BC hydro
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Report Title: Peace River Site C Development – Fisheries Habitat and Tributary Surveys 1989 Studies
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During Stage 2 of the Site C Project, studies are underway to update many of the historical studies and information known about the project.

The potential Site C project, as originally conceived, will be updated to reflect current information and to incorporate new ideas brought forward by communities, First Nations, regulatory agencies and stakeholders. Today's approach to Site C will consider environmental concerns, impacts to land, and opportunities for community benefits, and will update design, financial and technical work.

Second draft: subject to revision

PEACE RIVER SITE C DEVELOPMENT:

FISHERIES HABITAT AND TRIBUTARY SURVEYS

1989 STUDIES

Prepared for
B.C. Hydro
Environmental Resources
Vancouver, B.C.

July, 1991

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

PART I

INTRODUCTION

1.0 BACKGROUND

A survey of fish habitat in Peace River tributaries in the area between Hudson Hope and Fort St. John was conducted in the spring and fall of 1989. The study was one of three aquatic programs commissioned by B.C. Hydro to provide data which will be used in support of an Energy Certificate for a Site C dam. Information from the fisheries habitat and tributary study will be used in impact assessment and in mitigation planning.

Program objectives were as follow:

a). To provide a quantitative assessment of the aquatic habitats of the study area.

b). To examine fish utilization of tributary habitats.

c). To make a preliminary examination of possible mitigation or enhancement potentials in the tributary areas.

This report describes the results of data analysis conducted during 1989 and 1990. Other project outputs included a video record and habitat mapping of the Site C study Area.

Additional aquatic studies conducted in the Site C area for B.C. Hydro during 1989 include: an examination of fish populations in the mainstem Peace and Halfway River (Pattendon et al 1990) and a sportfishing survey (DPA Group, Inc 1990).

1.1 STUDY AREA

The fisheries habitat and tributary survey was designed to complement the other ongoing Site C aquatic programs, by examining the Peace River and its tributaries at varying intensities.

The task distribution can be summarized in three sections:

a). Mainstems
Biophysical characteristics were surveyed on the mainstem Peace River between Site C and the Peace Canyon Dam and on the lower 120 km of the Halfway River (Figure 1).

b). Tributaries
Fish species compositions and densities, as well as biophysical characteristics were examined on the Peace and Halfway River tributaries outlined in Table 1 below.

Table 1.
Fish and Habitat Sampling areas*

Maurice Creek	Lower 10.5 km
Lynx Creek	Lower 11 km
Farrell Creek	14 km
Cache Creek	20 km
Wilder Creek	to Highway 29
Moberly River	to Moberly Lake
Cameron River	Lower 5 km
Ground Birch Creek	Lower 5 km
Kobes Creek	Lower 5 km
Graham River	Lower 15 km

* see Figures 2 - 9.

c). Upper reaches.
Fish sampling and habitat typing surveys were conducted at a reconnaissance level in the upper reaches of the Graham River as well as the Colt, Blue Grave, Horseshoe, Chowade and Cypress systems.

1.2 PREVIOUS WORK IN THE STUDY AREA

A search through the B.C. Ministry of Environment files revealed that little quantitative work has been done in the study area. Most of the available habitat information was reported by Renewable Resources Consulting Services Ltd. (RRCS) who conducted surveys of the study systems for B.C. Hydro in 1974, 1975 and 1977 (RRCS 1979). More recently, Hammond (1986) conducted an angler survey. In addition, he used a series of habitat assessment models to review the likelihood of successful fish stocks within the proposed reservoir (Hammond 1987).

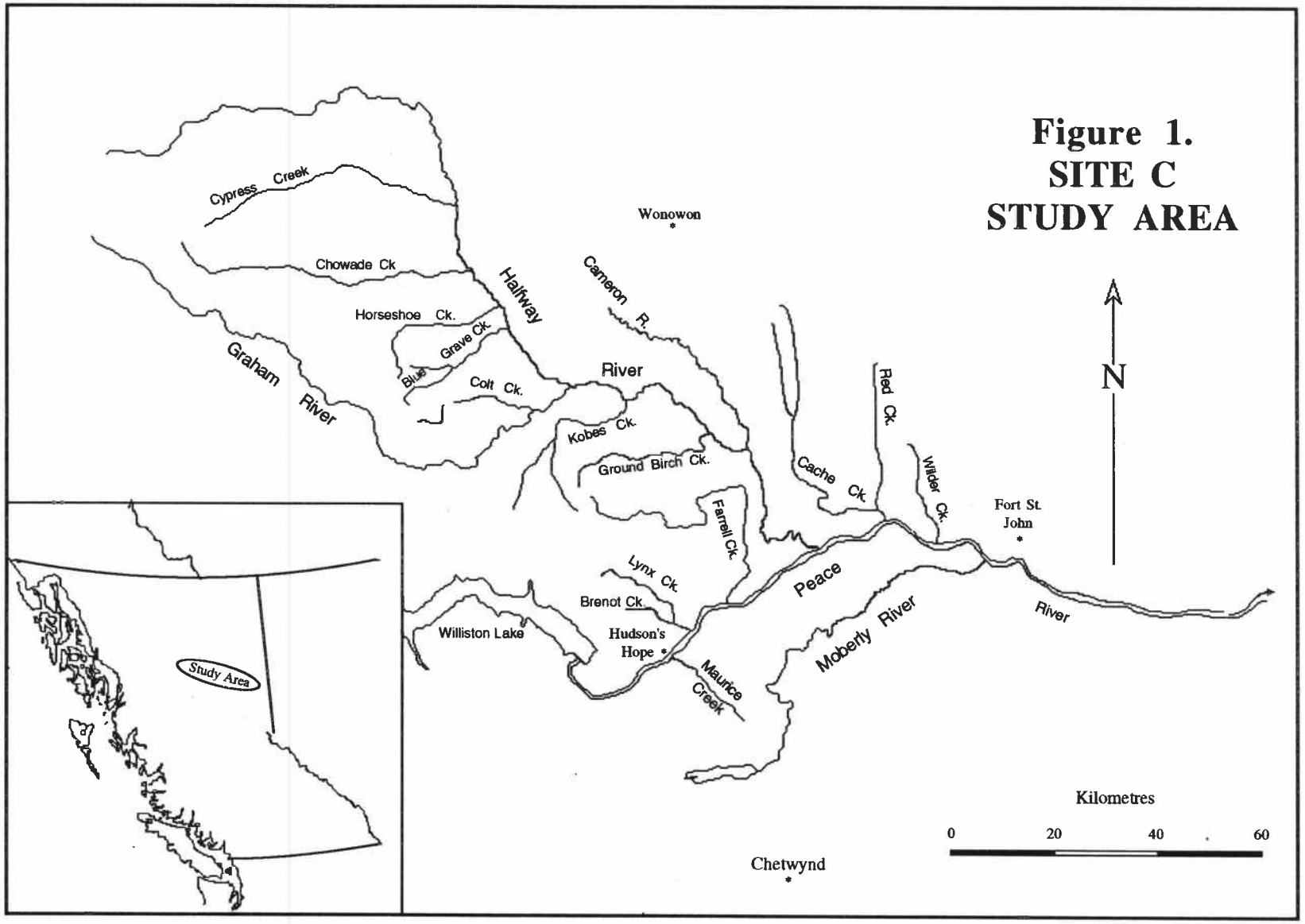
Figure 1.
SITE C
STUDY AREA
Cypress Creek
Chowade Ck
Horseshoe Ck.
Grave Ck.
Blue
Colt Ck.
Graham River
Halfway River
Wonowon
Cameron R.
Kobes Ck.
Ground Birch Ck.
Farrell Ck.
Lynx Ck.
Brenot Ck.
Williston Lake
Hudson's Hope
Maurice Creek
Cache Ck.
Red Ck.
Wilder Ck.
Fort St. John
Peace River
Moberly River
N
Kilometres
0 20 40 60
Chetwynd
Study Area

Figure 2.
Peace River

prepared for B.C. Hydro
prepared by: Aquatic Resources Limited
date: November, 1990.
digitized by: ESL Environmental Sciences Ltd.

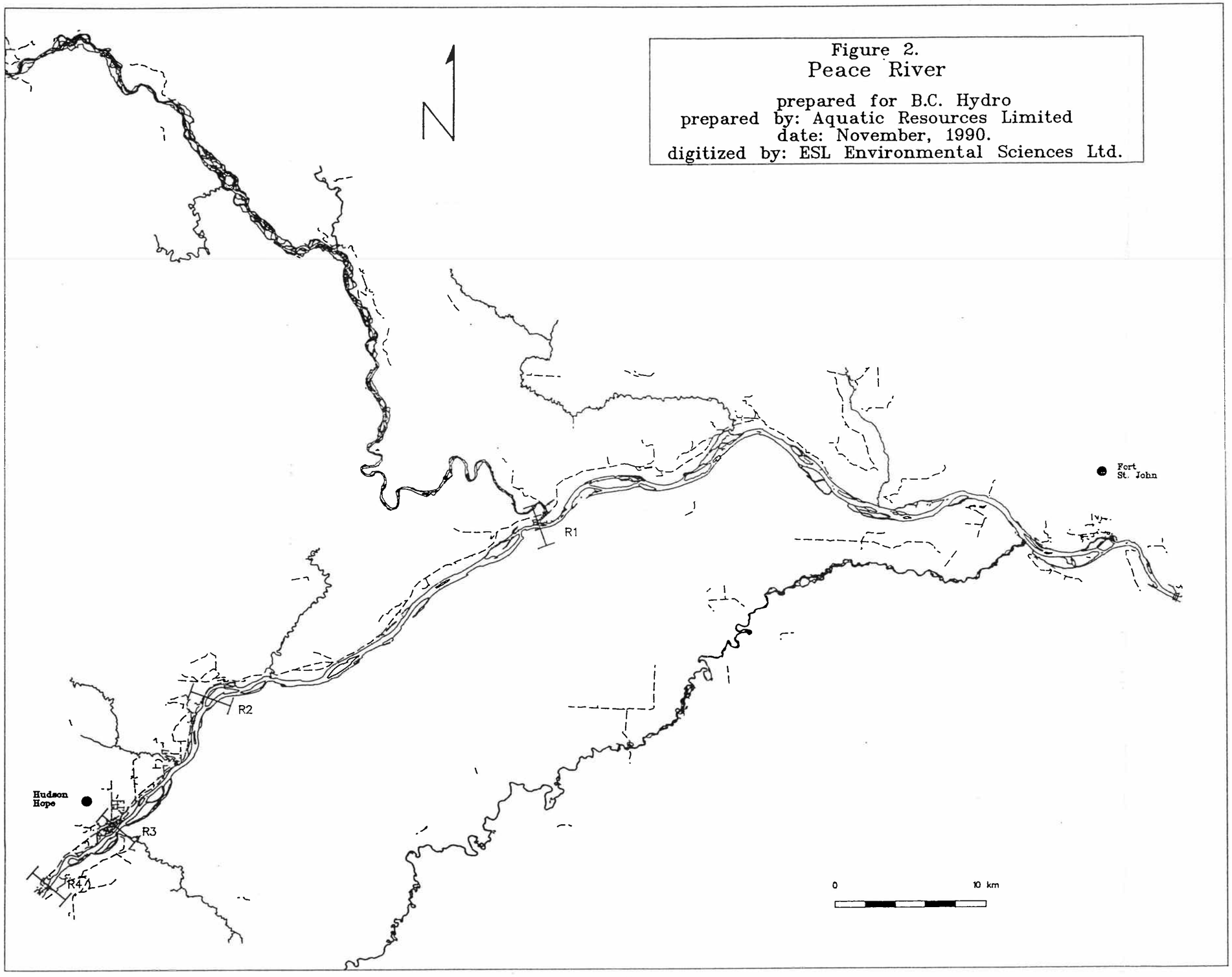

Figure 3.
Moberly River

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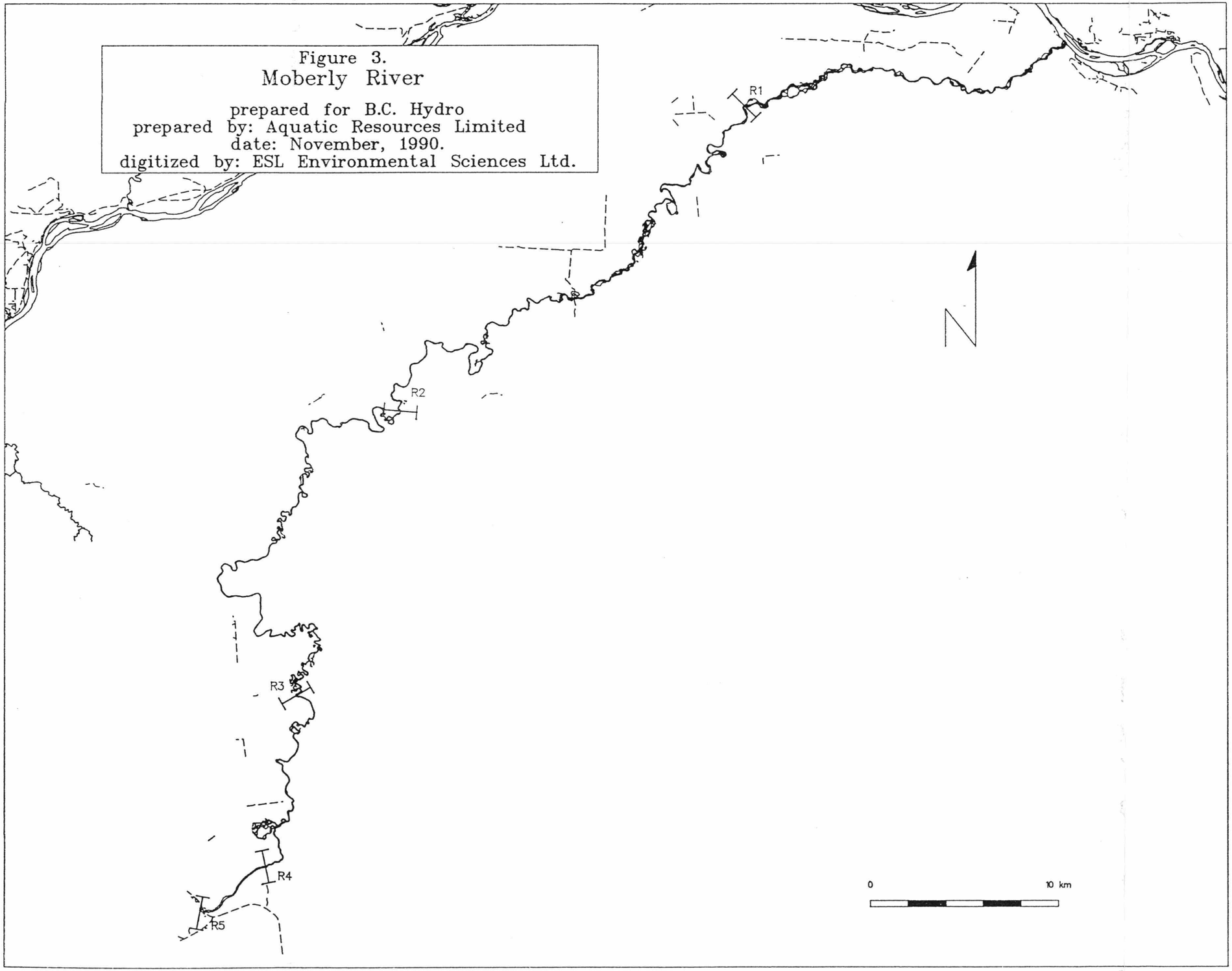

