ENVIRONMENTAL STUDIES ASSOCIATED
WITH THE PROPOSED KEMANO COMPLETION
HYDROELECTRIC DEVELOPMENT

VOLUME 4

FISH RESOURCES OF THE MORICE RIVER SYSTEM
BASELINE INFORMATION

Sections B+C

Prepared for:

ALUMINUM COMPANY OF CANADA, LTD
#400 - 1285 West Pender Street
Vancouver, B.C.
V6E 4B1

Prepared by:

ENVIROCON LIMITED
#300 - 475 West Georgia Street
Vancouver, B.C.
V6B 4M9

Telephone: (604) 687-7588
Telex: 04-53476

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1.0 INTRODUCTION

This study was conducted during late October - early November 1981 to supplement data collected in 1979 describing the abundance and relative distribution of juvenile salmonids in the Morice/Bulkley Rivers. Emphasis was placed on sampling side channel habitat in Reach 2 and main channel sites in Reaches 1 through 6.

Earlier studies of the distribution and abundance of juvenile salmonids in the Morice River during 1979 identified Reach 2 as important rearing habitat for juvenile salmonids prior to overwintering (Section A). During 1979, coho salmon juveniles showed a strong year-round preference for side channels offering low velocities and instream cover such as debris and vegetation. Chinook salmon juveniles were distributed throughout main and side channel habitats by the fall and early winter of 1979. Steelhead trout fry and parr showed similar utilization of side and main channel locations, suggesting a widespread distribution in the various channel types throughout the year. More recent studies (1981-1982) have indicated that low winter flows play a significant role in limiting production of juvenile salmonids in side channel habitats of the upper Morice River (Section C). Since a high percentage of adult steelhead trout and coho and chinook salmon returning to the Morice River overwinter in freshwater as juveniles (Whately et al. 1978; Shepherd 1979), an understanding of the year to year variations in relative distribution of juvenile salmonids utilizing main and side channel habitats is important to assess the potential effects of the proposed Kemano Completion flow regime on juvenile salmonid rearing within the system (Volume 19).

2.0 METHODS

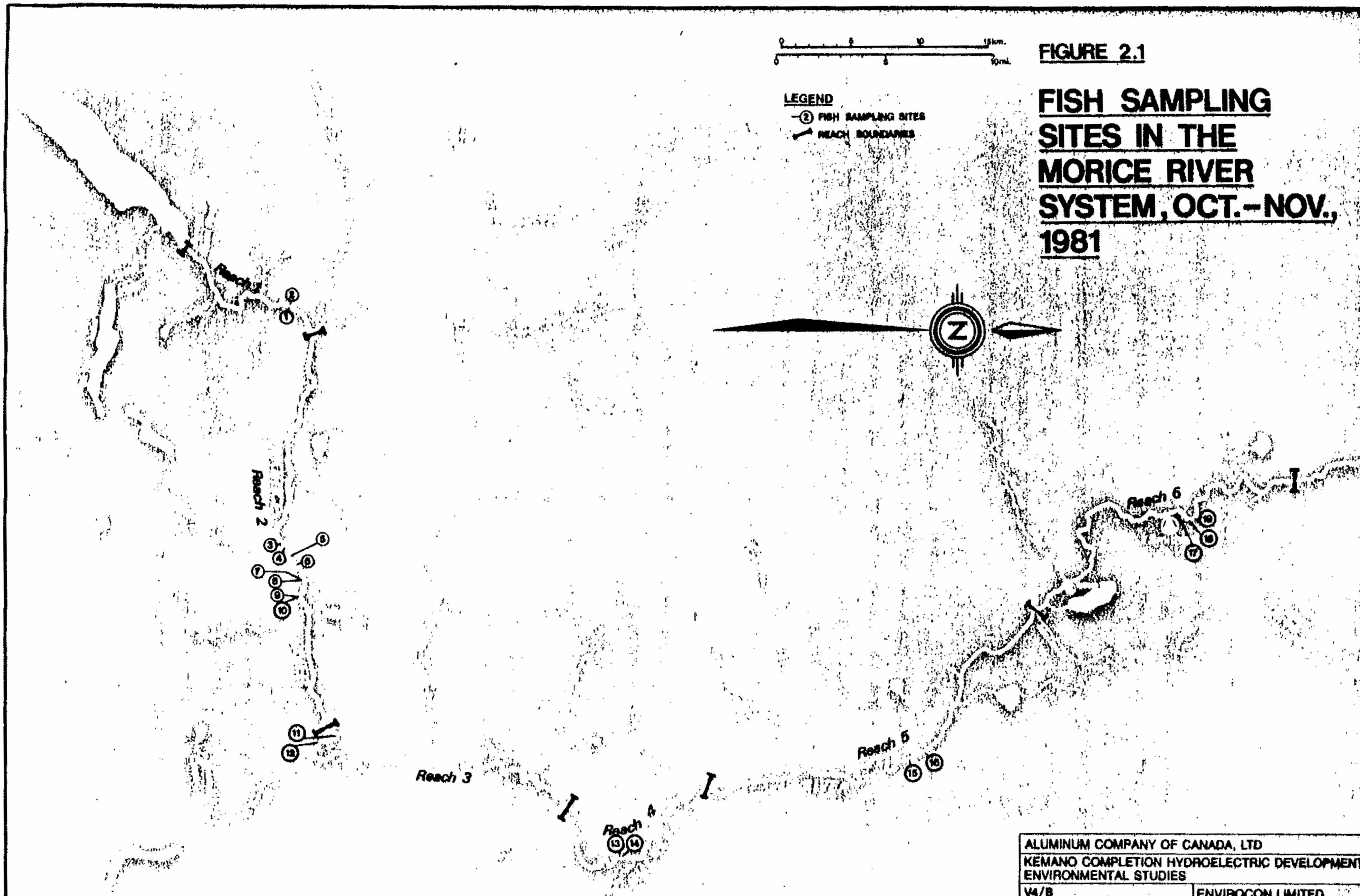
Totals of 13 main channel and 6 large side channel sites in the Morice/Bulkley Rivers from Morice Lake to Smithers (Reaches 1 to 6) were sampled during late October/early November 1981 (Figure 2.1). In addition, 4 small side channels in Reach 2 were sampled in a concurrent study (Section C) and the results of that study are included here.

Smith-Root Type VII electrofishers were used to sample fish abundance at each site and population sizes were estimated using the multiple pass removal method (DeLury 1951). To minimize fish movement out of the sampling area and to determine the area sampled, a 30m x 2.5m beach seine with 6mm mesh was attached to steel rods and positioned in a semi-circle from the shore. In small side channels, stop nets at each end of the sampling site prevented fish from moving out of the area. All fish captured were enumerated by species and life stage and fork length was measured to the nearest millimeter. Habitat characteristics including type (riffle, pool, run, flat, back eddy), and area (m^2) of hydraulic unit sampled, type and abundance of cover, substrate composition, and water temperature were recorded at each sampling site.

Main channel and large side channel population estimates were doubled at each site to account for both shoreline margins and expressed as fish per length of stream margin. Population estimates from small side channels were not doubled since it was assumed fish populations could utilize the entire width of the channel. Since extensive sampling of fish populations in side channel habitats was restricted to Reach 2 in this study, population estimates in side channels of other reaches were calculated based on main:side channel catch ratios from those reaches in September 1979 (Section A). For example, if coho salmon juveniles in Reach 3 had a main channel to side channel catch ratio of 1:3 in 1979, then the Reach 3 main channel catch from this study was multiplied by 3 to give the side channel coho population estimate. This extrapolation is a rough estimate and should be considered accordingly.

FIGURE 2.1

FISH SAMPLING SITES IN THE MORICE RIVER SYSTEM, OCT.–NOV., 1981



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3.0 RESULTS

Of a total of 1,352 juvenile fish captured in the Morice/Bulkley Rivers during late October - early November 1981, coho salmon juveniles (0+ and 1+) comprised 39.9% (539) (Table 3.1). Steelhead trout fry (0+) and parr (1+ and greater) comprised 23.6% (319) and 5.5% (75) of the total, respectively (Table 3.1). Juvenile chinook salmon (0+) represented 11.4% (154), and prickly sculpins, Rocky Mountain whitefish, Dolly Varden char, longnose dace and Pacific lamprey comprised the remaining 19.6% (265). Generally, steelhead trout and chinook salmon juveniles were slightly smaller in November 1981 than during a similar period in 1979, while coho salmon juveniles (0+) were of a similar size (Appendix B2).

Steelhead trout fry were in highest densities in Reaches 5, 4 and 2 (Table 3.2). Weighting these data to reach length indicated that fry were most abundant in side channel and main channels of Reach 2 in the upper Morice River and in the main channel of Reaches 4 and 5 in the lower Morice/Bulkley Rivers (Table 3.3). Margin areas of both shorelines with gravel/cobble substrate were most frequently utilized by steelhead trout fry. Steelhead trout fry were probably also utilizing side channel habitats in Reaches 3, 4 and 5 although these areas were not sampled. Extrapolation from 1979 main:side channel catch ratios indicated that Reach 1 side channels were probably used extensively by steelhead fry (Table 3.3; see also Appendix B1, Table B1.2). Comparison of total catches corrected for channel length indicated that approximately 71% of the steelhead trout fry reared in Reaches 2 and 5 (Table 3.3).

Steelhead trout parr were in greatest densities and most abundant in main channels of Reach 5 in the lower Morice/Bulkley Rivers and in the main and side channels of Reach 2 in the upper Morice River (Tables 3.2 and 3.3). Areas with coarse substrate and abundant cover in the form of log debris were most often utilized. Comparison of total catches corrected for channel length indicated that Reaches 2 and 5 accounted for the majority (71%) of steelhead trout parr (Table 3.3; Appendix B1, Table B1.3). More recent studies conducted in the Morice River main channel indicated that steelhead trout parr catches increased progressively from the upper river to the lower river, and that areas of the main channel offering gravel/cobble substrate and overhanging vegetation or log debris were most often used (Section F).

Coho salmon juveniles were in highest densities and most abundant in main and side channels of Reach 2 in the upper Morice River (Tables 3.2 and 3.3). Side channel areas offering deep pools, gravel-cobble substrate and abundant log debris or overhanging vegetation were heavily utilized by coho juveniles. Main channel areas most often

TABLE 3.1
Summary of Electrofishing Catches in Reaches 1 - 6
of the Morice/Bulkley Rivers During
Late October - Early November 1981

Species			
Common Name	Scientific Name	Numbers Captured	Percent of Total Species Captured
Steelhead trout fry	Salmo gairdneri	319	23.6
Steelhead trout parr	Salmo gairdneri	75	5.5
Coho Salmon	Oncorhynchus kisutch	539	39.9
Chinook Salmon	Oncorhynchus tshawytscha	154	11.4
Dolly Varden char	Salvelinus malma	1	0.1
Rocky Mountain whitefish	Prosopium williamsoni	108	8.0
Longnose dace	Rhinichthys cataractae	13	1.0
Prickly sculpin	Cottus asper	3	0.2
Pacific lamprey	Lampetra tridentata	140	10.3
		1,352	100

TABLE 3.2
Densities of Juvenile Salmonids in Reaches 1 - 6 of the Morice/Bulkley Rivers During Late October - Early November 1981[1]

Reach	Channel[2] Type	Shoreline Margin Sampled (m)	Area Sampled (m^2)	Density (Fish/km) Steelhead Trout Fry	Steelhead Trout Parr	Coho Salmon Fry	Chinook Salmon Fry
1	M	32	97	187	0	187	0
2	M	64	291	1219	562	1594	2125
	LS	66	404	1030	91	1485	424
	SS[3]	1305	15000	814	231	1397	213
3	M	24	78	833	83	0	417
4	M	27	91	2148	296	148	1333
5	M	27	142	3481	593	74	1704
6	M	20	95	600	100	0	400
	LS	34	56	59	176	0	647

1 Based on population estimates doubled to include both margins for mainstem and large side channel sites

2 M = Main Channel
LS = Large Side Channels
SS = Small Side Channels

3 From Section C. Population estimates were extrapolated from the area sampled to the total area sectioned off by fences in all study side channels. Population estimates were then converted to fish/km based on shoreline distance between fences in all study side channels. Note: Shoreline margin and area sampled are **total** distance and area between fences and not that sampled

TABLE 3.3
Abundance of Juvenile Salmonids in Reaches 1 - 6 of the Morice/Bulkley Rivers During Late October - Early November 1981[1]

Population Estimate (in 1,000's) Weighted to Channel Length

Reach	Channel Type	Steelhead Fry Numbers	Steelhead Fry %	Steelhead Parr Numbers	Steelhead Parr %	Coho Numbers	Coho %	Chinook Numbers	Chinook %
1	Main	2.9	6.7	0	6.1	2.9	5.2	0	6.1
	Side	23.6		5.3		16.8		14.4	
2	Main	41.2	39.6	19.0	44.8	53.9	62.2	71.8	47.2
	Side	115.9		20.2		181.1		40.0	
3	Main	23.2	6.6	2.3	3.8	0	2.1	11.6	5.2
	Side	3.2		1.1		8.0		0.7	
4	Main	38.9	11.1	5.4	11.7	2.7	8.1	24.1	10.2
	Side	5.2		4.9		28.1		0	
5	Main	121.8	31.2	20.8	26.5	2.6	6.9	59.6	25.3
	Side	1.8		2.5		23.4		0.4	
6	Main	18.7	4.7	3.1	7.1	0	15.5	12.5	6.0
	Side	0		3.1		58.6		1.8	

1 See Appendix B1, Tables B1.2 - B1.6 for calculations

used by coho salmon juveniles were those with low velocities and abundant log debris cover. More recent studies have indicated that pond areas adjacent to the main river in Reach 2 are also used extensively for rearing by coho juveniles (Section D). Extrapolation from 1979 main:side channel catch ratios to 1981 catches suggests that side channels of all reaches provide important rearing habitat for coho juveniles. Comparison of total catches corrected for channel length indicated that Reach 2 accounted for the majority (62%) of coho salmon juvenile rearing (Table 3.3; Appendix B1, Table B1.4).

