

# **Strategic Review of Fisheries Resources for the North Thompson Habitat Management Area**

Department of Fisheries and Oceans  
Fraser River Action Plan  
555 West Hastings Street  
Vancouver, B.C. V6B 5G3

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Canada<sup>131</sup>

**STRATEGIC REVIEW OF FISHERIES RESOURCES  
NORTH THOMPSON HABITAT MANAGEMENT AREA**

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**Final Draft**

**Fraser River Action Plan  
Department of Fisheries and Oceans  
555 West Hastings Street  
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## TABLE OF CONTENTS

LIST OF FIGURES .....	iv
LIST OF TABLES .....	vi
LIST OF PHOTOS .....	vii
LIST OF APPENDICES .....	viii
FOREWORD .....	ix
PREFACE .....	x
ACKNOWLEDGEMENTS .....	xiii
EXECUTIVE SUMMARY .....	xiv
1.0 INTRODUCTION .....	1
2.0 FISHERIES RESOURCES .....	7
2.1 Sockeye Salmon .....	7
2.1.1 Life history .....	10
2.1.2 Catches, escapements and escapement trends .....	10
2.1.3 Spawning and rearing habitat .....	13
2.1.4 Habitat productive capacities .....	13
2.1.5 Production objectives .....	15
2.1.6 Enhancement opportunities .....	15
2.2 Chinook Salmon .....	16
2.2.1 Life history .....	16
2.2.2 Catches, escapements and escapement trends .....	18
2.2.3 Spawning and rearing habitat .....	20
2.2.4 Habitat productive capacities .....	21
2.2.5 Production objectives .....	22
2.2.6 Enhancement opportunities .....	23
2.3 Coho Salmon .....	23
2.3.1 Life history .....	26
2.3.2 Catches, escapements and escapement trends .....	26
2.3.3 Spawning and rearing habitat .....	27
2.3.4 Habitat productive capacities .....	31
2.3.5 Production objectives .....	34
2.3.6 Enhancement opportunities .....	35
2.4 Pink Salmon .....	36

2.5 North Thompson Resident Fisheries .....	36
2.5.1 Introduction .....	36
2.5.2 North Thompson drainage - general .....	40
2.5.3 Unit descriptions .....	42
3.0 BIOPHYSICAL FEATURES .....	47
3.1 Physiographic Descriptions .....	52
3.2 Regional Hydrologic Regime .....	54
3.2.1 Hydrologic analysis .....	59
3.3 Climate Change .....	61
3.3.1 Predicted climate change .....	61
3.3.2 Historical variations in precipitation, air temperature and runoff .....	63
4.0 RESOURCE USE .....	65
4.1 Forestry .....	65
4.1.1 Administration .....	65
4.1.2 North Thompson HMA clearcut inventory .....	69
4.1.3 Percentage cut .....	71
4.1.4 Five year development plans .....	71
4.1.5 Future trends .....	73
4.2 Agriculture .....	75
4.2.1 Overview .....	75
4.2.2 Administration .....	76
4.2.3 Regional trends .....	76
4.2.4 Impacts on fisheries resources .....	79
4.3 Population and Settlement, Recreation and Transportation .....	80
4.3.1 Existing resources use .....	80
4.3.2 Projected developments .....	83
4.3.3 Impacts on fisheries resources .....	84
4.4 Mineral Resources and Placer Mining .....	84
4.4.1 Regional overview of mineral exploration and development .....	84
4.4.2 Mineral resources and mining activity .....	86
4.4.3 Impacts on fisheries resources .....	87

4.5	Water Use .....	87
4.5.1	Administration .....	87
4.5.2	Consumption and storage .....	89
4.5.3	Future trends .....	93
4.5.4	Water quality .....	94
4.6	Air Quality .....	96
5.0	WATERSHED MANAGEMENT ISSUES AND RECOMMENDATIONS .....	97
5.1	North Thompson River Valley .....	97
5.1.1	Description .....	97
5.1.2	Management priorities .....	100
5.2	Thompson Plateau Watersheds .....	102
5.2.1	Description .....	102
5.2.2	Management priorities .....	102
5.3	Shuswap Highland Watersheds .....	108
5.3.1	Description .....	108
5.3.2	Management priorities .....	109
5.4	Cariboo and Monashee Mountain Watersheds .....	116
5.4.1	Description .....	116
5.4.2	Management priorities .....	116
5.5	Quesnel Highland Watersheds .....	118
5.5.1	Description .....	118
5.5.2	Management priorities .....	121
5.6	Fraser Plateau Watersheds .....	121
5.6.1	Description .....	121
5.6.2	Management priorities .....	122
6.0	REFERENCES .....	123

## LIST OF FIGURES

Figure i	Fraser River Habitat Management Areas .....	xi
Figure 1.1	Location of the North Thompson Habitat Management Area (HMA) .....	2
Figure 1.2	Known salmon spawning streams in the North Thompson HMA .....	3
Figure 1.3	Average annual escapement of Pacific salmon to the drainage Sub-basins within the Fraser River Basin. Reproduced from Dorcey and Griggs 1991 .....	4
Figure 2.1	Ten year average escapements to the North Thompson HMA .....	8
Figure 2.2	Location of sockeye salmon spawning streams in the North Thompson HMA .....	9
Figure 2.3	Sockeye escapements to streams in the North Thompson 1951 to 1992 .....	12
Figure 2.4	Comparison of estimated sockeye salmon spawning and rearing capacity (adult spawners) in the Raft and Barriere systems .....	14
Figure 2.5	Location of chinook salmon spawning streams in the North Thompson HMA .....	17
Figure 2.6	Chinook escapements to streams in the North Thompson 1951 to 1990 .....	19
Figure 2.7	Location of coho salmon spawning streams in the North Thompson HMA .....	24
Figure 2.8	Coho escapements to streams in the North Thompson 1951 to 1991 .....	28
Figure 2.9	Location of pink salmon spawning streams in the North Thompson HMA .....	39
Figure 2.10	Units used for discussion of resident fisheries in the North Thompson HMA .....	41
Figure 3.1	Physiographic units (Holland 1976) in the North Thompson HMA .....	48
Figure 3.2	Generalized biogeoclimatic zones of the North Thompson .....	49
Figure 3.3	Annual precipitation in the North Thompson HMA .....	50
Figure 3.4	Annual snowfall in the North Thompson HMA .....	51
Figure 3.5	Hydrometric stations used in the Sigma Engineering Ltd. (1991) analysis .....	55
Figure 3.6	Streams in the North Thompson HMA with low ratios of seven day low flow to mean annual flow (Northwest Hydraulic Consultants Ltd. 1992) .....	60
Figure 3.7	Streams in the North Thompson HMA with high ratios of mean annual flood to mean annual flow (Northwest Hydraulic Consultants Ltd. 1992) .....	62
Figure 4.1	B.C. Ministry of Forests administrative boundaries in the North Thompson HMA	66
Figure 4.2	Percent drainage area logged of known salmon streams in the North Thompson HMA .....	70
Figure 4.3	Forest company harvest areas in the North Thompson HMA .....	72
Figure 4.4	Overview of areas in the North Thompson HMA proposed for logging in the next five years .....	74
Figure 4.5	Agricultural subdivisions in the North Thompson HMA .....	77
Figure 4.6	Mining divisions of the South Central Mining District in the North Thompson HMA .....	85
Figure 4.7	Water Management Division precincts in the North Thompson HMA .....	88

Figure 4.8 Number of fully recorded water licences in the North Thompson HMA . . . . . 90

Figure 4.9 Number of water storage licences in the North Thompson HMA . . . . . 91

Figure 4.10 Salmon streams in the North Thompson HMA with high potential water demand  
during the summer low flow period . . . . . 92

Figure 5.1 Physiographic land units in the North Thompson HMA, modified for watershed  
summaries . . . . . 98

Figure 5.2 Kamloops resource management plan resource units in the North Thompson  
HMA . . . . . 99

## LIST OF TABLES

Table 2.1	Comparison of escapements for coho, chinook and sockeye in the Thompson HMAs . . . . .	7
Table 2.2	Comparison of commercial and Native fishery catches for Fennell Creek and Raft River stocks for 1982 to 1992 . . . . .	11
Table 2.3	North Thompson HMA sockeye escapement . . . . .	11
Table 2.4	Sockeye spawning capacity of the North Thompson sockeye streams . . . . .	15
Table 2.5	Sockeye rearing capacity of North Thompson lakes . . . . .	15
Table 2.6	Summary of average chinook escapements to streams in the North Thompson HMA . . . . .	20
Table 2.7	Ten year average coho escapements for the North Thompson River and tributary streams . . . . .	25
Table 2.8	Estimated potential coho smolt production, based on Marshall and Britton coho model . . . . .	33
Table 3.1	Hydrology in the North Thompson area . . . . .	56
Table 4.1	Recent and total logging of salmon bearing watersheds in the North Thompson HMA . . . . .	69
Table 4.2	Trends in area (km <sup>2</sup> ) of crop land in the North Thompson Basin 1976 to 1986 . . . . .	78
Table 4.3	Trends in area (km <sup>2</sup> ) of crop land irrigated from 1981 to 1986 . . . . .	79
Table 4.4	Summary of exploration in the North Thompson HMA during 1990 . . . . .	86

## LIST OF PHOTOS

Photo 2.1	Coho spawning in Albreda River .....	29
Photo 2.2	Little Hell's Gate, partial barrier to chinook and coho migration. A potential enhancement project .....	29
Photo 2.3	Coho net rearing pens in Dunn Lake .....	37
Photo 2.4	Enumeration fence on Louis Creek .....	37
Photo 4.1	The North Thompson Valley at Vavenby showing the extent of logging .....	67
Photo 4.2	Recent logging in the North Thompson Valley upstream of Albreda River .....	67
Photo 4.3	Louis Creek, loss of riparian and instream habitat due to agricultural land use .	81
Photo 4.4	Lemieux Creek, loss of bank habitat on land cleared for agricultural use .....	81
Photo 5.1	Peddie Creek wetlands showing the location of the CN Twin Tracking encroachment .....	103
Photo 5.2	Cook Creek wetlands adjacent to the North Thompson River .....	103
Photo 5.3	Lower Lion Creek .....	119
Photo 5.4	Blue River downstream of the Highway Bridge .....	119

## LIST OF APPENDICES

### APPENDIX A - SALMON ESCAPEMENTS

#### Tables

Sockeye escapements by year  
Sockeye escapements by cycle years  
Chinook escapements by year  
Coho escapements by year

#### Bar Graphs

Sockeye escapements to Fennell Creek and Raft River, 1951 to 1992  
Chinook escapements to Clearwater and North Thompson rivers, 1951 to 1991  
Coho escapements to the North Thompson River, 1951 to 1991  
Coho escapements to Lemieux and Louis creeks, 1951 to 1991  
Coho escapements to Barriere River and Fennell Creek, 1951 to 1991  
Coho escapements to Dunn Creek, 1951 to 1991  
Coho escapements to Lion Creek, 1951 to 1991

### APPENDIX B - PHYSIOGRAPHIC AND BIOGEOCLIMATIC DESCRIPTIONS

Physiographic unit descriptions  
Biogeoclimatic zone descriptions  
Ecoprovinces of British Columbia

### APPENDIX C - RESOURCE USES

Forest inventory of salmon bearing watersheds in the North Thompson HMA  
Agricultural inventory of salmon bearing watersheds in the North Thompson HMA  
Human population estimates for salmon bearing watersheds in the North Thompson HMA  
Mineral interests in salmon bearing watersheds in the North Thompson HMA  
Summary of waste discharge permits for salmon streams in the North Thompson HMA  
Maximum possible daily loading from effluent permits in the North Thompson HMA  
Drainage and flow characteristics for salmon streams in the North Thompson HMA  
Sensitivity indices for salmon streams in the North Thompson HMA

## FOREWORD

The preparation of integrated fisheries management plans for the sub-basins of the Fraser River is one of the initiatives of the Fraser River Action Plan under Canada's Green Plan. The Strategic Review of Fisheries Resources for the North Thompson Habitat Management Area (HMA) is a contribution to this activity.

This review was largely completed prior to the initiation of the provincial planning framework that includes the regional land use planning processes CORE (Commission on Resources and the Environment) and LRMP (Land and Resource Management Planning). It also preceded the implementation of the Aboriginal Fisheries Strategy. These processes have emphasized proactive and cooperative management programs. DFO is presently participating in the Kamloops LRMP process with other government agencies, stakeholders and the public to develop a land use plan for the Kamloops area. DFO is also committed to negotiating agreements with Native Bands on fisheries issues in the Fraser Basin. It should be noted that the Strategic Review of Fisheries Resources for the North Thompson HMA does not fully reflect developments associated with these more recent activities and is intended to serve as a background reference document.

Fraser River Action Plan, January, 1994

## PREFACE

The Government of Canada and the Department of Fisheries and Oceans have made commitments towards achieving sustainable development of the fisheries resources. The principles that will guide the Department of Fisheries and Oceans (DFO) are those popularized by the 1987 World Commission on the Environment and Development - Our Common Future. However, it is difficult to take global concepts and apply them effectively in smaller geographic areas. This review of North Thompson fishery resources will provide a relevant fisheries data base to better allow multi-disciplined sustainable development discussions to take place in the Fraser River Basin.

In 1990, DFO established a small Task Force to address this challenge. The initial task of this group was to devise and complete a habitat management plan for the Fraser River. It was recognized that salmon habitat has been significantly degraded in the Fraser River Basin over the past 100 years. Despite that, the salmon stocks are being actively rebuilt towards historic levels. Obviously a link between the capability of the habitat to produce fish and stock rebuilding goals has to be established. Also, we must begin the process of better protecting existing habitat and to restore and enhance what is desirable within a plan involving more than DFO habitat and harvest managers.

To address this overall task a Habitat Planning Unit divided the Fraser River Basin into 15 Habitat Management Areas. This division was based on major river systems and salmon stocks. The North Thompson report follows the Stuart/Takla plan. It is DFO's attempt to define salmon habitat status, stock status and habitat restoration and protection priorities. This series is a first step towards establishing a data base for long-term environmental sustainable development discussions with other stakeholders in the basin.

Although the stock rebuilding initiative began several decades ago, it received greater priority after the 1985 Canada-U.S. International Agreement. Serious attempts to include habitat considerations into the process began in late 1988. In 1990, the initiative was incorporated into the National Green Plan's Fraser River initiative and is now called the Fraser River Action Plan.

As part of our commitment to sustainable development and Canada's Green Plan we have defined specific goals for sustainable fisheries development. Fish habitat management planning and associated DFO decisions and activities are guided by the goals of sustainable development. The two basic principles of sustainable development are:

- to maintain ecological diversity of the basin; and

# FRASER RIVER HABITAT MANAGEMENT AREAS

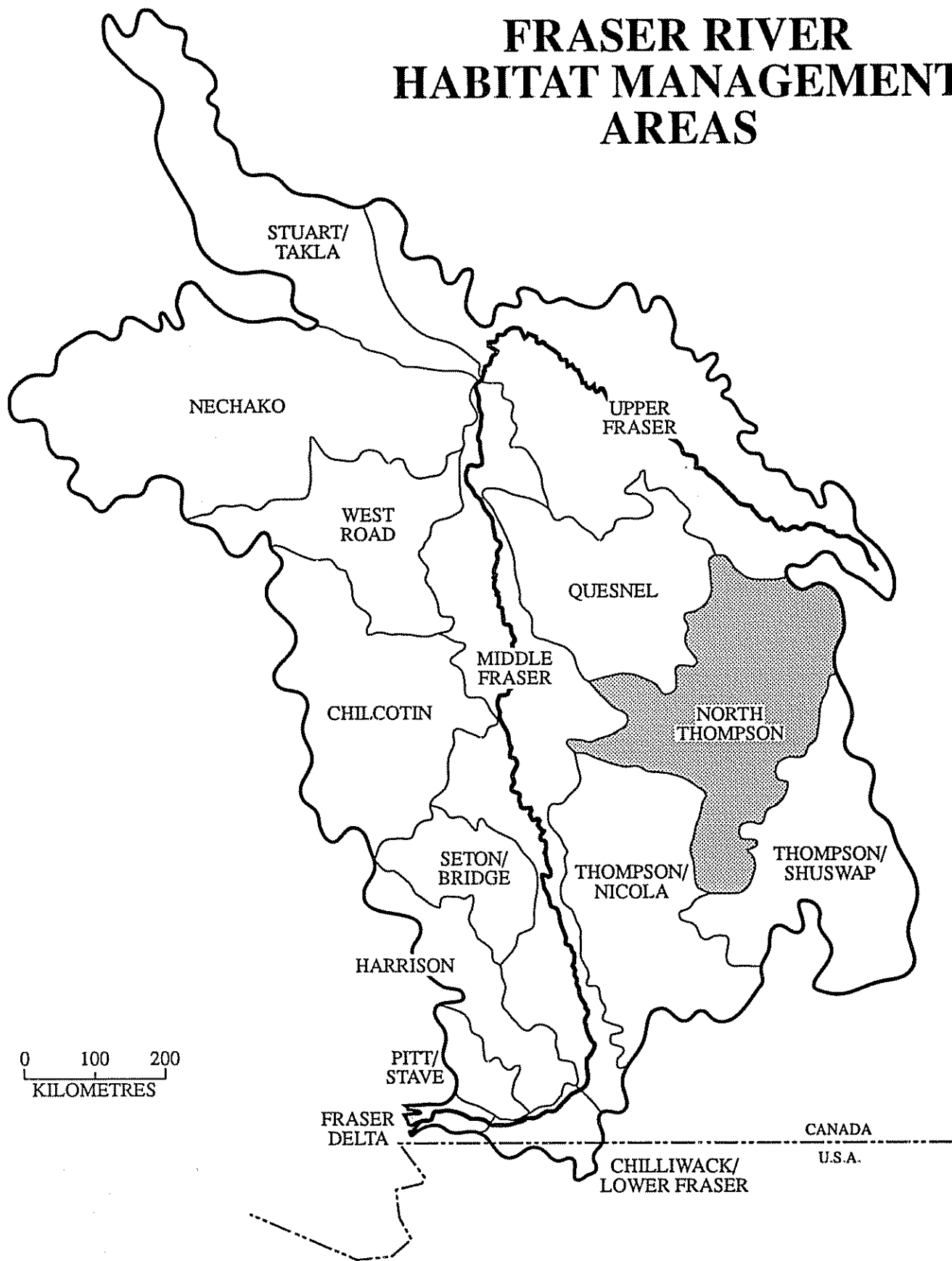


Figure i

Fraser River Habitat Management Areas

- to maximize the net economic benefits that can be derived from the resource.

DFO has defined the following seven measurable and achievable goals for sustainable fisheries development. They are as follows:

1. **Avoiding irreversible man made changes to fish producing habitats.**  
Alterations to fish habitat that reduce its capacity to produce valuable fish populations and cannot be reversed within a human generation will be avoided.
2. **Maintaining the genetic diversity of fish stocks.**  
No fish stock, however small, will be arbitrarily written off and, where possible, efforts to conserve and rebuild small and remnant stocks will be made.
3. **Maintaining the physical and biological diversity of fish habitats.**  
Physical and biological diversity of habitat provides fish with an opportunity to adopt alternative life history strategies, hence providing protection from natural variation.
4. **Providing a net gain in productive capacity by habitat management.**  
Ecological limits control productive capacity. Natural and self-sustaining production systems are preferred over semi-natural and artificial or non-self-sustaining systems.
5. **Maximizing the value of commercial, sport, and aboriginal fisheries.**  
Consideration of both tangible and intangible market and extra-market values measured in a way to permit comparison of competing users of the fisheries resources.
6. **Maximizing the non-consumptive values of fishery resources.**  
Intangible and cultural values associated with fishery resources must be given due consideration in decision making.
7. **Distributing fishery net benefits in a fair and equitable manner.**  
Local communities must be involved in the decision-making process with respect to habitat conservation, enhancement, and restoration, and particularly to who benefits and who pays.

It is hoped that this report will provide the basis for discussion resulting in the development of a more effective land use planning process that will better protect aquatic environments.

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Fraser River Action Plan  
1993

## ACKNOWLEDGEMENTS

This report represents a compilation and analysis of a wide variety of information sources.

Fisheries production and fisheries habitat data was compiled from published and unpublished literature sources and a number of Department of Fisheries and Oceans (DFO) and B.C. Ministry of Environment, Lands and Parks (MELP) sources. DFO personnel included Gordon Kosakoski (Habitat Management Head, S.B.C. Interior), Tim Panko (Fishery Officer in Clearwater), Wayne Saito and Neil Schubert (Management Biologists), Mel Sheng and Ken Petri (Salmon Enhancement Program). MELP (Fish and Wildlife) personnel that provided information on the North Thompson resident fisheries included Maurice Lirette, Brian Chan, Sandy MacDonald, Ian McGregor and Earl Sinclair (B.C. Parks).

The primary documents used for the biophysical description and the land and water use components of the North Thompson Habitat Management Area were prepared by Sigma Engineering Ltd. (1991) and Northwest Hydraulic Consultants Ltd. (1992) for the Fraser River Action Plan (FRAP). Susan Wilkins managed the project by Sigma and input was provided by subconsultants including Mike Miles (climate change), Karen Christie (forestry), Dan Schroeder (agriculture), John Dumbrell (population) and Paul Harder (impact assessment). The report by Northwest Hydraulic Consultants Ltd. (1992) on hydrology and water use for salmon streams in the Thompson River watershed was produced by Ken Rood and Roy Hamilton. In many cases, sections of these reports have been reproduced here.

Other groups contacted included Pat Matthews and Rick Olmsted of the Shuswap Tribal Council and David Toews of the B.C. Ministry of Forests.

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## EXECUTIVE SUMMARY

The North Thompson Habitat Management Area (HMA) encompasses the entire drainage area of the North Thompson River, which flows south from the Cariboo Mountains and Quesnel Highlands into the Thompson River at Kamloops, British Columbia. There are 30 salmon bearing streams for which escapements are recorded.

The North Thompson HMA supports sockeye (*Oncorhynchus nerka*), chinook (*O. tshawytscha*), coho (*O. kisutch*) and small populations of pink (*O. gorbuscha*) salmon. Based on data from recent years, sockeye, chinook and coho escapements in the North Thompson represent approximately 2%, 23% and 34%, respectively, of the total escapements to the Thompson River basin. All species are harvested in the Pacific Coast commercial fisheries and by the aboriginal fishery in the lower Fraser River. Coho and chinook and to a limited extent, sockeye and pink salmon are also taken in the Georgia Strait sport fishery. Resident fish species include rainbow trout (*O. mykiss*), kokanee (*O. nerka*), bull trout (*Salvelinus confluentus*) and lake trout (*S. namaycush*). The North Thompson is particularly noted for its lake fisheries. These include a large number of walk-in or semi-wilderness, high-quality rainbow trout fisheries. High-quality stream fisheries are found at only a few locations such as the Clearwater and Canim rivers.

### ESCAPEMENT TRENDS

**Sockeye salmon** dominant cycle runs in the HMA have ranged from 13,000 to 47,000 fish over the past five cycle years. Recorded escapements for the three lesser cycle years ranged from 4,000 to 11,000 fish. In the two major sockeye spawning streams, Fennell Creek and Raft River, escapements have been increasing and in the 1988 dominant cycle year were the highest ever recorded for these systems.

**Chinook salmon** escapements to the North Thompson HMA ranged from 4,000 to 11,000 over the period from 1981 to 1991. The major chinook producing streams are the Clearwater and North Thompson rivers. A number of tributaries, notably Finn Creek and Raft River, also produce chinook salmon. Over the last two decades, total chinook escapements to the North Thompson HMA have increased, largely due to increases in the Clearwater River.

**Coho salmon** in the HMA spawn in 27 streams throughout the North Thompson drainage. The 10-year average recorded escapement has been between 6,000 and 7,000 over the last two decades. There is concern that wild coho stocks are declining due to high exploitation rates and, in some cases, to degradation of habitat.

## ESCAPEMENT GOALS

Interim escapement goals have been established for sockeye and chinook salmon in the Fraser River. In 1988, the Sockeye Task Force made preliminary estimates of spawning capacity for sockeye streams. It was estimated that Fennell Creek and Raft River in the North Thompson HMA could support 14,500 and 12,800 spawners, respectively. These escapements have been exceeded in recent dominant cycles.

Under the Pacific Salmon Treaty, interim escapement goals to rebuild Canadian chinook stocks were based on doubling the average escapement estimates for the base period 1979-82 by 1988. These goals were not stream-specific and did not consider spawning ground and/or rearing capacities. When compared with the base period, total chinook escapements in the North Thompson HMA have increased by 60%, due to increases in a few tributaries, notably the Clearwater River.

Escapement targets for individual coho streams have not been determined. North Thompson average coho escapements recorded over the last 10 years have been maintained at existing levels, or in some streams have declined from the previous decade. Coho escapement trends are, however, difficult to verify due to the inaccuracy of counts. Based on the best escapement and catch data available, there is compelling evidence that wild coho stocks in the Fraser River are declining, due to overfishing and habitat losses. The Georgia Strait Coho Task Force recommended a reduction in the harvest rate to rebuild stocks and an increased emphasis on habitat protection (Department of Fisheries and Oceans 1992). This must be implemented quickly to reverse the trend of declining wild coho stocks. Although the decline of Thompson River coho stocks (which includes the North Thompson) appears to be somewhat less than that of the lower Fraser, there is concern that the interior stocks may be less productive than coastal stocks and may also require a lower exploitation rate.

## SALMON ENHANCEMENT

Hatchery production in the North Thompson has been limited. The chinook hatchery built in 1984 at Clearwater was experimental and was intended to assist in the development of an Upper Fraser chinook enhancement strategy. As with other Upper Fraser chinook facilities, survival rates have been poor. The chinook program at the Clearwater hatchery has been discontinued.

A coho enhancement project at Dunn Lake includes a hatchery and net pen rearing facility. Work initially was experimental and results have been mixed; Dunn Creek coho runs have increased substantially, while Louis Creek escapements have declined. Assessment of the results of coho releases to date indicates that spring smolt releases provide the best adult returns. It is

anticipated that the chinook will also be produced at the Dunn Lake facility, to improve survivals experienced at the Clearwater hatchery. Presently the facility is being upgraded to support both its present coho program and chinook production.