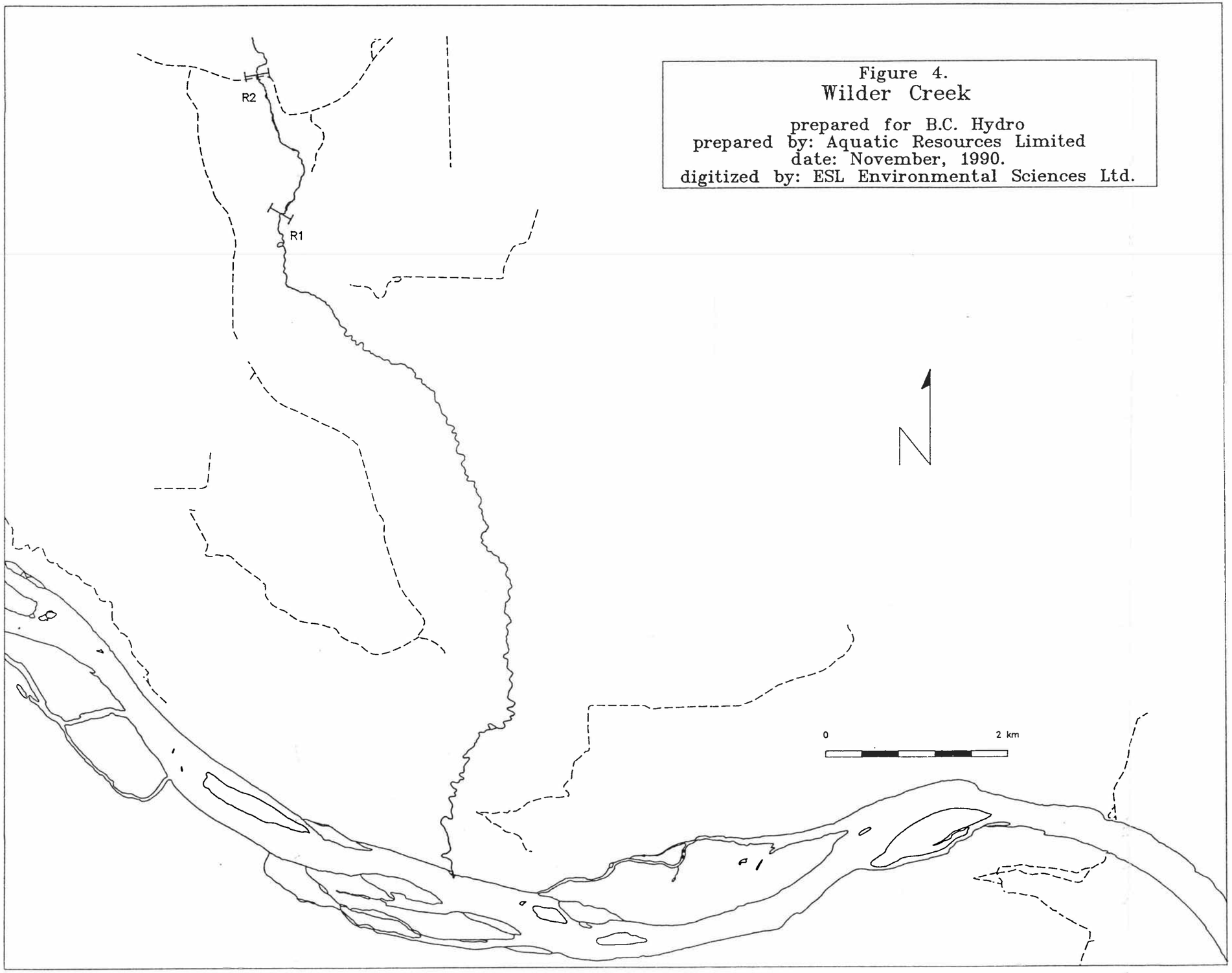

Figure 4.
Wilder Creek

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Figure 5.
Cache Creek

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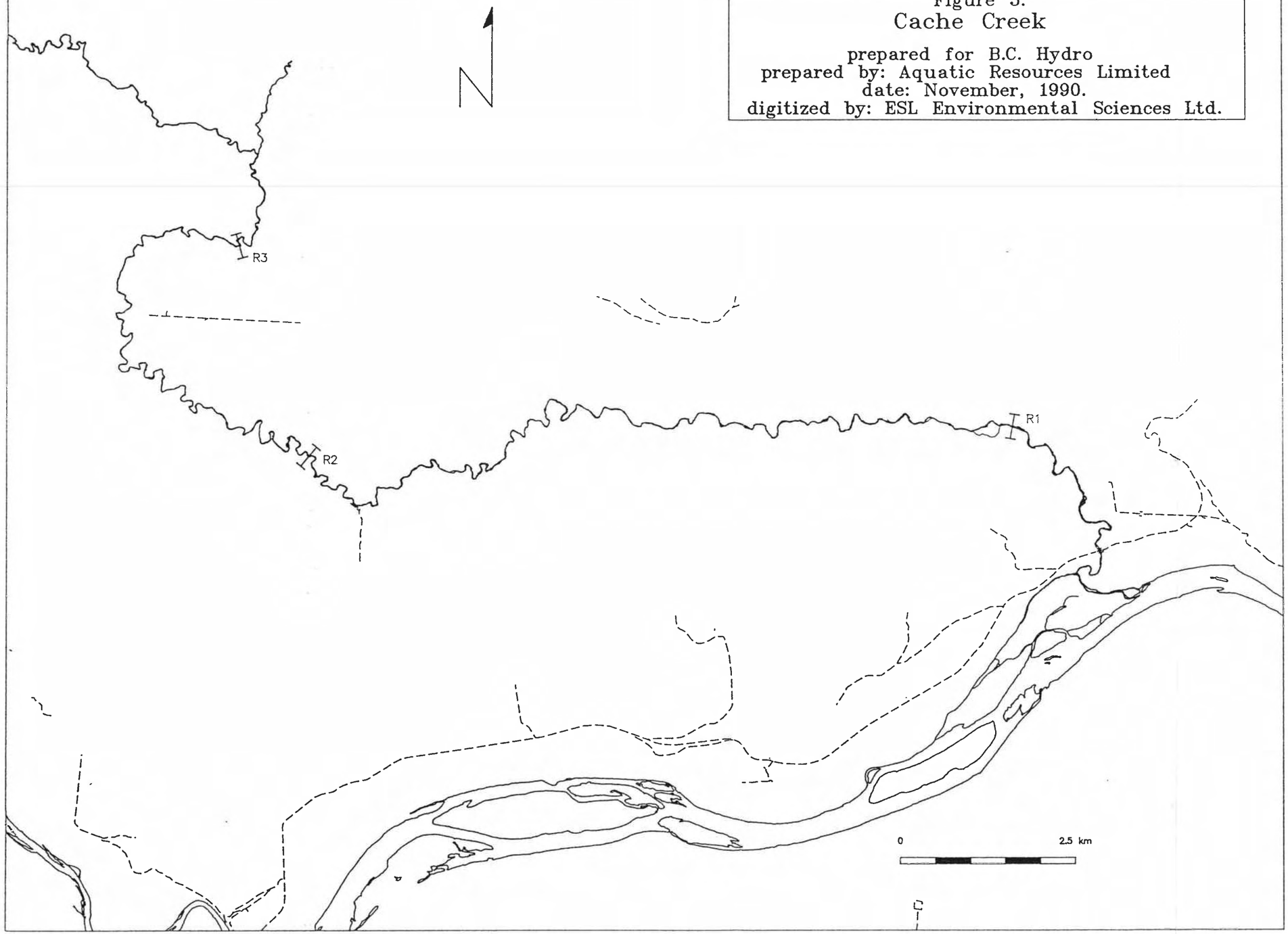

Figure 6.
Halfway River

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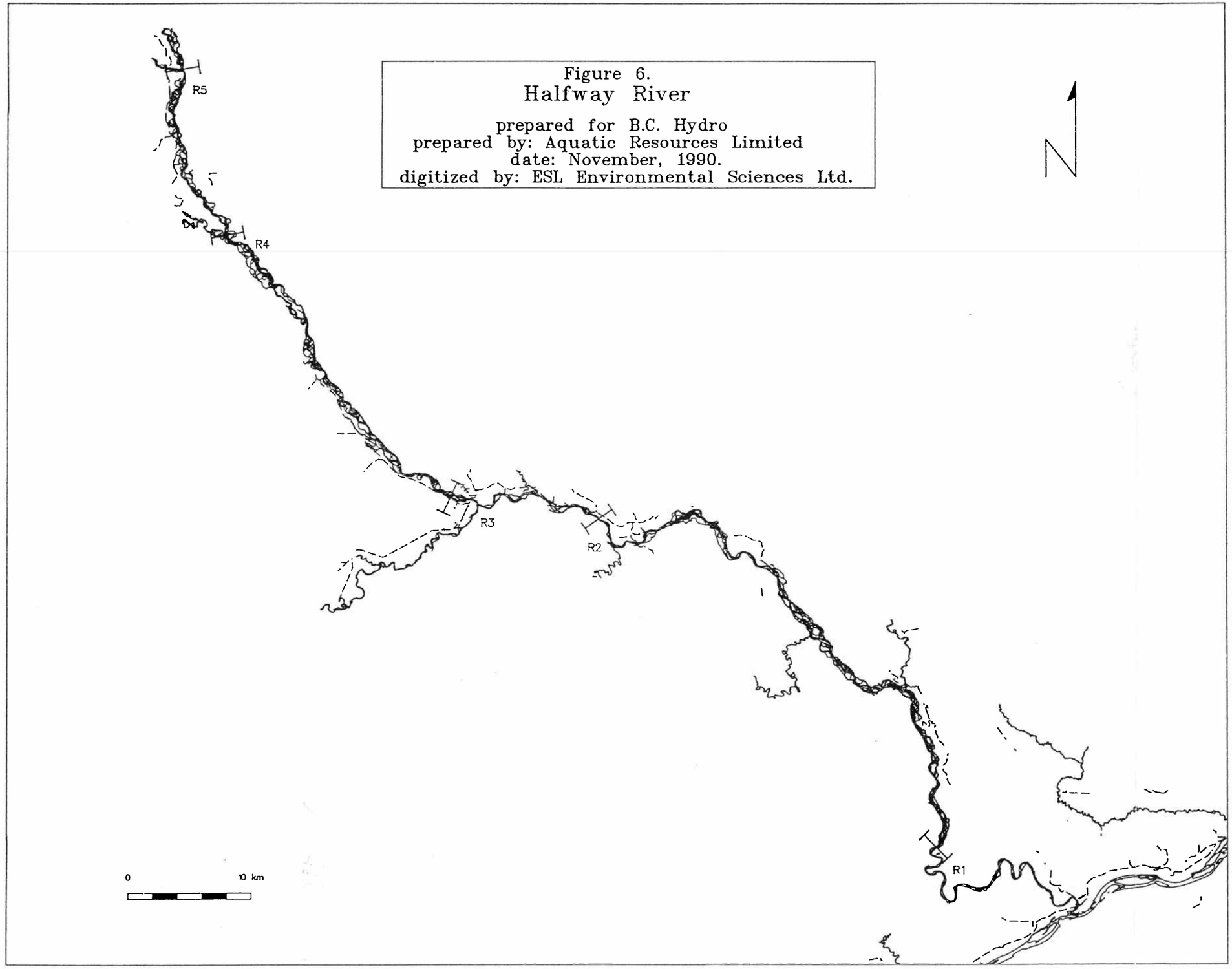

Figure 7.
Farrell Creek

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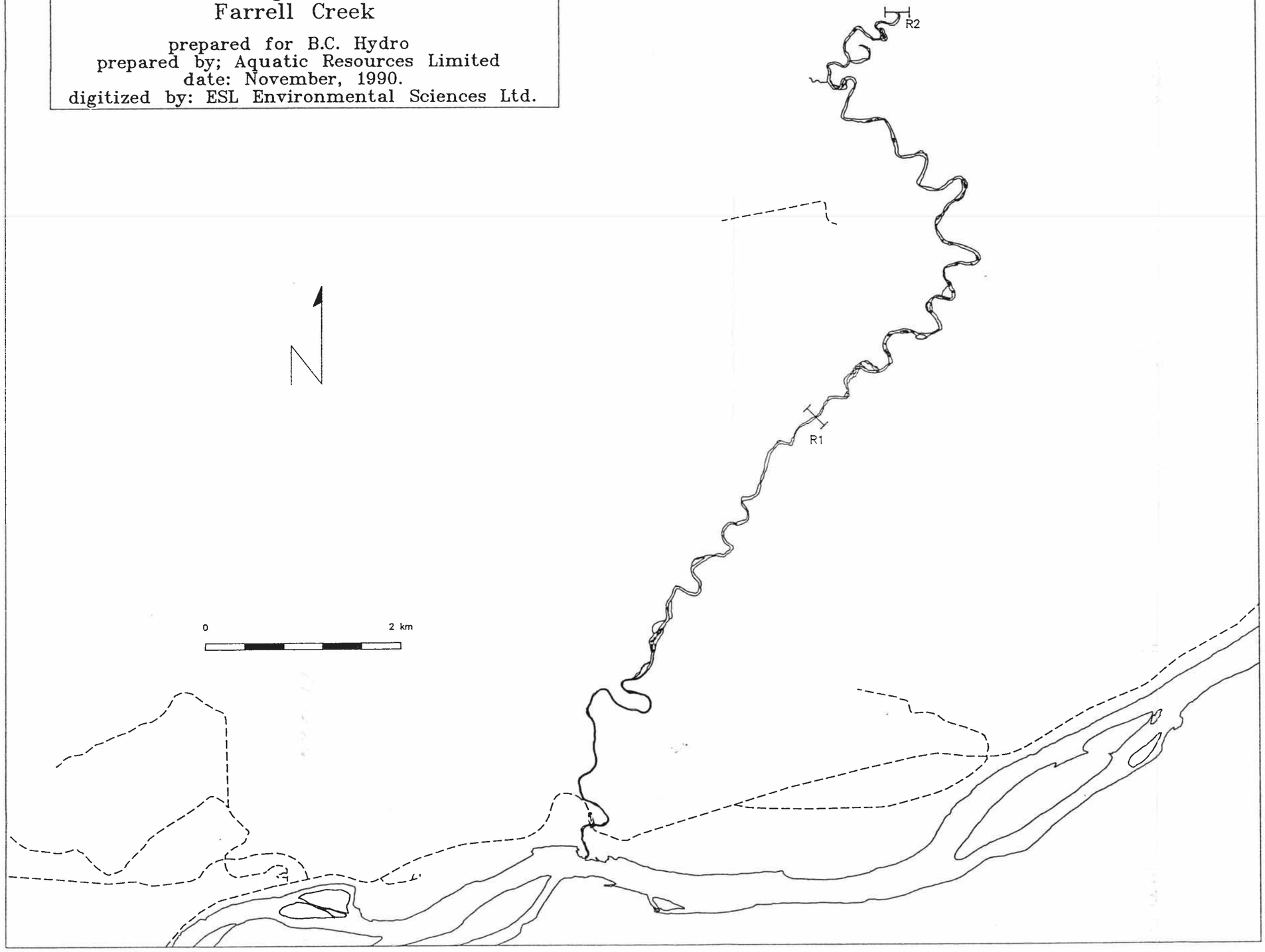

Figure 8.
Lynx Creek

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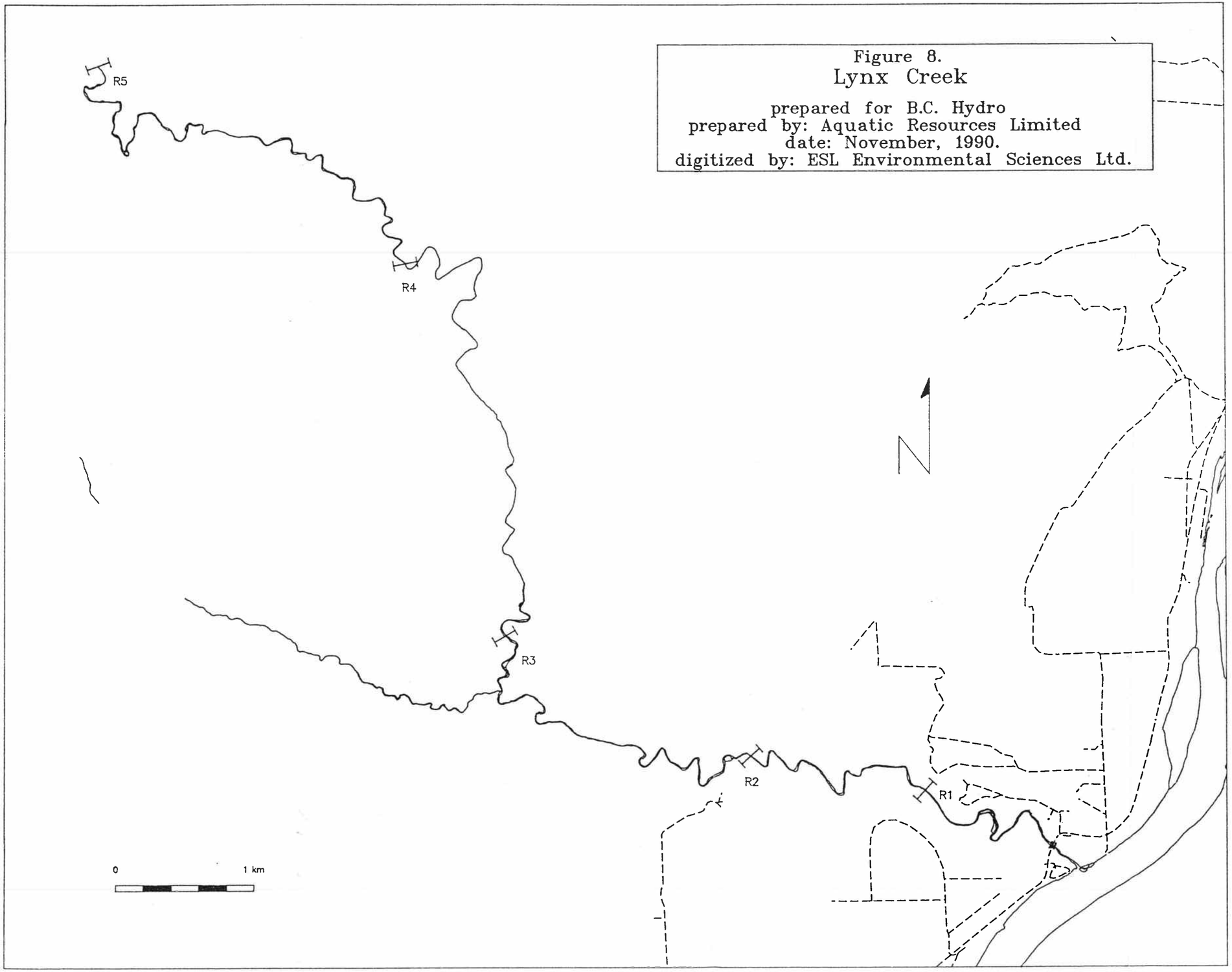
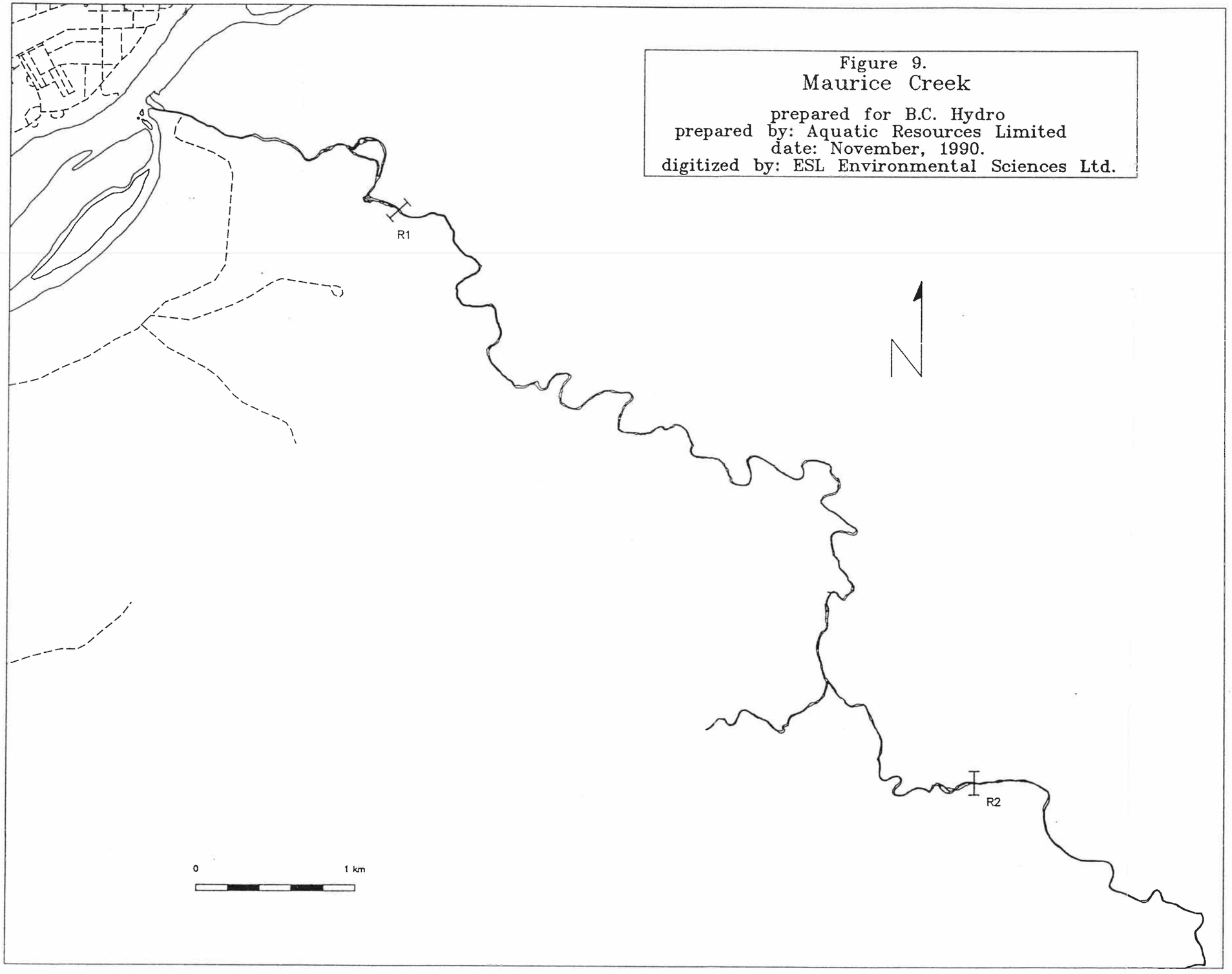


Figure 9.
Maurice Creek

prepared for B.C. Hydro
prepared by: Aquatic Resources Limited
date: November, 1990.
digitized by: ESL Environmental Sciences Ltd.



