D. Buxton

Interim Report (1975)

ENVIRONMENTAL STUDIES ON THE MORICE-NANIKA WATERSHED

presented by

Fisheries Service

Department of the Environment
Vancouver, B. C.

INTRODUCTION

B. C. Hydro has proposed developing various resources for meeting future electric power requirements of the province. The main resources included are: hydro-electric power, coal, oil, natural gas, wood waste and geo-thermal power. Prior to any development an extensive program of environmental and engineering studies was recommended to evaluate the feasibility of developing various resources, such as the Kemano II Project. Both B. C. Hydro and the provincial government guaranteed that the results of all environmental studies related to the proposed power project be made available to the public and that no decisions be taken to proceed with any project before all interested groups have had an opportunity to present their view points. Discussions with B. C. Hydro and concerned government agencies in 1973 dealing with potential environmental impacts from the Kemano II Project resulted in the Federal Fisheries and Marine Service developing and carrying out a comprehensive environmental study program. In addition, the provincial Fish and Wildlife Branch and the International Pacific Salmon Fisheries Commission conducted comparable studies. The following report is a presentation of the results obtained in the study of the Nanika River-Morice River-Morice Lake systems (Figure 1). Each system will be presented individually and discussed accordingly in terms of the proposed Kemano II power development.

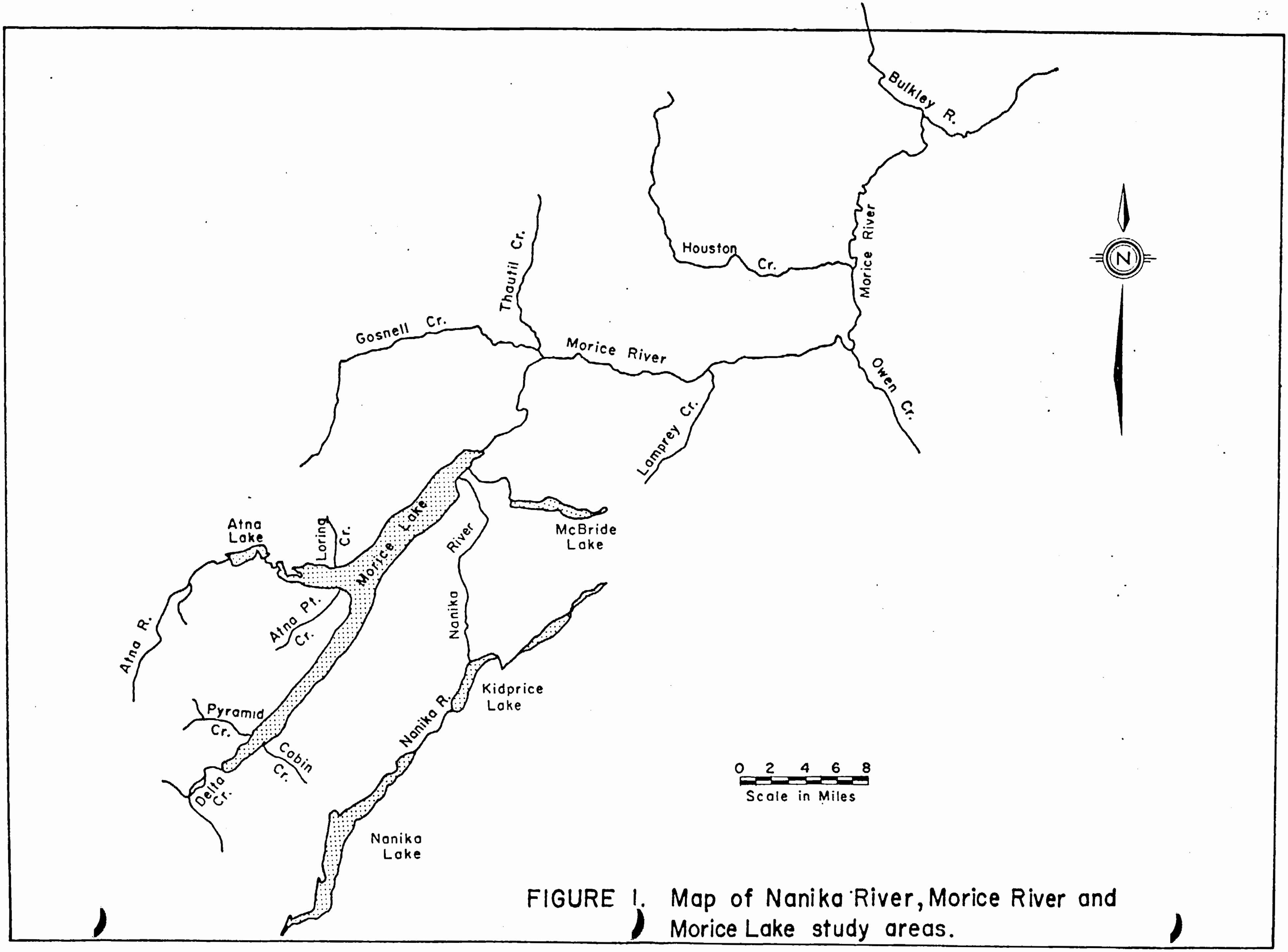


FIGURE 1. Map of Nanika River, Morice River and Morice Lake study areas.

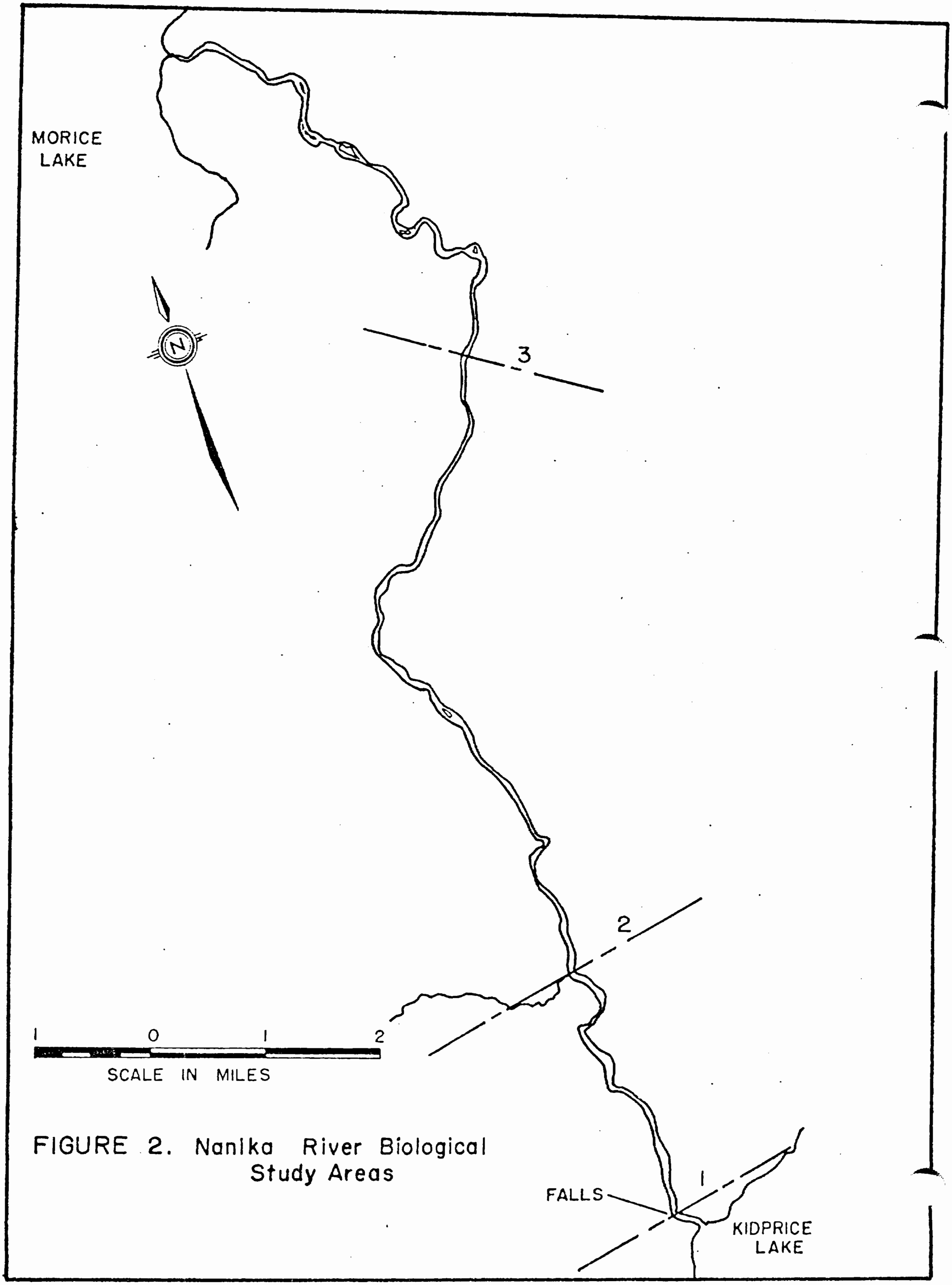


FIGURE 2. Nanika River Biological Study Areas

STUDIES ON THE NANIKA RIVER SYSTEM

The Nanika River (Figure 2) arising in Kidprice Lake and flowing in a northerly direction actually provides the final outlet to other moderately large bodies of water--Stepp and Nanika Lakes. This chain, in which Kidprice is centrally located, lies in a valley on the other side of a mountain range from Morice Lake about eight miles to the southeast. On the Nanika, immediately below its point of outflow from Kidprice Lake are falls forty feet in height which completely block the movement of salmon upstream. As part of the Kemano II Development proposal, B. C. Hydro has proposed a 155 foot high rock filled dam located about one-half mile below the outlet of Kidprice Lake. The project would consist of a gated low-level outlet and an unlined tunnel from the south end of Nanika reservoir to Nechako reservoir. The proposed 13-foot water supply tunnel would have a gated intake and a free discharge outlet at Tahtsa Lake in the Nechako reservoir.

Several basic concerns were voiced by Fisheries Service based on the proposed Nanika diversion. One concern was the flow requirement during spawning for the various salmonid species. In an interim report prepared by Fisheries Service in November, 1971, flow requirements during spawning were estimated as 800 cfs for a six week period. Recent concern is that the discharge period may not be long enough. In order to simulate natural flows during this period, it seems preferable to have a discharge ranging from 600 to 1000 cfs over a longer period. The reason for the extension is that chinook salmon enter this system in early August along with sockeye, while coho enter in late October, thus covering a span of at least 12 weeks duration. Consequently, a study was conducted to determine the timing, distribution and abundance of each salmon species throughout the entire Nanika River. This information would provide a means of determining the exact flow requirements for the system. Another concern was that adequate flow is required for incubation of eggs during winter months. In this regard, it is necessary to prevent ice from penetrating into the gravel and to provide sufficient inter-gravel flow to meet oxygen demands and to remove waste products from incubating eggs. It was considered that a discharge of 150 cfs would be necessary to meet these requirements. Conversely, reduced discharge in the summer months could result in high water temperatures which could be lethal to rearing juveniles and adult spawners. Consequently, a study was conducted to determine the temperature regime on Nanika and Kidprice Lakes to provide information necessary to indicate the temperature constraints that must be adhered to in the system. Another concern was the probable loss of juvenile chinook and coho rearing areas in the Nanika River in the event of the Nanika diversion. Studies were conducted to determine where and when chinook and coho rear in the Nanika River. These studies involved determining distribution patterns, rearing times and emigration timing. The intent of the above mentioned studies was to indicate the effect on the fisheries resource of the proposed hydro development.

Study Area and Sampling Sites

The study area on the Nanika River includes the entire river below Nanika River Falls to the confluence of the Nanika with Morice Lake. For study purposes, the river was arbitrarily divided into three sampling areas as shown in Figure 2. Sample Area 1 includes the area immediately downstream of Nanika Falls to Glacier Creek, a distance covering approximately four miles. Sample Area 2 is located between Glacier Creek and an old highway bridge approximately eight miles downstream of Glacier Creek. The third Study Area is located between the highway bridge and Morice Lake, a distance spanning approximately two and one-half miles. Study Area 1 was by far the largest single spawning area within the Nanika system and received the greatest study effort, in relation to the remaining areas.

Water Hydrology on the Nanika River System

The Bulkley River drainage basin overall can be divided into two major physiographic components: the interior plateau region which takes in most of the 4740 square miles of the drainage area and the coast mountains bordering the western boundary of the basin. The Morice-Nanika watershed is divided in the southwest portion of the Bulkley River drainage basin, draining a portion of the Tahtsa range of the coast mountains. The watershed ranges in elevation from 2600 to 7200 feet above sea level and is extensively glaciated. Approximately 15 percent of the entire Bulkley River drainage area occurs above the outlet of Morice Lake.

Nanika, Kidprice and Morice Lakes provide almost all of the lake storage in the Bulkley River system.

Climate records by the B. C. Department of Agriculture indicate that the mean annual precipitation is relatively uniform over the plateau areas with approximately 12 inches of rainfall and 75 inches of snowfall. Precipitation is much more intense in the coast mountains as indicated by the weather station near Tahtsa Lake. There, the mean annual precipitation is 78 inches which includes 36 inches of rainfall and 42 inches of snowfall.

D·scharge recording stations have been operated on the Nanika River for a number of years by the Inland Waters Directorate of the Department of the Environment. The single station located at the outlet of Kidprice Lake has been in operation since June, 1972 A seasonal recording gauge was also operated by the Aluminum Company of Canada on the Nanika River at the outlet of Kidprice Lake between 1950 and 1972. However, the daily discharge data provided by Alcan for the latter part of 1972 is substantially lower than recorded by Inland Waters. On September 24, 1971, a discharge of 751 cfs was measured by the Fisheries and Marine Service in the Nanika River a short distance below Kidprice Lake. The Alcan records indicate a discharge of 385 cfs on that date. With a large discrepancy occurring between the two sets of data, it seemed appropriate to conclude that data presented by Alcan is unreliable and was disregarded in this report.

Hydrographs of mean monthly discharge for the recording station operated on the Nanika, Morice and Bulkley Rivers are presented in Figure 3. The discharge pattern is seen to be relatively typical from year to year with peak flows occurring during the spring run-off period. A secondary freshet normally occurs prior to freeze-up. The quantity of water which the drainage area above the outlet of Morice Lake contributes to the Bulkley River varies throughout the year as shown on Figure 4. During the spring runoff, when other areas in the drainage basin are contributing a high rate of discharge from snow-melt, the Morice watershed can represent as little as 16 percent of the discharge at Quick. This is largely due to the storage capacity of Nanika, Kidprice and Morice Lakes.

Over the period 1962 to 1973 inclusive, the mean annual discharge out of Morice Lake averaged 2744 cfs. The drainage area above this station is 722 square miles resulting in a long term average unit discharge of 3.76 cfs per square mile. The Bulkley River at Quick, with an upstream drainage area of 2800 square miles, averaged 4971 cfs during this same period. Excluding the Morice Lake drainage area and discharge from these figures, the average unit discharge for the remainder of the drainage area above Quick is therefore 1.08 cfs per square mile. It is noted that the ratio of the above unit discharges compares reasonably well with the ratio of the mean annual precipitation at Tahtsa Lake in Smithers.