There is no enhancement of North Thompson sockeye at present, although the draft Fraser River Sockeye Management and Enhancement Plan (1988) identified Fennell Creek as a possible candidate for enhancement. Escapements have reached the estimated spawning capacity as a result of management of the fishery but it is believed that the rearing capacity of North Barriere Lake could support many more sockeye fry.

## **FISHERIES MANAGEMENT ISSUES AND PRIORITIES**

Information on present stock status, habitat carrying capacity and life history of salmon species, particularly for coho and chinook in the North Thompson and tributaries is quite limited. This information is required to better identify enhancement and fisheries opportunities in the sub-basin and to develop a comprehensive fisheries plan. Opportunities need to be determined and developed. New terminal fisheries are being assessed by the Aboriginal Fisheries Strategy for a number of stocks in the area.

### **Determination of escapement goals**

In the North Thompson HMA, preliminary estimates of spawning and rearing capacity have been made only for sockeye streams and lakes. For chinook and coho, data is not presently available to determine stream-specific escapement goals based on habitat capacity. Stock assessment of chinook and particularly coho is also difficult because of the limitations in the accuracy of escapement and catch data for specific stocks. More accurate counting techniques and better monitoring of catch are required.

Effort needs to be focused on assessing the potential carrying capacity of chinook and coho habitat in the North Thompson mainstem and selected streams. The simple models developed for coho and the paucity of data for interior streams does not permit an adequate estimate of stream carrying capacity. Research will have to be undertaken in order to better understand the factors regulating chinook and coho production in interior streams.

While fish production goals should be based primarily on the capacity of the spawning and rearing environment, escapement targets will be influenced by factors such as interactions with other fish species and harvest management objectives.

## **Salmon enhancement**

The chinook and coho hatchery program in the North Thompson HMA has had mixed results. Generally, chinook survival rates have been poor and increases in the chinook population have been largely attributed to better management of the fishery. Coho hatchery releases in a number of streams have not improved runs to those streams, while there have been significant increases in others (e.g., Dunn Lake). The results of these programs and any future hatchery work must be assessed, specific objectives set and an enhancement strategy developed that will maintain the genetic fitness of the wild stocks. It not known whether North Thompson coho are comprised of distinct stocks.

It is clear that enhancement alone cannot rebuild wild stocks. Therefore, a reduction in the exploitation rate is vital to increase spawning escapements of all stocks and increase production and harvesting opportunities in future years.

## **HABITAT IMPACTS**

Logging is the major resource activity in the North Thompson HMA. Logging, road building and silvicultural activity can all affect salmon streams by altering hydrology and channel stability and increasing sedimentation. Recent activity has been concentrated in the northern portion of the HMA. Virtually all watersheds have been logged; estimated logged areas range from 20% to 44% of the watershed. Fish habitat in watersheds with 20% or more of their area clearcut can be significantly affected by altered stream hydrology.

Agricultural activity, mainly feedcrop production and cattle grazing, is concentrated in the lower drainage or Plateau region. While the overall percentage of agricultural use in each drainage basin is relatively low, it is concentrated along the stream corridor and impacts to stream habitat can be considerable. Removal of riparian vegetation along the streams, for example, can seriously damage stream habitat. In addition, some streams, such as Lemieux and Louis Creeks, have high irrigation demands in the summer and fall, resulting in low flows that affect spawning and rearing habitats. Reductions of flow in some years may significantly reduce the rearing population and may impede spawning migrations.

Impacts on streams, wetlands and lakes are also related to construction and maintenance of the transportation corridor along the North Thompson and to urban and recreational developments adjacent to the more populated areas. These impacts can result in loss or degradation of habitat and the deterioration of water quality.

## WATERSHED MANAGEMENT PRIORITIES

Watershed management priorities to protect and restore fish habitat have been identified in the North Thompson HMA and are summarized below. Stream-specific habitat management priorities are presented in the report.

Improving passage over Little Hell's Gate would allow coho and, to a lesser extent, chinook to access the upper North Thompson mainstem and tributaries. Several studies have also indicated a large amount of suitable habitat above impassable barriers in tributary streams such as Finn Creek and Raft River, providing a potential opportunity to increase salmon production.

A review of the information reveals the importance of the mainstem North Thompson for rearing chinook and coho fry from the mainstem as well as from its tributaries. The mainstem from Barriere to Raft River, particularly, has a high spawning and rearing capacity. Offchannel habitat, which is important for coho, has been (and is potentially) affected by the transportation corridor and other activities along the river. A strategy for the protection of existing habitat and the restoration or creation of new habitat is recommended. For example, the development of sidechannels with groundwater water supplies should be considered. This would include mapping and assessment of all existing habitat and historic stream channels.

The development of a riparian management strategy and guidelines is a high priority. More detailed information about the stream corridor will be required, as well as an inventory and mapping of conditions at the stream reach level. Methods and a program to protect and restore riparian habitat and bank stability must also be developed. Restoration projects need to be monitored to assess their success and new methods developed.

Water storage opportunities must be assessed in those streams with low flow problems and fisheries maintenance flow agreements negotiated with water license holders where required. A process for instream flow assessment in streams should be implemented. The potential impacts of global warming on stream water supply and temperatures need to be considered in the analyses. Recognition of instream flows for fish in the Water Act is critical to reduce water use conflicts in the future.

On-going initiatives that will aid in the development and improvement of standards and guidelines for protection of interior streams need to be implemented. Of note are recent efforts by inter-agency committees and working groups related to fish-forestry interactions and watershed sensitivity. These include the development of a watershed workbook for the interior that will define watershed characteristics that indicate sensitivity to timber harvest. It is recommended that all watersheds in the North Thompson HMA that have clearcut areas approaching or exceeding 20% be evaluated using this methodology prior to further logging. Interior Fish,

Forestry & Wildlife Guidelines must be developed and implemented in this area. Guidelines should address rate-of-cut issues and designate a streamside management zone to protect the stream and riparian zone. Once implemented, they should be monitored for effectiveness and compliance.

Assessment of the productive capacity of tributary streams and the mainstem of the North Thompson is urgently required. Basic life history information and habitat inventory for chinook and coho in the North Thompson HMA, and in interior streams in general, is limited. Measurements of smolt production are virtually non-existent. This type of information is a research priority and is needed to assess habitat carrying capacity and to assess whether streams in the North Thompson are fully seeded or under-utilized. Some studies suggest that habitat in a number of streams in the North Thompson HMA is under-utilized based on fry densities and amount of wetted area, however more research needs to be undertaken. Ultimately, the setting of realistic escapement goals based on habitat capacity would better direct fish and habitat management planning in the sub-basin.

## 1.0 INTRODUCTION

The North Thompson Habitat Management Area (HMA) is located north of Kamloops, B.C., in the Interior Plateau and Eastern Mountains of British Columbia (Figure 1.1). The North Thompson drains an area of approximately 20,676 km<sup>2</sup>, or about 9% of the Fraser River basin (Dorcey and Griggs 1991). It flows south from the Cariboo Mountains and Quesnel Highlands and joins the South Thompson River at Kamloops to form the Thompson River. Major watersheds include the Clearwater, which originates in Wells Gray Park, and Mahood, which originates in the 100 Mile House area. Other significant drainages include the Barriere, Dunn, and Louis creeks and Raft River. The other drainages are small (100-500 km<sup>2</sup>) individual streams directly tributary to the North Thompson River.

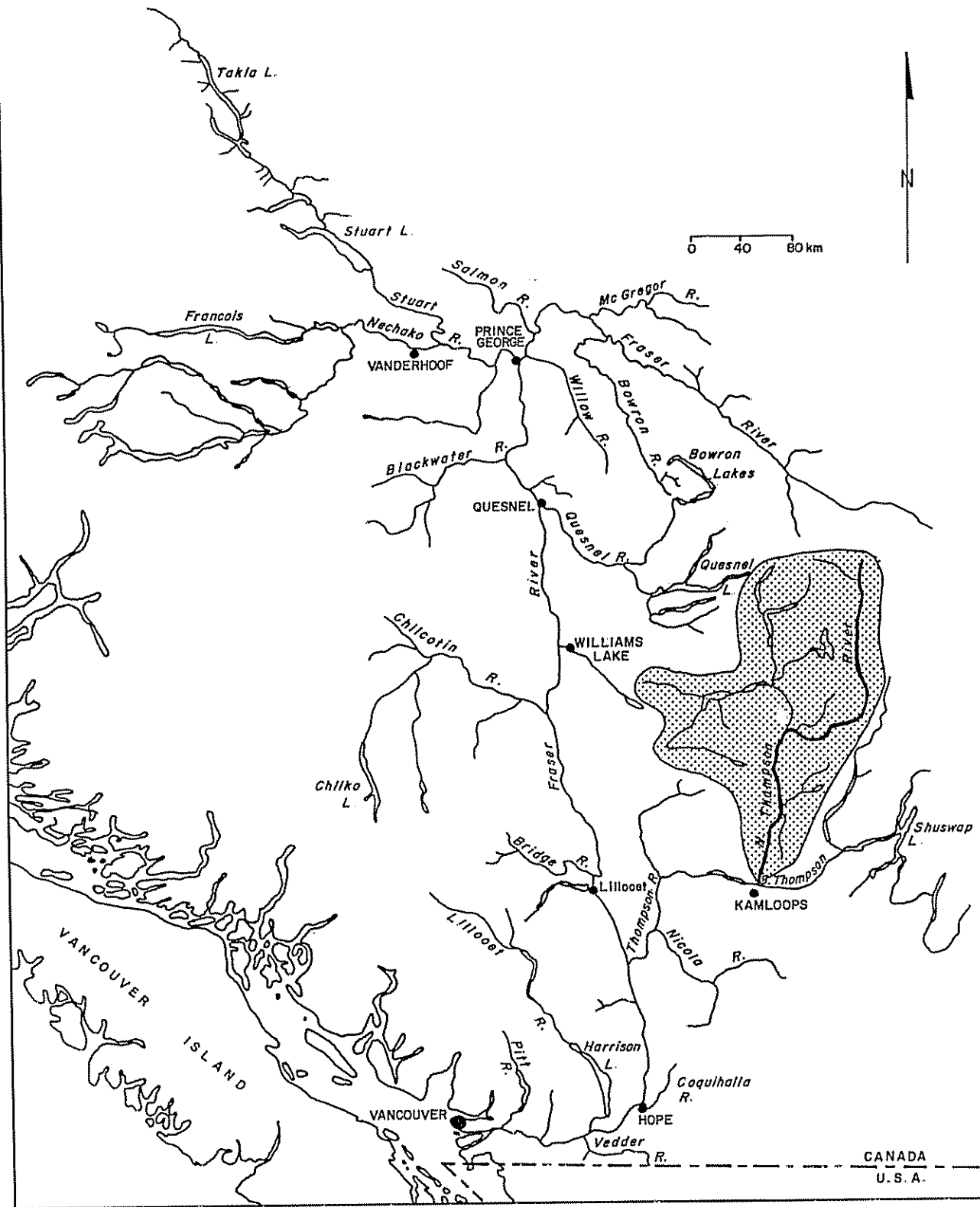
The North Thompson HMA supports sockeye (*Oncorhynchus nerka*), chinook (*O. tshawytscha*), coho (*O. kisutch*) and small numbers of pink salmon (*O. gorbuscha*). Sockeye are found primarily in two systems and rear in North Barriere or Kamloops Lakes. The chinook are generally found in the North Thompson mainstem and its larger tributary streams. Coho are produced throughout the North Thompson and its tributary streams. Pink salmon are found in the North Thompson and some tributaries in odd years. The locations of salmon spawning streams for which there are escapement records are shown in Figure 1.2. In the last 10 years, streams in the North Thompson HMA have supported escapements in the order of 8,000 chinook and 6,000 coho salmon. Sockeye escapements have been increasing and have averaged over 24,000 in the dominant cycle. Salmon production relative to other Fraser River sub-basins is shown in Figure 1.3.

Logging has occurred throughout the entire HMA and all known salmon-producing watersheds have been subjected to some level of logging. Agricultural development occurs in the southern portions of the HMA and in the area between 100 Mile House and Little Fort. Residential and recreational development has occurred near 100 Mile House, Clearwater and Kamloops. The mainstem of the North Thompson River is also a major transportation and utility corridor and in addition to a major highway there are CN Rail, hydro, oil and fibre optics transmission lines located within the river valley.

This strategic review presents an overview of fisheries resources and biophysical and land use issues that have affected or can affect fish production, and provides suggested fisheries habitat management priorities. This assessment is based on the collection and summary of existing information from fisheries and land use management agencies.

Much of the information in Section 2, Fisheries Resources, is from the Stream Information Summary System (SISS) and published literature, as well as from the direct input of management and habitat biologists and fisheries officers of the Department of Fisheries and Oceans (DFO) and

Figure 1.1 Location of the North Thompson Habitat Management Area (HMA)



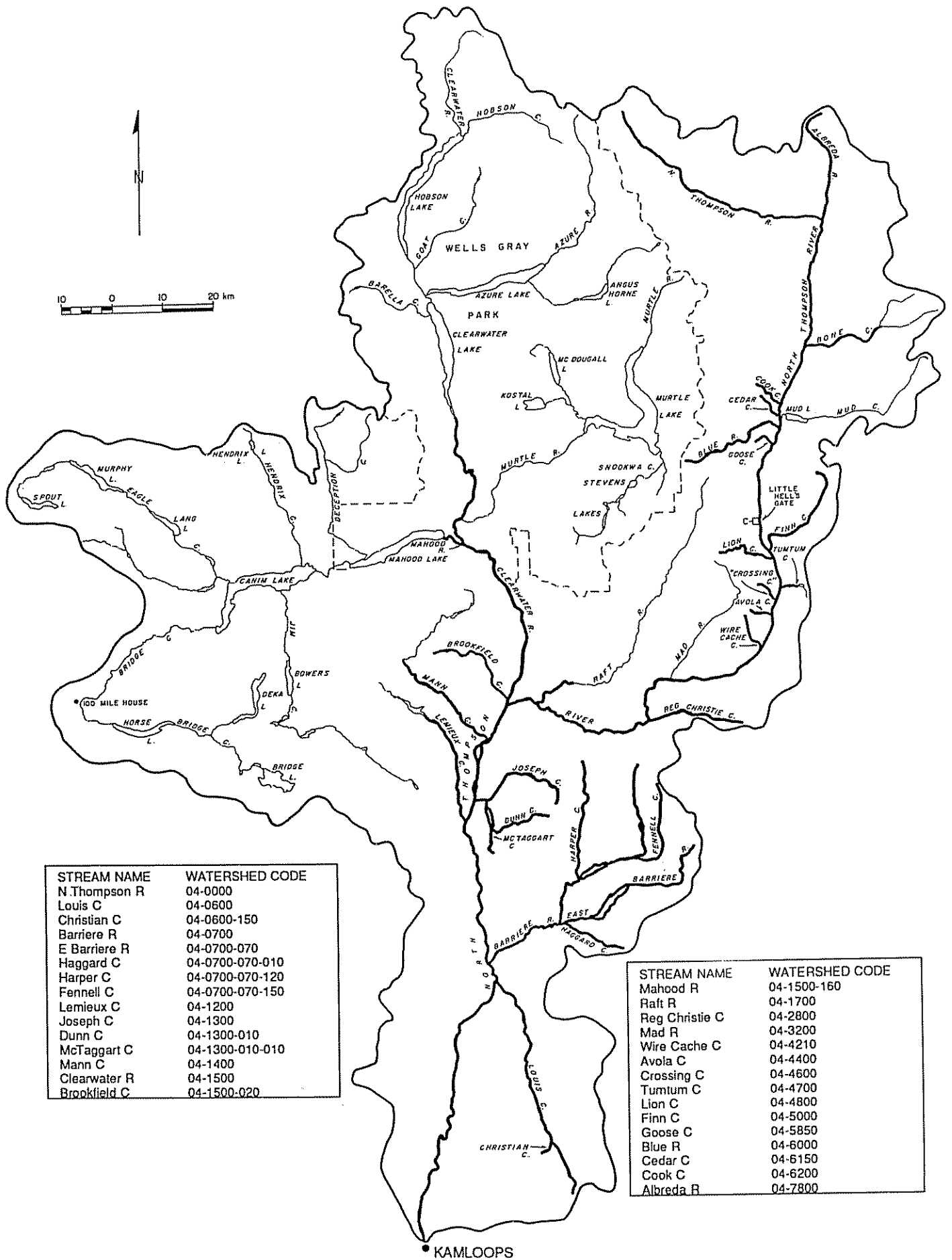


Figure 1.2 Known salmon spawning streams in the North Thompson HMA

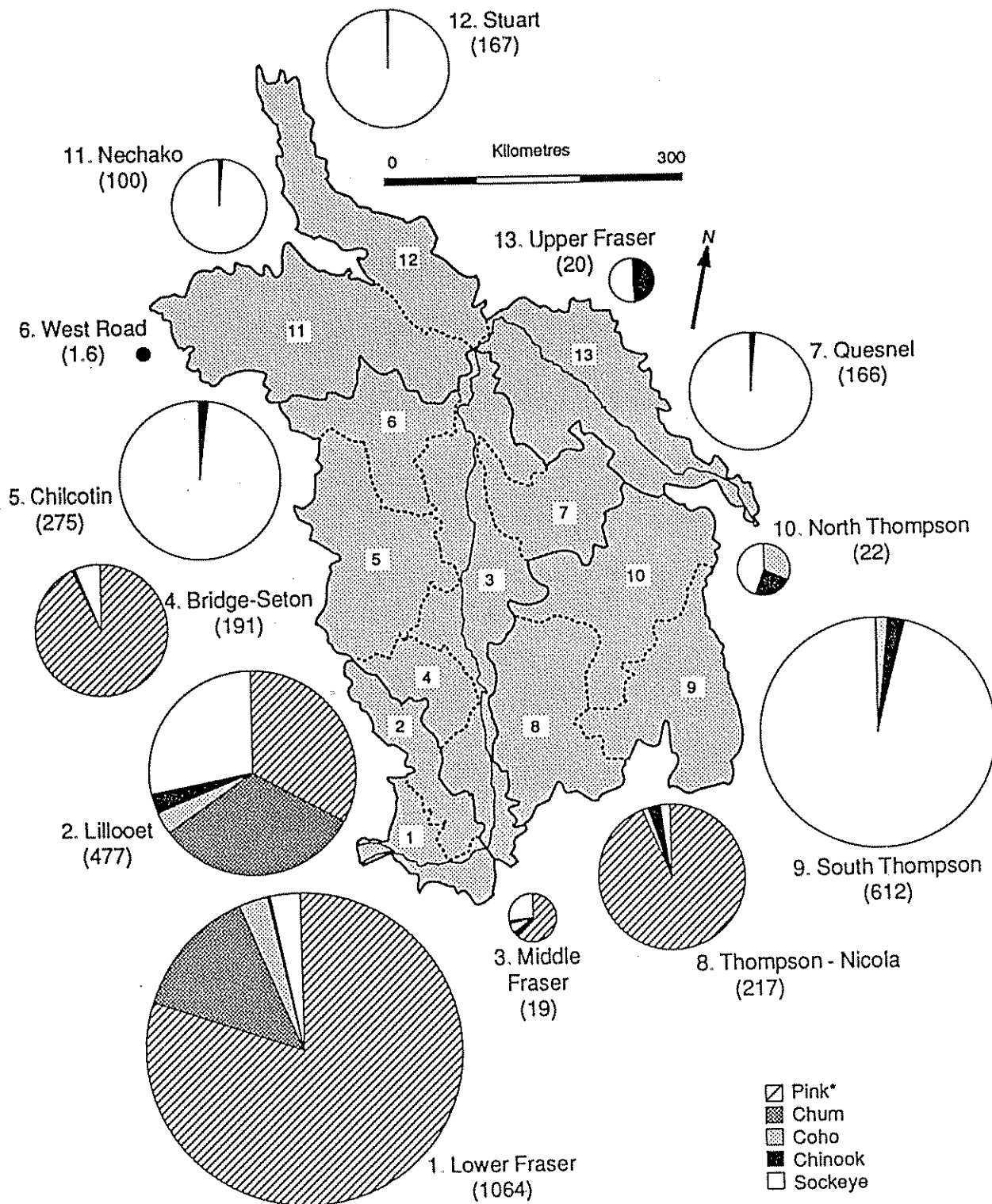


Figure 1.3

Average annual escapement (thousands; 1951 to 1989) of Pacific salmon to the drainage Sub-basins within the Fraser River Basin. Species making very small (less than 2%) contributions may not show in the pie diagrams (Dorcey and Griggs 1991)

habitat and management biologists of the B.C. Ministry of Environment, Lands and Parks (MELP). Most of the detailed biophysical information presented in Section 3, and the resource use information presented in Section 4, is from Sigma Engineering Ltd. (1991) and Northwest Hydraulic Consultants Ltd. (1992). These studies were conducted for this review.

## 2.0 FISHERIES RESOURCES

### Salmon stocks

Average salmon escapement over the period of record (from 1951) in the North Thompson HMA is shown in Figure 2.1. In the recent decade, escapements have averaged 14,000 sockeye, 8,000 chinook and 6,000 coho salmon. Using the 1981-1990 average, coho, chinook and sockeye escapements in the North Thompson HMA represent 34%, 23% and 2%, respectively, of the total escapements to the Thompson River Basin (Table 2.1).

Table 2.1. Comparison of escapements for coho, chinook and sockeye in the Thompson HMAs

Habitat Management Area	Coho Av. 1981-90	% Total for the HMA	Chinook Av. 1981-90	% Total for the HMA	Sockeye Av. 1981-90	% Total for the HMA
Thompson-Shuswap	9,945	54	20,697	60	439,321	98
Thompson-Nicola	2,130	12	5,806	17	0	0
North Thompson	6,263	34	8,248	23	14,714	2
Total	18,338		34,751		554,035	

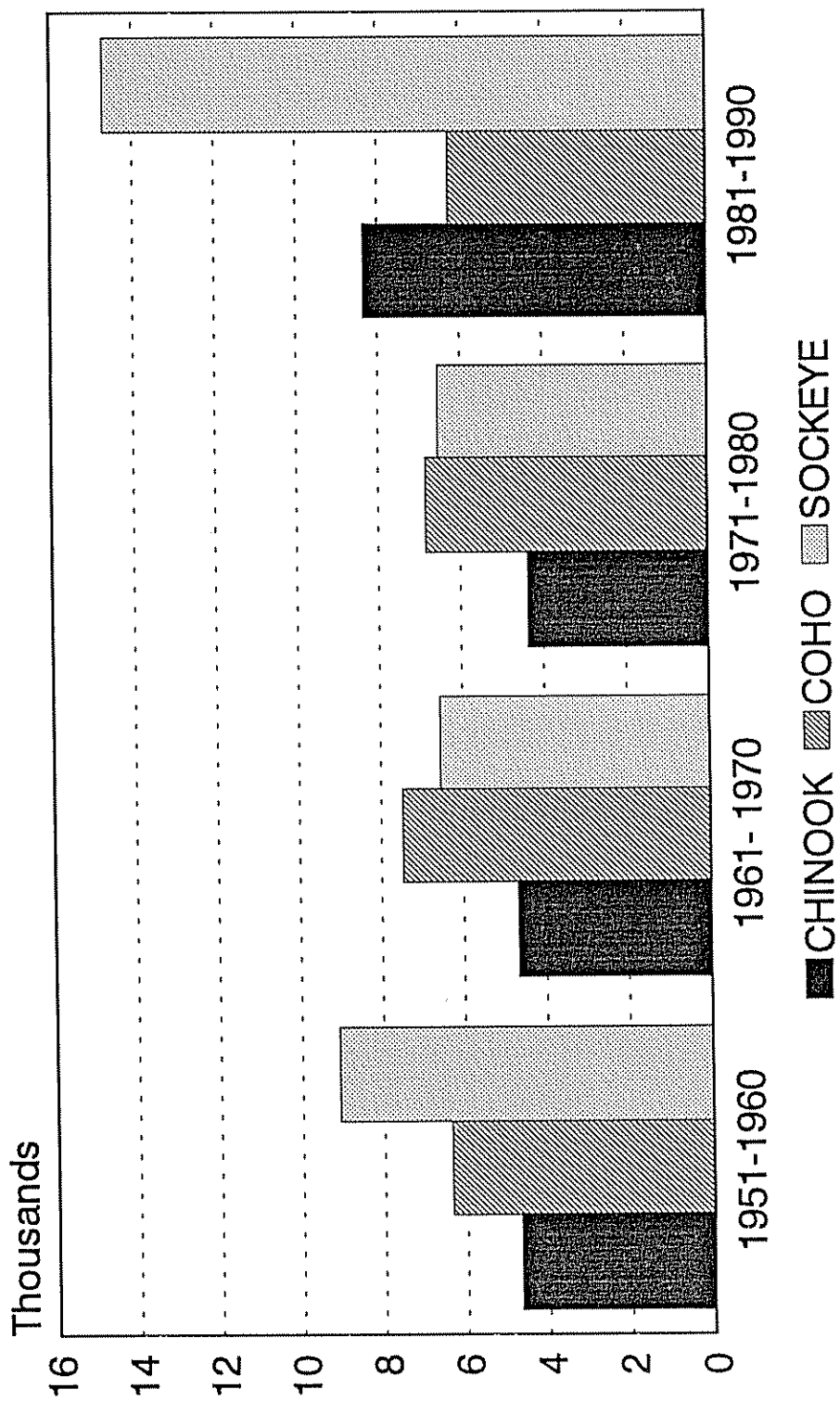
### Resident fish stocks

Important resident fish species include rainbow trout (*Oncorhynchus mykiss*), kokanee salmon (*O. nerka*), lake trout (*Salvelinus namaycush*), and bull trout (*S. confluentus*). Rainbow trout are found in lakes and streams throughout the HMA. Some of the resident rainbow stream populations, such as those in Canim and Clearwater Rivers, provide important sport fisheries. However, the numerous lakes throughout this region support most of the rainbow trout fisheries, and some of the lakes, such as Canim, contain a race of larger rainbows as well as lake trout.

### 2.1 Sockeye Salmon

The two main sockeye producing streams in the North Thompson HMA are Raft River and Fennell Creek. Small numbers of sockeye are produced in the North Thompson and Barriere rivers. Sockeye have also been observed in Clearwater River and Finn, Lemieux, Joseph, Dunn, Mann and Lion creeks, but escapements are not recorded on a regular basis. Sockeye salmon streams are illustrated in Figure 2.2 and sockeye escapements in Table 2.3 and Appendix A.