Chinook salmon juveniles were in highest densities in the main channels of Reaches 2, 4 and 5 (Table 3.2). Margin areas of the mainstem offering large cobble/boulder substrate at the base of runs or pools were most often used by chinook salmon fry. Based on 1979 main:side channel catch ratios, side channels of Reach 1 likely provide rearing habitat for chinook juveniles. Catches weighted to reach length indicated that chinook salmon fry were most abundant in the main channel of Reaches 2 and 5 and side channels of Reach 2 (Table 3.3). Comparison of total catches corrected for channel length indicated that Reach 2 accounted for approximately 47% of the chinook salmon rearing, while Reaches 4, 5 and 6 of the lower Morice/Bulkley Rivers together comprised approximately 42% of the total (Table 3.3; Appendix B1, Table B1.5).

4.0 DISCUSSION

Sampling efficiency during 1981 was increased by using stop nets to minimize the movement of fish out of the sampling area and by using the multiple-pass removal method of electrofishing in both main and side channel habitat. Sampling during 1981 was concentrated in main channel habitat in Reaches 1 to 6 and side channels of Reach 2, whereas 1979 sampling effort was more uniform throughout the various channels of all reaches. Although sampling effort was concentrated in different areas during 1979 and 1981, the importance of Reach 2 in the upper river for juvenile salmonid rearing prior to overwintering is readily apparent.

Most steelhead trout fry rearing occurred in the upper Morice River (Reaches 1-3) during 1979 and 1981 (Figure 4.1). Reach 2, which contains approximately 126 km of side channel habitat, accounted for a greater percentage of steelhead trout fry rearing than any other reach during both years of sampling. Both main and side channel habitats in Reach 2 were important for fry rearing. The main channel of Reach 5 in the lower Morice/Bulkley Rivers was also important for steelhead trout fry rearing during 1981 (Appendix B1, Table B1.2). Although side channel habitat in most reaches was not sampled during 1981, the concentration of steelhead trout fry rearing in the multi-channelled Reach 2 for both years indicates the importance of side channel habitat for steelhead fry rearing.

Steelhead trout parr were more evenly distributed throughout the Morice/Bulkley Rivers. However, as with steelhead fry, Reach 2 was utilized more extensively by parr than any other reach during both years of sampling (Figure 4.1). Main and side channels were important areas for steelhead parr rearing during 1979. In 1981, main channel areas had a higher abundance of steelhead than side channels. Although the area sampled in 1981 was small, this apparent shift of parr rearing into main channel habitat during 1981 may reflect a higher main channel sampling efficiency rather than a change in parr rearing habitat.

Most juvenile coho salmon rearing occurred in the approximately 126 km of side channels in Reach 2 of the upper Morice River during both years of sampling (Figure 4.1). Although side channel habitat in other reaches was not sampled (except Reach 6) during 1981, extrapolation from 1979 main channel to side channel catch ratios suggests that side channel habitat in other reaches could account for considerable additional coho rearing (Appendix B1, Table B1.4).

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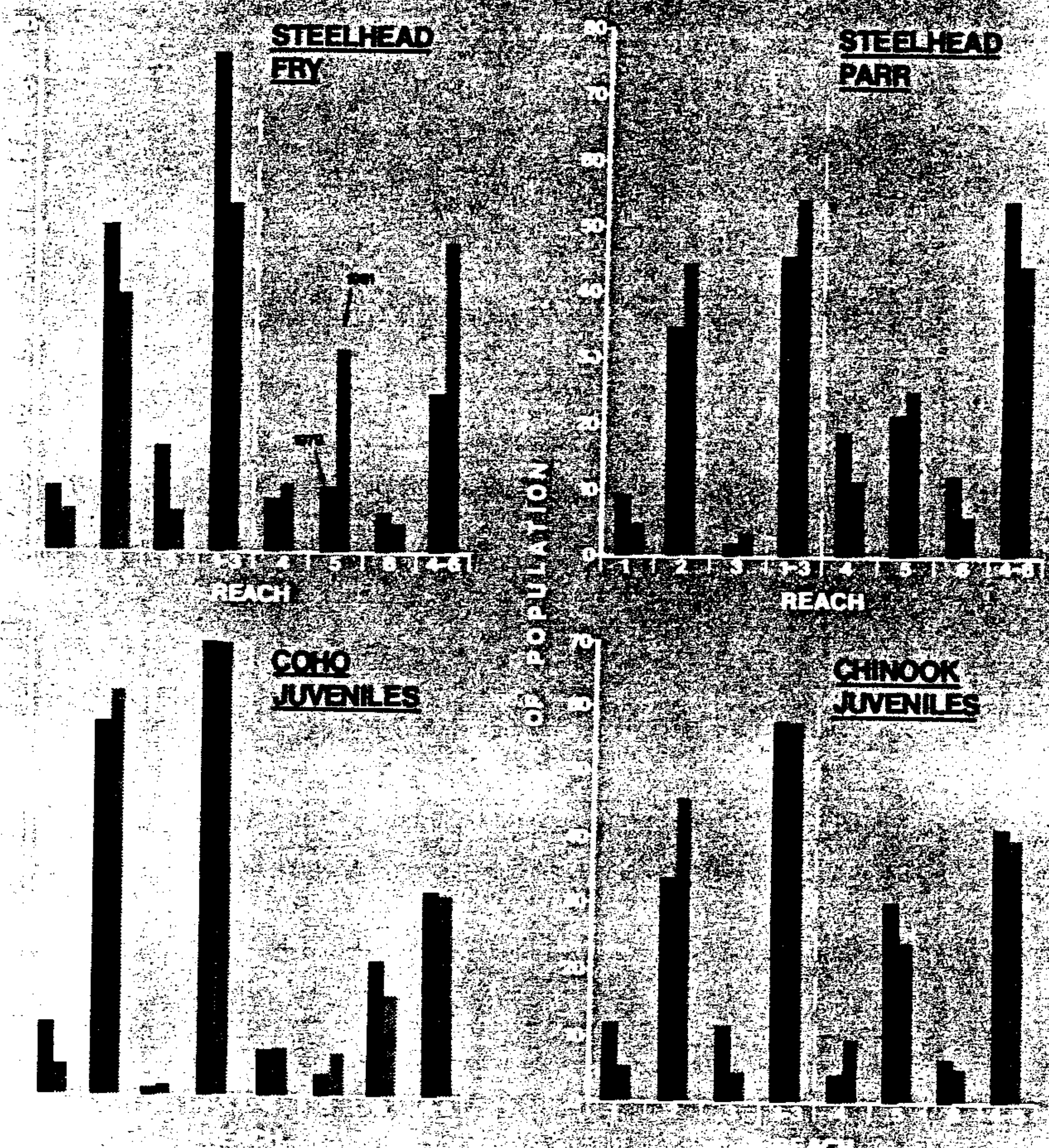
FIGURE 4.1: COMPARISON OF JUVENILE SALMONID DISTRIBUTION IN THE MORICE/BULKLEY RIVERS, LATE SEPT./NOV., 1979 AND OCT., 1981



Chinook salmon juveniles were distributed throughout the Morice and Bulkley Rivers during both years of study (Figure 4.1). As with steelhead trout fry and parr, and coho salmon juveniles, Reach 2 accounted for the majority of chinook juveniles compared to the other reaches. Main channel habitat was utilized more than side channel habitat during 1981. The main channel of Reach 5 in the lower Morice/Bulkley Rivers also provided important rearing habitat for chinook juveniles.

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APPENDIX B1

Catches, Population Estimates and Distribution of Juvenile Steelhead Trout, and Coho and Chinook Salmon in the Morice/Bulkley Rivers, October - November 1981

TABLE BI.I
Summary of Population Estimates Within Area Sampled with Multiple-Pass Removal Electrofishing from the Morice/Bulkley Rivers During October-November 1981

Reach	Channel Type[1]	Margin Sampled (m)	Area Sampled (m^2)	Steelhead Trout Fry	Steelhead Trout Parr	Coho	Chinook
1	M	32	97	3 (.031)	0	3 (.031)	0
2	M	64	291	39 (.134)	18 (.062)	51 (.175)	68 (.234)
	LS	66	404	34 (.084)	3 (.007)	49 (.12[illegible])	14 (.035)
	SS[2]	513	3,715	198 (.053)	50 (.013)	1,086 (.292)	59 (.016)
	x̄		44[illegible]	271 (.061)	71 (.016)	[illegible] (.269)	141 (.032)
3	M	24	78	10 (.128)	1 (.013)	0 (0)	5 (.064)
4	M	27	91	29	4	2	18
5	M	27	142	47	8	1	23
6	M	20	95	6	1	0	4
	LS	34	56	1	3	0	11

1 M = Main Channel
LS = Large Side Channel
SS = Small Side Channel

2 From Section C. Population estimates are for the enclosed sampling sites only

TABLE B1.2
Numbers Captured, Population Estimates and Distribution of Steelhead Trout Fry in Reaches 1 - 6 of the Morice/Bulkley Rivers During October - November 1981

Reach	Habitat[1] Type	Margin Sampled (M)	Numbers Captured	Population Estimate	Population Estimate (x2)	Fish Per km	Channel Length (km)	Population Estimate[2] Per Channel Length	Weighted Distribution (%) for All Channels
1	M	32	3	3	6	187	15.4	2880	6.7
	S	0	-	-		2,314**	10.2	23,603	
2	M	64	36	39	78	1,219	33.8	41,202	39.6
	LS	66	32	34	68	1,030 (922)	125.7	115,895	
	SS	1,305*	168	1,063*	1,063	814			
3	M	24	10	10	20	833	27.8	23,157	6.6
	S	0	-	-	-	599**	5.3	3,175	
4	M	27	20	29	58	2,148	18.1	38,879	11.1
	S	0	-	-	-	277**	18.6	5,152	
5	M	27	44	47	94	3,481	35.0	121,835	31.2
	S	0	-	-	-	148**	12.2	1,806	
6	M	20	5	6	12	600	31.2	18,720	4.7
	LS	34	1	1	2	0**	25.9	0	
							Total	396,304	

1 M = Main Channel
LS = Large Side Channel
SS = Small Side Channel
S = Side Channels (combined large and small)

Note: Small side channel fish populations are assumed to use the entire channel width, therefore population estimates were not doubled

2 Population estimates are not accurate to the nearest fish

* Extrapolated to include the entire channel length between fence traps for side channels A, B and D. Side channel C population estimates were extrapolated between the upstream and downstream sample sites

** Extrapolated based on 1979 mainstem: side channel fish population ratios

TABLE B1.3

Numbers Captured, Population Estimates and Distribution of Steelhead Trout Parr in Reaches 1-6 of the Morice/Bulkley Rivers During October-November 1981

Reach	Habitat Type[1]	Margin Sampled (M)	Numbers Captured	Population Estimate	Population Estimate (x2)	Fish Per km	Channel Length (km)	Population Estimate[2] Per Channel Length	Weighted Distribution (%) for All Channels
1	M	32	0	0	0	0	15.4	0	6.1
	S	0	-	-	-	523**	10.2	5,335	
2	M	64	10	18	36	562	33.8	18,996	44.8
	LS	66	2	3	6	91 (161)	125.7	20,238	
	SS	1,305*	45	302*	302	231			
3	M	24	1	1	2	83	27.8	2,307	3.8
	S	0	-	-	-	201**	5.3	1,065	
4	M	27	4	4	8	296	18.1	5,358	11.7
	S	0	-	-	-	261**	18.6	4,855	
5	M	27	8	8	16	593	35.0	20,755	26.5
	S	0	-	-	-	201**	12.2	2,452	
6	M	20	1	1	2	100	31.2	3,120	7.1
	LS	34	3	3	6	121**	25.9	3,134	
							Total	87,615	

1 M = Main Channel
LS = Large Side Channel
SS = Small Side Channel
S = Side Channels (combined large and small)

Note: Small side channel fish populations are assumed to use the entire channel width, therefore population estimates were not doubled

2 Population estimates are not accurate to the nearest fish

* Extrapolated to include the entire channel length between fence traps for side channels A, B and D. Side channel C population estimates were extrapolated between the upstream and downstream sample sites

** Extrapolated based on 1979 mainstem: side channel fish population ratios

TABLE BI.4
Numbers Captured, Population Estimates and Distribution of Coho Salmon Juveniles in Reaches 1 - 6 of the Morice/Bulkley Rivers During October - November 1981

Reach	Habitat Type[1]	Margin Sampled (M)	Numbers Captured	Population Estimate	Population Estimate (x2)	Fish Per km	Channel Length (km)	Population Estimate[2] Per Channel Length	Weighted Distribution (%) for All Channels
1	M	32	2	3	6	187	15.4	2,880	5.2
	S	0	-	-	-	1,643**	10.2	16,759	
2	M	64	39	51	102	1,594	33.8	53,877	62.2
	LS	66	36	49	98	1,485 (1441)	125.7	181,134	
	SS	1,305*	460	1,823*	1,823	1,397			
3	M	24	0	0	0	0	27.8	0	2.1
	S	0	-	-	-	1,513**	5.3	8,019	
4	M	27	2	2	4	148	18.1	2,679	8.1
	S	0	-	-	-	1,513**	18.6	28,142	
5	M	27	1	1	2	74	35.0	2,590	6.9
	S	0	-	-	-	1,917**	12.2	23,387	
6	M	20	0	0	0	0	31.2	0	15.5
	LS	34	0	0	0	2,262**	25.9	58,586	
							Total	378,053	

1 M = Main Channel
LS = Large Side Channel
SS = Small Side Channel
S = Side Channels (combined large and small)

Note: Small side channel fish populations are assumed to use the entire channel width, therefore population estimates were not doubled.

