate of the total fishing pressure applied to that portion of the Snake River fishery under consideration during the study period, accurate samples of the fishing pressure were collected and evaluated, as follows:

1. The census-taker either checked or counted all fishermen observed in each ecological area during each Saturday, Sunday and weekday census date of each 15 to 16-day sub-period.

2. The estimated total number of fishermen was calculated by expansion of the sample (from No. 1, above) to the total number of days of each category in each census period.

3. Had it been possible to count the number of fishermen in each ecological area during each census day, the number of fishermen in each area during a quarter-period such as Winter, Spring, Summer or Fall would have been the expanded sums of the number of fishermen counted during each of the six sub-periods of a quarter-period.

   Due to the size of the census sub-areas, however, it was impossible to check or count all fishermen in each ecological area during a census day. To determine what proportion of the fishermen were missed, creel census "efficiency checks" were initiated. The checks involved the use of two men. One man, the census-taker, would proceed, as usual, to collect creel census data on a regular creel census date. The other man, an observer, would station himself at a vantage point where he could observe and count all fishermen that actually fished a given section of the census area during the entire census date. The ratio of the number of fishermen who actually fished the given area, as counted by the observer, to the number of fishermen checked or counted by the observer, to the number of fishermen checked or counted by the census-taker was used as a correction factor. Nine such checks were made throughout the study area and a total of 329 fishermen were counted by the observer compared to 188 fishermen checked and counted by the census-taker in the same areas for a correction factor of 1.75. Therefore, the corrected number of fishermen in each ecological area each quarter-period was calculated by multiplication of the total sub-period estimates of fishermen by 1.75.

4. Quarter-period estimates of fishermen were summed to derive the census year estimates for each ecological area and these in turn were summed to derive the total estimated number of fishermen for the study area.

5. Even though the number of hours fished was tabulated for each fisherman checked during interview and was used to determine fishing success, the number of hours fished by the fisherman when checked was usually only a portion of the fishing pressure applied by that fisherman on that particular census day.

In order to estimate the total fishing pressure and thus the harvest, it was necessary to determine the length of the average fisherman day. This was determined by voluntary return of the necessary data from fishermen by means of self-addressed postcards.

As some fishermen were checked, the census-taker would note the date, ecological area, time started fishing, time when checked, number of fish when checked, and number of fishermen in party in the spaces provided on the self-addressed postcard. The postcard would then be given to the fisherman and he was requested to note the time when he completed fishing and the total number of fish caught by the party and to drop the card in a convenient mail box on his way home.

The average length of the fisherman-day for 123 anglers who fished primarily for warm-water fish species in the C. J. Strike reservoir and Swan Falls tailwater was 4.88 hours. The average length of the fisherman-day of 172 anglers who fished primarily for trout species through the Upper Salmon Falls, Lower Salmon Falls and Bliss areas, and in the C. J. Strike tailwater was 4.24 hours. The estimated total fishing pressure was calculated by multiplication of the estimated total number of fishermen by the number of hours in the average fisherman day for that particular ecological area.

Fishing success and fish harvest. The fishing success in fish per hour and fish harvest by species were determined for each ecological area by quarter-period. Fishing success is the quotient of catch divided by hours fished. The harvest of fish in each ecological area by quarter-period is calculated through multiplication of the rate of catch (fish per hour) for each species by the total estimated hours fished.

The estimated fishing pressure, catch by species and the rates of catch of game fish from Snake River in ecological area each quarter-period have been tabulated for 1953 and 1954 (Tables 57 to 66).

Although the white sturgeon is legally classified as a non-game fish in Idaho, a significant amount of fishing by rod and line method was observed in the Bliss and C. J. Strike tailwaters during 1953 and 1954. During 1953, set-line fishing for sturgeon was legal throughout the study area. During 1954, set-line fishing for this species was limited to the river upstream from Bliss dam, and rod and line fishing was the only legal fishing method below Bliss dam. The fishing success and estimated fishing pressure and catch of white sturgeon from Bliss and C. J. Strike tailwaters by the rod and line method have been tabulated for 1953 and 1954 (Tables 67 and 68).

A census of the sturgeon catch by the set-line method was not attempted since set lines were left unattended and fishermen difficult to contact.

Table 57. Estimated fishing pressure and game-fish catch by species, and the rate of catch, Upper Salmon Falls impoundment, 1953 and 1954.

Period	Fishermen	Game-fish catch					Game fish per hour
		Rainbow	Whitefish	Bass	Bluegill	Catfish	
1953							
Winter	299	325	...	..	..	..	0.26
Spring	1360	1510	285	23	..	..	0.32
Summer	1278	3186	75	75	37	..	0.63
Fall	632	1967	151	..	..	..	0.80
Total	3569	6988	511	98	37	..	0.51
1954							
Winter	2602	11338	218	..	..	..	1.06
Spring	2319	8716	272	29	..	58	0.93
Summer	616	1214	...	30	..	30	0.50
Fall	1025	8203	...	..	..	..	1.91
Total	6562	29471	490	59	..	88	1.10

Table 58. Estimated fishing pressure and game-fish catch by species, and the rate of catch, Upper Salmon Falls tailwater, 1953-54.

Period	Fishermen	Game-fish catch			Game fish per hour
		Rainbow	Whitefish	Bass	
1953					
Winter	385	524	6	..	0.33
Spring	522	691	55	..	0.34
Summer	386	745	..	..	0.46
Fall	46	19	..	..	0.10
Total	1339	1979	61	..	0.36
1954					
Winter	513	4234	..	..	1.97
Spring[1]	1531	6062	167	13	0.97
Summer	789	2327	..	..	0.70
Fall	1050	5060	..	..	1.15
Total	3883	17683	167	13	1.10

[1] Dolman Island Rapids opened to fishing April 1, 1954.

Table 59. Estimated fishing pressure and game-fish catch by species, and the rate of catch, Lower Salmon Falls impoundment, 1953-54.

Period	Fishermen	Game-fish catch		Game fish per hour
		Rainbow	Whitefish	
1953				
Winter	712	468	...	0.16
Spring	71	10	...	0.03
Summer	57	....	...	0.00
Fall	129	622	69	1.28
Total	969	1100	69	0.29
1954				
Winter	1070	1650	211	0.42
Spring	820	1735	103	0.54
Summer	353	485	49	0.36
Fall	1186	1739	...	0.35
Total	3429	5609	363	0.42

Table 60. Estimated fishing pressure and game-fish catch, and the rate of catch, Lower Salmon Falls tailwater, 1953-54.

Period	Fishermen	Game-fish catch		Game fish per hour
		Rainbow trout	Whitefish	
1953				
Winter	1055	1056	...	0.24
Spring	905	838	99	0.25
Summer	560	1220	19	0.53
Fall	261	1532	...	1.40
Total	2781	4646	118	0.41
1954				
Winter	2254	4193	57	0.45
Spring	2088	3255	...	0.37
Summer	858	2326	...	0.65
Fall	779	2069	...	0.63
Total	5979	11843	57	0.48

Table 61. Estimated fishing pressure and game-fish catch, and the rate of catch, Bliss impoundment, 1953-54.

Period	Fishermen	Game-fish catch	Game fish
		Rainbow trout	per hour
1953			
Winter	42	71	0.41
Spring	191	112	0.14
Summer	151	285	0.45
Fall	259	737	0.68
Total	643	1205	0.45
1954			
Winter	754	2379	0.75
Spring	1472	6069	0.98
Summer	522	2592	1.19
Fall	371	1315	0.85
Total	3119	12355	0.95

Table 62. Estimated fishing pressure and game fish catch, and the rate of catch, Bliss tailwater, 1953-54.

Period	Fishermen	Game-fish catch					Game fish per hour
		Rainbow	Whitefish	Bass	Catfish	Perch	
1953							
Winter	663	1367	..	..	..	..	0.49
Spring	807	1163	..	44	..	..	0.36
Summer	516	776	26	..	..	26	0.38
Fall	271	227	..	..	20	..	0.22
Total	2257	3533	26	44	20	26	0.39
1954							
Winter	495	3138	..	..	..	..	1.50
Spring	845	1863	..	..	..	..	0.53
Summer	483	0	..	..	..	..	0.00
Fall	215	216	..	..	..	..	0.24
Total	2038	5217	..	..	..	..	0.61

Table 63. Estimated fishing pressure and game fish catch, and the rate of catch, Snake River arm of C. J. Strike reservoir, 1953-54.

Period	Fishermen	Game-fish catch				Game fish per hour
		Rainbow	Bass	Catfish	Crappie	
1953						
Winter	0	...	....	...	..	....
Spring	0	...	....	...	..	....
Summer	0	...	....	...	..	....
Fall	0	...	....	...	..	....
Total	0	...	....	...	..	....
1954						
Winter	0	...	....	...	..	....
Spring	636	40	785	99	40	0.31
Summer	550	...	166	499	..	0.25
Fall	618	537	838	...	..	0.46
Total	1804	577	1789	598	40	0.34

Table 64. Estimated fishing pressure and game-fish catch, and the rate of catch, Bruneau River arm of C. J. Strike reservoir, 1953-54.

Period	Fishermen	Game-fish catch					Game fish per hour
		Rainbow	Bass	Bluegill	Catfish	Crappie	
1953							
Winter	....	..	....	..	.....	...	....
Spring	315	..	....	..	4342	...	2.83
Summer	495	..	39	..	4458	...	1.86
Fall	117	..	....	..	1404	...	2.46
Total	927	..	39	..	10204	...	2.26
1954							
Winter	287	..	811	..	336	...	0.82
Spring	2532	..	2833*	..	8204	470	0.93
Summer	991	..	52*	..	6026	...	1.26
Fall	266	93	93	16	668	...	0.67
Total	4076	93	3789	16	15234	470	0.99

* Area closed to bass fishing from March 24 to June 4, 1954.