Figure 2.1 Ten year average escapements to the North Thompson HMA



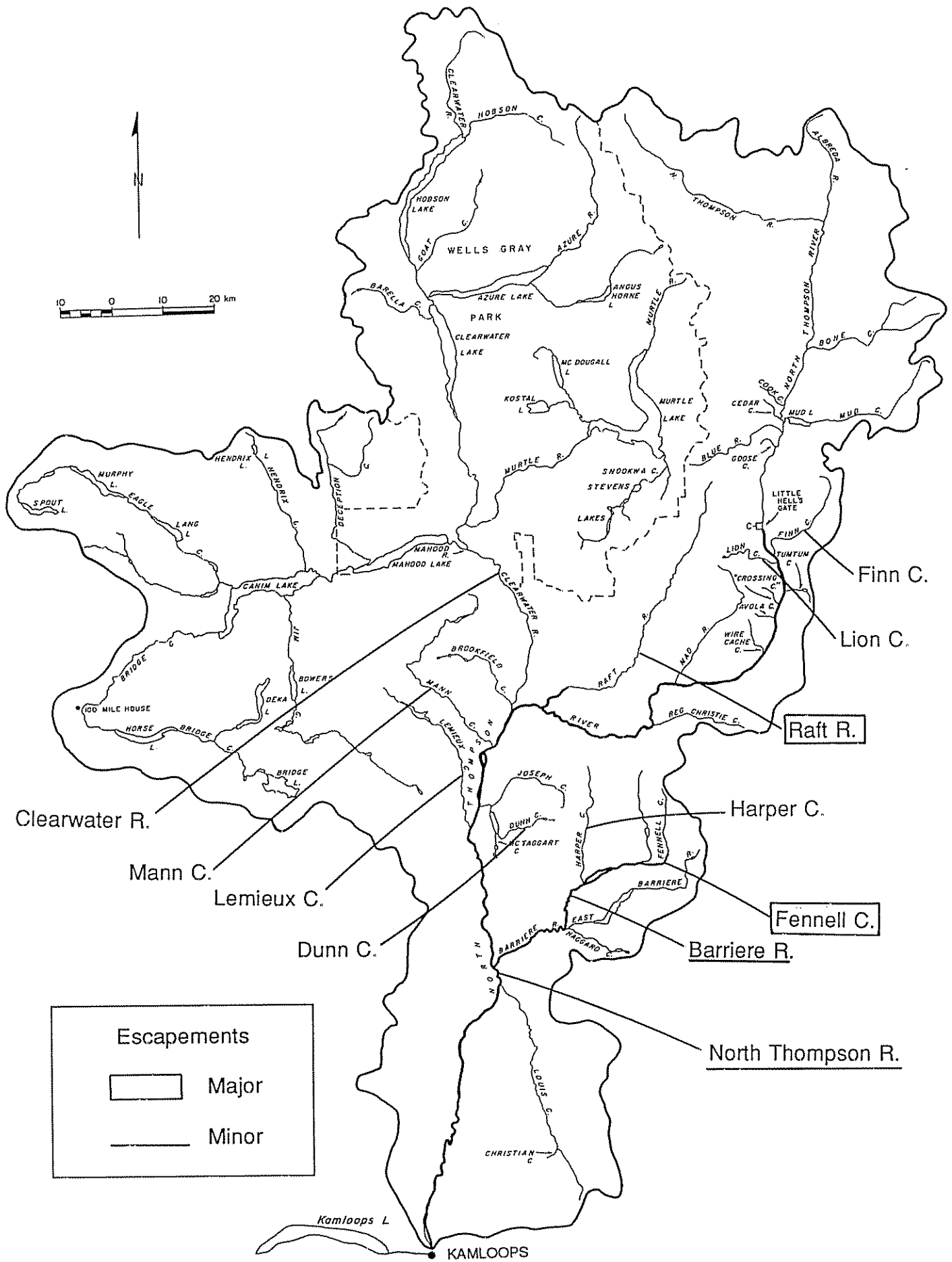


Figure 2.2 Location of sockeye salmon spawning streams in the North Thompson HMA

### **2.1.1 Life history**

North Thompson sockeye stocks are included in the Fraser River early timing or early summer runs. They move through the lower Fraser River, usually in late June or early July. The Fennell Creek and Raft River runs are generally seen in the North Thompson by late July. Spawning begins in early August, peaks in late August, and is complete by late September. Peak spawning in the North Thompson mainstem occurs in mid-September.

The vast majority of Fraser River sockeye return to spawn at four years of age. Most populations have a pattern of abundance, referred to as cyclic dominance, characterized by a dominant year, a subdominant year and two weak years. The dominant cycle in the North Thompson occurs in the 1988-92 cycle year. Typical of sockeye life history, the North Thompson stocks emerge in the spring and migrate to a lake, where they rear for one year. The Fennell Creek stock rears in North Barriere Lake, while the Raft River and Barriere River sockeye, which spawn below Barriere Lake, rear in Kamloops Lake. Sockeye smolts migrate downstream to the sea in spring, following a year of lake rearing.

### **2.1.2 Catches, escapements and escapement trends**

Recent work by the Department of Fisheries and Oceans has provided information on the total run size and estimated catch by both commercial and aboriginal fisheries. This information, based on Raft River and Fennell Creek, suggests that approximately 50% of the run is taken in the commercial catch, and 12-23% in the aboriginal catch, with escapement representing 30% of the total run (Table 2.2) (Saito, pers. comm.).

The commercial catch represents all tidal water fisheries (ocean and the lower Fraser River). The aboriginal catch represents all native fisheries; however, most of the catch occurs in the Fraser River. The aboriginal fishery in the North Thompson includes both Raft River and Fennell Creek. The Raft River fishery from 1989 to 1992 was limited to less than 100 fish per year. Previous to that, catches ranged from 2,000 to 3,000 fish, but the estimated size of the catch was based on escapement counts. In Fennell Creek, the catch has been limited to several hundred fish per year (Olmsted, pers. comm.).

Table 2.2. Comparison of commercial and native fishery catches of Fennell Creek and Raft River stocks for 1982 to 1992 (Saito, pers. comm.)

Name	Av. Total Run	Av. Commercial Catch (% of total run)	Av. Aboriginal Catch (% of total run)	Av. Escapement (% of total run)
Fennell Creek	39,220	19,137 (49%)	8,971 (23%)	10,860 (28%)
Raft River	19,356	11,047 (57%)	2,401 (12%)	5,738 (30%)

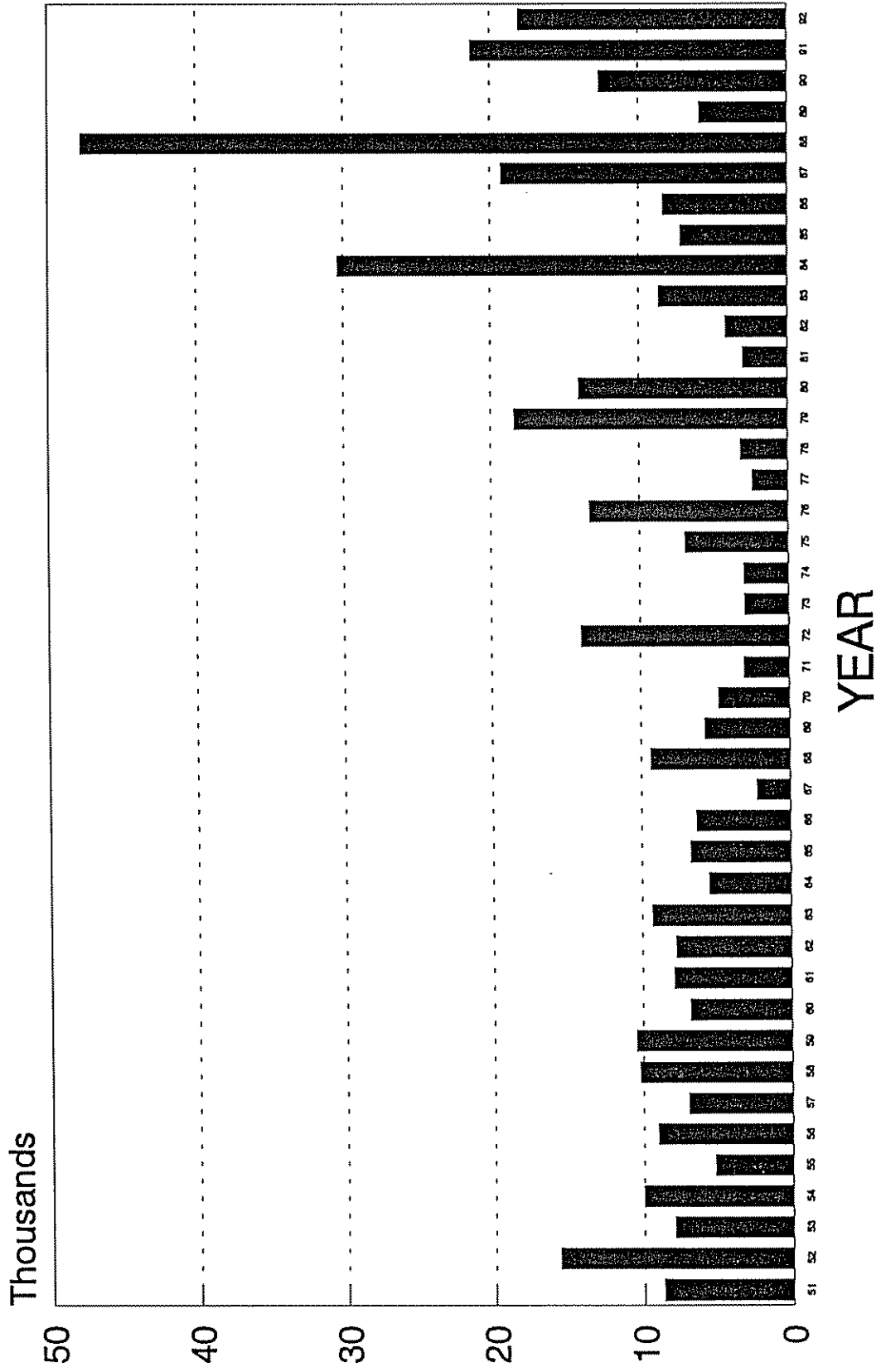
Sockeye escapements to the North Thompson River System have shown a gradual increase over the past 15 years (Table 2.3) ( Figure 2.3), largely due to the increased escapement to Fennell Creek (Appendix A). Over the past five cycle years, dominant cycle runs have averaged more than 24,000 fish, and have ranged from 13,000 to more than 47,000 fish. Escapements in non-dominant cycle years have averaged 4,000 to 11,000 fish. In the two main sockeye spawning streams (Fennell Creek and Raft River), escapements in 1988 increased to 27,000 and 20,000, respectively, which are the highest escapements ever recorded for these systems. In 1992, the returns of the 1988 brood year were less than 10,000 sockeye in each stream.

Table 2.3. North Thompson HMA sockeye escapement

Year	Escapement	Year*	Escapement	Year	Escapement	Year	Escapement
1951	8,669	1952	15,617	1953	7,909	1954	9,995
1955	5,178	1956	9,039	1957	6,919	1958	10,220
1959	10,440	1960	6,784	1961	7,861	1962	7,717
1963	9,325	1964	5,470	1965	6,728	1966	6,300
1967	2,239	1968	9,350	1969	5,685	1970	4,755
1971	3,033	1972	13,983	1973	2,956	1974	2,986
1975	6,914	1976	13,357	1977	2,391	1978	3,175
1979	18,397	1980	14,028	1981	2,999	1982	4,131
1983	8,625	1984	30,366	1985	7,141	1986	8,338
1987	19,258	1988	47,791	1989	5,864	1990	12,628
1991	21,311	1992	18,055				
Average escapement for the last 5 cycle years							
	14,901		24,719		4,270		6,251

\* Dominant cycle year

Figure 2.3 Sockeye escapements to streams in the North Thompson HMA, 1951 to 1992



### 2.1.3 Spawning and rearing habitat

The main spawning habitats for sockeye in the North Thompson HMA are above North Barriere Lake in Fennell Creek and in Barriere River, just below North Barriere Lake. In Raft River sockeye are found throughout the lower 4 km. Raft River is inaccessible above the falls at 4.7 km.

High pre-spawning mortality of sockeye has been noted in Raft River. In 1981, 30-40% die-off of sockeye occurred in Raft River, and it was suggested that high water temperatures (18°C) and low flows may have stressed the sockeye and influenced the die-off (Scott et al. 1982a).

Fennell Creek sockeye rear in North Barriere Lake. Sockeye fry from Raft and lower Barriere rivers migrate downstream and rear in Kamloops Lake, outside of the North Thompson HMA.

### 2.1.4 Habitat productive capacities

Preliminary estimates of spawning capacity of sockeye streams, and rearing capacity of lakes in the Fraser River, were made by the Fraser River Sockeye Task Force (1988). Estimated capacity of spawning grounds in Raft River, Barriere River and Fennell Creek are shown in Table 2.4. The total useable spawning area for these streams is 132,000 m<sup>2</sup>, which is estimated to potentially support a total of 252,000 spawners. The majority of the area is in the Barriere River, which is largely unused.

Figure 2.4 and Table 2.5 show the rearing capacity (in terms of the number of spawners) of lakes in the North Thompson HMA. Spawning capacity in Raft and Barriere rivers, 237,500 spawners, far exceeds the rearing capacity of Kamloops Lake (50,000 spawners). North Barriere Lake could support the progeny of 124,000 spawners but is limited by the spawning habitat of Fennell Creek, which has an estimated capacity of only 14,500 spawners. The spawning capacity of Fennell Creek was exceeded in 1988, when the estimated escapement to Fennell Creek was 26,500 spawners. Although the estimated spawning capacity of Barriere River far exceeds that of both Raft River and Fennell Creek, very few sockeye spawn in the Barriere River below the lake.

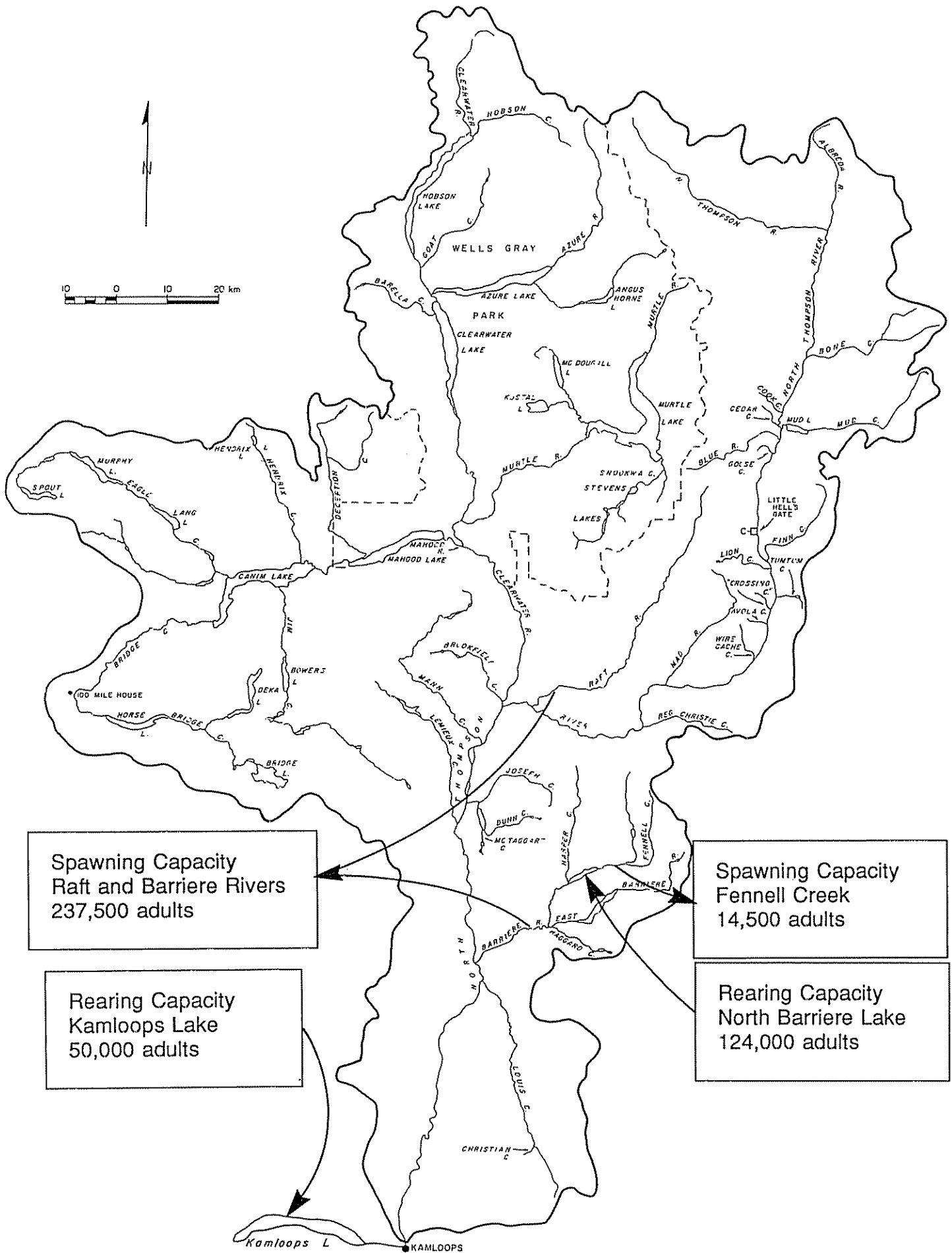


Figure 2.4

Comparison of estimated sockeye salmon spawning and rearing capacity (adult spawners) in the Raft and Barriere systems

Table 2.4. Sockeye spawning capacity of North Thompson sockeye streams (Fraser River Sockeye Task Force, 1988)

Stream	Useable spawning area (m <sup>2</sup> )	Spawning capacity (adults)
Barriere River	117,000	224,700
Raft River	7,000	12,800
Fennell Creek	8,000	14,500
Total	132,000	252,000

Table 2.5. Sockeye rearing capacity of North Thompson sockeye lakes (Fraser River Sockeye Task Force, 1988)

Lake	Rearing capacity in terms of number of spawners	Supporting sockeye spawning streams	Total spawning capacity (adults)
North Barriere Lake	124,000	Fennell Creek	14,500
Kamloops Lake	50,000	Raft and Barriere Rivers	237,500

### 2.1.5 Production objectives

Interim escapement targets were established for all cycle years for Fennell Creek and Raft River by the Sockeye Task Force (1988), based on the estimated spawning habitat present in the two streams. The interim escapement target of 14,500 for Fennell Creek was achieved in the 1987, 1988 and 1990 cycle years (Appendix A). The interim target escapement of 12,800 for Raft River has only been achieved for the dominant cycle years in 1984 and 1988. These increased escapements to interim target levels are attributable to DFO's rebuilding efforts and the relatively high sockeye productivity experienced in recent years. Escapement goals will be re-assessed, and adjustments may be made, when sufficient information is gathered on these stocks (Saito, pers. comm.). The North Thompson sockeye stocks are managed as part of the early summer stock group. Since they are relatively small stocks in a mixed stock fishery, it is difficult to manage for stock-specific goals.

### 2.1.6 Enhancement opportunities

The Fraser River Sockeye Management and Enhancement Plan (1988) identified Fennell Creek in the North Thompson watershed as a possible candidate for enhancement, based on the potential rearing capacity of North Barriere Lake. There is preliminary indication that the rearing potential in Barriere Lake can support fry from eight times as many spawners as the present spawning capacity supports (Table 2.5). If additional spawning habitat is created by a spawning

channel, a major increase in sockeye production may be realized. It was noted that this would require the development of a surplus fish utilization policy, otherwise escapement would grossly exceed the spawning capacity of Fennell Creek. The local Indian band could potentially benefit from the returns if a satisfactory arrangement could be worked out for harvesting the surplus.

The capital costs for developing a spawning channel at Fennell Creek or construction of a facility for hatchery augmentation of North Barriere Lake could be considerable. However, this project appears to have a reasonable chance for success, although further information would be required to determine the project feasibility, including:

- re-assessment of the sockeye spawning capability of Fennell Creek and the rearing potential of North Barriere Lake;
- determining suitable locations for a spawning channel; and
- assessment of the impact of a potential eight-fold increase in sockeye production on existing rainbow trout and kokanee populations in North Barriere Lake.

Improvement of the sockeye run below North Barriere Lake may also provide an enhancement opportunity.

## **2.2 Chinook Salmon**

Chinook salmon escapements are recorded in 13 streams in the North Thompson HMA and are shown in Figure 2.5. Chinook are recorded as far upstream as Blue River, however their distribution may extend further upstream in the North Thompson (Panko, pers. comm.). The major producers (greater than 1,000 spawners) in the HMA are Clearwater River, North Thompson River and Finn Creek. Louis, Mahood, Raft and Barriere rivers also produce significant numbers of chinook (greater than 100 spawners).

### **2.2.1 Life history**

Adult chinook bound for the North Thompson pass through the lower Fraser in June, July and August. Chinook arrive in the North Thompson in early to mid-July through to late September. Peak spawning usually occurs in September.

The majority of North Thompson chinook return to spawn in their fifth year. Incubation occurs over the winter; fry emergence and downstream migration in April/May often coincide with an increase in stream temperature and discharge. More than 95% of the chinook in the North Thompson are stream type ( i.e., they remain in fresh water for one year before migrating to the

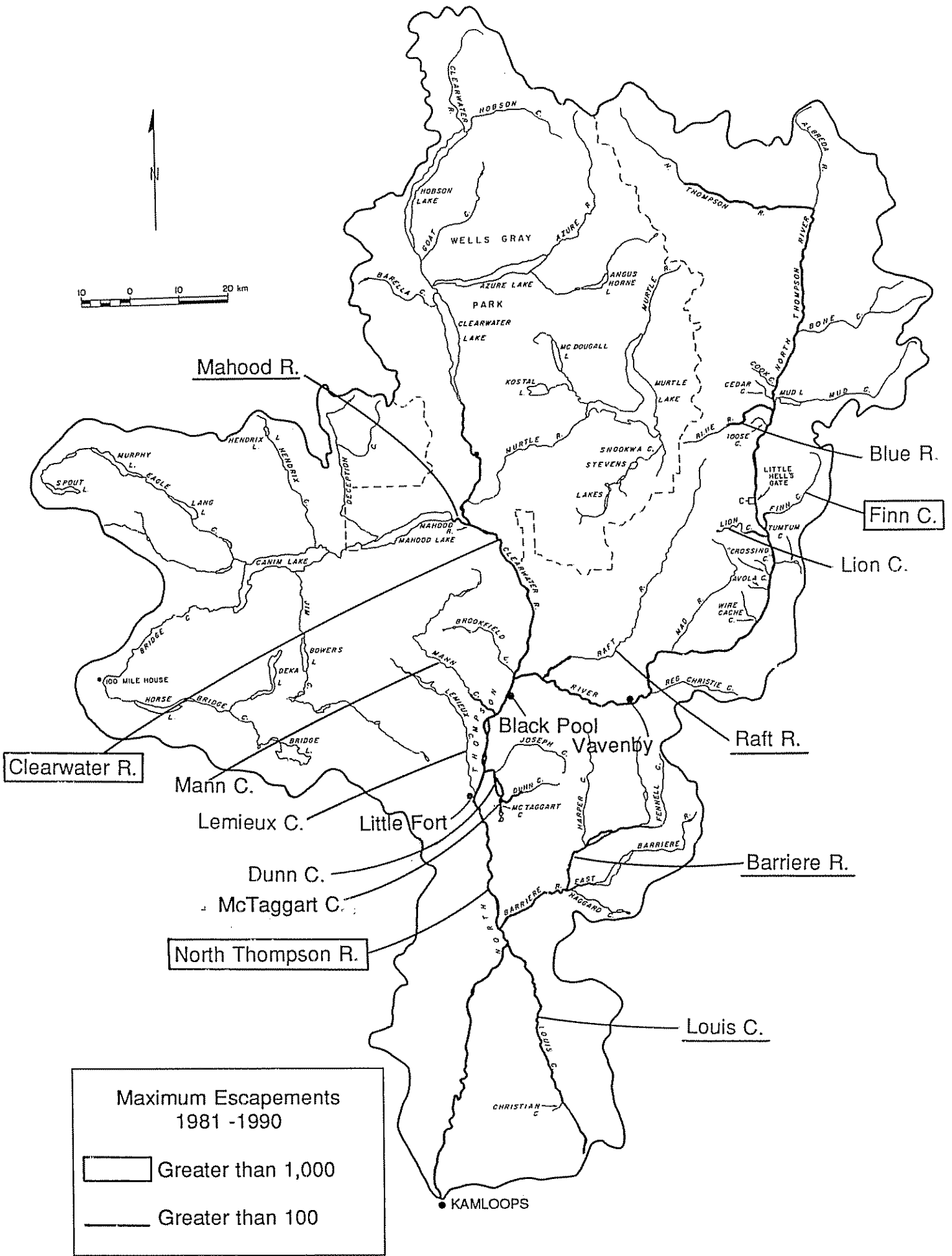


Figure 2.5

Location of chinook salmon spawning streams in the North Thompson HMA

sea as smolts) (Scott et al. 1982a). The progeny of chinook that spawn in the larger mainstem rivers, including the North Thompson and Clearwater, remain in their natal stream to rear. Chinook fry from smaller tributary streams may move downstream following emergence in late summer to rear and overwinter in the mainstem (Stewart et al. 1983). Smolt migration generally occurs in late March to April.

### **2.2.2 Catches, escapements and escapement trends**

Based on the coded wire tag (CWT) data for Clearwater chinook stocks, the primary chinook fisheries include the Northern troll fishery (approximately 50%), the North and South West Vancouver Island troll fishery and the Fraser River gill net fishery when a sockeye fishery takes place.

There is a sport fishery on the lower Fraser River that takes only a very limited number of North Thompson chinook. In the Thompson and North Thompson rivers, the sport fishery for chinook was closed in 1980. Since 1986 several sport fisheries have been re-opened:

- The Thompson River at Spences Bridge was re-opened in 1988 with a harvest ceiling of 150 (Schubert, pers. comm.).
- The Clearwater River was re-opened in 1986 with a harvest ceiling of 300 (Schubert, pers. comm.).
- The North Thompson River between Barriere and Clearwater was re-opened in 1992.

