WATER QUALITY STATUS REPORT

EFFLUENT LIMITATIONS ANALYSIS

Kootenai River
(Boundary County)

Report Prepared by:

Larry E. Comer

April 1977

Department of Health and Welfare
Division of Environment

WATE QUALITY SERIES NO. 27

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TABLE OF CONTENTS

APPENDIX

INTRODUCTION

The Kootenai River is a major tributary to the Columbia River, draining southern British Columbia, northwestern Montana, and portions of northern Idaho. One-third of the river total length lies in the United States, as its' source and mouth lies in Canada. An impoundment exists behind Montana's Libby Dam, completed in 1972, and the Kootenai River feeds the Canadian Kootenay Lake 30 miles after leaving the Idaho-British Columbia border (see map, Appendix I, II). The average discharge is 14,000 cfs, as it enters Idaho at Leonia, and 16,000 cfs as it re-enters British Columbia at Porthill, Idaho. The vast majority of the drainage basin is forest land, with some agriculture in areas north of Bonners Ferry.

MUNICIPAL WASTEWATER SOURCES

The City of Bonners Ferry operates a municipal wastewater treatment facility, consisting of two aerated and two facultative stabilization lagoons. It has an average discharge of 350,000 gpd, and serves approximately 2500 people. The four lagoons have a total surface area of five acres, with an average retention time of 25 days. The facility provides no disinfection and has an above surface discharge to the Kootenai River at river mile 152.8.

The City also operates a potable water treatment plant, designed to filter 1.5 mgd from Myrtle Creek and the Kootenai River as a supplemental source. Approximately 12,000 gallons of backwash wastewater is dischaged to the Kootenai River at river mile 164.5, during each backwash cycle. Backwashing frequency varies seasonally with raw water quality.

Additional municipal wastewater discharges to the United States portion of the Kootenai River are found at Libby and Eureka, Montana.

OTHER WASTEWATER SOURCES

There are no permitted industrial discharges to the Kootenai River in Idaho. However, a vermiculite mine and a lumber/plywood mill discharge to the river near Libby, Montana. The Corps of Engineers found "an abrupt decrease in a number of water quality parameters (Ca, SO_4, F, and PO_4) in the Kootenai River in September, 1968, which could be attributed to treatment of an industrial discharge entering the St. Mary River, a tributary of the Kootenai River, in British Columbia."

Agricultural and silvicultural runoff and septic tank seepage are possible non-point wastewater sources. Several agricultural drainage/pumping districts are located near Bonners Ferry, that pump drainage water in the spring from low lying agricultural land. The impact of this wastewater source has not been quantified.

KOOTENAI RIVER WATER QUALITY

The U. S. Geological Survey maintains water quality and discharge monitoring stations at Leonia and Copeland, Idaho, although minimal water quality data is available at the Leonia site. Additional water quality data is available from a special survey conducted by the U. S. Corps of Engineers (see references). EPA/IDHW network water quality sampling on the Kootenai River provides background data on an inconsistent quarterly basis from 1968 to 1974. Network sampling on the Kootenai was terminated in February, 1975. Daily flow data is available from U.S.G.S. yearly water resource data summaries.

In order to determine the impact of a point discharge on a receiving stream, it is preferable to have flow and quality information, which corresponds to the point discharge data, at locations upstream and downstream of the discharge point. In the case of the Bonners Ferry wastewater lagoons, consistent NPDES self-monitoring of effluent quality began in January, 1975, although the facility began operation in 1968. When EPA/State network sampling on the Kootenai was terminated in February 1975, it eliminated the only water quality station which was near Bonners Ferry and also upstream of the City. Other sources of upstream water quality information, the Corps of Engineers Preimpoundment Study and U.S.G.S. monitoring station at Leonia, Idaho, either date prior to initiation of effluent sampling or have data for only a few water quality parameters. In short, much of the consistent water quality data for the Kootenai River is either from the wrong place or time to allow a customary analysis of a point source discharge impact.

Complete water quality and river discharge information is available from a site 40 miles downstream from Bonners Ferry, at Copeland. This site is maintained by U.S.G.S. and provides monthly data over the time frame of available lagoon effluent data.

It is felt that maintaining temporal consistency between effluent and river quality data is more critical than comparing data from a location upstream of the discharge but from a different year. This is supported by conclusions from the Corps of Engineers report "Kootenai River Water Quality Inspections" which found significant yearly variations in many water quality parameters over the period of study (1967-1972). In addition, the following water quality comparison is intended to demonstrate relative impacts of the municipal wastewater discharge, and does not attempt to perform a realistic mass balance exercise.

RELATIVE IMPACTS OF BONNERS FERRY WASTEWATER LAGOONS ON THE KOOTENAI RIVER

The appendix contains tables giving monthly summaries of Bonners Ferry wastewater effluent quality and flow from January, 1975, to June, 1976, the available Bonners Ferry water treatment plant backwash quality from June, 1974, to July, 1975, and Kootenai River quality and flow at Copeland for water year 1975 (October, 1974, to September, 1975). These data have been reduced to show minimum, average and maximum values, and are compared graphically to show relative loading rates.