A reduction in discharges throughout the Bulkley River

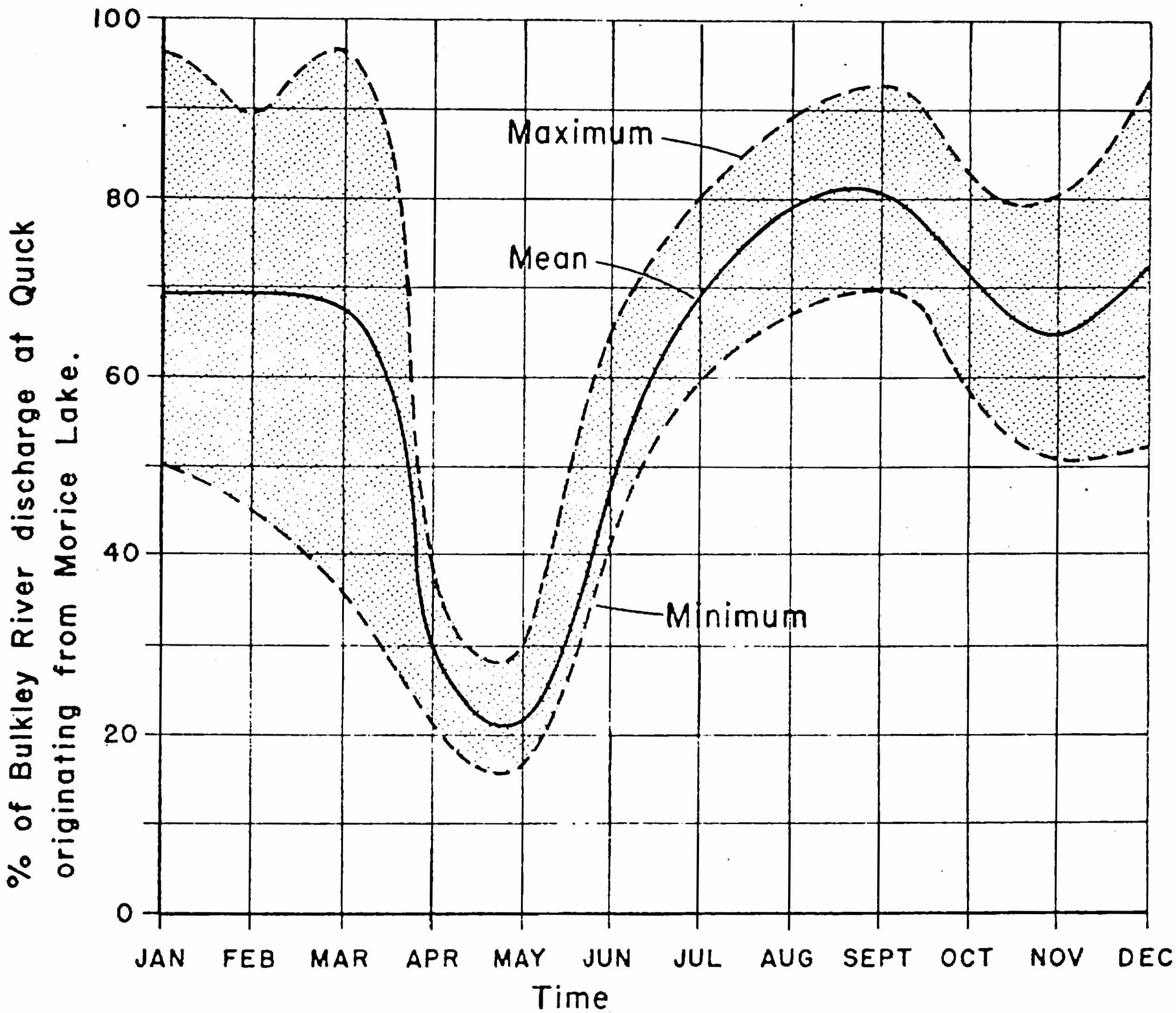


FIGURE 4. Relationship between Bulkley River discharge at Quick, B.C. originating from Morice Lake, and time. (based on mean monthly discharges between January, 1972 and December, 1973).

as the result of diversion of water from the Morice River can be determined simply by deducting the quantity of the diversion. However, the effect on discharges in the Morice and Bulkley Rivers as result of diversion of the Nanika River is complicated by the storage potential of Morice Lake. The system was therefore analyzed by computer to illustrate the effect of the Nanika diversion on daily discharges at recording stations on the Morice River and Bulkley River at Quick. The analysis was carried out for the period July 1, 1972 to September 30, 1974. It was assumed for illustrative purposes only that annual residual flows in the Nanika River would be in accordance with the preliminary minimum flow requirements recommended in the Fisheries and Marine Service report of November, 1971 as follows: May 15 to May 30 - 2000 cfs, August 1 to September 15 - 800 cfs, and remainder of year - 150 cfs. The results are shown on Figure 3 together with natural flows which occurred during the period

Diversion of the Nanika River would also alter the natural water level regime in Morice Lake. The computer analysis (Figure 3) indicates during spawning,the lake levels are reduced to the extent of possibly limiting access to Morice Lake tributaries. In addition, reduced levels will undoubtedly reduce rearing capacities both in the lake and tributary streams.

Hydrographical Studies on the Nanika River

Various hydrographical studies have been carried out since 1971 by the Fisheries and Marine Service on the primary spawning grounds of the Nanika and Morice Rivers. The purpose of the studies was to document hydraulic conditions within the primary spawning grounds under the natural flow regime and to obtain enough information on the physical nature of the river to allow hydraulic conditions to be determined under any reduced flow. This information in conjunction with biological studies conducted in the area forms the basis for assessing the minimum flows necessary to sustain fish populations in the river.

The lower Nanika River between Kidprice and Morice Lakes is approximately 14 miles in length and drops some 400 feet in elevation. Immediately below the outlet of Kidprice Lake, the river flows over Nanika Falls and is the upstream limit of all anadromous fish stocks. Practically all spawning in the Nanika River system occurs within the three miles of river below Nanika Falls (Figure 5). Over approximately the first mile downstream from the falls, the river is very turbulent and is comprised of a series of rapids, low waterfalls and interconnecting pools. Although this reach is not generally considered as being a highly productive spawning area, it does contain several small pockets of suitable spawning gravel. Over the next one-quarter mile, the flow becomes quite laminar as the river widens over a relatively shallow and flat-bottomed riverbed. This reach is the most productive spawning ground within the Nanika River and contains approximately 80 percent of the total available area within the system. For approximately the next one-quarter mile, the river flows through a wide and deep pool containing no suitable spawning gravel. Immediately downstream from this pool, however, the channel again narrows, but the flow remains relatively laminar. This channel contains some excellent spawning gravel adjacent to the right bank. Except for some minor spawning occurring slightly downstream of the oxbow bend, this forms the lower limit of the spawning area. Between this point and Morice Lake, the river generally flows in a single channel although it becomes quite anastomosing or multi-channelled throughout the lower few miles. Of the several sockeye salmon spawning areas located in the upper three miles of the river, only two major ones were studies in detail. These particular areas are located in Study Area 1 as described earlier. It is considered that the information collected in this study area should apply to the other spawning areas in the Nanika River. For the purposes of clarity within the report, the specific sites within Study Area 1 will be termed Area A and Area B.

Spawning Area A represents the largest single spawning area within the system, and it was therefore studied in the greatest detail. It contains approximately 20,000 square yards of suitable spawning gravel distributed over a length of approximately one-quarter mile. Spawning occurs within a relatively deep channel over a width of approximately 160 feet. Outside this channel, the

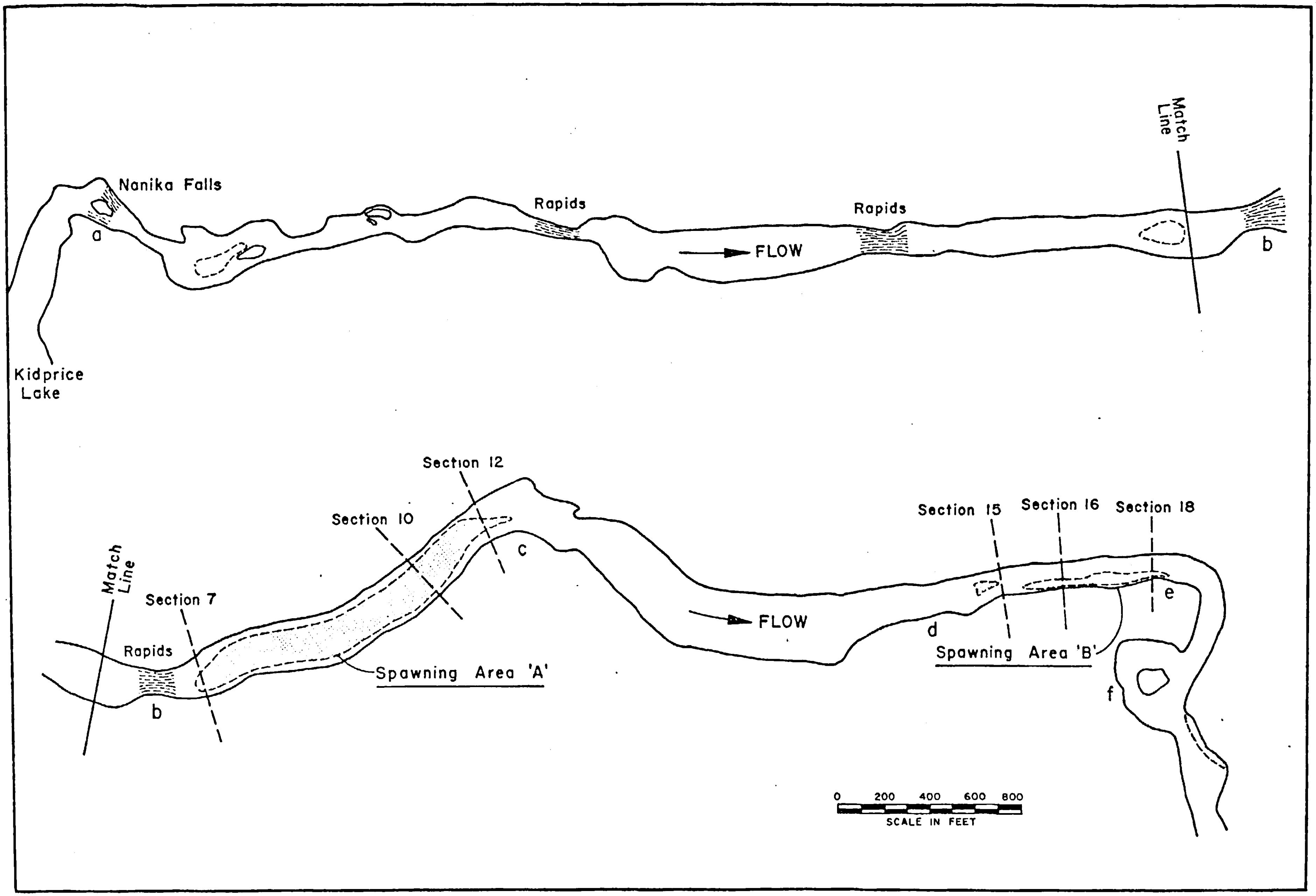


FIGURE 5. Location map of Upper Nanika River below Kidprice Lake, showing location of study areas and spawning ground.

riverbed and banks are very silty and therefore unsuitable for spawning. The depth of water over the spawning gravel is deeper and the water velocities are generally much lower than found in most sockeye spawning areas. However, a substantial depth of water also occurs over the entire spawning area during low winter discharges and as a result the spawn is not subject to dewatering or freezing during the incubation period. For this reason it is considered that survival rates in this spawning area are relatively high.

In order to assess the velocity, depth of water and available spawning area relative to discharge, six cross sections were established within the study area and monitored at discharges of 155, 830 and 2000 cfs. Cross section 10 was found to be representative of the general flow conditions throughout the study area and was therefore used to establish an overall discharge rating curve (Figure 6). This rating curve was assumed to apply over the entire study area because of the very low water surface gradient encountered. Water surface elevations were then selected from the rating curve for nine different discharges and using each of these elevations as datum points, the surveyed riverbed contours were measured by planimeter to determine the percent of the total spawning area covered by less than a specified depth of water (Figure 7). For example, if it is considered that any gravel covered by one foot of water or less is unsuitable for spawning, then the loss of spawning gravel at 830 cfs will be zero percent; at 500 cfs it will

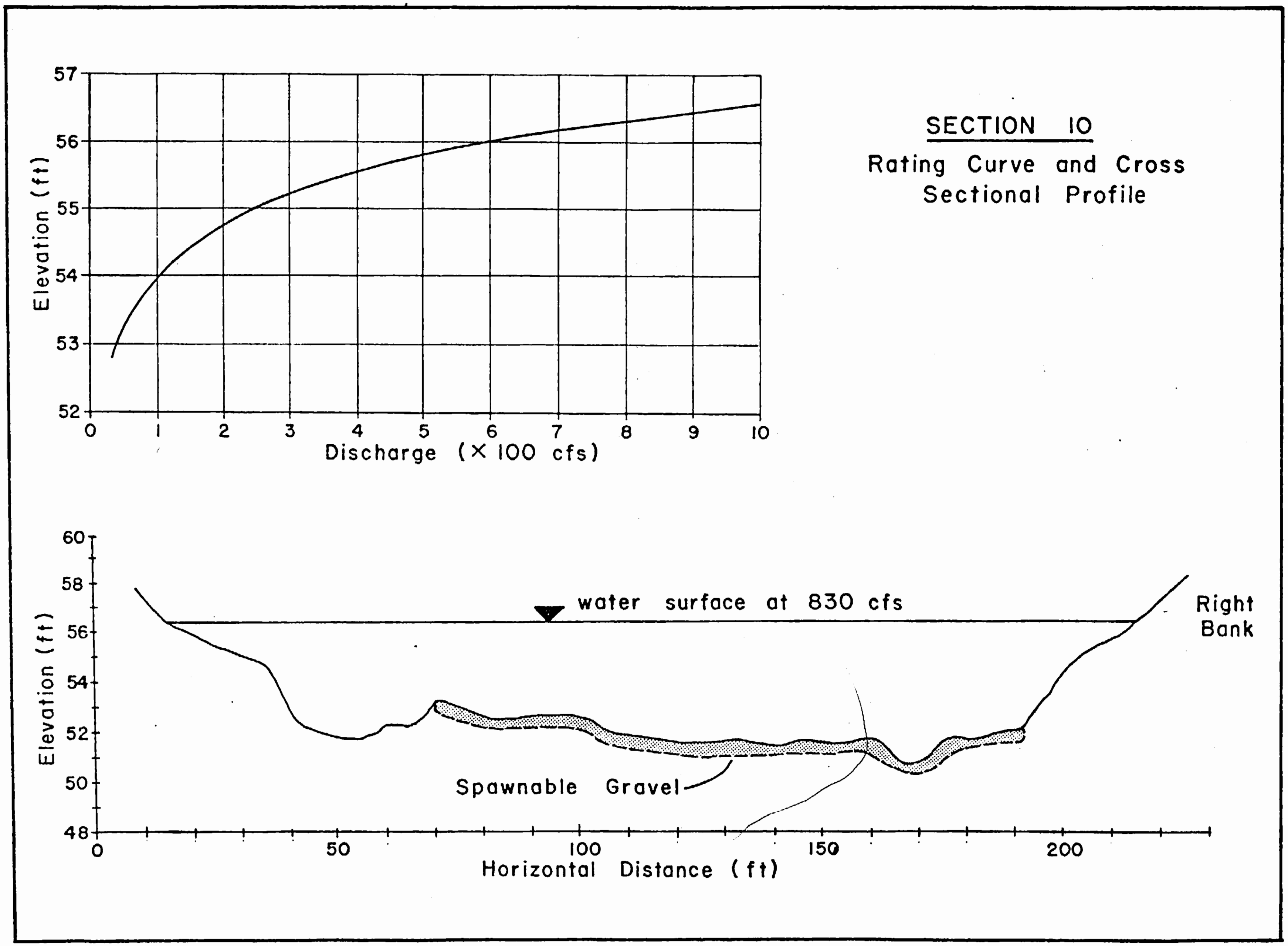


FIGURE 6. Rating curve and cross-sectional profile for Section 10.

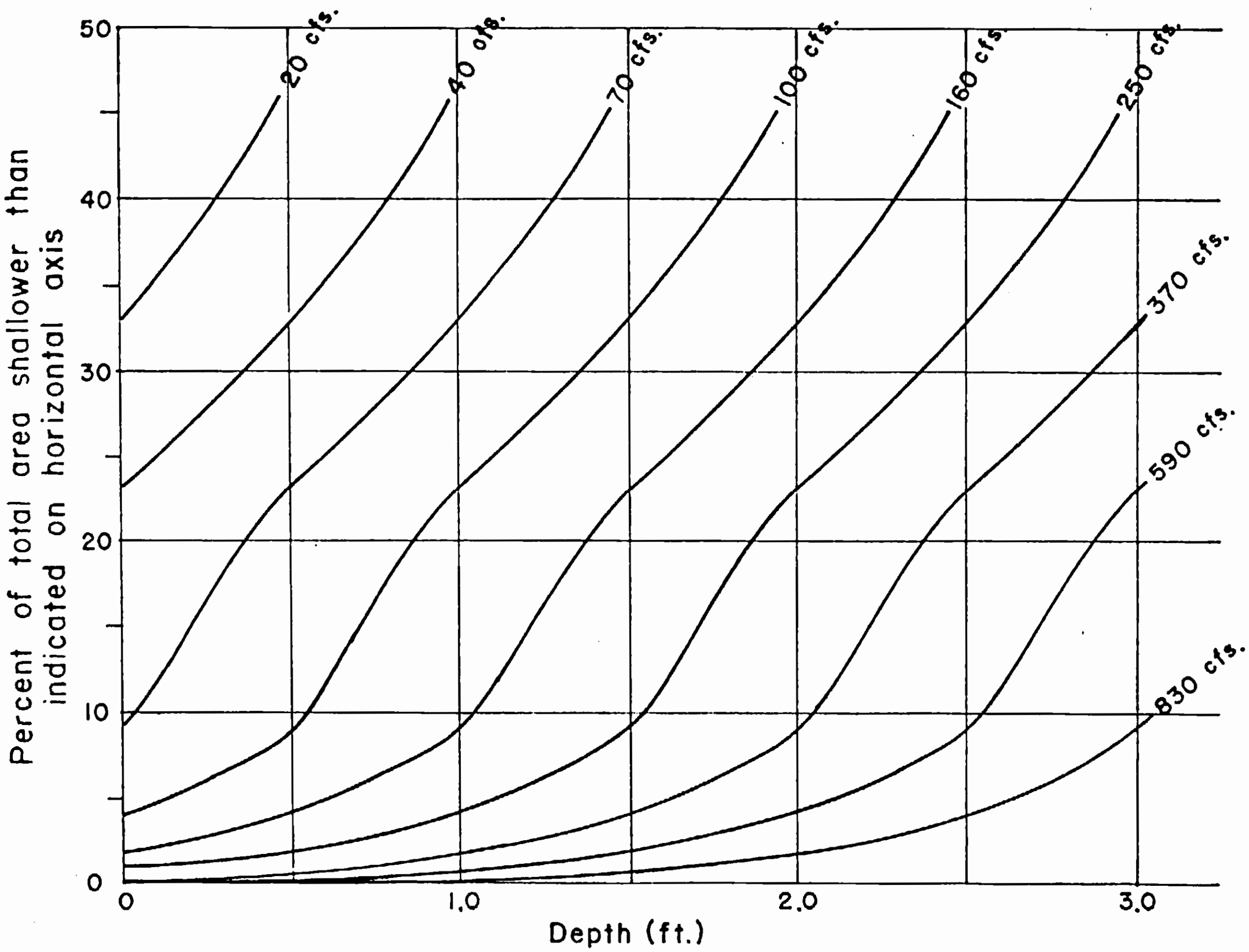


FIGURE 7. Relationship between spawnable area and depth of water for various discharges

be 2 percent; at 100 cfs it will be 23 percent, etc.