Table 65. Estimated fishing pressure and game-fish catch, and the rate of catch, C. J. Strike tailwater, 1953-54.

Period	Fishermen	Game-fish catch					Game fish
		Rainbow	Steelhead	Whitefish	Bass	Catfish	per hour
1953							
Winter	110	34	..	..	..	...	0.07
Spring	1285	2094	65	..	..	...	0.40
Summer	984	313	..	29	..	915	0.31
Fall	315	224	..	..	..	26	0.19
Total	2694	2665	65	29	..	941	0.33
1954							
Winter	1290	897	..	49	49	...	0.18
Spring	1162	1037	24	..	..	24	0.22
Summer	684	631	..	..	..	...	0.22
Fall	788	2153	..	..	..	20	0.66
Total	3924	4718	24	49	49	44	0.30

Table 66. Estimated fishing pressure and game-fish catch, and the rate of catch, Swan Falls tailwater, 1953-54.

Period	Fishermen	Game-fish catch						Game fish per hour
		Rainbow	Steelhead	Bass	Catfish	Crappie	Perch	
1953								
Winter	(no census)							
Spring	998	...	68	170	136	..	..	0.07
Summer	131	...	..	29	201	..	12	0.38
Fall	120	...	..	4	96	..	9	0.19
Total	1249	...	68	203	433	..	21	0.12
1954								
Winter	88	4	4	...	41	..	..	0.11
Spring	414	200	30	29	20	5	..	0.19
Summer	(no census)							
Fall	(no census)							
Total	502	204	34	29	61	5	..	0.17

Table 67. Estimated fishing pressure and sturgeon catch, and rate of catch, by the rod and line method from Bliss tailwater during 1953 and 1954.

Period	Fishermen	Sturgeon catch	Sturgeon per hour
1953			
Winter	0	...	....
Spring	0	...	....
Summer	100	33	0.07
Fall	295	73	0.07
Total	395	106	0.07
1954			
Winter	146	16	0.08
Spring	285	25	0.07
Summer	341	62	0.13
Fall	76	23	0.05
Total	848	126	0.08

Table 68. Rate of catch, and estimated fishing pressure and catch of white sturgeon by the rod and line method from C. J. Strike tailwater during 1953 and 1954.

Period	Fishermen	Sturgeon catch	Sturgeon per hour
1953			
Winter	0	..	....
Spring	0	..	....
Summer	42	12	0.03
Fall	0	..	....
Total	42	12	0.03
1954			
Winter	0	..	....
Spring	0	..	....
Summer	23	7	0.06
Fall	0	..	....
Total	23	7	0.06

Though few anglers fished directly for non-game fish, many were caught by anglers as they fished for game fish. The fishing success and estimated catch of non-game fish from Snake River per ecological area per quarter-period have been tabulated for 1953 and 1954 (Tables 69 to 77).

Economic Value of the Snake River Fishery, 1953-54

The economic value of the Snake River fishery during 1953 and 1954 was based entirely on expenditures made by anglers for their fishing trips to Snake River within the study area. Although the food value of fish taken during this period was certainly considerable, it was not used in this study. The amount and type of expenditures were determined by personal interview of 407 fishermen in conjunction with the creel census data collections.

Items purchased and methods of assessing the economic values of these items to the fishery were as follows:

1. Transportation: Round-trip miles from residence to fishing area were charged at the rate of $0.07 per mile per automobile and the cost prorated among the fishermen per automobile.

2. Fishing tackle: Cost of the fishing tackle purchased for the trip in question.

3. Boat rentals and boat motor gasoline and oil: Cost of boats rented or boat-motor gasoline and oil purchased for the trip.

4. Meals: Cost of meals at cafes on the current fishing trip.

5. Lodging: Cost of lodging made necessary for the trip.

The cost of the average angler trip varied between ecological areas because of the differences in the amounts and kinds of goods or services needed to get to and fish a particular area of Snake River. From the data collected, the average cost per angler day was calculated for each of the following parts of the study area:

1. Upper Salmon Falls impoundment . . . . $ 3.22

2. Upper Salmon Falls tailwater, Lower Salmon Falls impoundment and tailwater, and Bliss impoundment 3.00

3. Bliss tailwater 2.36

4. C. J. Strike reservoir 5.17

5. C. J. Strike tailwater 4.18

Most fisherman trips to Snake River were of less than one day in duration.

The economic value of the Snake River sport fishery for each of the ecological areas was calculated by multiplication of the estimated number of fishermen by the average cost per angler day in the particular ecological area concerned (Table 78).

Table 69. Fishing success and estimated catch of non-game fish from Upper Salmon Falls impoundment during 1953 and 1954.

Period	Non-game fish catch					Non-game fish per hour
	Carp	Chiselmouth	Chub	Squawfish	Sucker	
1953						
Winter	...	170	460	34	34	0.56
Spring	...	125	1863	1014	137	0.55
Summer	75	150	632	407	112	0.26
Fall	...	77	530	77	151	0.32
Total	75	522	3485	1532	434	0.40
1954						
Winter	...	491	6792	1025	76	0.77
Spring	573	126	3488	4343	2342	1.12
Summer	...	236	680	680	1272	1.13
Fall	202	17	430	786	417	0.43
Total	775	870	11390	6834	4107	0.87

Table 70. Fishing success and estimated catch of non-game fish from Upper Salmon Falls tailwater during 1953 and 1954.

Period	Non-game fish catch				Non-game fish per hour
	Chiselmouth	Chub	Squawfish	Sucker	
1953					
Winter	45	682	315	45	0.67
Spring	636	748	665	109	0.99
Summer	606	179	639	...	0.88
Fall	38	96	19	...	0.81
Total	1325	1705	1638	154	0.86
1954					
Winter	....	215	....	...	0.10
Spring	58	654	135	340	0.19
Summer	....	122	979	...	0.33
Fall	....	810	1822	101	0.62
Total	58	1801	2936	441	0.32

Table 71. Fishing success and estimated catch of non-game fish from Lower Salmon Falls impoundment during 1953 and 1954.

Period	Non-game fish catch				Non-game fish per hour
	Chiselmouth	Chub	Squawfish	Sucker	
1953					
Winter	....	2440	30	30	0.84
Spring	....	149	10	...	0.53
Summer	1159	145	72	...	5.76
Fall	....	....	...	69	0.13
Total	1159	2734	112	99	1.01
1954					
Winter	....	520	22	143	0.15
Spring	34	278	137	210	0.19
Summer	....	243	...	...	0.16
Fall	442	119	40	...	0.12
Total	476	1160	199	353	0.15

Table 72. Fishing success and estimated catch of non-game fish from Lower Salmon Falls tailwater during 1953 and 1954.

Period	Non-game fish catch					Non-game fish per hour
	Carp	Chiselmouth	Chub	Squawfish	Sucker	
1953						
Winter	...	44	199	75	168	0.11
Spring	...	228	387	485	243	0.35
Summer	38	38	...	167	333	0.25
Fall	...	...	...	146	....	0.13
Total	38	310	586	873	744	0.22
1954						
Winter	113	...	57	...	652	0.09
Spring	420	140	210	35	210	0.12
Summer	...	...	...	...	424	0.12
Fall	...	...	183	183	281	0.20
Total	533	140	450	218	1567	0.12

Table 73. Fishing success and estimated catch of non-game fish from the Bliss impoundment during 1953 and 1954.

Period	Non-game fish catch				Non-game fish per hour
	Carp	Chub	Squawfish	Sucker	
1953					
Winter	..	..	5	..	0.03
Spring	..	..	86	..	0.11
Summer	8	15	208	8	0.38
Fall	..	62	205	..	0.25
Total	8	77	504	8	0.22
1954					
Winter	38	..	...	..	0.01
Spring	..	..	142	..	0.02
Summer	..	..	...	..	0.00
Fall	..	..	...	61	0.04
Total	38	..	142	61	0.02

Table 74. Fishing success and estimated catch of non-game fish from Bliss tailwater during 1953 and 1954.

Period	Non-game fish catch					Non-game fish per hour
	Carp	Chiselmouth	Chub	Squawfish	Sucker	
1953						
Winter	....	392	325	500	239	0.52
Spring	152	666	1937	1011	345	1.22
Summer	620	221	91	1386	91	1.11
Fall	371	207	124	454	83	1.09
Total	1143	1486	2477	3351	758	0.98
1954						
Winter	133	....	....	286	27	0.22
Spring	467	280	4986	931	1445	2.30
Summer	221	111	....	332	111	0.38
Fall	....	86	....	86	130	0.34
Total	821	477	4986	1635	1713	1.13

Table 75. Fishing success and estimated catch of non-game fish from the Snake River arm of C. J. Strike reservoir during 1953 and 1954.

Period	Non-game fish catch			Non-game fish per hour
	Carp	Squawfish	Sucker	
1953				
Winter	...	....	..	0.00
Spring	...	....	..	0.00
Summer	...	....	..	0.00
Fall	...	....	..	0.00
Total	...	....	..	0.00
1954				
Winter	...	....	..	0.00
Spring	664	605	59	0.43
Summer	56	612	..	0.25
Fall	66	....	..	0.02
Total	786	1217	59	0.23

Table 76. Fishing success and estimated catch of non-game fish from the Bruneau River arm of C. J. Strike reservoir during 1953 and 1954.

Period	Non-game fish catch				Non-game fish
	Carp	Chiselmouth	Squawfish	Sucker	per hour
1953					
Winter	....	...	...	..	0.00
Spring	....	...	154	..	0.10
Summer	205	...	130	39	0.16
Fall	154	15	...	..	0.30
Total	359	15	284	39	0.15
1954					
Winter	505	...	...	..	0.36
Spring	3138	222	383	..	0.30
Summer	479	102	...	..	0.12
Fall	....	...	140	..	0.11
Total	4122	324	523	..	0.25

Table 77. Fishing success and estimated catch of non-game fish from C. J. Strike tailwater during 1953 and 1954.