Kootenai River BOD information is from the average values at Copeland, found by the Corps investigation over the period of their sampling (1969-1972). Suspended sediment loads in the river are compared with the suspended solids load from the lagoons, although it is acknowledged that these parameters each measure solids fractions which do not entirely overlap. Lagoon effluent nutrient load contributions are calculated from observed flows and assuming typical concentrations of medium strength domestic sewage (total nitrogen -N as 40 mg/l, and total phosphorus -P as 10 mg/l). This assumption is felt to be conservative. Fecal coliform concentrations have been transformed to daily total contributions from averaged observed monthly concentration data.

The ratio of the historical minimum, average, and peak discharges from the Kootenai River versus the Bonners Ferry lagoons are 2,400:1, 28,000:1, and 224,000:1, respectively. This great dilution factor is evidenced by observing the following average chemical loading ratios.

Chemical Parameter	Loading Ratio: Kootenai River to Bonners Ferry Lagoons
BOD	1,700:1
Suspended Solids (Sediment)	20,000:1
Total Nitrogen -N	150:1
Total Phosphorous -P	67:1

The impact of the organic load presented here is better understood by the fact in the Corps study, the average dissolved oxygen concentration over the period of October, 1969, to March, 1972, at Copeland was 104% of saturation. Due to the present operation of the Libby Dam release methods, the short term variations in the river discharge below the dam are extreme. In addition, the Columbia River Treaty of 1964 between Canada and the United States, may have a significant impact on minimum stream flow. The Treaty is paraphrased in reference 4; "Canada has the right at any time after 1984 to divert up to 1.5 million acre-feet annually from the Kootenai River to the Columbia River in the vicinity of Canal Flats, provided that the flows on the Kootenai River downstream of the point of diversion are not reduced to less than 200 cfs or natural flows, which ever is least."

Inspection of the fecal coliform loads show that the lagoons do contribute a significant number of organisms to the river, even though the lagoons contribution is 60 times less than the load found in the river. The average concentration of fecal coliforms found in the Kootenai at Copeland is 9/100 ml and the average added by the non-disinfected wastewater effluent at Bonners Ferry is 3600/100 ml.

The microbiological impact of the lagoon effluent on the river is complicated by the fact that the discharge point is from a pipe on the river bank several feet above the water surface. This type of discharge prevents adequate mixing and encourages the effluent to remain in a downstream plume next to the bank.

State Water Quality Standards for Class A_2 waters specify that fecal coliform concentrations may not exceed (a) a geometric mean of 50/100 ml, (b) 200/100 ml in 10% of the samples over a 30 day period, and (c) a maximum of 500/100 ml for any single sample. In order to demonstrate possible localized violations of this standard from the Bonners Ferry lagoon, a mass balance is performed to show the dilution necessary for the discharge to meet water quality standards (50 /100 ml, geometric mean):

$$Q_{final} \times C_{final} = Q_1 \times C_1 + Q_2 \times C_2$$

where C is concentration
and Q is flow

WQ Standards — Lagoon Load — River Load

$$Q_{dil} \times 50/100\text{ ml} = (3600/100\text{ ml} \times 0.56\text{ cfs}) + (9/100\text{ ml} \times 15{,}000\text{ cfs})$$

Necessary dilution to meet WQ Standard: $Q_{dilution} = 2700$ cfs

Necessary dilution as percentage of total flow: $\%Q = \frac{2700\text{ cfs}}{15000\text{ cfs}} \times 100 = 18\% \approx 20\%$

The lagoon effluent (on the average) must mix with 20% of the total river flow before water quality standards for fecal coliforms (50/100 ml) are met. This demonstrates the possibility of localized water quality violations and potential public health hazards. These calculations, however, do not consider coliform die-off. Since river velocities and dispersion coefficients are not known, it is not possible to estimate the downstream travel distance and time necessary to achieve 20% dilution.

Due to mechanical aeration and adequate retention time encouraging nitrogen oxidation, ammonia toxicity should not be a problem in the receiving water. Operational pH ranges have been well within permit limits during the period of lagoon monitoring.

BONNERS FERRY WATER TREATMENT PLANT BACKWASH

The sketchy NPDES monitoring data for the cities water filter plant backwash is summarized in a table in the appendix. These data indicate an average suspended solids load of 40 lb/day is discharged to the Kootenai River. Although the permittee reported 40 lb/day (12,000 gpd) backwash solids, this is more accurately a per backwash figure than a daily loading. As previously mentioned, backwashing frequency varies seasonally, reflecting raw water quality; some seasons require only one backwash per month and spring runoff conditions may require several backwashings per day. The backwash water presently receives no solids settling treatment prior to discharge. Under the present NPDES permit for this source, 200 mg/1 average is to be maintained until July 1, 1977, at which time a restrictive 30 mg/1 average is to be met. The loading which would be produced by a 30 mg/1 SS standard with present backwash rates is 3 lb/day. By the nature of filter plant functions, the highest amount of backwash solids are discharged when seasonal runoff causes the source and receiving water to be highly turbid from natural conditions.

CONCLUSIONS AND RECOMMENDATIONS

1. From the results of the waste loading contribution exercise as presented, it is recommended that a field survey to determine effluent limitations not be conducted. More water quality information on the Kootenai River would be helpful to determine impacts of other "non-point" sources such as the agricultural drainage pumping districts discharges. An intensive survey scheduled during this seasonal pumping would be warranted.
2. The comparative loadings from the Bonners Ferry lagoon show minimal impact on the Kootenai River, even though the facility does not consistently meet defined secondary treatment removals (30 mg/1 and 85% removal). Effluent BOD is generally at secondary levels. However, the facility does not show the capability of consistently meeting suspended solids limitations more stringent than the existing permit limits (70 mg/1 and 175 lb/day AVG; 105 mg/1 and 262 lb/day MAX). Lagoon effluent disinfection would be required to correct localized in-stream violations of fecal coliform concentrations.