A survey was conducted during September, 1973, while spawning was actually in progress. Discharges during the survey ranged between 750 and 830 cfs. Velocities were metered on cross section 10 at regular intervals across the width of the channel at depths above the riverbed of 0.4 feet and 0.4 times the depth of the water column. Using this data in conjunction with mean velocity measurements obtained at lower discharges, a discharge velocity relationship was established as shown on Figure 8. It is seen from this draft that the mean nose velocity (0.4 feet above the riverbed) at 830 cfs is 0.81 gps while the mean river velocity is 1.1 feet per second. At a discharge of 150 cfs, the mean nose velocity and river velocity are 0.3 fps and 0.4 fps respectively. To establish the preferred nose velocities, meterings were taken at numerous points throughout the spawning ground where salmon redds were being actively occupied. The velocities recorded ranged between 0.41 fps and 1.23 fps with a distribution as shown on Table I. It is noted that the average nose velocity is 0.81 fps which is identical with that recorded at cross section 10 at 830 cfs.

As mentioned earlier, the discrepancy existed between the Alcan and the Inland Water discharge data from the Nanika River. On the basis of Alcan data, the discharge of 830 cfs under which measurements were taken to establish preferred conditions seemed to be reasonably close to the long term mean monthly discharge for September. However, when the Inland Waters data became available,

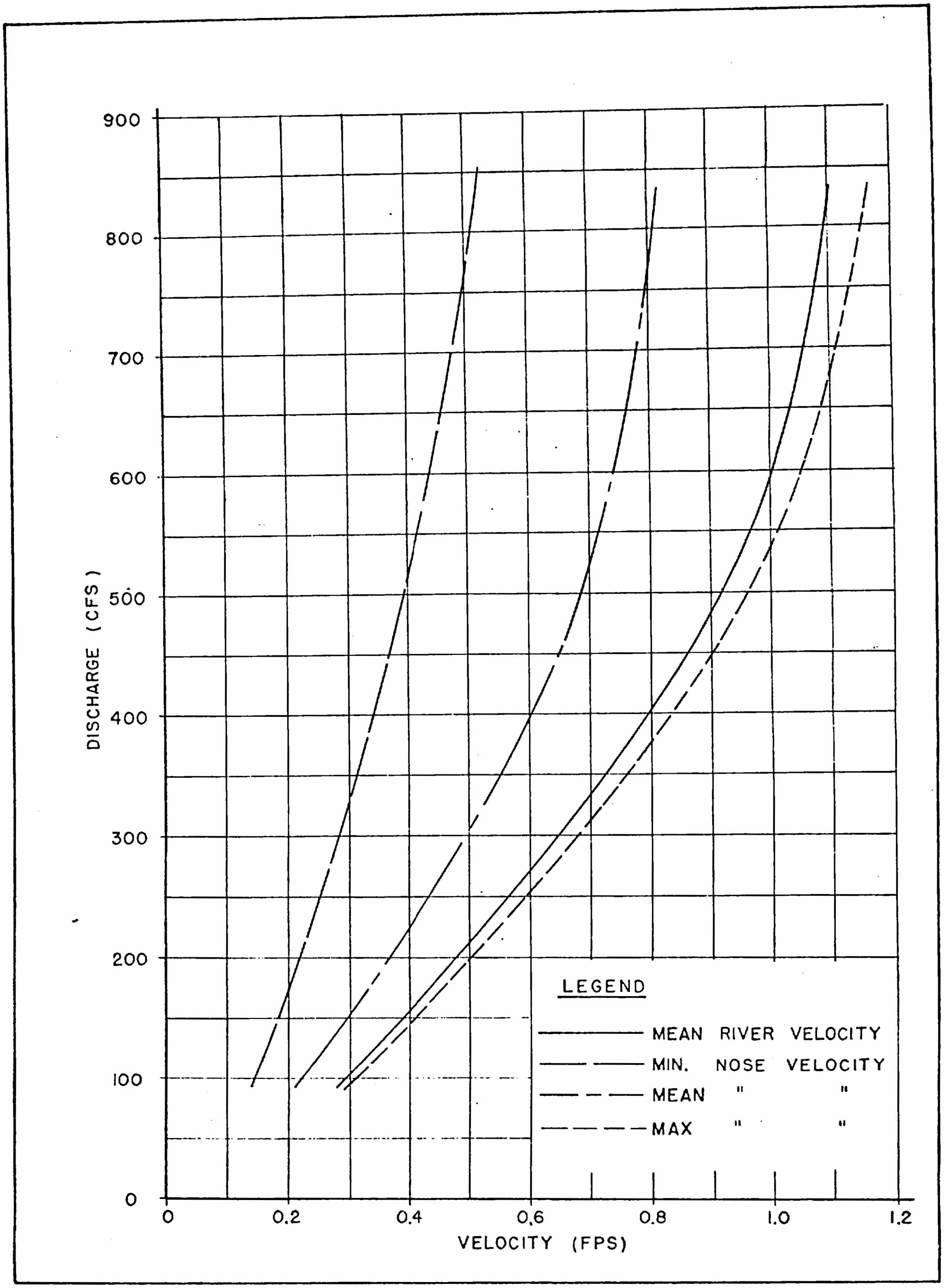


FIGURE 8. Relationship between nose and mean river velocities and discharge at Section 10.

TABLE I. Water velocities recorded at points on the spawning ground wh salmon redds were being occupied.

VELOCITY RANGE (fps)	NO. OF READINGS
0.2 - 0.4	0
0.4 - 0.6	2
0.6 - 0.8	5
0.8 - 1.0	2
1.0 - 1.2	3
1.2 - 1.4	1
1.4 - 1.6	0

The average nose velocity is 0.82 fps which is almost identical to that recorded at Section 10 at 830 cfs.

it was found that 830 cfs is actually well below the mean monthly average. For the purpose of this report, it can be therefore concluded that the information on depth, velocity and discharge referred to above, are more representative of the absolute minimum conditions which would normally occur during the spawning period.

Spawning Area B, located in Study Area 1, is much smaller and consists of approximately 2100 square yards of spawnable gravel. It is also quite different from Area A, in that it is located adjacent to the right bank rather than across the width of the channel. This situation is more critical with respect to spawning and incubation as the gravel becomes dewatered with reduced discharge.

Cross sections 15 to 18 inclusive, were established within this spawning area and monitored under various discharges. Cross section 16 was found to be representative of general flow conditions throughout the area and was therefore used to determine the relationship between discharge and available spawning area. The cross section and its discharge rating curve are shown in Figure 9. Using this rating curve and the contours of the riverbed, the percent of the total normal spawning area covered by less than a specified depth of water was computed and illustrated (Figure 10). Assuming that a 1.0 foot depth of water is the minimum required for spawning, then the loss of available spawning gravel at 830 cfs is 22 percent and the loss at 160 cfs is 90 percent. This represents a significant loss to potential production from the river in the areas characterized by near-shore spawning. Conversely, in years of low production or low spawning, the probability of spawners spawning in areas of this nature would be very low. Therefore, any reduction in flows would probably have little effect on total productivity of the river on a given year. However, from the opposite approach when populations are extremely large, these areas would contribute nothing to the total production that would be realized in subsequent years if low flows occurred during spawning.

An aerial surveillance of potential low flow obstructions between Morice Lake and Nanika Falls was carried out in 1971 to determine whether a reduction in Nanika River flows would create obstacles to upstream migration of spawning salmon adults. The river discharge at this time was 155 cfs. The results indicated that although several falls and rapids were observed, no major obstacles could be seen that would present any problem to migrating salmon. It was not established, however, at what discharge below 155 cfs the river would become impassable.

Adult Population Studies in the Nanika River

Sockeye spawning in the Nanika River is restricted primarily to the area lying within Study Area 1 which is located between Glacier Creek and Kidprice Lake. Data accumulated since 1959 by the Fisheries and Marine Service indicate that the timing and abundance of sockeye spawners in the Nanika River varies from year to year (Table II). For example, in 1959 sockeye spawning

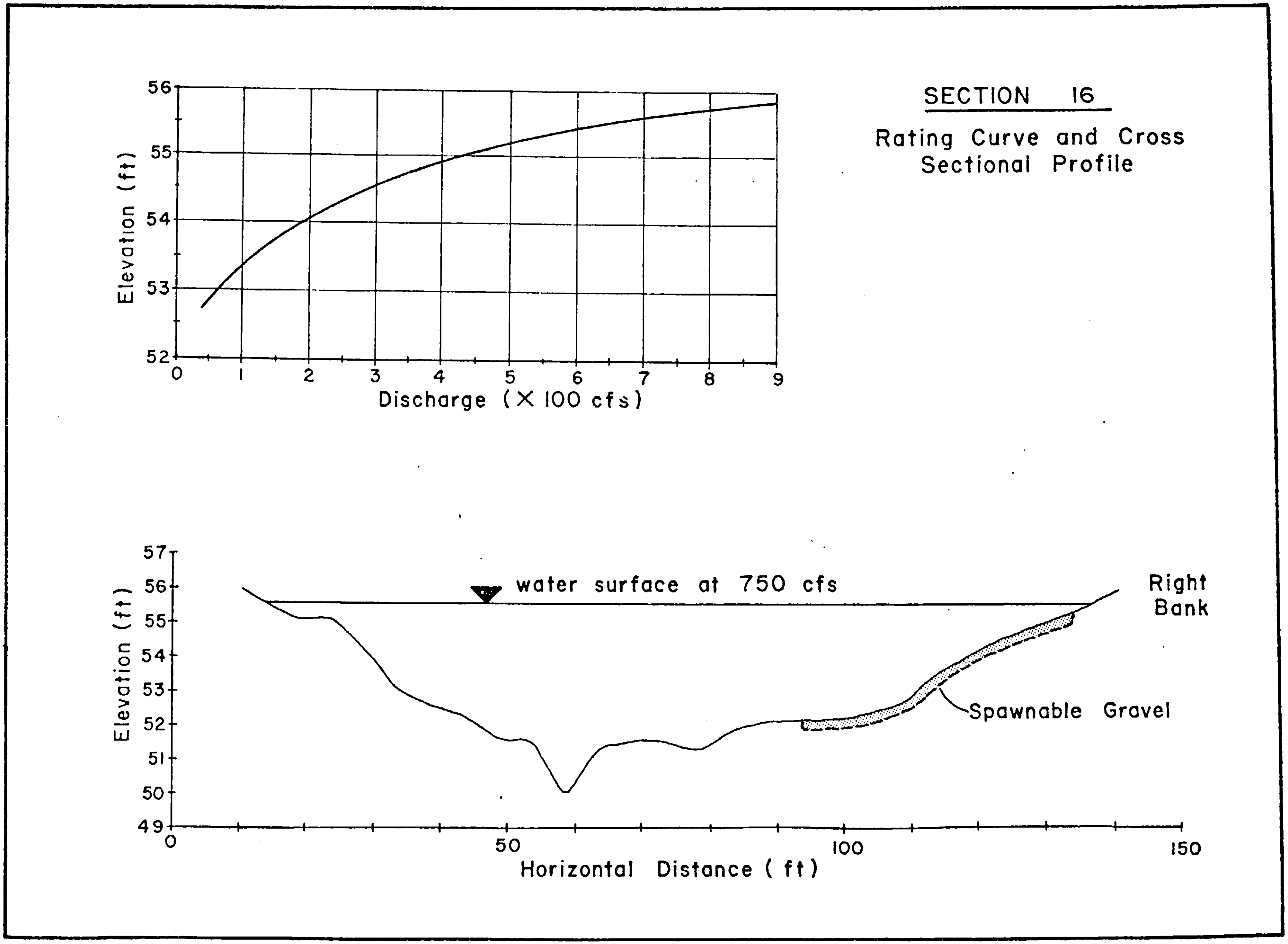


FIGURE 9 . Rating curve and cross-sectional profile for Section 16.

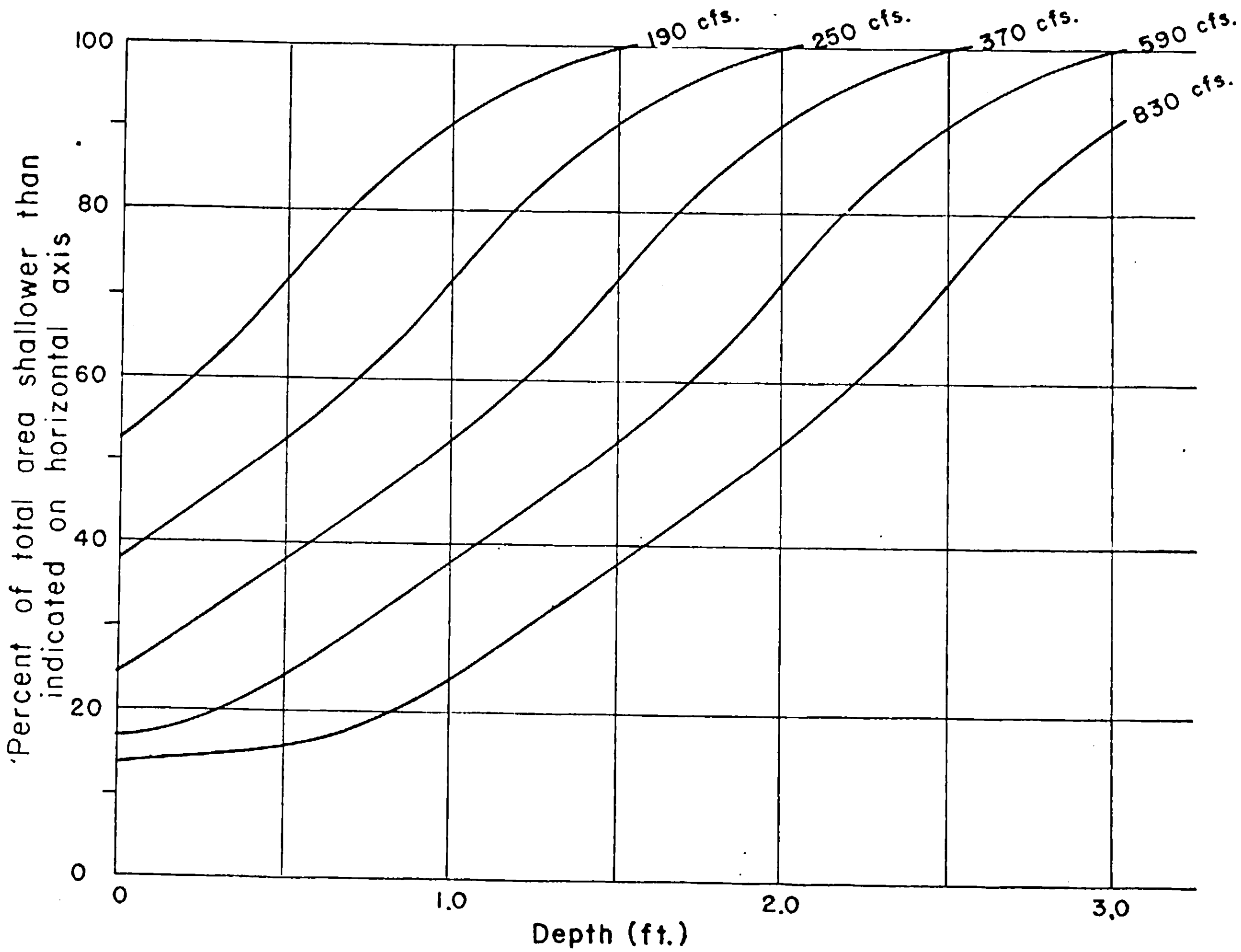


FIGURE 10. Relationship between spawnable area and depth of water for various discharges.