PART II

METHODS

2.1 TIMING AND LOGISTICS

The 1989 program was designed to be conducted in two parts. A spring survey would investigate conditions in the lower reaches of smaller Peace River tributaries which might be used by spring spawning fishes. The remainder of the program would then be conducted in late summer and fall during low water conditions. In practise, the program ran somewhat later than anticipated (Table 2).

Table 2
Schedule of Fall Field Activities

System	Spring Session	Fall Session
Blue Grave Creek		Sept. 27
Cache Creek	Jun. 6 - 8	Sept. 13 - 14
Cameron River		Oct. 7
Chowade Rive		Oct. 11.
Colt Creek		Sept. 26 - 27
Cypress Creek		Oct. 5, Oct. 11
Farrell Creek	Jun. 9 - 10	Sept. 15 - 16
Graham River		Oct. 3 - 4, Oct. 11
Ground Birch Creek		Oct. 6
Halfway River		Sept. 9 - 14, Oct. 5
Horseshoe Creek		Sept. 27, 28
Kobes Creek		Sept. 18, Sept. 26
Lynx Creek	Jun. 9 - 10	Sept 20, Oct. 9, 10
Moberly River		Sept. 3 - 10, Oct. 8 & 13
Maurice Creek	Jun. 8	Sept. 20
Peace River		Sept. 17 - 27
Wilder Creek		Sept. 12

The spring program was not authorized until well after freshet had subsided and, although RRCS (1979) reported rainbow trout spawning in June, few spring spawners were observed. This session therefore was more representative of early summer conditions. The fall session was conducted between September 3, 1989 and October 16.

Most of the systems are accessible by vehicle or on foot, however, boats were required on the Moberly, Halfway and Peace systems. A helicopter was used to access the Chowade River as well as upper portions of the Cypress, Graham, Lynx, and Maurice systems.

2.2 BIOPHYSICAL SURVEYS AND MAPPING

Biophysical information was collected with the goals of quantifying habitat types within the study area, detecting limits to fish production, and observing opportunities for fish enhancement. A computer mapping system (QUIKmap) was used for information storage and plotting as well as calculating the area and extent of habitat types and

The biophysical survey was conducted at four scales. The Peace River mainstem was surveyed at 1:12,000 while the rest of the areas below the reservoir's full supply level were examined at 1:5,000. Above this, the remainder of the Peace and Halfway River tributaries were surveyed at 1:15,000 except for the upper Graham River and those farther north, where the work was of a reconnaissance level and a scale of 1:50,000 was used.

Survey techniques and data recording procedures generally followed the Fish Habitat Inventory and Information Program (FHIIP) outline (DFO/MOEP 1987) although some changes were necessary as survey scales varied throughout the study. Air photos at the required survey scale were used in the field and survey intensity was adjusted to suit the level of detail apparent in the photos. For example, features, such as individual habitat units, were mapped on the larger systems, where they could be readily identified. Habitat units could not be identified or plotted individually on photos of the smaller creeks so they were replaced by observations of run/riffle ratios for specified stream segments. Field observations were recorded on FHIIP data cards, in field books and directly on the air photos.

The first step in the mapping program was to prepare uncontrolled airphoto mosaics of the study area. These were made from existing 1980 - 1987 airphoto coverage which was enlarged as necessary to suit the survey scales. River outlines and significant cultural and physical features were then digitized, and the resulting outline maps were then trued using prominent features such as bridges and gas wells.

Biophysical features were then plotted by field staff as a series of points and polygons on the outline maps. Attributes of the plotted features were input to a

series of database files. QUIKmap and the biophysical data were then used to prepare a series of habitat maps.

River outline digitizing was based on existing air photos taken during the spring although the stream surveys were conducted during fall low water. To compensate for this, wetted outlines were adjusted on the photos during the field survey. Once the mapping was complete, wetted width measurements made at approximately 340 locations during the field survey were remeasured using QUIKmap so that calculated areas could be calibrated (Appendix 1). The adjusted habitat areas were summed to determine the areas of the dominant habitat types in each reach as well as in reach segments above and below the proposed reservoir level.

2.3 FISH

Fish survey and sampling techniques were adjusted to suit both the nature and the survey scale of each water course. Capture techniques included beach seine, electroshocker and angling. In the upper tributaries, a brief snorkel survey was often used to observe the presence or absence of fish.

Beach seines used ranged from an 18 m x 2 m net of 1 cm stretch mesh which was deployed by boat or diver, down to a 5.5 m x 1 m net of 0.8 cm stretch mesh which was waded through smaller areas. In smaller tributaries and side channels, an electroshocker (Smith Root Mk VII) was used in conjunction with 0.8 cm stretch mesh stop nets so that a measured area could be sampled repeatedly. Electroshocker catches were then used to calculate fish densities (Seber and LeCren 1967). On the larger systems, where beach seines were used, the area swept by the net was estimated and recorded so that estimates of catch per unit effort (CPUE) could be made. This result was expressed as fish·m^{-2}. To assist interpretation of some tables, the seine results were scaled up to fish·100 m^{-2}set. The CPUE values for seine sets are at best an index of true densities as detailed calibrations (Parsley et al. 1989) were not possible on this roving survey.

Captured fish were identified and counted. Except in large (>100 fish) catches, which were subsampled, all sportfish were anesthetized in 2-phenoxy ethanol and measured (nose-fork length ±1 mm). They were then weighed (±0.02 g <150 g, ±5 g >150 g) and a scale sample was taken. The condition of the fish was noted along with the presence of marks or tags. Those fish >250 mm in length were marked with a numbered Floy tag. All fish were released following examination. Non sportfish were handled in a similar manner but were not weighed or tagged.

PART III

RESULTS AND DISCUSSION

The following section outlines the study findings and discusses them in terms of the three study goals. It begins with a short section designed to compare the 1989 survey year with "normal" conditions in the study area. This is followed by sections on the three study objectives: habitat assessment, fish utilization and mitigation/ enhancement opportunities.

3.0 1989 CONDITIONS

3.0.1 Climate

The 1989 study year was slightly warmer and drier than normal. Mean temperature and precipitation at four stations located around the perimeter of the Site C study area are summarized in Table 3.

Table 3
Mean temperature and total precipitation
at Environment Canada Stations in the Site C study area*

Station**	Years of Record	Mean Temp. (°C)		Total Precip. (mm)	
		1989	Normal	1989	Normal
Ft. St. John	1942-89	2.5	1.4	448	473
Hudson Hope.	1965-88	***	1.6	***	536
Wonowon	1974-89	3.3	2.4	549	556
Chetwynd	1971-89	3.3	2.4	440	464

* Source: Environment Canada file data, EAU 1982.

** See Figure 1

*** Complete record not available.

All stations were slightly cooler than usual during the late winter of 1988/89 and slightly warmer over the summer months (Figure 10). The biggest deviation from this pattern was at Hudson Hope where, although records are not complete, March through May temperatures appear to have been 5 - 10°C above normal. During September, when the bulk of the biophysical survey was completed, temperatures were very close to the long term averages at all stations.

1989 precipitation amounts varied considerably across the study area. Although annual totals were slightly below long term averages at all stations (Table 3), the monthly patterns showed considerably more variation (Figure 10). During the first half of the year, total precipitation was at or near normal at all stations except Wonowon in May and Hudson Hope in June. At these locations, rainfall was

Figure 10.
Temperature and precipitation in the Site C area, 1989.

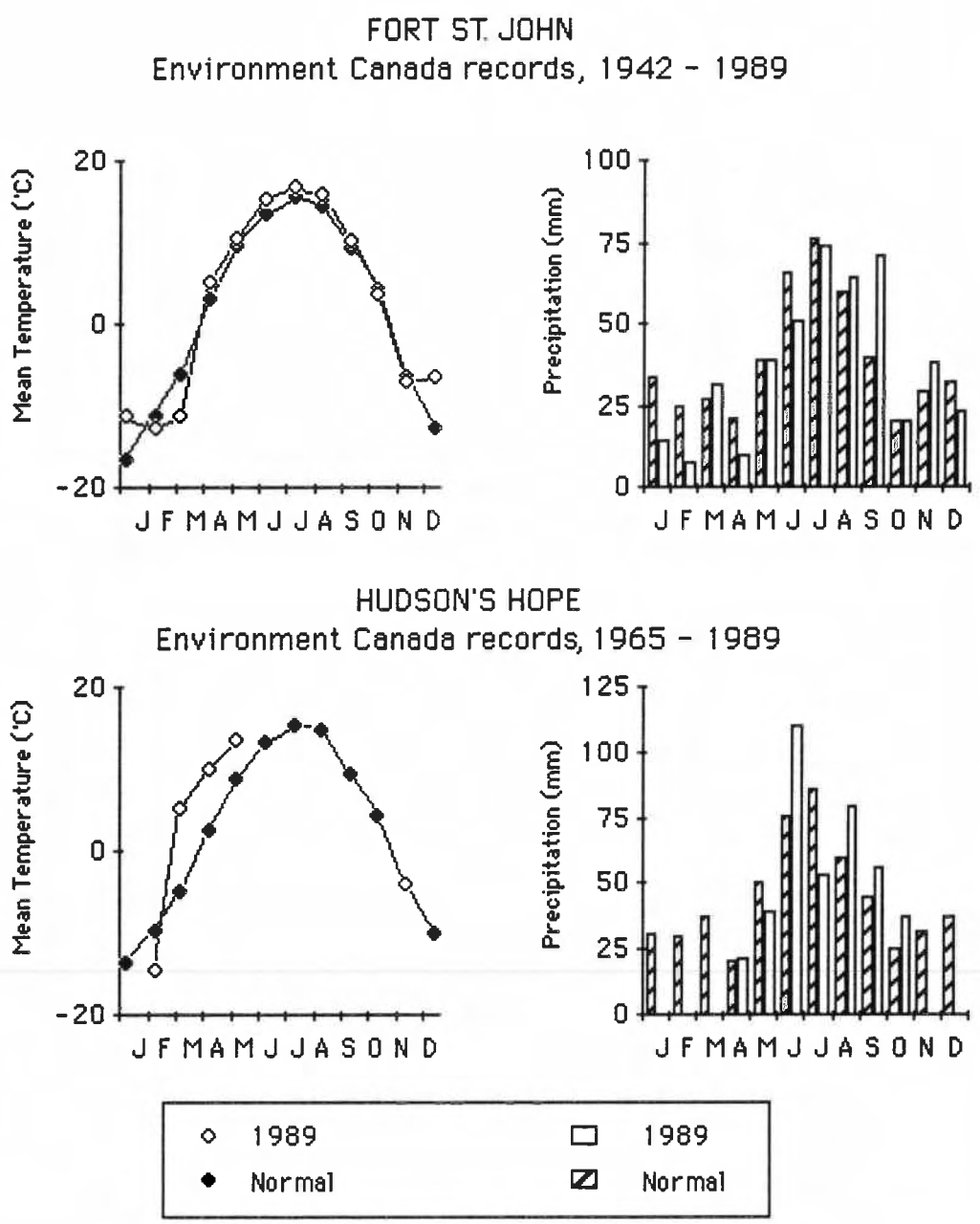
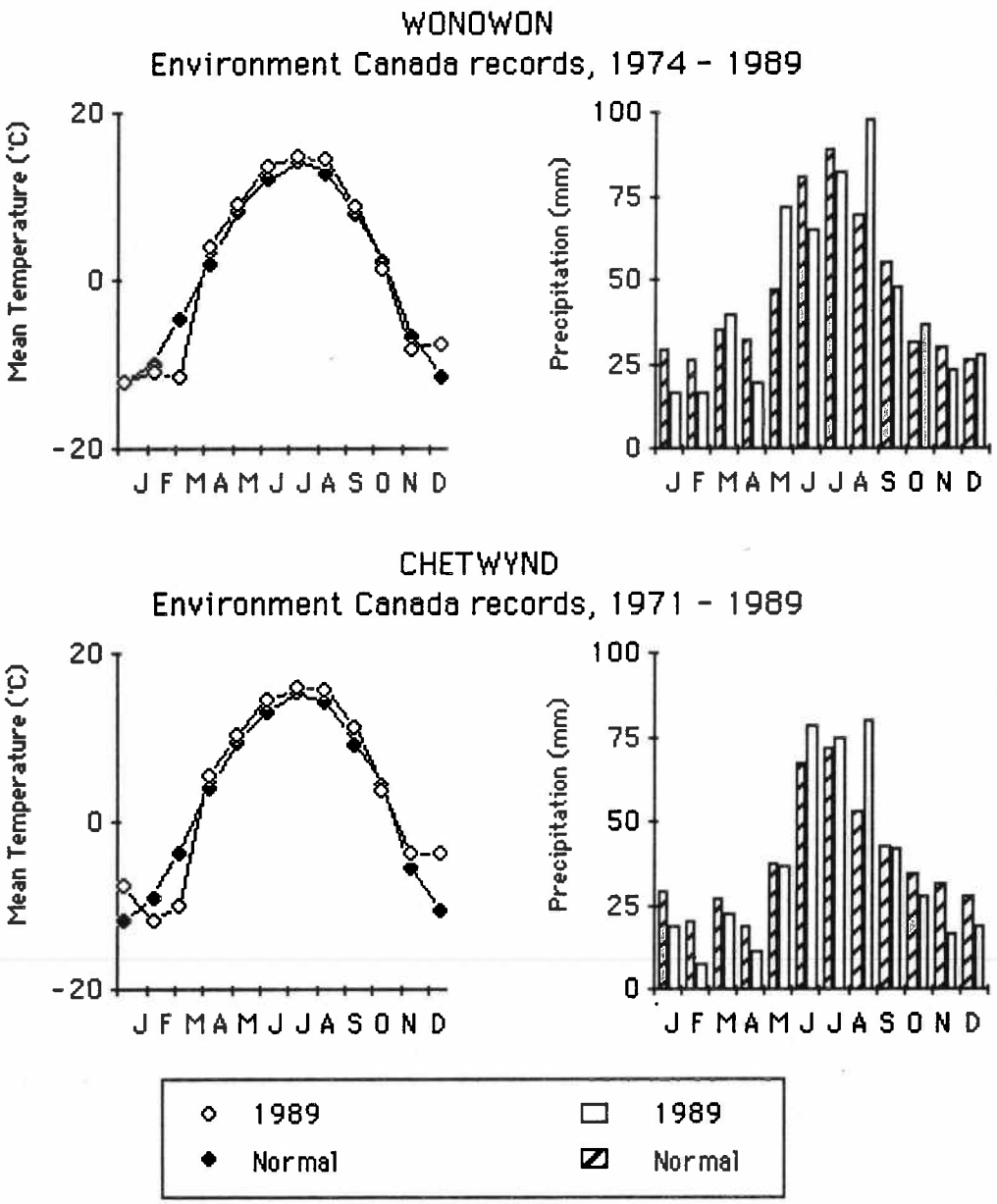


Figure 10 (continued)
Temperature and precipitation in
the Site C area, 1989.



46% greater than normal. Later, during August, rainfall was high at Wonowon and Chetwynd. In September, precipitation was near long term normals at all stations except Fort St. John where it was 77% above the long term average.

3.0.2 Streamflow

Discharge patterns in the tributary systems of the Site C area vary considerably from those of the Peace River mainstem. In the gauged tributaries, freshet typically begins in late April. Although maximum instantaneous flows may occur in May, monthly mean flow usually peaks in June and declines by November to a winter base flow which is about 3-5% of the spring peak (Figure 11). In September, when the 1989 biophysical surveys were conducted, flows are usually close to the annual mean. In comparison with the smaller systems, mean monthly flows in the mainstem Peace River remain relatively constant except for a slight decline through the summer months.

