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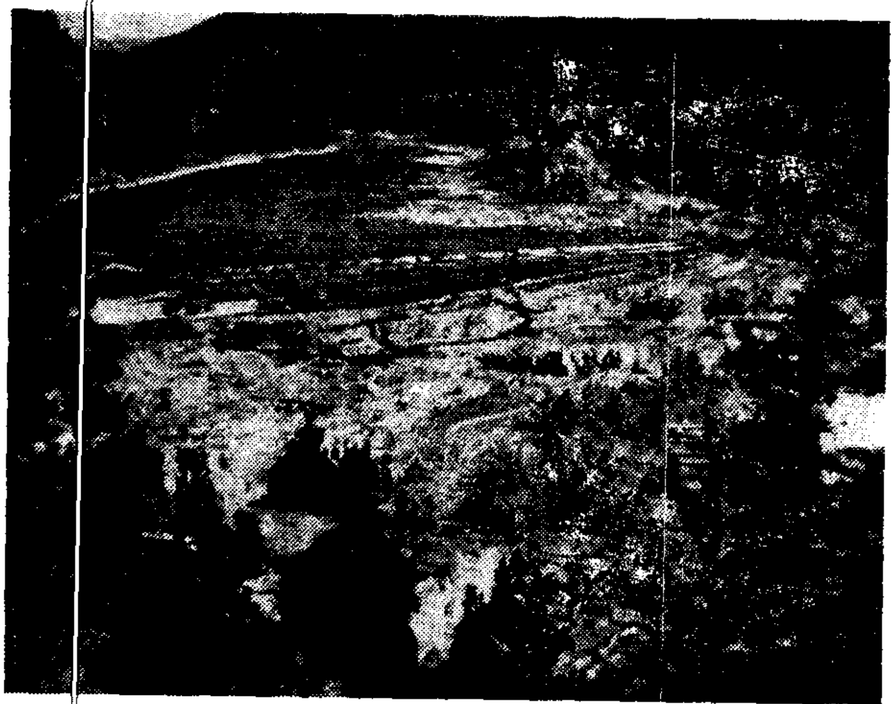
KOOTENAI FALLS AQUATIC ENVIRONMENT STUDY

FINAL REPORT



Prepared for Northern Lights, Inc.

and

The Montana Department of Natural Resources and Conservation

by

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Montana Department of Fish and Game

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Cover photo and frontispiece by Lance Schelvan, Figure 13 by Brad Shepard, and all other photos by the author.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure		Page

INTRODUCTION

This report contains an analysis of data collected on the aquatic environment in the Kootenai Falls area to assess the probable effects of a proposed hydroelectric diversion project, just upstream from the falls, on the aquatic biota. An impact analysis will appear in a separate document. The facility which would be built by Northern Lights, Inc. in cooperation with other electrical power cooperatives, includes a 30-foot high diversion dam on Kootenai Falls (Figure 1). An 18-foot high concrete base would support 12-foot high hydraulically operated gates that would be used to maintain a relatively constant pool level ($\pm$ 1 foot). The dam would back water over 3.5 miles upstream from Kootenai Falls and the proposed operational plans would essentially dewater Kootenai Falls and approximately 1 mile of river downstream. Proposed flow over the falls would be 750-1000 cfs. Figure 2 represents a flow of approximately 20,000 cfs and Figure 3 represents a flow of 4,000 cfs. The lowest historical mean daily flow was 1,000 cfs. A semi-circular intake structure (250 foot inside diameter) with metal grates would be built on the south bank. Water would fall about 100 feet down a tunnel and be carried to four generators located in an underground powerhouse. The generators could pass 24,000 cfs of water, the entire peak flow from Libby Dam. The water would return to the river via another tunnel. The mouth of the outflow tunnel would theoretically be large enough to reduce returning water velocities to near natural conditions.

DESCRIPTION OF THE STUDY AREA

The Kootenai River draws the majority of its surface runoff from Canada and hydrologically is separated from all other river basins in Montana flowing directly into the Columbia River after returning to Canada via Idaho. Over one-half (50 miles) of the main stem in Montana has been inundated by Libby Dam, a power peaking hydroelectric project, which backs water well into Canada. A "regulatory" dam, in the process of construction would inundate 20 percent of the remaining free-flowing river in Montana.

Kootenai Falls, located at river mile 193, is a relatively wide falls with water cascading down a series of bedrock faults through the canyon area (Figure 4). It is the largest falls remaining on a Montana river that has not been dammed or impounded. The riverbed slopes to a maximum depth along the north side with a large portion of the water flowing along the north bank during low discharges (less than 5,000 cfs). The river flows through a canyon area with steep, vertical sides for several miles and then returns to the narrow valley created by steep, heavily timbered mountain slopes. In the lower canyon water depths usually exceed 80 feet and a maximum of 99 feet was measured during low flows. In the upper canyon, there are a series of rapids and falls alternating with relatively deep pools (20-40 ft.). The water surface elevation at a discharge of 5,000 cfs drops 81.1 feet from the proposed dam site to the proposed outlet site.

Upstream from the falls, the river would be impounded for a distance of over 3.5 miles. This area contains 4 pools, 2 large riffle areas and a rapids known as "China Rapids." Most of this river section can be viewed from the road and is easily accessed. At a discharge of 5,000 cfs, the water surface elevation drops 7.4 feet per mile in this section. A more complete description of the physical characteristics of each area is presented in the Results section.

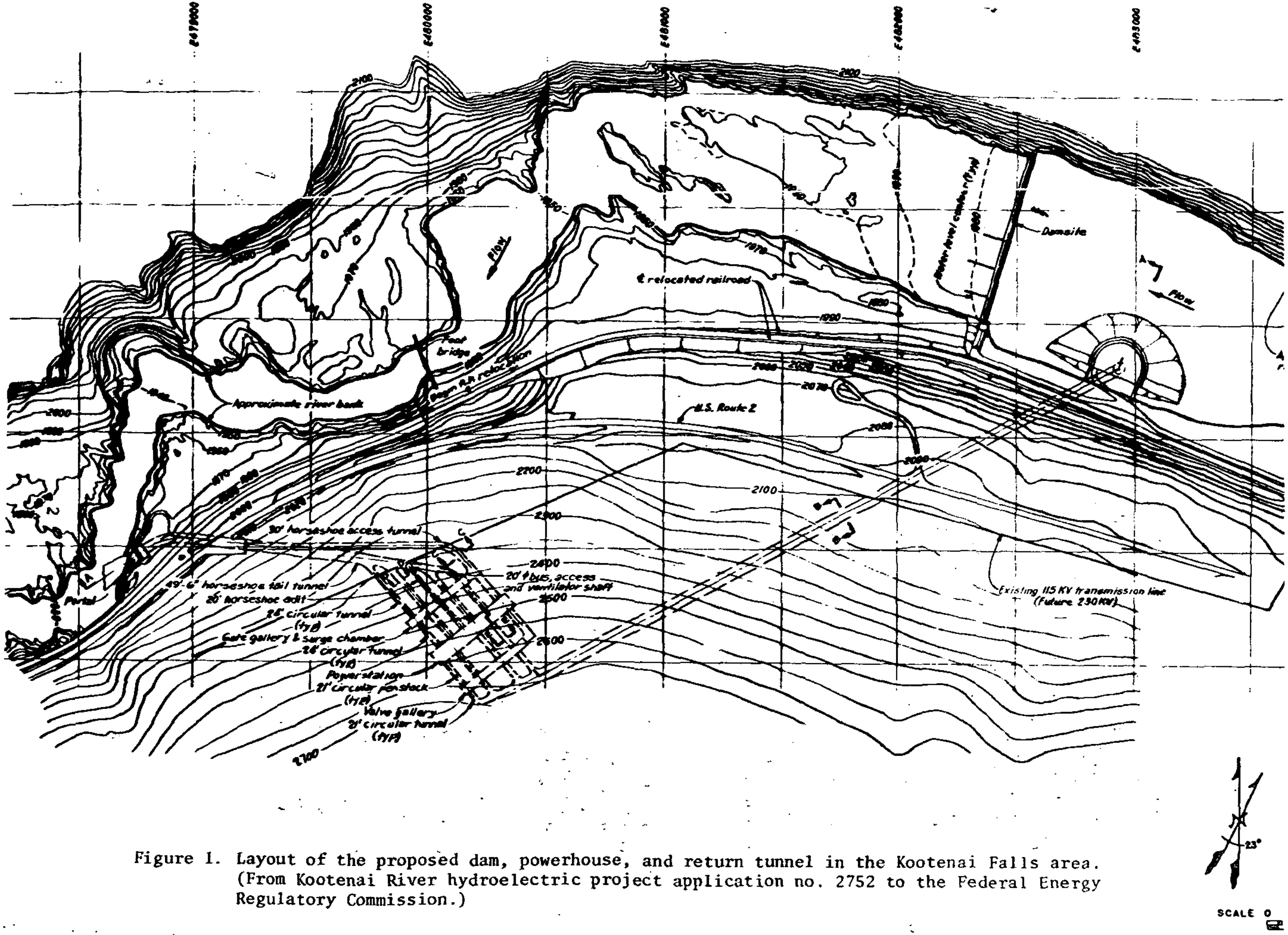

Figure 1. Layout of the proposed dam, powerhouse, and return tunnel in the Kootenai Falls area. (From Kootenai River hydroelectric project application no. 2752 to the Federal Energy Regulatory Commission.)

Figure 2. Kootenai Falls at a discharge of approximately 20,000 cfs.

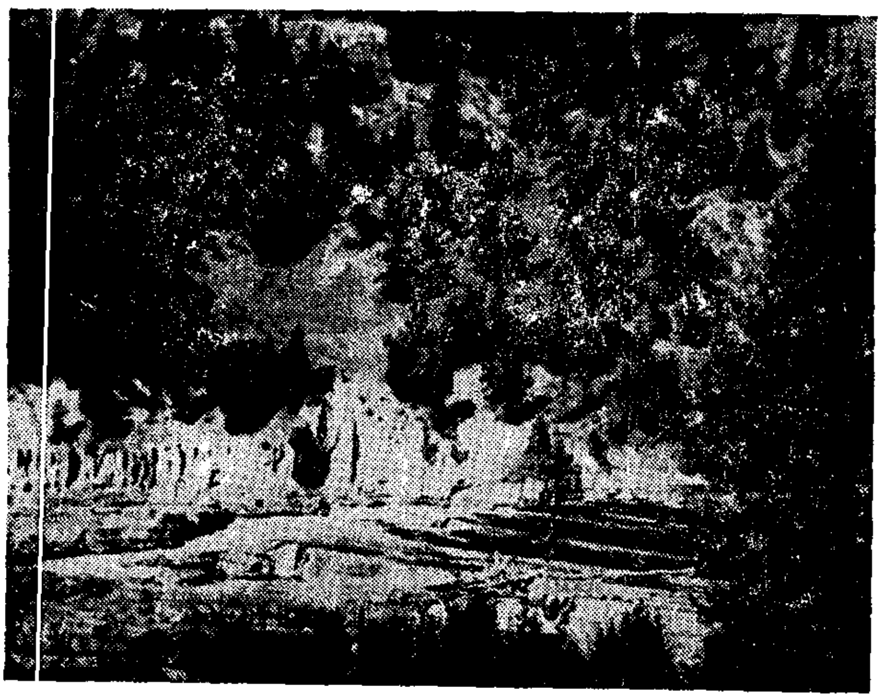

Figure 3. Kootenai Falls at a discharge of approximately 4,000 cfs.

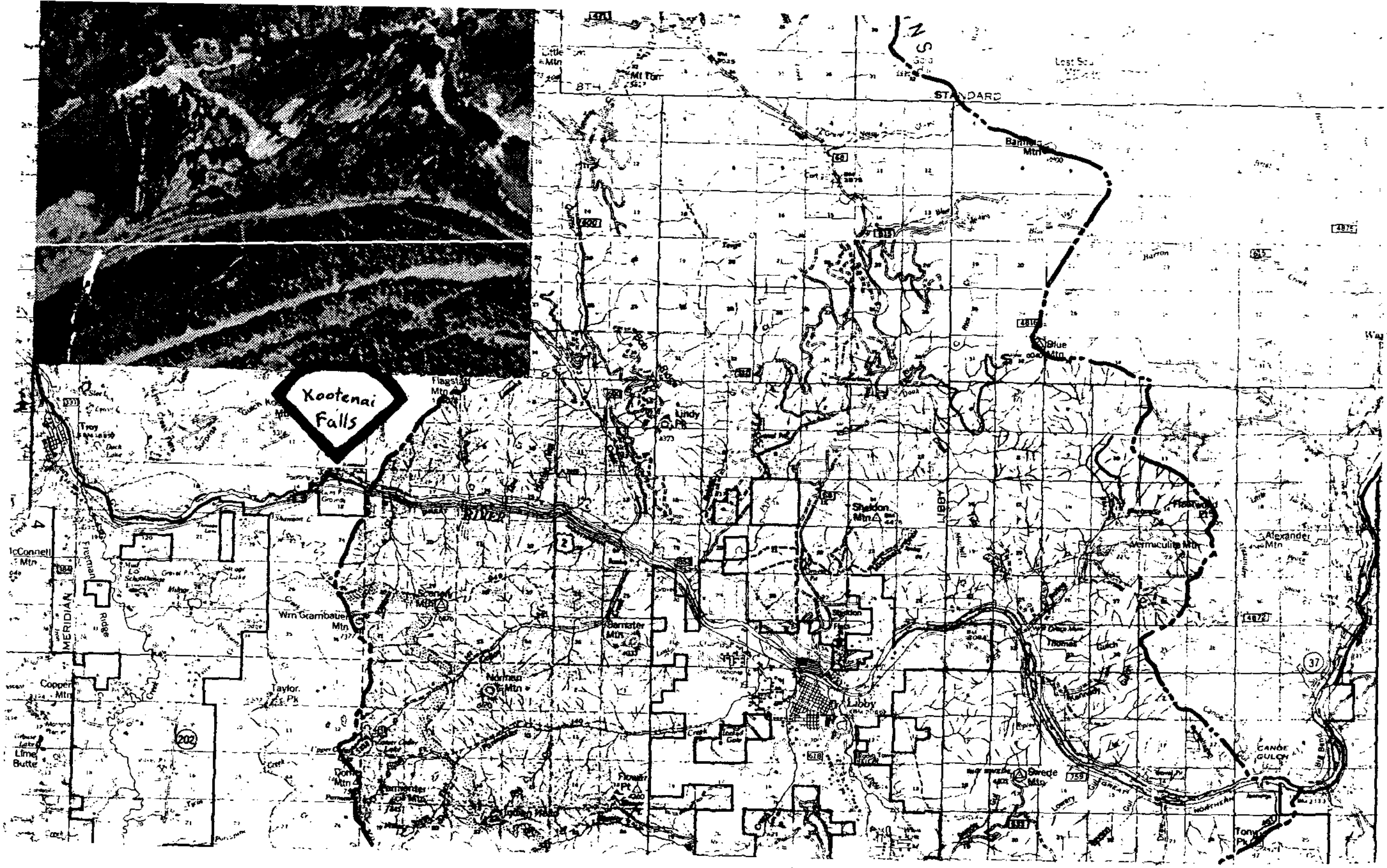

Figure . A map of Kootenai Falls area located at river mile 193 on the Kootenai River between Troy and Libby, Montana with an aerial photo insert.

Changes in water quality occurred after impoundment of the Kootenai River by Libby Dam. The annual flow regime was reversed from its natural pattern when the largest flows occurred from April through July with peaks usually occurring from mid-May to mid-June (**Figure 5**). Smallest discharges occurred during the winter and early spring with a historic daily mean flow of approximately 4,000 cfs. During May and June, historic mean daily flows ranged from 16,000 to 47,000 cfs. Since impoundment, lowest mean monthly flows normally occur from April through June or July depending on the length of time needed to fill the reservoir. During the remainder of the year, mean daily flows generally range from 7,000 to 20,000 cfs.

Daily flows were relatively stable under natural conditions. Due to the power-peaking operation from Libby Dam, daily flows can fluctuate four feet vertically per day during the summer and six feet per day during the winter. Post-impoundment annual and daily flow fluctuations altered: 1) chemical ion and sediment loads in the river, 2) seasonal and daily habitat available to aquatic and semi-aquatic organisms. and 3) morphological features **in the river by allowing deltas to form at the mouths of tributaries downstream** from the dam.

Several water quality parameters decreased rapidly in September of 1968 which was attributed to treatment of discharge from a fertilizer plant on the St. Mary River, a tributary to the Kootenai River in British Columbia (Bonde and Bush, 1975). Decreases occurred in $CaSO_4$, F and PO_4 **and reflected changes** in specific conductance and water hardness.

To illustrate some of the recent changes in water quality a comparison is made here of some water quality parameters measured during both a pre- and post-impoundment year. Both 1970 and 1977 were low water years being 75 and 77 percent of normal respectively. During 1977, dam operation was considered to be similar to "typical" operation with a general period of water storage during late spring and early summer (Figure 5), followed by discharges from selective withdrawal gates in the reservoir beginning in July and continuing into the fall. The 1970 flow regime was typical of the free-flowing Kootenai River (Figure 5).

Levels of both total phosphorus and dissolved orthophosphate decreased to low levels from 1970 to 1977 (Figure 6). This reflects both the additional cleanup of the Canadian fertilizer plant on the St. Mary River and the trapping of nutrients in the reservoir. The pH ranged between 7.0 and 8.5 during both years (Figure 7). Specific conductance was more constant in 1977 than 1970, and did not exhibit the seasonal low levels which occurred from dilution during naturally large spring flows nor did 1977 levels reach the high levels of specific conductance which occurred naturally during low flows in late summer and through the winter (Figure 8). In general, specific conductance was lower in 1977 than 1970.

The water temperatue regime in the river has been significantly affected by Libby Dam. Water temperatures during the summer were cooler in 1977 than 1970 as a result of selective water withdrawal from the reservoir (Figure 9).