Period	Non-game fish catch					Non-game fish per hour
	Carp	Chiselmouth	Chub	Squawfish	Sucker	
1953						
Winter	...	47	....	414	13	1.03
Spring	...	1615	571	3263	571	1.12
Summer	400	202	660	3121	173	1.11
Fall	145	330	....	1663	40	1.65
Total	545	2194	1231	8461	797	1.17
1954						
Winter	49	....	70	622	324	0.20
Spring	49	122	195	1806	360	0.52
Summer	238	....	....	2084	175	0.87
Fall	40	....	....	637	142	0.25
Total	376	122	265	5149	1001	0.42

Table 78. Estimated economic value of the Snake River fishery during 1953 and 1954 by ecological area. Based on cost of transportation, tackle, meals, lodging, and boat rentals to Snake River fishermen.

Area	1953	1954
Upper Salmon Falls impoundment	$ 11,492	$ 21,130
Upper Salmon Falls tailwater	4,017	11,649
Lower Salmon Falls impoundment	2,907	10,287
Lower Salmon Falls tailwater	8,343	17,937
Bliss impoundment	1,929	9,357
Bliss tailwater	5,327	4,810
C. J. Strike reservoir		
Snake River arm	......	9,327
Bruneau River arm	4,793	21,073
C. J. Strike tailwater	11,261	16,402
Total	$ 50,069	$ 121,972

The total and proportionate expenditures made for each kind of item purchased by the Snake River fisherman during the 1953-54 period have been tabulated (Table 79). These do not include most investment expenditures, however.

Table 79. Estimated economic value of the Snake River fishery during the period, 1953-54, by totals and percentages of kind of goods and services purchased by fishermen.

Goods or services	Value	Per cent
Transportation	$ 115,268	67
Fishing tackle	43,010	25
Boat rental	3,441	2
Meals	8,602	5
Lodging	1,720	1

ANALYSIS AND DISCUSSION OF DATA

The three major components of hydroelectric power operations are: (1) the dam, (2) the impounded water above the dam, and (3) the manipulation of the water flows through the dam. The purpose of this section of the report is to analyze the collected data and other pertinent information and to discuss these so that beneficial and detrimental effects of these major components of hydroelectric power operations on the fishery of Snake River within the study area may be pointed out.

Physical and Chemical

Water-flow and Water-level Fluctuation

Although seasonal flows from upstream areas fluctuate considerably, the flows within the study area are stabilized by the large volume of water from relatively constant-flow springs that arise and flow into Snake River within and immediately above the study area.

The seasonal water flows of Snake River within the study area during 1953 were typical. That is, the water flows were moderate during the Winter period (November and December, 1952 and January and February, 1953); higher during the Spring period (March, April, May, June, 1953); and lower during the Summer-Fall period (July, August, September, October, 1953).

The mean daily flow of water in Snake River through the study area or past any given point within the study area is relatively constant. In fact, the average daily flow of water in Snake River during 1953 and 1954 would have been substantially the same if there had been no dams on Snake River within the study area. In other words, the volume of usable storage above the dams is small and is only used to control the water flows of Snake River within the daily, 24-hour period.

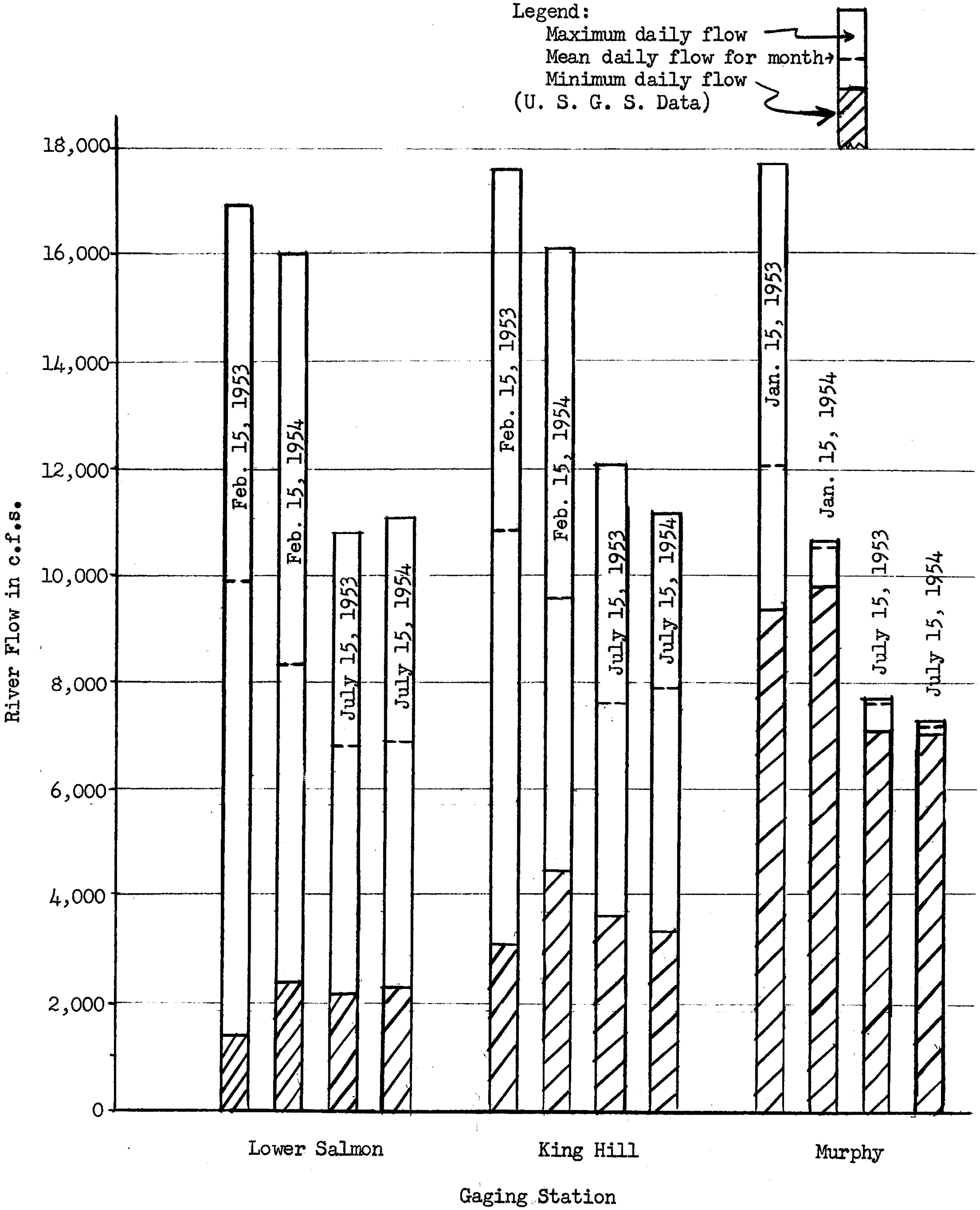
Even though the storage volume above the hydroelectric installations is small, the manipulation of these waters causes severe diurnal fluctuation of water levels in several sections of Snake River within the study area. Analyses of the water-level fluctuation and flow data reveal the general operation in effect at the dams. These analyses will be discussed in order that the effects of diurnal fluctuation of flows and levels on the fisheries of the several sections of Snake River will be more understandable. Figure 19 shows typical daily flows, summer and winter, through the area.

The water flows and water levels of Upper Salmon Falls impoundment and tailwater are subject only to seasonal fluctuations. The Upper Salmon Falls and Cavanaugh diversion dams do not store but only divert water for the production of power at the upper and lower power plants at Upper Salmon Falls.

A considerable portion of the Lower Salmon Falls impoundment is usable storage. In general, tailwater and forebay pool flows are proportionate to power production while impoundment elevations vary indirectly.

The river flow in Lower Salmon Falls tailwater averages approximately 12,000 cubic feet per second during the 16-hour day period from 6 A.M. to 10 P.M. and averages approximately 2,500 cubic feet per second during the 8-hour night period

Figure). Maximum and minimum daily f /s, in c.f.s. of Snake River through the study area of summer and winter flows selected as typical, 1953 - 4.



from 10 P.M. to 6 A.M. During periods of peak consumption of electricity, 10 A.M. to 12 Noon and 5 P.M. to 7 P.M., the tailwater below Lower Salmon Falls has a volume of 15,000 cubic feet per second. The daily flow of Snake River past Lower Salmon Falls dam during the 1953-54 period averaged 8,300 cubic feet per second.

Waters released from Lower Salmon Falls impoundment reach the Bliss impoundment in approximately one hour. The release of waters through Bliss dam is coördinated with the arrival of waters from Lower Salmon Falls tailwater in such a manner that, even though the surface area and volume of usable storage of Bliss impoundment are small, the water levels fluctuate only slightly. Because of this, the volume of water flowing through Bliss impoundment is low during the night period and quite high during the day.

The rather severe fluctuation of the flows and levels of Bliss tailwater result mostly, then, from the release of waters from Lower Salmon Falls impoundment. As the distance increases downstream from the Bliss dam, the fluctuation of flow and level of the Bliss tailwater becomes less severe.

Since the volume of usable storage in C. J. Strike reservoir is relatively large, flows through most parts of this reservoir and the reservoir elevations are subject to a slight diurnal fluctuation only. During the day, when large flows of water are released through C. J. Strike dam, the rate of water flow through the long and narrow upper section of the Snake River arm of C. J. Strike reservoir is quite rapid. The rate of water flow through the narrow canyon which separates the Bruneau River and the Snake River arms of C. J. Strike would likewise be rapid during the daytime drawdown period.