2 Population estimates are not accurate to the nearest fish

* Extrapolated to include the entire channel length between fence traps for side channels A, B and D. Side channel C population estimates were extrapolated between the upstream and downstream sample sites

** Extrapolated based on 1979 mainstem: side channel fish population ratios

TABLE B1.5
Numbers Captured, Population Estimates and Distribution of Chinook Salmon Juveniles in Reaches 1-6 of the Morice/Bulkley Rivers During October-November 1981

Reach	Habitat Type[1]	Margin Sampled (M)	Numbers Captured	Population Estimate	Population Estimate (x2)	Fish Per km	Channel Length (km)	Population Estimate[2] Per Channel Length	Weighted Distribution (%) for All Channels
1	M	32	0	0	0	0	15.4	0	6.1
	S	0	-	-	-	1,412**	10.2	14,402	
2	M	64	39	68	136	2,125	33.8	71,825	47.2
	LS	66	12	14	28	424 (318)	125.7	39,973	
	SS	1,305*	52	320*	320	213			
3	M	24	5	5	10	417	27.8	11,593	5.2
	S	0	-	-	-	140**	5.3	742	
4	M	27	18	18	36	1,333	18.1	24,127	10.2
	S	0	-	-	-	0**	18.6	0	
5	M	27	12	23	46	1,704	35.0	59,640	25.3
	S	0	-	-	-	35**	12.2	427	
6	M	20	4	4	8	400	31.2	12,480	6.0
	S	34	11	12	24	70**	25.9	1,813	
							Total	237,022	

1 M = Main Channel
LS = Large Side Channel
SS = Small Side Channel
S = Side Channels (combined large and small)

Note: Small side channel fish populations are assumed to use the entire channel width, therefore population estimates were not doubled.

2 Population estimates are not accurate to the nearest fish

* Extrapolated to include the entire channel length between fence traps for side channels A, B and D. Side channel C population estimates were extrapolated between the upstream and downstream sample sites

** Extrapolated based on 1979 mainstem: side channel fish population ratios

TABLE B1.6
Summary of Multiple-Pass Electrofishing in the
Morice/Bulkley Rivers During October - November 1981

									Species Captured											
									Steelhead											
									Fry			Parr			Coho Salmon			Chinook Salmon		
Date	Reach	Site	Channel[1] Type	Area Sampled (m^2)	Length Sampled (m)	Habitat Type (C°)	Water Temp.	Pass No.	n	mean length (mm)	Range	n	mean length (mm)	Range	n	mean length (mm)	Range	n	mean length (mm)	Range
Nov. 3/81	1	1	M	68.6	12.5	Flat	6.5	1	2	-	49, 53	0	-	-	1	-	68	0	-	-
								2	0	-	-	0	-	-	1	-	66	0	-	-
								3	0	-	-	0	-	-	0	-	-	0	-	-
	1	2	M	28.6	19.6	Pool	6.0	1	1	-	41	0	-	-	0	-	-	0	-	-
								2	0	-	-	0	-	-	0	-	-	0	-	-
								3	0	-	-	0	-	-	0	-	-	0	-	-
Oct. 27/81	2	3	M	105.3	18.5	Run/Flat	5.5	1	12	40.7	36-51	0	-	-	0	-	-	12	63.2	56-67
								2	3	40.3	36-43	0	-	-	0	-	-	5	61.6	58-65
								3	0	-	-	0	-	-	0	-	-	2	-	56, 62
	2	4	M	92.0	18.3	Run	5.5	1	0	-	-	3	76.7	71-84	9	71.8	61-89	2	-	68, 82
								2	4	54.5	49-58	2	-	102, 103	8	64.5	53-73	4	71.7	71-73
								3	4	44.2	38-48	0	-	-	3	67.3	55-74	2	-	78, 78
	2	5	S	114.2	17.5	Run	5.0	1	7	49.7	46-54	0	-	-	0	-	-	0	-	-
								2	4	45.0	40-51	0	-	-	0	-	-	0	-	-
								3	0	-	-	0	-	-	0	-	-	1	-	68
	2	6	S	179.4	17.5	Pool	-	1	4	44.7	40-50	1	-	84	15	57.4	50-72	6	68.5	65-72
								2	0	-	-	1	-	85	13	62.5	51-75	2	-	70, 78
								3	0	-	-	0	-	-	6	60.3	46-70	1	-	73
Oct. 28/81	2	7	S	45.3	15.8	Run	-	1	3	42.7	39-45	0	-	-	1	-	50	0	-	-
								2	1	-	40	0	-	-	0	-	-	0	-	-
								3	0	-	-	0	-	-	0	-	-	0	-	-

(Continued)

TABLE B1.6 (Continued)

									Species Captured											
									Steelhead						Coho Salmon			Chinook Salmon		
									Fry			Parr								
Date	Reach	Site	Channel[1] Type	Area Sampled (m²)	Length Sampled (m)	Habitat Type (C°)	Water Temp.	Pass No.	n	mean length (mm)	Range	n	mean length (mm)	Range	n	mean length (mm)	Range	n	mean length (mm)	Range
Oct. 28/81	2	8	S	64.9	14.9	Run	8.5	1	8	42.6	37-46	0	-	-	1	-	55	1	-	58
								2	4	40.2	32-49	0	-	-	0	-	-	2	-	63, 79
								3	1	-	42	0	-	-	0	-	-	0	-	1
	2	9	M	58.8	13.2	Pool	7.5	1	4	47.7	45-52	1	-	82	10	63.3	52-92	1	-	75
								2	1	-	47	2	-	93, 123	6	64.5	52-73	5	69.2	64-79
								3	1	-	44	2	-	81, 84	3	61.7	57-69	4	77.2	72-84
Oct. 29/81	2	10	M	62.3	14.0	Run	6.5	1	6	40.3	36-45	0	-	-	0	-	-	1	-	61
								2	1	-	49	0	-	-	0	-	-	1	-	57
								3	0	-	-	0	-	-	0	-	-	0	-	-
	3	11	M	31.4	14.6	Pool	-	1	1	-	48	1	-	89	0	-	-	0	-	-
								2	1	-	62	0	-	-	0	-	-	0	-	-
								3	2	-	39, 43	0	-	-	0	-	-	0	-	-
Oct. 30/81	3	12	M	46.5	9.5	Pool	-	1	5	46	40-54	1	-	75	0	-		3	73.7	69-77
								2	0	-	-	0	-	-	0	-	-	1	-	67
								3	1	-	51	0	-	-	0	-	-	0	-	-
								4	0	-	-	0	-	-	0	-	-	1	-	71
Oct. 29/81	4	13	M	44.8	13.4	Run	-	1	8	43.6	39-55	3	86.7	80-93	2	-	-	2	-	69, 71
								2	5	44.8	35-52	1	-	73	0	-	-	0	-	-
								3	2	-	40, 41	0	-	-	0	-	-	0	-	-
Oct. 30/81	4	14	M	46.2	13.2	Run	6.0	1	1	-	42	0	-	-	0	-	-	12	71.2	64-81
								2	3	49.3	43-56	0	-	-	0	-	-	2	-	66, 81
								3	1	-	49	0	-	-	0	-	-	2	-	70, 71

(Continued)

TABLE B1.6 (Continued)

Date	Reach	Site	Channel[1] Type	Area Sampled (m^2)	Length Sampled (m)	Habitat Type	Water Temp. (C^o)	Pass No.	Steelhead Fry n	Steelhead Fry mean length (mm)	Steelhead Fry Range	Steelhead Parr n	Steelhead Parr mean length (mm)	Steelhead Parr Range	Coho Salmon n	Coho Salmon mean length (mm)	Coho Salmon Range	Chinook Salmon n	Chinook Salmon mean length (mm)	Chinook Salmon Range
Oct. 31/81	5	15	M	59.3	12.3	Run	6.0	1	8	39.1	40-57	2	-	82, 85	1	-	66	2	-	71, 71
								2	5	44.6	41-50	0	-	-	0	-	-	2	-	63, 71
								3	0	-	-	0	-	-	0	-		2	-	63, 68
	5	16	M	82.3	14.3	Run	-	1	21	41.8	35-54	5	88.6	73-99	0	-	-	3	58.7	54-66
								2	8	39.6	35-48	1	-	77	0	-	-	2	-	64, 71
								3	2	-	40, 41	0	-	-	0	-	-	1	-	64
Nov. 2/81	6	17	S	52.9	16.3	Run	-	1	1	-	58	2	-	87, 155	0	-	-	0	-	-
								2	0	-	-	1	-	109	0	-	-	0	-	-
								3	0	-	-	0	-	-	0	-	-	0	-	-
	6	18	S	41.8	17.3	Run	-	1	0	-	-	0	-	-	0	-	-	7	69.1	59-79
								2	0	-	-	0	-	-	0	-	-	2	-	74, 77
								3	0	-	-	0	-	-	0	-	-	2	-	65, 83
	6	19	M	55.8	19.5	Pool	-	1	3	43.7	38-50	0	-	-	0	-	-	4	69.5	67-74
								2	1	-	45	1	-	74	0	-	-	0	-	-
								3	1	-	43	0	-	-	0	-	-	0	-	-

1 M = Main channel
S = Side channel

APPENDIX B2

Summary of Mean Fork Lengths of Juvenile Steelhead Trout, and Coho and Chinook Salmon Captured in the Morice/Bulkley Rivers During November 1979 and 1981

TABLE B2.1
Summary of Mean Fork Lengths of Juvenile Salmonids Captured in the Morice/Bulkley Rivers During November 1979 and 1981

Species	Year	Sample Size	Mean Fork Length (mm)	Standard Deviation (mm)
Steelhead Trout Fry (0+)	1979	52	50.0	8.9
	1981	100	44.9	5.8
Steelhead Trout Parr (1+)	1979	58	95.2	-
	1981	29	90.2	17.1
Coho Salmon Fry (0+)	1979	55	60.9	8.5
	1981	74	61.2	7.4
Chinook Salmon Juveniles (0+ and 1+)	1979	54	73.8	7.6
	1981	98	68.6	6.9

SECTION C

JUVENILE SALMONID OVERWINTER SURVIVAL IN SELECTED SIDE CHANNELS OF THE MORICE RIVER DURING 1981-1982

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1.0 INTRODUCTION

Most studies of the relationship between discharge and juvenile salmonid rearing have stressed the importance of low summer flows in limiting fish populations (Burns 1971; Shepherd 1979). Observations during field studies conducted on the Morice River in 1979 suggest that low winter flows might be a major factor limiting juvenile salmonid (chinook and coho salmon, and steelhead trout) production (Section A). As flows decline during the late fall-early winter period in the Morice system, side channels become isolated from the mainstem flows. Fish must either move out of these channels or be confined to side channel habitats which may dewater or freeze as flows decline during the winter. Stranded juveniles were found dead in dried channels in April 1979 and in frozen side channel pools in November 1979 (Section A). Mason (1974) has also suggested that winter habitat availability and winter mortality can limit the production of coho smolts in coastal streams.

A program of field studies undertaken jointly by Envirocon Limited and the Department of Fisheries and Oceans was conducted in the late fall 1981 and the early spring 1982 to determine:

(1) the importance of side channel habitats to juvenile salmonid rearing during the late fall period;

(2) whether juvenile salmonids migrate from side channel locations as flows decline during late fall; and

(3) overwinter survival of juvenile salmonids in representative side channel habitats under winter low flow conditions.

2.0 STUDY AREA DESCRIPTION

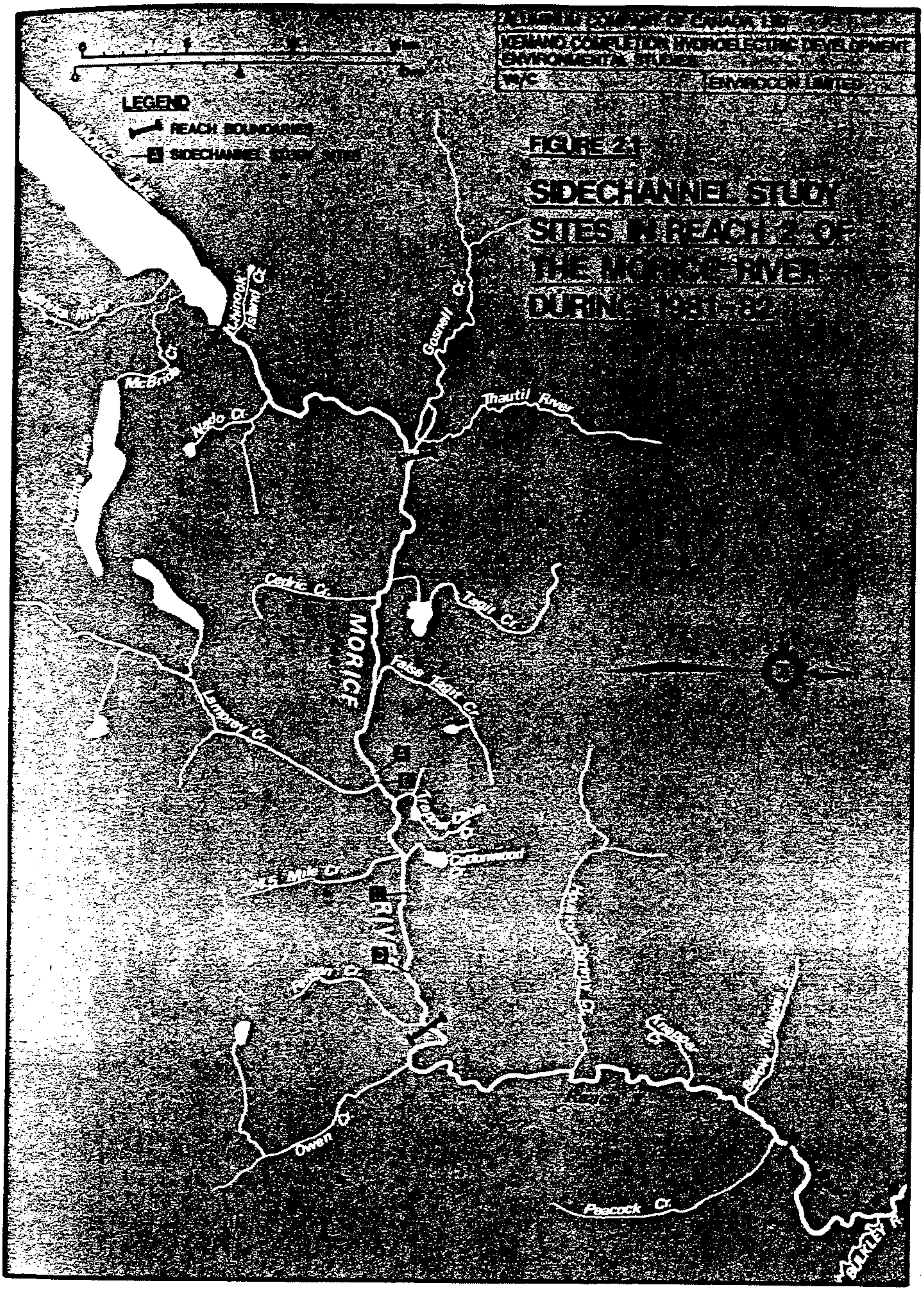
The study area included four side channels in Reach 2 of the Morice River from just upstream of Lamprey Creek to Fenton Creek (Figure 2.1). Side channels were selected to represent a range of conditions with respect to flow and cover type and abundance. Side channel selection was also governed by winter access and suitability for constructing and maintaining upstream and downstream fences on the channels. Site suitability for sampling by electrofishing was another consideration.