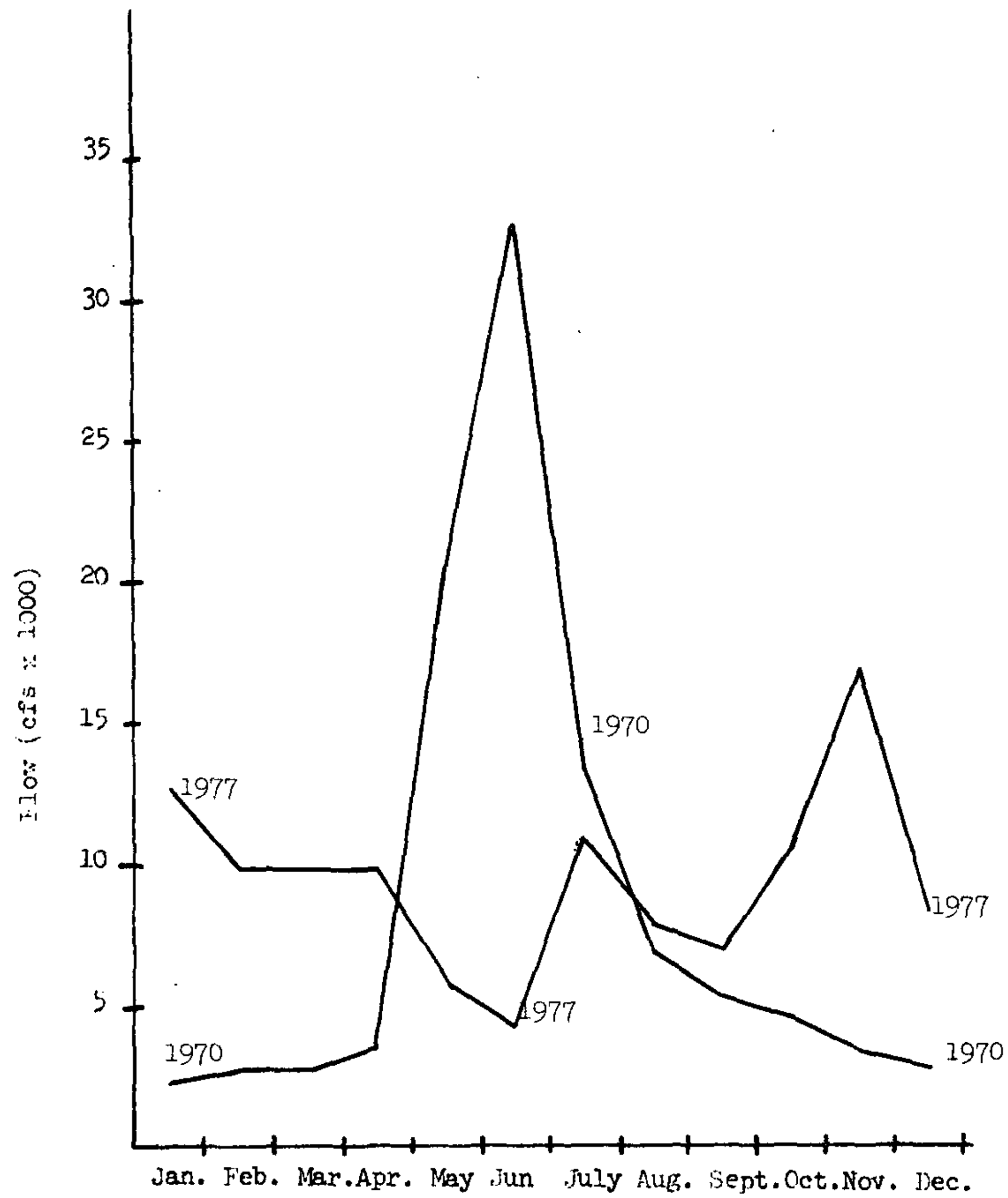

Figure 5. Monthly averages of mean daily discharge downstream from the Libby Dam site prior to impoundment (1970) and following impoundment (1977).

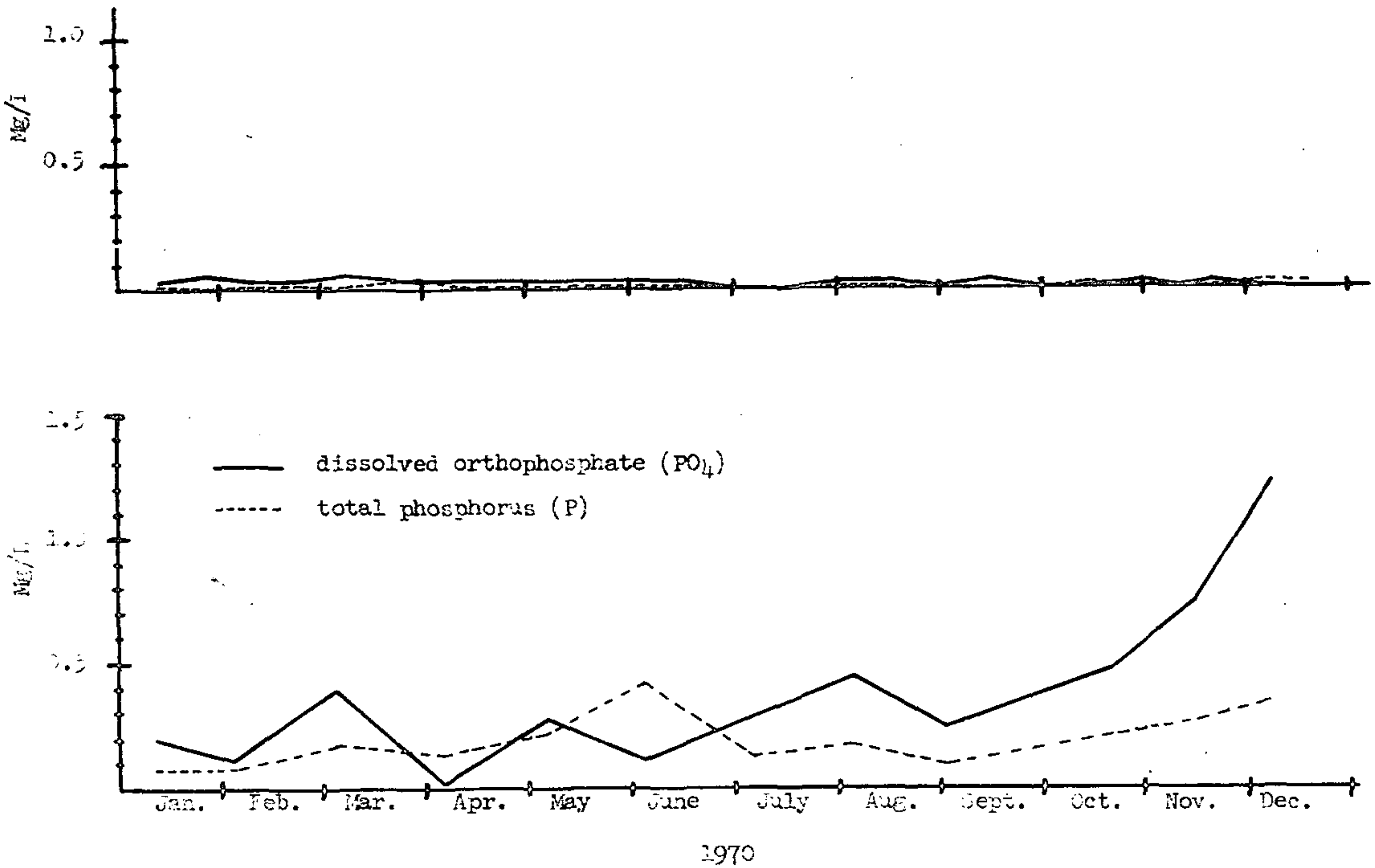

Figure 6. Total phosphorus and dissolved orthophosphate measured downstream from the Libby Dam site prior to impoundment (1970 and following impoundment (1977)

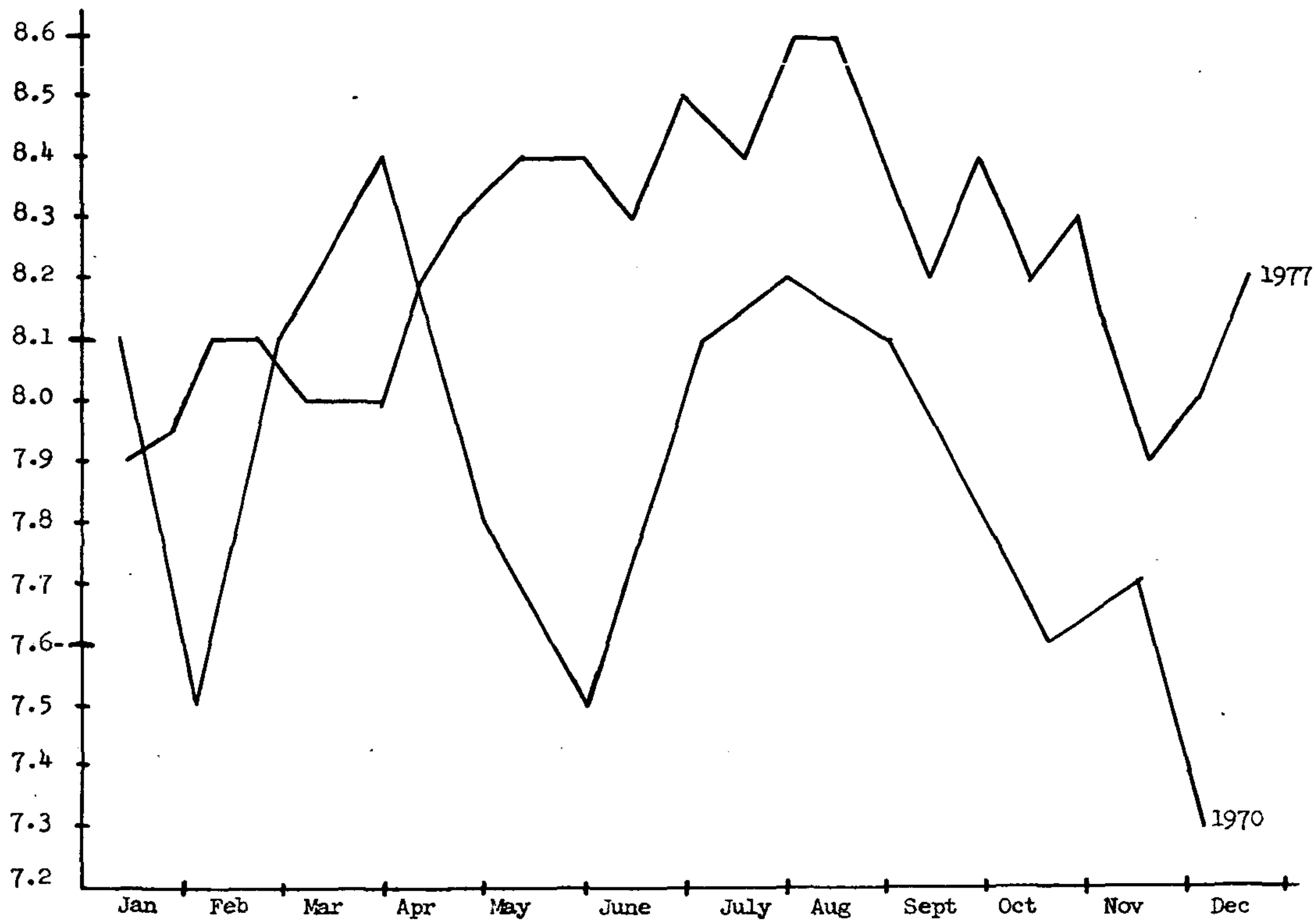

Figure 7. The pH in the Kootenai River below the present Libby dam site prior to impoundment (1970) and following impoundment (1977)

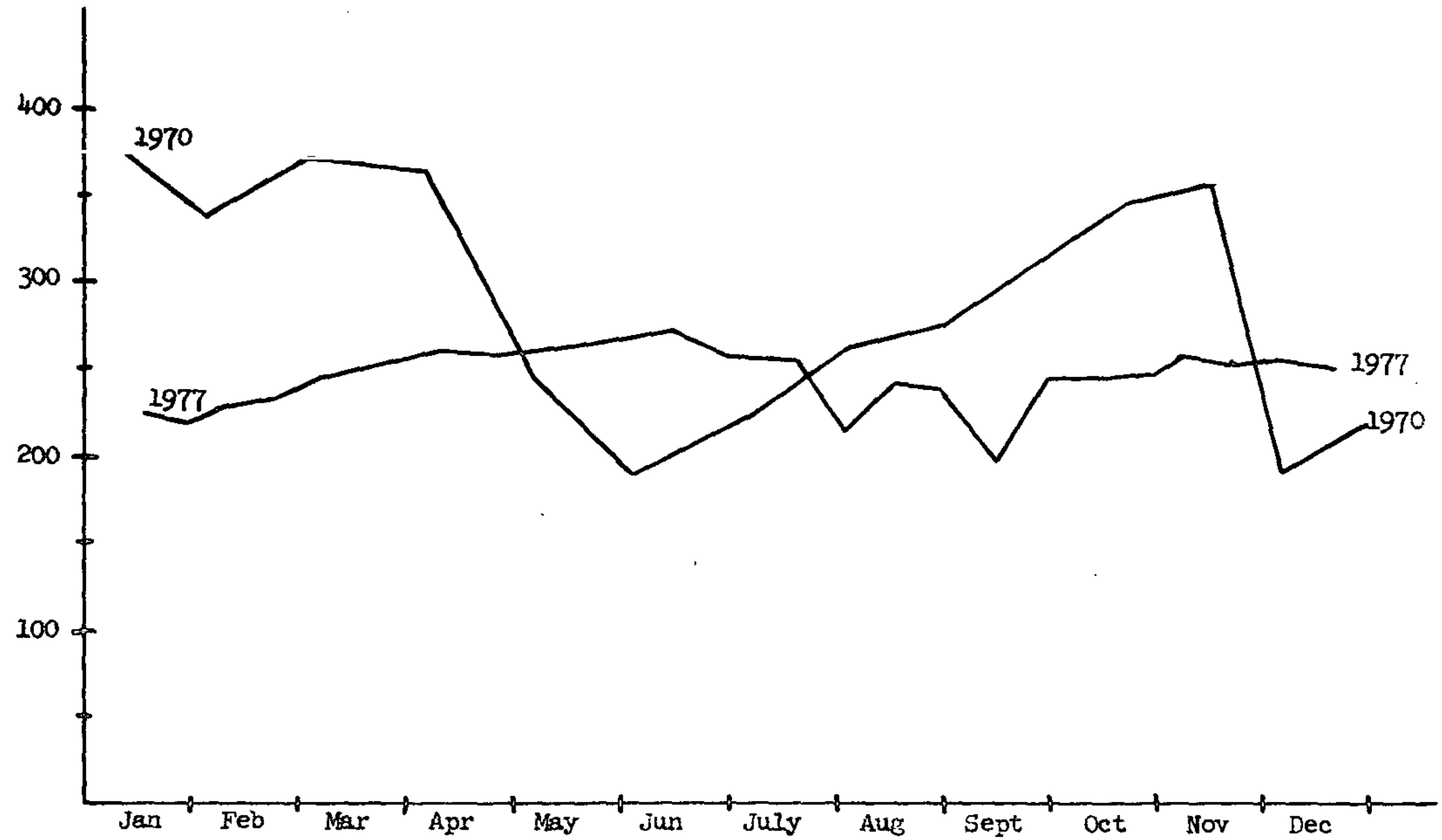

Figure 8. Specific conductance measured in the Kootenai River downstream from the Libby dam site prior to impoundment (1970) and following impoundment (1977)

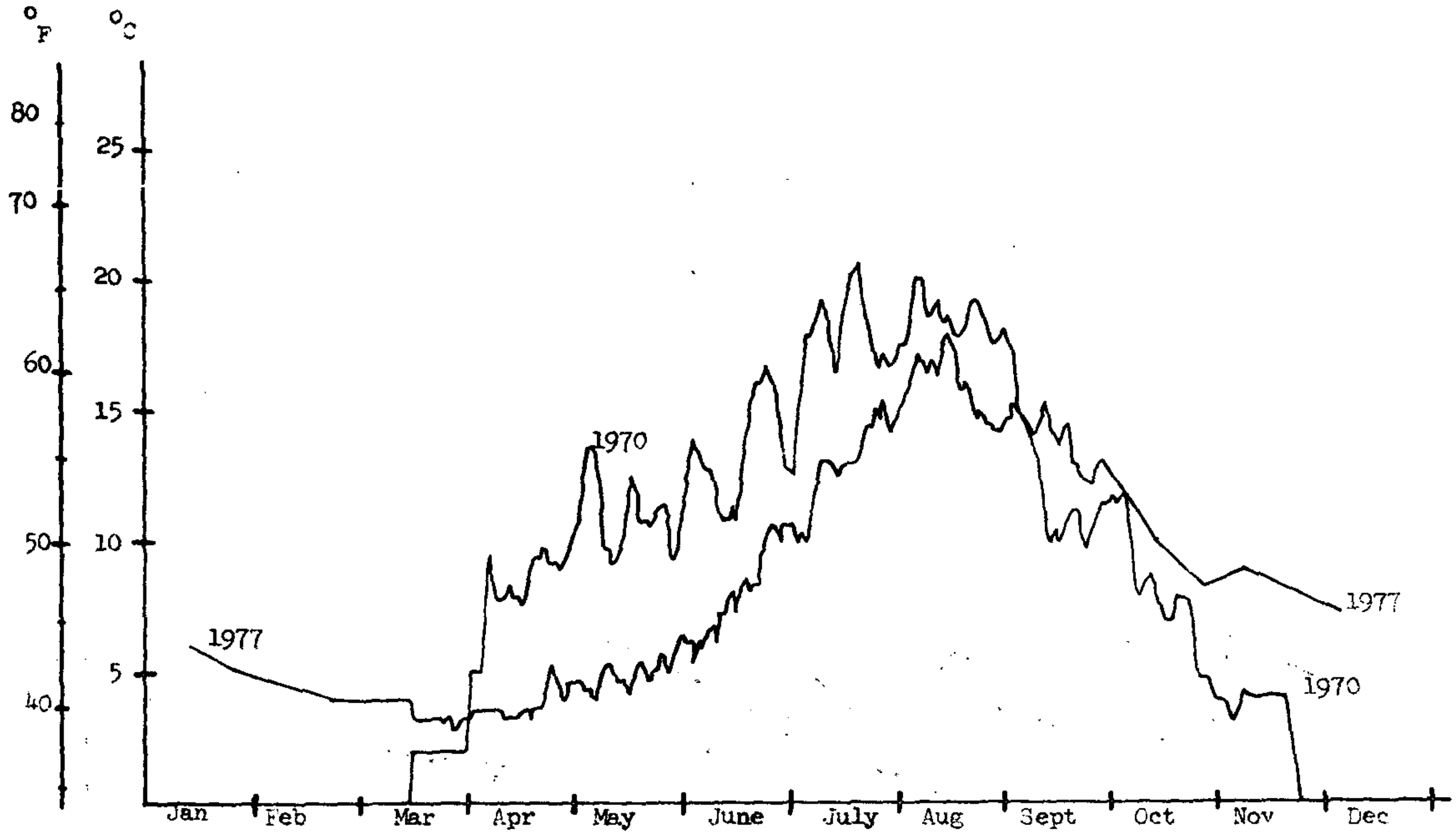

Figure 9. Mean daily water temperatures measured downstream from the Libby Dam site prior to impoundment (1970) and following impoundment (1977). Water temperatures from January to mid-March and October to December were measured once every two weeks

Mean monthly temperatures ranged from 55° to 60°F from July through September to provide optimum growing conditions for trout. Water temperatures were also higher during the fall in 1977 than 1970 to increase the length of the growing season. Temperatures were not low enough in the winter to allow ice cover to form and daily flow fluctuations further prevented formation of an ice cover which was normal under natural flow conditions. An annual rule curve was established in 1977 by the U.S. Army Corps of Engineers and Montana Department of Fish and Game as a guide for daily water temperatures out of Libby Reservoir in succeeding years.