The C. J. Strike tailwater fluctuates in flow and water level in a manner similar to that of the Lower Salmon Falls tailwater.

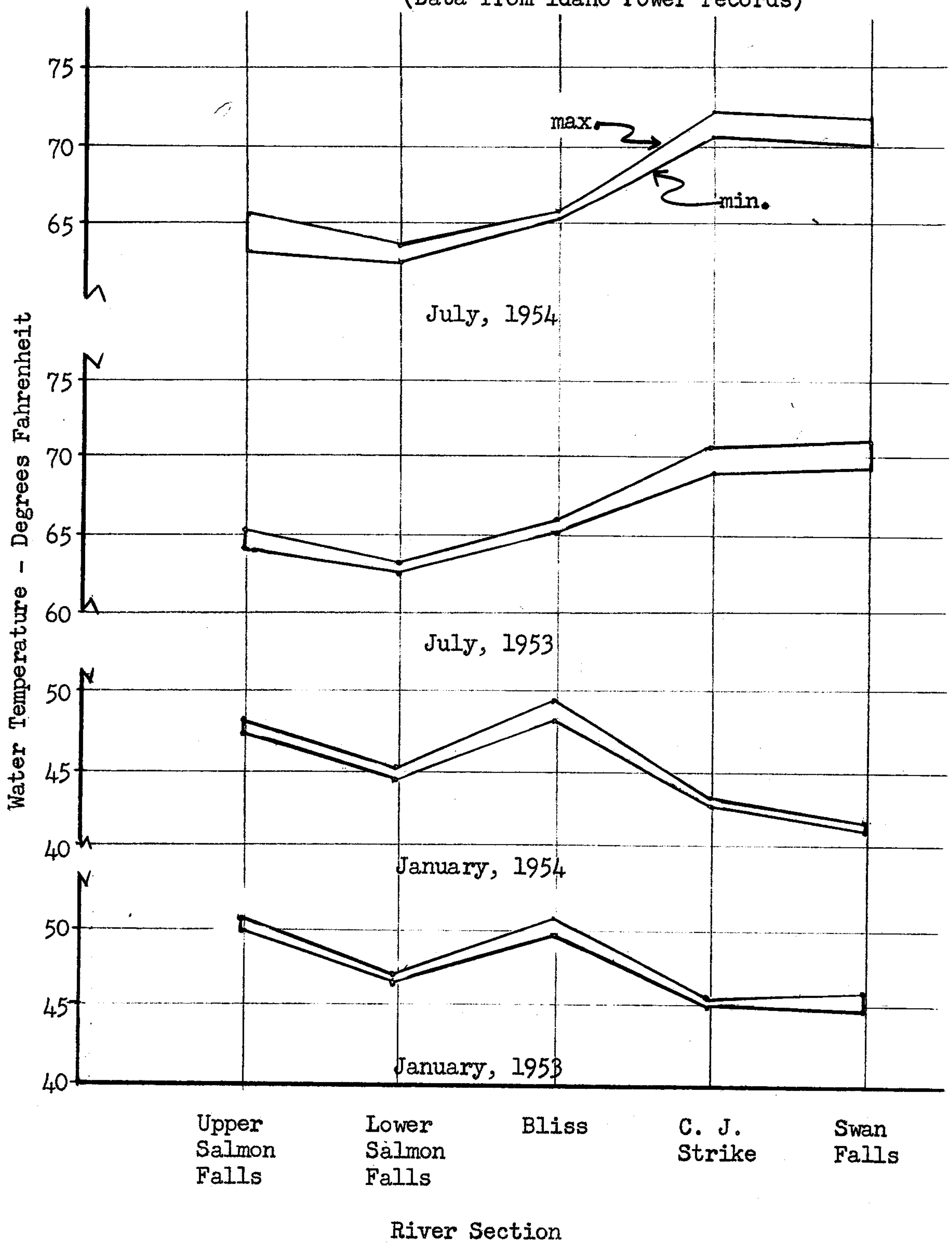
During the early part of 1953, the flow and water levels of Swan Falls impoundment fluctuated moderately, but the flows and levels of Swan Falls tailwater were subject to rather severe fluctuation. The release of waters through Swan Falls dam during the latter part of 1953 and in 1954 resulted in rather severe elevation fluctuations of the forebay, but smoothed out the flows of its tailwater.

The size and volume of impounded waters; distance between impoundments, need for re-regulation or smoothing of certain tailwater flows; timing of power production to meet power demand, all of these factors complicate the operation of the hydroelectric installations. In turn, these factors complicate the study of their effects on the fishery. The effects will be discussed in detail under specific headings.

<u>Water temperature</u>. The temperatures of water in the upstream as compared to the downstream areas of Snake River within the study area are cooler in summer and warmer in winter (Figure 20). This is typical of spring-fed streams in temperate zone climates. Actually, the water temperatures of Snake River within the study area varied less than 15° F at any given time during the 1953-54 period.

The waters within each impoundment and within the impoundment-like upper section of the Snake River arm of C. J. Strike reservoir are considered to be

Figure 20. Monthly average maximum and minimum water temperatures through the study area for July (summer) and January (winter), each year. (Data from Idaho Power records)



homothermous at any given time. This appears to be typical and is a result of the relatively rapid rate of water exchange in the impoundment basin (see Table 9).

Though the waters of the Bruneau River arm and the lower section of the Snake River arm of C. J. Strike reservoir are not homothermous, thermal stratification does not occur. Stratification of the waters of the Bruneau River arm is prevented by circulation of these shallow waters by frequent winds. Though the temperature of the water of the lower section of the Snake River arm ranged from 60.3° F. at a depth of 80 feet (near the bottom) to 73.0° F. at the surface on August 8, 1954, no thermocline was found and thermal stratification appears to be prevented by wind action as well as the large volume of inflow. Since the waters released through C. J. Strike dam are drawn from near the surface of the reservoir, the C. J. Strike tailwater might be slightly warmer in summer and colder in winter than normally occurred prior to construction of the dam.

The changes in temperature of Snake River waters due to hydroelectric installations are so small that they are believed to have little effect on the fishery. The exception to this is when temperatures are near or at the critical level for certain species of trout, for example.

Water turbidity. Turbidity measurements of Snake River waters within the study area indicate hydroelectric installations and their impounding and manipulation of water flows have little effect on turbidity. The deposits of silt on the bottoms of impounded water indicate impoundments and reservoirs provide settling basins for at least the larger materials carried in suspension in the tailwaters. Clarification of tailwaters by deposition of silt in the impounded waters above is of benefit to the fisheries down river.

The plankton production in the Bruneau River arm of C. J. Strike reservoir caused a slight increase in the turbidity of this water, but the food value of the plankton is of more benefit to the fishery than the detrimental effect of the slight increase in turbidity.

Water chemistry. There is no appreciable difference in water chemistry of Snake River through the study area. The slight changes which occur are due to irrigation return or organic decay. Nutrient elements, leeched from soils inundated by impounded waters, would enrich the waters of impoundments and reservoirs and the fishery benefitted accordingly. Also, the waters of reservoir areas which provide a habitat for aquatic vegetation would be enriched by the release of elements from decomposition of vegetative materials that would accumulate in the reservoir basin.

Biological

Production and Utilization of Aquatic Organisms

Effect of water-level fluctuation. During the 1953-54 period, a period during which the hydroelectric operations within the study area were fairly typical, the manipulation of water flows for power production resulted in diurnal fluctuations of water levels, of various degrees, in impoundments and reservoirs, except for Upper Salmon Falls impoundment; and, in tailwaters, except for Upper Salmon Falls tailwater.

This diurnal fluctuation of water levels resulted in the formation of a rather definite zone of fluctuation. This zone was covered by water during part of each day and exposed to the drying and freezing action of the air for the balance of each day. The average surface area of this zone of fluctuation in four typical sections of the Lower Salmon Falls and Bliss tailwaters was 18 per cent of the surface area during high diurnal flows.

The areas of the zones of fluctuation of impoundments were not measured, but that of Bliss would be small, and that of Lower Salmon Falls and Swan Falls impoundments large.

The growth of submergent forms of aquatic plants within the zones of fluctuation is prevented by the lack of a constant water cover. Most of the growth of emergent forms occurs along the upper margin of the fluctuation zones. The intermittant flow of water has an adverse effect on emergent plants.

Most aquatic bottom invertebrates require a constant water cover and most lack the mobility to migrate with the diurnal movement of waters. In addition, the production of these bottom invertebrates depends to a large extent on the production of aquatic plants.

The production of aquatic bottom invertebrates within the zones of fluctuation of Lower Salmon Falls and Bliss tailwaters during the 1953-54 period was confined to moist or water-filled depressions beneath rubble or other materials. This was comprised of 15.8 per cent, by number, and 7.4 per cent, by volume, of the production within the adjacent low or permanent-flow zone (Table 80). Actually, the production of aquatic bottom invertebrates in the permanent-flow zone of these fluctuating tailwaters was not as large as it would have been had the permanent flow zone been in shallower, better-lighted waters closer to the shoreline.

Since there is evidence of a reduced production of aquatic plants and bottom invertebrates within the zones of fluctuation of Lower Salmon Falls and Bliss tailwaters, it can be assumed that a similar reduction occurs in all other areas subject to diurnal fluctuation of water levels; namely, Lower Salmon Falls and Swan Falls impoundments and C. J. Strike tailwater. Aquatic plants and especially aquatic bottom invertebrates formed the basic food supply of rainbow trout and mountain whitefish in impoundment and tailwater areas of Snake River during the 1953-54 period.

Since aquatic bottom invertebrates form the basic food supply of these important game fish species, as well as other game and non-game species of fish, and, since it has been shown that the diurnal fluctuation of water levels reduces the production of this food supply, it can be stated that the diurnal fluctuation of Snake River water flows is detrimental to the Snake River fishery.