Total 1989 discharge from the Halfway River and northern portion of the Site C area was slightly above average (Table 4). However by September, when the bulk of the biophysical surveys were completed, flows in most systems were near normal (Figure 11). Conditions were slightly different in the southern portion of the study area. There the Moberly River discharge was about 10% below the average of the previous nine years although late summer rainfall brought it higher than normal during the September surveys.

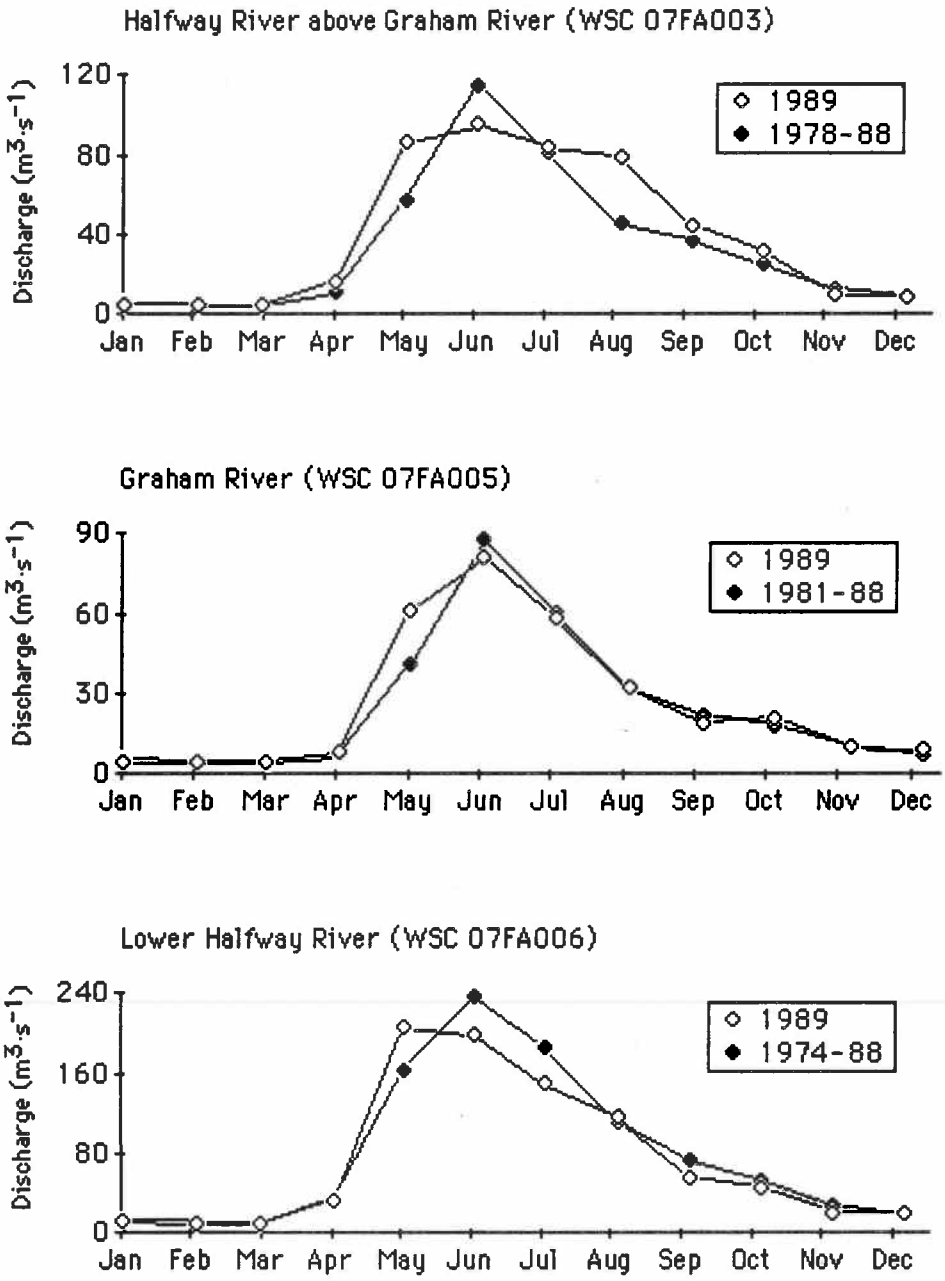
Table 4
Summary of discharge patterns in the Site C area

System	Total discharge[1]			Mean monthly flow[2]		
	1989	Normal	Record	Feb	Jun	Sept
Halfway R. (U)	1.24	1.07	78-88	4.5	95.1	37.4
Graham R.	0.83	0.79	81-88	4.7	87.0	21.7
Halfway R. (L)	2.31	2.22	84-88	10.3	231	56.8
Moberly R.	0.34	0.38	80-88	1.5	42.8	7.0
Peace R. (H. Hope)	35.3	37.6	81-88	1,231	860	1,211
Peace R. (@ Pine)	38.3	40.8	80-88	1,301	1,217	1,283

1 - $dam^3 x 10^6$ (WSC 1989, 1990).
2 - $m^3 \cdot s^{-1}$. Includes period of record plus 1989.

The Upper Halfway River had a total discharge about 16% above normal in 1989 although precipitation at nearby Wonowon was below average that year (Figures 1, 10; Table 4) and only slightly above average in late 1988. This may be an effect of localized precipitation but it could also be a result of long term storage and groundwater inputs to the system. Mean monthly flows remained high from

Figure 11.
Discharge at stations in the Halfway system.



May through August (Figure 11) and were 22% above the 1978-88 normal by September.

Graham River flows in 1989 were very near the 1981-88 average.

Mean monthly flow in the lower Halfway River peaked in May rather than June of 1989 and flows during June and July were 80-83% of mean flow of the previous five years (Figure 12). August rainfall brought flows above the 113 $m^3 \cdot s^{-1}$ normal but by September the flows had returned to about 80% of the average. The monthly averages however, are somewhat deceptive as they tend to smooth out flood events. The ratio of daily maximum/daily minimum flows on the Halfway River has averaged 79:1 over the last 10 years reaching 130:1 in 1980 (WSC 1989, 1990). This variability is not restricted to spring runoff. In many years the maximum daily flow occurred in July or August and appeared to be the result of heavy rainfalls.

The Moberly River is much smaller than the Halfway River with a mean discharge of 12 $m^3 \cdot s^{-1}$ compared to 70 $m^3 \cdot s^{-1}$ in the Halfway River (WSC 1989). In addition, the drainage contains a large lake. None the less, it is similarly variable with a maximum/minimum flow ratio of 73:1 over the last 10 years. In 1989, mean monthly flows in the Moberly River were below average through June and July (Figure 12). However, as a result of higher than normal rainfall in late August (Figure 10), the mean September discharge (11.2 $m^3 \cdot s^{-1}$) was well above average.

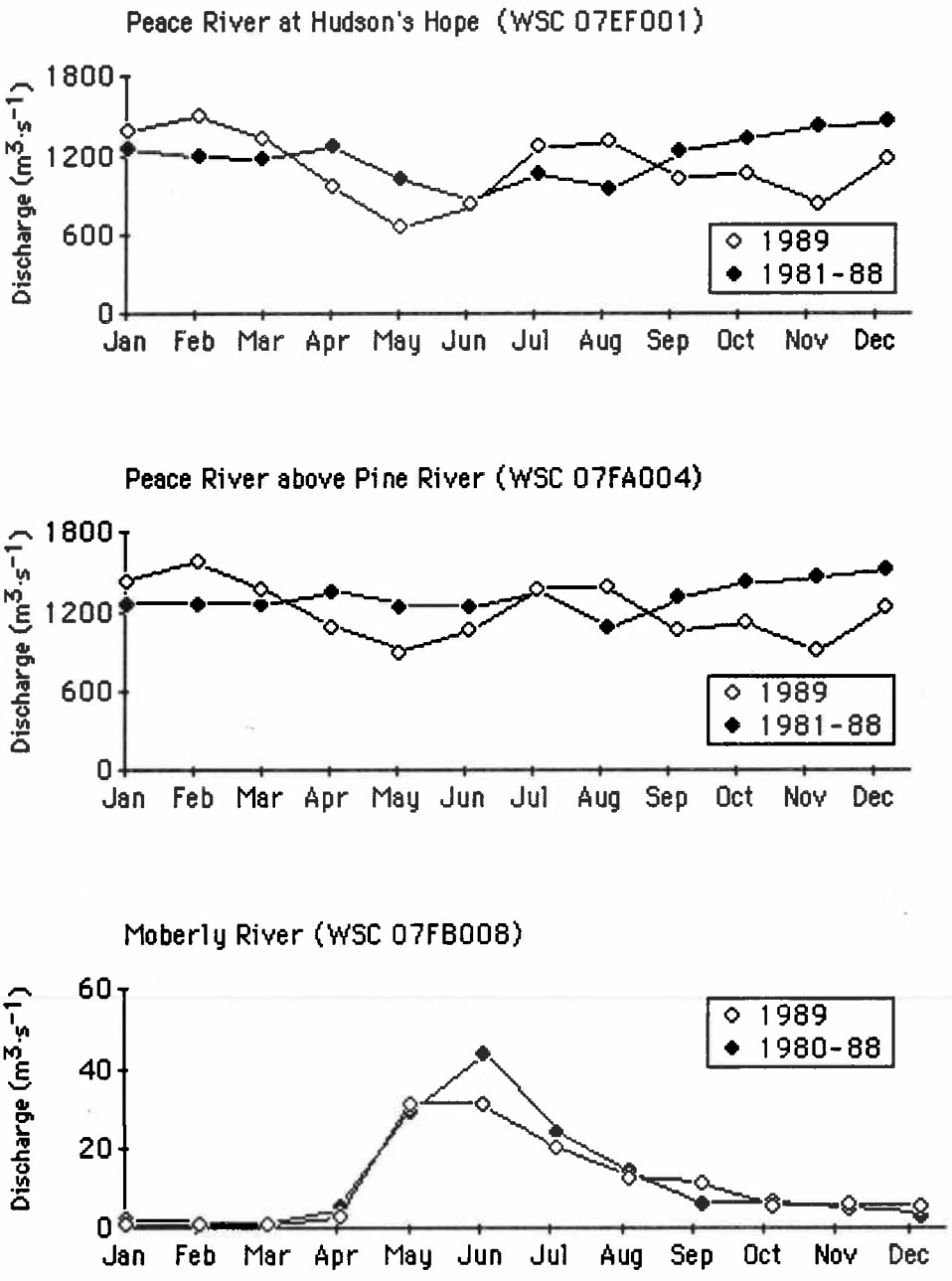
In the ungauged tributaries, freshet was well over by the time the first surveys were made in June 1989. Flows declined through the summer and by September, two of the systems (Cache and Wilder creeks) had short sections without surface water flows.

The discharge of the Peace River is regulated by the W.A.C. Bennett and Peace Canyon Dams. Total flows in the mainstem Peace River were about 7% below average during 1989 (Table 4) with the lowest flows occurring in May and November (Figure 12). During September, 1989 mean discharge was 81-83% of the previous years' average.

3.1 HABITAT

The watercourses of the Site C study area can be roughly divided into three types: larger mainstems, plateau tributaries, and foothills tributaries. The mainstems include the Peace and Halfway systems both of which originate outside the study area. Within the study area, these contain a wide range of habitat types but have relatively low gradients. The plateau tributaries drain portions of the Peace

Figure 12.
Discharge in the Peace and Moberly Rivers.



Plateau/Interior Plains and include the Wilder, Cache, Cameron, Colt, Kobes, Farrell, Lynx and Maurice systems (Figure 1). These flow over substrates which are mainly silts and shales with occasional sandstone outcrops. They are characterized by deeply entrenched channels and turbid waters. The Moberly River represents an intermediate between the plateau and mainstem types being clear and low gradient in its upper reaches and then becoming turbid as it drops steeply to the Peace River. The foothills tributaries originate in the Rocky Mountain Foothills and flow into the upper Halfway River. These include the Graham, Blue Grave, Horseshoe, Chowade, and Cypress systems and can be characterized by their varied gradients and substrates, bedrock intrusions, and high water clarity.

3.1.1 Mainstems

3.1.1.1 Peace River

Between Site C and the Peace Canyon Dam the Peace River is confined in a narrow valley with silt and shale walls extending 200 - 220 m up to the Peace Plateau. The south side of the valley is generally steep with many areas which are unstable, cut by the river and unvegetated. On the north side of the river, the slopes are generally less steep, almost all areas are vegetated, and there are a series of benches 40 - 50 m above the water.

Within the study area, the Peace River is characterized by four reaches (Figure 2). The first extends from Site C 40 km upstream to the Halfway River and has an area of 14.2 km^2 (Table 5). In this area the river is generally 300 - 400 m in width, narrowing in a few areas to 150 m. Mean gradient is 0.06%. The reach was examined September 17 - 21, 1989. At that time discharge ranged from 1,050 - 1,080 $m^3 \cdot s^{-1}$ at the Peace above Pine station (WSC 1989) and water velocity in the thalweg ranged from <1 $m \cdot s^{-1}$ in broad glides to 2 $m \cdot s^{-1}$ in the narrowest riffles. Dominant habitat type (71% of total area) is deep glide with an average maximum depth of 3 - 4 m although there are a few deeper scour holes reaching 8 - 10 m (Plate 1). Riffle is the second most common habitat type covering 3.0 km^2 or 21% of the reach area (Table 5). Substrate types range from cobble/boulder in riffle areas to gravel/cobble in the larger glides. Finer materials, silt and sand, fill all substrate interstices contributing about 10% of the substrate in the mainstem areas and almost 100% in side channels and sloughs. Within this reach there are 34 islands of sufficient size and relief to support perennial vegetation. These, together with a large number of sloughs and bars, provide 1.02 km^2 of shallow, low velocity habitat (Table 5). Under normal September conditions, with about 200 $m^3 \cdot s^{-1}$ more flow (see 3.0.2), the amount of this shallow glide and pool habitat would increase substantially.

Plate 1.

Deep glide habitats predominate in Reach 1 of the Peace River (upper right) which is bounded on the north side by steep silt and shale slopes. Reach 2 (lower right) is mainly a single channel although sloughs and secondary channels (below) are found in both reaches.

Table 5
Areas[1] of dominant habitat types in the Peace River within in the Site C study area during September, 1989

Habitat type		Reach			
		1	2	3	4
Glide	(<1 m)[2]	0.374	0.108	0.070	0.079
Glide	(>1 m)	10.1	6.84	2.70	0.788
Pool	(<1 m)	0.652	0.126	0.107	0.016
Pool	(>1 m)	0.100	0.265	0.021	0.004
Riffle		3.01	0.679	0.534	1.03
Totals		14.2	8.02	3.43	1.92

[1] - km^2
[2] - mean maximum depth

Reach 2 lies between the Halfway River and the sandstone island at the Gates (km 66). It was surveyed September 25 - 26, 1989 when the Peace River at Hudson Hope was discharging 1,080 - 1,170 $m^3 \cdot s^{-1}$. Water velocity ranged from 0.7 $m \cdot s^{-1}$ in thalweg glides to 2.2 $m \cdot s^{-1}$ in narrows. Side channel velocities ranged from near nil in many of the smaller side channels to 0.5 $m \cdot s^{-1}$ in the larger examples. As in Reach 1, the dominant habitat type (85% of total area) is deep glide. However, the gradient is slightly less (0.057%) and Reach 2 has much less riffle (8%) than Reach 1 (21%). In addition, silts and sands are less evident in the substrates, and water clarity increases. There are a few sandstone outcrops evident along the shore but the banks and valley walls remain predominantly silt/shale. Channel form is slightly simpler than Reach 1. Islands, bars and sloughs are less numerous as is the associated shallow water habitat.

Reach 3 extends from the Gates (km 66, Plate 2) upstream to the mouth of Maurice Creek (km 78). The area was examined September 26 - 27, 1989 when discharge ranged from 1,170 - 1,050 $m^3 \cdot s^{-1}$. Water velocity was near 0.8 $m \cdot s^{-1}$ in most of the thalweg glide although it increased to 1.8 $m \cdot s^{-1}$ near km 73. Overall gradient (0.059%) is slightly higher than Reach 2 particularly near km 74 where velocities of 2 $m \cdot s^{-1}$ were observed. Channel form is again simpler than in the preceding reach although there is a large island and side channel complex along the south shore just downstream from Maurice Creek. Deep glide was again most common (79%) while riffle (16%) was a larger proportion than in Reach 2 (Table 5). Banks on both shores are steep and largely composed of silt with varying proportions of gravel, and boulder. The absence of vegetation in many areas suggests constant erosion.

Plate 2.
Peace River Reach 3 extends 12 km upstream from sandstone outcrops at 'the Gates' (above). Turbulence in the foreground is caused by a series of stone sills. Cobble and boulder is common on the islands and bars of this reach and increased stability is evident in the succession of riparian vegetation (below).

Reach 4 extends from Maurice Creek (km 78) upstream to the Peace Canyon Dam. The reach is quite distinct from those below due to an increased gradient (0.11%) and large areas of sandstone and siltstone in both bank and channel substrates (Plate 3). Dominant habitat type is riffle (1.03 km^2, 54%) with deep glide comprising 41% of the reach's total area. The north shore is confined by near vertical sandstone walls 30 - 40 m in height which extend almost the whole length of the reach. On the south shore, steeply cut silt and shale banks approximately 30 m in height extend from the mouth of Maurice Creek upstream to km 80. Above km 80, the south bank is vertical sandstone similar to that of the north shore. The thalweg lies along the north shore through most of this reach and steps down over a series of sandstone ledges which extend out from the north shore. The ledges and numerous rock outcrops result in numerous small but deep holes and pools. The area was surveyed September 27, 1989 when the Peace River discharge was 1,050 $m^3 \cdot s^{-1}$. Water velocities exceeded 2.5 $m \cdot s^{-1}$ throughout most of the main channel areas but there were low or negative water velocities in many of the deep holes, pools and gyres. At the downstream end of the reach, water depth over the ledges was generally <1 m increasing to 2 m in the channels between them. Further upstream, water depth increased to 3.5 - 5 m in between the ledges.