METHODS

Chemical-Physical Data

Water chemistry data was analyzed by the U.S. Geological Survey and was taken at a station just downstream from the Libby Dam Site. Gas supersaturation measurements were made approximately one mile upstream and downstream from Kootenai Falls. Prior to 1978, data was collected and analyzed by Tom Bonde (U.S. Army Corps of Engineers, Libby, MT). Total partial pressure was measured with a Weiss saturometer (Fickeisen et al 1975). Barometric pressure was measured at the site. Dissolved oxygen was determined using the Winkler method and samples were fixed immediately upon collection. Parameters used in calculations include:

P_0 standard atmospheric pressure (mmHg)

P_{sat} saturometer gauge pressure (mmHg)

P_{H2O} saturation vapor pressure (mmHg)

BO_2 Bunsen coefficient for O_2 (mg/liter - mmHg)

D.O. dissolved oxygen (mg/liter)

S oxygen at 100 percent of saturation in moist air (mg/liter)

P_{atm} barometric pressure

Formulas

Percent Saturation Oxygen =

$$\frac{D.O.}{\left(\frac{P_{atm} - P_{H_2O}}{P_o - P_{H_2O}}\right) \cdot S} (100)$$

Percent Saturation Nitrogen and Argon =

$$\left[\frac{P_{atm} + P_{sat} - \left[\frac{D.O.}{B_{O_2}} (0.532)\right] - P_{H_2O}}{(P_{atm} - P_{H_2O})\ (0.7902)}\right] (100)$$

Percent Saturation Total Gas =

$$\left[\frac{P_{atm} + P_{sat} - P_{H_2O}}{P_{atm}}\right] (100)$$

Water surface profiles were taken on nine transects across the river within 3.5 miles upstream from Kootenai Falls by James Sewall and Associates, Newport, WA (Figure 10). Water depths were measured with a weighted line suspended from a boat at distances along a tape stretched across the river. Staff gauges were set up on all nine transects to determine a stage-discharge relationship using discharge measurements from the U.S. Geological Survey gauge station at Libby. To compare potential changes of hydraulic parameters in the proposed pool area, I analyzed transects two through seven. Transect one was excluded because of its close proximity to the proposed dam site. Transect eight was also excluded because daily fluctuations in water elevations would be largest at that site due to its proximity to the upstream end of the proposed pool.

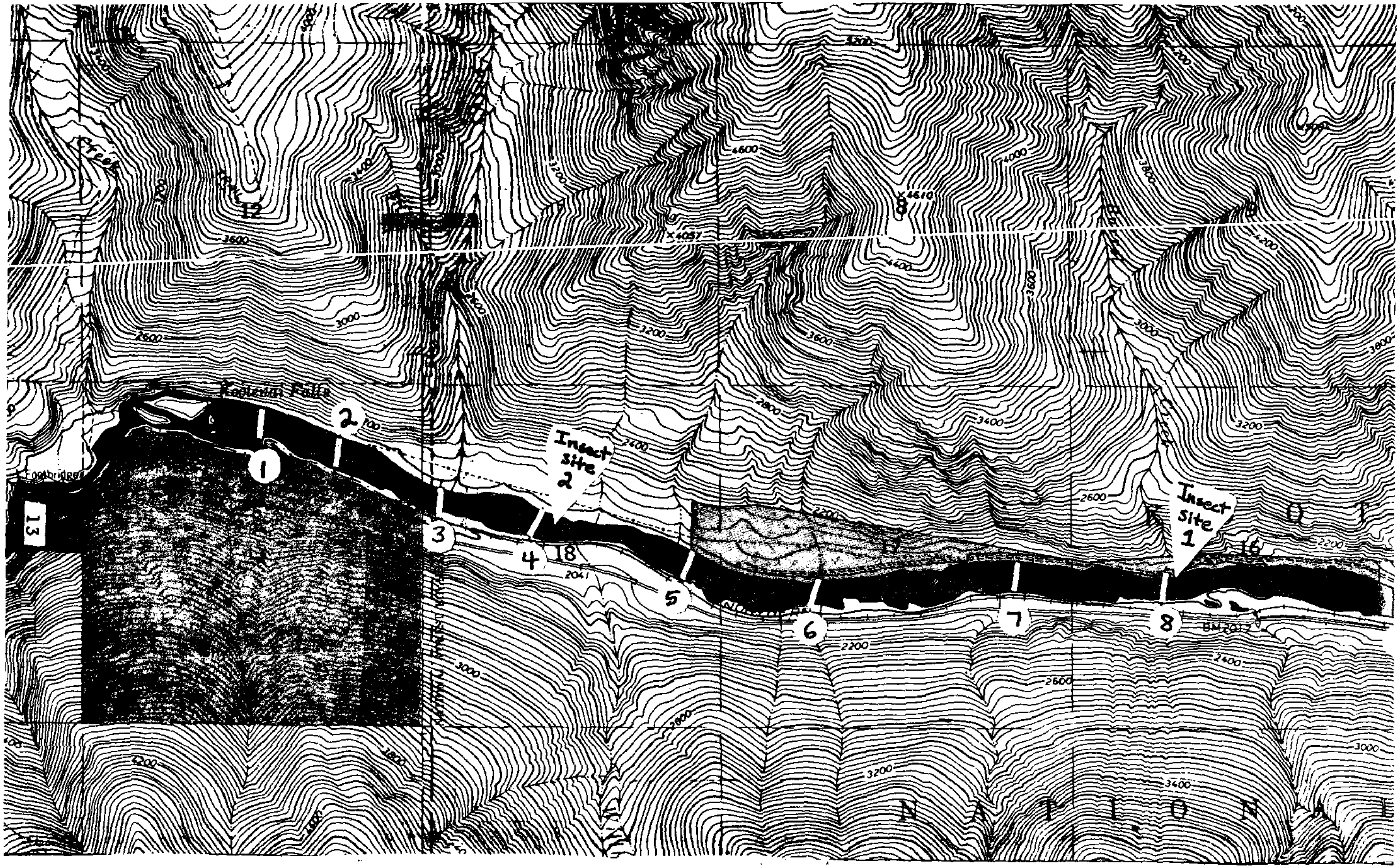

Figure 10. A map of the Kootenai Falls area marking 9 cross-sectional transects and 2 insect sampling sites upstream from falls

Benthic Invertebrates

Benthic invertebrates were collected to identify existing fauna in different habitats within the study area. Insect data were also collected at several sites near the present Libby Dam site from 1968 through 1971 prior to impoundment of the Kootenai River (Bonde and Bush 1975). Large differences would be expected between these samples and the present insect population because temperature and flow regimes and total and seasonal abundance of sediment and nutrients in the river have been significantly altered. Accurate analysis of the effects of these changes on the benthic community is compounded by reductions in other sources of pollution during the same period. A few comparisons were made to illustrate the changes in the benthic community.

Three types of samples were taken at two general locations upstream (Figure 10) and downstream (Figure 11) from Kootenai Falls. Sites one and two were 2.5 and 0.8 miles upstream from the falls and sites three and four were 0.5 and 2.5 miles downstream from the falls, respectively. A modified rounds sampler was used to collect samples in riffle areas from 1.0 to 1.5 feet in depth. Substrate was small to large gravel with sand loosely compacted in the interstices to a depth of 3-6 inches where it became tightly compacted. This sampler was described by Bonde and Bush (1975). Kick samples were taken on riffle areas to check for diversity of insects collected with the round sampler. Cylindrical chromium-plated baskets, 7 inches in diameter and 11 inches long, were filled with similar sized stream gravel and placed on the riverbed in pool areas. Baskets were set in water depths of 8, 19 and 24 feet at sites 1, 2 and 3, respectively. Two baskets, one containing gravel averaging 4 inches in length and one containing gravel averaging 2 inches in length, were placed next to each other with a buoy attached.

Bottom samples were collected on April 13 and 14, August 1 and 2 and November 20 and 21. Basket samples were set on April 13 and 14 and pulled on May 30, placed in plastic bags and sorted upon return to the field station. Power peaking seldom occurred at Libby Dam during the spring and daily flow fluctuations were relatively small. During the summer, daily flows often fluctuated by 10,000 cfs or more. Summer samples were collected under low flow conditions (4,000 cfs). Autumn samples were taken at the end of October and again in late November, but were of little value for comparison. The samples were obtained under high flow conditions which prevailed during this period. Little colonization occurred in the low to high water fluctuation zone. That area might be considered a freshwater "tidal zone." Substrate was limiting (primarily riprap and bedrock), occasional dewatering and freezing occurred, and many sample areas were subject to backwashing at high flows. These data were not included because of the low numbers of insects and the appearance of several semi-aquatic forms that may have been backwashed into the sample area.

Insects were stored in a mixture of formalin, acetic acid and alcohol. Samples were sorted to order then sent to Richard Oswald (Montana State University) for identification on to genus or species. The total samples were quantified by weight and volume. Weight was measured as "wet weight" by removing invertebrates from alcohol and placing them on blotting paper until no moisture appeared on the paper. Invertebrates were weighed on a Mettler H16 electronic balance capable of weighing to 0.00001 gr. Dried invertebrates were then placed into a conical graduated tube filled with

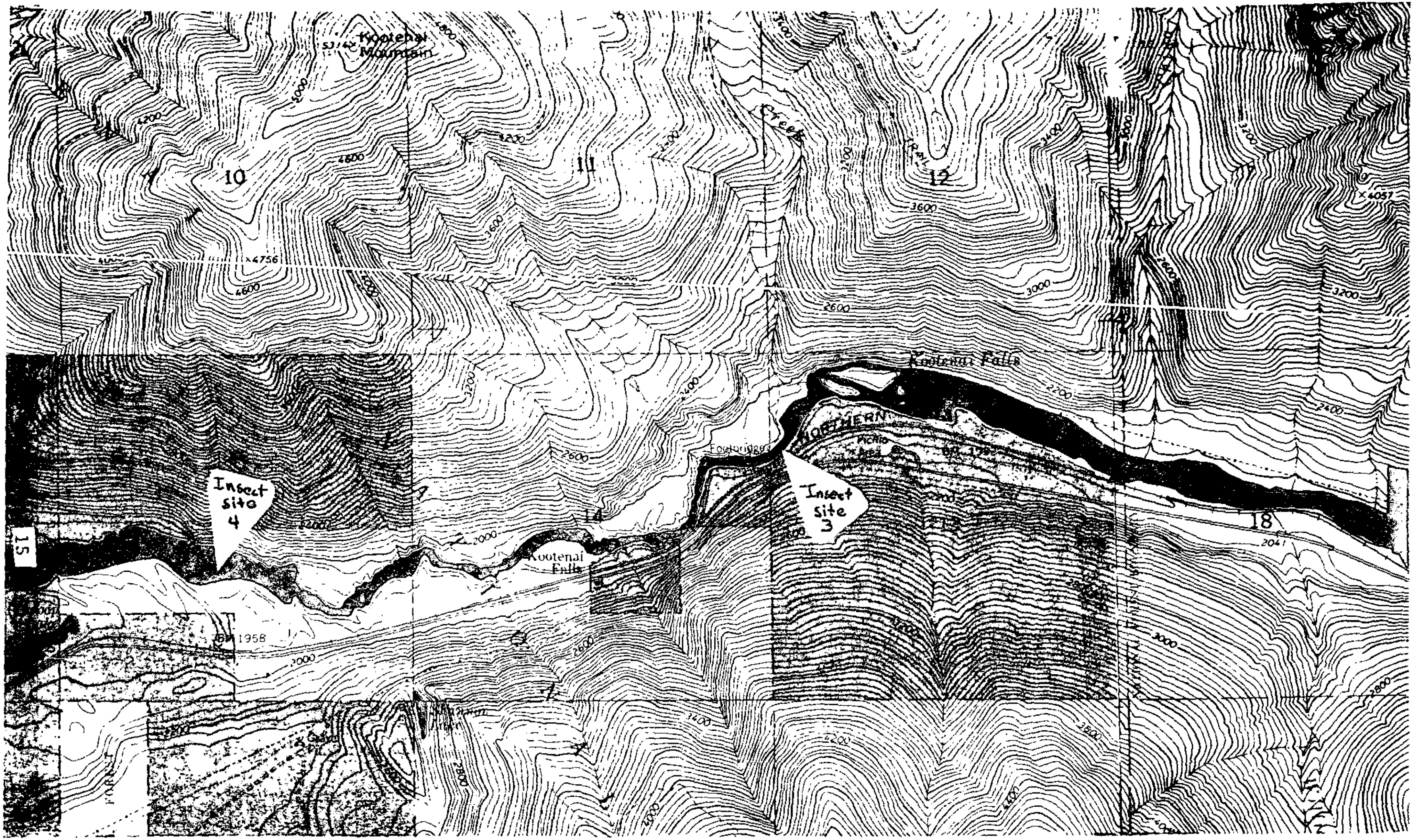

Figure 11. A map of the Kootenai Falls area marking 2 insect sampling sites downstream from the falls

95 percent ETOH for measurement of volume.

To further assess insect community structure, standard mathematical analyses which are often used to index communities were performed by computer analysis on the samples. Calculations were made for species diversity (Shannon-Weaver and Brillouin), maximum and minimum diversity, redundancy, evenness, equitability, and species richness as described by Newell (1976).

(1) Shannon-Weaver (approximate) (H')

$$\hat{H}' = -\Sigma\frac{Ni}{N}\log\frac{Ni}{N}$$

(2) Brillouin (H)

$$H = \frac{1}{N} = \log\frac{Ni}{N_1!N_2!\ldots N_s!}$$

S = Number of species
N = Number of individuals
Ni= Number of individuals in the i^{th} species

(3) Redundancy (R)

$$R = \frac{d_{max} - \bar{d}}{d_{max} - d_{min}}$$

$\bar{d}$ = species diversity index

$$d_{max} = (1/N)\ [\log_2 N!-S\log_2(N/S)!]$$

$$d_{min} = (1/N)\ \{\log_2 N!-\log_2[N-(S-1)]!\}$$

(4) Evenness

$$\text{Evenness} = \frac{\text{diversity}}{\log_2 S}$$

S = number of species
Diversity = Shannon-Weaver diversity index

(5) Equitability (E_m)

$$E_m = \bar{d}/\log_2 S$$

(6) Species Richness (SR)

$$SR = \bar{d} - \bar{d}/\log_2 N$$

White Sturgeon

The only white sturgeon (*Acipenser transmontanus*) population in Montana is found in the Kootenai River downstream from Kootenai Falls. There is a general lack of knowledge about this species across its entire range, and little information was available on the white sturgeon population in Montana, past or present. White sturgeon have been captured by anglers in the canyon downstream from Kootenai Falls, primarily from April through June (Applegate 1971).

Attempts to capture white sturgeon were made regularly from late April to early July. Effort was concentrated in a large hole at the canyon mouth, 2.2 miles downstream from the falls, because white sturgeon were captured there regularly in the recent past. We made continuous sets of two 3-inch and two 5-inch square mesh trammel nets (Figure 12), 100 feet in length, near the mouth of the canyon at depths ranging from 20 to 90 feet. We also set trotlines with approximately 10 hooks per line. Hook sizes ranged from 03 to 06 single and treble hooks. Many types of bait were used including night crawlers, squid, chunks of sucker, squawfish, whitefish, and beef liver. In the area 1 mile downstream from the falls we angled for sturgeon during both light and dark hours using size 05 single hooks baited with night crawlers, cut bait and liver.

Sturgeon were tagged with consecutively numbered floy cinch tags through the fleshy base of the dorsal fin. A section of the first ray of the pectoral fin was cut out for aging as described by Coon et al. (1977). Total length, fork length and weight were taken on all fish captured.

Radio transmitters, built by Smith-Root, were implanted into two white sturgeon to monitor their seasonal movements. Tags were implanted surgically into the ventral body cavity just anterior to the pelvic fins. Tags were 0.75 inches in diameter, 3.2 inches long, and weighed approximately 1 ounce in water. Tags ranged in frequency from 40.60 to 40.69 mHz in 10 KHz increments, with a code rate of one per second.

Several problems were encountered while tracking because fish were often in water depths of 80-90 feet. The transmitter signal was generally not discernible from shore and required bringing the RF-40 receiver within about 50 feet or less of the fish's location. A braided copper antenna, 5.5 inches long on an implanted tag was allowed to extend from the posterior end of the cut and trail outside. The antenna was sutured to the skin to prevent coiling. The connection between the antenna and transmitter was too weak for this setup and broke off one transmitter after 1 day and the other after 1 week.

Tags were modified by strengthening the connection with epoxy and later by a plastic coating. Tags were then attached to an external saddle described by Haynes et al. (1978) (Figure 13). One sturgeon was tagged using this method during October.

Fish Populations

A game fish population estimate was made during early May in a section of river 6.6-11.2 miles upstream from the falls referred to as the Flower-Pipe Section. Estimates were also made in this section in 1973, 1974, 1975 and 1977. Although this section was not in the actual study area, knowing trends in

Figure 12. White sturgeon were captured with 3 and 5" trammel nets.

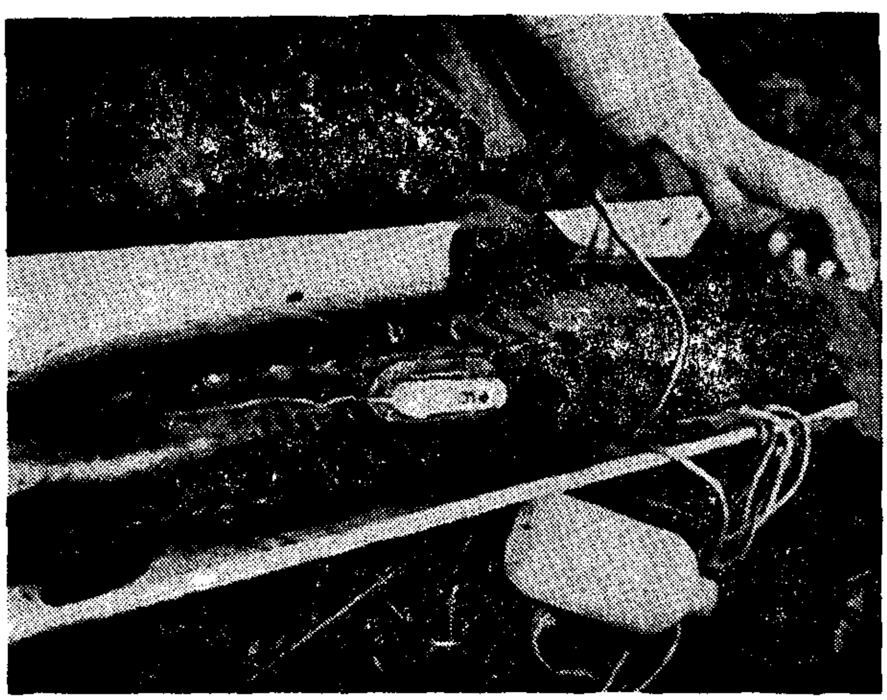

Figure 13. White sturgeon were tagged with a radio transmitter using a plastic saddle-mount.

fish abundance is often more meaningful in a study of this type than a single population estimate. A spring population estimate was run in a section known as the Troops Lake Section, 1.7-5.2 miles downstream from the falls. An autumn population estimate was run in the section of river downstream from China Rapids to Kootenai Falls. Marking runs were made on 3 consecutive nights in this section because rapids and boulders limited access between the various sections at night.

Fish were collected at night using an electrofishing boat mounted with booms. Pulsed direct current of approximately 3 amps and 100 volts was used with a pulse width of 50 percent and frequency of 100 pulses per second. Fish were held overnight in cages, anesthetized, measured, fin punched or tagged, and released. Trout were weighed and scales taken for aging. General methods and analysis for the mark and recapture estimate were described by Vincent (1971). Two mark and recapture runs were made on each section. Relative abundance data were compiled on each section as to the number of fish per 1,000 feet per run.

Fish movement data were compiled from angler returns. Fish were tagged during population estimates made from 1973 through 1978. A recapture distance of 3 miles or more from the midpoint of the shocking section was considered as movement. Recaptures of fish during an estimate were not included.

Creel Census

A creel census was conducted on the Kootenai River from Kootenai Falls upstream approximately 3.5 miles to the mouth of Dad Creek. This census provided information on the potential fishery in the area and about the fish population in general. Specific information obtained includes fishing pressure, angler success, catch rates, species composition and average size, total harvest, angler origin, and type of gear used.