Aboriginal fisheries for chinook occur in the North Thompson, Clearwater, Mahood and Raft rivers and Finn Creek (Schubert, pers. comm.). Harvest levels are currently small but are expected to increase in response to needs identified through the Aboriginal Fisheries Strategy process. The major interception of North Thompson stocks is by the aboriginal fishery in the lower Fraser River. This is presently being addressed by negotiations between the Department of Fisheries and Oceans and the native bands.

Chinook escapements to the North Thompson River system are shown in Table 2.6 and Figure 2.6. Escapements have ranged from a low of 4,000 to a high of 11,000 over the 1981 to 1990 period. The largest chinook producer is the Clearwater River, which averaged over 4,000 chinook from 1981 to 1990. The North Thompson mainstem had an escapement of close to 2,000 chinook in the same time period. Other significant producers (greater than 100 spawners) include Finn and Louis creeks and Raft and Mahood rivers. Escapement records for each year from 1951 are shown in Appendix A.

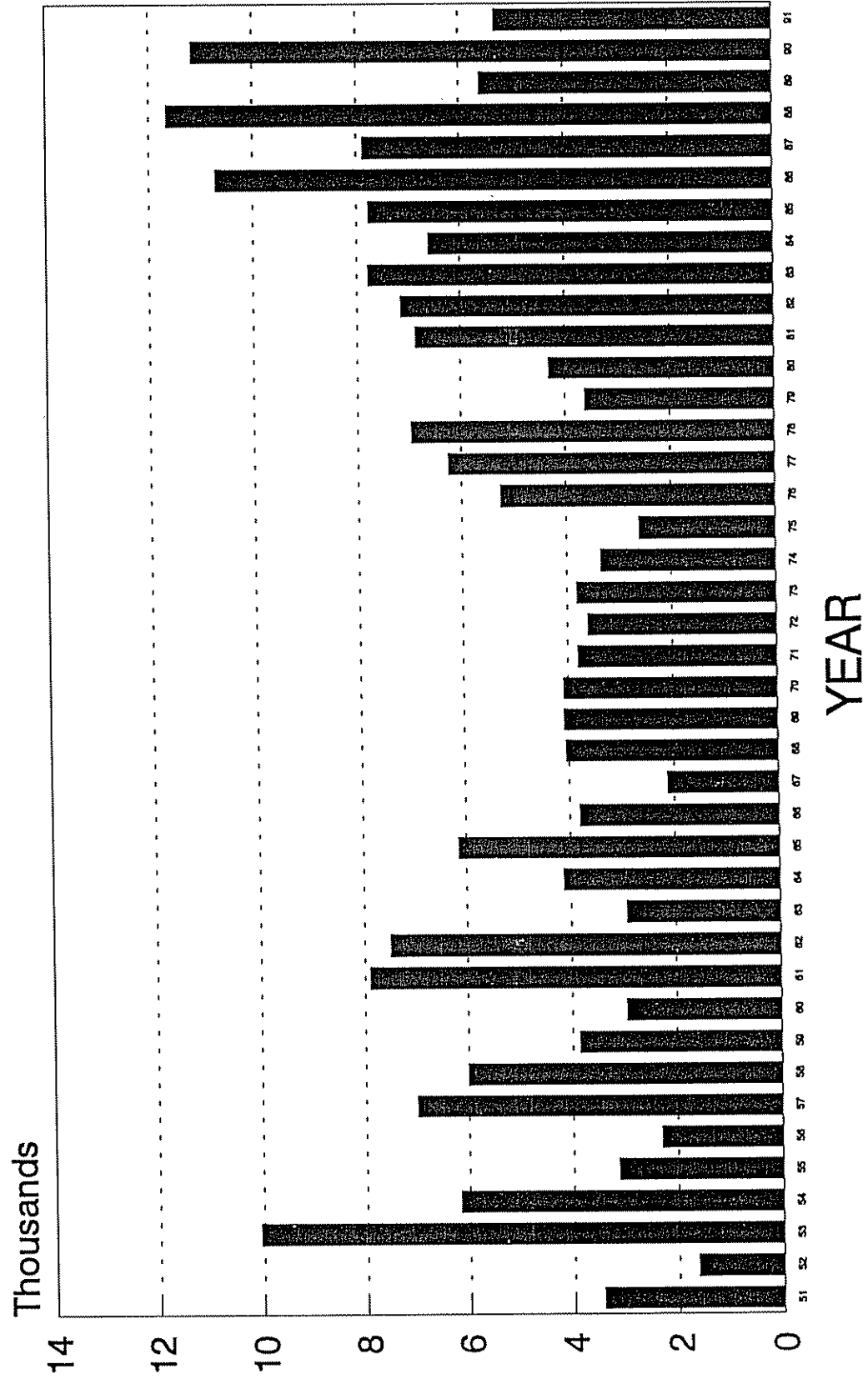


Figure 2.6 Chinook escapements to streams in the North Thompson HMA, 1951 to 1990

The Canada-U.S. Pacific Salmon Treaty of 1985 committed Canada to achieving escapement goals by 1988; goals were set by doubling the average escapements during the 1979-82 base period. Rebuilding was to be accomplished by reducing brood year exploitation rates by 15 percentage points through management actions in ocean sport, troll and net fisheries. Comparison of 1979-82 average escapements to 1986-91 escapements in the North Thompson HMA (Table 2.6) shows an increase of 59%. Returns to Clearwater and Raft rivers and Finn Creek have all improved, on average. However, because the size of the Clearwater run varies considerably from year to year, a clear rebuilding trend is not indicated. Hatchery contributions to these systems and better enumeration of spawners may have over-estimated the actual increases.

Table 2.6. Summary of average chinook escapements to streams in the North Thompson HMA

Stream	10 year averages		Canada - US Agreement (1985) Comparison	
	1971 to 1980	1981 to 1990	1979 to 1982 (Av.)	1986 to 1991 (Av.)
North Thompson River	1,435	1,945	1,675	1,947
Louis Creek	94	126	81	116
Barriere River	23	81	33	94
Lemieux Creek	20	11	8	8
Dunn Creek	n/r	5	n/r	4
McTaggart Creek	18	0	3	n/r
Mann Creek	n/r	6	3	2
Clearwater River	1,790	4,092	2,500	4,423
Mahood Creek	275	358	215	366
Raft River	203	518	238	625
Lion Creek	21	4	4	6
Finn Creek	515	1,155	719	1,110
Blue River	18	33	9	29
Mad River	n/r	n/r	n/r	n/r
Total	4,353	8,320	5,486	8,722

### 2.2.3 Spawning and rearing habitat

Chinook spawn in two main areas in the Clearwater; in the Whitehorse Bluff area (32 km upstream) and at Horseshoe Bend (60 km upstream). They also spawn in the lower portion of the Mahood River. In the North Thompson River, spawning extends primarily from Little Fort to Blackpool, and near Vavenby (Figure 2.5). The spawning area is characterized by runs with gravel/cobble substrate and many floodplain channels and sidechannels.

In the North Thompson there is abundant chinook rearing habitat, with heavy utilization from Little Fort to Blackpool. A large proportion of chinook fry from smaller tributaries may move in to the North Thompson mainstem to rear. Scott et al. (1982b) found that chinook were most abundant in the North Thompson River and that an increase in summer indicated that fry were moving into the mainstem from the tributaries and upstream areas. They also found that North Thompson chinook juveniles had better growth rates and condition factors than rearing chinook in Raft and Blue rivers and in Finn and Lion creeks. Whelen and Lister (1985) conducted juvenile studies in the North Thompson mainstem in 1983 and 1984, during summer and fall. Rearing chinook were associated with natural gravel bars, areas of low to moderate velocity and back-eddies, and were found in the mainstem and sidechannels. Water velocity was found to be the most significant factor influencing juvenile chinook distribution (Whelen and Lister 1985). As chinook increased in size, they utilized sites with higher velocities and larger substrates.

#### 2.2.4 Habitat productive capacities

The productive capacity (i.e., the number or biomass of fish per unit area) of North Thompson streams for chinook is difficult to estimate. Measurement of spawning area can overestimate the spawning capacity. The criteria for the measurement of spawning gravels (gravel size and velocity) is often not fine tuned enough to provide an accurate estimate of chinook spawning area, and does not take into account areas of groundwater upwelling, which may be critical. For example, estimated spawning area for the North Thompson River, as determined by Scott et al. (1982b), was 2,688,200 m<sup>2</sup>. Whelen and Lister (1985) counted 584 chinook redds covering an area of 13,700 m<sup>2</sup> in the mainstem North Thompson. Using the average redd area observed (approximately 25 m<sup>2</sup>/redd) and 2.5 fish/redd, the potential escapement in the North Thompson would be over 250,000 chinook. Since 1951, North Thompson chinook escapements have never exceeded 4,000 fish.

In stream-type populations, the rearing lifestage may be limiting, so that some measurement of chinook juvenile production would be appropriate. Some estimates of rearing area and fry densities in the North Thompson and some tributaries have been documented (Scott et al. 1982a; Scott et al. 1982b). Measurement of rearing area in the natal stream, however, does not account for the migration and seasonal movement of chinook juveniles. That is, chinook production appears to be dependent upon habitat downstream of the spawning stream. Work in the North Thompson has shown that there is limited chinook rearing in some of the smaller streams, while sampling studies for the CN Twin Tracking project (Whelen and Lister 1985) have shown that numerous chinook fry are found rearing in the North Thompson mainstem. These studies have provided some chinook density data for chinook rearing in the North Thompson along various types of banks, including large and small rip-rap, natural silt/boulder banks and silt/gravel bars. By using this data and quantifying how much habitat of each type is available, assessment of the rearing potential of the mainstem could be attempted. However, in order to assess the carrying

capacity of streams in the North Thompson it is apparent that studies are required to gain a better understanding of chinook life history, seasonal movements, habitat utilization and smolt production in selected streams.

### **2.2.5 Production objectives**

#### Natural production

The present objective of the Department of Fisheries and Oceans is to increase chinook production through management of commercial, sport and aboriginal fisheries, allowing greater escapement onto the spawning grounds to naturally rebuild runs. Coastwide interim escapement goals for chinook were established under the Pacific Salmon Treaty in 1985, based on doubling the average chinook escapement from the base period of 1979-82. These goals were to be achieved by a reduction of the commercial and sport catch along the Pacific Coast.

Although there have been some increases in chinook escapements in the North Thompson HMA, particularly in Clearwater and Raft rivers and Finn Creek, a clear rebuilding trend is not apparent. It should be noted that the Pacific Salmon Treaty escapement goals were not stream-specific and did not consider potential spawning or rearing habitat capacities.

To date, the targets for the North Thompson have not been reassessed using habitat criteria. Some of the difficulties in assessing habitat capacity were outlined in the previous section.

#### Hatchery production

The objective of hatchery production in the North Thompson HMA has been to increase the survival rate of hatchery introductions, in order to augment existing chinook stocks.

The Clearwater River facility, located in the town of Clearwater, began operations as a pilot facility in 1984. The purpose of the project was to develop upper Fraser chinook enhancement strategies, to help rebuild depleted stocks, and to evaluate the rearing success of coho released as juveniles into under-utilized natural rearing areas. Chinook broodstock was obtained from Clearwater and Raft rivers and Finn Creek. Fry-to-adult survivals were relatively low, ranging from 0.05% to 0.6%. The Raft River chinook showed the best survival rates. These rates are comparable with survivals from other chinook facilities throughout the province (Sheng, pers. comm.).

In 1991, the Clearwater hatchery became a training and demonstration facility as a result of a contract with the North Thompson Indian Band (Shuswap Nation Tribal Council). The

objectives were to continue developing experimental strategies for chinook production, while training native staff in fish culture and hatchery management. However, operations at the Clearwater hatchery have been discontinued and it is proposed that the experimental chinook program be moved to the Dunn Lake facility, once it has been upgraded. Long-term objectives at Dunn Lake are to achieve a total production of no more than 1 million smolts. Short term goals are to increase production to 400,000-500,000 chinook smolts. Chinook stocks include upper and lower Clearwater and Raft rivers and Finn Creek. The hatchery would rear the fry over the winter to yearling smolts before release, in an attempt to improve the poor survivals experienced at the Clearwater hatchery. The upgrade of the Dunn Lake facility to support both its present coho program and the intended chinook program is underway.

### Co-management initiatives

The objective of the North Thompson Indian Band is to increase chinook escapements to historic levels or greater, in order to provide greater opportunity for harvest. To that end, the band has developed a proposed fisheries program that includes habitat development, hatchery production and other cooperative management initiatives. These programs are in the early stages of development.

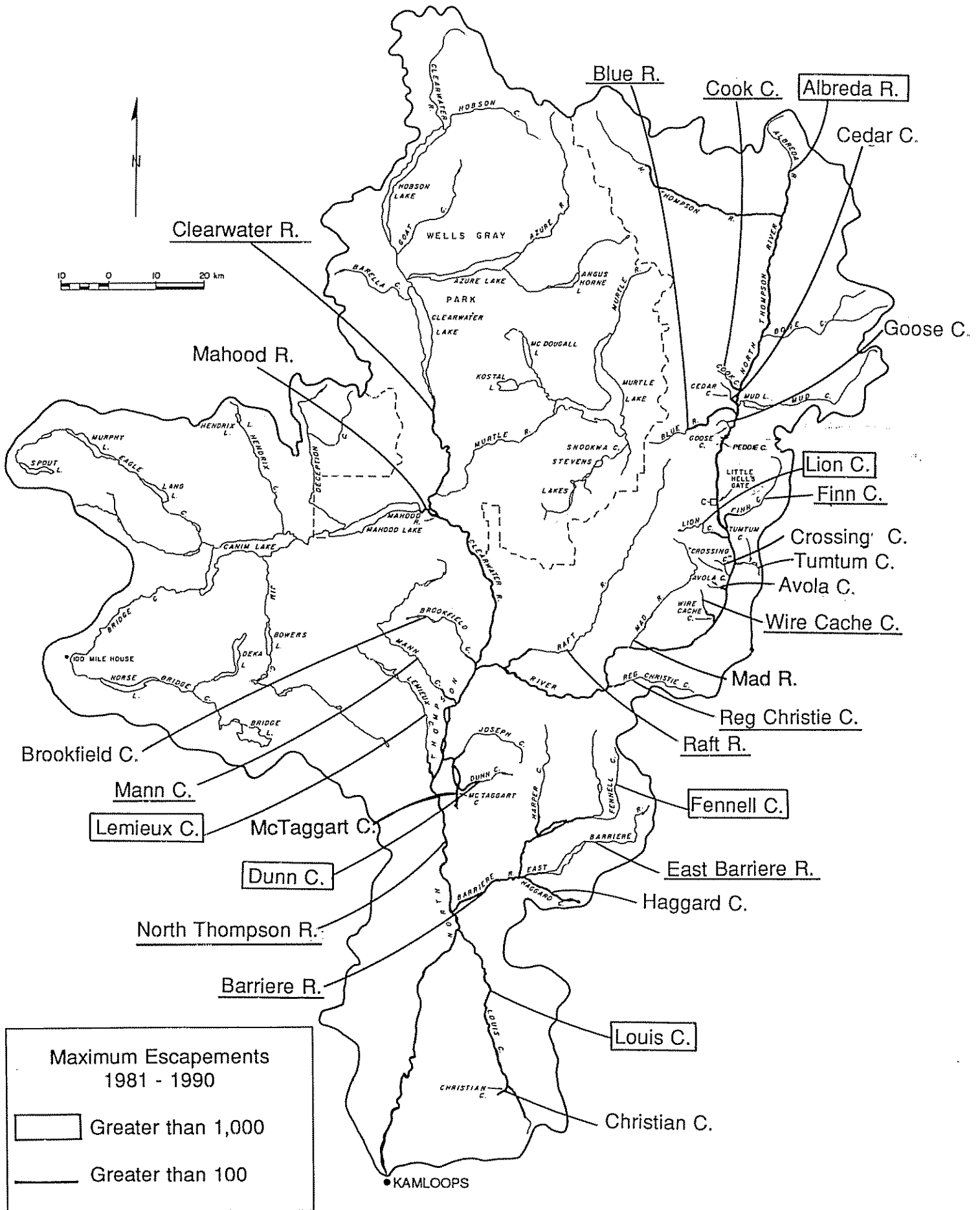
#### **2.2.6 Enhancement opportunities**

The improvement of fish passage over the falls known as Little Hell's Gate, located between Finn Creek and Blue River, is an opportunity for chinook enhancement (Photo 2.1). This will provide better access for chinook and particularly coho to the upper North Thompson River. Some remedial blasting of the falls occurred in 1992 and the Salmonid Enhancement Program (SEP) has proposed a feasibility study in 1993.

A few other enhancement opportunities have been identified. Proposed stream restoration projects include fencing and bank stabilization in Louis and Lemieux creeks to improve chinook and coho habitat. Chinook habitat utilization studies in the mainstem North Thompson should also be pursued to identify opportunities to restore or develop chinook spawning and rearing habitat.

### **2.3 Coho Salmon**

There are 27 streams in the HMA for which there are escapement summaries (Figure 2.7) (Table 2.7). Coho spawn throughout the North Thompson River from Louis Creek to the headwaters. The major producers (more than 1,000 spawners) are Lion, Louis, Fennell, Dunn and Lemieux creeks and Albreda River. Significant producers (more than 100 spawners) include Barriere, East Barriere, Blue, Clearwater, Raft and North Thompson rivers and Finn,



24 Figure 2.7 Location of coho salmon spawning streams in the North Thompson HMA

Table 2.7. Ten year average coho escapements for the North Thompson River and tributary streams

Stream	Ten year averages		Range of run sizes from 1981 to 1990	
	1971 to 1980	1981 to 1990	maximum run	minimum run
North Thompson R	818	437	774	90
Louis Creek	1843	700	1,525	110
Barriere River	371	389	600	100
East Barriere River	73	143	250	60
Haggard Creek	18	5	5	1
Fennell Creek	308	500	1,250	60
Lemieux Creek	571	615	1,528	296
Dunn Creek	416	727	1,400	149
McTaggart Creek	38	31	66	15
Mann Creek	50	46	110	15
Clearwater River	971	124	200	50
Brookfield Creek	14	n/r	n/r	n/r
Mad River	n/r	n/r	n/r	n/r
Mahood River	17	1	5	n/r
Raft River	411	392	900	50
Reg Christie Creek	21	32	200	5
Wire Cache Creek	n/r	62	130	25
Avola River	5	6	40	10
Crossing Creek	n/r	9	40	5
Tumtum Creek	20	26	80	25
Lion Creek	1006	1,000	1,600	500
Finn Creek	52	201	450	20
Goose Creek	n/r	10	20	n/r
Blue River	369	235	450	50
Cedar Creek	61	34	90	20
Cook Creek	43	66	200	45
Albreda River	230	850	2,300	50
Total	6,846	6,262	8,515	4,295

Cook, Wire Cache, Reg Christie and Mann creeks. Additional small tributaries of the North Thompson may also provide spawning and/or rearing habitat for coho in their lower reaches.

### **2.3.1 Life history**

The migration of North Thompson coho through the lower Fraser River is thought to occur in September. Migration to North Thompson streams continues through December. Coho spawn over an extended period from late October to January. In most streams, the majority of spawning occurs in November and December.

Generally, coho salmon are three years old when they return to spawn in their natal streams. They migrate as far as the headwaters of the North Thompson River, and also spawn in many of its tributaries. Fry emergence follows chinook, and occurs before and after peak river discharge. Movements of juveniles have been documented, and coho may move downstream or into the North Thompson mainstem from smaller tributaries in late summer (Scott et al. 1982a; Stewart et al. 1983). Movement from the North Thompson to the tributaries has also been observed in the Raft River. Whelen and Lister (1985) found that coho juveniles increase in abundance in late summer in both the mainstem and tributaries. Low densities in the mainstem in the fall indicated a late fall migration to accessible wetlands and tributaries. High densities of overwintering coho in these wetlands and tributaries indicate that most coho probably overwinter in areas off the mainstem.

It appears that there may be at least two rearing strategies for coho in the North Thompson. In many streams, it appears that a large percentage of fry move into the North Thompson mainstem to rear. In some systems such as Fennel Creek, coho may rear and overwinter in their natal stream.

Depending on stream temperatures and growth rate of fry, coho may spend one or two years in freshwater to reach smolting size. Hutton et al. (1983) reported that up to 10% of coho spawning escapements to the North Thompson River tributaries had spent two years in fresh water. Whelen and Lister (1985) also noted that there were considerable numbers of potential two-year-old smolts in the North Thompson in mid-summer and early fall. Smolt migration peaks in mid-May (Sheng, pers. comm.).

### **2.3.2 Catches, escapements and escapement trends**

Commercial, sport, and native fisheries all harvest wild coho salmon stocks from the Fraser River. Based on the coded wire tag (CWT) data for Dunn, Lemieux and Louis coho stocks, approximately 40% of North Thompson area stocks are harvested in the west coast of Vancouver Island troll fishery and about 40% by the Strait of Georgia sport fishery.

In the North Thompson, Dunn Lake hatchery releases indicate, on average, a 65% exploitation rate (Sheng, pers. comm.). Exploitation rates determined for the entire Fraser stock were as high as 75-80%, resulting in a decline of wild coho stocks (Department of Fisheries and Oceans 1992). Even with hatchery contributions and possibly lower exploitation rates, coho escapements to the North Thompson are not increasing, and in some cases are declining.

Sport and aboriginal fisheries in the Thompson and North Thompson are minor. Although some harvest occurs in Dunn Creek for the surplus hatchery fish, it appears that the late arrival of the coho into the North Thompson is one of the main reasons for the limited catch. There is also some harvest of coho from the lower Fraser sport fishery; however, the aboriginal in-river gillnet fishery takes the greatest percentage (Schubert, pers. comm.). There is potential for new terminal fisheries in Lemieux and Dunn creeks in 1994.

Trends in coho spawning escapements to the North Thompson HMA are shown in Figure 2.8 and stream averages in Table 2.7. Maximum escapements in the historical record up to 1974 were in the order of 10,000 to 15,000 coho. In the last two decades, average escapements were approximately 6,000 coho. Maximum returns have been less than 10,000 fish. An increase in escapement has occurred in Dunn Creek, while a notable decrease is evident in Louis Creek. Escapement records for each year from 1951 are shown in Appendix A.

Escapement records and trends should be interpreted with caution, particularly for coho. Accurate escapement data for coho are difficult to obtain, due to their protracted spawning period, problems with ice cover or turbid water conditions, and the fact that most spawning areas are not easily accessible or visible from the air. As well, since there is no consistent method for extrapolation of counts to estimate totals and because escapements include both wild and hatchery fish, the escapement trends may not always reflect the true trend in wild coho populations (Department of Fisheries and Oceans 1990). Comparison of fence counts and visual counts in some North Thompson streams has indicated that spawner returns could be significantly underestimated and that actual escapements may be in the order of four times the recorded escapements (Department of Fisheries and Oceans 1992b).

### **2.3.3 Spawning and rearing habitat**

Distribution of coho in the North Thompson drainage is shown in Figure 2.7. The main coho spawning area in the North Thompson River is from the Barriere River to the Raft River confluence. Whelen and Lister (1985) documented coho spawning in the upper North Thompson above Blue River, and coho have since been observed in the headwaters as far north as Pleasant Creek. Important coho spawning tributaries that have supported greater than 1000 spawning coho include Albreda River (Photo 2.1) and Dunn, Fennell, Louis, Lemieux and Lion creeks. Lion Creek is well utilized and egg-to-fry survival is expected to be very high due to groundwater influence.

Figure 2.8 Coho escapements to streams in the North Thompson HMA, 1951 to 1991

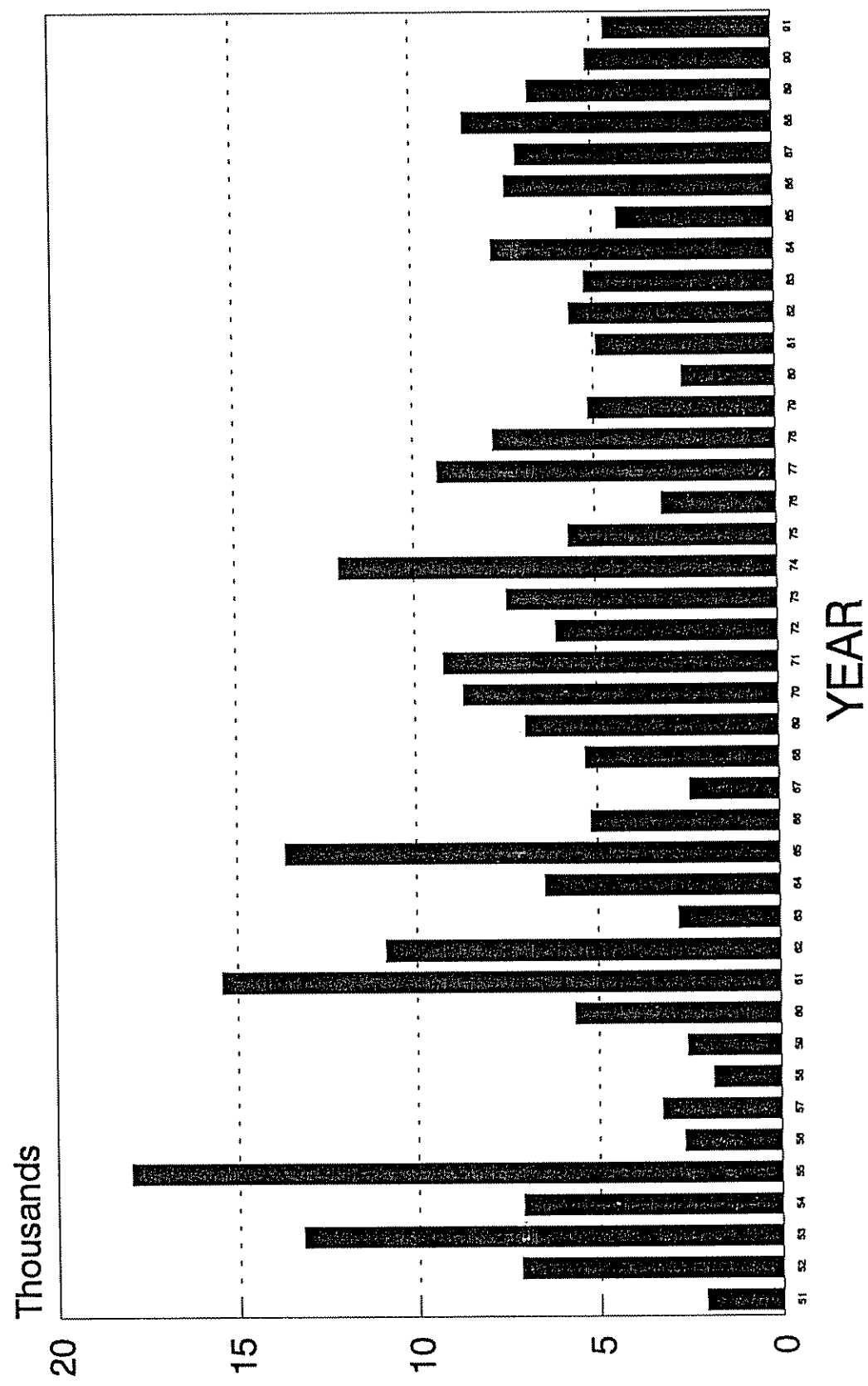




Photo 2.1 Coho spawning in Albreda River (photo courtesy of G. Kosakoski).