Side Channel A, located approximately 1.0 km upstream of Lamprey Creek, was the smallest flowing channel examined, with 2,200 m^2 of wetted area in October 1981 (Figure 2.2, Table 2.1). This channel is characterized by primarily riffle and pool hydraulic units with substrate comprising mainly gravel. Channel banks were unstable, with little overhanging vegetation, although log jams and some undercut bank area provided cover for rearing juvenile salmonids. By early April 1982, flows had ceased in Side Channel A and only three isolated pools totalling 20 m^2 (1% of October area) of wetted area remained (Table 2.1, Figure 2.2).

Side Channel B, situated parallel to Side Channel A, was the largest channel studied, with 8,600 m^2 of wetted area in October 1981 (Figure 2.2, Table 2.1). Hydraulic units were generally riffle and pool with some run and flat areas. Substrate was mainly gravel and cobble. Channel banks were stable, with little overhanging vegetation, although some log debris and cobble provided cover. By early April 1982, only seven isolated pools totalling 300 m^2 (3% of October area) of wetted area remained (Table 2.1, Figure 2.2).

Side Channel C, located approximately 5 km downstream of Lamprey Creek, had no flow but had 1,250 m^2 of isolated pools in October 1981 (Table 2.1, Figure 2.3). Pools generally had an abundance of overhanging vegetation and moderate log debris cover. Leaf litter also provided abundant cover for rearing juvenile salmonids. Substrate was predominantly gravel. By early April 1982, wetted area within the isolated pools had been reduced by 88% to 150 m^2 (Figure 2.1). Groundwater input was suspected to be sustaining the water level in the lower pool of this side channel.

Side Channel D, located approximately 5 km upstream of Fenton Creek, was the second largest channel examined, comprising 3,300 m^2 of wetted area in October 1981 (Figure 2.4, Table 2.1). Hydraulic units were characterized by numerous riffle/pool combinations with few runs. Substrate was primarily gravel, with log debris and boulders providing the majority of cover for juvenile salmonids. By early April 1982,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LEGEND
REACH BOUNDARIES
SIDECHANNEL STUDY SITES
FIGURE 2.1
SIDECHANNEL STUDY SITES IN REACH 2 OF THE MORICE RIVER DURING 1981-82
Gosnell Cr.
Thautil River
McBride Cr.
Nado Cr.
Cedric Cr.
Tagit Cr.
MORICE
False Tagit Cr.
Lamprey Cr.
Cottonwood
N.S. Mule Cr.
RIVER
Owen Cr.
Peacock Cr.
BULKLEY R.

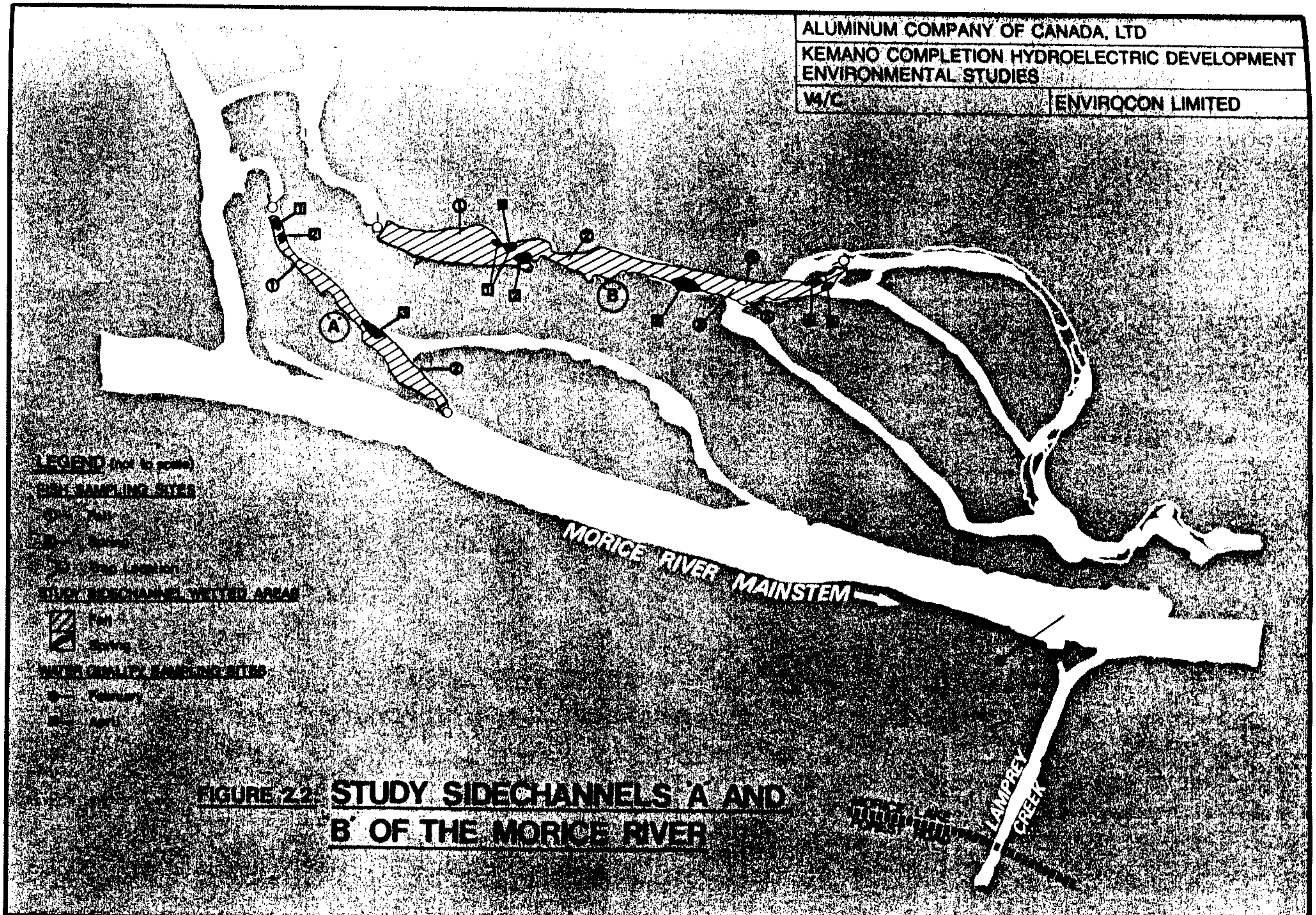

FIGURE 2.2: STUDY SIDECHANNELS 'A' AND 'B' OF THE MORICE RIVER

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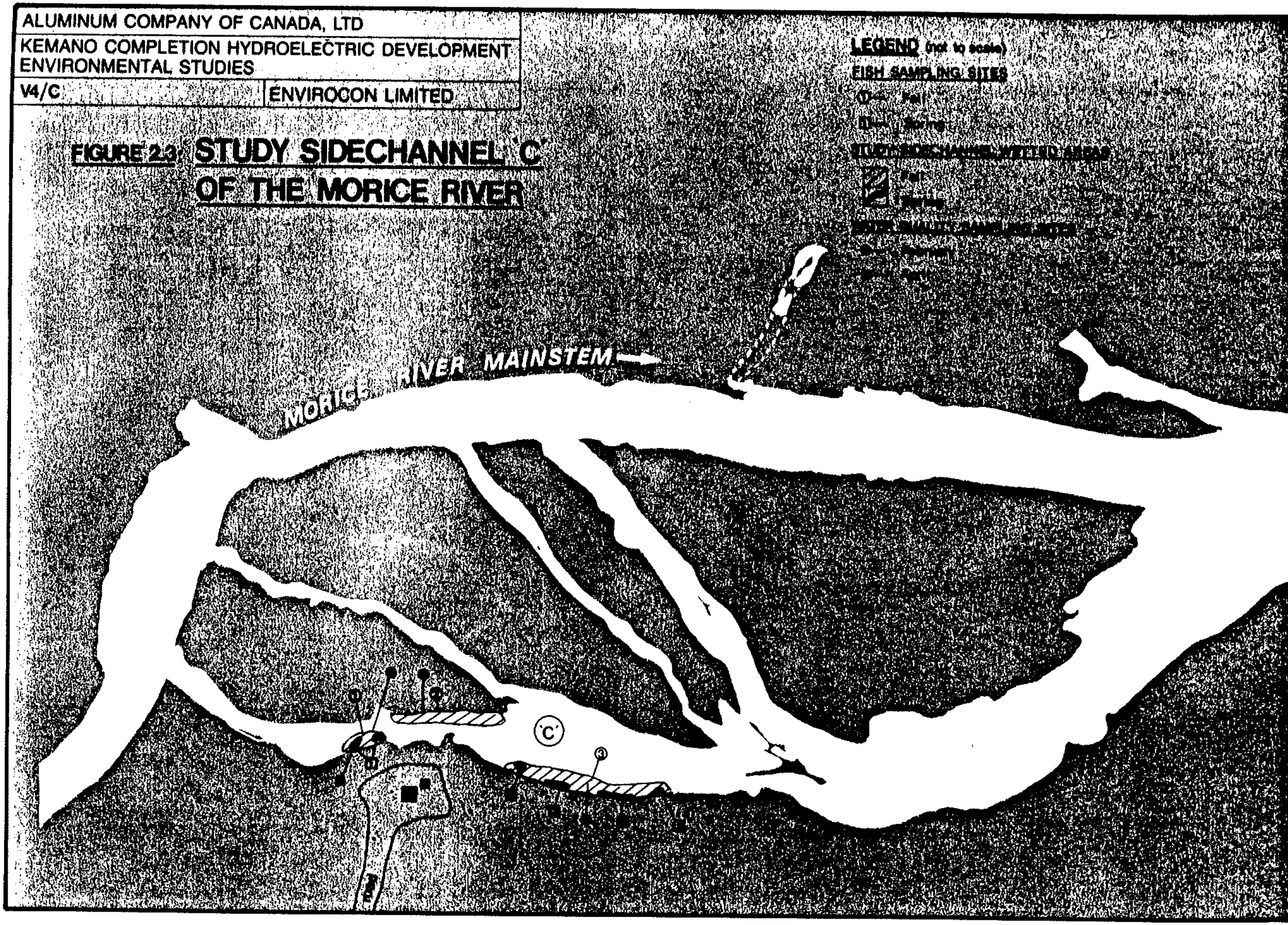

FIGURE 2.3: STUDY SIDECHANNEL 'C' OF THE MORICE RIVER

FIGURE 2.4

STUDY SIDECHANNEL 'D' OF THE MORICE RIVER

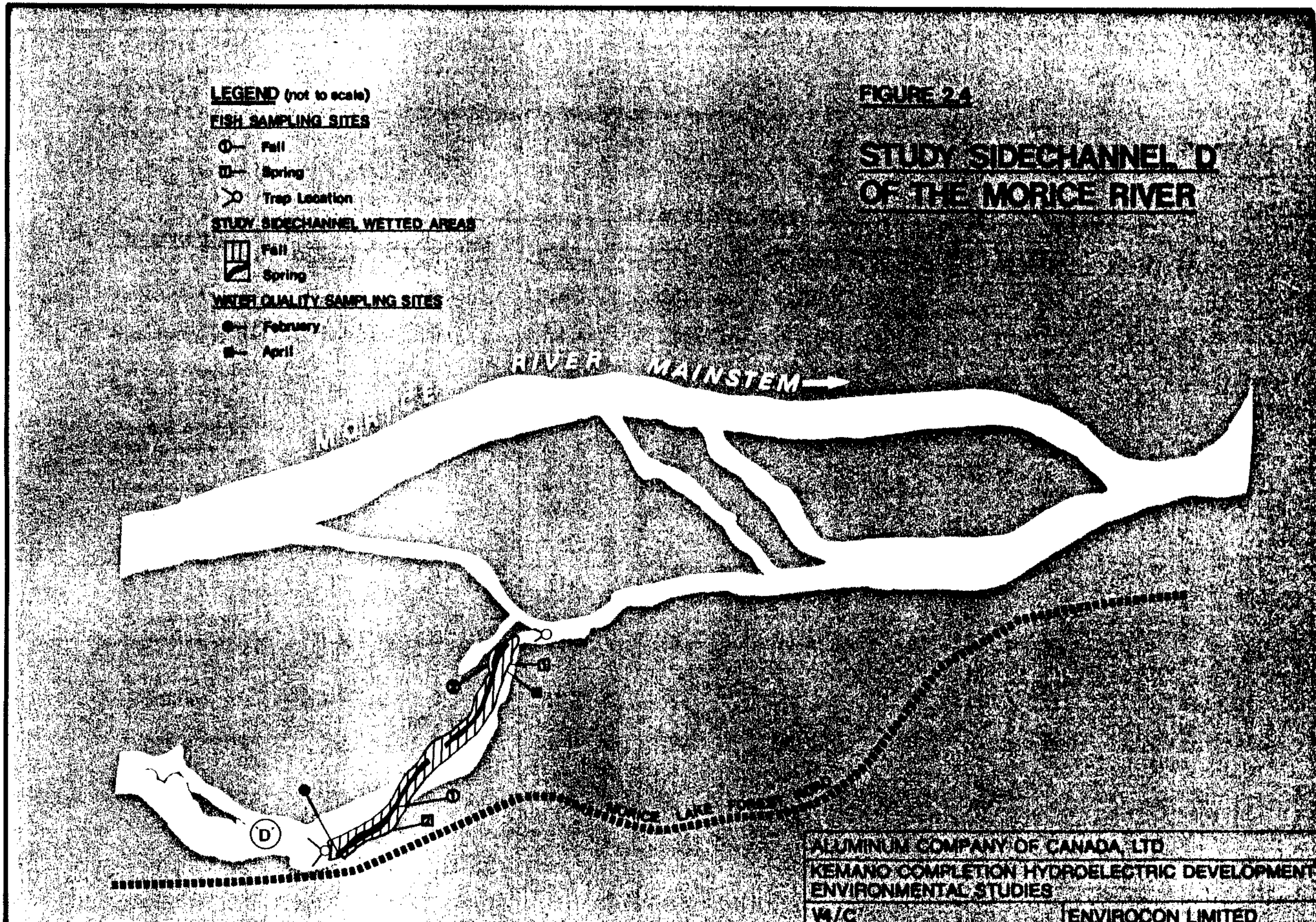

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TABLE 2.1
Physical Characteristics of Selected Side Channels in Reach 2 of the Morice River During October 1981 and April 1982

Characteristics	Selected Side Channels							
	A		B		C		D	
	October	April	October	April	October	April	October	April
Wetted Area (m^2)	2,200	20	8,600	300	1,250	150	3,300	1,500
Maximum Depth (m)	1.3	.3	1.4	.8	1.5	.3	1.4	1.0
Percent Area <0.75 m deep	80	100	90	100	70	100	75	85
Percent Area >1.0 m deep	5	0	5	0	15	0	10	5
Predominant Substrate	gravel	gravel	gravel-cobble	gravel-cobble	gravel	gravel	gravel-cobble	gravel-cobble
Cover:								
% log debris	10	20	1-5	5	10	10	5	5
% over stream vegetation	1-5	0	10	0	20-30	0	10	0
% instream vegetation	1-5	0	5	5	5	0	5	0
% cobble-boulder	1-5	0	10	0	-	0	15	1-5

3.0 METHODS

Population estimates of overwintering juvenile salmonids were calculated for all four side channels in early winter (1981) and in the following spring (1982) before flows resumed in these channels. Representative sections (12-93% of the total wetted area between fence traps) within each side channel were electrofished utilizing either the multiple-pass removal method or the mark-recapture method of estimating population sizes for each species and life stage. In shallow areas with little cover the multiple-pass removal method was used, while in deeper areas with an abundance of log debris or ice cover the mark-recapture method was used. Stop nets were employed in both methods to minimize the movement of fish out of the sample area.