Flushing effect of water-flow fluctuation. The effect of water-level fluctuation on the production and utilization of aquatic organisms is confined principally to the zone of fluctuation. The production and utilization of aquatic organisms within the permanent-flow zone as well as the fluctuation zone may be affected by the flushing action of increasing and decreasing water flows.

The oven-dry weight of aquatic vegetation strained by 24 sets of drift-organism nets from high flows was 4.6 times greater than that of 24 sets from low flows of Lower Salmon Falls and Bliss tailwaters. When it is considered that the

Table 80. Organisms sampled from 24 square feet of bottom area of the low and of the high daily flows of Lower Salmon Falls and Bliss tailwaters during the period, 1953-54.

Organisms	Low			High		
	Occurrence	Number	Volume	Occurrence	Number	Volume
Animals	24	3740	46.2	21	593	3.4
Insecta	24	1621	17.9	14	170	0.8
Coleoptera	15	95	0.6	2	4	tr.
Diptera	20	446	1.1	10	112	0.6
Ephemerida	19	220	1.2	5	27	0.1
Odonata	4	9	2.6	...	....	...
Trichoptera	20	851	12.4	8	27	0.1
Hydrachnidae	7	52	tr.	1	1	tr.
Amphipoda	21	1055	3.8	10	238	1.3
Decapoda	3	3	3.3	...	....	...
Hirudinea	4	8	0.3	2	2	tr.
Tubificidae	12	39	0.2	13	66	0.5
Pulmonata	21	958	20.7	7	111	0.8
Pelecypoda	4	4	----[1]	1	5	---[1]

[1] Pelecypoda measured by occurrence and number only.

low flows and the high flows of these tailwaters averaged approximately 2,500 and 12,000 cubic feet per second, respectively; the weight of aquatic vegetation transported by high flows was approximately 22 times as great as the weight of vegetation transported by the low flows (4.6 times 12,000/2,500)!

It is not intended to imply that all of the vegetative material transported in Snake River is a result of fluctuations in water flow. A vast amount of aquatic vegetation is carried by the non-fluctuating flows of Upper Salmon Falls impoundment and tailwater. In fact, the amount of vegetation that clogs the trash racks at the Upper and Lower Salmon Falls power plants presents a serious maintenance problem. In these waters, a luxuriant growth of aquatic vegetation develops and it is a normal reproductive process that much of this vegetative material will break off from parent stock and be transported downstream. The comparison of the relative amounts of vegetative material carried by the high and low flows of Lower Salmon Falls and Bliss tailwaters is intended to illustrate the flushing action of the diurnal fluctuation of these tailwater flows.

An average of 65 aquatic invertebrates were strained by 48 sets of drift-organism nets from low flows compared to 53 strained by 48 sets from high flows of Lower Salmon Falls and Bliss tailwaters. Considering the volume of low flows as compared to the volume of high flows for a given period of time, approximately 3.9 times as many invertebrates drift in the high flows as compared to the low flows (53/65 times 12,500/2,500)!

As with aquatic vegetation, it is normal for aquatic invertebrates to become detached or actively abandon their bottom habitat, drift with the current to a new location or, as in the case of many insects, the nymphs or pupae must move from their bottom habitat to the shoreline or water surface to complete their life cycle as adults. Should the fluctuation of water flows cause undue numbers of immature forms of invertebrates to become dislocated from their bottom habitat and be consumed by fish or other animals; the annual production of aquatic invertebrates would decline. It may be significant that of the orders of aquatic insects with larval, pupal and adult life stages (Coleoptera, Diptera, and Trichoptera); larval forms comprised 63 per cent of the diet of rainbow trout from the non-fluctuating Upper Salmon Falls tailwater compared to 77 per cent in the fluctuating Lower Salmon Falls and Bliss tailwaters.

Effect of water impoundment. The initial effects of water impoundment upon the river environment, which may cause changes in the production of aquatic organisms, are: (1) increase in water depth, (2) increase in surface and bottom area of water, and (3) decrease in stream gradient and thus the current velocity. Subsequent effects of water impoundment which may cause changes in the production of aquatic organisms are: (1) deposition of silt on the bottom of the impoundment basin, (2) decrease in the turbidity of the waters as a result of deposition of silt, and (3) stability of the surface level of the impounded waters.

The absolute effect of water impoundment on the production of aquatic bottom invertebrates is unknown since it was not possible to measure the changes in production of aquatic bottom invertebrates within a particular river section before and after inundation. The production of aquatic bottom invertebrates within the permanent-flow zone of tailwater sections of the river, however, is considered to be representative of the production of aquatic bottom invertebrates in a river section prior to inundation. To determine some of the changes which may occur in the production of aquatic bottom invertebrates as a result of water impoundment, the production of aquatic bottom invertebrates sampled from equal areas of the permanent-flow zones of impoundments and tailwaters are compared in Table 81.

The data for Table 81 were compiled from bottom dredge samples collected from Upper Salmon Falls, Lower Salmon Falls and Bliss impoundments and the upper section of the Snake River arm of C. J. Strike reservoir (Tables 28 to 31); and, from square-foot bottom samples of Upper Salmon Falls, Lower Salmon Falls and Bliss tailwaters (Tables 18 to 22).

These data indicate that impoundments produce a greater number of invertebrates than do tailwaters. Further analysis of the data reveals that over 70 per cent of the invertebrates sampled from impoundments were aquatic worms (Tubificidae) which live in the silt and detritus of the bottom environment and are not directly available as food to the important game fish of these waters.

Of the game fish food organisms produced in both environments, only midge larvae (Diptera) were produced in significantly greater numbers in the impoundment environment. Important rainbow trout food organisms such as beetle larvae (Coleoptera), mayfly nymphs (Ephemerida), dragonfly nymphs (Odonata), caddisfly larvae (Trichoptera), freshwater shrimp (Amphipoda), crayfish (Decapoda) and freshwater snails (Pulmonata) were all produced in greater numbers in tailwater environments (Table 82).

The quality of the aquatic bottom invertebrates produced in the shallow, non-fluctuating Upper Salmon Falls impoundment is excellent. On the other hand, the quality of the aquatic bottom invertebrates produced in the relatively deep, fluctuating Lower Salmon Falls impoundment and the deep, narrow Bliss impoundment and the upper section of the Snake River arm of C. J. Strike reservoir is poor.

The quality of the aquatic bottom invertebrates produced in the Bruneau River arm of C. J. Strike reservoir is fair or slightly below average. In addition to the bottom invertebrate production, the stable waters of the Bruneau River arm provide a suitable habitat for the production of plankton species that are excellent fish food. The plankton production in the upper section of the Snake River arm is similar to that of the impoundments and the large flows of water that pass through the lower section of the Snake River arm limit the production of plankton in this section.

Since the water levels of C. J. Strike reservoir are relatively stable and the bottom area covered by the waters of the reservoir far exceed that of the former river channel, the production of aquatic organisms, both plant and animal and including plankton, will far surpass that of the former river environment and the fishery will benefit thereby.

Movement of Fish

Effect of hydroelectric and diversion dams. All hydroelectric and diversion dams across Snake River within the study area form obstacles, in varying degrees, to the upstream movement of fish. The upstream movement or migration of mature fish to suitable spawning areas is necessary for the perpetuation of natural runs of some game fish species (steelhead, chinook salmon, rainbow trout, whitefish and possibly sturgeon) as well as some less desirable non-game fish species (suckers, chiselmouth and Columbia River chub).

Table 81. A quantitative and qualitative comparison of the aquatic invertebrates sampled from 50 square feet each of impoundment[1] and tailwater bottom environments of Snake River during the 1953-54 period.[2]

Invertebrates	Impoundment		Tailwater	
	Number	Per cent	Number	Per cent
Total animals	10948	100.00	8320	100.00
Insecta	1919	17.53	3333	40.06
Coleoptera	3	0.03	174	2.09
Diptera	1877	17.14	760	9.13
Ephemerida	23	0.21	392	4.72
Odonata	12	0.11	15	0.18
Trichoptera	4	0.04	1992	23.94
Hydrachnidae	12	0.11	87	1.05
Amphipoda	302	2.76	2583	31.05
Decapoda	.....	......	5	0.06
Hirudinea	177	1.62	134	1.61
Tubificidae	8085	73.84	145	1.74
Pulmonata	440	4.02	2026	24.35
Pelecypoda	13	0.12	7	0.08

1 Does not include samples of organisms from Bruneau River arm of C. J. Strike reservoir.

2 Data compiled from bottom dredge samples collected from Upper Salmon Falls, Lower Salmon Falls and Bliss impoundments and the upper section of the Snake River arm of C. J. Strike reservoir and from square-foot bottom samples of Upper Salmon Falls, Lower Salmon Falls and Bliss tailwaters.

Table 82. The percentage composition of the kinds of aquatic bottom invertebrates sampled from all impoundment and tailwater environments compared to the composition of organisms sampled from stomachs of 266 rainbow trout from these environments of Snake River during the 1953-54 period.

Invertebrates	Impoundment[1]		Tailwater	
	Production	Utilization	Production	Utilization
Animals	100.00	100.00	100.00	100.00
Insecta	17.53	31.12	40.06	85.05
Coleoptera	0.03	0.04	2.09	4.38
Diptera	17.14	29.43	9.13	37.42
Ephemerida	0.21	1.08	4.72	12.67
Odonata	0.11	0.43	0.18	0.77
Trichoptera	0.04	0.14	23.94	29.81
Hydrachnidae	0.11	1.31	1.05	0.09
Amphipoda	2.76	59.21	31.05	7.65
Decapoda	......	0.01	0.06	0.09
Hirudinea	1.62	0.36	1.61	0.45
Oligochaeta[2]	......	0.10	......	0.06
Tubificidae	73.84	......	1.74	......
Pulmonata	4.02	7.89	24.35	6.61
Pelecypoda	0.12	......	0.08	......