Photo 2.2 Little Hell's Gate, partial barrier to chinook and coho migration. A potential enhancement project (photo courtesy of L. Jaremovic).

Whelen and Lister (1985) identified additional coho spawning streams such as Bone and Pyramid creeks. Potential of these streams is limited, in that only the lowest reaches are useable. Other small watercourses, including Foghorn and McDougall creeks, were identified as having some spawning and rearing potential in their lower reaches as well.

Many tributary streams, including Lion, Louis, Lemieux and Fennell creeks and Albreda River, provide good rearing habitat for coho. Coho juveniles preferred low gradient reaches with low velocities, gravel substrate and abundant instream cover composed of log debris, cutbanks and overstream vegetation. Areas presently inaccessible in Raft and Finn creeks have high potential for coho colonization (Stewart et al. 1983). Some coho rearing likely occurs in lakes including North Barriere, Dunn and McTaggart; however, very little data on lake rearing is available.

In the North Thompson mainstem, coho preferred areas of zero and low water velocities, sidechannels and embayments that are associated with riparian vegetation and instream wood debris (Whelen and Lister 1985). Coho also utilized wetlands and small tributaries. It is apparent that there are numerous reaches throughout the entire length of the North Thompson that contain sidechannel and backwater habitats. Some of these high potential rearing areas include the reach of the North Thompson from Avola to Finn Creek, the upper Thompson near Albreda River and a long reach near Clearwater. Coho from tributary streams may rear and overwinter in these areas of the mainstem. A large proportion of fry from Lion and Finn creeks, for example, appear to rear in the North Thompson.

Coho production in the North Thompson HMA is potentially affected by low flows (e.g., in Louis and Lemieux creeks), problems of accessibility (e.g., Little Hell's Gate) and possibly by lack of refuge habitat in high water. Little Hell's Gate Falls on the North Thompson River may limit the access of coho to the upper reaches of the river (Photo 2.2). Some systems may be subject to freezing (e.g., Raft and Blue rivers and Tumtum and Finn creeks, where discharge levels are reduced during the winter). However, in many streams (e.g., Albreda River and Louis, Lemieux and Lion creeks), coho spawn in groundwater areas, and egg-to-fry survival is believed to be high (Sheng, pers. comm.). Many of the tributary streams in the North Thompson HMA, including Cook, Wire Cache, Mann, McTaggart, Cedar, Tumtum, Reg Christie, Crossing, Christian, Avola, Goose, Haggard, Joseph, Mahood and Brookfield creeks, have limited accessible length. Stewart et al. (1983) also indicated that most streams they studied had low levels of total dissolved solids, which may be limiting coho populations.

#### **2.3.4 Habitat productive capacities**

The productive capacity of coho streams can be assessed by measuring stream carrying capacity (maximum fish biomass that a stream can support during the period of least available habitat, which may occur in the late summer/fall or during the winter period). Whelen and Lister

(1985) suggests that carrying capacity in the North Thompson is probably approached in fall. To date, studies in the North Thompson and its tributaries have indicated relatively low densities of coho (fish/m<sup>2</sup>), although there appears to be abundant rearing habitat. Stewart et al. (1983) noted that Finn, Lemieux, Dunn and McTaggart creeks and Raft and North Barriere rivers appear to be under-utilized. Ptolemy (1982) estimated the actual smolt output for Louis Creek in 1981 to be 27,400, but, using estimates of existing habitat, the potential smolt output was estimated to be 284,000 smolts. More work is required to substantiate habitat under-utilization in specific streams and determine when the "bottleneck" in smolt production occurs.

The carrying capacity of a number of coastal coho salmon streams was analyzed by comparing coho smolt yields (expressed as number or biomass) with rearing space (expressed as length or area of stream accessible to spawners) by Marshall and Britton (1990). Their model was applied to the North Thompson streams and the results are shown in Table 2.8. Overall, the model indicates a potential smolt production of 1.3 million smolts, or adult return of over 50,000 spawners, compared with the 159 thousand smolts estimated from the average escapement recorded over the last 10 years. Potential production of the tributary streams (excluding the North Thompson River) was 400 k smolts. Estimates of smolt production using similar methods have ranged between 300 to 400 k smolts (Sheng, unpublished data). As shown in Table 2.8, the potential capacity is greatest in the largest streams, including the North Thompson, Clearwater and Barriere rivers, and in Louis Creek. On the other hand, many of the smaller streams presently appear to produce more smolts than would be predicted (enhancement potential is negative). This is consistent with the observations of downstream movement of fry from the tributaries to the North Thompson mainstem.

Available habitat and fish utilization data in the North Thompson HMA does not allow for a more detailed analysis. Actual smolt production data in interior streams is very limited and the Marshall and Britton model was based mostly on small coastal streams. Overall, it appears that there are no suitable biostandards for coho production in the HMA and testing and calibration of the model would be required. Application of this model assumes that the productivity of interior streams is similar to coastal streams, which may not be the case. A model being developed by MELP for steelhead incorporates productivity by including alkalinity of streams. A more detailed assessment of habitat units in streams may also be required for a realistic estimate of coho production in individual streams. Density of juvenile coho may be quite variable, depending on type of habitat. For instance, Whelen and Lister (1985) found that coho distribution in the mainstem North Thompson ranges from 0.10 to 4.21 fish/m of shoreline, depending on channel type, bed material present and seasonal flow (velocity) characteristics. The relationship between fry abundance and smolt production would also have to be determined.

Historical escapement data and trends (recognizing escapement data limitations) indicate that many streams supported larger coho escapements in the past, including the Barriere,

Table 2.8. Potential coho smolt production, based on Marshall and Britton coho model

Stream name	Coho distribution (km)	Potential smolts <sup>2</sup>	Average escapement 1980-91 <sup>3</sup>	Estimated smolts <sup>4</sup>	Enhancement potential <sup>5</sup>
North Thompson R	334.3	910,441	437	10,488	899,953
Louis C	52.1	107,224	700	16,800	90,424
Christian C	0.8	877		0	877
Barriere R	38.1	74,799	389	9,336	65,463
East Barriere R	6.4	9,603	143	3,432	6,171
Haggard C	0.5	511	5	120	391
Fennell C	5.5	8066	500	12,000	-3,934
Lemieux C	8.0	12,414	615	14,760	-2,346
Joseph C	1.5	1,809		0	1,809
Dunn C	0.6	630	727	17,448	-16,818
McTaggart C	2.4	3,106	31	744	2,362
Mann C	1.6	1,948	46	1,104	844
Clearwater R	41.3	82,073	124	2,976	79,097
Brookfield R	4.0	5,591	n/r	0	5,591
Mahood R	0.5	511	1	24	487
Raft R	4.0	5,591	392	9,408	-3,817
Reg Christie C	0.5	511	32	768	-257
Mad R	0.0	0	n/r	0	0
Wire Cache C	0.3	284	62	1,488	-1,204
Avola C	0.2	178	6	144	34
Crossing C	0.1	80	9	216	-136
Tumtum C	0.5	511	26	624	-113
Lion C	3.0	4,016	1000	24,000	-19,984
Finn C	3.0	4,016	201	4,824	-808
Goose C	2.1	2,664	10	240	2,424
Blue R	10.0	16,048	235	5,640	10,408
Cedar C	1.6	1,948	34	816	1,132
Cook C	1.1	1,266	66	1,584	-318
Albreda R	24.1	44,159	850	20,400	23,759
TOTAL	548.1	1,300,875	6,641	159,384	1,141,491

- 1 accessible stream length (SISS)
- 2 Marshall and Britton (1990)  $Y=ax^b$
- 3 average escapement from 1980 to 1991
- 4 assume 50% females x 1600 eggs x 3% egg to smolt survival
- 5 potential smolts less estimated smolt production
- n/r not recorded

Clearwater, Raft and North Thompson rivers, and Finn, Lemieux, Louis and Mann creeks. Although there is some indication that many North Thompson streams may be underseeded, studies to date have not been conclusive. If better estimates of stream carrying capacity are to be made, it is apparent that further studies need to be conducted on coho life history, seasonal movements and habitat utilization, and that adult escapements and smolt production need to be measured for selected interior streams.

### **2.3.5 Production objectives**

#### Natural production

There are no defined escapement goals for Fraser River coho salmon. The poor reliability of the escapement data for coho and the uncertainty of marine catch data, due to the difficulty of identifying specific coho stocks in the mixed stock fishery, makes coho stock assessment the most difficult of all species (Department of Fisheries and Oceans 1990). Exploitation rates are known for only a few stocks. For management purposes, coho are aggregated into only two groups; the lower Fraser and the Thompson River. However, using the best data available on escapements and catches, it is apparent that there has been a consistent decline in wild coho stocks in the Fraser and that there are fewer coho-producing streams (Department of Fisheries and Oceans 1992).

The DFO initiative to rebuild Strait of Georgia and Fraser River coho stocks through harvest rate reductions and through increased production and restoration of coho habitat is expected to substantially increase coho returns to the Fraser River when it is implemented (Department of Fisheries and Oceans 1992). Increased returns will provide opportunities to test the habitat capacity of these systems and will also provide future opportunities for both single stock and mixed stock terminal fisheries.

This conservation initiative will help to rebuild North Thompson stocks as well. Although the decline in wild stocks appears to be somewhat less in the Thompson and the exploitation rate appears to be less than in the lower Fraser, there is concern that interior streams may be less productive and may require a lower exploitation rate (Department of Fisheries and Oceans 1990).

In order to evaluate the rebuilding potential and to actively manage coho stocks, more reliable and consistent escapement and catch data is required. In addition, more effort needs to be directed towards estimating the spawning and rearing capacity of streams to determine stream-specific escapement targets. As discussed in the previous section, there is presently very little data to help in assessing the carrying capacity of North Thompson streams or interior Fraser River streams in general.

## Hatchery production

Coho smolt releases from the North Thompson hatchery into Louis, Lemieux and Dunn creeks have increased returns to Dunn Creek, but have had mixed results in the other two streams. The coho hatchery is operated by the North Thompson Indian Band and is located at the outlet of Dunn Lake. Fish are reared in net pens in Dunn Lake (Photo 2.3). This project was designed to examine rates of straying and various production strategies for several interior coho stocks. Coho smolts from three stocks -- Dunn Lake, Lemieux and Louis creeks, and previously Fennell Creek -- are produced to assess production strategies (size and time of release, straying). Initial results indicated that the most successful strategy was spring smolt releases. The hatchery has achieved a 10% smolt to adult survival rate with spring smolt releases and hatchery returns account for 25% of the escapement into Louis (Photo 2.4), 20% into Lemieux and 50% into Dunn (Sheng, pers. comm.). In high escapement years, a 50% return to Dunn Creek is approximately 700 fish.

Further assessment of hatchery results is required to ensure that future hatchery practices and strategies are developed that will maintain the genetic diversity and fitness of the North Thompson coho populations (Department of Fisheries and Oceans 1992b). Because the stocks in each stream are small, only a few fish are required for broodstock and the entire gene pool cannot be represented. There is also a need to further assess and minimize the straying of spawners back to the Dunn hatchery, rather than to the stream of origin where the smolts are released.

### **2.3.6 Enhancement opportunities**

While the key to rebuilding coho stocks is to increase spawner returns to North Thompson streams, there is a need at the same time to protect existing habitat, restore damaged habitat and create coho habitat. An enhancement opportunity that has been identified is the improvement of fish access at Little Hell's Gate, which will aid in natural migration of coho into the upper end of the North Thompson River. Little Hell's Gate Falls is located on the North Thompson River between Finn Creek and Blue River (Photo 2.2). This obstruction was first reported in 1970, and a detailed investigation of the obstruction was made in 1986. It appears that the obstruction is limiting the migration of coho salmon and, to a lesser extent, chinook salmon in the North Thompson River and tributaries upstream of Little Hell's Gate. Fish migration has been obstructed at low and high water velocities. The build-up of ice on the rock surface may also impede the passage of late arriving stocks. Observations of a complete obstruction in 1984, and partial obstructions in 1985, 1986 and 1987, revealed the extreme difficulty of the passage conditions. The problem may have been aggravated by a slide in the winter of 1991, which further obstructed the channel (Panko, pers. comm.). Remedial blasting was undertaken in 1992 and a study of the feasibility of improving fish passage will be conducted in 1993. There are also opportunities for the production of coho in presently inaccessible reaches of Raft River and Finn

Creek that should be assessed.

Habitat enhancement opportunities should be identified in sidechannel and offchannel habitat on the mainstem North Thompson. These habitats appear to be critical for rearing and overwintering coho. Assessment of these habitats and their utilization by coho may identify areas where fry augmentation may be feasible or areas where benefits would be realized by restoring or creating additional coho spawning and/or rearing habitats.

Habitat restoration opportunities identified for specific streams are presented in the next sections of the report. In addition to identifying opportunities, there is a need to monitor and assess restoration projects that have been undertaken and to develop new ways of restoring or creating habitat.

Goals and strategies for both hatchery and natural enhancement activities should be developed for the North Thompson HMA. The development of a comprehensive enhancement plan, however, has been constrained by the absence of critical information on coho stocks in the North Thompson, including life history information, accurate escapement counts, carrying capacity estimates and genetic composition (Department of Fisheries and Oceans 1992).

## **2.4 Pink Salmon**

A small number of pink salmon are found in the North Thompson River (maximum escapement recorded was 835) and their presence has been noted in Barriere River and Dunn and Mann creeks (Figure 2.9). There is normally no return of pink salmon to the North Thompson, except in odd years when there are large returns to the Fraser-Thompson system.

## **2.5 North Thompson Resident Fisheries**

### **2.5.1 Introduction**

The resident fisheries of the North Thompson River watershed are managed by two regions of the BC Ministry of Environment, Lands and Parks (MELP). These are Region 3 (Thompson - Nicola), headquartered in Kamloops, encompassing most of the HMA, with the exception of the Mahood River drainage, and Region 5 (Cariboo), headquartered in Williams Lake, which is responsible for the Bridge Creek and most of the Canim River watershed, including Canim Lake and its tributaries. The boundary between Region 3 and Region 5 cuts across Canim River at a point located approximately halfway between Canim Lake and Mahood Lake.



Photo 2.3 Coho net rearing pens in Dunn Lake (photo courtesy of M. Sheng).



Photo 2.4 Enumeration fence on Louis Creek (photo courtesy of M. Sheng)

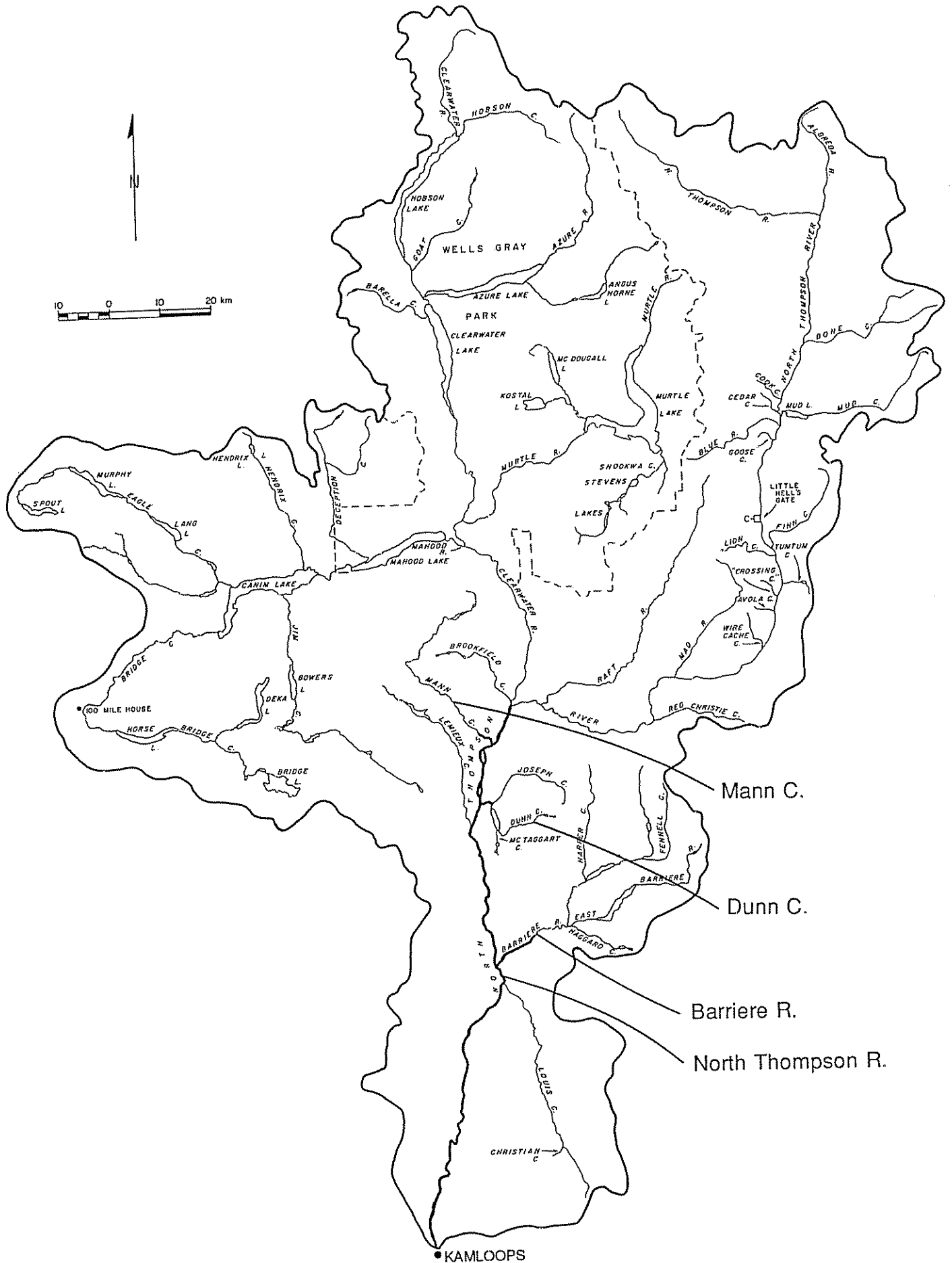


Figure 2.9 Location of pink salmon spawning streams in the North Thompson HMA

To simplify the following discussion of the resident fisheries resources, the HMA has been divided into smaller units, or groups of lakes with some similarities among them (Figure 2.10). These units are not intended or proposed as management units, but are simply a referencing system to facilitate discussion.

### **2.5.2 North Thompson drainage -- general**

The North Thompson is an important watershed because it is the area where all of the remaining wild stock rainbow trout lakes in Region 3 are found. It is also one of the few remaining areas that contain numerous walk-in and semi-wilderness fishing lakes, most of which are found north of Clearwater, on the east and west sides of the North Thompson and in Wells Gray Park.

Presently, MELP is involved in access management planning, timber harvesting guidelines, and establishing visual quality guidelines for lakes around Little Fort, Darfield and Barriere to Clearwater. This area, where the majority of fishing resort operators are situated, and where the walk-in lakes and numerous wild stocks are located, is under increased logging pressure.

Very little lake and stream inventory data is available for the North Thompson, as compared to the areas south of Kamloops, and there is also a lack of good lake catch to effort data. However, an ever-increasing number of people are heading north to get away from the crowds, and the sport fishing use of these areas is therefore increasing. As well, as a result of the Coquihalla Highway, there has been a noticeable shift in fishing effort from lower mainland and Okanagan anglers. There has been a definite increase in effort in the Little Fort/Bridge Lake area, as there are many good fishing lakes between Little Fort and Bridge Lake, both north and south of Highway 24.

As far as other resident species are concerned, most of the bull trout sport fishery is confined to the North Thompson River mainstem, and most tributaries of the mainstem support some bull trout spawning and rearing. The whitefish sport fishery is not too significant, although it is increasing, due to angling restrictions on other species. It mainly occurs as incidental catch, although some anglers do target them. Kokanee are found mainly in Barriere and Dunn lakes, in the Clearwater system and in some of the larger lakes in Wells Gray Park and the Mahood Creek drainage. Some of the lakes in the Mahood Creek drainage also support a very important lake trout fishery. Species such as kokanee, lake trout and burbot are utilized at an unknown level for aboriginal food fisheries, in lakes throughout the Louis, Barriere, Dunn and Mahood drainages.

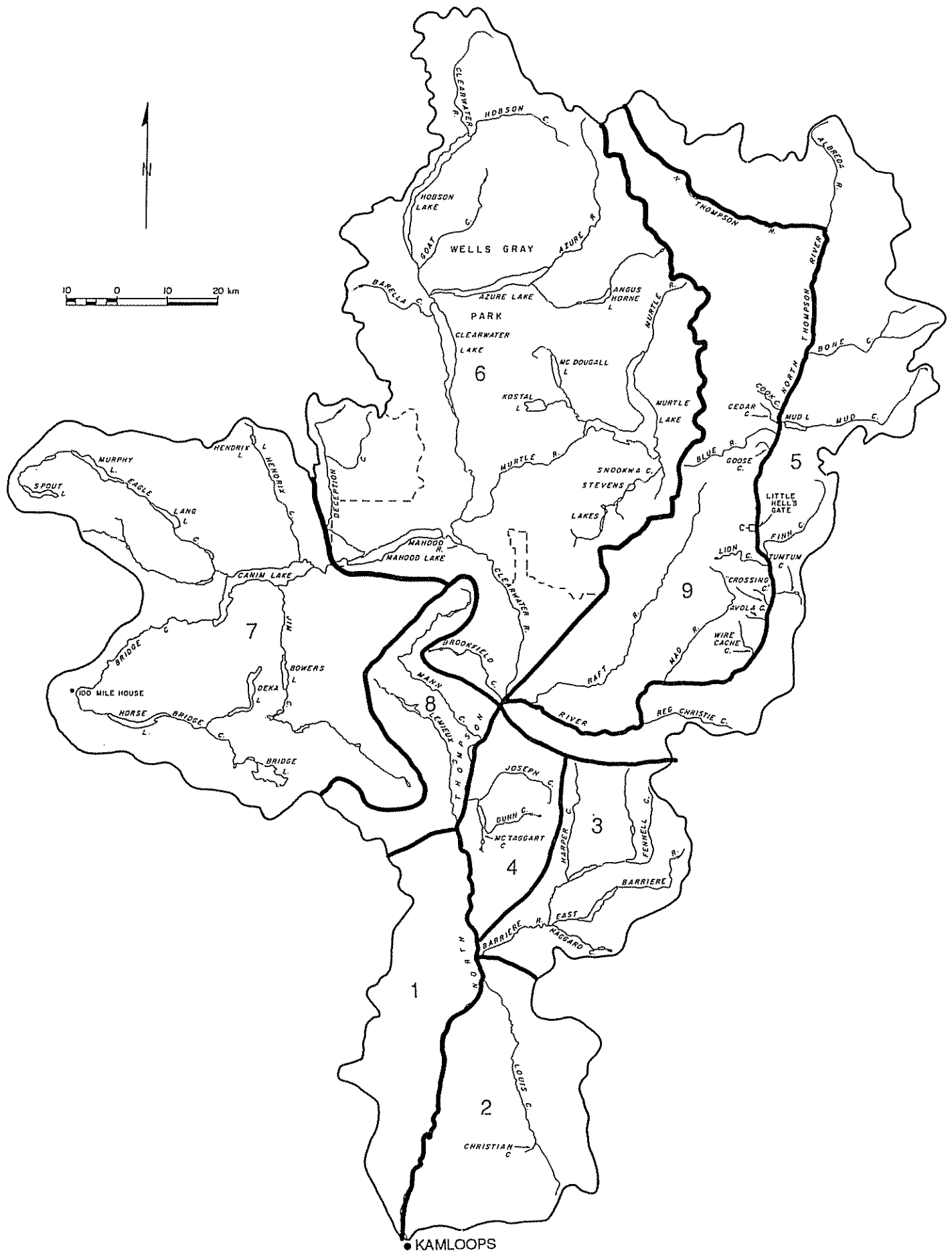


Figure 2.10 Units used for discussion of resident fisheries in the North Thompson HMA

Outside of the Wells Gray Park area, which is protected, the biggest threat to the watershed is pressure from logging and its associated road access development into wild, pristine lakes and streams, which then become roadside accessible systems. This results in increased sportfishing pressures, as well as the general degradation of habitat. Pressure from urban development, concentrated at the southern end of the North Thompson watershed near 100 Mile House, and around some of the larger lakes, is also of concern.

### 2.5.3 Unit descriptions (Figure 2.10)

#### Unit 1: West side of North Thompson River -- mouth to Little Fort

The Darfield, Lindquist and Caverhill areas support a number of high-use, wild stock rainbow fishing lakes. These semi-wilderness lakes have been identified for protected area status (as a management strategy). Darfield Creek is very small, with good quality clear, cold water, some coho rearing and spawning in the lower end, and good potential for enhancement. Peterson Creek and Jamieson Creek have very small accessible areas, near their junction with the North Thompson. At the north end of the unit, in the Darfield/Little Fort area, lakes such as Smith, Janning, Mulholland, Patrick, Thuya and Gorman are all high-use, wild stock rainbow lakes. Other high use, wild stock lakes include Dunsapie, Totunkwa, Beauregard, Allan and Boulanger. In the southern end of the unit, Nobel and Isobel lakes are stocked with rainbow trout and brook trout, respectively.