Fisherman counts were stratified by weekdays and weekends, time of day, and month of the year. During the period of generally low fishing pressure, from October 1 through April 30, counts were made on 2 week days and 4 weekend days selected randomly each month. Five counts a day were made every 2 hours. The starting time varied by randomly selecting one of four half hour intervals during the first 2-hour block each day.

During periods of increased fishing pressure, May 1 through September 30, counts were made on 2 weekend days and 3 weekdays selected randomly during each 15-day period. Because of increased day length, six counts were made each day and the number of 2-hour blocks in a day varied to include sunrise and sunset in the first and last block of the day, respectively. Counts were made at the midpoint of each 2-hour block (7, 9, 11 a.m., and 1, 3, 5, 7, 9 p.m.). On weekdays the last three counts of each day were always included in the census because of increased fishing pressure during that period. Other hourly counts were selected at random without repeating a particular combination of hours until every combination had been used to ensure that all hours would be equally surveyed.

On days when counts were made, direct personal contacts and postal card surveys were employed. If fishermen had fished less than one-half hour when first contacted or if time did not permit direct contact, a postcard was left at the angler's vehicle. In direct contacts, the information acquired included starting time and time of the interview, whether or not the trip was complete, number of anglers in a party, whether the anglers were from in-county or out-of-county, or out-of-state, the date, day of week, number of successful anglers, number of fish caught, kept, and released by species, size of fish kept, type of gear used (natural, lure, flies or a combination) and whether they were fishing from shore or a boat.

Postcards included the number of anglers, the number of successful anglers, number of each species caught, kept, and released, hours fished, and whether fishing from shore or boat. Cards were pre-stamped and dated. Returns were not mandatory but a card explaining the purpose of the creel census was attached to inform and encourage them to return the cards even if no fish were captured. During periods of low success, such as the winter months when anglers generally fished less than half an hour, fewer cards were returned.

Anglers had some problems distinguishing rainbow from cutthroat trout. Some rainbow trout exhibited weak morphological traits of the cutthroat because of some mixed breeding in the past. To minimize complications, I applied the same percent composition of rainbow and cutthroat trout determined from direct contact to the postal card survey.

Fishing pressure was determined using stratified count data similar to a method by Neuhold and Lu (1957). Fishing pressure was calculated in hours and converted to man-days by dividing monthly totals by average length of completed trip (2.1 hours). Catch was determined by multiplying monthly pressure in hours by monthly catch rate.

RESULTS AND CONCLUSIONS

Chemical and Physical Data

Chemical or physical parameters of the Kootenai River which could affect or be modified significantly by the proposed Kootenai Falls Dam include the various hydraulic parameters associated with discharge, suspended sediment, and gas supersaturation.

Obvious physical changes would occur upon impoundment to over 3 miles of the river upstream from the falls. Current and depth, which are important factors in fish and insect habitat, would be significantly altered. I compared present conditions in what would be the lower pool area (transects 2, 3 and 4) and the upper pool area (transects 5, 6 and 7) to conditions that would be found at the proposed pool elevation. A medium flow of 10,000 cfs was used for both conditions. The river's width would increase by 57 percent in the lower pool area, from 337 feet to 595 feet, and by 36 percent in the upper end to a width of 551 feet (Table 1). Mean depth would increase by 2.5-fold to a mean depth of 22.6 feet and a maximum depth of approximately 40 feet in the lower end and increase 2.0-fold in the upper end to a mean depth of 16.7 feet. Volume of the river, measured by cross-sectional area would increase nearly 5-fold in the lower end and over 2.5 times in the upper end (Figure 14). Mean velocity of the river would decrease significantly at all discharges. Under present conditions the mean velocity at 10,000 cfs is 3.93 and 3.12 ft/sec for the lower pool (2, 3, 4) and upper pool (5, 6, 7), respectively. Following impoundment mean velocities would be 0.85 and 1.43 ft/sec for the lower and upper areas, respectively.

Downstream from the falls and directly around the falls area the major impact will be a reduction in flows caused by the diversion. Downstream from the falls the aquatic environment is characterized by vertical canyon

Table 1. Some hydraulic parameters of transects across the Kootenai River upstream from Kootenai Falls at different discharges under present conditions and at the proposed full pool level (elevation 2,000 ft) Transects 2,3,4, and 5,6,7, would be in the downstream and upstream ends of the pool, respectively

Discharges (cfs)	Mean velocity (ft/sec)	Width (ft)	Mean depth (ft)	Cross-Sectional Area (ft)
		Transects 2,3,4		
5,000	2.49	337	8.0	2,520
10,000	3.93	380	8.9	3,077
20,000	5.58	419	10.2	3,690
Full Pool		595	22.6	11,867
5,000	0.42			
10,000	0.85			
20,000	1.70			
25,000	2.13			
		Transects 5,6,7		
5,000	2.06	360	7.6	2,743
10,000	3.12	406	8.6	3,490
20,000	4.56	462	10.0	4,583
Full Pool		551	16.7	9,230
5,000	0.56			
10,000	1.43			
20,000	2.25			
25,000	2.81			

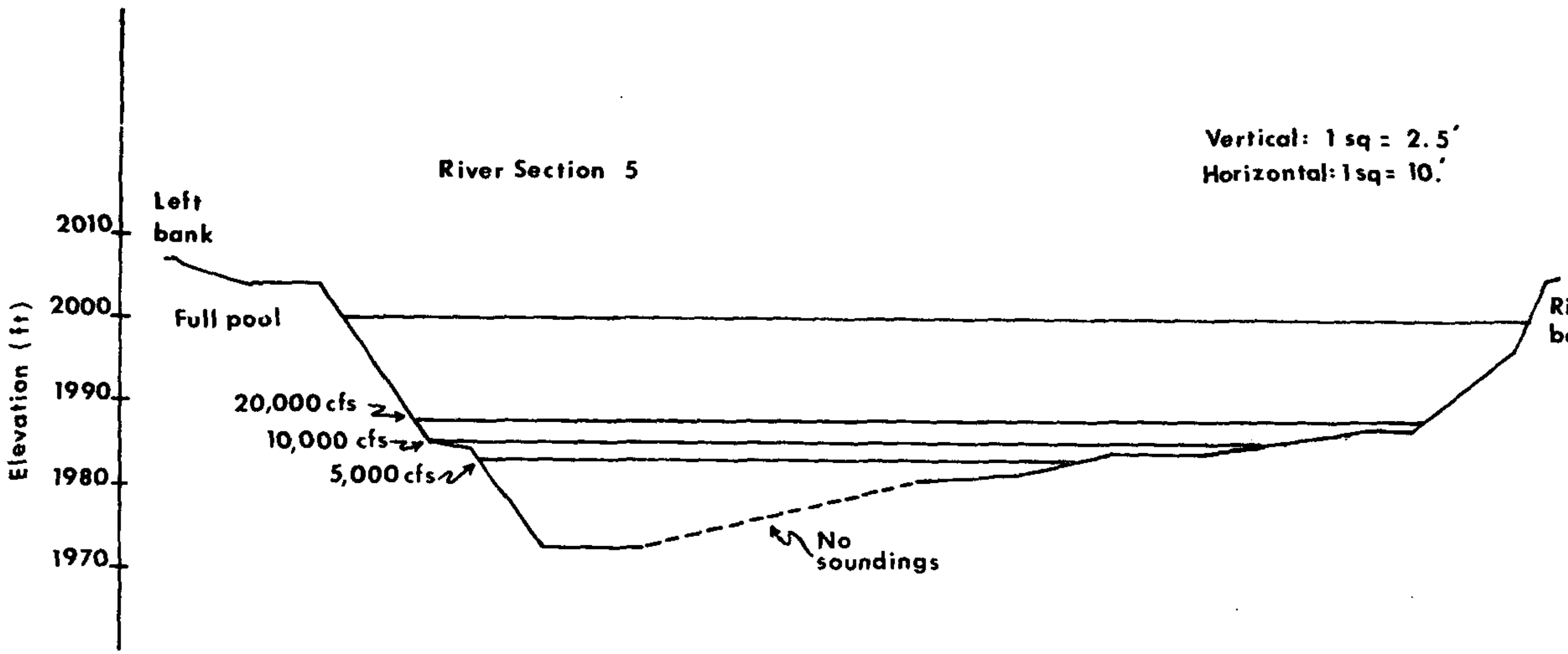

Figure 14. Cross-sectional profile number 5 across the Kootenai River upstream from Kootenai Falls depicting water elevations at 3 flows under natural conditions and at the proposed full pool level of the reservoir

walls along both shores with many small coves, a relatively narrow channel and deep pools broken up abruptly by rapids and falls. Two gravel bars are present in the area that would be directly impacted by the project. One is located on the north shore just upstream from the foot bridge. This bar constitutes the largest single insect producing area within the first mile of the canyon. The other bar is on the south shore just downstream from the out-flow tunnel, and is composed largely of rubble.

Because of the unique nature of the area, shallow water fish habitat appears to be limited to cove areas in this section of the river. Coves have formed along the flex lines between fault blocks in the canyon wall and developed after the relaxation of the compression forces which uplifted the bedrock in the falls area. These coves, eroded by glacial floods, provide shallow water fish habitat at flows from 4,000 to 24,000 cfs which was the range of flows observed during the study period. Because these coves are on bedrock blocks they abruptly drop off and provide no habitat at lower flow levels. The minimum flow at which this would occur could not be determined in this study.

Suspended sediment can cause changes and reductions in aquatic life if it settles out in significant quantities on the stream bottom and is not flushed out (Cordone and Kelley 1961). The sediment reduces habitat as it fills the interstices or spaces between the river gravel. Where sediment covers the bottom it provides very unstable habitat for insects. Fine grain sediments can also cause physical damage by clogging the external gills of some insects.

Mean annual suspended sediment loads in the Kootenai River have decreased considerably since impoundment by Libby Dam. From 1967 through 1971 annual sediment discharge averaged 1.6 million tons and decreased to 62,000 tons between 1973 and 1975. During the years 1967 to 1975 the Fisher River contributed an average of 97,000 tons of suspended sediment annually. The proposed reregulating dam would reduce this amount somewhat. But the large daily flow fluctuations would probably carry much of it downstream.

Reduced water velocities in the pool area of the Kootenai Falls project would cause some sediments to settle out. These sediments would probably be concentrated in the mid-stream and lower end of the pool area. Although the amount of sediments won't be significant from an engineering viewpoint, biologically the accumulation of sediments will significantly alter the benthic invertebrate community. An equilibrium situation will be reached because of the constant pool elevation and the modified range of flows occurring from Libby Dam.

Gas supersaturation, when high, has had marked effects on aquatic life in the Kootenai River causing fish kills, limiting whitefish and torrent sculpin populations, and causing flotation of insects clinging to gas bubbles resulting in increased downstream drift and susceptibility to predation. Factors which increase percent gas saturation or prevent the reduction of a high percent gas saturation would damage aquatic organisms downstream from the falls.

Gas supersaturation problems occurred in the Kootenai River from 1972 through the fall of 1975 and resulted from the use of sluices, and to a lesser degree, spillways to discharge water from the dam. Beginning in the fall of 1975 water was discharged from turbines or a combination of sluices and turbines which reduced percent gas saturation.

Gas supersaturation can result in gas bubble disease in fish which occurs when total dissolved gases in the water exceeds a certain percent of saturation. These gas pressures can kill fish if the percent saturation is high or sub-lethal levels can cause reductions in swimming ability and blood calcium, and increase deformities in young-of-the-year fish (Dawley and Ebel 1975). Blindness and secondary fungal infections in fish can also result from gas supersaturation (Bouck et al. 1976). Death from gas bubble disease usually results from stasis of the blood caused by gas emboli in the vascular system. Chronic exposure to the disease results in a build-up of metabolic wastes in the tissues coupled with low concentrations of dissolved oxygen which causes tissue death from anoxia. Fish can reduce the effects of gas supersaturation by seeking deeper water where hydrostatic pressure is greater.

The amount of saturated water discharged, level of discharge in the water column, water temperature and depth of water all contribute to the percent saturation and its toxocity on fish (Adair and Hains 1974, May and Huston 1973). Species of fish is also related to toxicity. Ranked in order of increasing tolerance are: mountain whitefish *(Prosopium williamsoni)*, rainbow trout *(Salmo gairdneri)*, largescale suckers *(Catostomus macrocheilus)*, torrent sculpin *(Cottus rhotheus)* (Fickeison and Montgomery 1978, May and Huston 1973 and 1974). Although torrent sculpins were tolerant of supersaturation, gas bubbles would develop and cause them to turn upside down and float downstream (Fickeison and Montgomery 1978).

Levels of gas saturation in the Kootenai Falls area in 1978 were not in the range considered to be toxic to fish at low and medium flows. Discharges from Libby Dam during this period were through the turbines which is the planned mode of operation for the future. However, the Kootenai Falls project could increase gas saturation below the falls when sluices or spillways were used at Libby Dam by diverting the flow around the falls and also in the design and structure of the turbines and tail tunnel.

When percent gas saturation was relatively low, as it is presently, gas saturation levels were primarily a function of discharge, water temperature and the plunging and churning actions of the falls and rapids in the area. Upstream from the falls, percent total gas saturation averaged 102.6 percent at discharges of 5,000 to 9,000 cfs, and increased to 104.5 percent at a discharge near 20,000 cfs in 1978. Downstream from the falls, percent gas saturation was higher, averaging 109.5 percent at discharges from 5,000 to 9,000 cfs and increased to 112 percent at 20,000 cfs. Under these conditions, diverting part of the flow around the falls would reduce the natural increases in percent gas saturation unless it is increased in the process of power generation.

When percent gas saturation was relatively high, as from 1972 through mid 1975, percent gas saturation in the falls area was also a function of how water was discharged from Libby Dam. Operational differences in Libby Dam were most noticeable immediately below the dam (Figure 15). Differences in percent gas saturation with different modes of operation were still noticeable above Kootenai Falls although they were approaching equilibrium. Water discharged from turbines and a combination of turbines and sluices resulted in decreased percent gas saturation, while water discharged from the spillways at high flows and the sluices at all flows resulted in increased percent gas saturation (Figure 16). The range of percent total gas saturation below the falls (110.2 to 111.8 percent) was small compared to the range upstream from the falls, 103.2 to 114.2 percent (Figure 17).

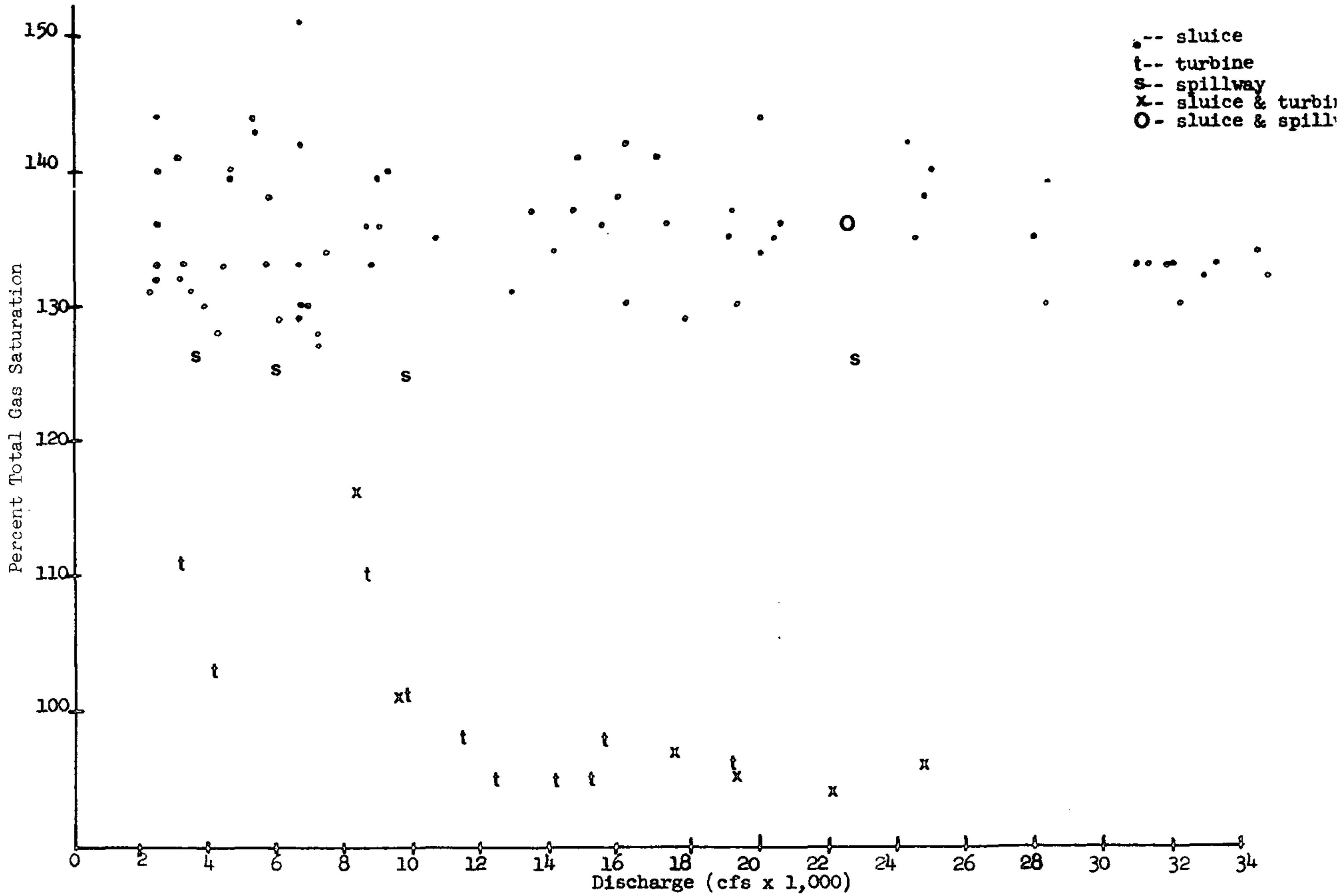

Figure 15. Percent total gas saturation in the Kootenai River at different dam operations measured below Libby Dam from 1972 to 1975