3.1.1.2 Halfway River

The Halfway River drains an area of 9,350 km^2 while flowing 250 km to the Peace River. It originates in Robb Lake which is located in the Muskwa Range of the Rocky Mountains. For the first 80 km below the lake, the river flows east and is similar in character to the foothills tributaries. At 'the Elbow', the river turns south east and changes to a meandering mainstem character as it flows along the edge of the Peace Plateau. Between the Elbow and the Peace River, the Halfway River has an almost constant grade. This is broken only by a short series of sandstone sills near the confluence the Graham River, the system's largest tributary.

1989 investigations included surveys of the lower 130 km of the river. This area consists of five homogeneous reaches which are summarized in Table 6 and Figure 6. The first 93 km between the Peace River confluence and Blue Grave Creek were examined September 7 - 14. Water levels in this area were slightly below normal (Figure 11) and dropping steadily. The next 30 km up to the mouth of Cypress Creek were examined October 5. Water levels had dropped considerably but were still 30% above normal in the upper river (Figure 11).

Plate 3.
Peace River Reach 4 is confined by vertical sandstone walls over most of its length (upper) and a series of sills extends out across the mainstem. At the 'Coffee Pot' outcrops, deep holes, and large gyres result in productive fish habitats (lower).

Table 6
Areas[1] of dominant habitat types in the Halfway River between the Peace River and Cypress Creek, September, 1989

Habitat type		Reach					
		1 (to FSL)	1 (total)	2	3	4	5
Glide	(<1 m)[2]	47.4	109	586	228	658	433
Glide	(>1 m)	518	1,150	2,020	487	333	13.2
Pool	(<1 m)	8.38	27.4	198	9.55	51.7	23.6
Pool	(>1 m)	-	-	-	5.75	180	-
Rapids/Cascades		-	-	-	-	15.7	11.2
Riffle		595	924	1,360	325	643	223
Totals		1,170	2,210	4,170	1,060	1,880	792

[1] - m^2 x 1,000

[2] - mean maximum depth

Water temperatures during September ranged from 10 - 11.8°C and the Secchi depth was generally near 0.5 m (Table 7). Spring turbidities are likely to be much higher; however, no data were immediately available.

Reach 1 (Figure 6) extends from the Peace River upstream 21 km. Throughout this reach the river is confined by valley walls which rise 250 - 300 m up to the Peace Plateau. This feature is particularly prominent between 15 and 20 km where the silt/shale walls are being actively cut by the river and present shear faces on both sides of the river (Plate 4). Recent slumps are also evident in many areas and a particularly large one temporarily blocked the river at km 14 during the summer of 1989. Through most of this reach, the river is essentially a single channel with a steady grade averaging 0.2% and gravel/cobble substrates (Table 7). Wetted width averaged 66 m and channel width 108 m. Mean maximum depth was generally 1 - 2 m in runs and 0.6 m in riffle areas. Few deep pools were evident. Development of the Site C reservoir would flood approximately half of the Reach 1 area (Table 6). The alienated habitat includes 64% of the riffle in this reach but only 30% of the shallow pool.

Plate 4.

The Halfway River discharges into the Peace River through a shallow delta (upper right). Further upstream, Reach 1 is confined by cut banks up to 220 m in height (lower right). In Reach 2, the valley opens out and the river becomes braided.

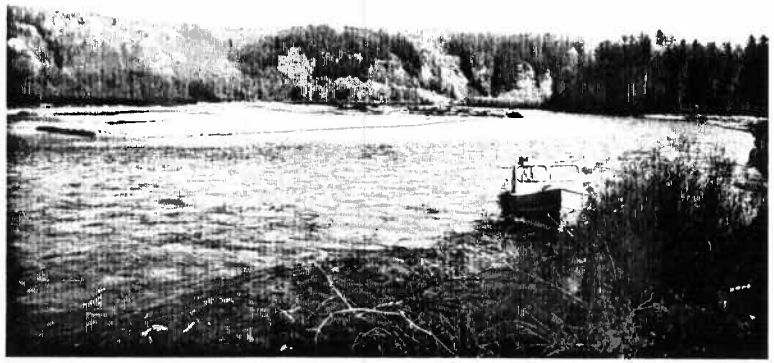


Table 7
Summary of Halfway River Habitat Characteristics

Reach No.	Points Examined	Mean wetted width (m)	Mean chan. width (m)	Mean glide velocity ($m \cdot s^{-1}$)	Mean Secchi depth (m)	Mean temp. (°C)	Bed Composition F %	G %	C %	R %
1	15	66	108		0.3	11.8	35	26	46	0
2	12	65	103	2.1	0.5	11.0	16	43	42	0
3	3	50	87		0.3	10.8	10	40	40	10
4	2	39	121			10.0	23	38	40	0
5	1	22	49	0.8	0.7	7.5	10	45	45	0

In Reach 2, the Halfway River valley broadens slightly, the river is only occasionally confined and a more braided character becomes evident with numerous islands, bars and side channels (Plate 4). Wetted width (mean = 65 m) is similar to that of Reach 1 but total channel width is approximately one kilometre in many areas. The reach extends upstream to km 67 with depth and substrate characteristics generally similar to those in Reach 1 although the proportion of shallow glide increases slightly (Tables 6 and 7).

Reach 3 lies between kilometres 67 and 77 and is distinguished by sandstone and siltstone which is evident in numerous outcrops, in vertical river banks up to 20 m in height, and in a series of sills (Plate 5). The rock results in steep riffles in a few areas however the overall gradient of Reach 3 (0.3%) is similar to that of those above and below it. The Graham River, which contributes about half of the total flow, enters near the upper end of the reach. Average wetted width declined to 50 m in Reach 3 with a total channel width of 87 m.

Reach 4 lies between kilometre 77 and the mouth of the Chowade River near kilometre 110. Average wetted width was 39 m with total channel width ranging from 120 - 500 m reflecting the reach's braided character. The river is occasionally confined by the valley's northeast side which rises steeply. Scour holes along this side account for 10% of the total habitat despite the braided channel.

Reach 5 lies between the mouths of the Chowade and Cypress systems, (kms 110 - 130). In character it is very similar to Reach 4 but with much lower discharge and slightly higher gradient (0.4%). It is composed of 55% shallow glide and 28% riffle. There are no pools >1 m in depth but the reach includes 13,200 m^2 of deep glide (Table 6).

The Halfway River discharge is typically at its annual mean during September (Figure 11, WSC 1989). However, during February and March the flows usually

Plate 5.
Reach 3 of the Halfway River (upper) passes over a series of sandstone sills including this one at the confluence of the Graham River. Further upstream, Reach 4 has a braided character although occasionally confined by the valley's eastern side (lower).

decline to 15% of those observed in September. As a result of these low flows and the absence of deep pools, over wintering habitat appears very limited.

Few signs of groundwater flow were seen in the Halfway River area. Some of the shale banks show salt deposits suggesting seepage and perched water tables, but for the most part, flows seem to be derived from surface sources. Springs were observed in sandstone outcrops between Kobes Creek and the Graham River as well as further downstream near the lower powerline crossing at km 8. However, none of these were large enough to have more than a very localized impact on winter water temperatures or flows.

3.1.2 Peace River Tributaries

3.1.2.1 Moberly River

The Moberly River was surveyed by boat September 3 - 10, 1989 starting from Moberly Lake and working downstream to its confluence with the Peace River. The river's discharge, which dropped during the survey from 18.4 - 2.6 $m^3 \cdot s^{-1}$, was about double seasonal normals (Figure 12, WSC 1990). Water temperatures varied from 11°C at the mouth on September 10, 1989 to 15°C at the lake outlet on September 3, 1989. Water clarity (Secchi depth) varied from 1.5 m at the outlet to 0.6 m at the mouth. By October 8 when the river was examined again, water levels had dropped substantially and water clarity had increased to 2.0 - 2.5 m. The water temperature at the Moberly Lake outlet was 7.5°C on October 13.

The 130 km of river between Moberly Lake and the Peace River consists of five reaches (Figure 3). Reach 1 extends from the mouth at the Peace River to a point approximately 25 km upstream. The channel along this section is unstable, braided and has an abundance of organic debris (Plate 6). The banks are eroding in many places causing trees to fall into the channel. In other places, aggradation is evident. The habitat consists largely of riffle (42%) and shallow, fast flowing glide up to 1 m deep (37%) (Table 8). Mean gradient is 0.5% and there is little pool habitat. The channel is occasionally confined and has an average width of 33 m. The Site C reservoir would flood 298,000 m^2 or about 46% of Reach 1 (Table 8). This includes all of the deep glide/riffle complex and shallow pool habitat but is otherwise similar to the unaffected portion

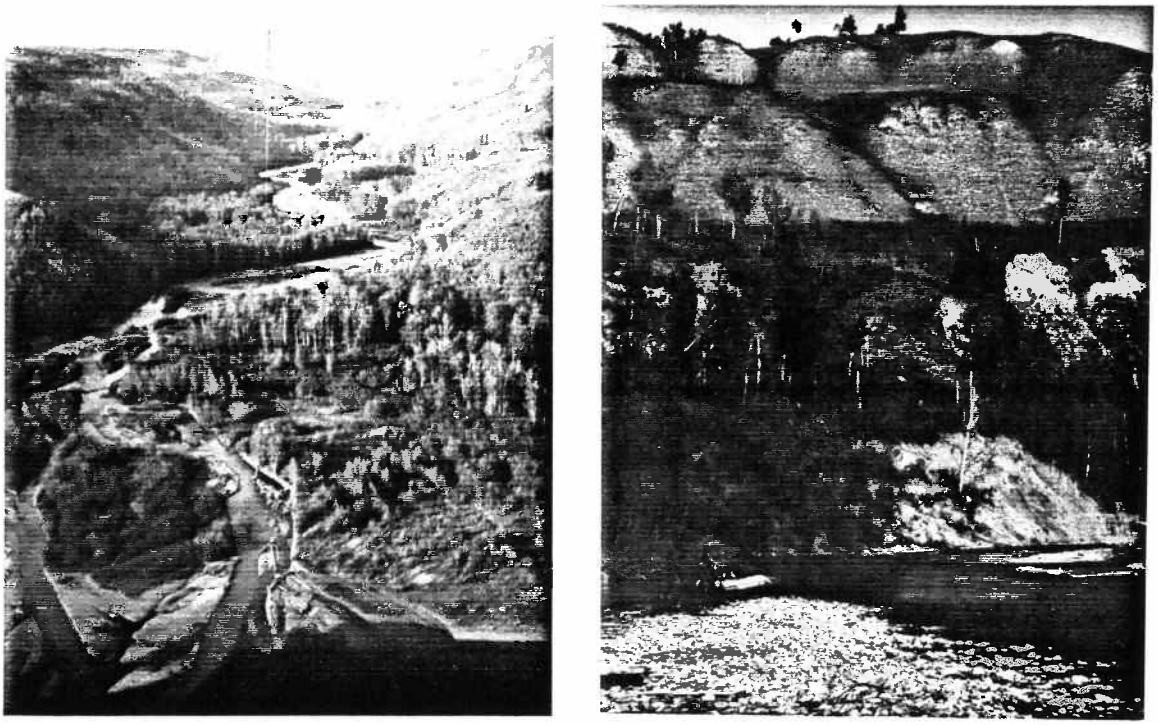


Plate 6.
Moberly River Reach 1 (above) is fast flowing and braided with large amounts of organic debris and other evidence of recent channel changes. Reach 2 (below) has a single channel and much greater confinement.

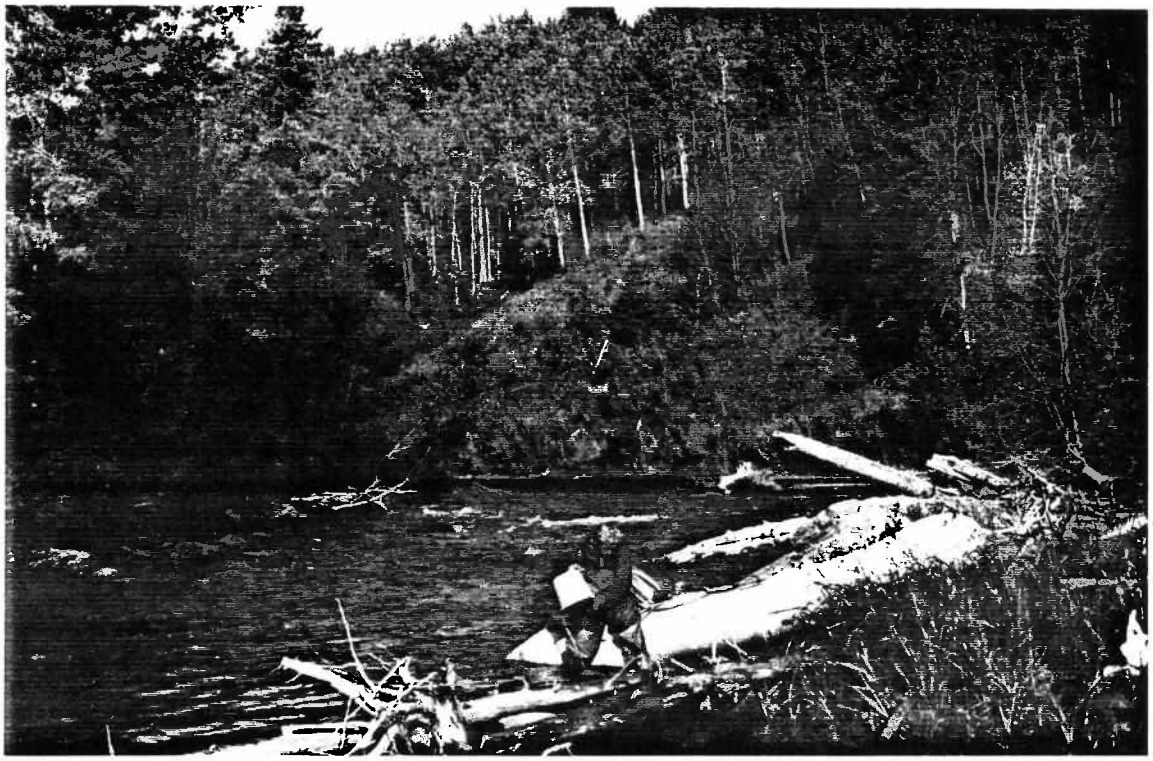


Table 8
Areas[1] of dominant habitat types in the Moberly River
between the Peace River and Moberly Lake, September, 1989

Habitat type	Reach					
	1 (to FSL)	1 (total)	2	3	4	5
Glide (<1 m)[2]	134	239	767	1,140	222	11.6
Glide (>1 m)	-	-	130	189	162	316
GRC[3] (<1 m)	44.3	113	2.21	38.3	16.4	-
GRC (>1 m)	8.68	8.68	-	-	-	-
Pool (<1 m)	0.97	0.97	53.9	112	19.1	21.7
Pool (>1 m)	-	-	-	-	-	-
Rapids/Cascades	15.3	27.6	55.9	-	-	-
Riffle	95.1	264	465	84.6	19.9	-
Totals	298	653	1,470	1,560	438	349

[1] - m^2 x 1,000. Based on preliminary QUIKmap calculations. These tend to under estimate features >1 m depth and will be revised in the next draft of this report.

[2] - mean maximum depth

[3] - Glide riffle complex. Individual features too small to separate at survey scale.

Reach 2, extending from 25 to 75 km above the Peace River, is more stable and slightly more confined than Reach 1 and the gradient declines to 0.2%. A few sections are braided, but the reach generally consists of one channel averaging 28 m in width. Debris accumulations are frequent along the outside curves of the irregular meandering channel and often block small side channels. Reach 2 contains a higher proportion of fast flowing shallow glide (52%) than Reach 1 and less riffle (31%). Depths are generally less than 1 m throughout Reach 2 although there are 130,000 m^2 (9%) of deep glide (Table 8).

Reach 3 extends from 75 to 110 km. Channel configuration in this low gradient (0.1%) section varies from irregular to tortuous meanders. Most (85%) of the habitat consists of slow moving glide that varies in depth from 1 to 1.7 m (Plate 7). The remainder is primarily riffle and corner pools that average 3.7 m maximum depth. The reach is also characterized by oxbows and oxbow lakes, chutes and side channel swamps. There are few bars in this reach as the wetted width is only a few metres less than the channel width (33 m).

Gradient increases in some areas through Reach 4 causing a faster flow character although the overall gradient (0.1%) is similar to Reach 3. The irregular channel

Plate 7.

The gradient of the Moberly River declines in Reach 3 (right) and the system meanders through a series of glides. It becomes slightly steeper in Reach 4 (lower right) with about 20% riffle. Reach 5 regains the slow glide character with large areas of submergent vegetation and moderate numbers of northern pike.

is less stable therefore there is more channel debris (5 - 10%) and gravel bars (10%). The reach is 15 km long and extends from 110 km to 125 km.

The upper reach (Reach 5) consists of a 5 km long, wide (58 m), slow moving glide that averages 1.6 m in depth. The channel is straight, stable, has no bars, and is close to 0% gradient. Large organic debris was estimated at 0 - 5% and lies mainly along the stream margins. In some areas the banks are flat and covered with emergent vegetation. The channel has an abundance of submergent vegetation, primarily pond weed (Plate 7).

3.1.2.2 Wilder Creek.

Wilder Creek was surveyed on foot on September 12, 1989 from the highway bridge at the 11 km mark to the Peace River (Figure 4). Flows ranged from approximately 0.02 $m^3 \cdot s^{-1}$ in the upper portion of the survey section to no surface flow near the mouth. Water temperature was 12°C and visibility varied between 5 cm in beaver pond habitat to 50 cm in pool habitat.

The surveyed section is divided into two reaches. Reach 1 extends from the Peace River to a point 9 km upstream. The 5.5 m wide channel is entrenched along this section and the valley walls, rising up to 150 m on either side of the creek, are mainly of fine material. In some areas the walls are being eroded and are slumping into the channel (Plate 8). The average gradient of the reach is steep at 2.5%. One section 6 km upstream has a slope of 6%. The creek consists almost entirely of shallow glide/riffle (30/70) with average depths of 3 cm (Table 9). The remainder of the habitat is pool with average maximum depths of 20 cm.