3. Operation and maintenance assistance to the City may help improve lagoon effluent quality. For instance, a baffled final effluent structure or variations on series - pond flow structures may reduce suspended solids loadings.
4. The impact of the water treatment plant is minor compared to the sediment load of the Kootenai River. Some sedimentation capability for the backwash water may be needed, but at this point, it is a policy decision and cannot be dictated from water quality information. Effluent limitations of 30 mg/1 suspended solids appears unduly restrictive in this case.

APPENDIX

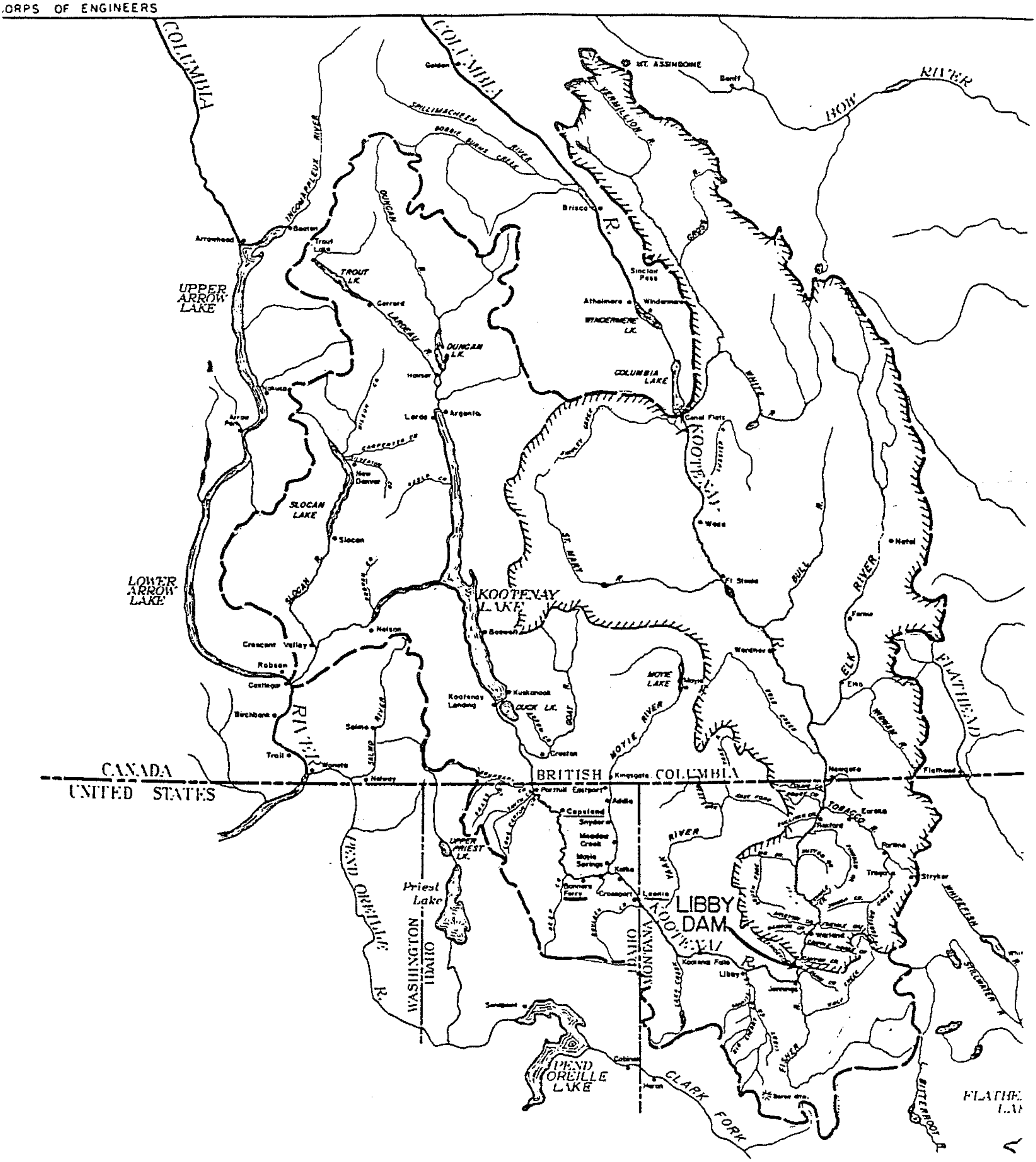


FIGURE I-KOOTENAI RIVER DRAINAGE BASIN

Scale in Kilometers

10 0 10 20 30 40 50 60 70 80 90

Scale in miles

10 0 10 20 30 40 50


COPELAND
BONNERS FERRY
LEONIA
CRESTON 8 MI.
YANK 11 MI.
400 000 FEET (IDAHO)
R 2 W
R 1 W
R 1 E
R 2 E.
R 3 E
CANADA
UNITED STATES
BRITISH COLUMBIA
IDAHO
116°00'
49°00'
30'
15'
45'
Porthill
Eastport
Copeland
KV Ranch
KOOTENAI IND RES
HOGUE MOUNTAIN
HARVEY MOUNTAIN
HALL MTN.
Lookout (abandoned)
COPPER MOUNTAIN
Addie
Sinclair Station
Lookout tower
Lookout station
BUSSARD MTN
Snyder Station
FISHER PEAK
KANIKSU NATIONAL FOREST
WALL MOUNTAIN
DEER RIDGE
BUCKHORN MOUNTAIN
2 600 000 FEET (IDAHO)
SMITH PEAK
PYRAMID PEAK
RUSSELL MOUNTAIN
BOISE MERIDIAN
Meadow Creek
SOLOMON MOUNTAIN
BOUNDARY COUNTY
LINCOLN COUNTY
IDAHO
MONTANA
KOOTENAI NATIONAL FOREST
Eileen Station
KOOTENAI
BURTON PEAK
IND RES
MYRTLE CREEK GAME PRESERVE
Moyie Springs
Boundary Co
Bonners Ferry
Lookout tower COOKS PEAK
KOOTENAI N W R
Katka
GREAT NORTHERN
PARADISE PEAK
Moravia
Station
TWIN PEAKS
KATKA MOUNTAIN