1 Does not include samples of organisms from Bruneau River arm of C. J. Strike reservoir

2 Other than Tubificidae

The provision of a fishway over a dam does not guarantee the upstream passage of sufficient numbers of each fish species to perpetuate natural runs of each species. Observations of the use made of fishways over dams in the study area, plus analyses of creel census and fishway collection data, indicate the only beneficial uses made are by a few steelhead that use the fishway over Swan Falls dam and a substantial run of whitefish that use the fishway over Lower Salmon Falls dam. The use of fishways by species of non-game fish is rather extensive and can only be considered detrimental to the fishery of the area.

Very likely many fish fail to find the entrance of even the more efficient fishways, such as those over Lower Salmon Falls dam and the Cavanaugh diversion dam, because of the lack of attracting influence of water that issues from these fishways. Even fewer fish use the fishway over the Upper Salmon Falls diversion dam due to, with other things, the poor location of its lower entrance. Few game fish utilize the fishway over Swan Falls dam because of the intermittant flows.

Field observations tend to show that some of the fish that do finally gain entrance to a fishway and pass over a dam have been delayed to the extent that they are in poor condition and are unable to spawn successfully.

The Bliss and C. J. Strike dams form impassable barriers to the upstream movement of fish since fishways were not constructed at these installations.

The hydroelectric dams slowed, but did not appear to stop the downstream movement of hatchery-reared rainbow trout. Of the 405 tags returned from tagged rainbow trout planted in Lower Salmon Falls impoundment, 197 or nearly 50 per cent were recovered below the dam. One tag was returned from a rainbow trout caught in the Bliss tailwater which is separated from the planting site by two dams and one tag was returned from a rainbow trout caught in C. J. Strike tailwater, three dams downriver.

These tagged trout could have passed downstream over Lower Salmon Falls dam via the fishway, but those caught in Bliss and C. J. Strike tailwaters would have to pass downstream over the spillway, or through the turbines or trash chute. Five tagged rainbow trout were collected from the Lower Salmon Falls fishway and tags were returned from two rainbow trout found stranded in pools below the spillway at Lower Salmon Falls dam.

It is believed that the majority of tagged trout that moved downstream past Lower Salmon Falls dam did so with the waters that flow through the turbines. Observations on the movement of concentrations of hatchery trout from the area just above the upper plant at Upper Salmon Falls to the area just below this plant tend to substantiate this belief.

Based on the movement of tagged rainbow trout; it appears that these dams, with or without fishways, do not present much of an obstacle to the downstream movement of fish less than a foot long. The mortality of trout or other species of fish that pass downstream through the hydroelectric installations within the study area was not ascertained.

<u>Effect of water-flow and water-level fluctuation</u>. The relative location of the recovery site to stocking site of tagged hatchery-reared rainbow trout indicates these trout have a greater tendency to move downstream than upstream (Table 83).

Table 83. Movement of tagged rainbow trout planted in tailwater- and impoundment-type areas of Snake River based on location of recovery site to stocking site.

Release area	Recovery site of tags returned					
	Upstream		At stocking site		Downstream	
	Number	Per cent	Number	Per cent	Number	Per cent
Upper Salmon Falls tailwater						
Dolman Rapids	3	1.3	208	91.4	17	7.3
Lower Salmon Falls impoundment						
Upper section	25	11.5	56	25.8	136	62.7
Central section	15	15.3	20	20.4	63	64.3
Lower section	9	10.0	18	20.0	63	70.0

Most of the trout stocked in Upper Salmon Falls tailwater not only remained near the planting site, but were caught more quickly than the trout planted in Lower Salmon impoundment (Table 84). The downstream movement of the trout planted in the fluctuating waters of Lower Salmon Falls impoundment was nine times greater than that of the trout planted in the non-fluctuating waters of Upper Salmon Falls tailwater. The more rapid rate of downstream movement may be due directly to the fluctuation of the water flows and levels or indirectly due to the poorer quality of the food supply in Lower Salmon Falls impoundment.

Rate of Growth of Fish

Effect of power plant operations. Since rainbow trout appeared to have freedom of downstream movement from one ecological area to another, differences in the rate of growth of rainbow trout for each ecological area could not be determined. Any effects which would increase or decrease the food supply would tend to have a direct effect on the growth rate of fish.

Fish Populations

The samples of the fish population of Snake River collected by means of gill-net, hoop-net, seine and hook-and-line methods indicate each method to be selective for certain species or kinds of fish (Tables 56 and 85 to 87). The selectivity of each of the four methods is illustrated by the species composition of the samples collected from the fish population of Upper Salmon Falls and Lower Salmon Falls impoundments (Table 88).

Further, since it appears that smaller fish can move downstream from one ecological area to the next through the turbines, the species composition of any particular ecological area might not be indicative of some of the more important environmental effects of that area on the fish population.

Table 84. Rate of return of tags from rainbow trout tagged and planted in tailwater- and impoundment-type areas of Snake River.

Period Tags recovered		Accumulative totals of tags returned			
		Upper Salmon Falls Tailwater		Lower Salmon Falls Impoundment	
		Number	Per cent	Number	Per cent
March	1954	...	....	6	1.5
April		172	75.6	132	32.6
May		213	93.7	199	49.1
June		215	94.5	238	58.7
July		218	95.8	267	65.9
August		219	96.2	284	70.1
September		220	96.6	315	77.8
October		224	98.3	348	86.0
November		226	99.2	380	93.9
December		226	99.2	385	95.1
January	1955	227	99.6	396	97.8
February		228	100.0	400	98.8
March				405	100.0

Table 85. Species composition of the catch of fish in 28 gill-net sets in Upper Salmon Falls, Lower Salmon Falls and Bliss impoundments and 36 gill-net sets in C. J. Strike reservoir during the 1953-54 period.

Species	Impoundment		Reservoir	
	Number	Per cent	Number	Per cent
Rainbow trout	35	1.5	....	.....
Mountain whitefish	254	10.5	5	0.3
White sturgeon	....	.....	2	0.1
Brown bullhead	3	0.1	159	8.8
Black crappie	....	.....	2	0.1
Bluegill sunfish	5	0.2	....	.....
Largemouth bass	....	.....	14	0.8
Yellow perch	43	1.8	4	0.2
Total game fish	340	14.1	186	10.3
Carp	2	0.1	368	20.3
Chiselmouth	116	4.8	15	0.8
Chub	435	18.0	132	7.3
Squawfish	217	9.0	419	23.2
Sucker	1303	54.0	690	38.1
Total non-game fish	2073	85.9	1624	89.7
Total fish	2413	100.0	1810	100.0

Table 86. Species composition of the catch of fish in 67 hoop-net sets in Upper Salmon Falls, Lower Salmon Falls and Bliss impoundments, and 49 hoop-net sets in C. J. Strike reservoir during the 1953-54 period.

Species	Impoundment		Reservoir	
	Number	Per cent	Number	Per cent
Rainbow trout	6	0.3	....	.....
Mountain whitefish	30	1.5	....	.....
Brown bullhead	1	0.1	772	60.0
Channel catfish	1	0.1	....	.....
Black crappie	....	.....	9	0.7
Bluegill sunfish	13	0.6	....	.....
Green sunfish	2	0.1	4	0.3
Pumpkinseed sunfish	....	.....	9	0.7
Redear sunfish	1	0.1	3	0.2
Largemouth bass	2	0.1	4	0.3
Yellow perch	6	0.3	....	.....
Total game fish	62	3.2	801	62.2
Carp	27	1.4	354	27.5
Chiselmouth	38	1.9	36	2.8
Chub	689	35.3	6	0.5
Dace	2	0.1	5	0.4
Shiner	544	27.9	7	0.5
Squawfish	119	6.1	15	1.2
Sculpin	3	0.2	....	.....
Sucker	467	23.9	63	4.9
Total non-game fish	1889	96.8	486	37.8
Total fish	1951	100.0	1287	100.0

Table 87. Species composition of the angler harvest of fish from Snake River within the study area during the 1953-54 period, and number and per cent of fish caught, by species, per type of ecological environment compared to the total harvest.

Species	Tailwater		Impoundment		Reservoir		Total	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Rainbow trout	52284	21.4	56728	23.2	670	0.3	109682	44.9
Steelhead	89	tr.	.....	....	.....	....	89	tr.
Mountain whitefish	507	0.2	1433	0.6	.....	....	1940	0.8
White sturgeon	251	0.1	.....	....	.....	....	251	0.1
Brown bullhead	1005	0.4	88	tr.	26036	10.6	27129	11.0
Black crappie	......	....	.....	....	510	0.2	510	0.2
Bluegill sunfish	......	....	37	tr.	16	tr.	53	tr.
Largemouth bass	106	tr.	157	0.1	5617	2.3	5880	2.4
Yellow perch	26	tr.	.....	....	.....	....	26	tr.
Total game fish	54268	22.1	58443	23.9	32849	13.4	145560	59.4
Carp	3456	1.4	896	0.4	5267	2.2	9619	4.0
Chiselmouth	6112	2.5	3027	1.2	339	0.2	9478	3.9
Chub	13501	5.5	18846	7.7	.....	....	32347	13.2
Squawfish	24261	9.9	9323	3.8	2024	0.8	35608	14.5
Sucker	7175	3.0	5062	2.0	98	tr.	12335	5.0
Total non-game fish	54505	22.3	37154	15.1	7728	3.2	99387	40.6
Total fish	108773	44.4	95597	39.0	40577	16.6	244947	100.0

Table 88. Species composition of the fish catch, by method of capture, from Upper and Lower Salmon Falls impoundments during the 1953-54 period.