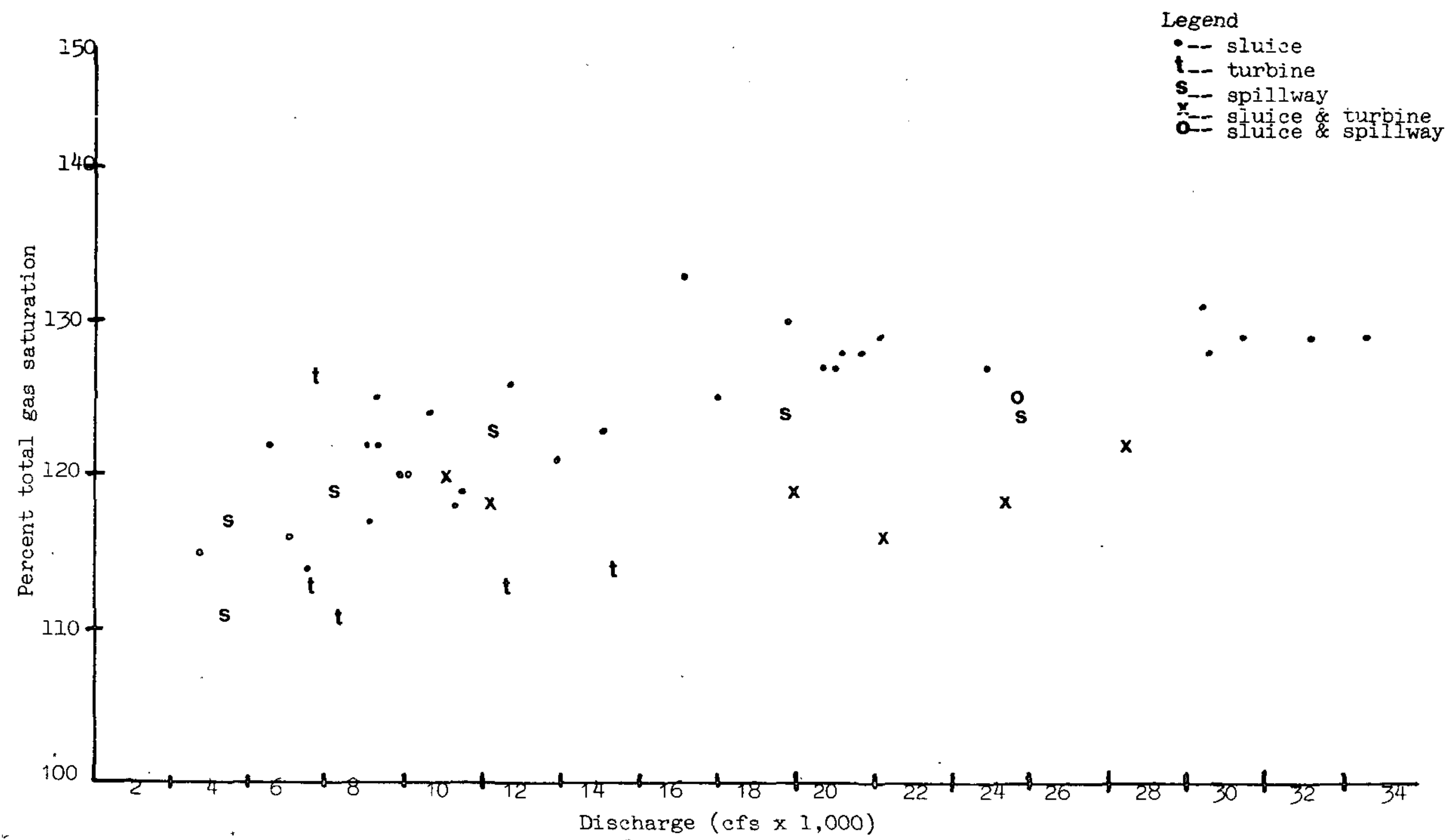

Figure 16. Percent total gas saturation in the Kootenai River at different dam operations measured above Kootenai Falls from 1972 to 1975

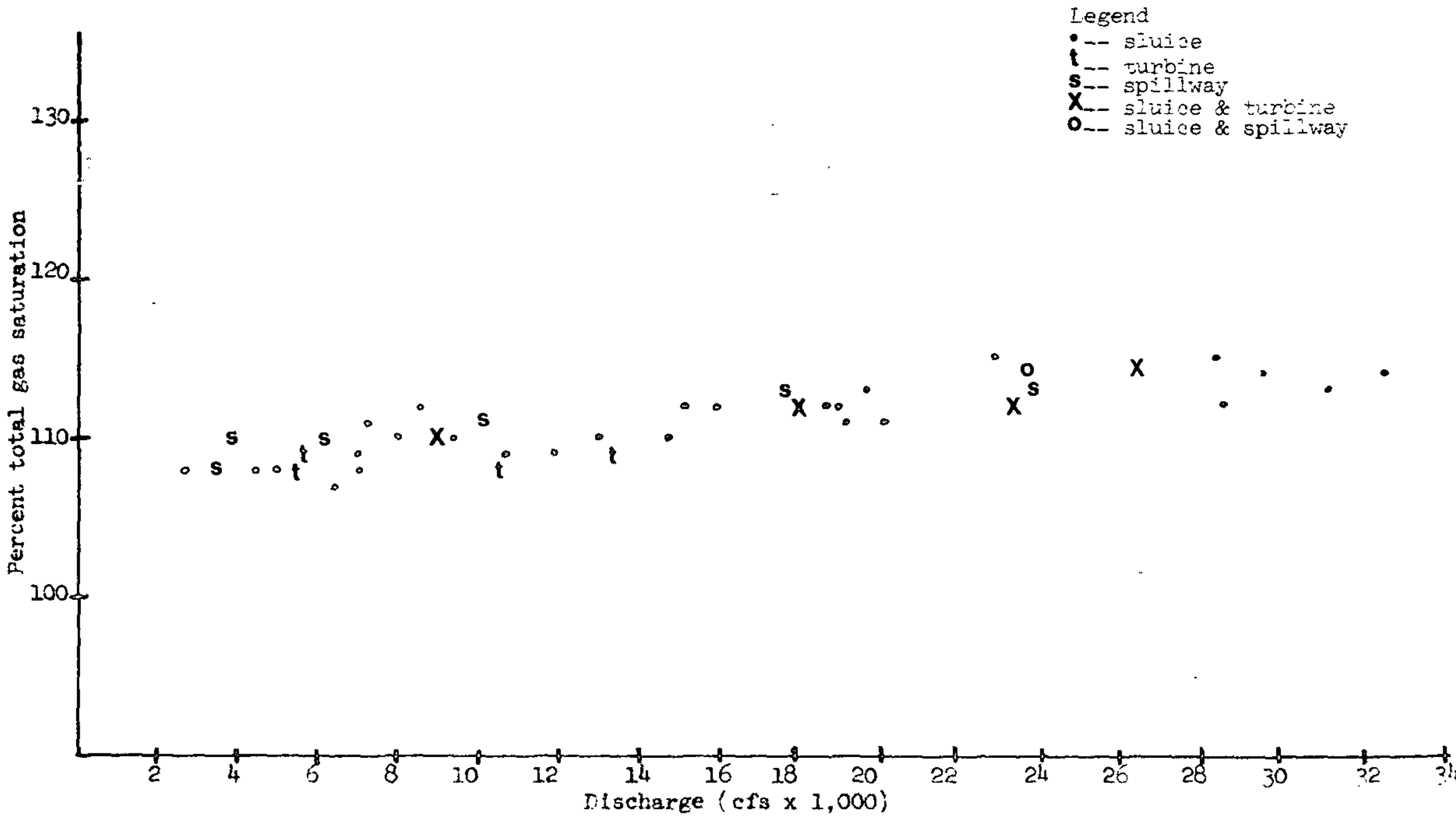

Figure 17. **Percent total gas saturation in the Kootenai River at different dam operations measured below Kootenai Falls from 1972 to 1975**

With large discharges, the percent total gas saturation was smaller after going over the falls, with the reverse occurring at small discharges (Table 2). Downstream from the falls, 21.5 miles at the Montana-Idaho border, there was no difference in gas saturation between modes of operation, and percent gas saturation continued to decrease, although it remained over 110 percent at large discharges (Figure 18).

By routing the major portion of the flow around Kootenai Falls, the equalizing effect of the falls on gas saturation would be significantly reduced. The affect would probably not be detrimental to the aquatic biota downstream from the return tunnels unless Libby Dam discharged from sluice, spillways, or a combination of the two. This would be particularly true at discharges over 15,000 cfs.

Benthic Invertebrates

Aquatic macroinvertebrates are animals without backbones that are large enough to be seen with the unaided eye. These creatures cling to rocks, algae and aquatic macrophytes or burrow into the substrate. Many of the insects are immature forms with a terrestrial adult stage. Other groups include earthworms, snails, clams, flatworms, roundworms, crustaceans, sponges, mites, and adult insects. These creatures eat primarily plant and other organic material and provide an essential energy link between sunlight and fish. Fish feed almost entirely on macroinvertebrates and the general health of a population depends upon the number and type of macroinvertebrates available for consumption. Macroinvertebrates are also useful in determining past and present water quality because of the sensitivity of some organisms to different types of water pollution, water velocity, and depth.

Spring and summer macroinvertebrate samples included a minimum of 10 orders, 26 families and 47 genera (Table 3). Only *Hesperoperla pacifica*, a stonefly, (Plecoptera) was found in the qualitative samples and not the quantitative samples, although many genera were poorly represented in the quantitative samples. In general the taxa present reflected a stream of relatively high water quality. However, several major differences were found between the existing invertebrate population and the population prior to impoundment of the river by Libby Dam.

Bottom sample sites 1, 2 and 4 were comparable in depth, velocity and substrate size. Site 3 included two samples on a bedrock shelf in the canyon below Kootenai Falls during the spring, although for the summer samples, one was taken on the gravel bar upstream from the foot bridge (sample 6). Total weight and number of insects were similar at sites 1, 2 and 4 during both the spring and summer (Table 4). Standing crop at each site was comparable between seasons with a mean of 0.97 and 0.82 grams for spring and summer samples (1, 2, 4), respectively. Numbers of insects were more variable because of the abundance of small dipterans (true flies). Site 3 was relatively impoverished, largely because of the bedrock substrate. Sample 6 at site 3 during the summer produced a significantly larger biomass than other samples in the canyon area. This sample was taken on the gravel bar.

Substrate baskets were only used during the spring when daily flow fluctuations were smallest. Substrate baskets provided good opportunity for insect colonization; however, they do not accurately represent standing crop or relative abundance of the bottom community because the artificial substrate is selective for insects which prefer it. Because the deep water

Table 2. Summary of gas saturation data upstream and downstream from Kootenai Falls during different discharge operations at Libby Dam and over a range of flows from 1972 through 1978

	Kootenai River 1972 - 1978					
	D.O. % Sat.		Nit + Ar.% Sat.		Tot.Part.Press % Sat.	
Type of Operation	Above (n)	Below (n)	Above	Below	Above	Below
Sluice only	114.2 (31)	110.7 (30)	116.0	113.0	114.2	111.1
Spillway only	112.8 (5)	113.8 (5)	109.8	112.0	108.4	110.4
Sluice & spillway	115.0 (1)	112.0 (1)	117.0	116.0	115.0	114.0
Turbine only	109.1 (10)	101.0 (12)	104.2	113.2	103.2[1]	110.2[2]
Turbine and sluice	109.2 (5)	113.2 (5)	111.0	113.0	109.4	111.8
Flow (discharge) Range						
0 - 10,000 cfs	109.8 (17)	110.2 (16)	109.9	110.7	108.4	109.2
10,000 - 20,000 cfs	116.5 (14)	111.7 (14)	115.7	112.9	114.5	111.2
over 20,000 cfs	114.7 (12)	112.75(12)	119.3	115.75	116.8	113.6

[1] N -- 14

[2] N -- 13

Table 3 continued. Taxa collected in the Kootenai River above and below Kootenai Falls in the spring and summer, 1978.

Order	Family	Genus	Species
Coleoptera	Elmidae	*Heterelmis*	
		Narpus	
		Optioservus	
Nematoda			
Oligochaeta	Lumbriculidae		
	Lumbricidae	*Eiseniella*	
	Naididae	*Ophidonais*	*serpentia*
	Tubificidae		
Turbellaria			
Acari			
Gastropoda	Lymnaeidae	*Lymnaea*	

Table 4. Number of aquatic macroinvertebrates collected with a modified round square foot sampler in the spring and summer, 1978 above (1,2) and below (3,4) Kootenai Falls.

	Spring								Summer							
	Site 1		Site 2		Site 3		Site 4		Site 1		Site 2		Site 3		Site 4	
Taxa	R1	R2	R3	R4	R5	R6	R7	R8	R1	R2	R3	R4	R5	R6	R7	R8
Capnia group	1	1														
Alloperla group		2							5	3	4	4		1	4	6
Cultus (Isogenus)							1									
Baetis	12	18	77	134	1		8	5	157	164	84	99	2	4	41	117
Psendocloeon									4	12	12	21			11	16
Ephemerella flavilinea	1			3				1		1	1	1				
Ephemerella inermis	48	79	51	62			91	56		1	2					
Ephemerella hecuba										2	1					
Ephemerella doddsi									1		1	1				
Ephemerella margarita										6	37	3		4	6	
Ephemerella tibialis									27	17	15	16			1	6
Epeorus																1
Heptagenia										2	17			5	11	5
Cinygmula				1												
Rithrogena hageni	23	10	46	123			10	22	13	8	1	7			2	4
Paraleptophlebia			1					1								
Brachycentrus									2	2						
Glossosoma			1	11			2	5	10		11	1			2	
Arctopsyche											1					
Cheumatopsyche										1						
Hydropsyche	1		1	8			4	7	1	3	6	34		2	5	1
Ceraclea											1					
Lepidostoma							1									
Neophylax												2				
Rhyacophila							1								1	

Table 4 continued. Number of aquatic macroinvertebrates collected with a modified round square foot sampler in the spring and summer, 1978 above (1,2) and below (3,4) Kootenai Falls.

	Spring								Summer							
	Site 1		Site 2		Site 3		Site 4		Site 1		Site 2		Site 3		Site 4	
Taxa	R1	R2	R3	R4	R5	R6	R7	R8	R1	R2	R3	R4	R5	R6	R7	R8
Simulium	3	3	3	12	1	1	1	1	12	7	2	8	1	2	1	7
Protanydarus								1								
Antocha				3	4		40	26	4	1	1				3	
Hexatoma				1			1									
Thienemannimyia	6	12	3	2			17	11	3	19	21	32	1	6	40	16
Diamesa	19	13		5		1	10	3	4	12	18	15			13	1
Potthastia								2								
Sympotthastia															9	5
Micropsectra											1	4		3	2	
Microtendipes							2	2								
Polypedilum									22	7	10	24		39	7	6
Rheotanytarsus														1	11	
Tanytarsus										2		5			15	
Cardiocladius										1						
Cricotopus									2	8	4	12		1	6	5
Eukiefferiella	11	6	1	4		1	22	5	6	9	9	8	2	1	7	11
Orthocladius	503	432	128	61	79	58	1248	584	41	567	102	105	6	23	567	867
Parakiefferiella		2						3							9	4
Parametriocnemus							1		1			1		1		
Synorthocladius															10	1
Chironomid pupae	281	269	52	24	6	5	243	203	14	68	81	34		9	174	66
Heterelmis							1									
Narpus												1			1	
Optioservus				1			2				3	1			1	
Acari									1							1
Nematoda	4		1				12	15	19	27	17	10		6	18	2

Table 4 continued. Number of aquatic macroinvertebrates collected with a modified round square foot sampler in the spring and summer, 1978 above (1,2) and below (3,4) Kootenai Falls.

	Spring								Summer							
	Site 1		Site 2		Site 3		Site 4		Site 1		Site 2		Site 3		Site 4	
Taxa	R1	R2	R3	R4	R5	R6	R7	R8	R1	R2	R3	R4	R5	R6	R7	R8
Turbellaria		1	5	2						2	1	3				1
Lumbriculidae										3		1		4	3	38
Eiseniella											3			21	5	7
Ophidonais serpentina											1			7		
Lymnaea									1		1	3				
Total Number	913	850	370	457	91	66	1718	953	350	955	467	456	12	140	987	1196
Total Weight (gr)	.776	.647	.819	1.743	.035	.015	.971	.873	.385	.724	.643	1.504	.003	.329	.963	.671

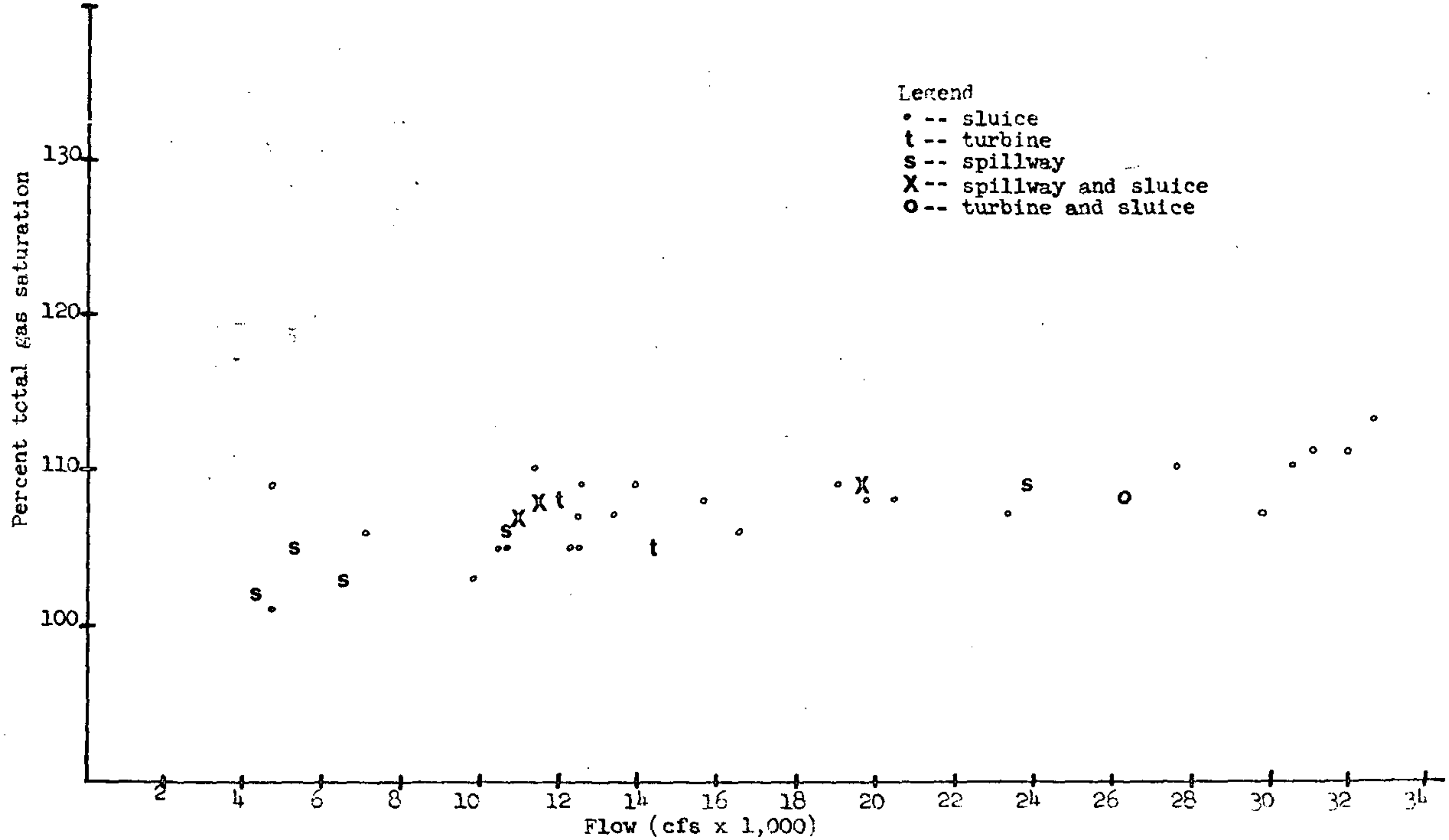

Figure 18. Percent total gas saturation in the Kootenai River at different dam operations measured at Leonia (Montana-Idaho border) from 1972-1975

habitat is relatively constant, few samples are needed to obtain good precision for number of taxa and number of individuals per sample in relatively pristine conditions (Rabeni and Gibbs 1978). There was undoubtedly some loss on retrieval because no bag was placed around the samples before retrieval. Rabeni and Gibbs (1978) estimated loss on retrieval of 26-30 percent for Diptera, Ephemeroptera and Trichoptera from substrate samplers in a deep Maine river.