Estimates of population sizes were calculated from electrofishing results (multiple-pass removal method) using Brataen's (1969) modification of DeLury's (1951) method (discussed in Ricker 1975). Confidence intervals (95%) for population estimates were calculated using a modification of DeLury's method (Appendix C1).

The Chapman (1951) modification of the Peterson method (cited in Ricker 1975) was used to calculate population sizes from the mark-recapture results. Confidence intervals (95%) for each estimate were calculated as described by Robson and Reiger (1971).

To determine the net movement of juvenile salmonids in and out of side channels during the late fall-early winter period and to correct side channel population estimates, upstream/downstream traps equipped with live boxes were placed at the inlet and outlet of Channels A, B and D (Plate 1). Wood frame fences covered with 6 mm wire mesh were angled from shore to lead fish into traps. Side Channel C did not require traps since it comprised a series of isolated pools and was totally separated from the mainstem Morice River flow throughout the study period.

Traps were operated continuously and checked daily from October 23 to December 9, 1981 and from May 3 to May 15, 1982. All fish captured were enumerated by species and life stage, and fork length was measured to the nearest mm. After December 9 and prior to May 3, flows were inadequate (based on visual observations and examination of WSC flow records) to permit fish to move in and out of the channels.

Staff gauges were installed in Channels A, B and D to determine stage. Minimum-maximum thermometers were installed in each side channel and water temperatures recorded daily during the period of trap operation to provide additional information on the physical environment during the fall-winter period.

To determine changes in water quality in side channel and mainstem habitats, water samples were collected on February 11 from Side Channels C and D and the mainstem Morice River, and on April 6 from Side Channels B, C and D and the mainstem Morice River (Figure 2.1). Samples were packed in ice and shipped within 48 hours to Chemex Laboratories in North Vancouver for subsequent determination of metals, nutrients, pH, alkalinity and conductivity. Dissolved oxygen measurements were taken at the time of water sampling using a YSI model 54A oxygen meter. Dissolved oxygen measurements were also taken during late March - early April at selected isolated pool habitats.

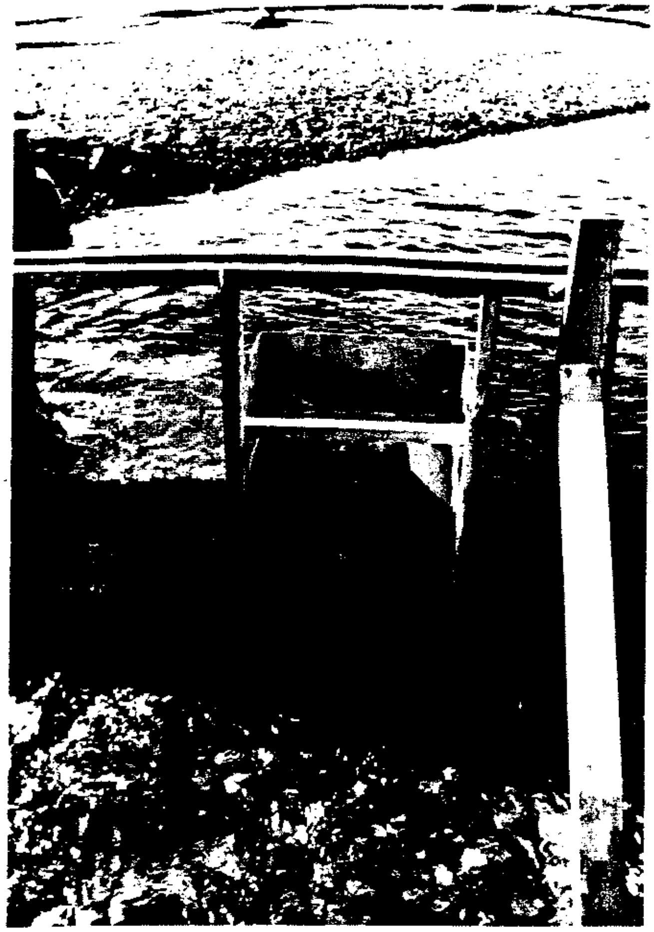

Plate 1: Fence traps equipped with live boxes in study side channels of the Morice River during October, 1981.

Upstream trap

Downstream trap

4.0 RESULTS

4.1 Movement In and Out of Side Channels

Of a total of 359 juvenile salmonids captured moving in and out of study side channels from late October - early December, 1981, chinook salmon juveniles were the only species to show substantial net movement. A total of 62 chinook juveniles, comprising approximately 16% of the estimated chinook population in the four side channels studied, moved out of the side channels into the main channel Morice River prior to freeze-up (Table 4.1; Appendix C2). Flows through side channels during that period were generally declining with water temperatures decreasing from approximately 8.0 to 0.5°C.

Some unrecorded movement of juvenile fish out of Side Channels B and D may also have occurred during mid-November and February. During a small fall freshet from November 11-13, some flow around fences in Side Channels B and D (Plate 2) allowed unrecorded movement of fish in and out of these side channels. No obvious trends in fish movement during this period were apparent from catches in those traps still operational, except for an increase in chinook salmon outmigration from Side Channel B on November 13, the first day trapping resumed. A total of 13 juvenile chinook salmon, comprising 3% of the estimated fall side channel chinook populations, left Side Channel B on that day, suggesting that other fish may have left Side Channels B and D during the previous 48 hours when traps were not operational.

As well, during a February reconnaissance of the study area, seepage flow into Side Channel D created a flowing channel around the downstream fence, allowing access to the mainstem Morice River. The potential for outmigration of fish populations during mid-winter from Side Channel D may have contributed to reduced population estimates by early spring, suggesting that overwinter survival for all species was higher than estimated for this channel.

4.2 Population Estimates and Overwinter Survival

Of a total 3,505 juvenile salmonids estimated in the study side channels in the fall, coho salmon comprised 51.9% (1,820), while steelhead fry and parr were 30.3% (1,062) and 8.6% (301), respectively (Table 4.2; Appendices C3 and C4). Chinook salmon represented the remaining 9.2% (323). Rocky Mountain whitefish, longnose dace, Pacific lamprey, Dolly Varden char and prickly sculpin comprised less than 10% of the total catch and were not included in population estimates. Side Channel C,

TABLE 4.1
Summary of Net Change in Fish Movements from Selected Side Channels of the Morice River During October - December 1981

	Fish Species							
					Steelhead Trout			
	Chinook Fry		Coho Fry		Fry		Parr	
Side Channel	Pop. Size	Net Change	Pop. Size	Net Change	Pop. Size	Net Change	Pop. Size	Net Change
A	27	-13	200	-10	124	+1	19	-2
B	278	-34	278	-7	515	-4	180	-1
C	1	0	987	0	18	0	3	0
D	78	-15	358	+14	403	+5	101	+1
Total	384	-62	1823	-3	1060	+2	303	-2

Plate 2: Study side channel D showing the additional channel (arrow) created during mid-November, 1981 flow increases.

TABLE 4.2
Population Estimates of Juvenile Salmonids in Selected Side Channels of the Morice River in October 1981

Species	Side Channel A		Side Channel B		Side Channel C		Side Channel D		All Channels	
	Number	% of Total in all Side Channels	Number	% of Total in all Side Channels	Number	% of Total in all Side Channels	Number	% of Total in all Side Channels	Number	% of Total Fish
Steelhead - fry	125	11.8	511	48.1	18	1.7	408	38.4	1,062	30.3
- parr	17	5.6	179	59.5	3	1.0	102	33.9	301	8.6
Coho	190	10.4	271	14.9	987	54.2	372	20.4	1,820	51.9
Chinook	14	4.3	244	75.8	1	0.3	63	19.6	323	9.2
All Species	346	9.9	1,205	34.4	1,009	28.8	945	27.0	3,505	100

characterized by isolated pool habitat, contained 54% of the total coho population overwintering in side channel habitats. Side Channel B, the largest of all side channels examined, comprised 48% and 59% of the steelhead fry and parr overwintering populations, respectively (Table 4.2). It also supported the majority (76%) of the overwintering chinook population in the four side channels.

As mainstem flows declined from October to May and side channels became isolated from Morice River inflow, total wetted area within side channels was reduced by 87% from 15,000 m^2 in November to 1,900 m^2 in April (Table 4.3; Figure 2.1). Side Channels A and B had the greatest reduction in total wetted area with only 1% and 3% of the wetted area remaining by the following spring, respectively. During the period of flow decline, overall fish densities increased from an average 0.23 fish/m^2 in October to 0.80 fish/m^2 in April. Side Channels A and C had the highest overall densities during April for all species combined with 5.7 fish/m^2 and 3.1 fish/m^2, respectively (Table 4.3).

Of the total 3,505 juvenile salmonids estimated in the four side channels during the fall, only 43% (1,520) survived to early May when flows through side channels resumed (Table 4.3; Appendices C3 and C4). Side Channel B had only 3% of the wetted area remaining by early spring and the lowest overall fish survival (30%). The 33% and 46% estimates of survival of juvenile salmonids in Side Channels A and C, respectively, may be high because deep pools in areas of extensive log debris made sampling difficult during the fall period when higher flows prevailed. By early May, pool areas were much shallower, allowing more efficient sampling of fish populations. Side Channel D had 45% of the wetted area remaining by early spring and the highest overall fish survival (61%). Steelhead trout parr and fry had the lowest survival of 23% and 30%, respectively, while chinook salmon juveniles had the highest overwinter survival of 61% (Table 4.3). Coho salmon survival averaged 52%.

4.3 Water Quality

Water quality in study side channels of the Morice River during February and April 1982 was generally within accepted limits set for fish culture (Sigma 1979) (Appendix C5, Table C5.2). Higher levels of several water quality values in Side Channel D, notably conductivity, hardness and dissolved solids, may be indicative of groundwater input.

Dissolved oxygen content in study side channels ranged from 0.7 to 11.2 ppm in February to March samples.

TABLE 4.3
Summary of Change in Wetted Area, Fish Densities and Juvenile Salmonid Overwinter Survival Estimates in Selected Side Channels of the Morice River During 1981-82[1]

Location	Steelhead Fry	Steelhead Parr	Coho	Chinook	All Species	Approximate Total Wetted Area (m²)[2]	Density (fish/m²)
	Numbers of Fish						
Side Channel A							
October	125	17	190	14	346	2,200	0.2
April	20	4	75	15	114	20	5.7
% Survival	**16**	**23**	**39**	**N/A**	**33**	**1%**	
Side Channel B							
October	511	179	271	244	1,205	8,600	0.1
April	54	7	178	123	362	300	1.2
% Survival	**11**	**4**	**66**	**50**	**30**	**3%**	
Side Channel C							
October	18	3	987	1	1,009	1,200	0.8
April	64	1	402	1	468	150	3.1
% Survival	**N/A**	**33**	**41**	**100**	**46**	**12%**	
Side Channel D							
October	408	102	372	63	945	3,300	0.3
April	178	56	286	59	576	1,500	0.4
% Survival	**44**	**55**	**77**	**94**	**61**	**45%**	
All Channels Combined							
October	1,062	301	1,820	322	3,505	15,000	0.23
April	316	68	941	198	1,520	1,900	0.80
% Survival	**30**	**23**	**52**	**61**	**43**	**13%**	

1 Fall population estimates have been corrected for movements in and out of the study side channels.

2 % of wetted area remaining over winter

Davis (1975) developed dissolved oxygen criteria for freshwater salmonids based on the average incipient oxygen response level of a fish community to the effects of low oxygen. Protection Level A, 7.75 ppm, is one standard deviation above the mean and represents "ideal conditions" ensuring a high degree of safety for freshwater salmonids. Protection Level B, 6.00 ppm, represents the oxygen level where the average member of a given salmonid community starts to exhibit signs of oxygen distress, and some proportion of the population is at risk if this level is sustained beyond a few hours. Protection Level C, 4.25 ppm, is one standard deviation below the mean and is the level at which a large proportion of the salmonid population may be severely affected by low oxygen if this level is sustained beyond a very few hours.