TABLE II. Annual salmon escapements to the Nanika River.

Year	Sockeye				Chinook				Coho			
		Start	Peak	End		Start	Peak	End		Start	Peak	End
1974	1200				200							
1973	1000				400				400			
1972	1139	Aug.	Aug.	Sept.	400	Aug.	Sept.	Sept.	200	Sept.	Oct.	Oct.
1971	4300	Aug.	Aug.	Sept.	25	Aug.	Sept.	Sept.	300	Sept.	Oct.	Nov.
1970	4700	Aug.	Aug.	Sept.	50				300	Sept.	Oct.	Nov.
1969	3400	Aug.	Aug.	Sept.	50	Aug.	Aug.	Sept.	300	Sept.	Oct.	Oct.
1968	3300	Sept.4	Sept.20	Oct. 10	100	Aug.15	Aug.20	Sept.15	200	Oct. 5	Oct. 20	Oct.30
1967	4100	Aug.17	Sept. 8	Oct. 16	200	Aug. 1	Sept.15	Oct. 1	300	Oct. 1	Oct. 15	Oct.30
1966	10700	Sept.10	Sept.30	Oct. 15	150	Sept.5	Sept.25	Sept.30	300	Oct. 15	Oct. 31	Nov.15
1965	9700	Sept. 5	Oct. 10	Oct. 31	-				300	Oct. 10	Oct. 31	Nov.15
1964	6000	Aug. 1	Aug. 20	Sept. 7	-				500	Aug. 15	Sept.15	Oct.30
1963	1200	Sept.10	Sept.30	Oct. 15	-				400	Sept.25	Oct. 20	Nov.15
1962	3500	Sept.15	Sept.30	Oct. 10	-				500	Sept.30	Oct. 15	Oct.30
1961	7500	Sept.15	Sept.30	Oct. 5	-				-			
1960	3500	Sept.10	Sept.26	Oct. 5	200	Sept.1	Sept.15	Sept.30	-			
1959	1000	Sept.10	Sept.26	Oct. 5	75	Sept.1	Sept.15		25	Sept.19	Oct.	Nov.30
1958	1000				-				-			
1957	1000				-				-			
1956	6000				-				-			
1955	4000				-				-			
1954					-				-			
1953	35000				-				-			
1952					-				-			
1951	58000				-				-			

commenced around September 10 and ended approximately October 5; in 1972, spawning commenced in late August and was complete in mid-September; in 1974, aerial surveys and reconnaissance by boat verified the existence of sockeye spawning in the Nanika beginning in late July and extending through to the middle of October. Annual escapements to the Nanika River have ranged from approximately 10,000 in 1966 to 12,00 in 1974; the latter represents one of the poorer years for sockeye escapement to the Nanika River. However, the data does suggest that low escapement years are almost always followed by years of relatively high escapement.

The migration and spawning of chinook salmon in the Nanika River occurs almost simultaneously with that of sockeye (Table II). Surveys in 1974 indicated that chinook spawning on the ~~Nhaika~~ Nanika River occurs or begins in the latter part of August and proceeds on to the end of September and even to the first part of October. Annual escapements have ranged from 400 in 1973 to a low of 25 in 1971. Again, the major area of chinook spawning in the Nanika is located in the upper study area.

Coho salmon (Table II) also spawn in the Nanika and their distribution is again in the upper portion of the river. Unusually high water conditions in the fall of 1974 created conditions unfavourable for observation of coho in the Nanika River. Consequently, accurate estimates of adult population densities were impossible to attain. Annual escapement records assembled by this Service, indicate that coho normally enter the system in the latter half of September and remain until die-off well into late October or middle November. Annual escapements, which are, at best, poor estimates, do indicate, however that the Nanika River does have a significant coho population in that the average escapement in the last decade has averaged approximately 200 individuals. A high density of 500 adults occurred in 1962 and 1964 and 1973. The lowest escapement ever recorded occurred in 1959 where 25 individuals were observed.

The above study and the results indicate that the Nanika River, although not being a large producer of salmon, still supports discrete populations of chinook, coho and sockeye salmon. Sockeye is by far the largest spawning population in the system while chinook and coho appear rather insignificant. When one compares the Nanika River chinook and coho populations with other populations along the coast, it is evident that present populations in the Nanika River are not beyond that expected, and they remain, and probably will remain, a contributor to the commercial and sports fisheries that occur beyond and within the Skeena system. The results also verify the early concern presented by the Fisheries Service in 1971 that full discharge requirements of 830 cfs must be extended over a longer period of time. In the event that a major hydro development occurs on the Nanika River and since sockeye first appear on the grounds in early August and coho have been observed on the grounds at the end of November, the flow requirements during the spawning should not be less than 800 cfs for a period of 15 weeks rather than the earlier stated six weeks. Any attempt at reducing the length of these requirements would result in obvious mortality of spawners and a resultant lower annual production from the system. Not only would a reduction in water discharge have an effect on the productivity of the system, it would also have some effect on the fishery resource along the the northern Pacific Coast.

Juvenile Chinook-Coho Studies in the Nanika River

Juvenile chinook and coho distribution and rearing patterns within the Nanika River were studied from June 4, 1974 to October 20, 1974. The methods incorporated in the study were beach seining, electro-shocking and fyke net trapping. The study was conducted in the three sample areas mentioned earlier. Most of the sampling effort was restricted to Areas 1 and 3, and based entirely on area access. A comparison among sampling sites within Study Area 3 indicated that most juveniles were captured in areas characterized by marginal slack water one or two feet in depth with marshy vegetation. Throughout the sampling period, significant numbers of chinook and coho were trapped within this area situated within one mile of Morice Lake. The area by its character permits the capture of food with the minimum expenditure of energy. Wherever minimum expenditure of energy occurs and prolific food abundance occurs, high density coho and chinook rearing occurs in nature. Study Area 1 also is characterized by slack water, however, it is relatively insignificant compared to Area 3. Area 1 has deep, large pools while Area 3 has pools which are shallow and expansive. This difference between the areas supports the reason of fewer chinook and coho being captured in Area 1. A possible reason for the lack of fish in Area 2 is that the area is characterized by steep banks, rapids and high water velocities which represents a poor rearing habitat. Not only is the area indicative of maximum expenditure of energy of rearing fish, but it is also a very poor spawning area.

Emigration timing of fish migrating from Nanika River to Morice Lake was difficult to assess accurately because of the lack of study time. Nanika River sockeye fry migrate in early May through to July with a late carry-over into August. The 1974 program was not initiated until early June, consequently, a major portion of the migration occurred prior to commencement of trapping. There is an indication, however, that coho fry on emergence from the gravel remain within the Nanika to feed until the latter part of the summer at which time they begin migrating downstream. Information on chinook fry indicates that they emigrate from Nanika River around the first of August. There is also an indication that the emigration from Nanika River might be based on size limit in that upon reaching the 40 to 45 mm size range, coho fry begin migrating into Morice Lake. Similarly, chinook fry migrate when their length approximates 50 to 55 mm. Examining sockeye age compositions (Table III) indicates that many sockeye remain within the system upon emergence from the gravel for up to two years, thus indicating that extensive rearing occurs in the system. Although the data is

TABLE III. Nanika River Sockeye Age Compositions

Year	3_1	3_2	4_2	4_3	5_2	5_3	6_3	6_4	7_4	
1964	-	-	2	1	16	161	8	-	-	188
%	-	-	1.1	0.5	8.5	85.6	4.3	-	-	100.0%
1965	-	-	11	2	37	115	130	2	-	297
%	-	-	3.7	0.7	12.5	38.7	43.7	0.7	-	100.0%
1966	-	-	3	1	3	186	28	1	-	222
%	-	-	1.4	0.5	1.4	83.8	12.6	.5	-	100.2%
1967	-	-	4	-	3	69	293	9	-	378
%	-	-	1.1	-	0.8	18.3	77.5	2.4	-	100.1%
1968										
%										
1969										
%										
1970	1	16	14	39	48	279	87	1	1	486
%	0.2	3.3	2.9	8.0	9.9	57.4	17.9	0.2	0.2	100.0%
1971	-			-	20	102	312	-	-	434
%	-			-	4.6	23.5	71.9	-	-	100.0%
1972	-	7	56	2	6	48	2	-	-	121
%	-	5.8	46.3	1.7	5.0	39.7	1.7	-	-	100.2%
1973										
%										
1974	-	2	12	36	6	179	19	1	-	255
%	-	0.8	4.7	14.1	2.4	70.2	7.5	0.4	-	100.1%
Total	1	25	102	81	139	1,139	879	14	1	2,381
%	0	1.0	4.3	3.4	5.8	47.8	36.9	0.6	0	99.8%

not available for chinook and coho, it would appear likely that rearing occurs over the same time period for these two species because of the fact that coho spend at least one year in fresh water and 90-day chinook smolts only occur in coastal areas.

The above studies indicate very definitely that the Nanika River represents, at least in the lower sections, a major chinook and coho rearing habitat. Any attempts at reducing the available rearing area by reducing water levels would result in a impoverished habitat with little if any salmonid production. The fact that much of the rearing chinook and coho were located in areas characterized by water depth of one to two feet suggests that a drop in the wetted perimeter of Nanika River of approximately one foot would destroy the productivity of the river as indicated in Figure 11. The effects of low summer flow have been identified wherever there are positive correlations between adult coho production and the minimum summer flow of the river two years previously as reported by Neave and Wicket (1953). Reduction of flow at least reduces the supply of drifting food and their living area; at most it leaves the fish dying in isolated pools.

Flow control has been known to be a promising means of elevating the carrying capacity of a stream. However, a minimum flow must be large enough to maintain the present rearing areas. It is of course necessary to have not merely flow regulation for improved production but appropriate regulation. In the Big Qualicum River on the east coast of Vancouver Island, winter flows have been stabilized (primarily to increase production of chum salmon) and the minimum summer flows have been raised. These measures have apparently increased coho fry production twelve times that under natural flow, but most of the fry are lost at sea and smolt production has shown little variation (Lister and Walker, 1966). Presumably, the carrying capacity of the river has remained unchanged. This capacity, on the basis of present arguments, is determined by the area of shallow, marginal, slack water and shallow riffles. Removing the shallow, marginal areas by reducing the summer flows in the Nanika would totally destroy the chinook and coho productivity of the system if measures were not taken to limit the reduction beyond that which occurs normally.

MORICE LAKE STUDIES

Morice Lake (Figure 12) at an elevation of 2600 feet extends in a southwesterly direction for approximately 30 miles and is almost completely encircled by snow-capped mountains which drop steeply from heights of four to five thousand feet. Only the region and northeast corner around McBride Lake and the mouth of the Nanika River is realtively flat. In the high, deep valleys between the mountains, snow fields and ice bibs provide a reservoir from which numerous streams and waterfalls tumble down pouring cold, silted water into the lake. In most areas of the lake, the water reaches depths of at least 200 feet while on the southern arm and central portion there are large basins over 500 feet in depth.

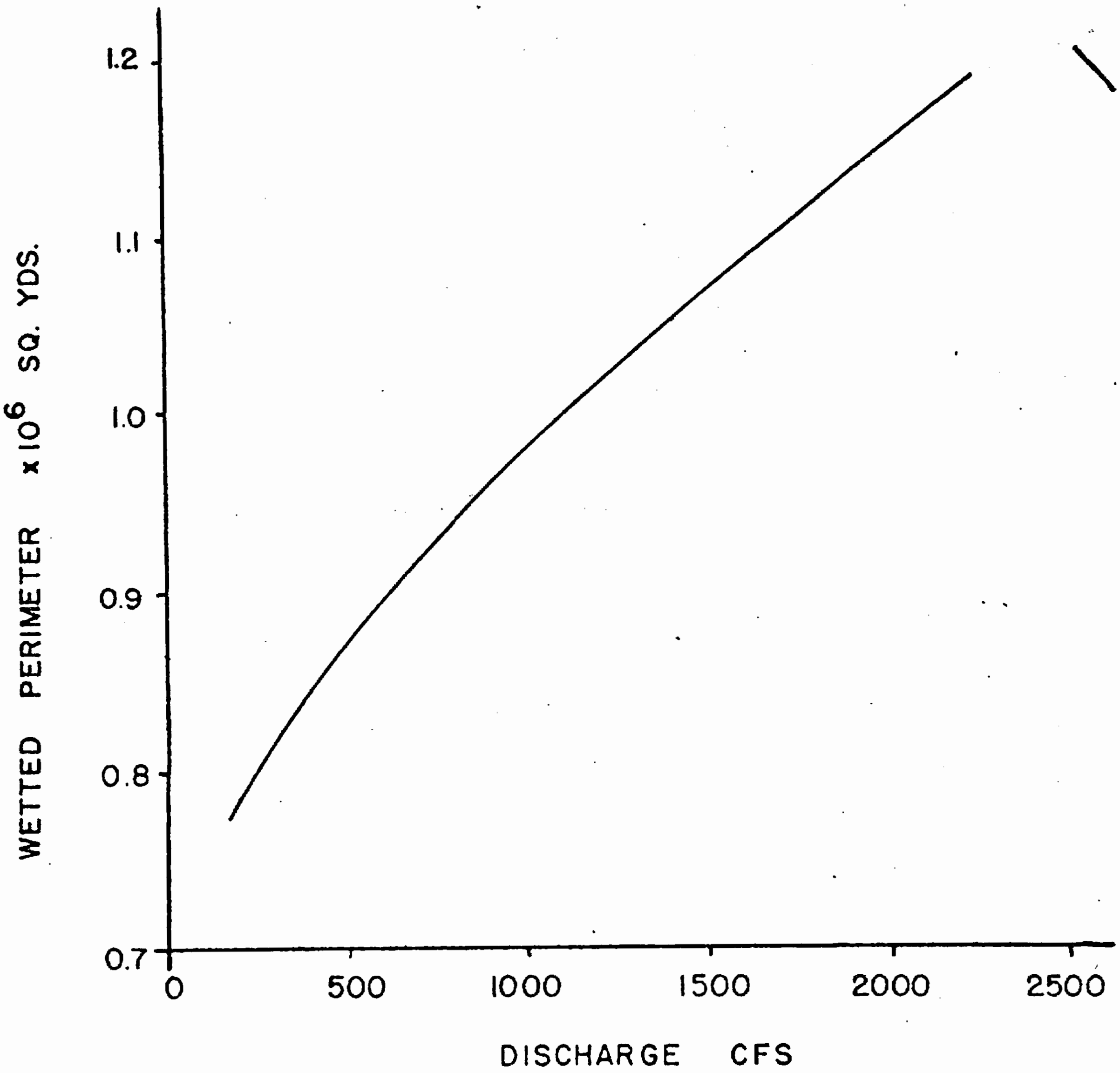


FIGURE 11. Relationship between wetted perimeter and discharge in Nanika River.