Biomass of insects in substrate baskets was considerably larger at sites 1 and 2 than at site 3 (Table 5). The deeper water at site 3 (24 ft) and the shading by steep canyon walls might explain some of the difference. Some differences between substrate and bottom samples were more attributable to availability of suitable substrate on the river bottom. Dipterans in general were less abundant in the substrate baskets than bottom samples, and *Simulium* and *Eukiefferiella* replaced *Orthocladius* as the dominant species in the substrate samples. *Simulium* larvae prefer more laminar flow as opposed to turbulent flow because the comb-like bristles which they extend into the current to catch food are more efficient in more laminar flow (Hynes 1970). The clean gravel substrate also provides more surface area for attachment.

Mayflies were relatively more abundant in the basket samples than substrate samples, although fewer *Baetis* larvae were present in the substrate baskets. *Hydropsyche* were much more abundant in the substrate samples upstream from the falls than downstream, and more abundant than in bottom samples. They are net spinning filter feeders which have specific current requirements (Philipson 1954) and colonize artificial substrates because of the large amount of surface area available for attachment. Relative abundance of dominant species of mayflies appeared to be correlated. *Ephemerella inermis* decreased in abundance downstream from site 1 to 3, while *Rhithrogena hageni* increased in abundance.

To further assess the structure of the insect community, calculations were made of species diversity (Shannon-Weaver and Brillouion) (Kaesler and Herricks 1977, Pielou 1977), redundancy (Wilhm and Dorris 1968) evenness (Egloff and Brakel 1973), equitability (Krebbs 1972) and species richness (Orr et al. 1973). In general, species diversity values were intermediate to low. The insect community was generally monotipic and dominated by *Orthocladius* at all sites except site 2 (Appendix A-1). Present conditions seem to favor a few of the more tolerant species.

Diversity of insects was largest at site 2 in both spring and summer samples (Figure 19). Diversity was larger in summer than spring samples at all sites (Figure 19, Appendix A-1). Diversity was smallest in the canyon area downstream from the falls due largely to generally poor substrate conditions. Diversity of insects on the gravel bar just downstream from the falls (site 3_2:summer sample) was larger than at either site 1 or 4 (Figure 19). Site 3_1 was located on bedrock substrate in the canyon area and had the smallest diversity of the spring samples and second smallest diversity during the summer. Site 3_1 also had the smallest number of taxa during both seasons.

The impoundment of the Kootenai River by Libby Dam has resulted in significant decreases in insect diversity and probably standing crop, although studies in areas where pre-impoundment collections were made are needed to quantify the changes. Flow fluctuations have also resulted in the loss of significant amounts of habitat. In a river subject to fluctuation from a hydroelectric facility, Fisher and LaVoy (1973) found that benthic invertebrates increased markedly in density and taxonomic diversity from the high to low water mark. Fall samples near the high water mark in the Kootenai

Table 5. Number of macroinvertebrates collected in cylindrical substrate samplers upstream (1,2) and downstream (3) from Kootenai Falls and colonized from April 13, 14 to May 30, 1978.

Taxa	Small Substrate Baskets			Large Substrate Baskets		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
Alloperla			2			1
Pteronarcella badia	1					
Baetis	17	38	4	29	24	3
Ephemerella inermis	491	238	57	402	249	83
Ephemerella flavilinea	2	2		7	3	
Ephemerella heterocaudata		2			2	
Rithrogena hageni	63	124	140	27	56	51
Paraleptophlebia	4		7	2		
Brachycentrus	5	4		4	2	1
Glossosoma	1					
Hydropsyche	469	356	22	365	348	47
Lepidostoma	7			2		1
Simulium	121	374	4	271	628	36
Antocha		2	1		1	
Theinemannimyia	18	2	1	12	3	
Diamesa	2		1	4		
Micropsectra	2				1	
Cricotopus				1	3	
Eukiefferiella	63	56		47	65	2
Orthocladius	7	4	12	6	6	2
Chironomid pupae	9	8	4	6	8	1
Nematoda				1	3	
Turbellaria	26					
Lumbriculidae				1		
Lymnaea					1	
Total Number	1308	1210	243	1193	1403	229
Total Weight (gr.)	9.489	8.790	1.363	7.158	8.524	1.466

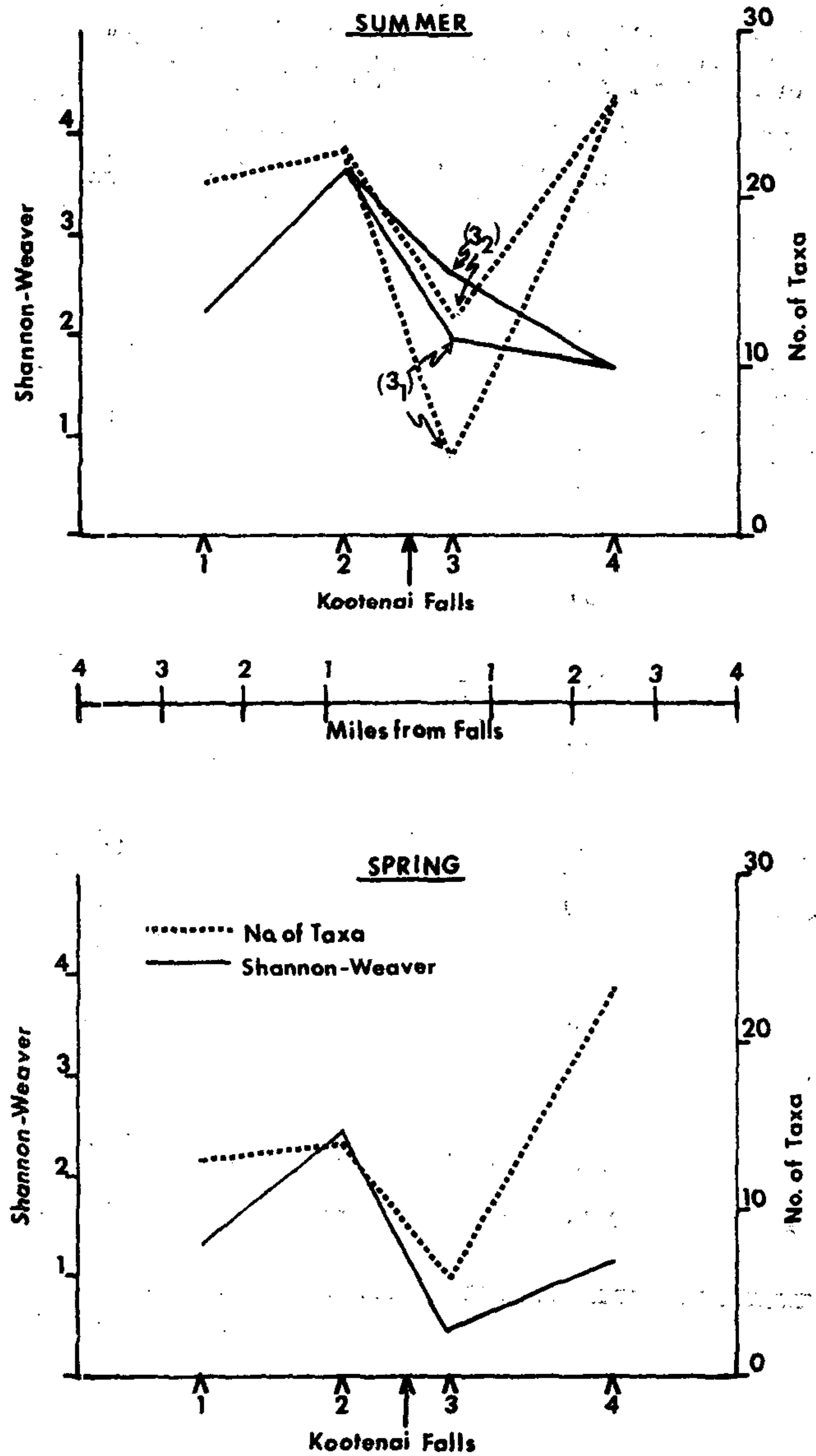

Figure 19. Insect species diversity and number of taxa per square foot at sections 1 and 2 upstream from Kootenai Falls and sections 3, 4 downstream from Kootenai Falls, sampled during the spring and summer, 1978.

River produced few taxa or insects. Therefore, in addition to reduced diversity, and probably abundance, within the wetted area, the area of insect production has also been limited to a much smaller area since impoundment of the river by Libby Dam.

The status of the insect population downstream from Libby Dam has not been studied extensively since impoundment. Some work was done during periods of high gas saturation in the river (Fickeison and Montgomery, undated). Results indicated that the flotation of insects resulting from the physical presence of gas bubbles in the river was a more important factor in insect survival than gas bubble disease. Although many changes were observed in the insect population in this study compared to pre-impoundment, they are likely a result of many interrelated changes that occur in a regulated river as discussed by Ward (1976) and Spence and Hynes (1971).

To compare pre- and post-impoundment macroinvertebrate communities, I selected the downstream-most site sampled in pre-impoundment studies at Lowery Gulch (Bonde and Bush 1975 -Appendix), 19.7 miles upstream from Kootenai Falls. Samples collected from 1969 to 1971 were pooled. Both pre- and post-impoundment samples were made with the same sampler and at sites with similar size substrate, water depth and velocity. Only the four major insect orders were compared. In pre-impoundment studies, 42 genera were collected compared to 26 genera in the present study. Chironomidae were only reported to family in the pre-impoundment study and have therefore been lumped together here for comparison. Standing crop after impoundment was 0.894 gr/ft^2 (sites 1, 2, 4) compared to 3.38 gr/ft^2 in the pre-impoundment study.

Number of stonefly genera and density were significantly reduced after impoundment (Table 6). Only 3 genera were collected in this study compared to 13 genera in the pre-impoundment study. Densities ranged from 0-5/ft^2 after impoundment compared to 38/ft^2 prior to impoundment. In pre-impoundment samples (Lowery Gulch) stoneflies comprised 15 percent of the sample by number and 27 percent weight. In this study stoneflies comprised less than 0.5 percent of the sample by number; probably less than 1 percent by weight. Decreases in stonefly densities have occurred in many rivers downstream from impoundments (Spence and Hynes 1971, Ward 1976). Several reasons have been suggested for their absence including changes in thermal regime (Lehmkuhl 1972) and oxygen availability to nymphs (Spence and Hynes 1971). Decreases in the Kootenai River may have occurred during periods of high gas saturation, but presently higher winter and lower spring and early summer temperatures and fluctuating flows probably limit stonefly numbers in the Kootenai River. Completion of the life cycle is dependent on thermal cues for egg development, growth and emergence. Lack of certain maximum and minimum temperatures, or too few degree days could result in elimination of certain species of insects (Lehmkuhl 1972).

Number of mayfly genera decreased from 11 genera prior to impoundment to 8 genera post-impoundment. Densities were significantly larger after impoundment ranging from 97 to 184/sq ft compared to 31/sq ft prior to impoundment (Table 7). Although abundant, the mayflies were small in size. In pre-impoundment samples mayflies comprised approximately 12 percent of the sample by number and 7 percent by weight. After impoundment mayflies comprised a larger percent by number (19 percent). Only total sample weight was calculated from post-impoundment samples, which was only 26

Table 6. Density of Plecoptera (stoneflies) at three sites in the Kootenai Falls area collected during the spring and summer, 1978 and at Lowery Gulch collected from 1969-1971 using a modified round sampler.

	Number of insects per square foot						
	Kootenai Falls						Lowery Gulch
	Site 1 & 2		Site 3		Site 4		
Genera	Sp 1/	Su 2/	Sp	Su	Sp	Su	T 3/
Alloperla	x 4/	4	-	x	-	5	
Capnia	x	-	-	-	-	-	
Cultus (Isogenus)	-	-	-	-	x	-	
Total	1	4	0	x	x	5	38

1/ Spring

2/ Summer

3/ Mean for spring, summer and autumn samples

4/ Present, less than 1/square foot

Table 7. Density of Ephemeroptera (mayflies) at three sites in the Kootenai Falls area collected during the spring and summer, 1978 and at Lowery Gulch collected from 1969-1971 using a modified round sampler.

	Number of insects per square foot						
	Kootenai Falls						Lowery Gulch
	Site 1 & 2		Site 3		Site 4		
Taxa	Sp[1/]	Su[2/]	Sp	Su	Sp	Su	T[3/]
Baetis	60	126	x	3	6	79	
Ephemerella flavilinea	1	x[4/]	-	-	x	-	
Ephemerella heterocaadata	-	-	-	-	-	-	
Ephemerella inermis	60	x	-	-	74	x	
Ephemerella hecuba	-	x	-	-	-	-	
Ephemerella doddsi	-	x	-	-	-	-	
Ephemerella margarita	-	12	-	2	-	3	
Ephemerella tibialis	-	19	-	-	-	4	
Epeorus	-	-	-	-	-	x	
Heptagenia	-	5	-	2	-	8	
Rythrogena hageni	51	7	-	-	16	3	
Paraleptophlebia	x	-	-	-	x	-	
Pseudocloeom	-	12	-	-	-	14	
Cinygmula	x	-	-	-	-	-	
Total	173	184	x	8	97	111	31

1/ Spring

2/ Summer

3/ Average for spring, summer and autumn

4/ Present, less than 1 per square foot

percent of the pre-impoundment samples. The decrease in standing crop caused by reductions in stonefly abundance was not significantly compensated for by the mayflies.

The increase in mayfly abundance seems to conflict with the thermal regime theory by Lehmkuhl (1972); however, in general the mayfly community was dominated by only a few taxa including *Baetis* spp., *Ephemerella inermis*, and *Rythrogena* in the spring and *Baetis* spp. in the summer. Their success in part appears to be due to their ability to reproduce under existing conditions and exploit areas and food sources used by insects presently absent in the river.

The number of Trichoptera (caddis flies) genera remained the same with nine genera collected from pre- and post-impoundment samples (Table 8). However, density decreased significantly from 56/sq ft at Lowery Gulch to 11/sq ft at Kootenai Falls. One significant factor which may limit the abundance of caddis flies is the amount of suitable habitat. Their numbers in substrate samples were large compared to bottom samples. *Hydropsyche* are net-spinners and utilize the current to carry food into their nets. These nets require a definite current to function properly (Philipson 1954). Some sediments have filled interstices in the gravel and rubble and have reduced the amount of surface area for these net-spinners to attach. This condition in the Kootenai Falls area is probably at near equilibrium and is not likely to improve without flood flows which shift and scour bottom materials and carry sediment downstream. Fluctuating flows from the dam are not sufficient and probably reduce the suitable rearing areas for the caddis flies because of constantly changing water velocities. Impoundment of the area by a dam at Kootenai Falls would cause more sediments to settle out and produce too slow a current for these insects.

Number of dipteran (true flies) families decreased from seven families prior to impoundment to three families post-impoundment. Density of dipterans increased after impoundment from 125/sq ft to 494/sq ft (Table 9). In the present study *Orthocladius* completely dominated the Dipteran community. In the present study Dipterans comprised 61 percent of the samples by number compared to 50 percent prior to impoundment (21 percent by weight). Chironomids (Tendipedidae) or midges predominated pre- and post-impoundment Dipteran collections, but the complexity of the family and the incompleteness of the data precludes further analysis.

White Sturgeon

White sturgeon, the largest freshwater game fish in the United States, are limited in their distribution in Montana to the Kootenai River downstream from Kootenai Falls. Limited work was done on the white sturgeon in Montana by the Fish and Game, with six being captured in 1975 and two in 1976, using large mesh gill nets (May and Huston 1977). They ranged in length from 34.0 to 48.0 inches and averaged 18 years in age. No sturgeon were captured using set lines during that period.

Sturgeon have probably never been abundant in respect to other game fish in this or any other river. Experienced biologists on the Snake River managed to catch only 0.4 sturgeon per hour from 1973 through 1975 (Coon et al. 1977). However, their large size and fighting ability make for a quality experience. Applegate (1971) documented an angler catch of 30 sturgeon,

Table 8. Density of Trichoptera (caddis flies) at three sites in the Kootenai Falls area collected during the spring and summer, 1978 and at Lowery Gulch collected from 1969-1971 using a modified round sampler.

	Number of insects per square foot						
	Kootenai Falls						Lowery Gulch
	Site 1 & 2		Site 3		Site 4		
Genera	Sp 1/	Su 2/	Sp	Su	Sp	Su	T 3/
Brachycentrus	-	1	-	-	-	-	
Glossosoma	3	6	-	-	4	1	
Cheumatopsyche	-	x 4/	-	-	-	-	
Hydropsyche	2	11	-	1	6	3	
Lepidostoma	-	-	-	-	x	-	
Rhyacophila	-	-	-	-	x	x	
Arctopsyche	-	x	-	-	-	-	
Ceraclea	-	x	-	-	-	-	
Neophylax	-	x	-	-	-	-	
Total	6	19	0	1	10	4	56

1/ Spring

2/ Summer

3/ Mean for spring, summer and autumn samples

4/ present, less than 1 square foot

Table 9. Density of Diptera (true flies) at three sites in the Kootenai Falls area collected during the spring and summer, 1978 and at Lowery Gulch collected from 1969-1971 using a modified round sampler.

	Number of insects per square foot						
	Kootenai Falls						Lowery Gulch
	Site 1 & 2		Site 3		Site 4		
Genera	Sp 1/	Su 2/	Sp	Su	Sp	Su	T 3/
Simulium	5	7	1	2	1	4	
Protanyderus	-	-	-	-	x	-	
Antocha	1	2	2	-	33	2	
Hexatoma	x 4/	-	-	4	x	-	
Thienemannimyia	6	19	x	-	14	28	
Diamesa	9	12	-	-	6	7	
Potthastia	-	-	-	-	1	-	
Sympotthastia	-	-	-	20	-	7	
Polypedilum	x	16	-	2	-	6	
Micropsectra	-	1	-	-	-	1	
Microtendipes	-	-	-	-	2	-	
Rheotanytarsus	-	-	-	x	-	6	
Tanytarsus	-	2	-	-	-	8	
Cardiocladius	-	x	-	-	-	-	
Cricotopus	-	6	-	x	-	6	
Eukiefferiella	6	8	x	2	14	9	
Orthocladius	281	204	68	14	916	717	
Parakiefferiella	x	-	-	-	2	6	
Parametriocnemus	-	x	-	x	x	-	
Synorthocladius	-	-	-	-	-	6	
Total	305	277	72	93	990	812	125

1/ Spring

2/ Summer

3/ Mean of spring, summer and autumn samples

4/ Present, less than 1 per square foot

with five being released from 1968 through 1970 at the canyon mouth, 2.2 miles downstream from the falls. His work was instrumental in determining minimum and maximum size limits for white sturgeon which may not mature until 11 to 22 years of age for males and 26 to 34 years of age for females (Samakula and Larkin 1968). The need for protection of this long-lived species has been recognized in many states. In Idaho, only catch and release fishing is allowed for white sturgeon in the Snake River.

In an attempt to determine the present status of white sturgeon in the Kootenai River, we captured and tagged these fish with radio transmitters to follow their movements and document areas of preferred use. Three different white sturgeon were captured a total of seven times. All sturgeon were caught in 3 or 5 inch trammel nets. Seventy-two overnight sets were made during the spring and summer and nine sets were made in the fall. In addition, 80 trotlines were set overnight and 102 hours were spent fishing during the spring and summer.