The dissolved oxygen levels (5.5-6.9 ppm) recorded in isolated pools of Side Channel C during February (Appendix C5, Table C5.1) are below Protection Level A and may have caused some stress to overwintering fish populations although no mortalities were observed. Dissolved oxygen levels in Side Channel D in February were 9.0 ppm, well above Protection Level A (7.75 ppm), and likely provided good conditions for overwintering fish. By early April, dissolved oxygen levels were low in Side Channels A and B, with the lowest recorded values (0.7 to 5.7 ppm) observed in Side Channel B. All but one of these measurements were below Protection Level C (4.25 ppm) and likely contributed to the overwinter loss of more than 100 fish in two of the three largest pools remaining in Side Channel B (Appendix C5, Table C5.1). However, oxygen levels in isolated pool #1 of Side Channel A were approximately 3 ppm and although juvenile fish appeared to be stressed, mortalities were not observed. Oxygen levels in Side Channels C and D were relatively high in April (6.6-11.2 ppm) with no observed fish mortalities (Appendix C5).

5.0 DISCUSSION

Results from the seven weeks that the traps were maintained indicate that when the data were combined for all the channels, there was a less than 1% change in steelhead fry or parr numbers, no net change in coho salmon numbers, and an outmigration of approximately 20% of the estimated chinook population. These results suggest that most juvenile salmonids do not leave these side channels with decreasing flow and water temperatures during the late fall and early winter, but remain in the vicinity of rearing areas utilized during late October.

Bjornn and Morrill (1972) suggest that in Idaho streams during the fall the number of migrating trout and salmon probably reflects the availability of suitable winter cover. This suggests that Morice River side channel locations in the late fall period probably provide adequate cover for juvenile salmonids. However, as flows decline in late winter, fish would not have the choice to leave side channels because most side channels are isolated from the mainstem river by this time.

Juvenile salmonid overwinter survival in side channels in Reach 2 of the Morice River suggests that those channels with groundwater inflow had the least reduction in wetted area through the winter period and the highest overwinter survival of juvenile fish populations. The higher overwinter survival of coho and chinook salmon compared to steelhead trout fry may be a reflection of coho and chinook juveniles' preference for deep pool habitats with log debris cover during the fall. These areas are less subject to freezing and dewatering during the winter period, and the abundant log debris provides cover during the early spring when predation from birds may occur. The shallower riffle areas occupied by steelhead trout fry are more subject to freezing and dewatering, and the lack of available cover at these sites may expose fry to greater predation during the early spring. Reasons for the poor steelhead parr survival in this study are not clear as these fish tended to occupy similar habitats to those of chinook salmon during the fall.

Observations at the study channels, particularly during late March and April, indicated that stranding and freezing of juvenile fish, low dissolved oxygen levels and predation on juvenile fish by birds contributed to overwinter fish losses in the side channels.

Stranding of juveniles in isolated pools which subsequently dewatered in the spring occurred in all side channels except Side Channel D, which had the least reduction in wetted area of all channels. Observations during March and April suggested that groundwater from adjacent slopes was seeping into the upper end of Side Channel D and the lower end of Side Channel C. During initial site selection, groundwater seepage was not identified since this input was masked by far greater flows from the mainstem Morice River. Overwinter survival of juvenile salmonids was higher in these two channels than in Side Channels A and B which did not have any groundwater input. Side Channels A and B also had the greatest reductions in wetted areas with consequent higher numbers of stranded fish.

During clear cold periods in early winter and spring, shallow pools not covered with ice and insulated by snow can freeze to the bottom with resulting fish mortalities. Widespread incidences of this were observed in November 1979 throughout side channels in the Morice and Nanika Rivers (Section A). However, during the 1981-82 study period, freezing did not appear to be a significant mortality factor.

Oxygen levels during late winter in some isolated pools of Side Channels A and B were below 4.16 ppm (Protection Level C, Davis 1975), the level at which a large proportion of a given salmonid population may be severely affected. This may have been responsible for some winter losses of juvenile fish populations. Upon removal of 15 cm of ice cover from two of the three pools remaining in Side Channel B, all fish were decomposed, suggesting that mortalities had occurred earlier in the winter. Benthic invertebrate fauna and lamprey ammocoetes in these pools had moved out of the bottom silts and were very active, apparently under stress. Depressed winter oxygen levels beneath ice cover have been found in two Yukon rivers and attributed in part to respiration of aquatic and benthic flora and fauna and reduction of the reaeration rate by ice cover (Albright et al. 1980; Schreier et al. 1980). The two pools in Side Channel B with winter kill had substantial accumulations of leaf litter, and oxygen concentrations in the pools probably decreased both as a result of bacterial decomposition and respiration of juvenile fish. This, in conjunction with little or no exchange of the water in the pools and the prevention of reaeration by ice cover, probably led to the low oxygen levels resulting in fish mortalities.

Juvenile fish in other isolated pools of Side Channels A and B survived, but they were darker in colour and more agitated in their movements than fish in areas with higher oxygen levels, suggesting that they were stressed. Fish captured in these areas during spring population sampling were sensitive to handling. Davis (1975) reports that, for a variety of species, dissolved oxygen concentrations below 5 ppm have deleterious effects on swimming ability, respiration, circulatory dynamics, metabolism and behaviour, and that in some cases the threshold response level was above 5 ppm. Schreier et al. (1980) suggest that natural oxygen concentrations below 5 ppm in the late winter are a widespread phenomenon in northern environments.

Winter kill does not occur every year in these pools. Side Channel B was sampled in late April 1979, and over 120 juveniles were captured, with no evidence of winter mortalities. One explanation for this difference may be the occurrence of a fall freshet capable of moving leaf litter out of these side channels which occurred prior to the winter in 1978 but not in 1981. This would have reduced oxygen consumption and severe depletion would not have occurred.

Oxygen concentrations in Side Channels C and D exceeded 6 and 10 ppm dissolved oxygen during the March-April period, suggesting that oxygen depletion was not a problem for overwintering fish in these two channels. These channels had more seepage inflows during the winter resulting in open water areas and thus higher oxygen levels.

Predation on juvenile fish, particularly by birds, may also have contributed to overwinter losses of fish populations in side channels. An isolated pool of Side Channel A was sampled shortly after the ice had melted (April 12, 1982) and again on April 28 before flows had connected the pool to the mainstem river. During this period, fish populations decreased from 159 to 59 fish in this pool. The large reduction in fish numbers was probably the result of bird or small mammal predation since oxygen levels (6-7 ppm) were not in the lethal range and there were no apparent mortalities in the initial sampling. The maximum depth in this pool was 15 cm and available cover was sparse. The most likely predators were mergansers, since over 50 were observed on a 25 km section of the Morice River during this period. Elson (1962) found that, under suitable conditions, mergansers can take a heavy toll of juvenile fish populations.

6.0 SUMMARY

Of a total 359 juvenile salmonids captured moving in and out of study side channels from late October - early December 1981, chinook salmon were the only species to show a substantial net movement. A net total of 62 chinook juveniles, comprising approximately 16% of the estimated chinook population in the four side channels, moved into the main channel Morice River prior to freeze-up.

Of a total 3,505 juvenile salmonids estimated in the four side channels during the fall, coho salmon comprised 52% (1,820), while steelhead trout fry and parr were 30% (1,062) and 9% (301) of the total, respectively. Chinook salmon represented the remaining 9% (323). As flows declined during the early winter period and side channels became isolated from the main channel flow, total wetted area within side channels was reduced by 87% from 15,000 m^2 to 1,900 m^2. Only 43% (1,520) of the juvenile fish overwintering in side channel habitats survived to early May when flows through side channels resumed. Side Channels A and B, which had only 1% and 3% of the total area remaining wetted by early May, had the lowest overall survivals of 33% and 30%, respectively. Side Channels C and D, which had groundwater inflow and had 12% and 45% of the total area remaining wetted by early May, had the highest overwinter survivals of 46% and 61%, respectively.

Steelhead trout parr and fry had the lowest overall survival of 23% and 30%, respectively, while chinook salmon juveniles had the highest overwinter survival of 61%. Chinook and coho salmon survival averaged 61 and 52%, respectively. The generally higher overwinter survival of chinook and coho salmon may result from a tendency to occupy deep pool habitats with log debris cover, rather than the shallow riffle areas with less cover occupied by steelhead fry during the fall.

Observations at the side channels, particularly during late March and April, indicated that stranding and freezing, low dissolved oxygen levels and bird predation on juvenile fish were some of the observed mortality factors affecting the survival of overwintering fish populations. The low percent overwinter survival of steelhead trout fry and parr and coho salmon juveniles would imply that low winter flows play a major role in limiting juvenile salmonid production in the Morice River.

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APPENDIX CI

Method of Calculating 95% Confidence Intervals for Population Estimates from Multiple-Pass Electrofishing Results

Electrofishing results from the multiple-pass removal method were utilized to calculate population size based on a variation of Delury's (1951) method.

In Delury's (1951) method, the population estimate is taken as the intercept of the regression line with the x-axis (c(t)), and the confidence limits of this estimate are the roots of a quadratic equation. This technique causes difficulties when the determinant of the quadratic equation is negative.

If the assumption of constant catchability is not met, the fit of the regression line to the data will be poor. This can result in a high value of P. If the absolute value of P is greater than that of the slope, the confidence intervals cannot be evaluated. This is because the evaluation of Equation 1 would give a positive (rising) slope and would therefore not intercept the x axis, meaning there would be no upper bound to the population estimate confidence interval.

To circumvent this problem a different technique was used. The intercepts of the confidence limits of the slope of the regression line with the x-axis (c(t)) were used to give the confidence limits of the population estimate. The confidence limits of the slope were calculated as follows:

$$\text{conf. Int} = \text{Slope} \pm P$$

where

$$P = t_{\alpha/2}\,\text{S.D.}\sqrt{\frac{N}{N(\sum_{i=1}^{N} c(t))^2 - (\sum_{i=1}^{N} c(t))^2}} \quad \text{(Equation 1)}$$

and where $t_{\alpha/2}$ is the tabulated t-value of the $1-\alpha$ confidence level with N-2 degrees of freedom. N is the number of passes and S.D. is the standard deviation from the regression.

If the lower bound of the population estimate confidence interval was less than the total catch, then the lower bound was adjusted to equal the total catch.

APPENDIX C2

Daily Fish Migrations in Morice River Side Channels, October to December 1981

TABLE C2.1
Daily Fish Migrations in Side Channel A, 1981

Date		Staff Gauge (cm)	Water Temp. (°C)	Species Capture: Steelhead Trout, Fry: In	Fry: Out	Fry: Net Change	Parr: In	Parr: Out	Parr: Net Change	Coho Salmon: In	Out	Net Change	Chinook Salmon: In	Out	Net Change	Rocky Mountain Whitefish: In	Out	Net Change	Total Species Net Change
October	24	-	8.0	1		+1	1		+1		1	-1				2		+2	+3
	25	-	8.0							1	1	0		1	-1	1	1	0	-1
	26	-	7.5					1	-1					1	-1	2		+2	0
	27	-	5.0				2	1	+1				1	1	0	2	3	-1	0
	28	-	7.0	1	1	0													0
	29	37.5	7.0					1	-1		1	-1							-2
	30	36.0	-					1	-1					1	-1		2	-2	-4
	31	42.5	6.5								1	-1							-1
November	01	42.5	5.0											4	-4				-4
	02	-	4.0											2	-2				-2
	03	45.5	4.5		1	-1							4	3	+1	1	1	0	0
	04	-	-											1	-1		2	-2	-3
	05	42.7	5.0								1	-1		1	-1	2	2	0	-2
	06	42.5	5.0								2	-2							-2
	07	42.5	4.0							2	3	-1	1	3	-2	1	1	0	-3
	08	43.0	5.5								1	-1	1	1	0	1	1	0	-1
	09	46.5	4.5							1		+1				1	1	0	+1
	10	48.5	5.0	1		+1	1		+1				1		+1				+3
	11	50.7	5.0					1	-1		1	-1		3	-3	2		+2	-3
	12	-	-																
	13	63.0	4.0											1	-1				-1
	14	61.3	4.0																
	15	63.0	-							1		+1	1		+1				+2
	16	53.0	4.5																
	17	54.0	4.0										1		+1	1		+1	+2
	18	60.5	4.0																
	19	55.0	4.0																
	20	55.5	4.0								3	-3							-3
	21	53.3	4.0										1		+1				+1

(Continued)

TABLE C2.1 (Continued)

Date	Staff Gauge (cm)	Water Temp. (°C)	Species Capture: Steelhead Trout: Fry: In	Out	Net Change	Parr: In	Out	Net Change	Coho Salmon: In	Out	Net Change	Chinook Salmon: In	Out	Net Change	Rocky Mountain Whitefish: In	Out	Net Change	Total Species Net Change
November 22	-																	
23	52.0	4.0																
24	54.8	3.5																
25	-																	
26	54.0	5.0																
27	-																	
28	-																	
29	38.7	3.0																
30	36.0	2.0							1		+1				6		+6	+7
December 01	37.3	2.5							3		+3				1		+1	+4
02	38.7	2.5								1	-1	1		+1	1		+1	+1
03	33.3	2.0											1	-1				-1
04	33.0																	
05	33.5	2.0								1	-1							-1
06	32.5	2.0													2		+2	+2
07	-	1.0							1		+1				1	1	0	+1
08	-																	
09	-	0.5					1	-1		3	-3		1	-1				-5
Total			3	2	+1	4	6	-2	10	20	-10	12	25	-13	27	15	+12	-13

TABLE C2.2
Daily Fish Migrations in Side Channel B, 1981

Date		Staff Gauge (cm)	Water Temp. (°C)	Species Capture: Steelhead Trout: Fry: In	Out	Net Change	Parr: In	Out	Net Change	Coho Salmon: In	Out	Net Change	Chinook Salmon: In	Out	Net Change	Rocky Mountain Whitefish: In	Out	Net Change	Total Species Net Change
October	23	-	7.0													1		+1	+1
	24	-	8.0																
	25	-	6.5								3	-3							-3
	27	-	5.5		1	-1													-1
	28	-	7.0																
	29	-	7.0																
	30	-	-																
	31	51.5	6.0																
November	01	51.5	5.0																
	02	-	4.0																
	03	52.0	5.0											4	-4				-4
	04	51.0	5.0		1	-1					1	-1		4	-4				-5
	05	51.0	4.5											2	-2		1	-1	-3
	06	51.5	5.0								1	-1							
	07	51.5	3.5								1	-1		1	-1				-2
	08	51.5	4.0																
	09	52.0	4.5																
	10	54.5	5.0											1	-1				-1
	11	55.5	5.0																
	12	-	-																
	13	62.5	4.0										3	13	-10				-10
	14	61.3	4.0										2		+2				+2
	15	63.0	-										5		+5				+5
	16	63.0	4.5																
	17	62.0	4.0										1	1	0				0
	18	61.0	4.0										1		+1				+1
	19	59.5	4.0										2		+2				+2
	20	61.0	4.0										2	2	0				0
	21	60.0	4.0										1	1	0				0