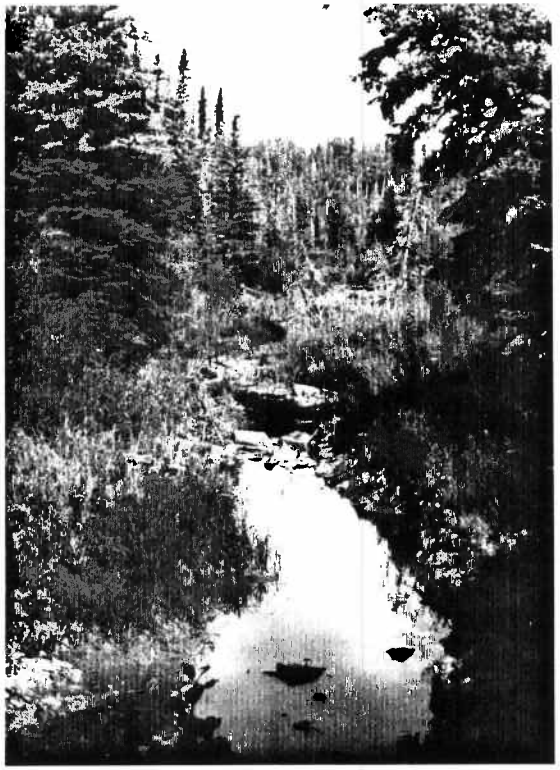
Table 9
Areas[1] of dominant habitat types in Wilder Creek
between the Peace River and Highway 29 during September, 1989

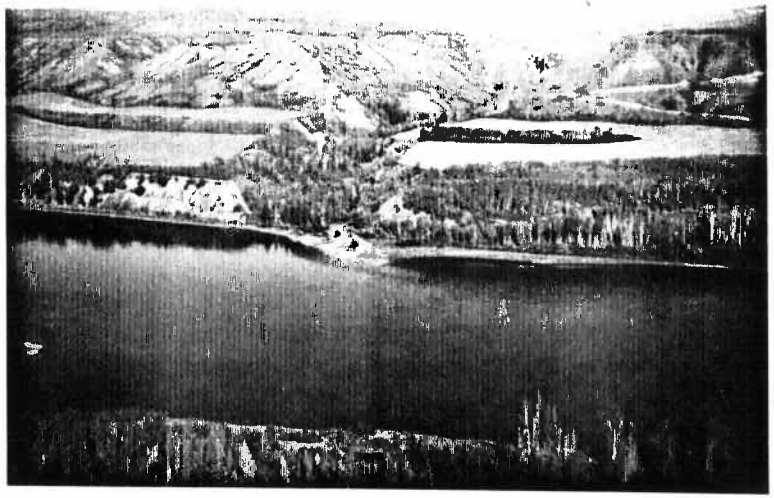
Habitat type		Reach		
		1 (to FSL)	1 (total)	2
GRC[3]	(<1 m)[2]	4	23.0	2.37
Pool	(<1 m)	4	0.200	3.89
Pool	(>1 m)	4	0.074	0.770
Totals		4	23.3	7.03

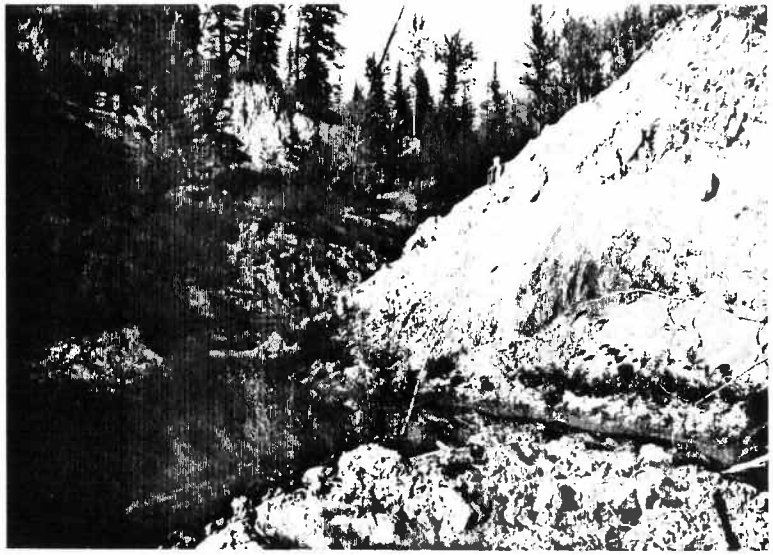
1 - m^2 x 1,000
2 - mean maximum depth
3 - Glide riffle complex. Individual features too small to separate at survey scale.
4 - Calculations will be included in the next draft of this report.

In Reach 2 the gradient decreases to 1%. Between the start of the reach at 9 km and the highway bridge, there are four large beaver dams up to 2.5 m in height.

Plate 8.
Wilder Creek drops steeply down to the Peace River. Banks in Reach 1 (lower right) are eroding rapidly. Further upstream, near the highway, gradient decreases and the creek flows through a series of beaver ponds (below).







The dams create ponds that average 100 m in length and 8 m in width. Although this section of creek is still confined, it is not canyonous in nature like Reach 1. The valley walls slope back from the stream channel at a much lower gradient. Beaver pond habitat comprises about 30% of the reach (Plate 8). Another 35% consists of smaller pools averaging 25 cm deep in a 5 m wide channel. The rest of the stream was almost dry with flows at approximately 0.02 $m^3 \cdot s^{-1}$

3.1.2.3 Cache Creek

The 30 km of Cache Creek surveyed on September 13 and 14, 1989 had very little flow. Discharge was estimated at only 0.004 $m^3 \cdot s^{-1}$ in the upper two reaches and 0.01 - 0.02 $m^3 \cdot s^{-1}$ below Red Creek in Reach 1 (Figure 5). Water temperatures ranged from 9 to 11°C and visibility varied from 5 cm in beaver pond habitat to 30 cm in smaller pool habitat.

Cache Creek was divided into 3 reaches (Figure 5). Reach 1 extends from the Peace River confluence 6 km upstream to the Red Creek confluence. In this section the channel width averages 24.7 m of which only 3.8 was wet. Most of the fish habitat is pools 15 to 80 m long with average maximum depths of 48 cm connected together by shallow (8 cm) glide/riffle which covers 21,500 m^2 of the Reach's 36,300 m^2 area (Table 10). At higher flows the habitat would probably be classified as being mainly glide (Plate 9). Reach 1 is occasionally confined and has a gradient of 1%.

Table 10
Areas[1] of dominant habitat types in Cache Creek
within in the Site C study area during September, 1989

Habitat type		Reach			
		1&2 (to FSL)	1	2	3
GRC[3]	(<1 m)[2]	24.3	21.5	56.0	41.5
Pool	(<1 m)	9.02	6.26	7.32	0.881
Pool	(>1 m)	0.225	0.130	0.336	-
Riffle		-	-	4.85	0.220
Sloughs		9.15	8.48	4.61	37.8
Totals		42.6	36.3	73.1	80.4

1 - m^2 x 1,000
2- mean maximum depth
3- Glide riffle complex. Individual features too small to separate at survey scale.

Reach 2 extends above Red Creek to a point 20 km from the Peace River. As Red Creek contributes a substantial portion of the system's flow, the Cache Creek channel is much narrower (16 m wide) above this confluence. Habitat in Reach 2 consists mainly of pools 8 to 60 m long and 3 m wide with average maximum

Plate 9
Reach 1 of Cache Creek in June, 1989 (above). By September this area had become a series of shallow pools. Much of Reach 2 is confined by instable banks which contribute large amounts of silt to the system (right). Gradient and confinement decline in Reach 3 (below).

depths of 0.5 m. The pools, which comprise 30% of the habitat, are connected by shallow riffles with little flow. The channel of Reach 2 is occasionally confined, irregular, and has little large organic debris.

Reach 3 extends from 20 km to the limit of the survey, at 30 km above the Peace River and probably further. This reach has a flatter gradient (0.25%) than those further downstream and there are approximately 10 beaver dams scattered throughout this 10 km long section. The dams average 0.6 m high and create ponds that are up to 300 m long. The ponds average 9 m wide and 0.8 m deep. Many of the beaver dams probably get washed out by high flows each spring and then are rebuilt during the summer. Half of the reach has pool or beaver pond habitat and the rest is shallow glide and riffle. Average channel width for the reach was 12.2 m and the average wetted width 4 m.

Waters of the Site C reservoir would cover all of Reach 1 in Cache Creek and approximately 6,300 m^2 of Reach 2 (Table 10). This area includes a major portion of the pool habitat within the system although there are extensive slough areas further upstream.

3.1.2.4 Farrell Creek

On September 15 and 16, 1989 Farrell Creek was examined on foot from its confluence with the Peace River to a point 21 km upstream. Water temperature was 10.5°C, the discharge was roughly estimated at 0.3 $m^3 \cdot s^{-1}$, and the Secchi visibility was 60 cm.

The surveyed section was divided into two reaches. The first extends from the mouth to a point 9 km upstream. This reach is characterized by a confined, irregular to meandering channel. The valley walls rise up to 150 m on either side of the channel and are mainly covered by deciduous vegetation. In some areas on the outside of the meanders, the channel is eroding the valley wall and creating steep shale and fine banks up to 30 m in height (Plate 10). The channel averages 25 m in width although only 7 m were wet. The channel thus has a high percentage of bars. Over half of the habitat is riffle, 25% glide and most of the remainder is pool with average maximum depths of 0.8 m (Table 11). The channel appears fairly stable along this reach and, as a consequence, there is little channel debris.

Plate 10.

Lower Farrell Creek contains some deeply entrenched meanders which are bounded by silt and shale banks (right). In Reach 2, the valley opens up. At 10 km (lower right) the channel width begins to increase and at 20 km (below) decreased gradient results in a series of shallow glides.

Table 11
Areas[1] of dominant habitat types in Farrell Creek
within the Site C Study area during September, 1989

Habitat type	Reach		
	1 (to FSL)	1 (total)	2
Glides[4] (<1 m)[2]	3.26	13.7	19.9
GRC[3,4] (<1 m)	1.68	1.68	36.5
Pool (<1 m)	3.86	7.25	10.7
Pool (>1 m)	0.24	1.13	1.76
Riffles[4]	4.53	30.7	32.3
Totals	13.6	54.4	101

1 - m^2 x 1,000

2 - mean maximum depth

3 - Glide riffle complex. Individual features too small to separate at survey scale.

4 - Based on preliminary QUIKmap calculations. These tend to over estimate wetted widths in this habitat type and will be revised in the next draft of this report.

The Site C reservoir would cover 13,600 m^2 (25%) of the 54,400 m^2 in Reach 1 (Table 11). The inundated portion would include 53% of the shallow pool habitat within the reach but only 20% of the deep pools.

Reach 2, above 9 km, is less confined than Reach 1. In addition, the channel increases to 31 m in width and appears less stable. The regularly meandering channel is braided in some areas and is causing some bank erosion and aggradation. Reach 2 therefore contains a little more organic debris than Reach 1. The amount of pool habitat is similar to Reach 1, but Reach 2 contains less riffle habitat (Table 11).

3.1.2.5 Lynx Creek

The lower 17 km of Lynx Creek was surveyed on foot on September 13, 1989. Water temperatures in this area varied between 5.0 to 5.5°C and discharge was estimated at 0.3 $m^3 \cdot s^{-1}$ in the lower reaches and 0.1 $m^3 \cdot s^{-1}$ above Brenot Creek.

Reach 1 of Lynx Creek extends from the Peace River to a point 1.9 km upstream (Figure 8). This section is mainly bouldery glide/riffle (10%/90%), with average depths to 0.25 m (Table 12). The channel is 8.3 m in width, is only occasionally confined and appears fairly stable.

Table 12
Areas[1] of dominant habitat types in Lynx Creek
within the Site C study area, September, 1989

Habitat type	Reach					
	1 (to FSL)	1 (total)	2	3	4	5
GRC[3] (<1 m)[2]						
Pools (<1 m)						
Sloughs						
Rapids/Cascades						
Riffle						
Totals	Revised area calculations will be presented in the next draft.					

1 - m^2 x 1,000
2 - mean maximum depth
3 - Glide riffle complex. Individual features too small to separate at survey scale.

Reach 2 is entrenched into a terrace of the Peace River (Plate 11). The steep 30 m high valley walls and the river channel are primarily shale. The channel is 7 m wide, appears stable and has little channel debris.

Though Reach 3, which extends from 4 to 7.5 km, is confined, it is not canyonous in nature like Reach 2. The 10 m wide channel appears fairly stable and is irregular in shape. The habitat is similar to Reach 2 in that there are few pools (10%) and mainly riffle (45%) and glide (45%). Brenot Creek, a major tributary that flows into Lynx Creek 6.5 km from the Peace River, carried an extremely heavy silt load which reduced water visibility from 1 m in Upper Lynx Creek to 0.5 cm below the confluence. About two years ago, a spring developed along the south bank approximately 3 km upstream of its confluence with Lynx Creek. (L. Noble local resident, pers. comm.). Prior to that time the creek use to be relatively clear. A section of fine bank approximately 200 m across has been eroded over the past year by the spring which contributes about half of the creek's discharge.

In Reach 4 the 8 m wide channel again becomes entrenched and flows through a canyon with steeply reposed fine and shale walls rising to 150 m on either side.

The proportions of habitat are similar to Reaches 2 and 3 with 10% pool, 45% glide and 45% riffle. There are three 4 to 6 m high waterfalls located between 9.9 km and 10.2 km in this reach. These are likely to obstruct upstream fish passage at all flows.

Gradient decreases from 2% in Reach 4 to 0.55 in Reach 5, and the proportion of pool habitat increases to 40%. The pools are largely created by 15 or more beaver

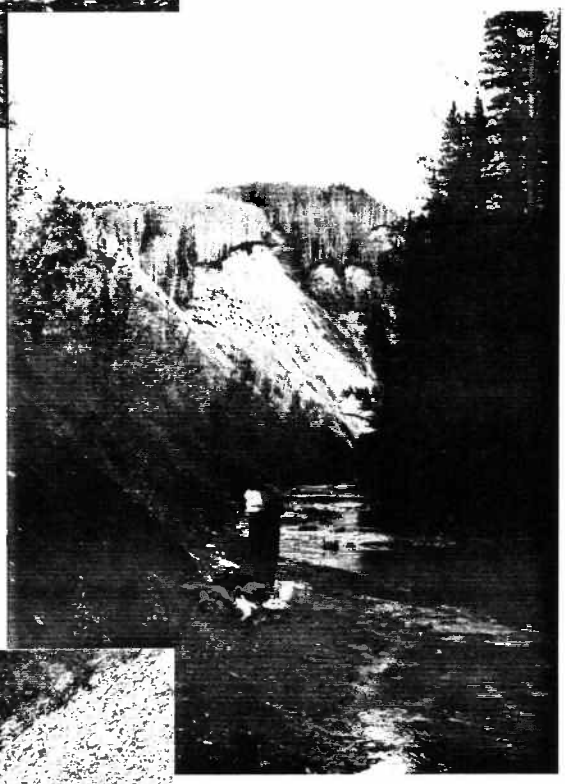
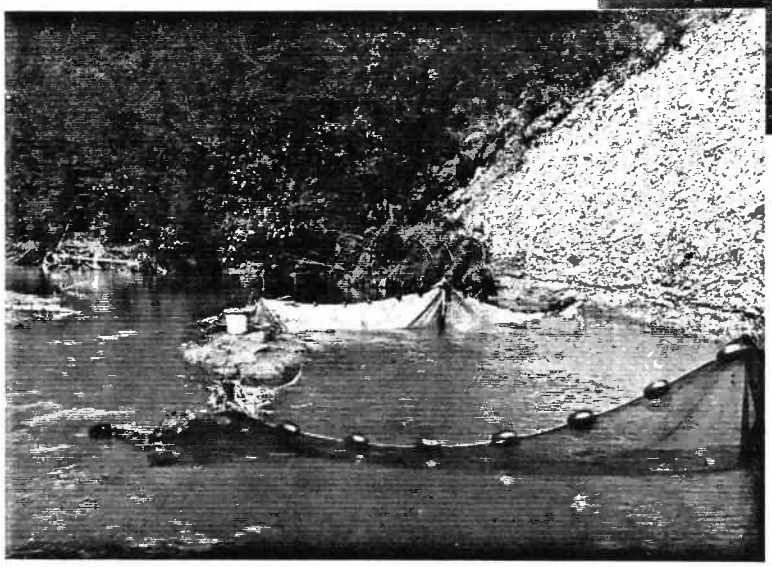


Plate 11.
Shallow glide and riffle predominate in Reach 3 of Lynx Creek (above). In Reach 4 the system is confined by unstable valley walls up to 150 m in height. Reach 5 is less confined, has a lower gradient, and contains many beaver ponds (below).



dams located throughout the 4 km of creek surveyed in this reach. The channel appears to be relatively stable although there is an abundance of channel debris.

3.1.2.6 Maurice Creek

Maurice Creek was briefly examined in June and sampled in more detail by helicopter on September 20, 1989 up to a point 10.5 km from the mouth of the river. Then on October 9, 1989 the creek was surveyed on foot from the mouth to a point 6.5 km upstream. Water temperatures ranged from 7°C on September 20, 1989 to 8°C on October 9, 1989. Discharge was estimated at 0.6 $m^3 \cdot s^{-1}$ and water visibility was relatively clear at 75 cm during the October survey.

Maurice Creek is divided into two reaches (Figure 9). The first reach is 1.7 km in length and extends upstream from the Peace River. The channel form in this area is somewhat variable. The first kilometre is a confined single channel with little debris and an average width of 20 m (Plate 12). The channel then increases in width (up to 85 m wide) and becomes braided. Wetted width averages 7 m throughout the reach. This reach has mainly riffle habitat (80%) and little pool (7%) and glide (15%) (Table 13). The pools have average maximum depths of 0.8 m.

Table 13
Areas[1] of dominant habitat types in Maurice Creek
within the Site C study area during September, 1989

Habitat type	Reach		
	1 (to FSL)	1 (total)	2
Glides (<1 m)[2]	0.148	0.148	-
GRC[3] (<1 m)	3.82	16.7	68.2
Pool (<1 m)	1.29	1.65	0.551
Pool (>1 m)	-	-	0.179
Rapids/Cascades		-	0.45
Riffles	-	4.94	4.84
Totals	5.23	23.4	74.2

1 - m^2 x 1,000
2 - mean maximum depth
3 - Glide riffle complex. Individual features too small to separate at survey scale.