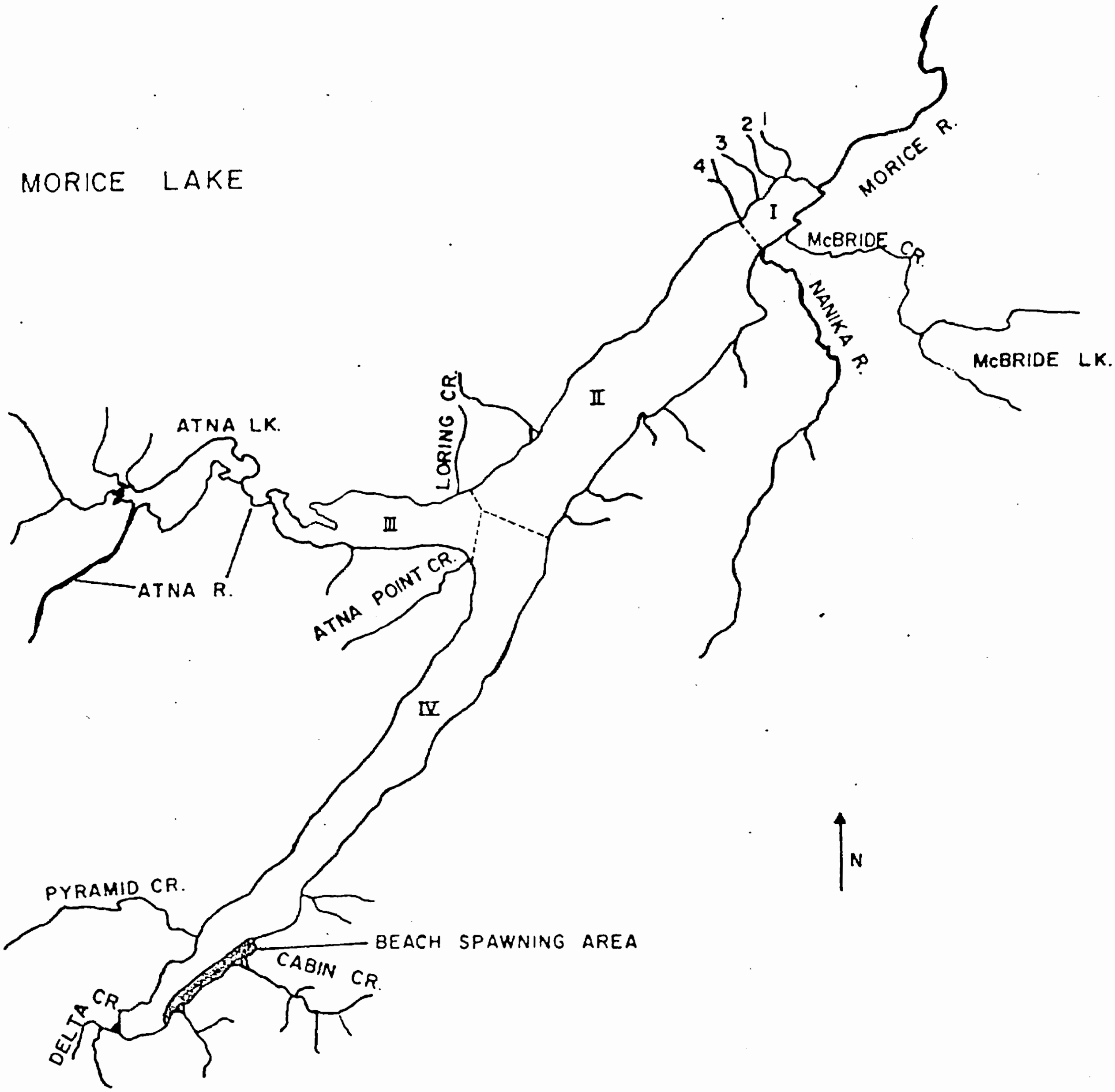


FIGURE 12. Map of study areas within Morice Lake basin.

The maximum depth has been recorded as 918 feet. The shoreline is irregular and rocky with little gravel or sand except in the regions of the outlet of Nanika River and the outlet of Morice Lake. Shallow waters are also evident at the mouths of some of the small tributary streams which are situated around the lake perimeter. There are several streams of volume and importance to the Morice Lake basin and these are the Nanika, the Atna, McBride Creek plus two minor streams--Pyramid and Delta Creeks. The Atna River draining the mountainous area to the west expands into a small lake a few miles before it flows into Atna Bay. Three-quarters of a mile from its outlet are two falls, one just above the other, and are respectively 13 and 10 feet in height. These falls are not considered a complete barrier to salmon migration but they do constitute a hazard to upstream movement. McBride Creek, a small tributary flowing from the east in a westerly direction, enters Morice Lake between the outlet of Morice Lake and Nanika River.

Morice Lake has been proposed as an integral part of the Kemano II development in that a dam would be located near the outlet of Morice Lake and water would be pumped from some point on the southeast shore of Morice Lake to Nanika Lake for a diversion into the Nechako reservoir. Pumping would be carried out primarily during the summer months. No consideration has yet been given to the actual location of the dam within the Morice River, however a proposed project layout consists of a 60-foot high concrete gravity dam at the outlet of the lake with an uncontrolled spillway, gated low level sluiceway and a fish ladder. The fish ladder would be designed to permit adult movement into the upper Morice system including the Nanika River.

One of the primary concerns of the proposed hydro development is the effect of the Nanika diversion on the productivity of Morice Lake. The Nanika River presently contributes as much as 50 percent of the water supply to Morice Lake. Loss of this water may cause a decline in nutrient levels in the lake and an associated reduction in rearing potential for juvenile salmonids. Past information indicates that juvenile coho rear in the lake in shallow areas where productivity is high and there is an abundance of terrestrial insect outfall. With the reduction in lake level caused by the Nanika diversion, these shallow, productive areas could be reduced in area at least during certain times of the year. Additionally, sockeye salmon spawn in Morice Lake in noted beach spawning areas. It is possible that a decline in lake level could also result in a loss of these spawning areas. Additionally, a drop in lake level would result in problems of accessibility of salmon to spawn in the tributary streams of Morice Lake. Conversely, if a dam was constructed on Morice Lake, the above-mentioned problems would still result. A rise in lake level might eliminate spawning areas for coho and change the groundwater flow in areas where beach spawning presently occurs. To find solutions to these problems and gain more information on the biological characteristics of Morice Lake, a series of studies were conducted to locate these spawning areas, to describe their characteristics, including the population densities of salmonids in these areas plus a spawning ground survey on the various tributary streams of Morice Lake. The latter study would be to primarily determine which streams had coho and chinooks spawners, how abundant they were and what the distribution patterns were along the various streams.

Study Area and Sampling Sites

For comparative purposes, Morice Lake was divided into four study areas (Figure 12). Study Area 1, was located near the outlet of Morice Lake, while Study Area 4 was located at the southern sector of the lake. Adult distribution patters and population sizes within the Morice Lake study areas were determined by employing the techniques of gillnetting, aerial surveys, foot surveys and beach seining. All tributary streams were covered on foot commencing in early September and continuing on into late October to determine species spawning sites. Deep spawning areas were located by means of scuba diving and surface observation.

Adult sockeye were first observed in Study Area 1 in the Morice Lake on August 2. Later observations in the Nanika River on August 5 suggests that the fish observed within Morice Lake were destined for the Nanika. Coho were mainly observed in and around McBride Creek with the first siting occurring off the mouth of McBride Creek on August 24. Groups numbering up to 50 were observed throughout September and October in all areas of the creek from the outlet to approximately four miles upstream. The specific coho spawning area within McBride Creek is situated in the upper portion in the vicinity of a dammed off area created by beavers. Verification of this occurred on October 17 when approximately 35 adults were observed actively spawning in approximately two to five feet of water, having a velocity of one foot per second. Aerial surveys between November 4 and 19 in the same area indicated approximately 20 adult coho in a very mature spawning condition. Other tributaries in Study Area 1 were surveyed throughout September and October, however no fish were observed. These streams are quite small and have a steep gradient characteristic of many other coho streams on the Pacific coast. The possibility exists that these tributaries do have the potential for coho spawning populations. Adult chinook salmon were only observed on September 1 along the northwest shore of Morice Lake approximately one-half mile from the outlet to Morice River.

In Study Area 2, located between Nanika River and Atna Bay, one adult sockeye salmon was observed during the study period. A number of small tributary streams along the southeast shoreline were surveyed and all were considered capable of maintaining spawning populations.

In Study Area 3, sockeye, chinook and coho salmon were observed on different occasions throughout the study period. Sockeye were captured in gillnets along the beaches between Loring Creek and Atna River in September. The tributaries, Atna Point Creek and an unidentified creek west of Atna Point were surveyed, however no fish were observed throughout the study period. From past studies (D. Buxton, ~~1956~~ 1961), sockeye and coho were observed beach spawning off the mouths of the streams flowing into Atna Lake. During this past survey, coho were also observed in the upper Atna River and in a stream to the north. Both of these streams have excellent spawning gravel and are considered to have good potential productivity. One adult chinook salmon, captured in a gillnet at the mouth of lower Atna River on September 29, appeared to be proceeding to the lower Atna River to spawn. This assumption is based on its state of maturity and the fact that the lower Atna River appears to be the most suitable stream for chinook spawning within Study Area 3.

Study Area 4 appears to be the most productive sockeye spawning area within Morice Lake. This area is characterized by several beach spawning areas near Cabin Creek and tributaries to the south. Scuba diving surveys within this area on September 15 resulted in sitings of adult sockeye actively spawning in the vicinity of Cabin Creek. Approximately one week later, an estimated 200 sockeye were also observed. Salmon redds were located on gravel ridges 30 to 50 feet wide, at depths from 5 to 30 feet with a mean depth of 12 feet. The estimated total beach spawning population in 1974 was 500 sockeye.

Small numbers of adult chinook and coho were captured off Pyramid Creek during the study period. Coho and sockeye were captured off the mouth of Cabin Creek. Although surveys on Cabin Creek resulted in no sightings of spawning fish, the clear water and ideal spawning gravel suggests this area has good potential productivity and possibly in years of high populations in Morice Lake, these areas would be utilized for spawning. The surveys also indicated that Pyramid and Delta Creeks were quite turbid with high velocities and would probably be void of spawning populations. However, a small clearwater tributary of Delta Creek entering from the south-east approximately 600 yards from Morice Lake does appear to be suitable for coho salmon spawning, as two mature adult coho were observed spawning there on October 12.

The results of the above adult population studies indicate that a decline in the Morice Lake level would result in a loss of spawning area especially in streams tributary to Morice Lake. A reduction in lake level would also jeopardize beach spawning areas along the lake especially those located within 5 to 10 feet of water. With respect to the tributary streams, a reduction in lake level would create barriers to salmon migration into these streams. Conversely, if a dam was constructed on the Morice River, a rise in lake levels might eliminate spawning areas by flooding the lower reaches of the tributary streams. Additionally, a change in ground water flow in the beach spawning areas could occur which would also jeopardize the spawning productivity of the main lake. It would appear, therefore, that with or without construction of a dam on the Morice River, salmon productivity of Morice Lake would be affected by the Kemano II development. Considering the potential loss to individual species, it would appear that sockeye salmon would be the most severely affected by the Kemano II development. If the development proceeded, it would seem appropriate to ensure that the beach spawning areas along Morice Lake were not affected; that is, limits on reservoir draw-down would have to ensure minimal effects on all spawning areas.

Juvenile Chinook and Coho Studies on Morice Lake

Techniques employing the use of fyke nets, beach seines and gillnets were used in trapping juveniles to assess the productivity of various areas within Morice Lake. The studies indicated that McBride Creek was a prime area for juvenile rearing. Catches of chinook and coho fry were made in the lower mile of McBride Creek from June through to October. The peak of migration occurred during the last week of June. Coho catches ranged from 30 to 55 per day from June 26 to 30. Little movement occurred in July, however catches of 11 and 22 fry occurred in late August and early September signifying a bi-modal migration pattern. Chinook fry migration appears to coincide with that of coho in that peak catches occurred on June 24. Previous studies conducted by Fisheries Service suggest that much of the coho and chinook migrations occur prior to the first of June. Consequently, it becomes difficult to assess the exact timing of chinook and coho fry migration from McBride Creek.

A comparison of data collected in all study areas (Table III) of Morice Lake lend support to McBride Creek's rearing capability.

DAILY JUVENILE CATCHES 1974

WATER SURFACE TEMP. D.C.	COHO FRY	COHO SMOLT	CHINOOK FRY	CHINOOK SMOLT	OTHER
[illegible].0	2				
[illegible].0	1				
	1				
[illegible].5	36				
[illegible].5	2		2		1 sculpin 1 sockeye fry
					6 juvenile whitefish
					8 " " " 1-18 " lake tm
[illegible].0		1			
					1 sculpin 1 lake trout
.0		4		1	1 dolly varden
				1	
					2 whitefish
		1			
.5		1			
					1-1 1/2 lb. dolly varden

: LAKE DAILY JUVENILE CATCHES 1 .4

WATER SURFACE TEMP. D.C.	COHO FRY	COHO SMOLT	~~CATCH~~ CHINOOK FRY	CHINOOK SMOLT	OTHER
					1 whitefish
					1-12"Lk. trout 1-16" " "
8.0		2			
8.0		1			
9.0		7			1-4lb. rainbow 1-2lb. rainbow 1-2lb. dolly varden
		1			
		3			
					7 whitefish 1-3lb. Lk.trout 1-1lb. Lk.trout
		2			
INE	1				3 sculpin 3 juvenile whitefish
					2 whitefish 1-12"Lk.trout
12.0		1			1 whitefish 1-16"Lk.trout
INE					5 sculpin 1 sucker 1 whitefish

MORICE LAKE DAILY JUVENILE CA[illegible]S 1974

	WATER SURFACE TEMP. D.C.	COHO FRY	COHO SMOLT	CATCH CHINOOK FRY	CATCH CHINOOK SMOLT	OTHER
[illegible]NE	12.5	3		1		7 sculpin
	12.5					1 " "
	12. 5					1 " " 1 long nose dace
	12.5	1		1		1 whitefish 1 sculpin
	12.5					8 sculpin 3 whitefish
						40 sculpin
	15.0					1 sockeye fry 10 sculpin
						45 sculpin 5 whitefish 1 juvenile Lk. trout
						10 sculpin
	13.6				3	5 whitefish 2 long nose dace.
					1	1-14"whitefish
					1	

CE LAKE DAILY JUVENILE CATCHES 1974

WATER SURFACE TEMP. D.C.	COHO FRY	COHO SMOLT	~~CATCH~~ CHINOOK FRY	CHINOOK SMOLT	OTHER
					1-12" cut-throat
8.3	1				2 whitefish 1 sculpin
8.3	2				1 sockeye smolt 5 adult whitefish 3 juvenile whitefish
8.3	1				
8.3	2				
8.3		1			
6.6	1				

Areas in McBride Creek characterized by marshy, slack water contained coho fry and smolts and although catches were relatively small (one to four individuals per set), they do indicate that rearing occurs there and also in McBride Lake. Coho rearing also appears to occur in Morice Lake near the mouth of McBride Creek. Catches ranged from one or two individuals per set to as many as 36 on one occasion off the mouth of a tributary creek on the northwest shore.

Juvenile trapping in Study Area 2 resulted in a maximum of two coho fry per set with frequent zero catches. The catches, occurring primarily in the large body of water to the south of Nanika River and around its mouth suggests that Study Area 2 is a relatively poor rearing area in comparison to Area 1. All catches were made in depths from zero to ten feet and within 75 feet of the shoreline. Juvenile trapping in Study Areas 3 and 4 were comparable to Area 2 except in the vicinity of Pyramid and Delta Creeks. This area seemed to have a fairly high concentration of smolts (Table III). For example, four coho smolts were caught in one set at Pyramid Creek and seven at a later date at the same location. One chinook smolt was captured in Pyramid Creek while several were caught in Delta Creek. The apparent high concentration of smolts within this area can be related to the physical characteristics of the area. The area is characterized by slack water and marshy areas with dense vegetation existing along the wetted perimeter of the shoreline. Elsewhere in Study Areas 3 and 4 chinook smolts were captured in gill-nets in early September off of Atna and Loring Creeks. Coho fry were not captured in this area, however it appears to be inhabited by a fairly high concentration of sculpins and whitefish. (For additional information as to the timing and location of juvenile trap catches, refer to Table III).

The above juvenile studies indicate that the Morice Lake does contain several suitable rearing areas for juvenile chinook and coho and sockeye. The construction of a dam on the Nanika River, thereby reducing the flow into Morice Lake, would result in a lowering of the lake level and a reduction in the juvenile salmonid rearing potential of Morice Lake and its tributaries. The areas in which juveniles rear are characterized by shallow water, dense growths of vegetation and all are located near the wetted perimeter of the lake. With the construction of a dam, it is difficult to argue against the loss of rearing area, in that more rearing area would undoubtedly occur as a result of the increased shoreline perimeter. Overall, it would appear that construction of a dam on the Nanika or the Morice River or both would directly affect salmonid productivity of the Morice Lake basin.

STUDIES ON THE MORICE RIVER SYSTEM

The Morice River, arising from Morice Lake and flowing in a northerly direction, provides the major link between Morice Lake and the Bulkley River which is situated approximately ~~70~~ 50 miles from Morice Lake (Figure 13). Throughout most of the year, Morice River can be described as a cold, fast-flowing stream. No serious hazards occur within the river above its junction with the upper Bulkley, but salmon traversing this stream expend considerable effort in navigating the fast, whitewater, the many rapids, log jams and canyons which characterize its entire length. The main spawning area in the Morice is situated in the upper reaches of the river, within the last few miles before its origin at Morice Lake. Aside from Morice Lake, there are ~~four~~ four major tributaries to the Morice River. These streams are: Gosnell Creek-Thautil River, Lamprey Creek, Owen Creek and Houston-Tommy Creek.