(Continued)

TABLE C2.2 (Continued)

Date	Staff Gauge (cm)	Water Temp. (°C)	Steelhead Trout Fry In	Steelhead Trout Fry Out	Steelhead Trout Fry Net Change	Steelhead Trout Parr In	Steelhead Trout Parr Out	Steelhead Trout Parr Net Change	Coho Salmon In	Coho Salmon Out	Coho Salmon Net Change	Chinook Salmon In	Chinook Salmon Out	Chinook Salmon Net Change	Rocky Mountain Whitefish In	Rocky Mountain Whitefish Out	Rocky Mountain Whitefish Net Change	Total Species Net Change
November 22	-	-																
23	56.0	3.0																
24	49.7	3.5																
25	-	-																
26	-	-																
27	-	-																
28	-	-																
29	51.0	3.0																
30	48.0	2.0																
December 01	49.5	3.0														1	-1	-1
02	50.0	2.0											1	-1		1	-1	-2
03	47.2	2.0																
04	48.0	1.5		1	-1		1	-1					1	-1				-3
05	47.5	2.5										1	12	-11				-11
06	46.5	2.0								1	-1		6	-6				-7
07	44.5	1.0		1	-1								3	-3				-4
08	-	-																
09	44.5	0.5																
Total			0	4	-4	0	1	-1	0	7	-7	18	52	-34	1	3	-2	-46

TABLE C2.3
Daily Fish Migrations in Side Channel D, 1981

Date		Staff Gauge (cm)	Water Temp. (°C)	Steelhead Trout Fry In	Steelhead Trout Fry Out	Steelhead Trout Fry Net Change	Steelhead Trout Parr In	Steelhead Trout Parr Out	Steelhead Trout Parr Net Change	Coho Salmon In	Coho Salmon Out	Coho Salmon Net Change	Chinook Salmon In	Chinook Salmon Out	Chinook Salmon Net Change	Rocky Mountain Whitefish In	Rocky Mountain Whitefish Out	Rocky Mountain Whitefish Net Change	Total Species Net Change
October	24	-	6.0																
	25	-	6.0																
	26	-	-																
	27	-	4.5											1	-1	1		+1	0
	28	25.5	4.5								3	-3		2	-2		2	-2	-7
	29	25.0	5.0		1	-1					14	-14		3	-3				-18
	30	24.5	-								1	-1	1	4	-3	2	1	+1	-3
	31	26.2	4.0							1		+1	1	1	0				+1
November	01	27.0	4.0							1	2	-1	2	7	-5				-6
	02	27.5	3.0	1		+1				3		+3	1		+1				+5
	03	27.5	4.0											3	-3	1		+1	-2
	04	27.0	3.0							1	3	-2		1	-1				-3
	05	26.5	3.0								1	-1		1	-1				-2
	06	27.0	3.5	1		+1					1	-1	2	1	+1				+1
	07	27.2	2.5																
	08	26.8	3.0										1		+1				+1
	09	27.5	3.0								1	-1							-1
	10	29.0	3.5										2		+2				+2
	11	29.7	4.0										1		+1				+1
	12	39.0	3.5														1	-1	-1
	13	42.0	3.0										1		+1				+1
	14	43.0	4.0																
	15	42.0	4.0																
	16	41.5	4.0																
	17	38.5	4.0													1		+1	+1
	18	37.0	4.0																
	19	35.3	3.0																

(Continued)

TABLE C2.3 (Continued)

Date		Staff Gauge (cm)	Water Temp. (°C)	Species Capture: Steelhead Trout, Fry: In	Out	Net Change	Steelhead Trout, Parr: In	Out	Net Change	Coho Salmon: In	Out	Net Change	Chinook Salmon: In	Out	Net Change	Rocky Mountain Whitefish: In	Out	Net Change	Total Species Net Change
November	20	35.5	3.5														3	-3	-3
	21	38.5	-																
	22	32.0	3.5													3		+3	+3
	23	30.0	4.0																
	24	28.8	3.0														1	-1	-1
	25	27.5	2.0																
	26	27.5	0.5																
	27	-	-																
	28	24.5	-											1	-1				-1
	29	24.2	1.0													1		+1	+1
	30	23.0	1.0											1	-1				-1
Dec.	01	22.5	1.5																
	02	23.8	1.0													1		+1	+1
	03	22.1	1.0													1		+1	+1
	04	23.0	1.0														2	-2	-2
	05	-	1.0							24	1	+23	1		+1	6		+6	+30
	06	22.0	3.0	3	1	+2	1		+1	1		+1							+4
	07	21.8	1.0	2		+2				10	1	+9				2		+2	+13
	08	-	0.0							1		+1		2	-2	1		+1	0
	09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Total				7	2	+5	1		+1	42	28	+14	13	28	-15	20	10	+10	+15

APPENDIX C3

Multiple-Pass and Mark-Recapture Electrofishing in Morice River Side Channels in October 1981 and April 1982

TABLE C3.1

Multiple-Pass and Mark-Recapture Electrofishing from Side Channel A of the Morice River During the Fall 1981 and Spring 1982

							Species Captured											
							Steelhead Trout											
							Fry			Parr			Coho Salmon			Chinook Salmon		
Date	Site	Area Sampled (m^2)	Habitat Type	Water Temp. (C^o)	Electro-fishing Technique[1]	Pass No.	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range
Oct. 26/81	1	497	Run/Riffle Pool	8.0	MP	1	5	46.2	37-57	3	87.3	84-90	17	59.1	52-75	4	65.6	58-73
						2	5	40.8	38-45	0	-	-	11	54.0	43-71	2	-	57, 69
						3	3	38.7	35-45	0	-	-	2	-	55, 85	0	-	-
Oct. 25/81	2	318	Run	8.0	MP	1	14	40.8	35-51	3	96.0	69-135	15	56.9	50-61	3	65.3	55-82
						2	3	40.0	39-41	0	-	-	4	58.2	48-75	0	-	-
						3	6	42.2	37-45	1	-	82.0	11	57.4	40-78	1	-	59
April 12/82	3	-	Isolated Pool	9.0	MP	1	15	47.2	39-57	21	101.9	71-168	50	66.2	56-100	9	63.0	54-73
						2	6	43.2	38-50	5	95.4	74-145	18	58.6	45-94	8	68.1	62-76
						3	7	47.7	41-60	3	87.7	85-91	8	59.1	41-91	1	-	64
April 28/82	3	10.5	Isolated Pool	-	MP	1	6	51.2	44-56	2	-	71, 93	28	56.7	46-74	7	64.1	57-73
						2	3	41.3	40-43	0	-	-	7	56.8	45-74	3	63.7	59-70
						3	1	-	42	0	-	-	2	-	44, 49	0	-	-
April 12/82	1	8.0	Isolated Pool	5.0	MR	1	7	44.1	38-51	2	-	83, 84	14	57.1	49-75	2	-	60, 64
						2	5	42.6	39-50	0	0	-	7	55.0	46-74	1	-	75
April 12/82	2	2.0	Isolated Pool	-	MR	1	1	-	45	0	-	-	0	-	-	0	-	-
						2	-	-	-	-	-	-	-	-	-	-	-	-

1 MR = Mark-Recapture
MP = Multiple-Pass

TABLE C3.2
Multiple-Pass and Mark-Recapture Electrofishing from Side Channel B of the Morice River During the Fall 1981 and Spring 1982

							Species Captured											
							Steelhead Trout											
							Fry			Parr			Coho Salmon			Chinook Salmon		
Date	Site	Area Sampled (m^2)	Habitat Type	Water Temp. (C°)	Electro-fishing Technique[1]	Pass No.	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range
Oct. 26/81	1	87.8	Pool	5.5	MP	1	12	43.7	33-65	0	-	-	2	-	55, 59	2	-	67, 71
						2	2	-	38, 44	1	-	69	3	53.0	48-56	0	-	-
						3	1	-	47	0	-	-	1	-	58	0	-	-
	2	461.2	Run	5.5	MP	1	13	44.7	39-54	8	87.2	74-92	9	58.0	49-74	17	68.0	59-81
						2	6	42.2	36-48	9	89.4	70-116	6	62.5	55-88	9	70.7	62-79
						3	3	44.3	37-49	0	-	-	6	61.3	48-70	3	62.0	60-65
	3	146.0	Flat	5.5	MP	1	1	-	41	0	-	-	0	-	-	0	-	-
						2	2	-	44, 46	0	-	-	0	-	-	0	-	-
						3	2	-	36, 44	0	-	-	0	-	-	0	-	-
						4	1	-	41	0	-	-	0	-	-	0	-	-
	4	236.7	Riffle	5.5	MP	1	7	40.0	34-46	0	-	-	0	-	-	0	-	-
						2	3	40.7	-	0	-	-	0	-	-	0	-	-
						3	0	-	-	0	-	-	0	-	-	0	-	-
	5	123.5	Pool	5.5	MP	1	8	42.4	38-48	0	-	-	0	-	-	2	-	67, 70
						2	1	-	44	0	-	-	0	-	-	0	-	-
						3	0	-	-	1	-	92	0	-	-	0	-	-
April 12/82	1	1.9	Isolated Pool	7.0	MP	1	4	47.5	44-51	0	-	-	3	66.3	65-69	0	-	-
						2	0	-	-	0	-	-	1	-	58	1	-	73
						3	0	-	-	0	-	-	0	-	-	0	-	-
	2	51.7	Isolated Pool	4.0	MP	1	3	44.7	40-51	1	-	96	1	-	53	0	-	-
						2	0	-	-	0	-	-	1	-	78	0	-	-
						3	0	-	-	0	-	-	0	-	-	0	-	-
	4	6.6	Isolated Pool	3.0	MP	1	32	47.6	38-65	2	-	78, 83	19	58.2	38-85	5	65.2	58-72
						2	2	-	42, 51	1	-	80	3	68.7	61-76	2	-	61, 71
						3	1	-	49	1	-	84	1	-	49	0	-	-

(Continued)

TABLE C3.2 (Continued)

							Species Captured											
							Steelhead Trout											
							Fry			Parr			Coho Salmon			Chinook Salmon		
Date	Site	Area Sampled (m^2)	Habitat Type	Water Temp. (C^o)	Electro-fishing Technique[1]	Pass No.	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range
	5	4.0	Isolated Pool	6.5	MP	1	2	-	42, 43	1	-	77	5	57.0	46-78	1	-	69
						2	0	-	-	0	-	-	4	38.2	43-51	0	-	-
						3	0	-	-	0	-	-	2	-	58, 68	1	-	69
April 28/82	3	200	Pool	-	MR	1	3	38.7	36-41	0	-	-	14	59.5	43-74	20	68.1	59-80
						2	6	41.0	37-45	1	-	145	29	62.9	49-78	9	72.4	59-86

[1] MR = Mark-Recapture
MP = Multiple-Pass

TABLE C3.3
Multiple-Pass and Mark-Recapture Electrofishing from Side Channel C of the Morice River During the Fall 1981 and Spring 1982

							Species Captured											
							Steelhead Trout											
							Fry			Parr			Coho Salmon			Chinook Salmon		
Date	Site	Area Sampled (m^2)	Habitat Type	Water Temp. (C^o)	Electro-fishing Technique[1]	Pass No.	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range
Oct. 24/81	1	225.0	Isolated Pool	-	MP	1	5	51.8	45-61	1	-	88	46	72.8	52-95	1	-	65
						2	1	-	53	0	-	-	32	-	-	0	-	-
						3	1	-	50	0	-	-	9	-	-	0	-	-
	2	410.9	Isolated Pool	-	MP	1	5	56.8	53-62	1	-	80	57	74.5	55-104	0	-	-
						2	0	-	-	1	-	104	25	69.5	51-85	0	-	-
						3	0	-	-	0	-	-	22	-	0	-	-	-
Oct. 24/81	3	519.6	Isolated Pool	-	MR	1	5	46.8	45-50	0	-	-	71	67.0	49-97	0	-	-
						2	0	-	-	0	-	-	53	-	-	0	-	-
April 16/82	1	39.6	Isolated Pool	2.5	MR	1	7	50.6	45-56	1	-	82	47	67.7	48-106	0	-	-
						2	5	53.4	45-64	0	-	-	49	69.4	52-100	0	-	-
	1	34.0	Isolated Pool	-	MR	1	1	-	54	0	-	-	10	78.7	69-92	1	-	62
						2	0	-	-	0	-	-	16	77.1	56-90	0	-	-
	2	1.4	Isolated Pool	-	MR	1	4	56.7	52-63	0	-	-	3	72.7	68-78	1	-	72
						2	-	-	-	-	-	-	-	-	-	-	-	-
	3	15.0	Isolated Pool	4.0	MR	1	8	51.9	43-59	0	-	-	55	60.2	49-79	0	-	-
						2	12	50.6	40-58	0	-	-	57	59.6	47-79	0	-	-
	4	61.1	Isolated Pool	-	MR	1	0	-	-	0	-	-	51	70.6	52-98	0	-	-
						2	0	-	-	0	-	-	46	66.1	54-100	0	-	-
	5	13.2	Isolated Pool	-	MR	1	1	-	49	0	-	-	6	70.2	62-90	0	-	-
						2	0	-	-	0	-	-	7	69.7	53-90	0	-	-

1 MR = Mark-Recapture
MP = Multiple-Pass

TABLE C3.4
Multiple-Pass and Mark-Recapture Electrofishing from Side Channel D of the Morice River During the Fall 1981 and Spring 1982