Species	Hook and line	Gill-net	Hoop-net	Seine
	Per cent	Per cent	Per cent	Per cent
Game fish				
Rainbow trout	53	1	..	1
Rocky Mountain whitefish	2	15	2	1
Brown bullhead	tr.	..	..	..
Bluegill sunfish	tr.	tr.	tr.	..
Largemouth bass	tr.	..	tr.	tr.
Yellow perch	..	1	..	tr.
Total, game fish	55	17	2	2
Non-game fish				
Carp	1	tr.	1	2
Chiselmouth	4	5	2	1
Chub	23	23	44	25
Shiner	..	..	31	..
Squawfish	11	12	3	3
Sucker	6	43	17	67
Total, non-game fish	45	83	98	98

The samples of the fish population indicate that during the study:

1. Tailwater areas provide a favorable habitat for sturgeon, trout, steelhead, squawfish and chiselmouth;

2. Impoundment areas provide a favorable habitat for trout, whitefish, chubs and suckers; and

3. Reservoir areas provide a favorable habitat for largemouth bass, black crappie, brown bullheads and carp.

Effect of hydroelectric and diversion dams. Hydroelectric and diversion dams form obstacles, of varying degree, to the upstream movement of spawning migrations of certain species of fish; namely, chinook salmon, steelhead, trout, whitefish, suckers, chubs, chiselmouths, and possibly sturgeon. These dams, therefore, tend to limit the potential numbers of fish of these species in the fish population of Snake River.

Effect of water impoundment. Water impoundment followed by siltation and decreased velocities alter spawning areas for salmonoids. This limits the populations of trout if the impounded water inundates entire river sections between dams, as does Lower Salmon Falls impoundment.

Water impoundment and subsequent siltation cause changes in the populations of bottom food organisms. These changes generally favor bottom feeders such as suckers, carp and brown bullheads.

The relatively large number of sturgeon that were caught in the lower end of the Bliss tailwater just above C. J. Strike reservoir in 1953 indicates these sturgeon had moved upstream from their former river habitat when it was inundated by the waters of C. J. Strike reservoir.

Water impoundment that provides extensive warm and shallow still-water areas, such as C. J. Strike reservoir, provides a favorable habitat for certain fish species; namely, largemouth bass, crappie and other sunfish species, bullhead catfish, perch, carp and some other minnow species.

Effect of water-flow and water-level fluctuations. The diurnal water-level fluctuations in Lower Salmon Falls and Swan Falls impoundments are detrimental to the spawning of many fish species, especially largemouth bass. Diurnal fluctuations in good spawning areas of tailwaters such as that between Indian Cove bridge and Glenns Ferry is detrimental to trout, whitefish and possibly sturgeon spawning.

Fishing Pressure, Success and Harvest

From the data compiled in Tables 87 to 94 it can be noted:

1. The fishing pressure during 1954 was 2.3 times greater than that of 1953; the game fish catch during 1954 was 3.2 times that of 1953; the game fish catch per hour during 1954 was 1.4 times that of 1953; and, though the non-game fish catch during 1954 was 1.4 times that of 1953, the non-game fish catch per hour during 1954 was only 0.6 times that of 1953. Among reasons which might explain these differ-

Table 89. Comparison of the fishing pressure and catch of game fish from each and by type of ecological area of Snake River during the 1953-54 period (sturgeon catch excluded).

Ecological area	Fisherman hours		Catch of game fish	
	Number	Per cent	Number	Per cent
Upper Salmon Falls tailwater	21879	10.2	19903	13.7
Lower Salmon Falls tailwater	36704	17.1	16664	11.5
Bliss tailwater	17996	8.4	8866	6.1
C. J. Strike tailwater	27730	13.0	8584	5.9
Tailwater totals	104309	48.7	54017	37.2
Upper Salmon Falls impoundment	42407	19.8	37742	26.0
Lower Salmon Falls impoundment	18427	8.6	7141	4.9
Bliss impoundment	15762	7.4	13560	9.3
Impoundment totals	76596	35.8	58443	40.2
C. J. Strike reservoir				
Snake River arm	8804	4.1	3004	2.1
Bruneau River arm	24414	11.4	29845	20.5
Reservoir totals	33218	15.5	32849	22.6
Snake River fishery totals	214123	100.0	145309	100.0

Table 90. Estimated fishing pressure and game fish catch by species, and the rate of catch by type of ecological area, Snake River, 1953-54.

Area	Fishermen	Game-fish catch								Game fish per hour
		Rainbow	Steelhead	Whitefish	Bass	Bluegill	Catfish	Crappie	Perch	
1953										
Tailwater	9071	12823	65	234	44	..	961	...	26	0.37
Impoundment	5181	9293	..	580	98	37	.....	...	..	0.46
Reservoir	927	.....	..	...	39	..	10204	...	..	2.26
Total	15179	22116	65	814	181	37	11165	...	26	0.54
1954										
Tailwater	15824	39461	24	273	62	..	44	...	..	0.60
Impoundment	13110	47435	..	853	59	..	88	...	..	0.88
Reservoir	5880	670	..	...	5578	16	15832	510	..	0.79
Total	34814	87566	24	1126	5699	16	15964	510	..	0.74

Table 91. Estimated fishing pressure and non-game fish catch by species, and the rate of catch by type of ecological area, Snake River, 1953-54.

Area	Non-game fish catch					Non-game fish per hour
	Carp	Chiselmouth	Chub	Squawfish	Sucker	
1953						
Tailwater	1726	5315	5999	14323	2453	0.79
Impoundment	83	1681	6296	2148	541	0.50
Reservoir	359	15	....	284	39	0.15
Total	2168	7011	12295	16755	3033	0.64
1954						
Tailwater	1730	797	7502	9938	4722	0.37
Impoundment	813	1346	12550	7175	4521	0.48
Reservoir	4908	324	....	1740	59	0.25
Total	7451	2467	20052	18853	9302	0.39

Table 92. Estimated fishing pressure, game-fish catch by species, and the rate of catch from Snake River by seasons during 1953 and 1954.

Area	Fishermen	Game-fish catch								Game fish per hour
		Rainbow	Steelhead	Whitefish	Bass	Bluegill	Catfish	Crappie	Perch	
1953										
Winter	3266	3845	..	6	....	..	.....	...	..	0.28
Spring	5456	6418	65	439	67	..	4342	...	..	0.49
Summer	4427	6525	..	149	114	37	5373	...	26	0.65
Fall	2030	5328	..	220	....	..	1450	...	..	0.82
Total	15179	22116	65	814	181	37	11165	...	26	0.54
1954										
Winter	9265	27829	..	535	860	..	336	...	..	0.76
Spring	13405	28777	24	542	3660	..	8385	510	..	0.72
Summer	5846	9575	..	49	248	..	6555	...	..	0.64
Fall	6298	21385	..	...	931	16	688	...	..	0.85
Total	34814	87566	24	1126	5699	16	15964	510	..	0.74

Table 93. Fishing success and estimated catch of non-game fish from Snake River by seasons during 1953 and 1954.

Period	Non-game fish catch					Non-game fish per hour
	Carp	Chiselmouth	Chub	Squawfish	Sucker	
1953						
Winter	....	698	4106	1373	529	0.49
Spring	152	3270	5655	6688	1405	0.74
Summer	1346	2376	1722	6130	756	0.65
Fall	670	667	812	2564	343	0.59
Total	2168	7011	12295	16755	3033	0.64
1954						
Winter	838	491	7654	1955	1222	0.31
Spring	5311	982	9811	8517	4966	0.51
Summer	994	449	1045	4687	1982	0.36
Fall	308	545	1542	3694	1132	0.27
Total	7451	2467	20052	18853	9302	0.39

Table 94. Comparison of the fishing pressure and game and non-game fish catch from the Snake River fishery during the seasons of 1953 and 1954.

Period	Fisherman hours		Game-fish catch		Non-game fish catch	
	Number	Per cent	Number	Per cent	Number	Per cent
1953						
Winter	13684	21	3851	11	6706	16
Spring	23076	36	11331	33	17170	42
Summer	18891	30	12224	36	12330	30
Fall	8586	13	6998	20	5056	12
Total	64237	100	34404	100	41262	100
1954						
Winter	39016	26	29560	27	12160	21
Spring	58355	39	41898	38	29587	51
Summer	25516	17	16427	15	9157	16
Fall	26999	18	23020	20	7221	12
Total	149886	100	110905	100	58125	100

ences between years are increased stocking, populations becoming better established, and anglers locating better fishing areas.

2. Trout, largemouth bass and bullhead catfish comprised 98 per cent of the game fish catch. Chub and squawfish comprised 68 per cent of the non-game fish catch.

3. The catch of game and non-game fish varied slightly with the fishing pressure applied both by seasons and by type of ecological area.

4. The catch of game and non-game fish varied considerably with the fishing pressure applied in each ecological area as shown in Table 89.

Effect of hydroelectric and diversion dams. Since upstream migrations of fish concentrate below dams and hatchery-reared trout hesitate and thus become concentrated above dams while moving downstream, large numbers of fish are present in the waters of Snake River within a short distance above and below dams.

The Idaho Power Company permits the public, including fishermen, to use the private roads leading to hydroelectric and diversion dams and permits fishermen to fish from these dams, except in one or two areas where hydroelectric power operations would be dangerous to the fisherman.

The dams concentrate the fish and the liberal access policy of the Idaho Power Company helps concentrate the fishermen. The net result is increased fishing pressure, success and harvest of fish from the Snake River fishery.

Effect of water impoundment. Impounded waters provide approximately 85 miles of shoreline (35 per cent) of a total of approximately 245 miles of shoreline for the Snake River from the mouth of Salmon Falls Creek downstream to Grandview. The impounded waters received 51.3 per cent of the fishing pressure and provided 62.8 per cent of the game fish catch from the above section of Snake River during the 1953-54 period (Table 88).