Lookout
ROMAN NOSE
CLIFTY MOUNTAIN
BLACK MOUNTAIN
Leonia
T 33 N
TROY 11 MI.
Naples
IRON MOUNTAIN
BUCK MOUNTAIN
Shiloh Station
TIMBER MOUNTAIN
T 32
KANIKSU NATIONAL FOREST
McArthur
BALD EAGLE MOUNTAIN
JOY MOUNTAIN
BOUNDARY COUNTY
BONNER COUNTY
ROBERTS MOUNTAIN
Lookout tower
Elmira
STRAWBERRY MTN
Lookout tower (abandoned)
KOOTENAI NATIONAL FOREST
Caribou Lookout
MOUNT WILLARD
MT PEND OREILLE
Samuels

Bonners Ferry

Domestic Wastewater Effluent - Self-Monitoring Summary

January 1975 to June 1976

Self Reporting Period	Flow (MGD)		BOD				SUSPENDED SOLIDS				FECAL COLIFORM No./100 ml	
			Avg.		Max.		Avg.		Max.			
	Avg.	Max.	mg/l	lb/d	mg/l	lb/d	mg/l	lb/d	mg/l	lb/d	Avg.	Max.
Permit Condition			60	150	90	225	70	175	105	262		
1/75 to 3/75	0.391	0.481	20	64	29	79	29	95	105	114	5000	23,100
4/75	0.320	0.426	26	76	40	142	34	92	47	165	321	553
5/75	0.375	0.591	26	80	35	147	38	130	57	246	6217	12,400
6/75	0.300	0.341	27	70	34	97	38	103	60	170	3685	7200
7/75	0.315	0.360	20	55	27	81	52	139	60	180	2965	5730
8/75	0.290	0.300	13	31	22	55	52	125	59	147	177	340
9/75	0.330	0.360	11	31	13	37	41	119	50	158	533	1021
10/75	0.354	0.427	15	44	18	64	45	132	50	178	3705	5580
11/75	0.359	0.392	19	57	27	86	39	117	45	147	500	780
12/75	0.361	0.392	20	59	28	92	24	73	29	95	4210	7560
1/76	0.325	0.333	26	70	28	77	28	77	41	114	9100	13,500
2/76	0.318	0.332	24	64	30	81	31	81	41	114	6063	8550
3/76	0.364	0.370	29	88	38	117	43	130	58	178	9644	18,900
4/76	0.323	0.351	30	84	40	117	54	145	63	185	515	810
5/76	0.320	0.360	35	97	44	132	71	200	105	314	93	134
6/76	0.278	0.290	15	33	19	46	72	169	96	233	2000	3000
Avg.	0.357	0.393	22	63	29	89	42	118	65	165	3596	8631