Study Area and Sampling Sites

The study area on the Morice River was divided into three sampling areas. Sample Area 1 includes the area immediately downstream of Morice Lake to the rock bluff located approximately ~~at the midway point between Morice Lake and Gosnell Creek.~~ 2 miles below the lake outlet. Sample Area 2 is located between the rock bluff and the confluence of Gosnell Creek and Morice River. The final and largest sampling area extends from Gosnell Creek to the Bulkley River, a distance spanning approximately ~~50~~ 39 miles. Past records assembled by the Fisheries Service indicated that most fish populations concentrate in Study Area 1, thus it warranted the greatest sampling effort. All hydrographical studies were conducted in Study Area 1.

Water Hydrology on the Morice River System

Earlier in the report, the water hydrology of the Morice-

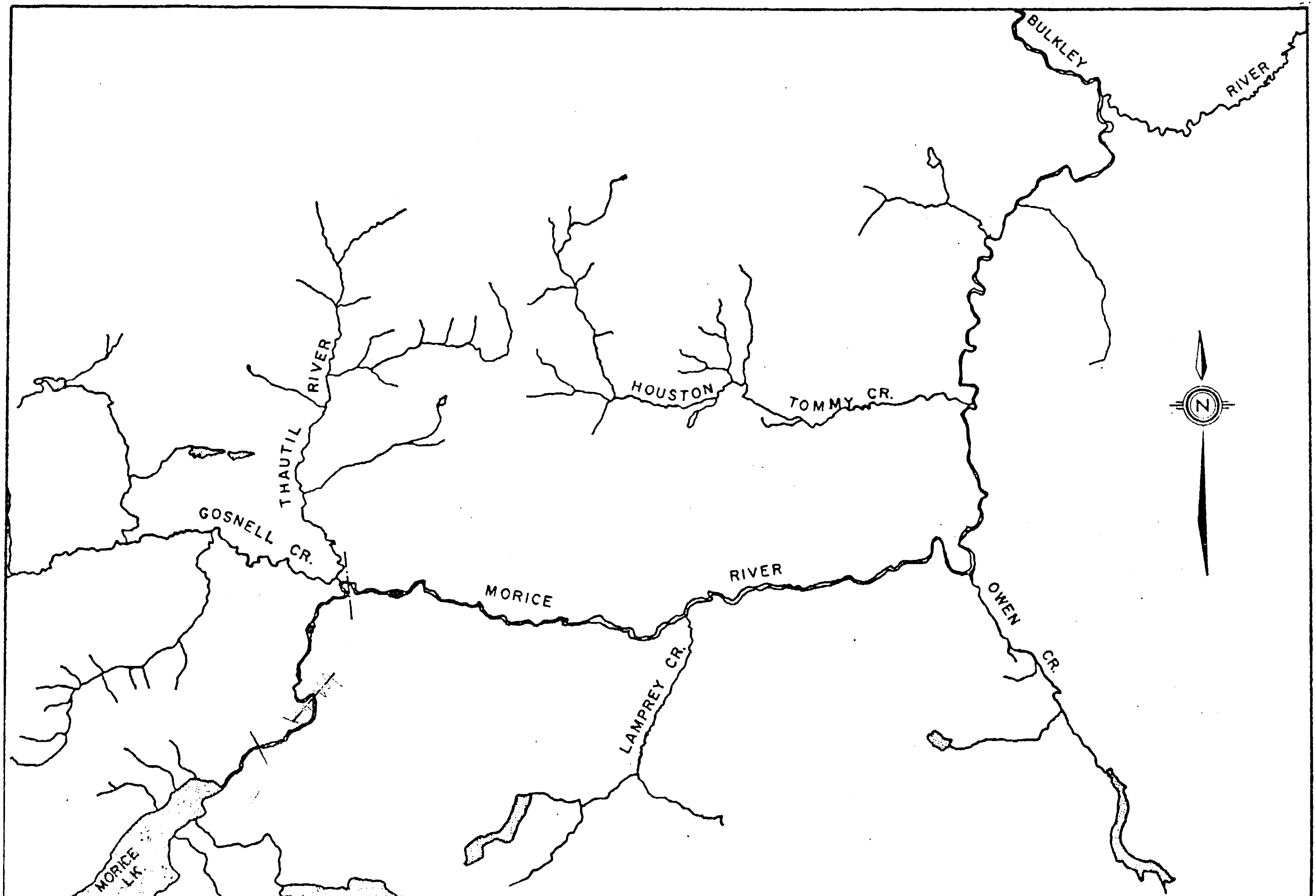


FIGURE 13. Map of Morice River study areas.

Nanika watershed in the Bulkley River drainage basin was discussed. It is important, however, to mention again some of the important parameters affecting the drainage system. For example, approximately 15 percent of the entire Bulkley River drainage area occurs above the outlet of Morice Lake and the Nanika, Kidprice and Morice Lakes provide almost all of the lake storage within the system. Of the remaining 85 percent drainage area which occurs below the outlet of Morice Lake, five above-mentioned tributaries to the mainstem Morice contribute significantly to the overall discharge.

Discharge recording stations have been operated on the Morice and Bulkley Rivers for a number of years by the Department of the Environment. These stations are located on the Morice River near the outlet of Morice Lake and on the Bulkley River at Quick, B. C. The former has been in operation since October, 1971, while the latter since 1930. Hydrographs, depicting the annual distribution of the mean monthly discharges for these recording stations are shown on Figure 3. As mentioned earlier, the discharge pattern is seen to be relatively typical from year to year with peak flows occurring during spring run-off. A secondary freshet normally occurs prior to freeze-up. The quantity of water within the drainage area above the outlet of Morice Lake contributing to the Bulkley River discharge, varies throughout the year. It is important to emphasize that during the spring run-off when other areas in the drainage basin are contributing a higher rate of discharge from snow melt, the Morice watershed can represent as little as 16 percent of the discharge at Quick. At other times of the year, the Morice Lake outflow can represent as much as 96 percent of the total discharge at Quick.

A reduction in discharges throughout the Bulkley River as a result of damming the Morice River can be determined simply by deducting the quantity of the diversion. The effect on discharges in the Morice and Bulkley Rivers as a result of the Nanika diversion, is complicated by the storage potential of Morice Lake, but indications of the discharge affect can be determined. The system was analyzed to illustrate the effect of the diversion of the Nanika River on daily discharges at recording stations on the Morice River and Bulkley River at Quick. Analyses carried out for the period July 1, 1972 to September 30, 1974 and the results are shown on Figure 4, together with natural flows which occurred during that period. As the graph indicates there are large differences between natural flows and the computer analysis flow which occurred during that period. (For illustrative purposes only, it was assumed that the annual residual flows in the Nanika River would be in accordance with the preliminary minimum flow requirements recommended in the Fisheries and Marine Service report of November, 1971.)

Hydrographical Studies on the Morice River

Hydraulic studies were conducted in the Morice River on a prime chinook spawning area some 2000 feet in length and located approximately one-half mile below the outlet of Morice Lake. This area located in Study Area 1 represents approximately one-third of the total chinook spawning area within the river. (For the purposes of clarity within the report, the specific site studies within Study Area 1 will be termed Area A and Area B). Surveys were conducted at discharges of 675 and 2500 cfs and were comprised of the following operations:

(1) River channel cross-sections at 13 sites within the study area.

(2) Velocity measurements over the width of the river on several of the cross-sections.

(3) Measurement of water surface profiles throughout the length of the study area.

(4) Topographical mappings of the riverbed in a small control area within the main study area.

Miscellaneous water levels were also obtained within the study area at discharges of 1500 and 9000 cfs. In addition, several miles of the river below the outlet of Morice Lake were photographed from the air for reference purposes.

A topographical map of the study area with riverbed contours, location of cross-sections and a general density of spawning is shown on Figure 14. Flow is divided within the study area by a relatively large island. The ratio of flow between the right and left channels (facing downstream) on either side of the island is 2.0 - 1 at 2500 cfs. and 3.5 - 1 at 675 cfs. Flow measurements below the island by the Fisheries and Marine Service agree closely with discharges recorded a short distance upstream by the Inland Waters Branch, but were approximately 15 percent higher than the of 675, 1350 and 2500 cfs. In most cases the riverbed is quite irregular along the section which is the result of the section crossing over the gravel dunes.

One criterion for assessing the affect of reduced discharges on spawning areas is to assume that an area is unacceptible to spawners if covered by less than one foot of water. Using this criterion, an analysis was carried out on the wetted area between Sections 3 and 13 (Figure 16). Sections 1 and 2 were not included as spawning is known to be quite limited in this area. The total wetted area between Sections 3 and 13 is 54,740 sq. yds. at a discharge of 2500 cfs. The percentage of this area covered by a depth of water of more than one foot at various discharges is summarized in Table IV. It should be noted that the above discussion related

TABLE IV. Relationship between Morice River discharge and spawning area. All measurements were obtained in the riverbed area covered by more than one foot of water between Sections 3 and 13, Study Area A.

Discharge (cfs)	Area (sq. yds.)	Percent of Total Wetted Area at 2500 cfs
2500	39,370	71.9
2000	36,760	67.1
1500	35,040	64.0
1000	31,190	57.0
675	23,590	43.1

only to the wetted perimeter within the study area and not to the available spawning area. The extensive dune formations throughout the lower half of the study area complicates the analysis of minimum spawning flow requirements. A certain percentage of the surface area of a dune is unsuitable for spawning under any discharge due to variability in the composition of the gravel and the water velocities over the width of the dunes. To provide some relationship between total wetted area and preferred spawning area, a detailed topographical survey was conducted on a small area with typical gravel dunes immediately below the island. This site, Area B, is located in Study Area 1. A detailed contour map and longitudinal sections of the area is shown on Figure 17. Biological observations during the chinook spawning period concluded that spawning normally occurs over approximately the upper two-thirds of the upstream slope of the dune. Using this information and the criteria that water depth must be greater than one foot for successful spawning, the preferred spawning areas within Area B were determined for discharges of 675, 1350 and 2500 cfs (Table V). Similar data applying to Area A is

TABLE V. Wetted area covered by more than one foot of water and preferred spawning area in Study Area B

Flow (cfs)	Wetted Area Covered by More Than One Foot of Water, Sq.Ft.	Preferred Spawning Area, (Sq.Ft.)	Percent of Wetted Area Preferred For Spawning
2500	5225	1701	32.6
2000	5052	1620	32.1
1500	4652	1480	31.8
1000	3773	1050	27.8
675	3013	411	13.6

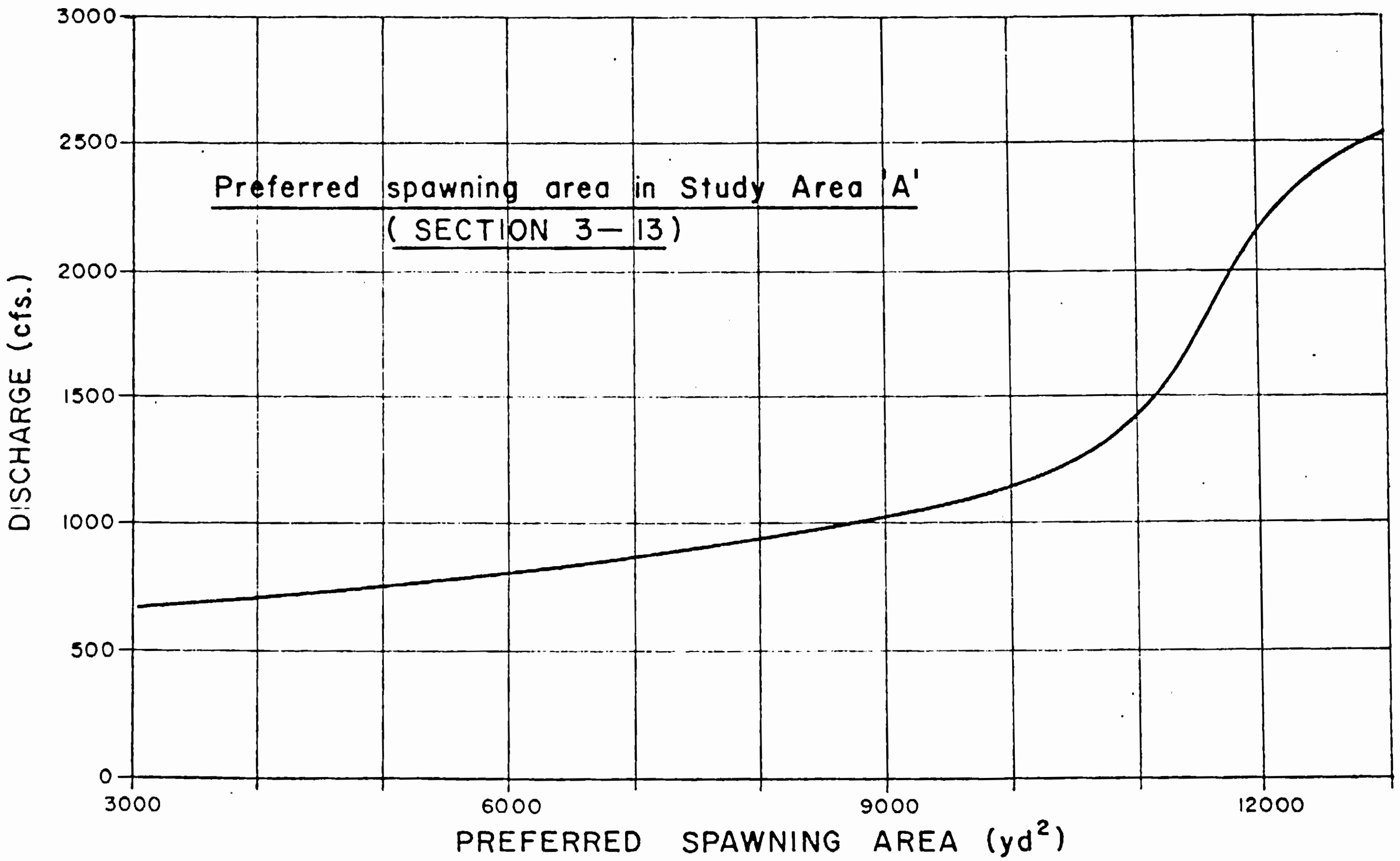


FIGURE 16. Preferred spawning area in Study Area 'A'.

presented in Table VI).

TABLE VI. Preferred spawning areas in Study Area A.

Flow (cfs)	Wetted Area Sq. Yds. (See Table 2)	Percent of Wetted Area Preferred For Spawning (See Table 3)	Preferred Spawning Area In Study Area A, sq.yds.	Percent Loss
2500	39,370	32.6	12,835	0
2000	36,760	32.1	11,800	8.1
1500	35,040	31.8	11,143	13.2
1000	31,190	27.8	8,671	32.4
675	23,590	13.6	3,208	75.0

Spawning chinook salmon require approximately five square yards of spawning gravel in which to deposit their eggs. Therefore, the total spawning population that could be expected to utilize Study Area A at the various discharges is as follows: At a discharge of 2500 cfs, the total number of spawners would equal 5134; at a discharge of 2000 cfs, spawning density would equal 4720; at a discharge of 675 cfs, only 1283 spawners could occupy, or successfully spawn, within that particular study section. The maximum number of chinook salmon spawners recorded in the Morice River between 1953 and 1973 was 15,000. If one-third of these spawned within Area A, the preferred spawning area would be fully utilized under a discharge of 2500 cfs. Additional spawning area is available at discharges above 2500 cfs, but this is comparatively small. (For more detailed relationships between discharge and number of spawners, please refer to Table VI).

It should be noted that the above assessment is based solely on the premise that spawning occurs on two-thirds of the upstream slope of the gravel dune at depths of water greater than one foot. Consideration was not given to nose velocities within the preferred spawning areas. Due to the suspected wide variability in water velocities over the surface of the dunes, existing velocity data for the study area is inadequate in assessing discharge - velocity relationships over the preferred spawning areas.

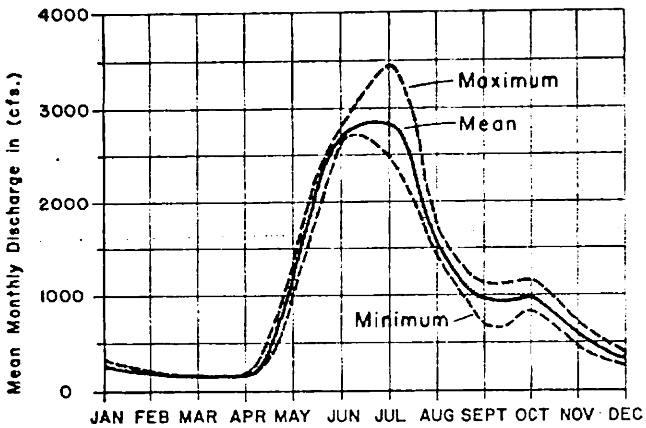
Another complex feature of the assessment is in regards to the reorientation of flows past the dunes as water levels drop to near or below the crest elevation of the dunes. For example, at a discharge of 675 cfs, the crest of the dunes within Area B are almost entirely exposed. In this case, the flow would meander through the dunes in such a way that the trough between adjacent dunes would act as individual river channels. The downstream face and a portion of the trough of the individual dunes is normally composed of fine, sandy material and in some cases could contain an accumulation of debris. Even with sufficient water velocities, such areas would be unsuitable for spawning. For this reason, it is considered that an adequate discharge must be provided during the spawning periods to maintain exceptable hydraulic conditions over the surface of the dunes. Additional velocity measurements will be required within the study area to assess these hydraulic conditions. However, in the meantime, it is estimated that at least 2000 cfs will be required during the spawning period. As indicated (Figure 18) this is approximately equal to the minimum mean monthly discharge in the Morice River between 1961 and 1974.