Little movement of the radio-tagged sturgeon could be documented. Antenna problems developed on two transmitters within 1-7 days after release and the third transmitter could not be picked up after 5 days. Water depths in the canyon area of 70-100 feet were beyond the useful limit of the radio transmitters. After release the white sturgeon would position themselves near the mouth of the canyon in this deep water.

Netting was restricted to the "sturgeon hole" because of irregular, steep canyon walls and fast water currents in upstream canyon areas. In the sturgeon hole two sturgeon were recaptured after their release. The first one was on June 5, 15 days after release. The second sturgeon was recaptured on July 14, 50 days after release and again on October 18, 96 days after the first capture.

One angler reported catching a 20-inch sturgeon in the canyon 1.6 miles downstream from the falls on July 20. Another sturgeon was reportedly observed in shallow water just downstream from Troy by a fisherman in a boat during mid-August.

Fish Populations

Fifteen fish species have been reported in the Kootenai River upstream from Kootenai Falls with four considered abundant and seven uncommon (Table 10). Downstream from Kootenai Falls, 16 species have been reported with five species considered abundant and nine uncommon. White sturgeon and kokanee salmon *(Oncorhynchus nerka)* were reported below, but not above the falls. Rainbow trout and mountain whitefish were the most abundant game fish in the unimpounded portion of the Kootenai River (May and Huston 1975). Dolly Varden *(Salvelinus malma)* and kokanee were seasonally abundant below the falls in the spring and fall respectively. Torrent sculpins which were abundant prior to impoundment by Libby Dam are presently considered rare in the 16-mile section downstream from the dam due largely to the effects of gas supersaturation (May and Huston 1975). Mountain whitefish populations also suffered declines for the same reason.

The electrofishing section below Kootenai Falls, sampled in 1978 was similar to the Troy section sampled by Fish and Game personnel from 1971 through 1974. In 1978, however, the section extended upstream into the steep

Table 10. Relative abundance of fish species collected upstream and downstream from Kootenai Falls

Common Name	Scientific Name	Upstream of Kootenai Falls 1/	Downstream of Kootenai Falls 1/
Westslope cutthroat trout	Salmo clarki lewisi	U	U
Rainbow trout	Salmo gairdneri	A	A
Dolly Varden	Salvelinus malma	U	U
Brook trout	Salvelinus fontinalus	U	U
Mountain whitefish	Prosopium williamsoni	A	A
White sturgeon	Acipenser transmontanus	N	U
Burbot	Lota lota	U	U
Kokanee	Oncorhynchus nerka	N	U
Torrent sculpin	Cottus rhotheus	U	U
Slimy sculpin	Cottus cognatus	R	R
Largescale suckers	Catostomus macrocheilus	A	A
Longnose suckers	Catostomus catostomus	U	U
Northern squawfish	Ptychocheilus oregonensis	R	U
Peamouth chub	Mylocheilus caurinus	R	A
Redside shiner	Richardsonius balteatus	U	R
Longnose dace	Rhinichthys cataractae	A	A

1/ A -- abundant U -- uncommon, R -- rare, N -- not reported canyon area and was shortened on the downstream end. In addition, the Troy section was sampled during the fall and the 1978 section was sampled during the spring. Despite these differences general comparisons can be made.

During the 4 years of sampling in the Troy section, the fish population was relatively stable with suckers comprising 50 to 81 percent of the catch (May and Huston 1975). Mountain whitefish were the most abundant game fish comprising 7 to 24 percent of the population. Rainbow trout were the most abundant game fish. In the spring of 1978 a population estimate could only be made of whitefish and suckers (coarsescale). Coarsescale suckers were the most abundant 746/1000 ft., followed by mountain whitefish 646/1000 ft. (Table 11). Together whitefish and coarsescale suckers comprised 93 percent of the catch (Table 12). The large number of whitefish could in part be due to a seasonal abundance of whitefish during the spring and summer followed by a subsequent decrease in abundance in the fall as part of the population begins to move on spawning migrations. Whitefish spawning migrations have been documented in the Kootenai River near the Fisher River area (May and Huston 1975) and in other major rivers (Pettit and Wallace 1975, Davies and Thompson 1978). Whitefish eggs were collected in the insect samples made on the gravel bar upstream from the foot bridge below Kootenai Falls.

Rainbow trout were the most abundant trout or char during all sampling periods. Dolly Varden abundance was larger in 1978 than 1971-1974. They were concentrated in the upper one-third of the section along the canyon walls. Average size of Dolly Varden was 19.1 inches.

In the steep canyon areas the small game fish and rough fish concentrated in cove areas. These areas provided the only gradual sloping bed along the canyon wall. Large numbers of age 1 whitefish were present on the three gravel bars downstream from the mouth of the canyon, indicating that spawning occurred in that area.

Population estimates of rainbow trout and mountain whitefish were taken in the Flower-Pipe Section 6.75-11.3 miles miles upstream from Kootenai Falls from 1973 through 1978, excluding 1976. This section had comparatively fewer suckers than upstream sections and those downstream from the falls (May and Huston 1975). Rainbow trout numbers increased from 24/1000 ft in 1973 to 64/1000 ft in 1974 and remained above 60/1000 ft of stream through 1977 (Table 13 and Figure 20). In 1978, rainbow trout increased to 116/1000 ft of stream. This estimate was taken later in the spring than in previous years, and probably resulted in an underestimate of large rainbow trout. We believed that some of the mature rainbows were still in spawning tributaries. The 1978 estimate was over two times larger than the 1977 estimate for trout between 7.0 and 14.9 inches, but fewer fish over 14.9 inches in length were collected. This decrease could also be related to high fishing mortality on large rainbow trout that was suspected to have occurred during the lower water summer of 1977. Because of the low flows, larger trout were more vulnerable to anglers as determined from reports by numerous anglers.

Estimated biomass of yearling and older trout increased from 18 pounds/1000 ft in 1973 to 43 pounds/1000 ft in 1974 and 1975 (Table 13). Biomass continued to increase to 67 pounds/1000 ft in 1977 and 74 pounds/1000 ft in 1978 (Figure 21).

The increase in biomass from 1977 to 1978 was only 10 percent compared to an 82 percent increase in numbers. This reflects the small number of larger fish in the 1978 estimate.

Table 11. Population estimate of mountain whitefish and coarsescale suckers (fish/1000 ft) in the Kootenai River 3.7 to 5.[illegible] miles downstream from Kootenai Falls during May, 1978

Mountain Whitefish		Coarsescale Suckers	
Group Length (in)	Estimate fish/1000 ft	Group Length (in)	Estimate fish/1000 ft
		6.6-13.9	188
9.0-11.9	241	14.0-17.9	255
12.0-18.7	404	18.0-28.0	303
Total	646 + 25%	Total	746 + 38%

Table 12. Number of fish per section, percent species composition and average size of fish in the Kootenai River below Kootenai Falls

Species	No. fish per section	% species composition	Average length (range)
Mountain whitefish	530.5	51%	12.3(5.4-18.7)
Coarsescale suckers	437.0	42%	16.4(6.6-28.0)
Peamouth chubs	30.8	3%	10.4(7.4-13.0)
Rainbow trout	16.8	2%	12.3(8.7-20.7)
Northern squawfish	12.2	1%	13.7(9.7-21.0)
Finescale suckers	4.5	<1%	14.4(9.7-16.8)
Dolly Varden	2.0	<1%	19.1(13.3-25.4)
Cutthroat trout	0.2	<1%	11.5 --

Table 13. Population estimates for rainbow trout in the Flower-Pipe Section of the Kootenai River from 1973 through 1977, given in numbers and biomass per 1000 feet of stream.

	Number/1000 ft (percent of total)				
Group length (in)	1973	1974	1975	1977	1978
7.0 - 10.9	9.5(39)	22.3(35)	26.1(41)	24.1(38)	52.7(46)
11.0 - 14.9	15.0(61)	35.8(56)	31.7(49)	23.4(37)	56.5(49)
> 14.9		5.9(9)	6.3(10)	16.1(25)	6.4(5)
Total	24.5+23%	64.0+13%	61.1+12%	63.6+16%	115.5±20%
	Biomass/1000 ft (lbs)				
	18.0+24%	43.0+13%	43.2+14%	67.2+22%	73.9±18%

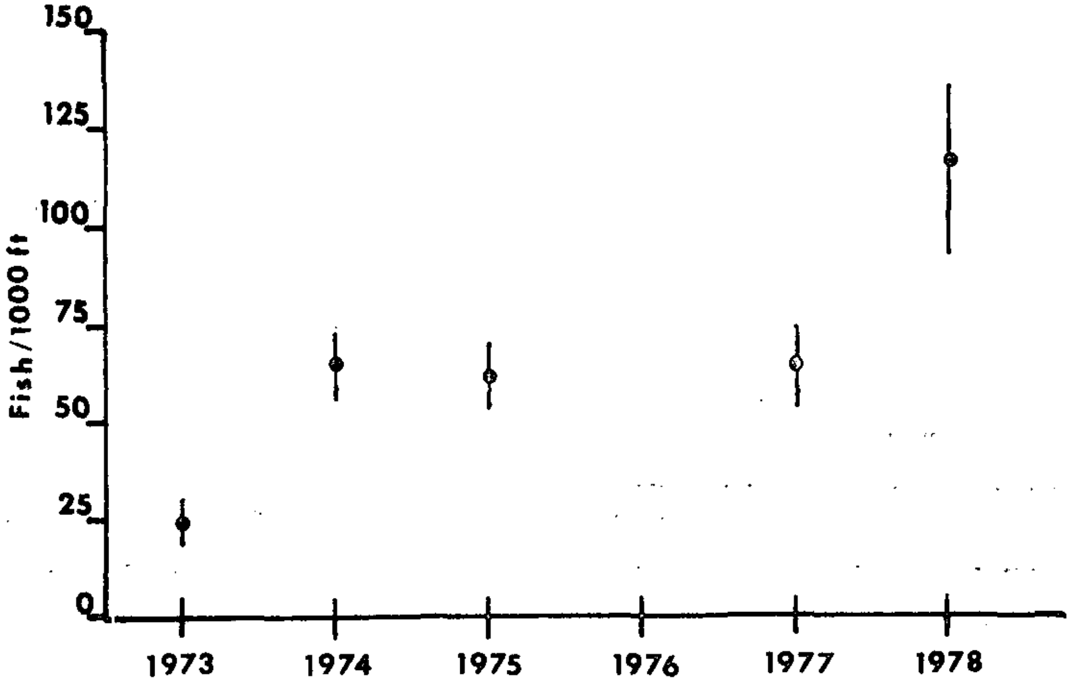

Figure 20. Population e^timates of rainbow trout in fish/1000 ft of stream in the Flower-Pipe Section of the Kootenai River from 1973 through 1977, excluding 1976.

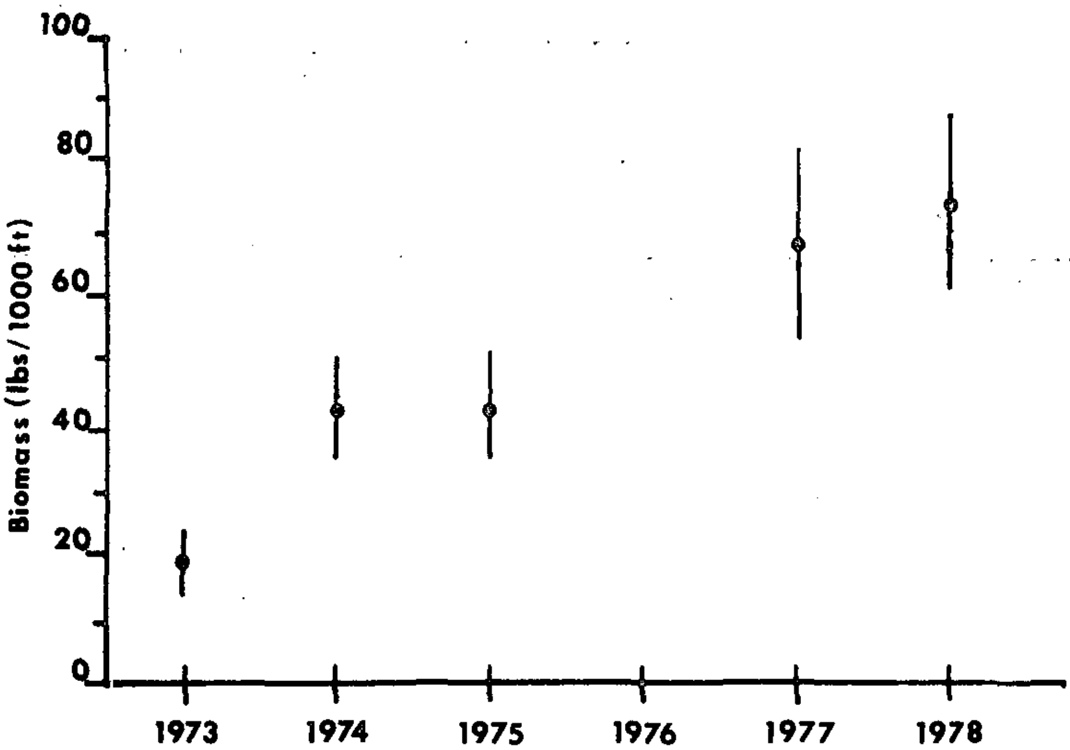

Figure 21. Biomass estimates of rainbow trout per 1000 ft of stream in the Flower-Pipe Section of the Kootenai River from 1973 through 1977, excluding 1976.

In general, growth rates of rainbow trout in the river have been excellent (May and Huston 1977). Age III rainbow averaged 17.9 inches in 1977 and 16.6 inches in 1978 compared to an average length of 11.4 inches for age III rainbows in 1973 (Table 14). Growth rates have continually increased for age I and age II rainbow trout from 1970 through 1977 (Table 14). In 1978 growth rates had slowed for all three age classes. This may be a reflection of higher densities of trout and whitefish in the river. Growth rates also slowed in the 1974-75 growing season, when growth of age II and age III fish slowed considerably. The growth increment for age II fish decreased by 40 percent from the 1973-74 to 1974-75 growing season, but increased by 97 percent in 1975-76 (Table 15). This decrease in growth was attributed to high flows and gas concentrations during 1974-75 (May and Huston 1975).

Rainbow trout densities in the China Rapids to Kootenai Falls section were larger than for any section of the river previously censused (Table 16). There were 228 (+33 percent) rainbow trout per 1000 ft of stream in this section, 97 percent more than estimated for the Flower-Pipe section sampled in the spring (Table 13). This included one +12 pound and one +7 pound rainbow trout (Figure 22). These estimates are undoubtedly low and are primarily useful in monitoring annual changes in relative abundance of rainbow trout. The total number of trout that would be expected in the 3.5 mile reach upstream from the falls using the 1978 estimate was 4,213 rainbow trout over 9.0 inches. A minimum total catch of rainbow trout was estimated to be 8,232 fish for the same stream reach (445/1000 ft) using the 1978 creel census data.

This estimate illustrates the large number of rainbow trout that are presently supported in the Kootenai Falls section. The large difference between the fall estimate in the Kootenai Falls section and the spring estimate in the Flower-Pipe is due in part to absence of some of the mature rainbow trout in the spring estimate because they were still in the spawning tributaries. A second factor was the fact many age I fish were more susceptible to electrofishing in the fall because they were larger. This was countered in part because the fall estimate only included fish over 9.0 inches in length compared to a 7.0 inch minimum length in the spring estimate.

Biomass estimates of rainbow trout in the Kootenai Falls section were 95 percent larger than in the Flower-Pipe section. Growth rates of rainbow between the two sections could only be compared for the 1976 year class because data were lacking in the Kootenai Falls section prior to 1978. Back calculated growth was 2.3 inches at age I and 9.8 inches at age II, for a 7.5 inch increment of growth in the Kootenai Falls section. Back calculated growth was 2.8 inches at age I and 10.8 inches at age II for an 8.0 inch increment of growth in the Flower-Pipe section (Table 15).

Kootenai River rainbow trout generally rear one or more years in a tributary stream, then migrate into the main stem of the Kootenai. Approximately 85-90 percent of the rainbow trout that "*smolt*" do so at age 1 and the rest follow at age 2. First year growth in the main river was excellent with an average increase in length of 9.3 inches from 1976 to 1977 (Table 15). After rearing in the main river, the rainbow trout migrate into tributary streams to spawn in the spring. As determined from the 1976 and 1977 spawning runs into Libby and Pipe creeks of those fish which spent 1 growing season in the tributaries before moving to the main river (X1) 40 percent returned to spawn at age 2, 44 percent at age 3, and 16 percent at age 4. Of the X2 fish, 50 percent returned

Table 14. Growth of rainbow trout by year class from Flower-Pipe section of the Kootenai River. Number of fish aged given in parenthesis.

Year Class	Back calculated growth for each age class			
	1	2	3	4
1970	-	9.4 (3)	11.4 (14)	16.3 (2)
1971	3.1 (8)	9.8 (12)	14.6 (16)	15.5 (15)
1972	2.7 (56)	10.6 (56)	13.5 (32)	-
1973	2.7 (94)	10.8 (94)	16.5 (4)	19.4 (4)
1974	2.4 (20)	11.7 (20)	17.9 (20)	19.2 (2)
1975	2.7 (70)	12.0 (70)	16.6 (17)	-
1976	2.8 (52)	10.8 (52)		

Table 15. Growth increments of rainbow trout by age class each year in the Flower-Pipe section of the Kootenai River.

Growth Year	Age Class		
	1	2	3 1/
1972-73	6.7	2.0	-
1973-74	7.9	4.8	4.9
1974-75	8.1	2.9	0.9
1975-76	9.3	5.7	-
1976-77	9.3	6.2	2.9
1977-78	8.0	4.6	1.3

1/ Growth increment based on small sample size.

Table 16. Population estimates for rainbow trout and mountain whitefish in the Kootenai River between China Rapids and Kootenai Falls in September 1978, in numbers and biomass per 1000 feet of stream.

Rainbow Trout			Mountain Whitefish		
Length group(in.)	Number/ 1000 ft(%)	Biomass/1000 ft(lbs)(%)	Length group(in.)	Number/ 1000 ft(%)	Biomass/1000 ft(lbs)(%)
9.0-13.4	192 (84)	93 (65)	8.9-10.9	835 (62)	245 (30)
13.5-28.0	36 (16)	51 (35)	11.0-19.4	519 (38)	566 (70)
Total	228±34%	144±28%		1354±25%	811±25%

Figure 22. A 7-plus pound rainbow trout captured in autumn sampling in the China Rapids-Kootenai Falls section. This area is known for producing trophy fish by many local fishermen.

to spawn at age 3, 46 percent at age 4, and 4 percent at age 5 (Montana Fish and Game files, Libby). Major spawning tributaries between Kootenai Falls and the proposed reregulating dam site are Quartz, Pipe, Bobtail and Libby creeks.

Trout usually showed small amounts of seasonal movement other than during the spawning season. In the Flower-Pipe section from 1973 through 1978, of 319 tagged trout (9%) were caught over one-half mile from the 4-mile long shocking section as determined by angler tag returns. Percent movement of tagged fish by species was similar for rainbow trout, cutthroat trout, and Dolly Varden at 7%, 13%, and 8% respectively. The majority of movement (78%) was downstream into the Kootenai Falls area. Average distance moved downstream was 10.4 and 8.0 miles for rainbow and cutthroat trout, respectively. Nearly half (46%) of the fish migrated over Kootenai Falls.

Four tags from the 1978 shocking section below Kootenai Falls have been returned to date. One rainbow moved upstream 4.2 miles to just below the falls and another was captured 1 mile upstream in the canyon area. One rainbow was captured 1.6 miles downstream from the shocking section. A Dolly Varden moved downstream 3.0 miles.