BONNERS FERRY WATER TREATMENT PLANT

BACKWASH WASTEWATER

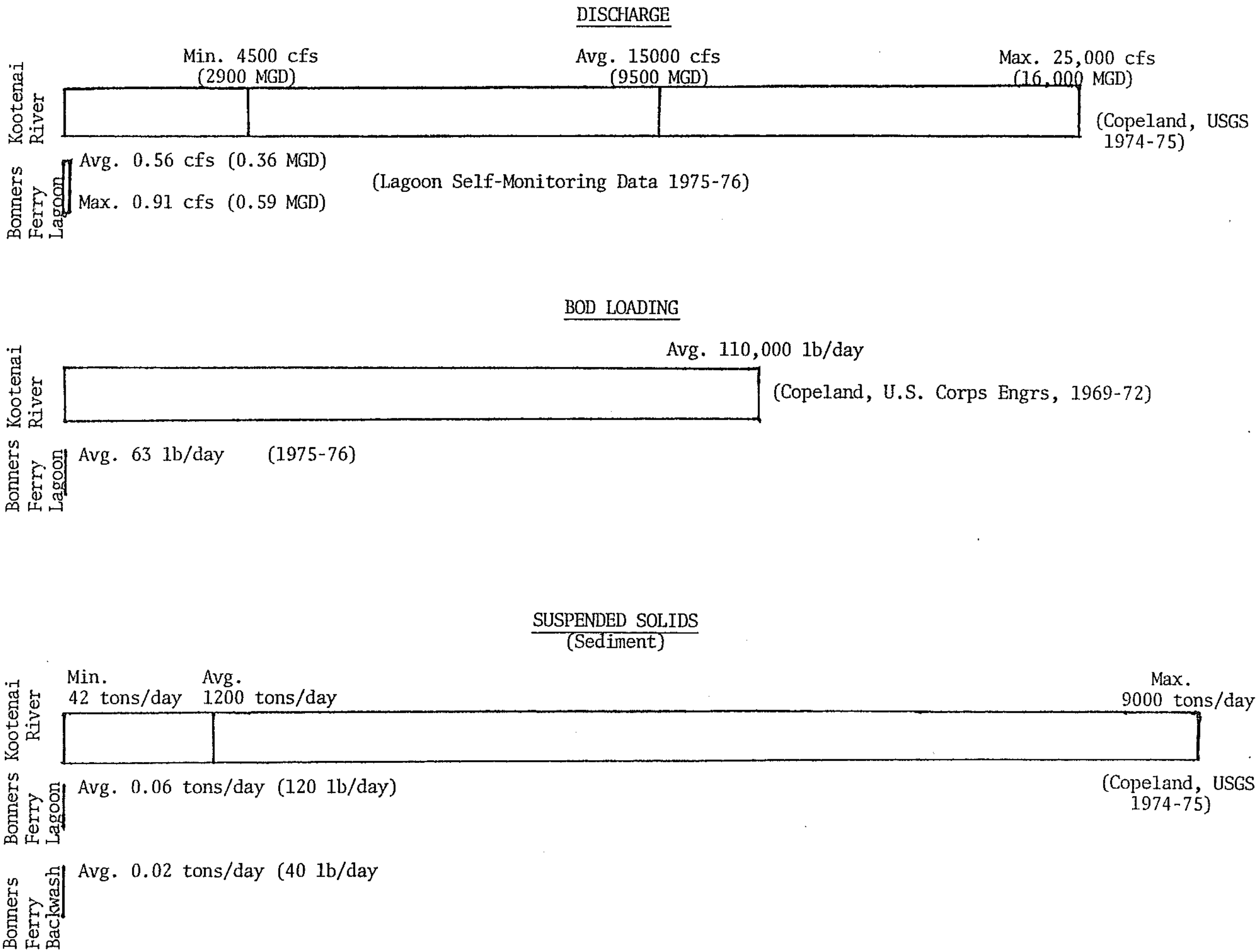
Date	Flow (GPD) Avg.	Flow (GPD) Max.	Suspended Solids Concentration (mg/l) Avg.	Suspended Solids Concentration (mg/l) Max.	Suspended Solids Loading (lb/day) Avg.	Suspended Solids Loading (lb/day) Max.
6/74 to 9/74	12,700	16,000	128	190	14	25
1/75	12,000	12,000	251	258	25	26
4/75	12,000	12,000	666	685	67	69
5/75	12,000	12,000	541	662	54	66
6/75	12,000	12,000	505	725	51	73
7/75	12,000	12,000	756	778	76	78
Monthly Avg.	12,260	13,500	388	460	39	48

KOOTENAI RIVER AT COPELAND

USGS DATA October 1974 - September 1975

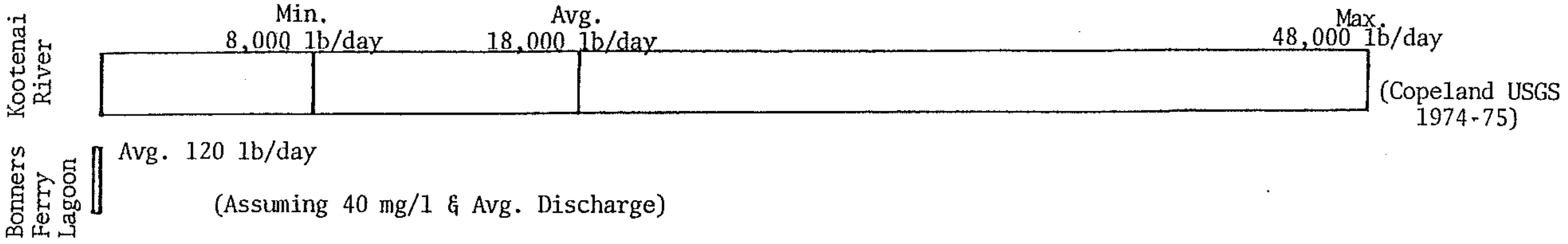
Date	Flow (cfs)	Total Nitrogen		Total Phosphorous		Fecal Coliforms (No/100 ml)	Suspended Sediments (ton/day)
		mg/l	lb/day	mg/l	lb/day		
10-1-74	17,700	.15	14,310	.02	1,908	6	577
11-20-74	25,100	.16	21,646	.04	5,411	27	1,020
12-09-74	14,700	.10	7,923	.02	1,585	27	76
1-20-75	16,200	.27	23,576	.02	1,746	5	475
2-18-75	23,200	.18	22,508	.01	1,250	8	312
3-18-75	10,100	.36	19,598	.03	1,633	1	9,040
4-24-75	11,300	.47	28,626	.10	6,091	2	399
5-22-75	23,900	.38	48,952	.01	1,288	7	1,440
6-17-75	16,700	.10	9,001	.01	900	10	535
7-15-75	5,510	.23	6,831	.01	297	8	101
8-15-75	4,520	.31	7,552	.01	244	2	48
9-23-75	7,760	.22	9.201	.03	1,255	9	42
Average	14,724 cfs		18,311		1,967	9	1,172