The Site C reservoir would cover 5,230 m^2 (22%) of Reach 1 (Table 13). This includes all of the shallow glide and 78% of the pool habitat in this reach.

Reach 2, extending from 1.7 km to the end of the study area at 10.5 km, is entrenched into the Peace River plateau. Most of the creek along this reach

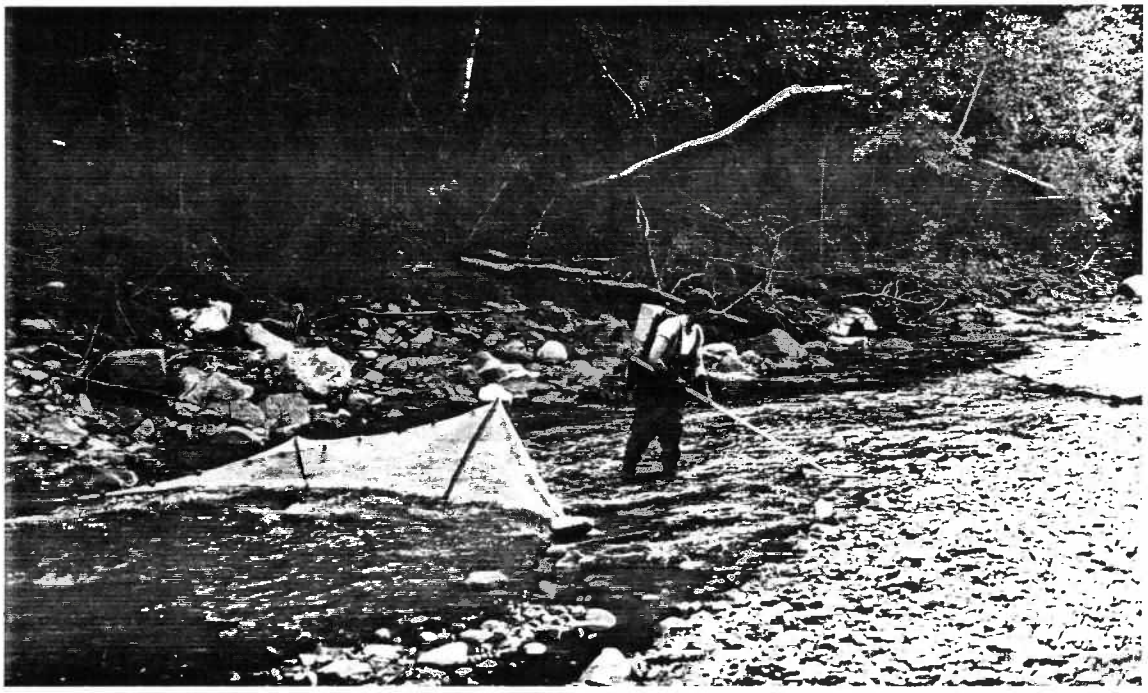
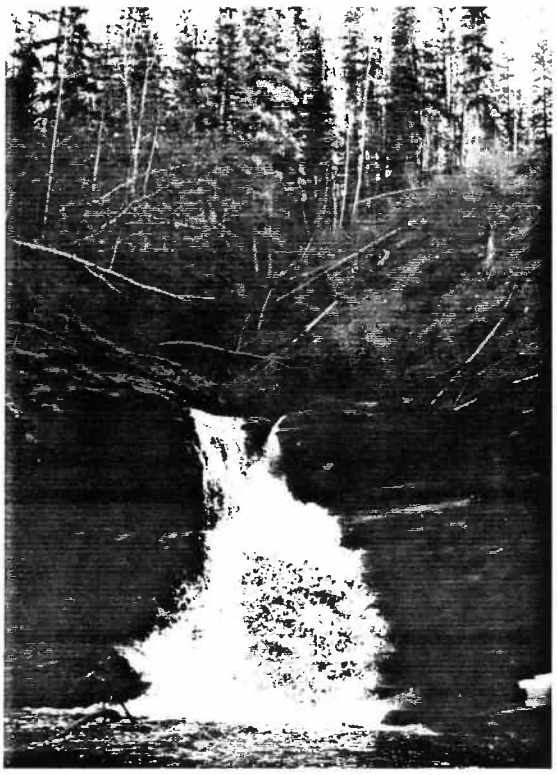
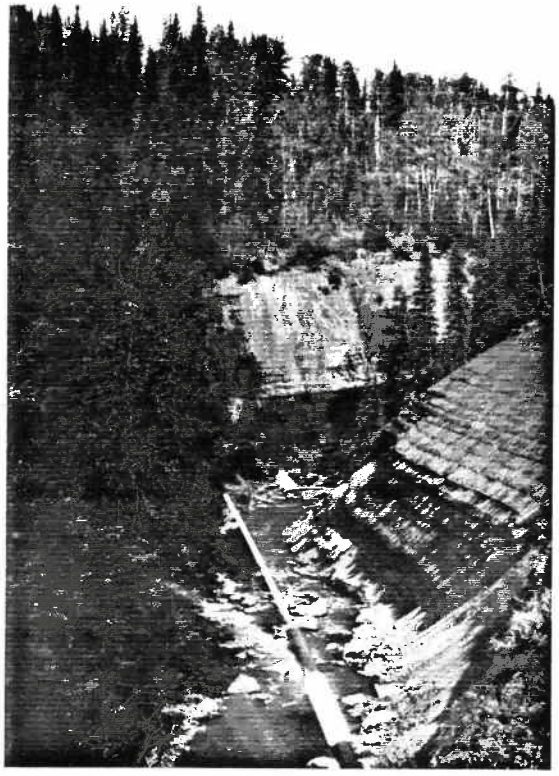


Plate 12.
Reach 1 of Maurice Creek is 1.7 km long and supports spawning and rearing rainbow trout from the Peace River (above). Reach 2 is very confined and carries a high silt load in the spring (below right). It could support rearing trout but is isolated by a series of five water falls up to 30 m in height.





meanders through a canyon with the valley walls steeply reposed away from the channel on either side. Approximately 50% of the valley walls are so steep that they lack vegetative cover. Although the gradient increases from 0.5% in Reach 1 to 2.5% in Reach 2, there is a slight decrease in the riffle portion of the glide/riffle habitat.

There are five sets of waterfalls along the lower end of the reach varying in height from 2.5 m to approximately 30 m. The first fall is located 3 km from the mouth and the last waterfall is located 5 km further upstream. In a few areas in the upper part of the reach, channel width increases to 70 m and the stream becomes braided.

3.1.3 Halfway River Tributaries

3.1.3.1 Cameron River

The lower 5 km of the Cameron River (Figure 60, which was surveyed on foot on October 7, 1989, is quite uniform and was designated a single reach. The river carried a fairly heavy silt load that reduced visibility to 5 cm at moderate flows (Plate 13). Discharge was estimated at 5 $m^3 \cdot s^{-1}$ and the water temperature was 7°C.

The stream channel is irregular but fairly stable with some slow bank erosion and aggradation evident. As a consequence there is little channel debris. The valley wall is cut by the frequently confined channel on some corners causing minor slumping and exposure of steep mud-shale banks up to 40 m high. The October flow only covered 60% of the channel which averages 37 m in width so there were numerous bars.

Gradient is low (0.5%) and the habitat is mainly glide (50%) with the remainder largely riffle (33%) and pool (12%). Average maximum pool depth was 1.7 m at October flows.

3.1.3.2 Ground Birch Creek

The lower 5 km of Ground Birch Creek was surveyed on October 6, 1989. At that time, the discharge, estimated at 0.7 $m^{-3}s^{-1}$, was at a moderate level, the water temperature was 6°C and visibility was 10 cm.

Reach 1 extends from the Halfway River to 2 km. The 27 m wide channel is unstable so the banks are eroding and aggrading in many places and there is an abundance of channel debris. In a few areas the channel is cutting into the valley wall and causing some slumping. Most of the habitat is riffle and glide (Plate 14). Average maximum depth of the few (5%) pools was 0.9 m.

Plate 13

The Cameron River contributes a large amount of silt to the Halfway River even during low flows in late fall (above). It has a moderately stable channel and is largely shallow glide (below).

Plate 14

The lower reach of Ground Birch Creek meanders irregularly and shows signs of active channel movement (right, below right). In Reach 2, the channel becomes narrower and more confined (below)

In Reach 2 the channel is more stable, narrower (17.1 m) and becomes more confined. There is less bank erosion and less channel debris (0-5%) in this reach. The channel cuts into the valley walls in several areas, creating slumps and exposing steep, shale slopes up to 30 m in height. The stream contains 5% pool, 30% riffle, and 65% glide. Average maximum pool depth was 1.3 m.

3.1.3.3 Kobes Creek

Kobes Creek flows into the Halfway River approximately 65 km from the Halfway River mouth (Figure 6). The lower 5 km of Kobes Creek, surveyed by foot on September 18, 1989, forms on homogeneous reach. During the survey the discharge was estimated at 1.2 $m^3 \cdot s^{-1}$, water temperature was 8.5°C, and the water visibility was 50 cm. This irregular meandering creek is entrenched 50 to 100 m into the Peace River Lowlands (Plate 15). The outside of the meander curves are often bounded by steep fine-shale valley walls rising up to 50 m in height. The channel averages 21 m wide with wetted widths averaging 12 m. The stream appears relatively stable as there is little channel debris and bank erosion. Most of the habitat is riffle (60%) with 33% shallow glide and a few pools (5%). The pools had average maximum depths of 1.4 m and the riffles averaged 0.2 m in depth. The substrate is primarily cobble and boulder.

3.1.3.4 Graham River

The lower 10 km of the Graham River was surveyed by boat on October 3 - 4, 1989. The remainder of the 93 km up to Christina Falls was examined by helicopter October 11, 1990. Discharge at this time was 26 $m^3 \cdot s^{-1}$ (WSC 1989), water temperature was 7.5°C, and water clarity was estimated to be 1.5 m. Water clarity had increased to 4.0 m and temperatures had declined to 3.5°C when the stream was visited again a week later.

The lower section of the river (Reach 1) extends from the Halfway River confluence upstream 27 km (Figure 1). Here the river has a single irregular channel that averages 63 m in width and a had a wetted width of 33 m at the time of the survey (Plate 16). The reach is estimated to contain 65% glide, 30% riffle, and 5% pool with average maximum pool depths of 2.5 m. The channel is occasionally confined cutting into the valley walls and creating steep fine/shale banks up to 40 m high. Except for a few small log jams, the river has little organic debris. The upper portion of the reach, above 13 km, appears more stable as there are fewer bars and vegetation often extends to the water. The lower part of the reach contains 50% bars and appears less stable with more aggradation and erosion taking place.

Plate 15

Kobes Creek enters the Halfway River through a narrow valley (above right). Most of the 5 km distance surveyed was riffle with the cobble substrates near 0.2 km (below right) becoming boulder (below) above 1 km.

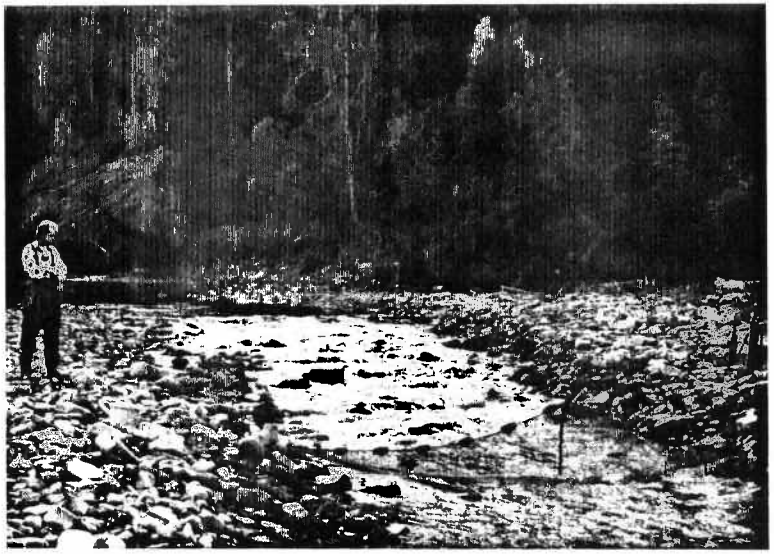


Plate 16
At their confluence, the discharges of the Graham and upper Halfway Rivers are roughly equal (above). Graham River Reach 1 (below) is largely glide with little organic debris. High fish densities in late fall suggest fish overwinter nearby.

Reach 2 extends from 27 km to 40 km. The relatively straight, stable channel is confined and becomes almost canyon like at the 35 km mark. The habitat is 40% riffle and the substrate consists primarily of boulder and cobble.

Reach 3 extends from 40 km to 87 km. The channel is irregular with occasional meanders. There is little channel debris. The habitat is mainly glide (80%) and the rest is riffle (Plate 17). Channel width is approximately 35 m and is not much greater than the wetted width throughout most of the reach. Substrate composition was 10% fines, 20% gravel, 50% cobble and 20% boulder.

Reach 4 is located between 83 km and Christina Falls at 93 km. In this area, the Graham River is entrenched and consists primarily of riffle habitat (70%) due to a steep gradient. The area sampled appeared typical with a channel width of 25 m and wetted width of 15 m. The substrate consisted of 5% fines, 10% gravel, 15% cobble, 30% boulder and 40% bedrock.

3.1.3.5 Colt Creek

This small humic stained creek flows into the Graham River approximately 12 km above the Halfway River (Figure 1). The lower 15 km of Colt Creek was inspected by helicopter September 23, 1989 and spot checks were made on the ground September 26 and 27. The discharge was estimated at 0.5 $m^3 \cdot s^{-1}$ on September 26, 1989.

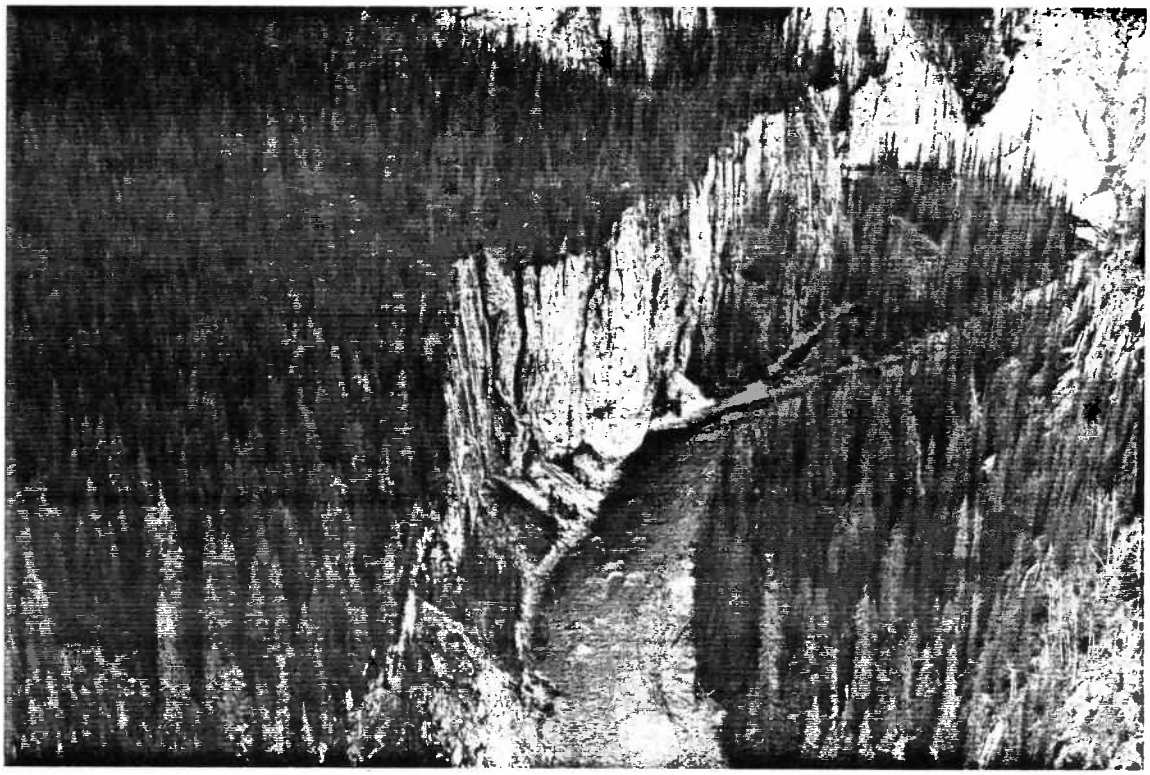
Colt Creek's lower 15 km were divided into two reaches. The lower one extends from the mouth approximately 1.5 km upstream. The channel is not well defined in this section as the system flows through beaver pond habitat. The actual location of the channel is difficult to define from the air in some sections due to a dense canopy of spruce and aspen overhanging the channel. This reach consists of mainly pool and glide habitat, has an abundance of organic debris, and appears slow flowing.