Date	Site	Area Sampled (m^2)	Habitat Type	Water Temp. (C^o)	Electro-fishing Technique[1]	Pass No.	Species Captured: Steelhead Trout: Fry n	Fry $\bar{x}$ length (mm)	Fry Range	Parr n	Parr $\bar{x}$ length (mm)	Parr Range	Coho Salmon n	Coho $\bar{x}$ length (mm)	Coho Range	Chinook Salmon n	Chinook $\bar{x}$ length (mm)	Chinook Range
Oct. 25/81	1	365.4	Pool/Riffle	6.0	MP	1	14	48.5	40-63	6	78.8	73-87	23	61.2	53-74	2	-	60, 63
						2	10	46.2	37-65	3	71.0	67-78	11	61.3	55-68	4	66.7	63-74
						3	5	46.8	41-51	1	-	75	8	61.1	50-68	1	-	62
	2	212.8	Run	6.0	MP	1	12	46.5	38-65	3	76.5	68-91	12	65.8	58-83	1	-	59
						2	6	46.5	39-55	2	-	73, 82	1	-	62	0	-	-
						3	6	45.8	42-49	1	-	84	3	62.7	62-63	0	-	-
April 13/82	2	719.0	Pool	6.0	MR	1	43	46.7	33-65	13	79.3	71-130	16	66.1	36-88	5	66.0	61-72
						2	28	48.7	36-64	6	96.2	74-129	12	61.0	35-79	9	59.8	40-67
April 26/82	1	313.0	Pool	-	MR	1	6	44.0	41-51	11	85.1	67-141	53	62.2	51-80	9	69.6	63-76
						2	8	49.6	40-63	8	90.1	75-149	32	60.1	51-70	4	65.7	62-71

MR = Mark-Recapture
MP = Multiple-Pass

APPENDIX C4

Population Estimates for Juvenile Salmonids in Morice River Side Channels for October 1981 and April 1982

TABLE C4.1
Side Channel A Population Estimates for October 1981 and April 1982

Fish Species	Life Stage	Year of Study	Total[1] Species Captured	Initial Population Estimate for Area Sampled	95% Confidence Intervals	Total Area Sampled (m^2)	Total Wetted Area (m^2)	Correction Factor	Corrected Population Estimate for Total Wetted Area	Net Species Change	Corrected Population Estimate for Species Migration	Percent Over-Winter Survival
Steelhead Trout	Fry	Fall 1981	36	46	-	815	2,200	2.7	124	+1	125	16.0
		Spring 1982	20	10		1	20	1	20	0	20	
				10 (MR)								
	Parr	Fall 1981	7	7	-	815	2,200	2.7	19	-2	17	23.5
		Spring 1982	4	2	2-2	1	20	1	4	0	4	
				2 (MR)								
Coho Salmon	Juvenile	Fall 1981	60	74	-	815	2,200	2.7	200	-10	190	39.5
		Spring 1982	56	38	36-40	1	20	1	75	0	75	
				37 (MR)								
Chinook Salmon	Juvenile	Fall 1981	10	10	10-14[2]	815	2,200	2.7	27	-13	14	N/A
		Spring 1982	13	10	-	1	20	1	15	0	15	
				5 (MR)								
Total Species	All Juvenile Life Stages	Fall 1981	113	137	-	815	2,200	2.7	370	-24	346	32.9
		Spring 1982	94	114	-	1	20	1	114	0	114	

1 Includes marks from previous catch in mark-recapture technique (MR)

2 90% Confidence Interval

TABLE C4.2
Side Channel B Population Estimates for October 1981 and April 1982

Fish Species	Life Stage	Year of Study	Total[1] Species Captured	Initial Population Estimate for Area Sampled	95% Confidence Intervals	Total Area Sampled (m^2)	Total Wetted Area (m^2)	Correction Factor	Corrected Population Estimate for Total Wetted Area	Net Species Change	Corrected Population Estimate for Species Migration	Percent Over-Winter Survival
Steelhead Trout	Fry	Fall 1981	62	63	62-66	1,100	8,600	8.18	515	-4	511	10.6
		Spring 1982	53	43	43-50	300	300	1	54		54	
				11 (MR)								
	Parr	Fall 1981	19	22	-	1,100	8,600	8.18	180	-1	179	3.9
		Spring 1982	7	7	-	300	300	1	7		7	
Coho Salmon	Juvenile	Fall 1981	27	34	-	1,100	8,600	8.18	278	-7	271	65.7
		Spring 1982	83	34	34-35	300	300	1	178		178	
				144 (MR)								
Chinook Salmon	Juvenile	Fall 1981	33	34	33-39	1,100	8,600	8.18	278	-34	244	50.4
		Spring 1982	39	10	-	300	300	1	123		123	
				113 (MR)								
Total Species	All Juvenile Life Stages	Fall 1981	141	153	-	1,100	8,600	8.18	1,251	-46	1,205	30.0
		Spring 1982	182	362	-	300	300	1	362		362	

1 Includes marks from previous catch in mark-recapture technique (MR)

TABLE C4.3
Side Channel C Population Estimates for October 1981 and April 1982

Fish Species	Life Stage	Year of Study	Total[1] Species Captured	Initial Population Estimate for Area Sampled	95% Confidence Intervals	Total Area Sampled (m^2)	Total Wetted Area (m^2)	Correction Factor	Corrected Population Estimate for Total Wetted Area	Net Species Change	Corrected Population Estimate for Species Migration	Percent Over-Winter Survival
Steelhead Trout	Fry	Fall 1981	17	5 (MR)								
				12	-	1,200	1,250	1.08	18	0	18	N/A
		Spring 1982	38 (MR)	64	20-108	150	150	1	64		64	
	Parr	Fall 1981	3	3	-	1,200	1,250	1.08	3	0	3	33.3
		Spring 1982	1 (MR)	1	-	150	150	1	1		1	
Coho Salmon	Juvenile	Fall 1981	124	685 (MR)	189-1181							
			191	229	220-240	1,200	1,250	1.08	987	0	987	40.7
		Spring 1982	347 (MR)	402	349-455	150	150	1	402		402	
Chinook Salmon	Juvenile	Fall 1981	1	1	-	1,200	1,250	1.08	1	0	1	100.0
		Spring 1982	21 (MR)	1	-	150	150	1	1		1	
Total Species	All Juvenile Life Stages	Fall 1981	336	935	-	1,200	1,250	1.08	1,010	0	1,010	46.3
		Spring 1982	388	468	-	150	150	1	468		468	

1 Includes marks from previous catch in mark-recapture technique (MR)

TABLE C4.4
Side Channel D Population Estimates for October 1981 and April 1982

Fish Species	Life Stage	Year of Study	Total[1] Species Captured	Initial Population Estimate for Area Sampled	95% Confidence Intervals	Total Area Sampled (m^2)	Total Wetted Area (m^2)	Correction Factor	Corrected Population Estimate for Total Wetted Area	Net Species Change	Corrected Population Estimate for Species Migration	Percent Over-Winter Survival
Steelhead Trout	Fry	Fall 1981	53	72	57-119[2]	600	3,300	5.6	403	+5	408	43.6
		Spring 1982	85 (MR)	127	81-173	1,050	1,500	1.4	178		178	
	Parr	Fall 1981	16	18	-	600	3,300	5.6	101	+1	102	54.9
		Spring 1982	38 (MR)	40	28-52	1,050	1,500	1.4	56		56	
Coho Salmon	Juvenile	Fall 1981	58	64	-	600	3,300	5.6	358	+14	372	77.0
		Spring 1982	113 (MR)	203	126-280	1,050	1,500	1.4	286		286	
Chinook Salmon	Juvenile	Fall 1981	8	14	-	600	3,300	5.6	78	-15	63	93.7
		Spring 1982	27 (MR)	42	15-69	1,050	1,500	1.4	59		59	
Total Species	All Juvenile Life Stages	Fall 1981	135	168	-	600	3,300	5.6	941	+5	945	60.9
		Spring 1982	263	412	-	1,050	1,500	1.4	579		576	

1 Includes marks from previous catch in mark-recapture technique (MR)

2 90% Confidence Interval

APPENDIX C5

Dissolved Oxygen Content and Water Quality in Morice River Main and Side Channels During Winter 1982

TABLE C5.1
Dissolved Oxygen Measurements in Side Channels of the Morice River During 1982

Date	Side Channel	Location[1]	Dissolved Oxygen (ppm)	Water Temp. (°C)	Comments
Feb. 11/82	C	Pool 1	6.9	1.0	
Feb. 11/82		Pool 2	6.9	1.0	
Feb. 11/82		Pool 3	5.5	2.0	
Feb. 11/82	D	Upper Fence	9.0	1.0	
April 4/82	A	Pool 1	3.0	2.0	
April 4/82		Pool 3	6.0	3.0	
April 6/82		Pool 3	6.7	4.0	
April 6/82	B	Pool 1	4.0	1.0	Ice cover
April 4/82		Pool 2	0.7	2.5	15 cm ice, 100+ dead fish
April 4/82		Downstream of Pool 2	3.8	5.5	Open water
April 4/82		Downstream of Pool 2	5.7	6.0	Open water
April 4/82		Downstream of Pool 2	2.6	9.0	18 fish dead 2 alive
April 4/82		Pool 3	2.5	2.5	
April 4/82		Pool 4	3.8	1.5	
April 4/82		Pool 5	4.1	4.0	
March 23/82	C	Pool 1	6.6	-	Ice cover
April 6/82		Pool 1	7.2	1.0	Ice cover
March 23/82		Pool 2	8.6	4.5	Seepage
April 6/82		Pool 2	8.0	1.0	Seepage
March 23/82		Pool 3	6.9	4.0	Seepage
April 6/82		Pool 3	7.2	3.0	Seepage
March 23/82	D	Upper fence	10.7	-	Open
March 23/82		Staff gauge	11.2	-	Ice cover
April 4/82	Mainstem	Lamprey Creek	7.8	3.0	

1 Refer to Section C, Figure 2.1

TABLE C5.2
Water Quality of the Mainstem and Side Channels of the Morice River, February 11, 1982

Parameter	Mainstem	Mainstem	Side Channel D	Side Channel D
pH (rel. units)	7.30	7.30	7.30	7.30
Nitrate/Nitrite (mg/l)	0.08	0.08	0.04	0.04
Ammonia (mg/l)	0.14	0.14	0.14	0.18
Kjeldahl Nitrogen (mg/l)	0.54	0.40	0.70	0.70
Tot. Organic Carbon (mg/l)	1	1	1	1
Sulphate (mg/l)	2.00	-	4.00	-
Total Iron (mg/l)	0.160	-	0.110	0.090

	Side Channel C			
Parameter	Pool I	Pool I	Pool I	Pool I
pH (rel. units)	7.20	7.10	7.20	7.30
Nitrate/Nitrite (mg/l)	0.11	0.11	0.12	0.12
Ammonia (mg/l)	0.04	0.01	<0.01	<0.01
Kjeldahl Nitrogen (mg/l)	1.60	1.40	0.30	0.40
Tot. Organic Carbon (mg/l)	2	2	1	1
Sulphate (mg/l)	-	-	-	-
Total Iron (mg/l)	-	-	-	-

(Continued)

TABLE C5.2 (Continued)

Parameter	Side Channel C Pool 2	Pool 2	Pool 2	Pool 2
pH (rel. units)	7.40	7.30	7.30	7.30
Nitrate/Nitrite (mg/l)	0.09	0.09	0.08	0.07
Ammonia (mg/l)	<0.01	<0.01	<0.01	<0.01
Kjeldahl Nitrogen (mg/l)	0.34	0.24	0.26	0.24
Tot. Organic Carbon (mg/l)	<1	<1	<1	<1
Sulphate (mg/l)	2.00	6.00	-	-
Total Iron (mg/l)	0.180	0.240	-	-

Parameter	Side Channel C Pool 3	Pool 3	Pool 3	Pool 3
pH (rel. units)	7.00	7.00	7.10	7.20
Nitrate/Nitrite (mg/l)	0.09	0.10	0.10	0.08
Ammonia (mg/l)	<0.01	<0.01	<0.01	<0.01
Kjeldahl Nitrogen (mg/l)	0.40	0.35	0.98	0.76
Tot. Organic Carbon (mg/l)	1	1	1	1
Sulphate (mg/l)	-	8.00	-	-
Total Iron (mg/l)	0.120	0.110	-	-

TABLE C5.3
Water Quality of the Mainstem and Side Channels of the Morice River, April 6, 1982[1]

Parameter	Mainstem	Side Channel B Pool 1	Side Channel C Pool 1	Side Channel D Pool 1
pH (rel. units)	6.65	6.75	6.45	6.50
Conductivity (umhos/cm)	50	80	45	150
Hardness (mg/l $CaCO_3$)	24.0	38.5	21.5	68.5
Alkalinity (mg/l)	21.0	35.0	19.0	69.0
Chloride (mg/l)	<0.1	<0.1	<0.1	<0.1
Dissolved Solids (mg/l)	13	37	21	67
Suspended Solids (mg/l)	<1	<1	<1	<1
Sulphate (mg/l)	<2.00	2.00	3.00	4.50
Turbidity (NTU)	0.45	1.05	0.50	0.40
Total Calcium (mg/l)	7.6	12.0	7.0	20.0
Total Magnesium (mg/l)	1.6	1.4	1.2	2.6
Total Potassium (mg/l)	0.52	0.64	0.52	0.76
Total Sodium (mg/l)	1.45	1.65	1.30	5.40
Nitrate/Nitrite (mg/l)	0.06	0.08	0.04	0.04
Ammonia (mg/l)	<0.02	0.05	<0.02	<0.02
Total SiO_2 (mg/l)	4.3	7.3	4.3	7.0
Total PO_4 (mg/l)	0.010	0.020	0.015	0.015
Total Cadmium (mg/l)	<0.001	<0.001	<0.001	<0.001
Total Chromium (mg/l)	<0.025	<0.025	<0.025	<0.025
Total Copper (mg/l)	0.001	<0.001	0.001	<0.001
Diss. Iron (mg/l)	0.040	0.140	0.060	0.020
Total Iron (mg/l)	0.100	0.350	0.200	0.090
Total Lead (mg/l)	0.004	0.003	0.006	0.008
Total Mercury (mg/l)	0.0003	0.0002	0.0003	0.0002
Total Zinc (mg/l)	0.006	0.004	0.006	0.080

1 Data for each location are means of 2 samples