TABLE VII. Relationship between discharge and spawner densities.

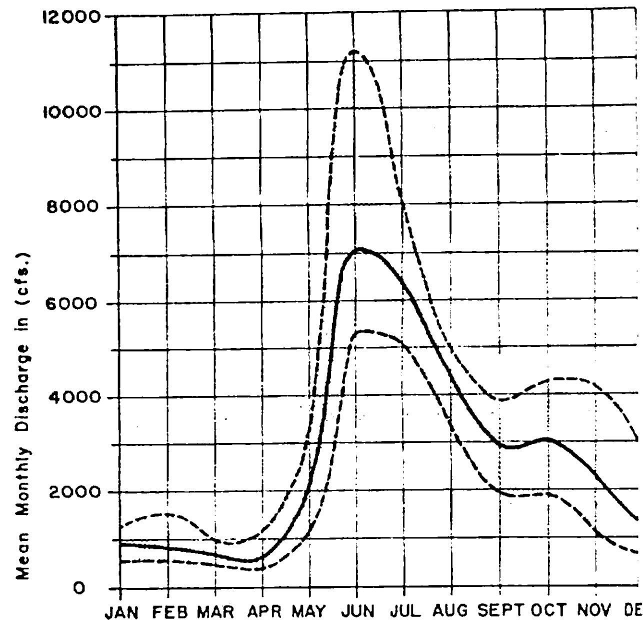
Discharge (cfs)	Number of Spawners
2500	5134
2000	4720
1500	4457
1000	3468
675	1283

Adult Population Studies in the Morice River

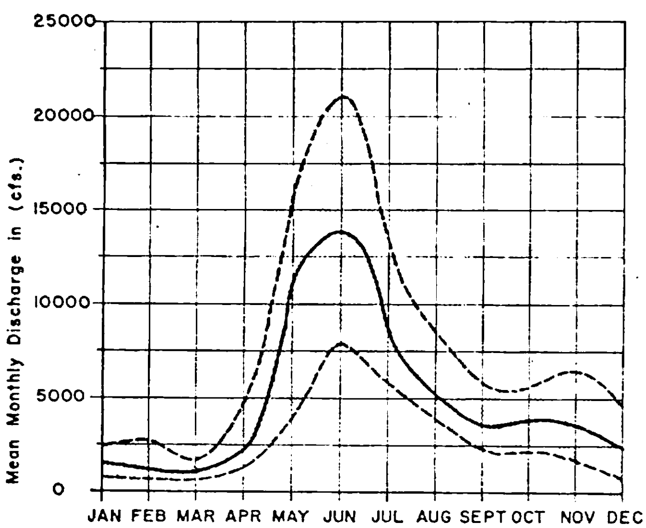
Visual observations of adult salmon were conducted by boat, helicopter and by scuba. The results of the surveys in Area 1 indicated that adult migration in the upper portions of the Morice River commenced around August 1st to a peak of 3500 - 4500 fish on September 13th. In late September, chinook spawning appeared to have already peaked as many spawned out adult chinook were observed. At this time, approximately 50 percent of the peak numbers of fish were on the grounds and by October 4th, spawning was all but complete. Chinook salmon spawning occurred mostly within the first 1.5 miles of river. For example, on August 28th, a total of 1400 chinook were observed in this area, while on September 13th, 3000 of the original



Nanika River below Kidprice Lake (1972-1974)



Morice River below Morice Lake (1961-1974)



Bulkley River @ Quick (1945-1973)

FIGURE 18. Annual distribution of mean monthly discharges Nanika, Morice, and Bulkley Rivers.

4500 fish estimated were located in the upper 1.5 miles.

Area 2 was studied in much the same manner as reported above. On August 3rd, August 15th and September 13th, observations revealed varying numbers of adult salmon with the fewest reported on the former date and the largest (800 - 1200 fish) on September 13th. ~~Of the latter population, 60 percent of them appeared to be chinook and the remainder were coho.~~ On September 27th, Gosnell Creek was observed by helicopter and about 400 yards from the Morice River, approximately 30 ~~fish~~ coho were observed. This creek has a very excellent spawning area over the first 7 miles, and usually contains spawners, however, only coho populations were observed. On November 9th, this same area was surveyed and numerous redds were observed. Apparently, the peak spawning in 1974 would have occurred after November 9th because the fish observed on that date were very mature but were not spawned out.

Area 3, the largest study area, appeared to have a sparse population compared to the other two sampling areas. Poor access, limited observations to helicopters and beach seining at a select number of sites. (The beach seining was conducted at the confluence of the Bulkley and the Morice Rivers to ascertain timing differences between the salmonid species). Helicopter surveys conducted on August 8th indicated that 350 adult chinooks were passing through this particular area. 95 percent were between Owen Canyon and Gosnell Creek. Poor visibility caused by very turbid water, provided poor or inadequate counts of fish in the area below Owen Creek.

The fact that the above fish were first observed on August 8th and if one relates the timing of arrival of these fish in the upper portions of the river and the later sparse populations occurring in the lower river, suggests that these early observed fish were migrating through the lower Morice on August 8th. This is further verified by an observation of 1200 fish between Gosnell and Lamprey Creeks on August 22nd and 100 - 1200 between Lamprey Creek and the Bulkley River. Apparently, adult migration through this particular area is all but over by the middle of September as very few fish were observed after mid-September. In addition, most of these fish were coho. This particular period coincides approximately with the peak of spawning for chinooks in Study Areas 1 and 2. During this same survey, 375 pink salmon were observed in Study Area 3.

Periodic checks of Lamprey, Houston - Tommy and Owen Creeks, indicated that all three were probably coho creeks. Owen Creek, remarkably similar to McBride Creek in colour, gradient, water depth and gravel composition, appears suitable for spawning.

Adult chinook salmon were tagged between August 2nd and 27th for the purposes of identifying the timing and destination in the Morice River. A total of 52 chinook salmon were tagged and all were ~~recovered~~ observed in the upper Morice. In addition, 112 coho were tagged between August 25th and September 25th. Three recoveries were made in the same tagging area on September 25th. These fish had been tagged on September 11th and September 20th respectively, indicating that the coho were either remaining in that particular area to spawn or were only using it as a resting and maturity location. No tagged coho were ever seen or recovered on the Morice, however 6 tags were recovered on the Bulkley River above the Bulkley-Morice confluence. ~~Possible~~ Possibly a portion of the coho population entering the Morice fell back and migrated up the Bulkley to spawn in the mainstem or its tributaries. The fact that coho were sited in the upper Morice and its tributaries indicates however, that the Morice does support a distinct coho population. Similarly, the fact that rearing coho smolts and fry have been observed in the Morice tributaries suggests that of all the 112 coho tagged in the Morice, a significant number of them probably were destined for the upper Morice and its tributaries.

Juvenile Chinook and Coho Populations in the Morice River

Juvenile and chinook and coho distribution and rearing patterns within the Morice River were studied from June to October, 1974. The methods incorporated in the study were gill-netting, beach seining, electrofishing, fyke net trapping and scuba diving. The study was conducted in the three sample areas described above.

The downstream migration of chinook fry through Study Area 1 had commenced earlier than June 6th, the date in which the first fyke net set was made. The total catch in the set, located approximately one-quarter mile downstream from the Morice Lake outlet, was 110 fry. Trap sets on June 8th, 10th, 11th and 18th, resulted in catches of 75, 57, 75 and 79 fry respectively. Regular sets throughout Area 1 at 2 - 3 day intervals after June 18th resulted in catches of 1 or 2 individuals per set until June 26th, when the migration ceased. Fyke nets were not set at the outlet of Morice Lake until July 6th which marked the end of the chinook downstream migration. Consequently, it is not known whether appreciable numbers of fry migrated out of Morice Lake or from the upper Morice River. Beach seining on July 3rd in the middle of Area 1 in Morice Lake, resulted in a capture of 18 chinook fry while electrofishing on July 23rd resulted in a capture of 13 individuals. Visual observations by swimmers of large numbers of chinook fry indicated that many chinook rear within this area of Morice Lake.

Chinook fry began to be captured in upstream migrant traps on June 5th in small numbers. The catches remained at this level until approximately August 1st. On August 3rd, a total of 37 were captured in the upstream traps but catches again declined to approximately 3 - 5 fry per evening until August 8th when catches increased to 79 chinook fry in both traps. After this period, all catches declined and finally terminated on September 15th. Average length of chinook fry ranged between 60 - 70 mm.

The upper area of the Morice River has many little side channels and sloughs which have heavy vegetation along the shoreline and appears to be a prime rearing area for both chinook and coho fry. It is noted though, that when the river was inspected in August, September and October, no observations of resident or rearing fish were made. Although the swimmers were mainly looking for adult salmon, it appears that if the chinook fry remained after the end of the migrations in these areas, some observations would likely have occurred. Consequently, it is felt that all chinook which occur in this particular area either migrate downstream to rear in the lower sections of the Morice River and its tributaries or migrate upstream to rear in the lake. From scale analysis information it appears that the chinook undoubtedly remain within the system for at least ~~2 - 3~~ 1 - 2 years. Consequently, it would appear appropriate to suggest that from scale data plus observations and catches of chinook in Morice Lake, a portion of the Morice River chinook fry migrate into Morice Lake to rear.

Chinook fry approaching what might be termed the smolt stage (70 - 80 mm size range) were captured in the upstream migration traps on October 9th and October 18th. There were no chinook smolts captured in any downstream migration traps throughout the survey, indicating that either the traps were inefficient in trapping smolts or that the smolts had immigrated from the system before the survey commenced.

Coho fry began to appear in downstream traps in Area 1 on June 18th and were caught at frequent intervals until September 15th. Catches generally averaged from 1 to 3 individuals and on many instances, catches were nil.

Coho fry were caught by beach seine in the middle of Area 1 on June 7th before any of the fyke nets began trapping fish.

This, and the fact that several coho fry were seen and captured on October 12th after the downstream had ceased, suggests that coho tend to spend all or part of their winter rearing in Area 1. Coho fry were captured in upstream migration traps from the beginning of June throughout the study period to the middle of October. From June 7th to August 10th, migration appeared to be spotty, however, at that time it began increasing to a peak catch of 28 on August 28th. Following August 28th, there appeared to be a decline followed by another peak on September 4th. Catches tapered off throughout September and by the first part of October, catches declined to approximately 5 - 10 individuals per set. On October 12th, the coho migration terminated.

The fact that coho were captured in the upstream traps during the summer along with age class composition of returning adults, suggests that coho spend from 1 - 2 years within the system prior to immigrating to the ocean. Part of this time spent in fresh water occurs in Morice River and Morice Lake. It appears that when coho first emerge from the gravel, they rear within the immediate vicinity until they reach suitable size for migrating upstream to rear in Morice Lake. Coho smolts were not captured in downstream migration traps, again suggesting that either the traps were inefficient or that the migration occurred prior to the beginning of the survey. Throughout the survey, in June, July and August, many small salmonids were captured in the upstream migrant traps. These were rainbow trout, cutthroat trout, dolly varden char and sockeye salmon fry.

In Study Area 2 of the Morice River, most of the juveniles captured were coho fry. All fish were captured in September and October in shallow, slow-moving side channels or backwaters. Coho fry were also observed in Gosnell Creek in late August. This stream, tributary to the Morice, appears to be an excellent rearing area in that it contains an abundant supply of coho food. The time of capture and the type of rearing area occurring within Area 2 suggests that these fish, rather than migrating upstream into Morice Lake to rear, occupy all of their freshwater life within this area. Chinook fry were also observed in Area 2 but on very few occasions. These fish were in deep pools and backwaters, however it is not known whether these fish eventually migrated upstream into Morice Lake or resided in this localized area until immigrating to the ocean.

Area 3 was not studied as intensely as the other two areas due to access difficulties. Only fyke nets, a Mark 7 electrofisher and Gees Minnow Traps were used within this area. Fyke nets set in Owen Creek and Lamprey Creek during the summer caught coho and chinook fry but in small numbers. The fact that the trapping procedures in this area were limited, it is difficult to draw any conclusions about the rearing habits of coho and chinook within this area except that coho and chinook do occur there. Electrofishing in backwaters of Lamprey Creek resulted in a catch of 30 coho fry. Coho fry were also caught in Houston - Tommy Creek, Owen ~~Canyon~~ Creek and in the lower Morice approximately 7 miles upstream from the confluence with the Bulkley River. All catches were made in shallow, slow-moving backwaters where dense vegetation overhangs the river banks.

Other evidence obtained indicating that coho remain within the system throughout the winters was obtained using Gees Minnow Traps baited with salmon roe. These traps were set in 12 locations in Area 3 on November 26th and 12 locations on November 27th. Sampling locations were within the lower 30 miles of the Morice River. All traps were left fishing between 3 1/2 - 4 1/2 hours during midday in 12 - 48 inches of water. Trap catches were small, however, a mixture of rainbow trout, steelhead and coho were captured in the traps.

The above results of the juvenile chinook and coho sampling program indicate that the Morice River and its tributaries can be considered an excellent rearing area for chinook and coho and other species. Although the survey began in late June, evidence collected suggests that chinook and coho do migrate into Morice Lake to rear at least from Study Area 1. The results also indicate that migration extends throughout the summer and is not a short term. Studies in Area 2 and 3 show that chinook and coho occupy backwaters and side channels of Morice River and its tributaries throughout the summer and reside there over the winter. In addition, scale samples obtained from returning adults indicate that coho and chinook reside within the Morice system for at least 2 years prior to their immigration to the ocean. In terms of the Kemano II project, any development within the system would probably have a harmful effect on the salmonid rearing communities within the Morice system. Declines in the wetted perimeter (Figure 19) would eliminate rearing areas. Periodic extreme discharges would affect the rearing communities in that, fluctuating discharge creates an unstable food supply for rearing fish. It is worth re-emphasizing that declines in water levels during spawning, incubation and rearing will destroy the salmonid productivity of a river system.

POTENTIAL EFFECTS OF DIVERSION ON THE BULKLEY RIVER

As mentioned earlier in this report, reduction of flow from the outlet of Morice Lake would entail a corresponding reduction throughout the Bulkley River. This presents various potential fishery problems which warrant further discussion. Of major concern is the possible adverse effects on the upstream migration of fish through Moricetown Falls as well as the potential problems which may be presented by increased concentrations of domestic and industrial effluent at Smithers.