#### Unit 2: East side of North Thompson River -- mouth to Barriere

Louis Creek supports a very important resident rainbow trout sport fishery, and McGillivray Lake supports a high-use wild rainbow trout sport fishery. Most lakes within this unit, with the exception of McGillivray Lake, are hatchery stocked. Community and Spooney lakes support high-use, hatchery-stocked, trophy rainbow sport fisheries. Other high-use lakes in Unit 2 are Heffley, Paul, Sullivan and Badger, all of which are stocked with rainbow trout.

#### Unit 3: Barriere River watershed

North and East Barriere lakes contain populations of large rainbow trout, and support an important resident sport fishery. In addition to salmon and rainbow trout, the Barriere Lakes have kokanee, bull trout, whitefish and coarsefish. These lakes support high-use, wild stock rainbow sport fisheries. Wild stock rainbow are also found in Dixon and Little Dixon lakes, as well as in Saskum Lake, which has a naturalized (fish originally introduced by stocking) population.

Unit 4: East side of North Thompson River -- Barriere to Clearwater

Dunn Lake, a deep, oligotrophic lake, has net pen rearing sites for coho, and expansion of its hatchery has recently been completed (the impacts on resident species have not been assessed). In addition to coho, Dunn Lake has a wild stock rainbow trout population, as well as kokanee and burbot, and supports a high-use sport fishery. Hallamore Lake is hatchery stocked with rainbow trout, and McTaggart Lake has a naturalized rainbow trout population.

Unit 5: East side of North Thompson River -- Clearwater to headwaters

Most of the streams in this unit have resident fisheries values in the bottom end, but little or no resident fish values upstream, because they are generally steep and very incised. Preliminary work indicates that the Mud River system, from the mouth up to and including Mud Lake, is an important spawning and rearing area for bull trout. Efforts are proceeding to determine the extent of the bull trout use. Mud Lake also has wild stocks of rainbow trout and whitefish. The Albreda system has an abundance of backwater channels with only a moderate silt load, which is why coho do well there, and it is also very important for bull trout.

Unit 6: Wells Gray Park and Clearwater River to mouth

The Clearwater and Mahood systems represent the best rainbow trout sport fishing in the North Thompson watershed. The most significant sport fisheries in the park are Clearwater, Mahood, Azure and Murtle lakes, as well as the Clearwater and Murtle rivers. Clearwater Lake has a fabulous, world class, wild rainbow trout sport fishery, which is managed through regulations and gear restrictions. The B.C. Parks Branch is in the process of collecting baseline fish inventory data in order to develop a fish management plan for Wells Gray Park, the objective being to maintain the natural wild stocks. The well known rainbow trout sport fishery in the Clearwater River has been depressed due to increased fishing pressures, as the river is fished mainly from Clearwater Lake to the mouth. Whitefish are caught near the mouth of the Clearwater in the spring (Sinclair, pers. comm.).

All of the lakes in Wells Gray Park, including Fight, Strait, Anderson, Little Anderson, McDougall and Angus Horne, have wild rainbow trout populations and are very important. Access to Angus Horne Lake, situated in a wilderness conservancy, is very difficult, with no existing trails, and none planned for construction. The Stevens Lakes support an excellent hike-in sport fishery with a naturalized rainbow trout population. Twin Lakes and Kostal, Foot, Placid, Alice and Cranberry lakes have hatchery-stocked rainbow trout populations.

Natural kokanee populations found in Murtle, Strait, Anderson and Mahood lakes support substantial kokanee fisheries. There have been two unexplained fish kills in Mahood Lake in the

past: approximately 2,000 kokanee were killed in 1990, and 1,500 were killed in 1989.

The small lakes in the Clearwater drainage outside of the Wells Gray Park, south of Mahood Lake, which include Reflector, Grizzly, Surprise, Italia, Ejas, Maury and Corsica lakes, generally have naturalized rainbow trout populations.

B.C. Parks has total jurisdiction over Wells Gray Park and no problems are expected from logging or other industrial developments. There are few potential outside influences, as the park is a completely contained watershed. The Parks Branch policy in Wells Gray Park is to not permit barrier removal or introduction of salmon species above existing natural limits (headwater stocking or transplanting programs). The protection of existing wild stocks of rainbow trout and the maintenance of those populations is the primary management objective (Sinclair, pers. comm.).

#### Unit 7: Cariboo Region -- Bridge Creek and Canim River watersheds

There are hundreds of lakes in the Canim/Mahood drainage, but few still have a wilderness fishery status. Protection of wild stocks is a very high priority in the strategic plans and goals of the Cariboo Region. A significant amount of natural production of wild rainbow stocks occurs in the more mountainous areas, whereas the lakes closer to 100 Mile House tend to be closed systems, and are supported by stocking. The primary habitat protection requirement is to ensure that recruitment capacity is maintained on the tributary streams of wild, natural-production lakes (Lurette, pers. comm.).

All of the natural rainbow trout production, which provides recruitment for dozens of lakes, originates in the upper Bridge Creek system above Horse Lake. These wild stock lakes include Wavey, East and West King, Otter, Stack, Wilson, Lesser Fish, Roe, Marais and Longbow lakes. The Jim Creek watershed, including its associated tributaries and lakes, has a substantial amount of natural rainbow trout production. The wild stock lakes in this area include Bowers, Needa, English, Preacher and Cougar lakes. Donnelly Lake has an augmented rainbow trout population, but is still managed as a quality wilderness fishery. To a lesser extent, Canim Lake depends on the natural production from Eagle, Bradley and Christmas creeks. Lakes in the Eagle, Bradley and Christmas systems include Hawkins, Succour, Roger, Boomerang, Lang, Bedingfield, Two Mile, Coffee and Eagle. Of these, only Lang and Roger lakes are thought to have lake trout populations.

The most important high-use lakes in this unit are Sheridan, Bridge, Canim, Horse and Deka lakes. Sheridan Lake, rehabilitated in 1964, supports the largest rainbow trout sport fishery in the Cariboo Region, and is stocked and managed as a quality sport fishery. The others mentioned above represent the largest sport fishery for lake trout in the Cariboo. Sheridan Lake has also been stocked with brook trout, to control the chub population. Bridge Lake also supports a substantial kokanee fishery, and both Bridge and Horse lakes are stocked with kokanee.

At one time, Canim Lake was primarily populated with rainbow trout, lake trout and whitefish, but was stocked with kokanee in the 1950s. The kokanee did very well until mysid shrimp were introduced. The kokanee population collapsed as a result of direct competition for phytoplankton. Although the kokanee population is currently depressed, the introduction of mysids has probably benefitted the lake trout population by increasing available food organisms. Canim Lake is utilized by the Canim Lake Indian Band for the harvesting of lake trout, kokanee and burbot for food.

Lorin, Howard, Greenlee and Valentine lakes, and Irish Lake, which is aerated, are hatchery stocked and managed for quality rainbow trout sport fisheries.

Unit 8:            West side of North Thompson River -- Little Fort to Clearwater

Lemieux Creek supports a very important resident rainbow trout sport fishery, and has wildlife areas on both sides of the creek. The backwater marshes along the North Thompson River within this unit are important rearing areas.

Virtually all of the lakes in the unit between Little Fort and Clearwater are important from the point of view of the sport fishery. Most are semi-wilderness, walk-in fisheries and there are numerous fishing camps throughout the area. Taweel, Rock Island, Laurel, Latremouille, Long Island, Tintlhohtan, Lost Horse, Muddy, Efdee, Tortoise, Emar and Moira lakes are some of the largest wild stock rainbow lakes, the last four having naturalized populations.

Lac des Roches, Phinetta, Birch, Moosehead, Lynn, Lemieux, Lolo and Dum lakes are some of the largest stocked lakes. Dum Lake is managed for a quality rainbow trout sport fishery.

Unit 9:            West side of North Thompson River -- Clearwater to headwaters

There are few sport fishing lakes in this area. Silence Lake, in the Raft River watershed, is the most important. Silence and Dutch lakes are stocked with rainbow trout. McCorvie Lake, a small lake also tributary to Raft River, has a naturalized rainbow trout population.

Not much inventory information on resident fish is available for the area north of Blue River to the headwaters of the North Thompson River, thus no lakes or streams with known resident sport fisheries have been identified.

### 3.0 BIOPHYSICAL FEATURES

The productive capabilities of lakes and streams throughout the HMA are governed directly by the physiography, climate and hydrology of the area. Physiography is the primary factor that affects the types and amounts of lake and stream habitat present. Specific climatic conditions are a result of the interaction of physiographic features and general climatic patterns of the southern interior. In turn, these physiographic and climatic conditions result in vegetation associations that are classified into biogeoclimatic zones.

The North Thompson drainage flows through six physiographic land units within the Interior Plateau of the Canadian Cordillera as described by Holland (1976). These land units are the Thompson Plateau, Shuswap Highlands, Monashee Mountains, Quesnel Highlands and Cariboo Mountains (Figure 3.1). Most of the North Thompson drainage falls within the first two land units; small portions of the upper North Thompson drainage originate in the Cariboo Mountain and Quesnel Highland units. The Mahood and upper Bonaparte (Thompson-Nicola HMA) drainages originate in the Fraser Plateau unit. A brief description of each physiographic land unit, based on Holland (1976), is included in Appendix B.

The biogeoclimatic ecological classification (BEC) is a hierarchical classification of ecosystems based on vegetation, climate and physical site characteristics. Because of the mountainous nature of the Thompson River basin, biogeoclimatic zones tend to occur as elevational bands that represent significant differences in climate. Nine zones occur within the Thompson basin: Alpine Tundra (AT); Engelmann Spruce-Subalpine Fir (ESSF); Montane Spruce (MS); Sub-Boreal Spruce (SBS); Sub-Boreal Pine-Spruce (SBPS); Interior Cedar-Hemlock (ICH); Interior Douglas-fir (IDF); Ponderosa Pine (PP) and Bunchgrass (BG) (Figure 3.2). General zonal characteristics (Lloyd et al. 1990) are described in Appendix B.

Annual precipitation and snowfall for the North Thompson HMA are presented in Figures 3.3 and 3.4. The precipitation and snowfall lines are approximate. There is a significant increase in both precipitation and snowfall from the south to the north, as can be seen in both figures.

Because there is such a wide range of biophysical conditions, from warm, dry plateaus to cold, wet mountain ranges, there is an equally wide range of aquatic habitats in the North Thompson HMA.



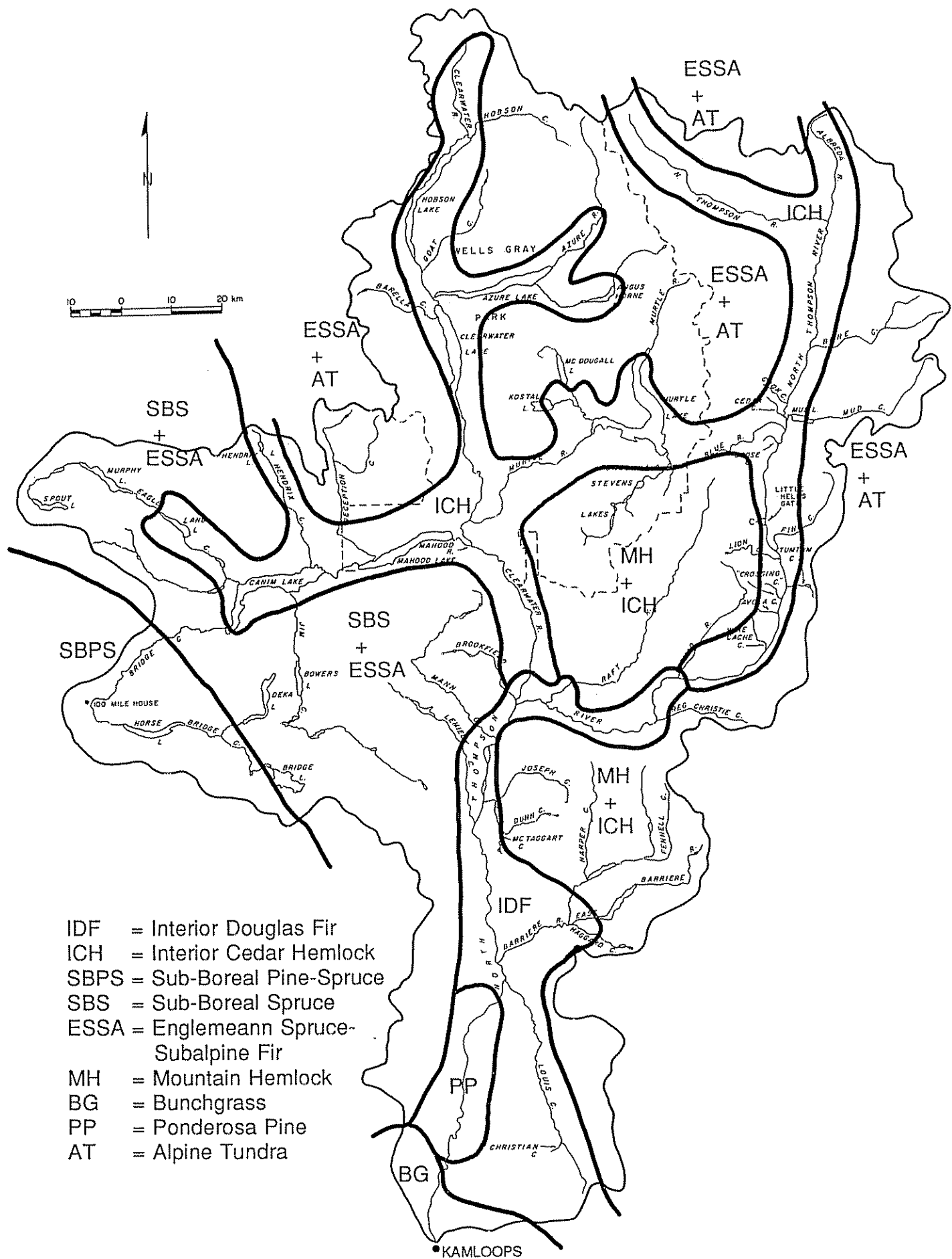
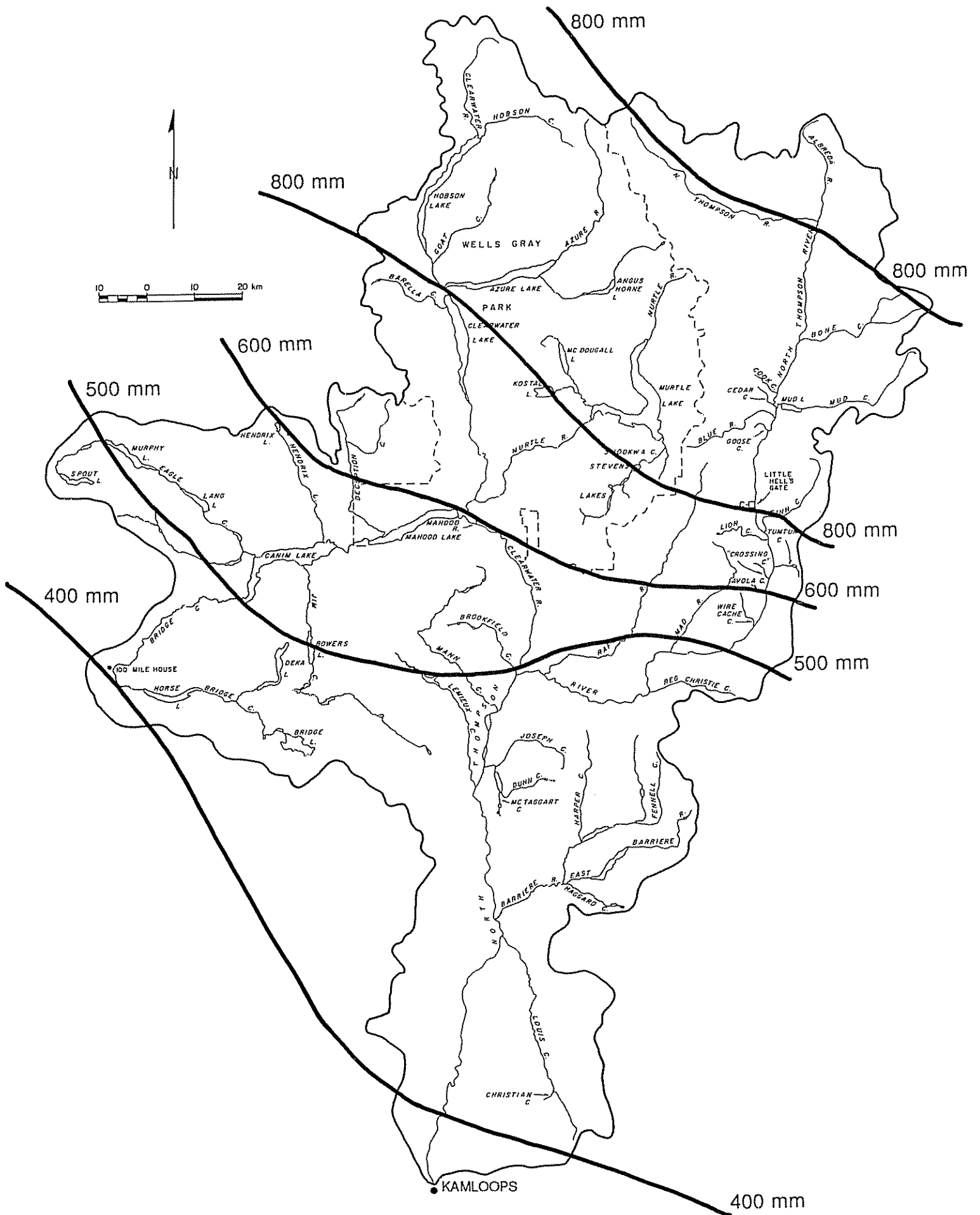


Figure 3.2 Generalized biogeoclimatic zones of the North Thompson HMA



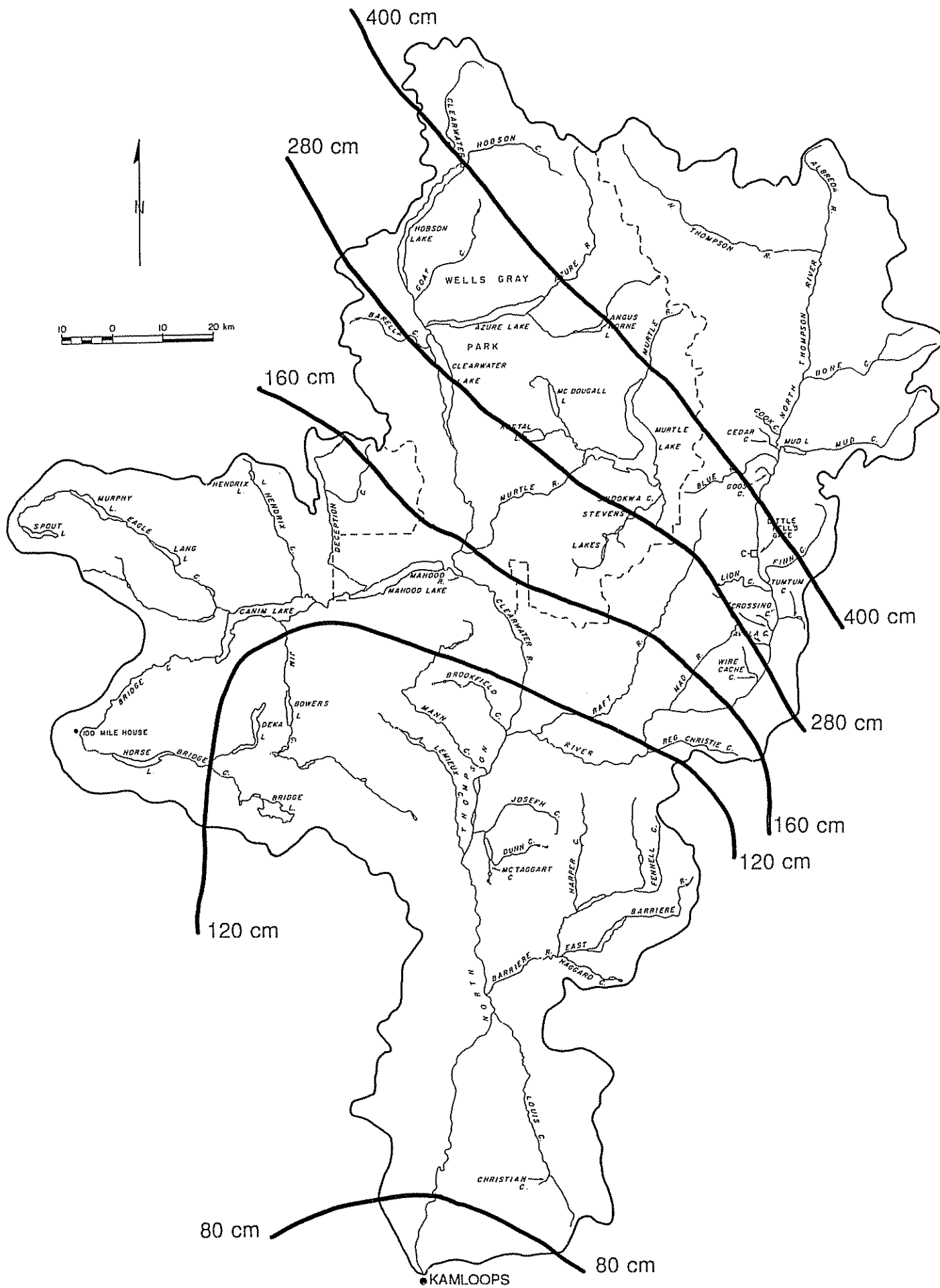


Figure 3.4 Annual snowfall in the North Thompson HMA

### 3.1 Physiographic Descriptions

#### Thompson Plateau

The Thompson Plateau and the margins of the Shuswap Highlands and Fraser Plateau have a similar mix of climatic and physiographic features. The land has a generally low relief, flat or rolling terrain, which has resulted in the creation of numerous lakes and stream systems. Streams generally have relatively low gradient channels and small (<100 km<sup>2</sup>) to moderate drainage areas, the largest being 500 km<sup>2</sup>. Climate is characterized by low precipitation (400 mm) and low snow pack (80-120 cm). Limited snow pack has resulted in a shortened spring runoff and, hence, streams warm up earlier in the spring, can be quite warm during the summer, and freeze up late in the fall. Overall, this makes these streams extremely productive and capable of significant fry and smolt production. However, potential low flows and warm water temperatures also affect production through loss of potential summer rearing area (dewatering), and high summer stream temperatures that can exceed 18°C, which is well above the optimum rearing temperature.

#### Shuswap Highlands

Across the Shuswap Highlands there is a gradual increase in relief from the flat or rolling terrain of the Fraser and Thompson plateaus to the steep, jagged peaks of the Cariboo and Monashee mountains. This has resulted in typically broad river valleys and has facilitated the development of larger drainage basins (up to 1,000 km<sup>2</sup>). Due to the numerous broad valleys, a number of moderately large (not the largest) lakes are also found in the unit. There is more variation in stream channel morphology, and mainstem stream channels display a range of bed materials, pool/riffle sequences and discrete reaches of extensive floodplain. Streams that form the headwater tributaries tend to be steep, confined, bouldery channels. Climate is characterized by relatively low levels of precipitation (500 mm) and snow pack (120 cm) in the southern half of the unit, but sharp increases occur on the northern edge, depending on the proximity to the Cariboo and Monashee mountains. This means that streams are slightly cooler than the southern plateau streams. Compared to the Thompson Plateau, for example, these generally steeper gradient streams will warm up later, freeze up earlier and are not as productive, due to cooler temperatures. There is potential also for larger peak storm events in this unit, which is likely a function of the greater potential for rain-on-snow events.

From a fisheries production perspective, these conditions are most favourable. Flow and temperature extremes appear to be moderated, neither very high nor very low during the summer growing period, and high sediment levels occur only during peak runoff periods. The Shuswap Highlands account for the largest proportion of the salmon production in the HMA and lake production is also important.

## Cariboo and Monashee Mountains

The Cariboo and Monashee mountains are characterized by steep, jagged peaks and ranges. The Cariboo Mountains contain the longest river valleys (Clearwater and Murtle rivers) and the largest lakes in the HMA. Most of the large streams in the Cariboo Mountains are found in Wells Gray Park and contain resident trout. The salmon-producing streams in the Monashee and eastern Cariboo ranges drain directly into the North Thompson River. They are generally small (50-150 km<sup>2</sup>), narrow, steep channels containing few lakes. Most often there are no high-quality rearing habitats, such as side channels and wetland areas. The highest levels of precipitation (800 mm) and snowfall (400 cm) are found in these ranges. Consequently, these streams have a late and often long duration spring-summer runoff. Higher turbidities often occur over the entire summer period due to glacial melt. This is mitigated in downstream areas by the larger lakes. Water temperatures are the coldest in the HMA and these streams are likely the first to freeze over.

Because of poor growing conditions (temperatures and water quality) and the lack of suitable rearing habitats, fish often migrate out of the tributary spawning streams and rear in side channels and wetlands of the mainstem North Thompson. Hence, unless a stream channel has side channel or wetland habitat, such as is found on the Albreda River, overall production capabilities in these northern streams are limited. Also, due to the unstable nature of some of these channels and the potential for the channel bed to freeze, egg survival can be quite variable. These conditions extend into the upper corner of the Shuswap Highlands and include a number of smaller streams from Avola River to Finn Creek.

## Quesnel Highlands

The portion of the Quesnel Highlands located in the HMA is a transition zone between the Fraser Plateau and Cariboo Mountains. Since no major drainages originate within the Highlands, the unit has little effect on Clearwater River or Clearwater Lake, which are affected by runoff from the Cariboo Mountains.

## Fraser Plateau

The Fraser Plateau's irregular, rolling relief is generally provided by glacial features such as eskers and drumlins, and, as a result, hundreds of lakes and wetlands have been formed throughout the unit. Stream channels are usually small and are connected to numerous wetlands and lakes. Annual precipitation (500 mm) and snowfall (150 cm) is slightly greater than in the Thompson Plateau; precipitation levels increase toward the north. Spring runoff occurs early, summer water temperatures are relatively warm, and freeze-up occurs late in the fall. Because of the lack of relief, stream channels are usually stable and potential suspended sediment discharges

can occur only during peak spring runoff events. There are likely numerous small watersheds that could be subject to critical low flows in the late summer and fall, although they have not been specifically identified.