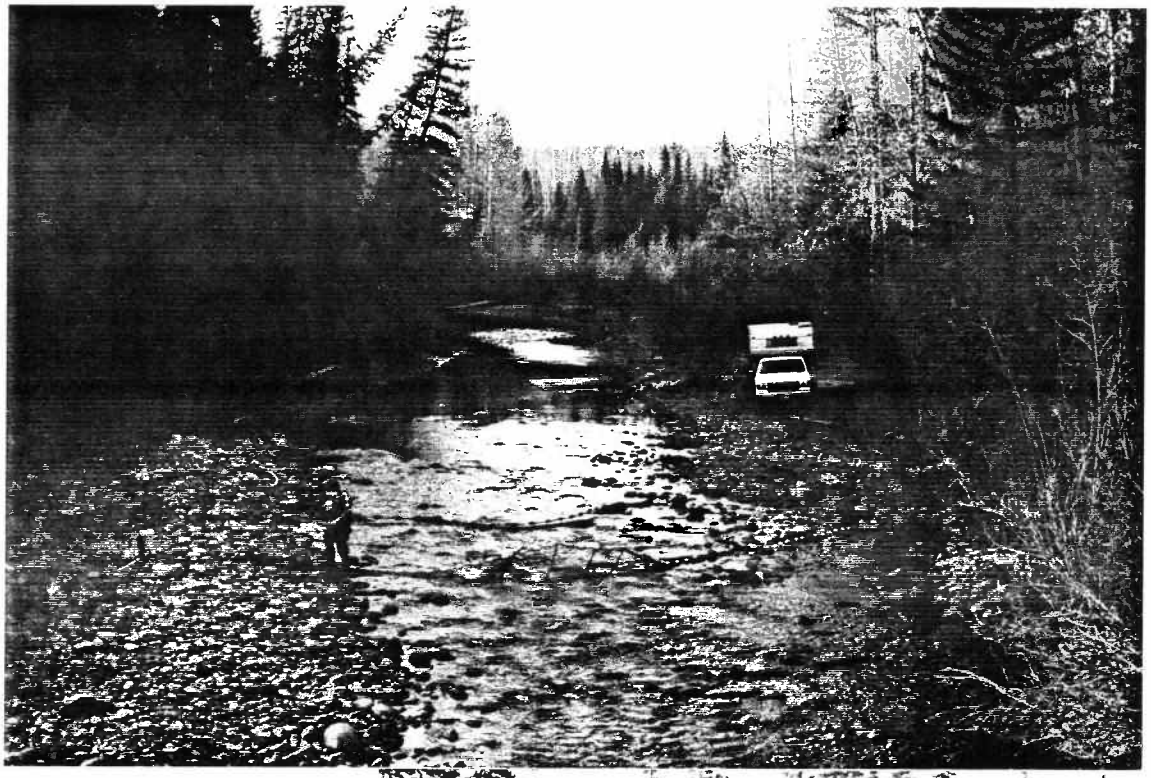
In Reach 2 the channel is more defined. Channel width averaged 20 m, of which 11 m was wetted at the time of the survey. Most of the habitat is riffle and glide with 15% pools to 0.75 m deep (Plate 18). The substrate consists of 10% fines, 35% gravel, 40% cobble and 15% boulder. Many of the banks were eroding which resulted in an abundance of scattered and accumulated debris that covered approximately 5% of the channel. This reach also contained several beaver ponds.

3.1.3.6 Blue Grave Creek

Blue Grave Creek's lower 20 km were surveyed by helicopter on September 23 and spot checks were made on the ground September 27, 1989 (Figure 10). The

Plate 17
Reach 3 of the Graham River is mainly glide with occasional meanders (above). In Reach 4 the gradient increases and the channel is confined by steep rock walls (below).





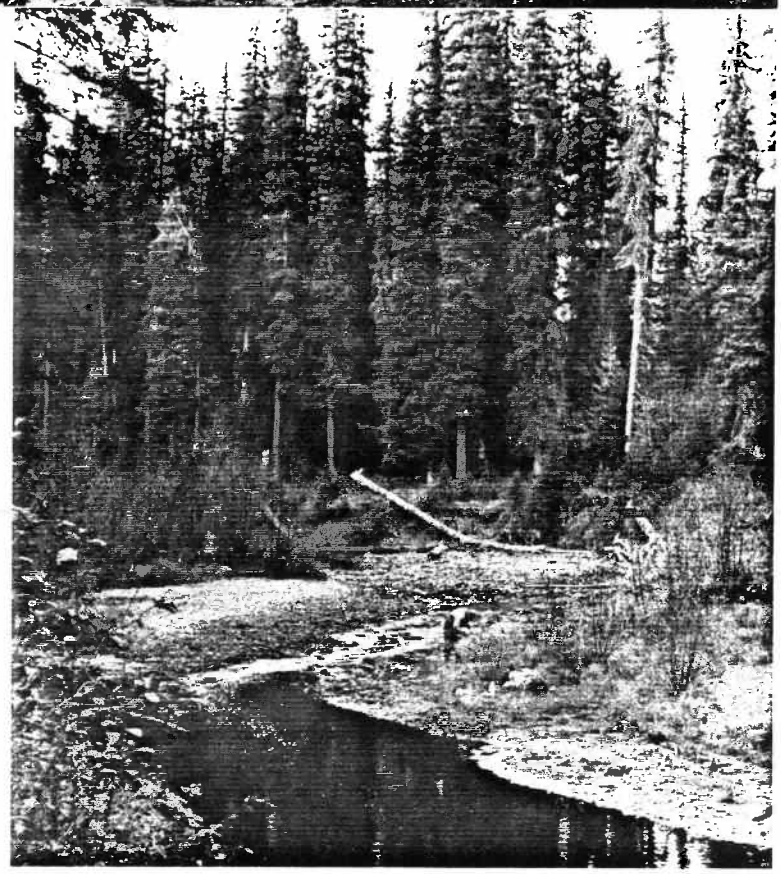


Plate 18
The Colt Creek channel averaged 20 m in width at 3 km (above) but narrowed to 3 m at 15 km (right). Beaver ponds, the dominant habitat type in Reach 1, were less common in Reach 2.

creek is quite small with a discharge estimated at 0.6 $m^3 \cdot s^{-1}$. Water visibility was 1 m. The creek flows into the Halfway River at the 93 km mark (Figure 1). The lower 15 km flows unconfined through a broad, flat bottomed valley with a wide and unstable channel that is braided in some areas (Plate 19). Riparian vegetation consists mainly of willow, aspen, alder, cottonwood and spruce. Near the mouth, the channel is 35 m wide and the wetted width was 6 m. Further upstream, at the 15 km mark, the channel was 10 m wide. An estimated 45% of the habitat is riffle, 45% is glide and 10% is pool. Average maximum pool depth averaged 0.7 m. Substrate consisted of 15% fines, 50% gravel, 35% cobble and 5% boulder, Banks were flat and aggrading in many areas while in others the banks were eroding. In consequence there was scattered and accumulated debris covering approximately 5% of the stream channel.

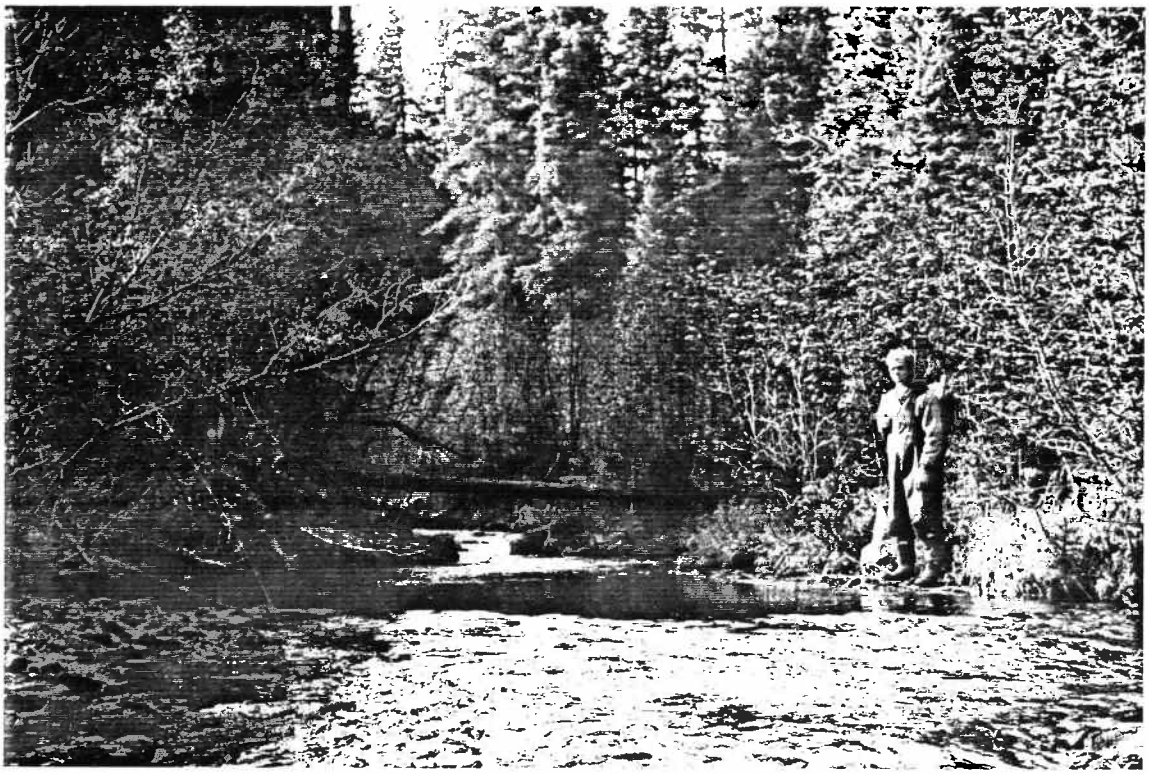
The character of Blue Grave Creek varied from beaver pond habitat to faster flowing areas, and is primarily riffle and glide habitat above the 15 km mark. In the swampy sections 90-100% of the channel was wetted, the vegetation overhangs 60% of the 3-4 m wide channel and there is an abundance of organic debris. In the faster flowing areas channel width averages 7.5 m, wetted width was 5 m, and the substrate consists of 15% fines, 55% gravel, 20% cobble and 10% boulder.

3.1.3.7 Horseshoe Creek

Horseshoe Creek was examined by helicopter from its confluence with the Halfway River to a point 15 km upstream (Figure 1). The creek was also sampled by road near the mouth and upstream approximately 16 km. The character of this creek is similar throughout the area surveyed. On September 27, 1989 the discharge was estimated at 0.4 $m^3 \cdot s^{-1}$, the water was clear and the water temperature was 9.5°C. Like Blue Grave Creek, Horseshoe Creek flows through a wide, flat bottomed valley (Plate 20). The creek is occasionally confined by steep silt/shale banks 20-30 m high.

Channel width ranges from 60 m at the mouth to 30 m at the 16 km mark. Only 9 to 10 m of the channel was wet. There was an abundance of scattered and accumulated debris due to high water erosion of some of the banks. Other banks were flat and aggrading. In many areas the channel is braided or divided into two channels. The substrate consists of 10% fines, 30% gravel, 50% cobble and 10% boulder. 10% of the creek is pool habitat with the remainder riffle (40%) and glide (50%). Maximum pool depth averaged 1 m.

Plate 19.
Blue Grave Creek flows unconfined through a broad flat bottomed valley. Near the mouth the channel is braided and up to 35 m wide (above). Further upstream, at 15 km, the channel is narrower with a regular sequence of 45% glides, 45% riffles and scattered shallow pools (below).



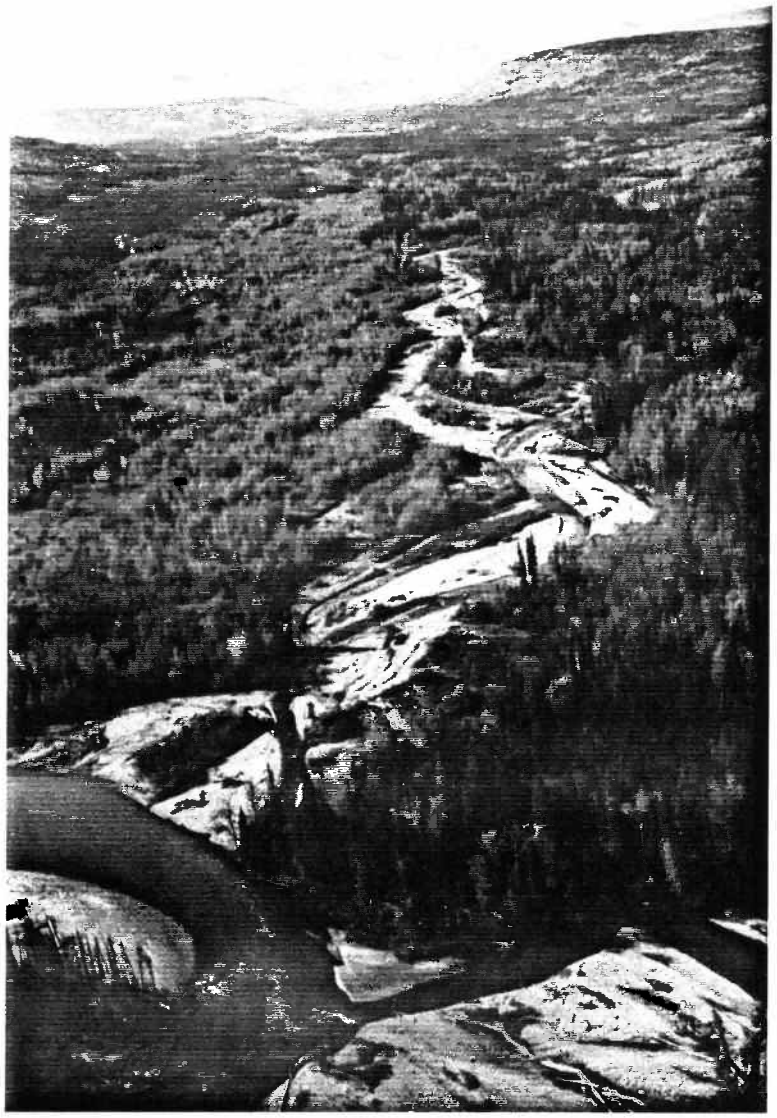


Plate 20
Horseshoe Creek flows through a broad, shallow valley. The channel is braided in many areas with large debris accumulations and other signs of recent bank erosion and channel movement.

3.1.3.8 Chowade River

The lower 45 km of the Chowade River was surveyed by helicopter on October 11, 1989 (Figure 1). Three reaches are apparent in the length surveyed. Reach 1 extends from the mouth approximately 3 km upstream. Here the river is very turbid due to the erosion of silt banks in the lower four kilometres of the river. Above Reach 1, the river is clear. Reach 1 is very unstable with an abundance of scattered and accumulated debris. The banks appeared to be either eroding or aggrading and the channel is braided in many areas. Average channel width was 50 m and the wetted width was 18 m during the survey. The channel is largely unconfined and meanders over the valley bottom (Plate 21). There were few pools (10%) as most of the river is glide (60%) and riffle (30%). Average maximum riffle depth was estimated at 0.6 m and average maximum pool depth was over 2 m. Most of the substrate consisted of fines (40%), gravel (40%) and cobble (20%).

Reach 2 extended from 3 km upstream to the 37 km mark. This reach is very similar to Reach 1 except that the water was clear.

In Reach 3 the river is more stable and largely confined to one channel. The gradient becomes steeper and, as a consequence, the habitat is mainly riffle (60%) with a few cascades and there is little pool habitat. The substrate is mainly boulder and cobble. Channel width at a sample site near the 42 km mark was 15 m and the wetted width was 6 m. Channel width appeared to equal the wetted width in many areas of this reach. The channel is irregular in shape and occasionally confined.

3.1.3.9 Cypress Creek

Cypress Creek flows into the Halfway River 127 km from the Peace River (Figure 1). The creek was sampled at the 1.5 km and 15 km bridge crossings on October 5, 1989 and was flown by helicopter from the mouth to 50 km upstream on October 11. Discharge was estimated at 10 $m^3 \cdot s^{-1}$, water clarity was 0.6 m and water temperature was 5°C on October 5, 1989. Three reaches were apparent over the 50 km of stream surveyed.

The lower reach extends upstream 23 km from the mouth. The creek is mainly unconfined over this section with frequent braiding and appeared very unstable with a wide flood plain (Plate 22). Channel width was 60 m at the 1.5 km mark and 30 m at the 15 km mark. Wetted width averaged 17 m. This reach is approximately 5% pool habitat with the remainder evenly split between glide and riffle. Substrate was mainly gravel (65%). Fines composed 10% of the substrate,

Plate 21

Reach 1 of the Chowade River meanders unconfined across the Halfway Valley (right). Some of the banks contain a large proportion of fines which result in high turbidities even during fall low flows. Reach 2 is similar in character but has much lower turbidity (below right). In Reach 3 (below) the river is stable and largely confined to one channel. The habitat is mainly riffle with a few cascades.

Plate 22

The lower reach of Cypress Creek is largely braided, unconfined, and unstable (left).

In Reach 2, the creek is confined to single channel with increased gradient that results in 60% riffle habitat (upper right)

At the upper end of Reach 3 the creek meanders through meadows (below right).

cobble 20% and boulder 5%. There was a large amount of scattered and accumulated debris (10%) due to the unstable nature of the channel.

Reach 2, extending from 23 to 32 km, is more stable and the flow is mainly confined to a single channel with less debris (5%). Gradient is slightly greater in this section resulting in increased riffle habitat (60%). Very little pool habitat is present. The substrate consisted of 10% fines, 30% gravel, 45% cobble, 10% boulder and 5% bedrock. Channel width was 26 m and the wetted width was 10 m. Water clarity was estimated to be 10 m.

The gradient decreases above Reach 2. The single channel meanders through meadow throughout most of Reach 3. This section contains little riffle (5%) and is mainly glide (75%) with a smaller proportion of pool (20%). The substrate consisted primarily of fines (50%), gravel (40%) and a small amount of cobble (10%). Channel widths averaged 16 m and wetted widths averaged 12 m. In one, 2 km section below the 45 km mark there is a series of cascades and falls dropping 2 to 3 m over bedrock sills. Above this point, the channel again meanders through meadow habitat. At 47 km the creek split into several channels in marsh habitat and is no longer as well defined.

3.2 FISH POPULATIONS

3.2.1 Species composition, distribution and morphology

A total of 17 species of fish was found within the study area during September and October 1989 (Table 14). Sport fish included burbot, rainbow trout, mountain whitefish, lake whitefish, northern pike, bull trout, and Arctic grayling. Six species of minnow (northern squawfish, peamouth, flathead chub, lake chub, longnose dace, and redside shiner), three species of sucker (white sucker, longnose sucker and largescale sucker) and sculpins were also found. Species composition in the Peace River tributaries studied generally appears to be similar to that reported by RRCS (1979) from surveys in 1974, 1975 and 1977. In some tributaries, species composition appears to shift between spring and fall (Table 15).