GRAPHICAL DISPLAY OF BONNERS FERRY WASTEWATER IMPACTS ON THE KOOTENAI RIVER

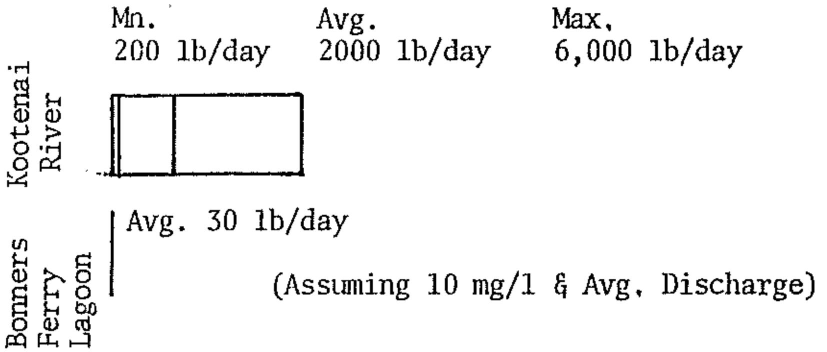


GRAPHICAL DISPLAY OF BONNERS FERRY WASTEWATER IMPACTS ON THE KOOTENAI RIVER

TOTAL NITROGEN - N

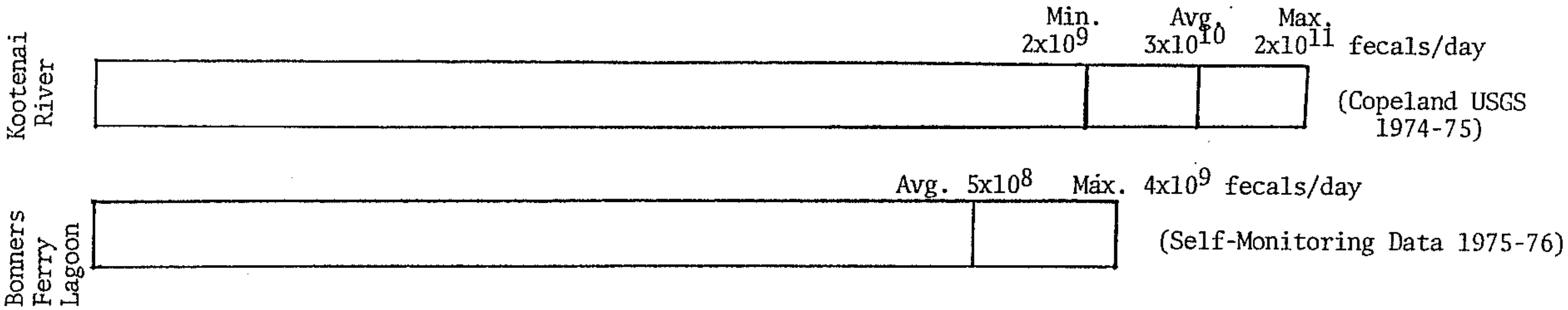


TOTAL PHOSPHOROUS - P

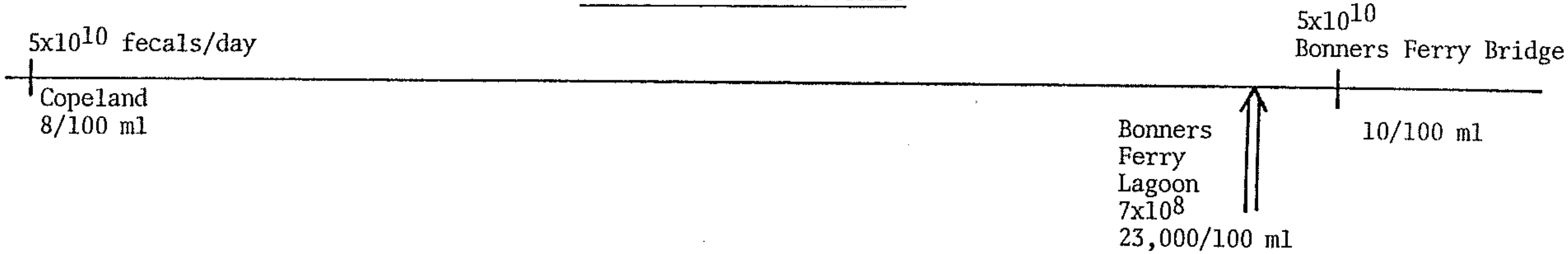


GRAPHICAL DISPLAY OF BONNERS FERRY WASTEWATER IMPACTS ON THE KOOTENAI RIVER

FECAL COLIFORMS



KOOTENAI RIVER SCHEMATIC



Fecal Values for February, 1975

Excerpt From: Kootenai River Water Quality Investigations,
Libby Dam Preimpoundment Study, 1967-1972.
U.S. Corps of Engineers (Ref. 6)

5.0 DISCUSSION

The Kootenai River is the second largest tributary of the Columbia River, with a discharge of nearly 800 cu m/sec (28,200 c.f.s.). The river, which has a length of about 780 km (485 miles) and a basin of almost 50,000 sq km (19,300 sq miles), is shared by Canada and the United States. Most of the river and its basin, along with the source and mouth of the river, lies in Canada. About one-third of the river's length and one-quarter of the basin area lies within the United States. The portion of the basin within the United States produces about one-fifth of the water discharged at the river mouth.