This area contains only resident fish and most of the important fisheries are associated with lake populations. However, in most cases, lake populations spawn in the inlet and outlet streams and low summer flows could have an effect on rearing trout populations in these streams. Impacts from high flows are almost negligible due to the short duration of runoff and the high retention capability of the wetlands and lakes. The most important stream fishery areas are in the lower Canim and Mahood rivers, where critical flow or temperature problems have not yet been identified.

### **3.2 Regional Hydrologic Regime**

The North Thompson River is typical of interior B.C. streams in that it is characterized by a nival (snow melt) hydrograph. The annual peak event usually occurs in June, with the actual timing (ranging from May to July) and the volumes of peak discharge controlled by snow pack volume and weather conditions during the melt period (Watt 1989). The North Thompson basin has much higher values for mean annual peak and low flow than the South Thompson and Thompson-Nicola basins. These patterns reflect the more mountainous nature of the basin and their proximity to the continental divide. Peaks in the headwaters of the North Thompson basin reach over 3200 m, with significant glaciation in the peaks of the Monashee Mountains above 2500 m. A late summer component of runoff from glacial melt is evident on the hydrographs of streams that drain from the Cariboo or Monashee mountains. In the southern end of the HMA, streams that drain from the Shuswap Highlands and the Thompson and Fraser plateaus have their peak snow runoff from April through June. With respect to low flows, the natural low flow period occurs during winter, between December and March.

Most of the rivers in the North Thompson HMA develop a winter ice cover, which probably lasts from two to four months. Smaller headwater streams will freeze over earliest (November), and the mainstem Thompson River at Blue River and at Kamloops freezes over in December (Allen 1977). Break-up ranges from late February to mid-April for the North Thompson at Kamloops, with a mean date of March 18 for over 25 years of record (Allen 1977).

The results of the hydrologic analysis by Sigma Engineering Ltd. (1991) of 29 active and discontinued hydrometric stations (Figure 3.5) summarized in Table 3.1 indicate a high degree of spatial (regional) variability across the basin. The spatial variability reflects the biogeoclimatic zonation, with a trend of increasing precipitation and snowfall from southwest to northeast (Figure 3.3 and Figure 3.4) and higher runoff. Altitudinal influences on precipitation and runoff rates are implicit in the biogeoclimatic classifications.

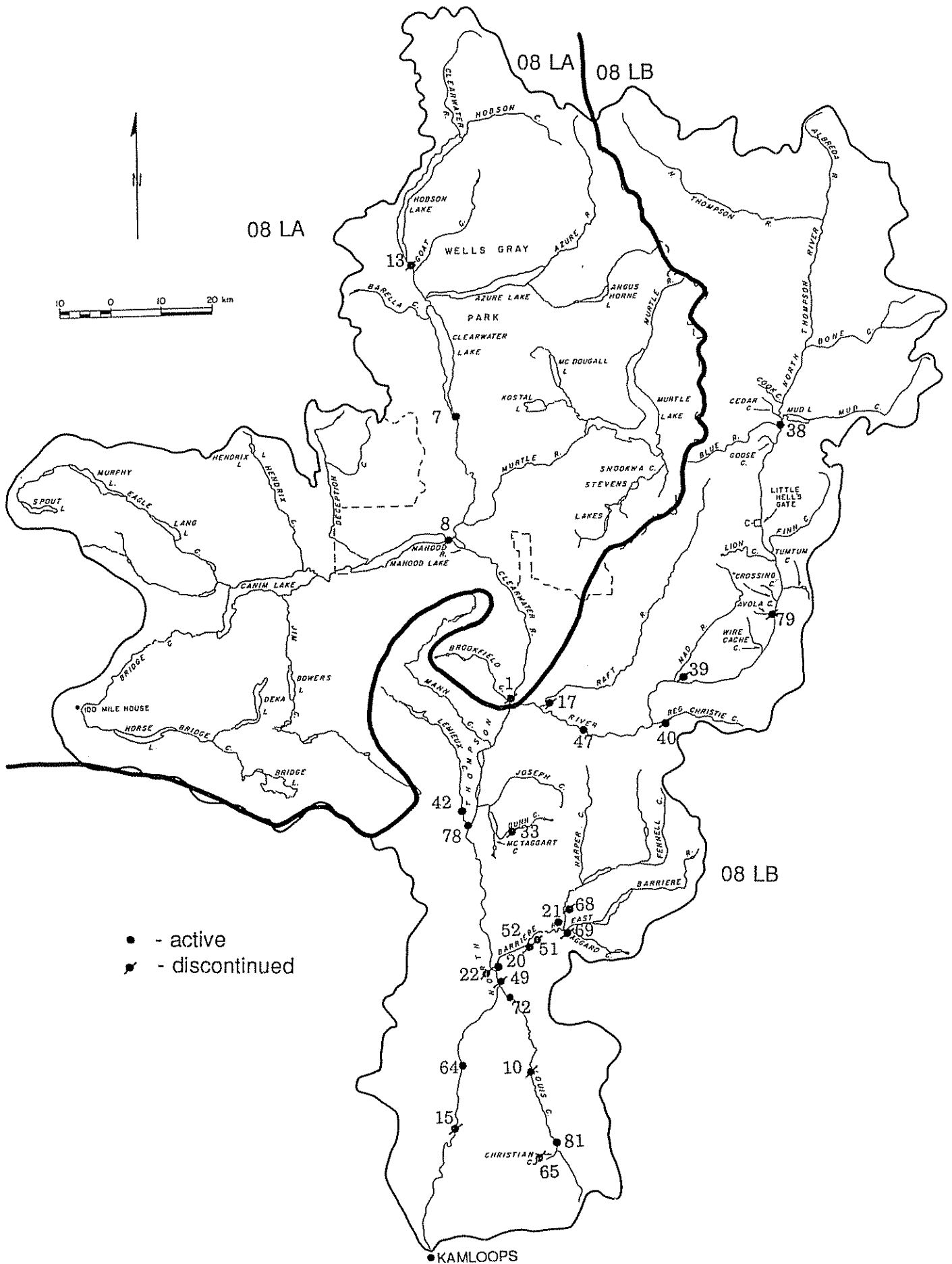


Figure 3.5 Hydrometric stations used in the Sigma Engineering Ltd. (1991) analysis

Table 3.1. Hydrology in the North Thompson HMA (reproduced from Sigma Engineering Ltd. 1991.)

Station Stream Information	Station Number	Station Name	Data Type	Gauge Area (km <sup>2</sup> )	Basin Area (km <sup>2</sup> )	Unit Mean Annual Flow (l/s/km <sup>2</sup> )	Unit Avg. 7 Day Low Flow (l/s/km <sup>2</sup> )	Unit Peak Daily Flow (l/s/km <sup>2</sup> )	Mean Annual Flow (m <sup>3</sup> /s)	Average 7 Day Low Flow (m <sup>3</sup> /s)	Peak Daily Flow (m <sup>3</sup> /s)	Comments
Name: North Thompson R WSC: 04 Lakes:	08LB047 08LB064 08LB072 08LB015	North Thompson River at Birch Island North Thompson River at McLure North Thompson River near Barmere North Thompson R near Black Pines	A A A A	4,450 19,600 17,700 N/A	20,742 20,742 20,742 20,742	33.5 21.8 22.2	3.4 2.78 2.7	189 110 117	695 452 460 0	70.5 57.7 56 0	3970 2282 2427 0	28 years -natural low flows Dec-Feb 30 years 39 years
Name: Louis Creek WSC: 04-0600 Lakes:	08LB081 08LB010 08LB072 08LB049	Louis Creek above McGillivray Creek Ck at Boundary of Railway Belt Louis Creek at the Mouth Louis Creek near Louis Creek	B	N/A 269 515 515	526 526 526 526	5.46	0.413	64.3	2.87	0.217	33.8	- natural low flows Dec-Feb, with 30% lows occurring in Aug-Sept 17 years
Name: Christian C WSC: 04-0600-150 Lakes:	08LB065 08NU069	Christian Creek near Heffley Creek Christian Creek near Perry Sliding	C	8 3	19	5.46		64.3	0.104	0	1.22	Based on Louis C at the mouth
Name: Barmere R WSC: 04-0700 Lakes: North Barmere L, Saskum L	08LB021 08LB070 08LB052 08LB068 08LB069 08LB051	Barmere R (East Fork) near Barmere Barmere River at the Mouth Barmere R. B.C.E.R. Flume near Barmere Barmere River below Lee Creek Barmere River below Sprague Creek Barmere River near Barmere (at Dam)	A A	155 1,140 N/A 585 624 1,000	1,151 1,151 1,151 1,151 1,151	12.6 18.1	1.38 1.83	101 168	14.5 0 0 20.8	1.59 0 0 2.11	116 0 0 193	37 years - natural low flows Jan-Mar 23 years
Name: East Barmere R WSC: 04-0700-070 Lakes: East Barmere L		No Water Survey of Canada Gauges	C	N/A	318	18.1		168	5.76	0	53.4	Based on Barmere R below Sprague C
Name: Haggard C WSC: 04-0700-070-010 Lakes: South Barmere L		No Water Survey of Canada Gauges	C	N/A	92	18.1		168	1.66	0	15.4	Based on Barmere R below Sprague C
Name: Fennell C WSC: 04-0700-150 Lakes:		No Water Survey of Canada Gauges	C	N/A	110	18.1		168	1.99	0	18.5	Based on Barmere R below Sprague C
Name: Lemieux C WSC: 04-1200 Lakes: Taxewal L	08LB042 08LB078	Lemieux Creek near Mount Oite Lemieux Creek near the Mouth	B	195 443	454 454	6.12	0.264	66.4	0 2.78	0 0.12	0 30.1	-natural low flows Dec-Feb, with 50% lows occurring in Aug-Sept
Name: Joseph C WSC: 04-1300 Lakes:		No Water Survey of Canada Gauges	C	N/A	259	5.46		64.3	1.41	0	16.7	Based on Louis C at the mouth
Name: Dunn C WSC: 04-1300-010 Lakes: Dunn L	08LB033	Dunn Creek near Chu Chua	C	N/A	105	5.46		64.3	0.573	0	6.75	Based on Louis C at the mouth

Table 3.1 continued

Salmon Stream Information	Station Number	Station Name	Data Type	Gauge Area (km <sup>2</sup> )	Basin Area (km <sup>2</sup> )	Unit Mean Annual Flow (lit/km <sup>2</sup> )	Unit Avg. 7 Day Low Flow (lit/km <sup>2</sup> )	Unit Peak Daily Flow (lit/km <sup>2</sup> )	Mean Annual Flow (m <sup>3</sup> /s)	Average 7 Day Low Flow (m <sup>3</sup> /s)	Peak Daily Flow (m <sup>3</sup> /s)	Comments
Name: McTaggart C WSC: 04-1300-010-010 Lakes: McTaggart L		No Water Survey of Canada Gauges	C	N/A	21	5.46		64.3	0.115	0	1.35	Based on Louis C at the mouth
Name: Mann C WSC: 04-1400 Lakes: Moira L	08LB050	Mann Creek near Blackpool	B	295	291	10.2	0.242	142	2.97	0.07	41.3	16 years - natural low flows generally Dec-Feb, with 25% lows occurring in Aug-Sept
Name: Clearwater R WSC: 04-1500 Lakes: Murtle L	08LA009 08LA007 08LA013 08LA001	Clearwater R @ Inlet to Clearwater L Clearwater R @ Outlet of Clearwater L Clearwater R @ Outlet of Hobson L Clearwater R near Clearwater Station	A A A A	2,380 2,950 994 10,200	10,551 10,551 10,551 10,551	46.1 49.9 21.9	5.38 5.21 2.85	249 243 109	486 526 231	56.8 33 28	2627 2564 1150	- natural winter low flows Jan-Mar 21 years 25 years 47 years
Name: Rmekfield C WSC: 04-1500-020 Lakes: Grizzly L, Reflector L		No Water Survey of Canada Gauges	C	N/A	92	18.1		168	1.67	0	15.5	Based on Barmiere R below Sprague C
Name: Mahood R WSC: 04-1500-160 Lakes: Mahood L, Canum L	08LA008	Mahood River at Outlet of Mahood Lake	A	4,710	4,915	7.16	0.667	44.6	35.2	3.28	219	22 years - low flows generally Dec-Mar, some Sept-Nov may be due to irrigation
Name: Raft R WSC: 04-1700 Lakes:	08LB017	Raft River near Clearwater	B	764	757	19.9	0.711	186	15.1	0.538	141	4 years
Name: Reg Christie C WSC: 04-2300 Lakes:	08LB040	Reg Christie Creek near Yavemy	C	72	76	10.2		142	0.775	0	10.8	Based on Mann Creek near Blackpool
Name: Mad R WSC: 04-3200 Lakes:	08LB039	Mad River near Irvine	C	280	227	19.9		186	4.52	0	42.2	Based on Raft R near Clearwater
Name: Unnamed C WSC: 04-4210 Lakes:		No Water Survey of Canada Gauges	C	N/A	11	19.9		186	0.219	0	2.05	Based on Raft R near Clearwater
Name: Avola C WSC: 04-4400 Lakes:	08LB079	Avola Creek (South Fork) near Avola	C	N/A	5	19.9		186	0.099	0	0.93	Based on Raft R near Clearwater
Name: Unnamed C WSC: 04-4600 Lakes:		No Water Survey of Canada Gauges	C	N/A	10	19.9		186	0.199	0	1.86	Based on Raft R near Clearwater
Name: Turatum C WSC: 04-4700 Lakes: Unnamed L		No Water Survey of Canada Gauges	C	N/A	24	19.9		186	0.48	0	4.48	Based on Raft R near Clearwater

Table 3.1 continued

Station Name	Station Number	Station Name	Data Type	Gauge Area (km <sup>2</sup> )	Basin Area (km <sup>2</sup> )	Unit Mean Annual Flow (l/s/km <sup>2</sup> )	Unit Avg. 7 Day Low Flow (l/s/km <sup>2</sup> )	Unit Peak Daily Flow (l/s/km <sup>2</sup> )	Mean Annual Flow (m <sup>3</sup> /s)	Average 7 Day Low Flow (m <sup>3</sup> /s)	Peak Daily Flow (m <sup>3</sup> /s)	Comments
Simon Stream Name: Lion C WSC: 04-4800 Lakes:		No Water Survey of Canada Gauges	C	N/A	46	19.9		186	0.915	0	8.56	Based on Raft R. near Clearwater
Simon Stream Name: Finn C WSC: 04-5000 Lakes:		No Water Survey of Canada Gauges	C	N/A	134	35.2		292	4.72	0	39.1	Based on Blue R near Blue River
Simon Stream Name: Goose C WSC: 04-5850 Lakes:		No Water Survey of Canada Gauges	C	N/A	9	35.2		292	0.317	0	2.63	Based on Blue R near Blue River
Simon Stream Name: Blue R WSC: 04-6000 Lakes:	08LB038	Blue River near Blue River	B	280	275	35.2	3.39	292	9.68	0.932	80.3	7 years
Simon Stream Name: Cedar C WSC: 04-6150 Lakes:		No Water Survey of Canada Gauges	C	N/A	11	35.2		292	0.387	0	3.21	Based on Blue R near Blue River
Simon Stream Name: Cook C WSC: 04-6200 Lakes:		No Water Survey of Canada Gauges	C	N/A	11	35.2		292	0.387	0	3.21	Based on Blue R near Blue River
Simon Stream Name: Alberta R WSC: 04-7800 Lakes:		No Water Survey of Canada Gauges	C	N/A	406				0	0	0	N/A

## Data Type

A - Indicates stations within DFO watersheds with more than 20 complete years of data. All data from type A gauges are presented.

B - Indicates stations with less than 20 years of complete record.

C - Indicates streams where there is no WSC station or where there are no complete years of record. For these basins a similar type A or B station was selected, or it was noted N/A if no station was suitable.

The unit mean annual flows (Table 3.1), ranging from 5.46 l/s/km<sup>2</sup> for Louis Creek to 49 l/s/km<sup>2</sup> for the Clearwater River, provide a good indication of variability. The unit mean annual flow for streams located in the mountainous regions further east in the HMA will probably exceed 75 l/s/km<sup>2</sup>. The unit peak daily flows show a similar pattern, ranging from a low peak unit runoff of 45 l/s/km<sup>2</sup> for the Mahood River at the outlet of Mahood Lake, to a high of 292 l/s/km<sup>2</sup> for Blue River.

The North Thompson basin displays a smaller range of variation of unit mean annual runoff than the South Thompson and Thompson-Nicola catchments, due to the higher minimum unit mean annual runoff value of over 5 l/s/km<sup>2</sup>. This pattern can also be observed in the unit average seven-day low-flow values, which reflect the more northern and mountainous nature of the North Thompson catchment area.

### 3.2.1 Hydrologic analysis

Northwest Hydraulic Consultants Ltd. (1992) prepared a detailed analysis of flow characteristics of North Thompson salmon streams that included mean annual stream hydrographs, distribution of seven-day low flows (the lowest average flow for seven consecutive days) and low flow frequency curves. Sensitivity indices were developed that compared the magnitude of low flows to mean flows to assist in the identification of potential low flow problems that may affect fish. Indices were calculated to compare summer and winter seven-day low flows to mean annual low flows (Appendix C). Actual seven-day low flows were used, so that indices reflect the current condition in streams with and without licensed water demands. Low values of the indices indicated streams with steep recession curves during summer drought. The seven streams whose indices are in the lowest 25% of the values are shown in Figure 3.6.

Most of the streams with low indices have small drainage basins, and some have licensed demand, while others are unaffected by diversion or storage. Typically, smaller streams have more extreme response to drought and, on the Thompson Plateau and Quesnel Highlands, measurements by the Water Management Division indicate that drainage basins up to 100 km<sup>2</sup> or greater may have zero discharge during moderate droughts.

Peak flow indices in which ratios of mean annual flood to mean annual discharge were compared are shown in Appendix C. Higher values or ratios indicate streams with the potential for ranges of peak flows that could potentially have an effect on stream channel stability. Streams whose ratio values are in the highest 25% are shown in Figure 3.7. These large values do not necessarily indicate unstable streams, because stability is also affected by channel configuration, bed and bank materials and channel gradient, which were not included in this analysis.

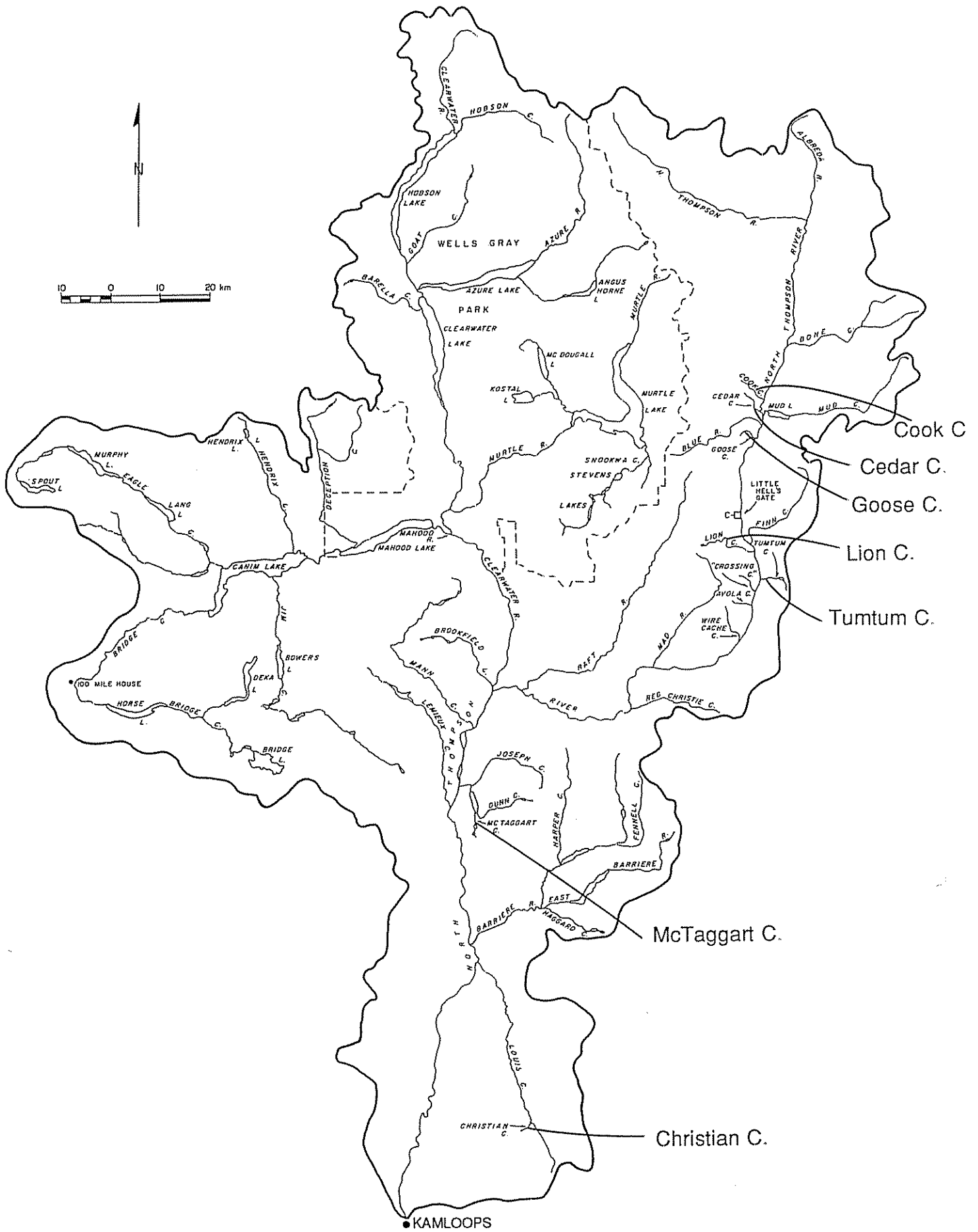


Figure 3.6 Streams in the North Thompson HMA with low ratios of seven day low flow to mean annual flow (Northwest Hydraulic Consultants Ltd. 1992)

With the exception of Mann Creek, all the streams noted (Fennell, East Barriere and Haggard creeks), are in the Barriere drainage in the Shuswap Highland physiographic unit. It is interesting to note that these streams are on the edge of the lowest precipitation and snowfall zone in the HMA. In the case of the Barriere system, which is located in mountainous terrain, high peak flows may indicate that this area is more susceptible to rain-on-snow events than are the areas to the north.

### **3.3 Climate Change**

Evidence indicates that air temperatures in B.C. have been increasing. It is predicted that increases in CO<sub>2</sub> will accelerate this warming trend. Global warming is expected to increase air temperatures, affecting stream temperature and natural runoff in streams. Increased water temperatures and changes in the hydrological regime may be detrimental to the fisheries resource. Detailed analysis of climate change is provided in Sigma Engineering Ltd. (1991) and Levy (1992).

#### **3.3.1 Predicted climate change**

A variety of models are available which, in very rough terms, suggest how increases in global CO<sub>2</sub> concentrations might affect the climatological regime in British Columbia (Ripley 1987). The Canadian Atmospheric Environment Service (AES) has recently developed a global circulation model for Canada (described in Cohen et al. 1990) which attempts to predict the effects of doubled atmospheric CO<sub>2</sub> concentrations. On the basis of the present rate of increase, a doubling of CO<sub>2</sub> concentrations is expected to occur within the next 50 years (Schneider 1990).

Based on AES analysis for the province, average annual temperature is projected to increase by approximately 3.5°C. However, this includes an increase of 3°C in the summer and fall, 4°C in the winter and 4.5°C in the spring. Average annual precipitation is expected to increase by approximately 15%. However, this includes a decrease in summer values of approximately 10%, and an increase in fall and winter values of 20% and 30%, respectively. The hydrological effects of these projections, although not studied in detail, will likely vary regionally in response to changes in precipitation regime and snow accumulation.

In general terms, increased total precipitation would most likely result in greater annual runoff volumes. Warmer and wetter fall and winter conditions have the potential to generate larger rain or rain-on-snow floods. Greater snow accumulations might be expected, although the effect on total snow accumulation is difficult to predict, as possible reductions due to warmer temperatures might be compensated for by a greater amount of snowfall at higher elevations. The effects on low flows would also likely vary in response to regional changes in the magnitude and timing of snow melt. In areas of increased snow pack, extended snow melt could conceivably result in increased summer minimum flows. In contrast, in areas of reduced snow accumulation, an

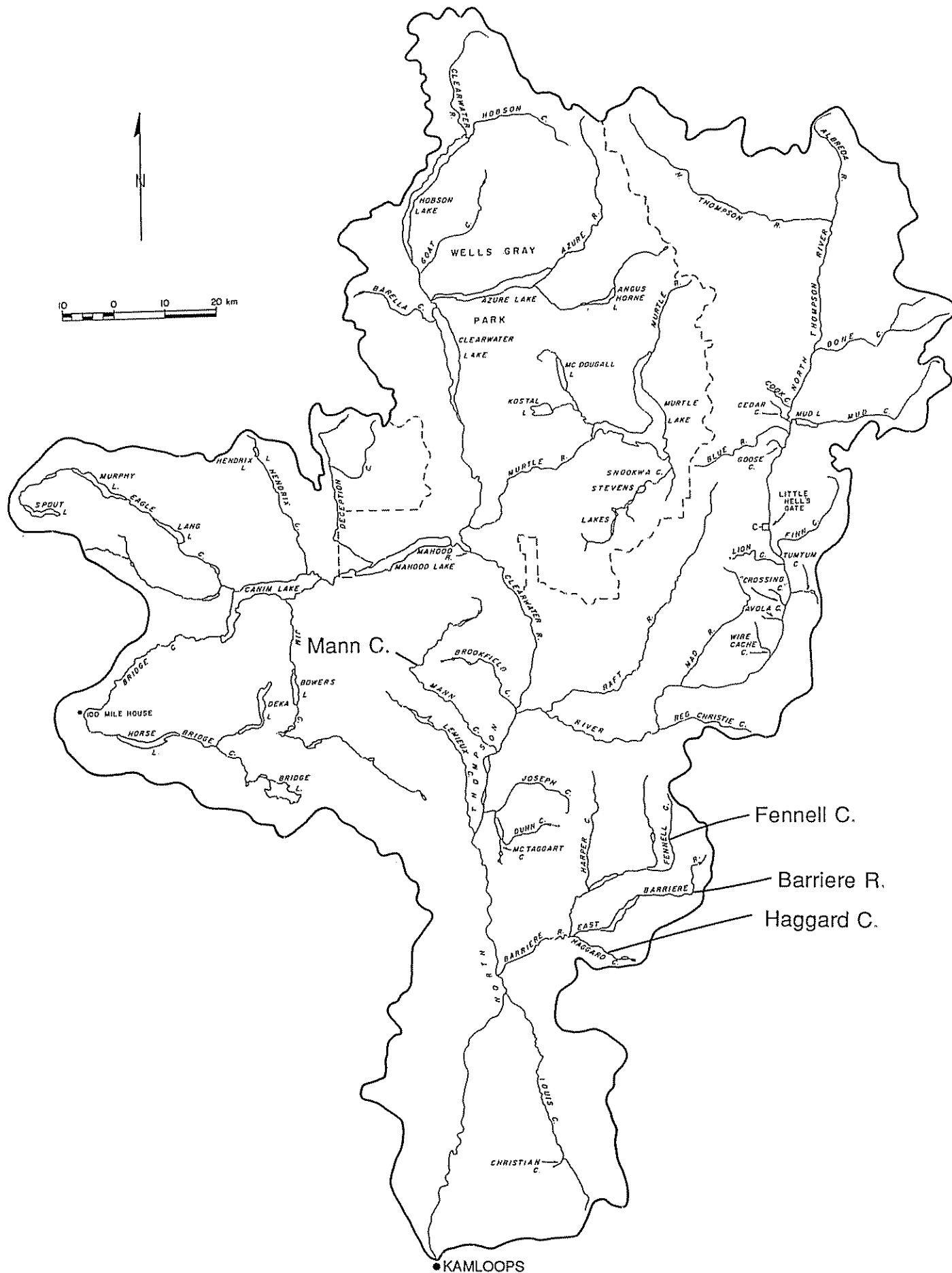


Figure 3.7

Streams in the North Thompson HMA with high ratios of mean annual flood to mean annual flow (Northwest Hydraulic Consultants Ltd. 1992)

earlier onset of snow melt, reduced summer precipitation, higher summer temperatures and greater evapotranspiration could lead to decreased summer flows, longer drought periods and warmer summer water temperatures. However, all of these scenarios need to be addressed in greater detail to ensure that all relevant factors have been considered and to estimate the potential magnitude of these effects. Even with additional work, there will be considerable unavoidable uncertainty. In fact, a recent review paper published by the provincial Water Management Branch (Coulson 1989) concluded that: "It is not that we just don't know the magnitude of the change on the water resource -- we don't even know the direction the change will take."