Moricetown Falls

Moricetown Falls has historically been a point of difficult passage for fish migrating up the Bulkley River. Studies conducted by the Fisheries and Marine Service prior to 1950 concluded that the migration of salmon and steelhead was being seriously delayed and in some cases blocked at certain water levels (Clay, 1949; Milne, 1950). The differential head across the falls increases with

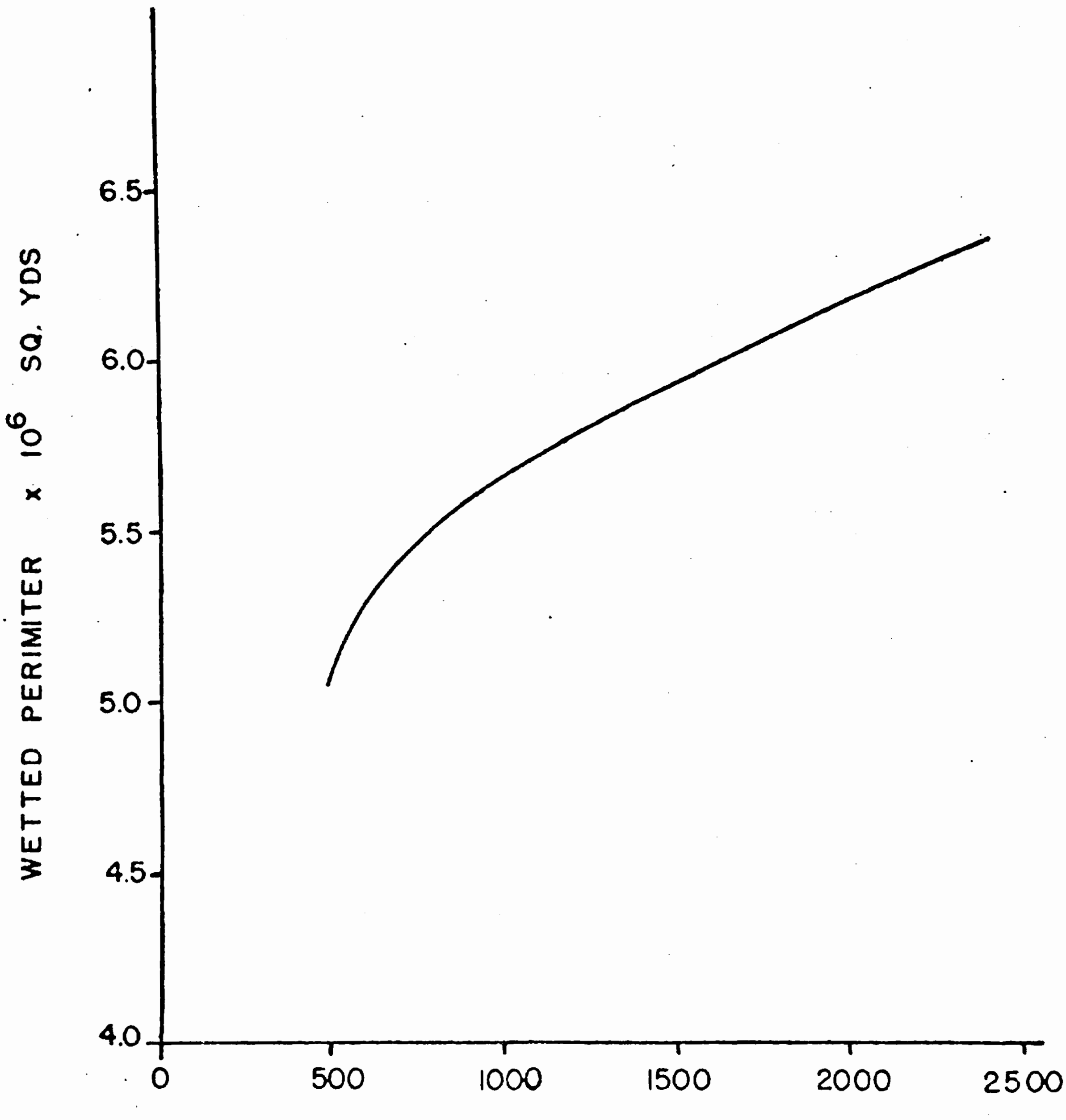


FIGURE 19. Relationship between discharge and wetted perimeter in the Morice River.

decreasing discharge and with less than 5000 cfs at Moricetown, the falls were virtually impassable.

In 1951, vertical slot fishways were installed on each side of the falls to alleviate this problem. Each fishway is approximately 150 feet in length with 6' x 10' x 6' deep pools designed to pass 5 fish per minute at a river discharge of 5000 cfs. The fishways can function over a discharge range of 2000 to 10,000 cfs. However, in the lower part of this range, it is unlikely that the fishways could handle the required numbers of fish during the peak of the migration since the depth and volume of water in the pools is considerably reduced.

The numbers of fish utlizing the fishways have been assessed on several occasions by the Fisheries and Marine Service (Palmer, 1964, 1967). In 1961, it was found that 34 percent of the total salmon escapement (excluding chum salmon) ascended the falls by means of the fishway. This included 36.5 percent of the sockeye escapement. Only 9.2 percent of the sockeye escapement utilized the fishway in 1962. Average discharges during the sockeye migrating period were approximately 2000 cfs higher in 1962 than in 1961, although it is not definitely known whether this is the primary reason for the decreased utilization rate in 1962.

An analysis of discharge data available for the Bulkley River at Quick and Smithers during 1971 and between 1946 and 1952, revealed that mean monthly discharges at the two stations can be closely represented throughout the year by the following linear relationship:

$$Q_S = 1.25\ Q_Q, \text{ where}$$

Q_S = mean monthly discharge at Smithers

Q_Q = mean monthly discharge at Quick

The relationship between mean monthly discharges at Hazelton and Quick is non-linear. Therefore, a regression analysis was carried out on the data available for these stations over the period 1930 to 1942. This resulted in the following relationship:

$$Q_H = 0.38\ Q_Q^{1.15} + 575, \text{ where}$$

Q_H = mean monthly discharge at Hazelton

Since no major tributaries enter the Bulkley River between Smithers and Hazelton and the watershed is reasonably similar over this length of river, it is assumed that the discharge at Moricetown can be interpolated between these two gauging stations on the basis of drainage area. The mean monthly discharge at Moricetown can then be represented as follows:

$$Q_M = 0.12\ Q_Q^{1.15} + 0.85\ Q_Q + 182, \text{ where}$$

Q_M = mean monthly discharge at Moricetown

Each of the above discharge relationships are presented graphically on Figure 20.

Salmon and steelhead trout migration through Moricetown Falls (Palmer, 1964) commences by June 1 and is essentially completed by September 30th (Table VIII).

TABLE VIII. Approximate timing of salmon and steelhead migration through Moricetown Falls.

Species	Main Migration Period	Peak of Run
Sockeye	July 1 - Aug. 31	Aug. 1
Chinook	June 1 - Sept. 30	Aug. 1
Coho	July 25 - Sept. 30	Aug. 15
Pink	July 25 - Sept. 10	Aug. 15
Chum	Aug. 15 - Sept. 15	Sept. 1
Steelhead	July 25 - Sept. 30	Aug. 15

From a correlation between monthly discharge frequency curves (Figure 21) and the mean monthly discharges for the Bulkley River (Figure 3), it is possible to estimate the effect of diversion of water from Morice River on the operation of the Moricetown Falls fishway. The frequency curves for Moricetown Falls were derived from Figure 15. For example, Figure 21 shows that the mean August flow at Moricetown has been less than 6000 cfs on a frequency of 20 percent over the past 43 years. From Figure 3, the mean flow from Morice Lake during August is 4500 cfs. If 2500 cfs were diverted from Morice River, it would therefore be expected that discharges at Moricetown Falls would be less than 3500 cfs during August on a frequency of 20 percent or 1 out of 5 years. Since this would coincide in timing with the peak of the salmon and steelhead runs, it is probable that the diversion would cause a much longer delay or total blockage of a large segment of the escapement. In this case, major modifications of the fishways would be required.

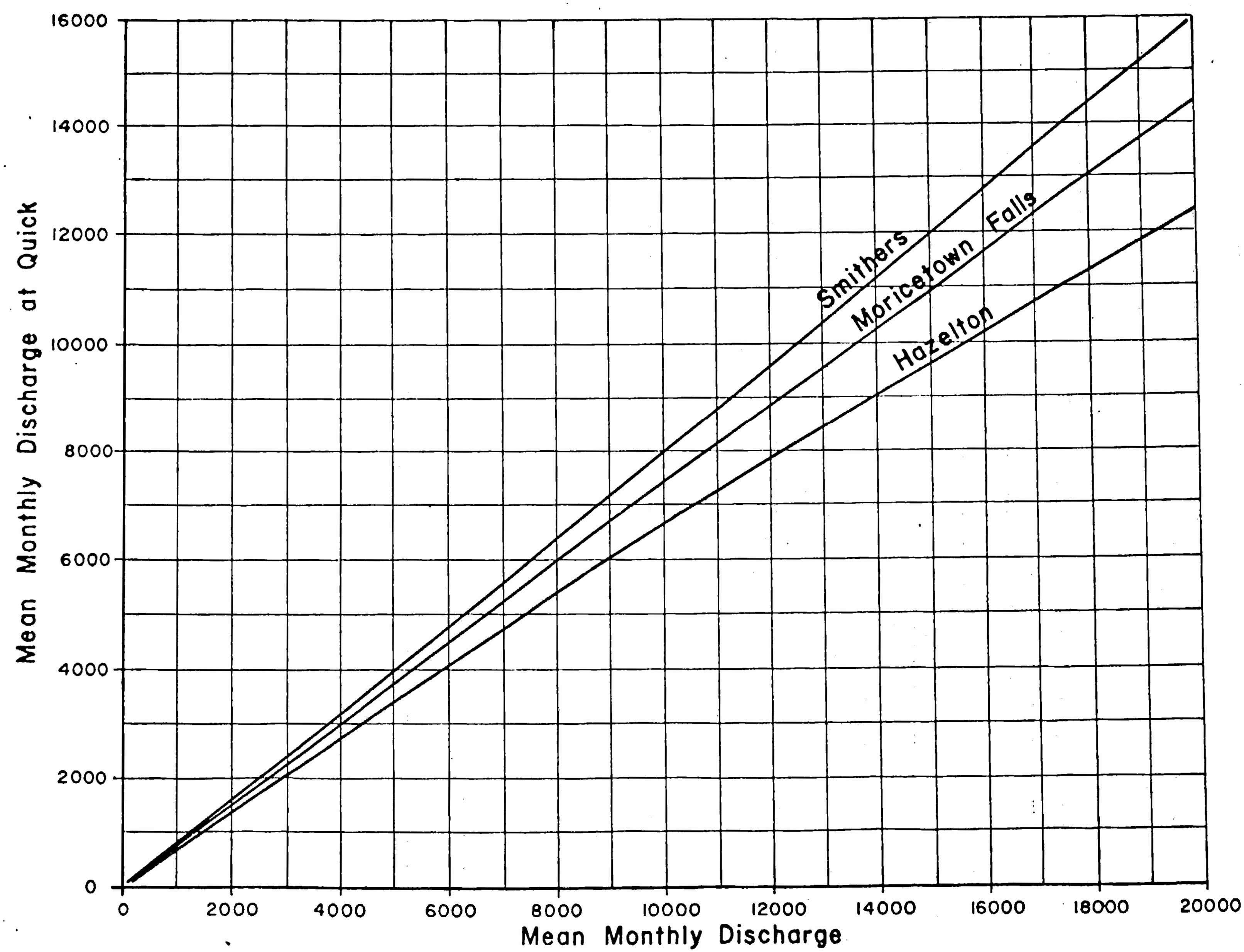


FIGURE 20. Estimated relationship between mean monthly discharges of the Bulkley River at Quick and various downstream locations.

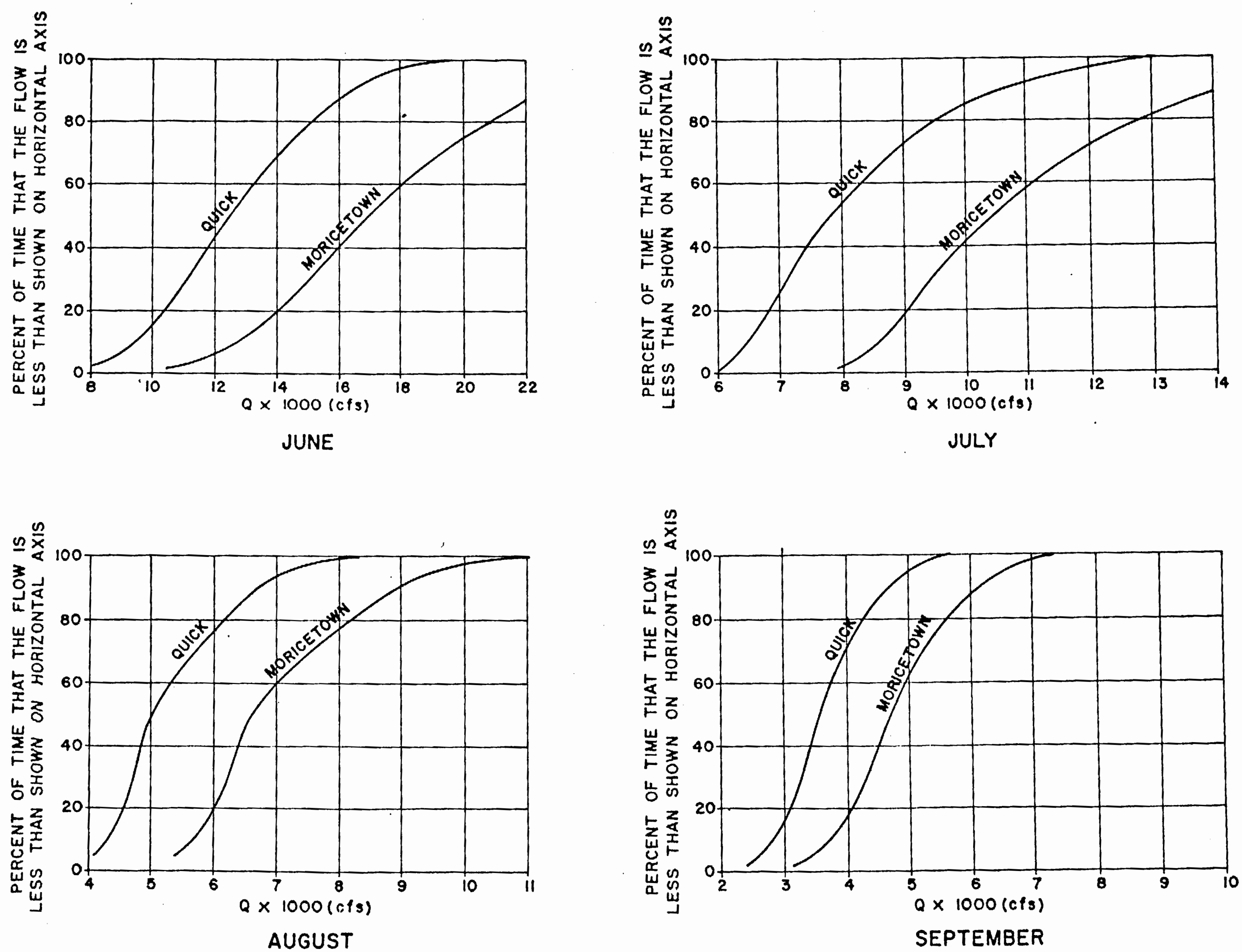


FIGURE 21. Mean monthly discharge frequency curves for the Bulkley River at Quick and Moricetown, 1931 to 1973.

Domestic and Industrial Effluent at Smithers

An inventory of sources and quantities of effluent currently being discharged into the Bulkley River at Smithers has not been conducted as part of this study. It is recommended that this assessment be carried out by either the Provincial Pollution Control Board or the Environmental Protection Service of D. O. E. Due consideration should be given to the projected population and industrial growth rates in the area.

DISCUSSION

The intent of the above environmental studies was to determine the environmental impact of the proposed Kemano II hydro-electric project relative to the salmon resource within the Morice, Nanika and Morice Lake watersheds. Legitimate concern voiced by Fisheries Service about the proposed project was not unwarranted as many of the results explicitly indicate that all anadromous species of salmon, except chum salmon, could be affected by the project. The main effect of the project appears to be "declines in salmonid productivity throughout the watersheds."

Significant populations of adult chinook, coho and sockeye occur within the systems. Hydrological and biological studies both indicated that reduction in discharges in the Nanika and Morice Rivers would reduce productivity if discharges were not maintained at 800 to 1000 cfs for a 12 to 15 week period. It was also suggested that incubation flows should not be less than 150 cfs throughout the incubation period and that regulated flows should not vary from those occurring naturally. Finally, identification of lake spawning areas in Morice Lake lends support to the serious affect of lowering or raising Morice Lake water levels on the sockeye population spawning in Morice Lake.

Juvenile salmonid studies indicated that rearing occurs within the system for as much as 2 years. With much of the rearing occurring in marginal areas, such as side channels, sloughs and backwaters, any reduction in the wetted perimeter of these areas would seriously affect salmonid productivity in these preferred areas. Some of these areas were lower Nanika River, McBride Creek, the upper Morice tributary streams, the mainstem Morice and its tributaries. Unfortunately, a significant portion of juvenile information was not obtained, thus is difficult to identify the total impact of the proposed development on the salmonid resource. Further studies will be conducted during the spring of 1975 to obtain the required information.

Moricetown Falls fishway currently assists in the upstream movement of salmon and steelhead journeying to the spawning grounds. The Kemano II project, by reducing discharges from the Morice - Nanika systems would affect the water levels at the fishway. The result would be a blockage of salmon and steelhead at this point. Modifications would be required to the fishways if water levels were reduced at the time of the upstream migration.

In conclusion, the studies and results presented in this interim report briefly point out the serious biological implications resulting from the proposed second phase of the Kemano development. Serious losses to the salmon resource occurred as a result of the Kemano I development, thus it appears appropriate to recommend that if development of Kemano II proceeds, measures must be taken to eliminate any of the possible deleterious effects on the salmonid communities. More specifically, natural flow regimes and elevations must be duplicated in every respect. Any variation beyond the normal occurring within the systems will undoubtedly result in a decline in salmonid productivity within the systems and in the total fish resource.

***