Practically all of the water that passes the background station at Rexford, near the Canadian-United States border, originates in Canada. At the Libby Dam site, about 90 percent of the water originates in Canada. The Canadian contribution of runoff in the river declines to 63 percent at the downstream border station near Porthill, Idaho. The water quality characteristics at the upstream station is, thereby, largely determined within the Canadian portion of the basin. Some of the many factors affecting water quality in the basin are delineated in previous reports (U.S. Corps of Engineers, 1969, 1970 and 1971) and by Shurr (1969) and Northcote (1972, 1973). Factors affecting water quality in the Canadian portion of the Kootenai River are discussed in the Canadian report (Crozier and Leinweber, 1975) published concurrent with this report to document the water quality of the river prior to impoundment by Libby Dam.

River discharge for the study period is 106 percent of normal, based on the period 1910-1972. River discharge of 118 to 120 percent of normal characterized the years 1967, 1969, and 1971. The year 1968 was a normal year in respect to discharge and 1970 was a low water year having 75 percent of normal flow.

Wide seasonal fluctuations in discharge are characteristic of the river. Flows entering the United States between calendar years 1967-1971 range from 37 to 1994 cu m/sec (1,300 to 70,376 c.f.s.) with a mean of 309 cu m/sec (10,906 c.f.s.). The range at Porthill is 74 to 2,784 cu m/sec (2,620 to 98,300 c.f.s.) with a mean of 488 cu m/sec (17,247 c.f.s.). Roughly, 70 percent of the rivers mean annual flow occurs during the spring and early summer. These fluctuations have rather dramatic effects upon the quality of the water. Suspended sediment concentrations, which are low during periods of base flow, increase during high water; while dissolved solids concentrations, which are high during base flow, decrease during high flows. With the bulk of the discharge occurring during the months of May, June, and July, dissolved and suspended loadings increase and are higher during that period than in the entire remaining 9 months of the year.

During the preimpoundment study period, the Kootenai River was a fast-flowing, cold-water river containing moderately hard to hard water of the calcium bicarbonate type. The river was quite fertile, as indicated by the high dissolved solids content and a large and diverse aquatic insect population. Dissolved oxygen concentrations invariably remained at or near saturation. High dissolved oxygen concentrations, along with the relatively low observed values for biochemical oxygen demand, indicate that the river was effective in assimilating organic loads without respiratory stress to aquatic life. For about 8 months of each year, the water was clear, transparent, and almost colorless. During periods of high discharge the river picked up a large suspended sediment load and became turbid and the true color increased. Increases could also be detected in total coliforms during periods of high water, but human contamination was not indicated since fecal coliforms were generally low (and within Montana's water quality standards for the river). The pH of the river water was often rather high for natural waters and the free carbon dioxide content, which strongly influences the pH, was generally low. The water, with bicarbonate as the dominant anion, had a high alkalinity which gave the river a high "buffering capacity."

Dissolved solids content of streams entering the Kootenai River from the Cabinet and Purcell Mountains was lower than that of the Kootenai and the river became more dilute as it traversed the United States; there was, however, an overall increase in the total dissolved solids load. This same phenomena was noted to occur in most of the major ions as well as in suspended sediments.

An important feature of the study was the detection of an abrupt decrease in a number of water quality parameters in the Kootenai River in September 1968 which could be attributed to treatment of an industrial discharge entering the St. Mary River, a tributary of the Kootenai River in British Columbia. The decrease was observed to occur in the concentrations of Ca, SO_4, F, and PO_4 was reflected in specific conductance and hardness determinations.

Concurrent with the reduction of the above stated water quality parameters was an observed change in the aquatic insect population. The population of aquatic insects increased between 1968 and 1969 and remained high throughout the remainder of the study. Such strongly suggests that the chemical changes in the river, following the waste water treatment of the industrial discharge in British Columbia, had a beneficial effect on the insect population.

Concentrations of trace elements monitored in the river were low or within the range characteristic of natural waters except Zn, Ba, and Sr. Only Zn, however, was observed in concentrations which may have, at times, exerted sublethal effects on aquatic organisms in the river.

The high F concentrations observed during the early part of the study were of concern as the concentration approached and, at times, exceeded, particularly at low flow, the level considered to be toxic to aquatic life (McKee and Wolf, 1963). As stated above, the F concentration significantly decreased after 1968.

Ammonia concentrations observed in the river were often very high; levels as high as 0.93 mg/l were observed. The mean level at the upstream border station was 11 mg/l. The high observed concentrations of NH_3 indicate that NH_3 toxicity may have been a problem in the upper reaches of the river. The high pH of the Kootenai River would have tended to increase the toxicity of ammonia.

Na and Cl concentrations increased during the study period. While the reason for the increase is not entirely clear, increases in industrial and domestic wastes are suspect.