Tags have also been returned from five rainbow and two cutthroat trout tagged in the fall estimate above Kootenai Falls. Two rainbow and one cutthroat moved downstream and over the falls, an average distance of 3.5 miles. A second cutthroat moved downstream 33 miles to the mouth of the Moyie River in Idaho. Three other rainbow were captured in the Kootenai Falls section. More returns are expected in the summer of 1979.

Mountain whitefish were abundant in the Kootenai Falls section. There were 1,354 whitefish/1000 ft of river in the fall population estimate. Whitefish were considerably more abundant in this section than in the Flower-Pipe section. There were 441 whitefish/1000 ft in the Flower-Pipe section in 1977 and a preliminary estimate in 1978 was 671 whitefish/1000 ft (Table 17).

The mountain whitefish population in the Kootenai River were directly affected by high flows and gas supersaturation prior to the fall of 1975 as indicated by data from fish collections in the Flower-Pipe section (May and Huston 1977). Abundance decreased by 65% from 1973 to 1974 and remained 49% below the 1973 level in 1975 (Figure 23). By 1977, the population rebounded to 441/1000 ft (Table 17). The strong 1975 year class, which accounted for most of the 1977 estimate, was produced the first year that percent gas saturation was significantly reduced (May and Huston 1975). The population continued to expand in 1978. Estimated biomass decreased by 40% from 1973 to 1974 and increased by 43% by 1975 and continued to increase in 1977 (Figure 24). The 1977 biomass estimate of 276 pounds/1000 ft was 89% larger than the 1973 estimate (Table 17). No biomass estimate was made in 1978.

Mountain whitefish had good growth, reaching an average of 14.9 inches at age 4 (Table 18). Average size at annulus has continually increased over the sampling period particularly for the older age classes. Growth increments have been variable but in general were larger for the 1975-76 and 1976-77 growing seasons than previous years (Table 19). The decrease in the growth increment during the 1974-75 for age 2 and older whitefish corresponds to that observed for rainbow trout. Large flows and gas supersaturation influenced growth during that period (B. May pers. comm.). Based on the 1978 collections, data indicate that growth of whitefish is slowing down, particularly in the age 3 and older fish (Tables 18 and 19).

Table 17. Population estimates for mountain whitefish in the Flower-Pipe Section of the Kootenai River from 1973 through 1977 given in numbers and biomass per 1000 feet of stream

Group length (in)	Number/1000 ft (percent of total)				
	1/ 1973	1974	1975	1977	1978
8.5-10.9	317.4 (68)	58.6 (36)	126.6 (53)	269.1 (61)	
11.0-12.3	150.6 (32)	106.6 (64)	58.9 (25)	86.7 (20)	
> 12.3	-	-	54.8 (22)	85.1 (19)	
Total	468.0+20%	165.2+22%	240.3+22%	440.9+13%	

	Biomass/1000 ft (lbs)				
	1973	1974	1975	1977	1978
	146+19%	165+19%	126+20%	276+20%	

1/ *Length groups in* 1973 were 7.0 - 9.9 and 10.0 - 18.6 inches

Table 18. Growth of mountain whitefish by year class from the Flower-Pipe Section of the Kootenai River. Number of fish aged given in parentheses

Year Class	Back calculated growth for each age class				
	1	2	3	4	5+
1970	4.4 (41)	7.2 (41)	10.1 (53)	12.3 (42)	13.2 (21)
1971	4.3 (18)	8.4 (29)	11.3 (32)	12.4 (25)	16.3 (10)
1972	4.1 (33)	10.1 (33)	11.2 (25)	14.4 (8)	16.3 (8)
1973	4.9 (30)	9.8 (39)	13.0 (32)	14.9 (32)	15.7 (40)
1974	5.6 (11)	10.9 (11)	14.0 (11)	14.7 (13)	-
1975	5.0 (37)	10.2 (37)	12.9 (48)	-	-

Table 19. Growth increments of mountain whitefish by age class each year in the Flower-Pipe Section of the Kootenai River

Growth Year	Age Class				
	0	1	2	3	4
1970-71	4.4	-	-	-	-
1971-72	4.3	2.8	-	-	-
1972-73	4.1	4.1	2.9	-	-
1973-74	4.9	6.0	2.9	2.1	-
1974-75	5.6	4.9	1.1	1.1	0.9
1975-76	5.0	5.3	3.2	3.2	3.9
1976-77	-	5.2	3.1	1.9	1.9
1977-78	-	-	2.7	0.7	0.8

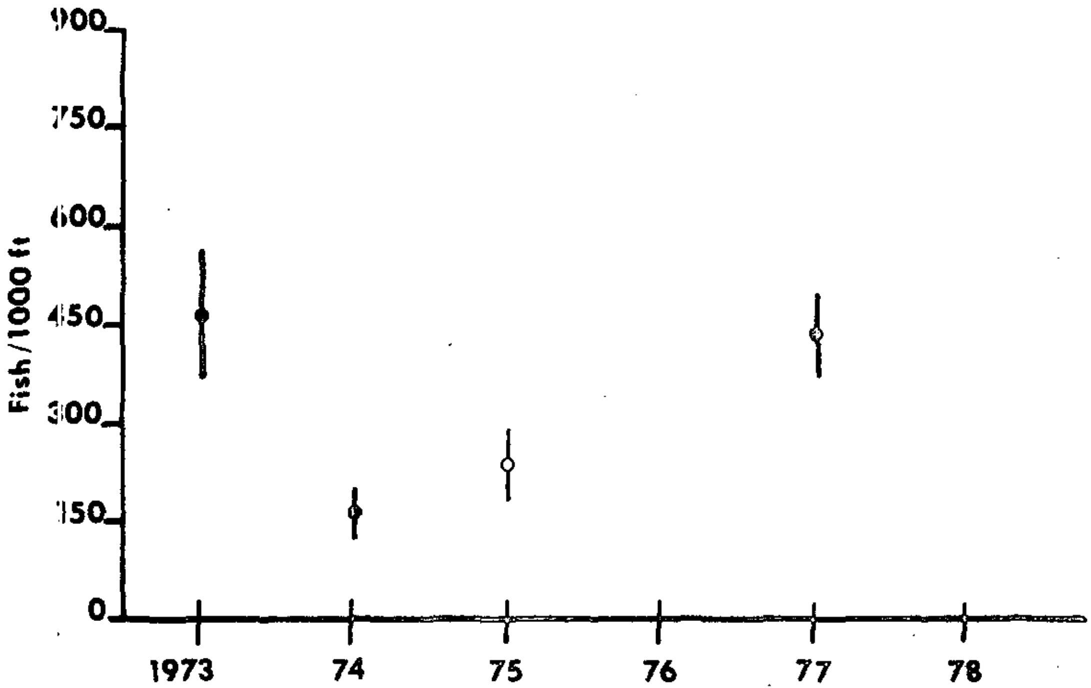

Figure 23. Population estimates of mountain whitefish per 1000 ft. of stream in the Flower-Pipe section of the Kootenai River from 1973 through 1977 excluding 1976.

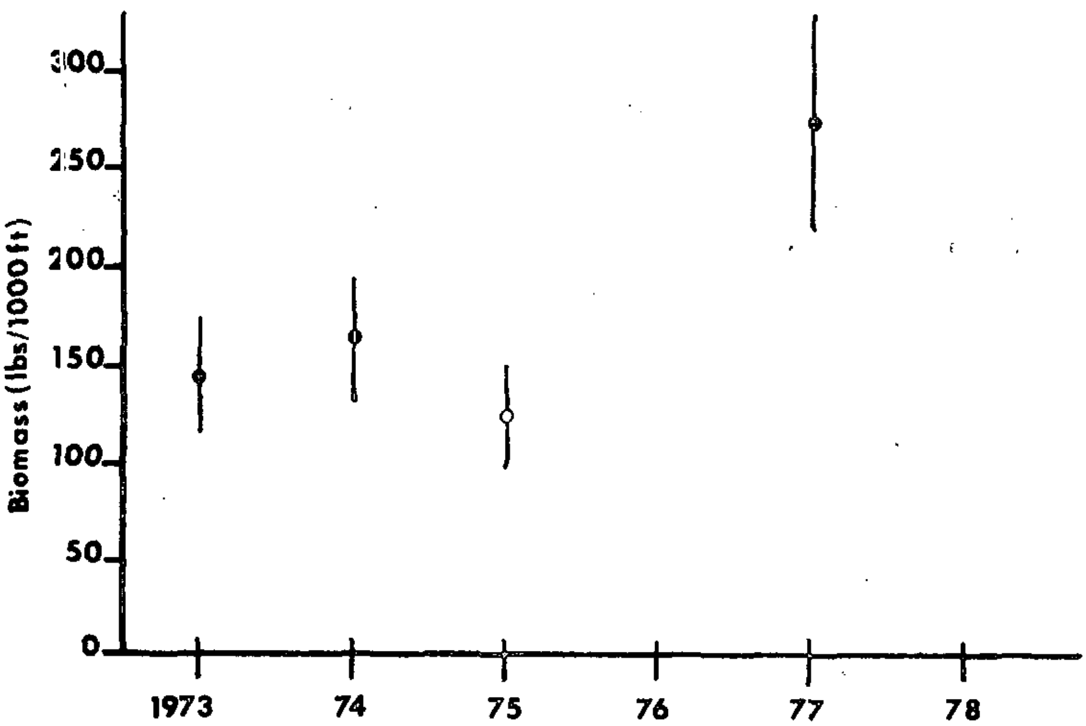

Figure 24. Biomass estimates of mountain whitefish per 1000 ft. of stream in the Flower-Pipe section of the Kootenai River from 1973 through 1977 excluding 1976.

Creel Census

A significant increase in fishing pressure has occurred on the unimpounded portion of the Kootenai River in recent years. Fishing pressure, as estimated from a mail survey, increased from 116 man-days per mile of river during the 1968-69 fishing season to 406 man-days per mile during the 1975-76 fishing season. The 1968-69 survey was on the entire 99 miles of free-flowing river in Montana prior to construction of Libby Dam and the 1975-76 survey was on the 50 miles of river downstream from Libby Dam.

Fishing pressure was high on the 3.5 mile reach of river upstream from Kootenai Falls in 1978. Estimated pressure was 1,251 man-days per mile in the summer and 1,630 man-days/mile for the year (Table 20). Although fishing pressure has been increasing in general on the river, the high estimates for the Kootenai Falls section are indicative of its popularity. Fisherman use is high because of good access, close proximity to Libby and Troy, and high catch rates of rainbow trout. Fishing pressure on the Kootenai Falls section was higher than on other trout streams surveyed in recent years. Summer pressure estimates averaged about 1,000 man-days/mile on the Madison River and 500 man-days/mile on the West Gallatin River (R. Vincent pers. comm.) compared to 1,251 man-days/mile on the Kootenai Falls section.

Nearly half (46 percent) of the anglers caught fish as determined from interview data and 55 percent were successful, as reported in the postal card survey (Tables 21 and 22). The majority of fishing pressure (72 percent) occurred from May through September (9,192 hours) compared to the period October through April (2,782 hours). Total pressure was divided evenly between weekdays and weekends, although pressure per day was over two times larger on weekends (Table 20).

Estimated catch of trout was 3,352 fish/mile and 8,232 fish total in the Kootenai Falls section in 1978 (Table 20). Mean monthly catch rates of trout from interview data was 0.64 fish/hr and ranged from 0.32-1.67 fish/hr, in March and October, respectively (Table 21). These catch rates were intermediate when compared to Montana's finest Blue Ribbon trout streams. Catch rates ranged from 1.2-2.7 fish/hr in the upper Madison River (R. Vincent pers. comm.), 0.6-1.0 fish/hr in the Big Hole (Peterson 1973) and 0.06-0.1 fish/hr in the upper Yellowstone River (D. Workman 1976).

Rainbow trout comprised 96 percent of the catch, followed by cutthroat trout (2 percent) and mountain whitefish (1 percent). Average size of rainbow trout was 12 inches in the 1978 survey. In a more limited survey in 1977, average size of rainbow trout was 13 inches (Table 21). Anglers kept 75 percent of their catch as determined from interview data and 65 percent as determined from postal card data (Tables 21 and 22).

Catch rates of trout for other river sections between the Kootenai Falls section and Libby Dam were lower than for the Kootenai Falls section and ranged from 0.11-0.87 fish/hr with a mean of 0.48 fish/hr (on file, Montana Department of Fish and Game, Libby). Rainbow trout comprised 86 percent of the total catch, followed by whitefish (9 percent) and cutthroat trout (4 percent). Average length of rainbow trout was 11.4 inches. Percent of successful anglers was similar for the different river section averaging 46 percent.

Table 20. Fishing pressure in total hours and man-days and catch for weekdays and weekend periods during the summer (May to September) and winter (October to April) fishery in a 3.5 reach of river upstream from Kootenai Falls, 1978.

Season/ Month	Weekdays Hours	Weekdays Man-Days	Weekdays Catch	Weekends Hours	Weekends Man-Days	Weekends Catch	Total Hours	Total Man-Days	Total Catch
Summer									
May	582	277	413	667	318	474	1249	595	887
June	1298	618	974	944	450	708	2242	1068	1682
July	1165	555	781	1280	610	858	2445	1165	1639
Aug.	1268	604	609	860	410	413	2128	1014	1022
Sept.	451	215	496	677	322	745	1128	537	1241
Sub.	4764	2269	3273	4428	2110	3198	9192	4379	6471
Winter									
Oct.	294	140	491	121	58	202	415	198	693
Nov.	40	19	58	20	10	29	60	29	87
Jan.	40	19	20	117	56	57	157	75	77
Feb.	239	114	96	409	195	164	648	309	260
Mar.	460	219	147	300	143	96	760	362	243
April	374	178	202	368	175	199	742	353	401
Sub.	1447	689	1014	1335	637	747	2782	1326	1761
Total	6211	2958	4287	5763	2747	3945	11974	5705	8232

Table 21. A summary by month of a personal contact survey of anglers in a section of the Kootenai River 0.4 miles upstream from Kootenai Falls in 1977 and 1978.

Year/ Month	Days Sampled	No. of Contacts	No. of Anglers	No. of Successful Anglers(%)	Fish/ Hour	No. Kept/ Total	Average Size of Rainbow Trout
1977							
January	1	2	4	2 (50)	0.75	6/6	19.5
February	2	10	22	5 (23)	0.44	12/18	11.5
March	1	2	3	0 (0)	0	0	--
April	1	1	2	1 (50)	0.5	3/3	14.2
June	4	29	58	16 (28)	0.35	17/31	14.9
July	5	12	15	6 (40)	0.25	13/13	13.0
August	2	3	5	2 (40)	1.2	8/8	10.3
September	2	6	11	5 (45)	0.5	10/13	10.4
October	1	1	1	1 (100)	4.0	0/4	-
Total	19	66	121	38 (31)	0.45	69/96 (72%)	13.1
1978							
January	7	6	12	3 (25)	0.49	8/10	11.4
February	7	22	42	18 (43)	0.40	42/46	12.45
March	6	30	59	17 (29)	0.32	36/40	11.96
April	6	24	39	20 (51)	0.54	38/43	12.76
May	10	41	89	35 (39)	0.71	85/115	12.59
June	12	80	144	72 (50)	0.75	125/169	11.70
July	10	64	122	55 (45)	0.67	137/188	12.41
August	9	53	95	39 (41)	0.48	54/88	11.53
September	11	41	67	42 (63)	1.10	91/133	11.21
October	6	8	10	4 (40)	1.67	23/23	10.25
November	6	4	7	4 (57)	1.44	9/9	13.56
Total	90	373	686	309 (46)	0.64	647/863(75%)	12.05

Table 22. A summary by month of a postal card survey of anglers in a section of the Kootenai River 0.4 miles upstream from Kootenai Falls in 1977 and 1978.

Year/ Month	No. of cards returned (%)	No. of Anglers	No. of Successful Anglers (%)	Fish/ hour	No. kept/ total
1977					
January	3	6		0.08	1/1
February	14	23		0.45	25/29
March	5	9		0.72	12/13
June	17	26		0.56	40/44
July	10	23		0.76	20/42
August	4	5		0.20	2/2
September	4	7		0.61	4/11
October	1	2		0.75	6/6
Total	58	101		0.56	110/148 (74%)
1978					
January	5	5	2 (40)	0.79	1/11
February	5 (19)	10	3 (30)	0.03	1/1
March	6 (26)	10	2 (20)	0.20	10/10
April	3 (30)	5	1 (20)	0.21	0/3
May	7 (39)	12	7 (58)	0.70	12/14
June	21 (49)	27	16 (59)	0.86	20/49
July	22 (44)	49	30 (61)	0.37	44/49
August	24 (62)	42	27 (64)	0.79	74/116
September	11 (37)	18	10 (56)	0.54	20/39
October	2 (50)	3	2 (67)	0.46	6/6
November	0 (0)	-	-	-	-
Total	101 (42%)	181	100 (55%)	0.54	206/318 (65%)

A significant mountain whitefish ice fishery existed during the winter prior to impoundment of the Kootenai River. Mountain whitefish comprised 99 percent of the catch in the 1971-72 winter fishery (May and Huston 1975) compared to 3 percent in the 1978 winter fishery. Warmer than normal winter flows from Libby Dam and large daily flow fluctuations (6 ft) presently prevent ice formation on the river.

A majority of anglers in the Kootenai Falls section were from Lincoln County (63 percent) compared to 87 percent for other sections of the river in 1978 (Table 23). The percentage of out-of-state anglers in the Kootenai Falls section (20 percent) was larger than other river sections (10 percent) probably because of good access from Highway 2. Most anglers (57 percent) used bait when fishing the Kootenai Falls section, followed by those using artificial flies (15 percent) and lures (11 percent) (Table 24). This compares closely with results from other river sections in 1978 (B. May pers. comm.).

Amount of discharge was thought to affect fishing success, as many anglers found it more difficult to fish at higher flows. I compared angler success during July and August at high flows (>10,000 cfs) and low flows (<10,000 cfs). Both high and low flow days occurred with relative frequency during these months. Fishing pressure was also large during July and August. Success was higher during low flows with one out of two fishermen catching fish during that period compared to one out of three fishermen catching fish under high flow conditions (Table 25). This difference was consistent during both months.

Table 23. Residence of anglers contacted in the Kootenai Falls angler survey in 1978.

Season	Residence of Fishermen		
	Lincoln County(%)	Out-of-County(%)	Out-of-State(%)
January - May	175 (75)	40 (17)	18 (8)
June - November	247 (57)	69 (16)	117 (27)
Total	422 (63)	109 (16)	135 (20)

Table 24. Type of gear used by anglers in the Kootenai Falls angler survey in 1978.

Season	Type of Gear			
	Natural(%)	Lures(%)	Flies(%)	Combination(%)
January - May	162 (68)	7 (3)	35 (15)	33 (14)
June - November	218 (51)	69 (16)	68 (16)	75 (17)
Total	380 (57)	76 (11)	103 (15)	108 (16)

Table 25. Number of successful anglers contacted on the Kootenai River under high flow (>10,000 cfs) and low flow (<10,000) conditions in July and August, 1978.

Month	High Flow		Low Flow	
	Number of Anglers	Number Successful(%)	Number of Anglers	Number Successful(%)
July	72	28 (39)	50	26 (52)
August	32	9 (28)	63	30 (48)
Total	104	37 (36)	113	56 (50)

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