The disproportionate amount of fishing pressure on impounded waters appears to be primarily a result of better fisherman access to these waters. All impoundments and reservoirs are accessible by public and private roads. Also, the more stable flow of impounded waters and the construction of public boat docks by the Idaho Power Company, Idaho Department of Fish and Game or private interests on all impounded waters have encouraged the use of boats on these waters by fishermen. Aided by boats, fishermen have access to the entire shorelines of impounded waters whereas access to many miles of tailwater shoreline is restricted by private property. The turbulence of some tailwaters limits the use of boats.

The fishing success and the harvest of game fish from impounded waters of Snake River during the 1953-54 period was good for two reasons: (1) 67 per cent of all legal-size, hatchery-reared rainbow trout planted in Snake River within the study area during the 1953-54 period were planted in impounded waters and (2) the catch of largemouth bass and brown bullheads from C. J. Strike reservoir during the 1953-54 period was a substantial portion of the entire catch of fish from Snake River within the study area.

Effect of water-flow and water-level fluctuation. The fishing pressure and success appeared to be highest in impounded waters when the water-levels were at a maximum. Under these conditions, the fish populations apparently moved into the shallow water near the shoreline and thus became more available to the fishermen. During March and April of 1955, the water level of C. J. Strike reservoir was lowered approximately four feet. Shoal areas near the mouths of the Bruneau River and Little Valley Creek, which had produced the bulk of the catch of largemouth bass and brown bullheads from C. J. Strike reservoir during the 1953-54 period, became too shallow as a result of this four-foot reduction in water level and the fishing pressure, success and harvest of fish declined. The fish were present in the reservoir, but were not available to the shore fisherman. Thus, the fluctuation of water levels in impounded waters causes a fluctuation in the availability of the fish to the fisherman.

The water flows or water levels of Lower Salmon Falls and C. J. Strike tailwaters were generally at a maximum during the daylight periods of fishing; however, fishermen could fish both high and low flows or levels of the Bliss tailwater. Trout fishing immediately below the Bliss dam was excellent during the early morning period of low flow. Most trout and sturgeon fishermen fished the Bliss tailwater only in areas and during periods when the water flow and level were at a minimum. During these periods, the fish were concentrated in smaller areas and the fishermen were able to reach them.

Comparisons between the fishing success and the diurnal fluctuation of water levels are shown in Table 95. Fluctuations of one foot or less have little or no effect on the fishing success. On the other hand, water level fluctuations in excess of three feet appear to have a detrimental effect on the fishing success. Other factors which affect fish populations, such as fish food production, movement of stocked and natural populations, and fisherman access, which are also influenced by water-level fluctuations undoubtedly influence the fishing success.

Table 95. Comparison of the average daily river fluctuation with game fish rate of catch by ecological areas, 1953-54.

Ecological area	Fluctuation, feet/day average	Game fish catch/hour
Impoundments		
Upper Salmon	0.0	0.89
Lower Salmon	4.0	0.39
Bliss	1.1	0.86
Tailwaters		
Upper Salmon	0.0	0.91
Lower Salmon	5.6	0.45
Bliss	3.5	0.49
C. J. Strike	3.3	0.31
Reservoirs		
C. J. Strike	0.6	1.00

CONCLUSIONS

A two-year study was conducted on a section of Snake River in which five hydroelectric dams are located. The purpose of the study was to determine the effects of the dams and their operations upon the Snake River fishery. As a result of the study the following conclusions are drawn regarding the several physical, chemical, and biological factors concerning the fishery:

1. Temperature - very little affected through this series of dams, unless near critical levels for trout. Lowering of penstock intakes might improve temperatures for trout through a series of dams of this type.

2. Turbidity - beneficial effect since impoundments act as settling basins.

3. Chemical content - not appreciably affected. Changes are so slight they can be assigned to variation in analysis techniques.

4. Production of game-fish foods - if the quality of game-fish foods produced in Snake River above the study area, in river sections unchanged by dams and hydroelectric plants, be graded as excellent, then the following classifications may be assigned to the various ecological areas within the study area:

   (a) excellent in non-fluctuating tailwaters (Upper Salmon Falls);

   (b) good in (1) fluctuating tailwaters within the permanent flow zone comprising about 80 per cent of tailwater areas (Lower Salmon Falls, Bliss, C. J. Strike, and Swan Falls);

   (2) shallow, non-fluctuating impoundments (Upper Salmon Falls);

   (3) wide, shallow reservoirs with little fluctuation of water levels (the Bruneau River arm and lower section of the Snake River arm of C. J. Strike reservoir). The increased quantity of game-fish food, especially plankton, produced in reservoir environments appears to offset the reduced quality. Plankton production is proportionate to rate of outflow.

   (c) fair in deep, long, narrow impoundments which fluctuate in elevation slightly (Bliss impoundment and the Snake River arm of C. J. Strike reservoir).

   (d) poor in shallow impoundments with severe water level fluctuation (lower Salmon Falls and Swan Falls impoundments); and,

   (e) virtually absent within the zone of fluctuation in fluctuating tailwaters, comprising about 20 per cent of food production area (Lower Salmon Falls, Bliss, C. J. Strike and Swan Falls tailwaters).

   The production of game-fish foods is further reduced through tailwater sections by the flushing action of increased water flows and velocities during power peaking operations.

5. Reproductive potentials - certain dams within the study area block, either partially or entirely, spawning migrations of chinook salmon, steelhead and rainbow trout, whitefish and possibly sturgeon.

Fluctuations of tailwaters limit the potential trout spawning areas, and fluctuations of impoundments limit spawning of members of the sunfish family, particularly largemouth bass.

6. Fish movements - downstream movements of fish are unhampered, but mortality rates of these fishes passing over spillways or through penstocks is not known. Upstream movements of fish are affected by the hydroelectric installations. Even dams with fishways remain partial blocks because of poor location of entrances, lack of attraction flows, or poor design.

7. Game fish growth rates - because downstream movements of fish were unaffected by the dams, changes in growth rates, due to the dams and the operation of their power plants could not be determined. Any factor detrimental to game fish food production, however, would also slow the growth rate of fish.

8. Game fish populations -

   (a) Trout and whitefish populations are reduced in impoundments because of siltation of spawning areas and changes in the quality of fish-food organisms.

   (b) Sturgeon populations are reduced in reservoirs because of changes in habitat.

   (c) Carp, sucker, catfish, largemouth bass and crappie populations are increased in reservoirs because of added habitat.

   (d) There appears to be correlation between age of impoundment and increases in the rates of non-game fish populations due possibly to differential rates of reproduction and removal between non- and game-fish species. Additional study is needed to confirm this.

9. Fishing pressure - new access roads and waters, developed in the study area have resulted in greater fishing intensity. This is particularly true of the C. J. Strike reservoir.

Fluctuation of tailwaters has tended to limit fishing to periods of minimum flows, except at Lower Salmon Falls tailwater.

10. Fishing success - the study indicates that diurnal fluctuation of water levels in excess of one foot had a detrimental effect upon fishing success for trout in impoundments.

Seasonal fluctuation of reservoir elevations had detrimental effects upon fishing success for warm water species.

11. The sport fishery on the section of Snake River under study had an economic value in excess of $120,000 in 1954 without including capital investment expenditures.

RECOMMENDATIONS

The following recommendations are made after due consideration of the results and the conclusions drawn from the study:

1. That careful study of plans be made during preliminary planning stages of all proposed hydroelectric installations or storage dams so that recommendations may be made to the construction agency for changes which will benefit the local fishery. These recommended changes would enhance temperature regimes for fish (depth of penstock openings), prevent losses to fish moving downstream over spillways and through turbines (position and type of spillway and kind of turbine), permit fish passage when desirable (fish ladders properly positioned, of adequate design, and conforming to recognized water flow criteria), enhance the fish habitat (by having less fluctuating flows or forebay elevations or by construction of re-regulating dams to smooth out river flows).

2. That Idaho Power Company be requested to consider in their future plans a re-regulating dam below Bliss dam to smooth out river flows through the King Hill - Indian Cove section of Snake River.

3. That Idaho Power Company continue to operate Swan Falls dam as a regulatory dam (as in 1954) so that flows below this plant are non-fluctuating.

4. That Idaho Power Company be requested to hold the C. J. Strike reservoir at or near maximum elevation at all times. This will improve the bass sport fishery and the spawning success of spiny-rayed species.

5. That Idaho Power Company be requested to make experimental plantings with amphibious plants (Bermuda grass, for example) which would prevent bank erosion and provide food for wildlife as well as serve as food producing areas for aquatic organisms in the fluctuating zones of forebays and tail-waters. Should experimental plantings be successful they should be made in all zones of fluctuation.

6. That Idaho Power Company be commended for its policy of recreational use and access development through the study area and encouraged to continue and enlarge upon such development, and that other construction agencies arrange, during preliminary planning, for such development for recreational use of impounded waters.

7. That, in the event fish passage is provided over dams under construction or proposed for Snake River from Lewiston to Weiser, the Idaho Power Company be requested to redesign and reconstruct the fish facilities at Swan Falls so that anadromous species may make better use of the river to C. J. Strike dam for spawning and rearing purposes.

8. That studies be continued on the fish facilities at the Salmon Falls dams and recommendations be made regarding the months of the year when operation of these facilities are desirable. Waters used in the facilities might better be used for power production the remainder of the year.

9. That follow-up studies be considered in portions of this study area for the purpose of correlating age of impoundments with fish populations and food production. The C. J. Strike area offers good opportunity for

such comparative studies inasmuch as it was a new water at the onset of this study.

10. That the findings of this study be used in the future whenever possible to forecast expected effects of new dams on the fishery.

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