Concentration of P in the Kootenai River as it entered the United States was high; particularly high in 1967 and 1968. Mean Ortho-P concentration for 1967, 1968, 1969, 1970, and 1971 was 0.52, 0.42, 0.08, 0.12, and 0.06 mg/l, respectively. Total P was not monitored at the upstream border station until mid-1969; the mean concentration for 1969-1971 ranged from 0.18 to 0.21 mg/l. The high P concentrations in the river are attributable to the waste discharges of a fertilizer plant to the St. Mary River in British Columbia (Northcote, 1972, 1973). Despite the waste water controls of the fertilizer industry in 1968, the levels in the river remained high.

Lower mean total and Ortho-P concentrations were characteristic of the downstream stations as the result of dilution from low P runoff waters to the river, to a loss of P by sedimentation processes, and to uptake by aquatic organisms.

Ortho-P loading of the Kootenai River entering the United States is estimated to have been in excess of 3,000 metric tons/year in 1968, declining to around 785 metric tons/year for the remainder of the study period. Northcote (1973) indicates that the PO_4-P loading of the Kootenai River below the confluence to the St. Mary River has approached 1,000 metric tons/annum since the 1960's. Total P loading for 1970 and 1971 is estimated to have been in the order of 2,000 metric tons/year.

Total N concentrations of the Kootenai River entering the United States were high. The mean for September 1969 through March 1972 was 0.41 mg/l. On the average, organic -N, NO_3-N, NO_2-N, and NH_3-N was 34, 38, 2, and 26 percent of total N, respectively. Upon leaving the United States, the percent of total N in the river that was organic increased to 39 percent, while the percent that was NO_3-N and NH_3-N decreased to 36 and to 23 percent, respectively.

The N loading of the Kootenai River entering the United States is estimated to have been in excess of 3,000 metric tons/year for 1970 and 1971.

Concern for the development of eutrophic conditions in the reservoir (Lake Koocanusa) formed by impoundment of the Kootenai River by Libby Dam, as a result of high P concentrations and loading in the river, has been expressed since initiation of the preimpoundment study. According to the best available guidelins on permissible P loading for lakes (Vollenweider, 1968; 1973), Lake Koocanusa will be receiving sufficient P to place it well into the category of eutrophic lakes if the P loading of the Kootenai River remains consistent with that found for 1969-1972. The annual P loading expressed per unit lake surface area would be in the order of 10 g/m^2; the estimate being based on a conservative estimate of total P loading, 1,500 metric tons/yr, and an average lake elevation of 738 meters (2,420 ft) with an average surface area of 1.5×10^8 m^2 (3.75×10^3 acres). For a lake with the mean depth (43 m (113 ft)) and retention time (0.5 yr) expected for Lake Koocanusa, the "permissible" and "dangerous" P loading level in regard to eutrophication given by Vollenweider (1973) is 1.0 and 2.0 g/m^2 yr, respectively. The total P loading estimated for Lake Koocanusa will be an order of magnitude greater than the "permissible" guideline presented by Vollenweider and the dissolved P loading will be approximately 4 times the guideline for "permissible" loading in respect to eutrophication. The dissolved portion would provide an immediate source of P for algal growth.

The critical concentration of N in a lake at the beginning of the growing season above which excessive algae blooms may be expected to occur is 0.2-0.3 mg/l when P concentrations are from 0.01 to 0.02 mg/l (Sawyer, 1947; Mackenthun, 1965; Vollenweider, 1968). The mean N concentration of the Kootenai River upon entry into the United States was 0.41 mg/l while the P concentration was on order of magnitude greater than the critical 0.02 mg/l value. The "permissible" and "dangerous" N loading level in respect to potential development of eutrophic conditions for a lake with the mean depth expected for Lake Koocanusa is predicted at 4 g/m^2 yr and 8 g/m^2 yr, respectively (Vollenweider, 1968). The estimated loading to Lake Koocanusa, based on river loading for the study period, is 20 g/m^2 yr, of which about two-thirds is inorganic N.

Although the exact biological response of a lake to nutrient enrichment is exceedingly difficult to determine, the state of the art does allow statements regarding a lake if it is threatened. It is noteworthy that Vollenweider's loading criteria in relation to development of eutrophic conditions in a lake are in excellent agreement with limnological experience. Lake Koocanusa can be expected to develop eutrophic conditions, particularly nuisance algae blooms, if P and N loading remains consistent with that found during this study.

The high nutrient content of the Kootenai River has resulted in eutrophic conditions developing in Kootenay Lake. The principal inflow to Kootenay Lake is the Kootenai River and, according to Northcote (1972, 1973), the accelerated eutrophication of Kootenay Lake is attributable to the single industrial outfall on the St. Mary River which is the major source of P in the Kootenai River. Northcote reports that the biological changes that have occurred in Kootenay Lake since the industry began to discharge to the St. Mary River have been increased algae abundance with extensive blooms occurring in some years and localized blooms on others. The extensive algae blooms have been reported to impart offensive odor and taste to the water and to fish.

The effect of dam construction on the river water quality appeared to be limited to increases in suspended sediment and turbidity. During the study period, the increase in suspended sediment between the sampling stations upstream and downstream of the dam site averaged around 10 percent. For short periods of time, considerable increases in suspended sediment did occur, however, particularly during the periods of high discharge in 1968 and 1969. The two major events which led to large increases in suspended sediment and turbidity were the river diversions for the first and second stage cofferdam construction.

The aquatic insect population for 14.5 km (9 miles) below the Libby Dam site was found to be smaller than the population above the dam site. The supression of the insect population below the dam is attributed to the increase in suspended sediment caused by construction activities related to the Libby Dam Project.

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