### **3.3.2 Historical variations in precipitation, air temperature and runoff**

The analyses presented in Sigma Engineering Ltd. (1991) indicate that there have been no statistically significant changes in hydrometeorological regime at many of the representative recording sites examined in the three Thompson HMAs. Where such changes have occurred, they are in the same direction as those predicted due to increasing CO<sub>2</sub> concentrations. Specifically, annual temperature near Revelstoke appears to be increasing, as does annual precipitation near Salmon Arm, Vavenby and Westwold. Snow cover at Blue River appears to be generally increasing, as does annual runoff on South Thompson River. There also appears to be a trend of increasing annual minimum flows in Adams River, the South Thompson and the Thompson River at Spences Bridge.

Reliable interpretation of the spatial variability of these results requires analysis of additional regional data. There is no valid method for determining whether observed trends are the results of increasing atmospheric CO<sub>2</sub> concentrations or other causes. Yet, from a management perspective, it is valid to assume that these results support the projections of the AES CO<sub>2</sub> model, and to further investigate the effects of these changes on the fisheries resource. Such an analysis should include the identification of river systems in which warmer summer water temperatures have the potential to adversely affect migration or spawning success.

Levy (1992) looked at the potential effects of global warming on the Fraser River watershed and suggests that global warming will generally increase air temperatures in the Fraser watershed, which will in turn affect water temperature and runoff regimes of the Fraser River. It is thought that increased water temperatures will increase migration and pre-spawning mortalities of salmon. Increased magnitude of winter floods due to increased temperatures will also greatly affect egg-to-fry survival, particularly in the Coastal Mountains. It is expected that there will be an acceleration of spring runoff, creating longer periods of low summer flow and increased summer water temperatures. Increases in summer water temperatures will force fish out of areas where water temperatures are already marginally too warm. As well, it is thought that warmer stream temperatures could increase competition between salmon and other warm water species.

Fraser River salmon populations within the interior portion of the watershed are particularly vulnerable to future global warming. In particular, sockeye, chinook and coho that rear in freshwater lakes and streams will be most affected by thermal and hydrological changes. Many streams in the Thompson and Fraser plateaus already have warm summer temperatures and suffer from critical low-flow conditions. The predicted changes will reduce low-flows even further and increase water demand problems. Stream temperatures could be increased to a point at which salmon and trout production would be reduced or eliminated.

## 4.0 RESOURCE USE

Fish production can be adversely affected by other resource uses in the watershed. Fish habitat is affected by logging development as well as by agricultural development, urbanization, utility corridor development and related water demand and water quality problems.

The following sections describe other land and water uses in the watershed, with an attempt to flag those salmon-bearing watersheds where development activities are presently affecting fish and fish habitat and, where possible, to identify future trends and problem areas. Much of this section is reproduced from studies that were conducted by Sigma Engineering Ltd. (1991) to assess resource use interactions in the North Thompson. The analysis of water use and development of stream indices were undertaken by Northwest Hydraulic Consultants (1992). Readers should refer to these sources for more detailed information on a stream-by-stream basis and to Appendix C for data tables.

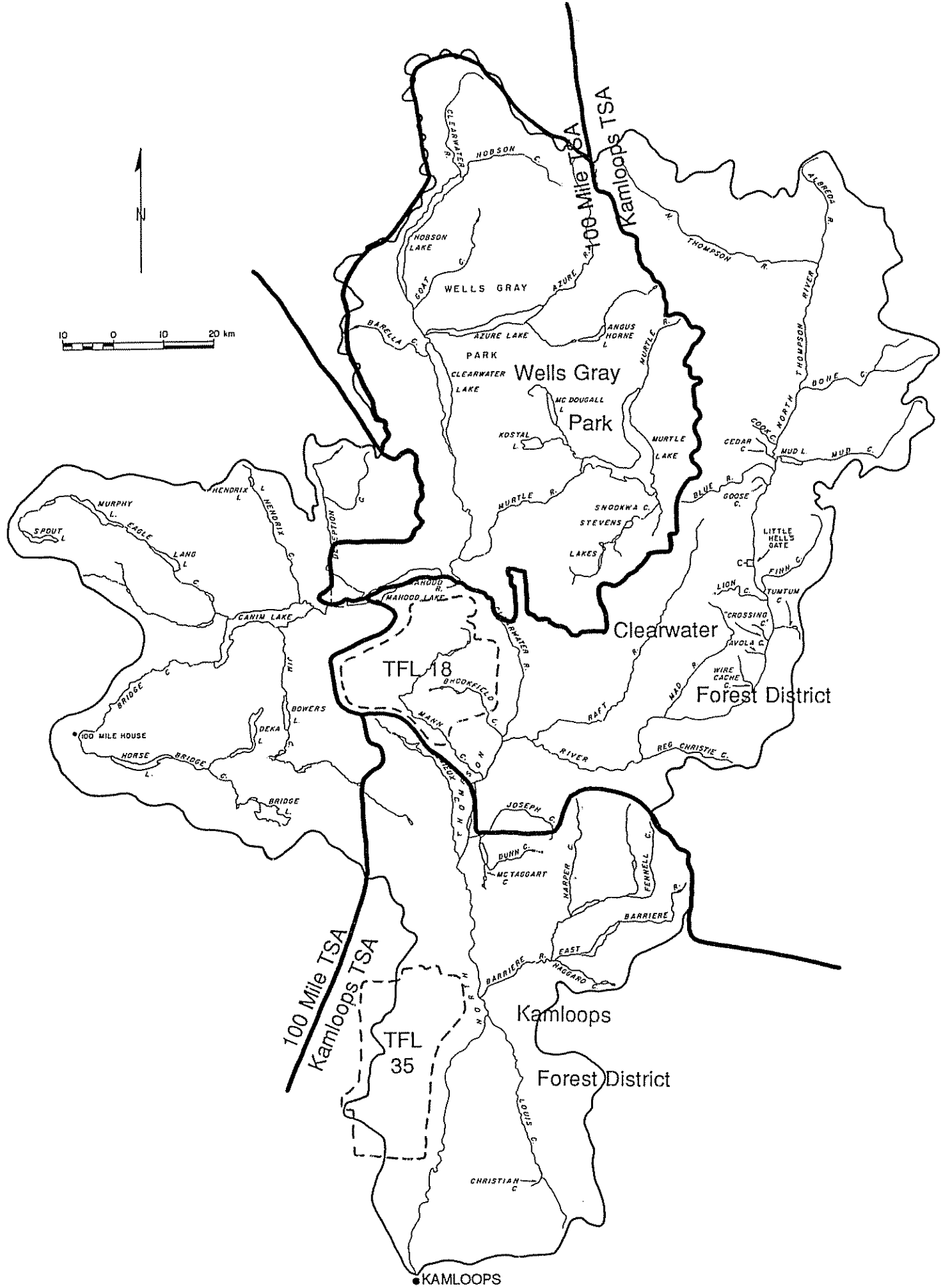
### 4.1 Forestry

Logging is the major resource activity in the North Thompson HMA. There has been logging activity in all salmon watersheds of the North Thompson HMA (Photos 4.1, 4.2). Significant logging activity in the HMA started in the 1960s and logging has continued in all of the known salmon-bearing watersheds in the area.

The potential effects of logging on streams and fish populations are of concern throughout the HMA. Many of the salmon-producing watersheds with valuable spawning areas (i.e., Finn Creek, Raft River) are located within very unstable sections of stream channel, and many streams are located adjacent to unstable hillslopes and valley walls. Most of the salmon-producing streams in the HMA have had over 20% of their watershed areas logged, suggesting an increased potential for changes in stream hydrology resulting from changes in snow accumulation and melt patterns (Toews et al. 1992). Potential changes in sediment transport, hillslope stability and channel stability due to harvesting and road building also affect fish habitat.

#### 4.1.1 Administration

The majority of the HMA is in the Kamloops Forest Region. Only the Mahood River drainage is located in the Williams Lake Forest Region and the 100 Mile Timber Supply Area (TSA). Most of the forest land within the Kamloops Forest Region is managed through the Kamloops TSA, which encompasses the Kamloops and the Clearwater forest districts, and includes two tree farm licences (TFL 18 and TFL 35) (Figure 4.1).



66 Figure 4.1 B.C. Ministry of Forests administrative boundaries for the North Thompson HMA



**Photo 4.1** The North Thompson Valley at Vavenby, showing the extent of logging (photo courtesy of T. Panko)



**Photo 4.2** Recent logging in the North Thompson Valley upstream of Albreda River (photo courtesy of L. Jaremovic).

#### 4.1.2 North Thompson HMA clearcut inventory

An inventory of clearcut areas for the North Thompson HMA was completed by Sigma Engineering Ltd. (1991); the percentage of recently logged and total logged area for each known salmon system is shown in Table 4.1 and logged areas Appendix C. Areas recently logged range from 0 to 35%; total area logged ranges from 2% to 45%. Fourteen watersheds have 30% or greater of their area logged. Only McTaggart and Avola creeks (community watersheds) do not have recently logged cutblocks (Table 4.1) (Figure 4.2).

The percentage of recently logged and total cutblocks (Table 4.1) was estimated from 1:250,000 (September, 1990) Landsat Imagery using comparison charts (Terry and Chilingar 1955) for visual estimation of cover. Recently logged cutblocks include non-green (brown) cutblocks with no evidence of vegetative cover; total cutblocks include all visible cutblocks. The extent of regeneration or green-up could not be distinguished. The accuracy of these estimates is also limited by the quality of the images (e.g., cloud cover), the margin of error inherent in defining the boundaries of the older clear cuts and the inability to distinguish burned areas from cutblocks. Watershed size must also be considered. The percentage of logged areas was estimated only for watersheds where there are salmon. In large watersheds, the distribution of logging is not clear. For example, logging may be very intensive in one or a few tributaries and this may not be reflected in the overall percentage. Despite these limitations, the data provides an indication of the intensity of logging in salmon-bearing watersheds; the majority of streams have total logging of more than 20% of their watersheds and one third have recent cutblocks covering 20% or more of their watersheds (Table 4.1).

Table 4.1 Recent and total logging of salmon bearing watersheds in the N. Thompson HMA

Stream	Recent (%)	Total (%)	Stream	Recent (%)	Total (%)
N.Thompson	12	22	Reg Christie	15	20
Louis	6	21	Mad	20	40
Barriere	10	30	Wire Cache	35	35
East Barriere	11	30	Avola	0	40
Haggard	15	30	Crossing	25	25
Fennell	5	25	Tumtum	10	15
Lemieux	10	20	Lion	20	40
Dunn	3	20	Finn	25	35
McTaggart	0	35	Goose	25	45
Mann	20	40	Blue	7	15
Clearwater	12	20	Cedar	1	3
Brookfield	25	40	Cook	10	25
Mahood	25	40	Albreda	7	15
Raft	15	40			



### 4.1.3 Percentage cut

Deforestation of more than 20% of the watershed can lead to changes in water yield and peak flows (Toews et al. 1992). This assumes that there has not been sufficient regeneration or green-up for hydrological recovery. Green-up time is defined as the number of years required for tree species on a satisfactorily restocked logged area to reach a height specified to provide hydrologic recovery after logging. Ongoing studies in the southern Interior show that removal of forest cover increases snow accumulation by about 25-35% and accelerates the rate at which snow melts. The increased snow pack in a clearcut, combined with the accelerated rate at which snow melts, produces higher peak flows. In a Southern Interior clearcut, a regeneration height of 10 m is assumed to provide 90% hydrologic recovery in the low to moderate snow pack zone and 70% recovery in heavy snow pack zone, while 3 m green-up is equivalent to 25% recovery (Toews et al. 1992). These estimates for hydrologic recovery are much higher than coastal rates of recovery, where 3 m is equal to 90% recovery and 7 m is equivalent to 100% recovery. Considering the slower growth rate and larger tree requirement in the Interior, this means hydrologic recovery is much slower in the interior than on the coast.

In the Southern Interior, it is estimated that 7 m green-up requires an average of 29-39 years and 3 m green-up requires an average of 13-21 years (Sigma Engineering Ltd. 1991). Since most of the logging in the HMA began in the 1960s, the majority of cutblocks would not have achieved 7 m green-up (70% recovery); recently logged and a subset of older logging would not have reached 3 m green-up (25% recovery). Partial green-up could not be accounted for in the values presented, and percentages are based on the assumption that cutblocks were 100% clearcut.

The impact of logging on streams cannot simply be described in terms of percent of watershed logged or rate-of-cut. In all cases, potential increases in levels of suspended sediment, potential for increase in landslide activity and delivery to the stream system, and potential changes to channel stability must be assessed, as well as hydrological impacts to determine potential risk to fish populations. The B.C. Ministry of Forests, in conjunction with DFO and MELP, is developing an "Interior Watershed Workbook" which will develop an assessment methodology to determine the cumulative effects of past and future logging (Kosakoski, pers. comm.). A study is also underway in Finn Creek to determine the effect of present levels of cut, currently at 20%, on chinook spawning habitat in the lower end of the creek.

### 4.1.4 Five year development plans

Harvest patterns and rates-of-cut are prepared by the logging companies in five year development plans. The major licensees in the Kamloops TSA include Tolko Industries Ltd., Slocan Forest Products Ltd., Weyerhaeuser Canada Ltd. and Gilbert Smith Forest Products Ltd. (Figure 4.3). In the 100 Mile TSA, Weldwood of Canada and Ainsworth Logging are the two main



companies. The general areas for the proposed five-year cutting plans are shown in Figure 4.4.

Tolko's timber supply blocks in the North Thompson are located in the extreme northern end of the HMA and the southern end. Tributaries in the North Thompson supply block scheduled for harvesting in the next five years include Manteau, Pleasant, Miledge, Lempriere, Chappell, and Canvas creeks. The Nehalliston Supply Block, located west and north of Barriere on the west side of the North Thompson River, has salmon-bearing watersheds scheduled for logging in the Lemieux, Taweel and Dunn Lake areas. In the Barriere Supply Block, located east and north of Louis Creek on the east side of the North Thompson River, logging is planned throughout the Barriere River drainage. The Niskonlith Supply Block is located south and east of Louis Creek on the east side of the North Thompson River. Watersheds scheduled for logging include Cahilty, McKnight, Paling, Christian and Cicero creeks, in the Louis Creek drainage. The other main area is in the Heffley drainage, which includes Devick, Community, and Armour creeks and Heffley Lake. Tributaries to the North Thompson scheduled for logging include Badger and Oliver creeks.

Slocan Forest Products Ltd. has areas in Central Thompson (Clearwater/Vavenby/Adams) and North Thompson (Clemina/Bone). Salmon streams scheduled for future logging include Reg Christie, Raft, Albreda, Serpentine, Bone, and South Mann creeks.

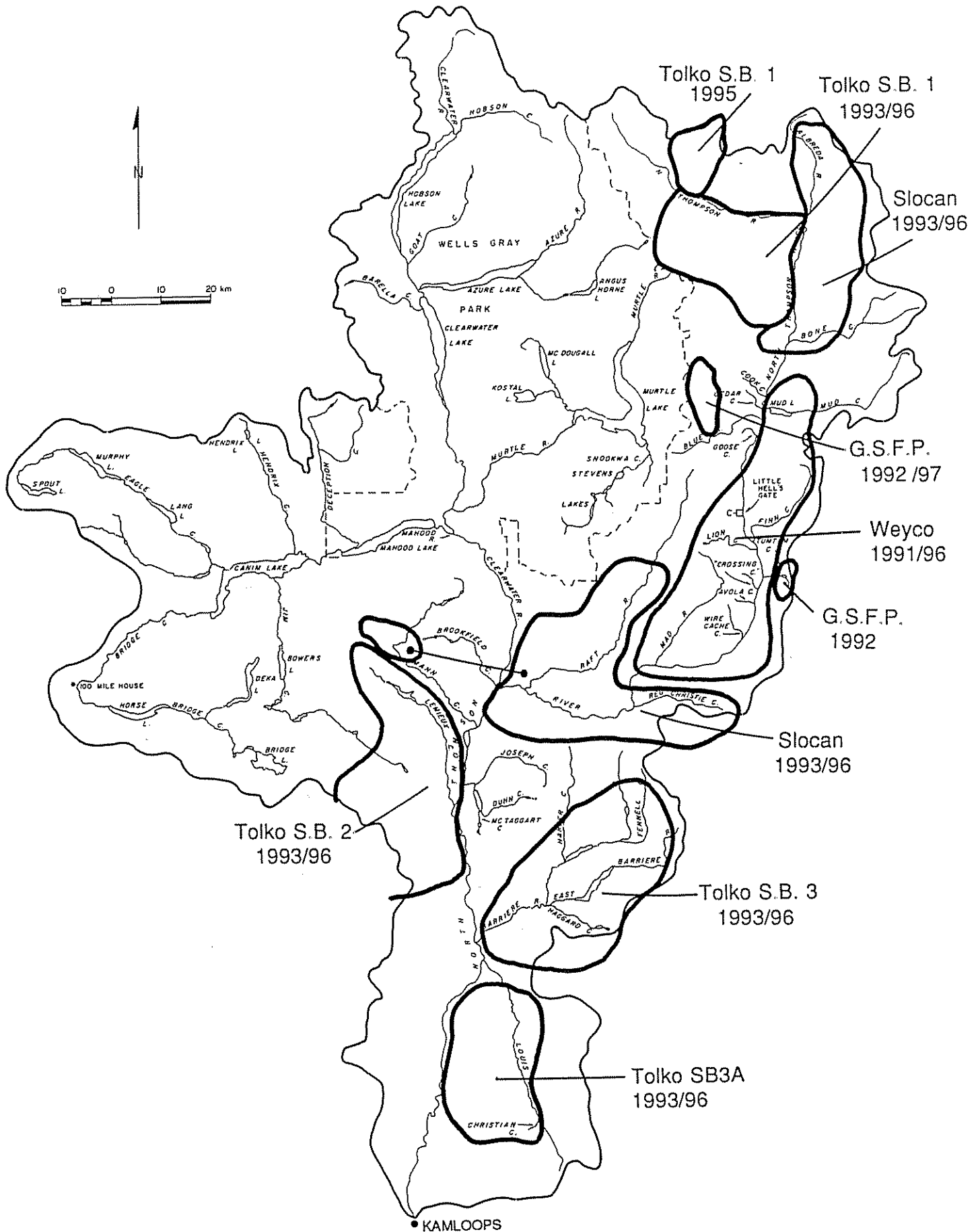
Weyerhaeuser's operating area extends from Vavenby to Finn Creek on both sides of the North Thompson. Salmon stream watersheds scheduled for logging in the next five years include Mad River and Tumtum, Finn and Avola creeks.

The Gilbert Smith Forest Products operating area is primarily in the North Blue River, Tumtum Lake and the upper Adams area.

#### **4.1.5 Future trends**

The B.C. forest industry is in a state of change which will likely continue through the next 20 years. In south-central B.C., intense resource use since the 1960s has consumed a large percentage of the accessible lower- to middle-elevation old growth timber. Mill technology is evolving to utilize the available timber, and as the old growth supply rapidly diminishes, smaller diameter trees from higher elevation sites and from second growth forests will represent increasingly larger proportions of the harvest.

Harvesting practices and the current rate of timber extraction will likely be affected by the new integrated resource management planning initiatives of the Ministry of Forests in cooperation with other agencies. One of the initiatives is the development of a Forest Practices Code, which sets forest standard practices and will consolidate legislation, regulations, policies and procedural manuals.



74 Figure 4.4 Overview of areas in the North Thompson HMA proposed for logging in the next five years

The new Land and Resource Management Planning (LRMP) process will replace the Forest Service's former TSA planning process. While the Forest Service continues to be the major agency, the concerns and priorities of other agencies will also be addressed. Land and Resources Management Plans will develop resource units and integrated resource management objectives and strategies for each unit and the overall planning area. Presently, a plan is underway for the Kamloops Forest Region, which includes the North Thompson HMA.

Interior Fish Forestry Wildlife Guidelines (IFFWG) have also been drafted for two ecoprovinces -- the Sub-Boreal Mountains and Central Interior Plateau (Appendix B). These areas are adjacent to the North Thompson HMA. These guidelines apply to forest operations in relation to fish and wildlife habitat management and protection. Forest operations include harvesting, silviculture and roads. The draft guidelines designate a minimum 30 m Streamside Management Zone (SMZ) on both sides of all permanent and ephemeral streams. The management objective in these areas is to maintain the productive capacity of fish habitats, including water quality and stream channel characteristics. No harvesting or in some cases only selective logging would be allowed in the SMZ for all streams that support anadromous salmonids and/or resident sport fish (Class A streams). Streams that have the potential to affect Class A streams would also be treated as Class A streams. The guidelines also address rate-of-cut issues with logging prescriptions to reduce the percentage of clearcut in a watershed, and a requirement to conduct a watershed cumulative effects assessment when the area of clearcut (or equivalent) reaches 20%. It is anticipated that similar guidelines will be adopted as enforceable standards under the proposed B.C. Forest Practices Code.

## **4.2 Agriculture**

The main agricultural activity in the North Thompson HMA is cattle grazing and feedcrop production, concentrated in the Thompson Plateau and along the North Thompson Valley up to Clearwater, and in the Fraser Plateau near 100 Mile House. While the overall percentage of agricultural use within each drainage basin is relatively low, the activity is generally concentrated along stream corridors and damage to the streams can be considerable. Potential impacts associated with agricultural development include land clearing, which can reduce stream bank stability and increase erosion. Livestock can also degrade riparian vegetation along the stream, and runoff from feedlots and winter feeding areas can reduce water quality in the receiving stream. Irrigation of crops can result in inadequate instream flows for fish and the application of fertilizers and pesticides can also reduce water quality.

### **4.2.1 Overview**

The agricultural sector of the Thompson Basin is predominantly a ranching industry which produces calves and yearlings for sale to Alberta and the lower mainland of B.C. The breeding

herd is overwintered on rations consisting primarily of alfalfa or grass/legume hay and silage. Calves are born in the late winter and early spring, usually on private pasture, and the herd is turned out to spend the summer and fall on Crown and private rangelands. Hay fields also provide aftermath grazing in the late summer and through the fall. Most calves are sold in the late fall, shortly after coming off the range. Calves that are to be used as replacement stock for the breeding herd, as well as calves that are to be later marketed as yearlings, are overwintered on feed.

Winter feed is generally produced on private lands, using sprinkler irrigation. Much cultivation occurs near surface water sources. While the emphasis in the region has traditionally been on calf production, considerable efforts have been made in recent years to increase the weights of feeder cattle sold to buyers from outside the region. These take the form of the following enterprises: overwintering calves to be sold in the spring as yearlings; overwintering calves and placing them on range for an additional season of grazing before selling them in the fall as yearlings, and "backgrounding" calves in feedlots, utilizing high energy feeds such as corn silage and/or purchased feed grains. The heavier animals produced are then sold to "finishing" feedlots, usually located outside the region, which fatten the animals to slaughter weights.

#### **4.2.2 Administration**

Agricultural data for the B.C. Ministry of Agriculture is summarized through Consolidated Census Subdivision (CCSD); the agricultural subdivisions used are shown in Figure 4.5. The three agricultural subdivisions in the North Thompson HMA are: the Thompson-Nicola Subdivision B, which includes Louis and Christian creeks; the Thompson-Nicola Subdivision A, which contains all other salmon-bearing streams; and the Cariboo Subdivision B, which includes the headwater, non-salmon-bearing part of the Mahood drainage.

#### **4.2.3 Regional trends**

##### Improved farmland

Agricultural development occurs in the Plateau and Shuswap Highlands regions of the HMA. In the salmon-bearing watersheds, there is agricultural activity in the Louis, Barriere, Lemieux, Joseph, Dunn and Clearwater systems (Appendix C). The current estimated area of improved farmland (cultivation including improved pasture) exceeds 1% of the total watershed area in three salmon streams -- Louis, Christian, and McTaggart creeks. In all cases, agricultural development is estimated to cover less than 1.75% of total watershed area; since this development is usually adjacent to the stream, it can have a significant impact on stream habitat.

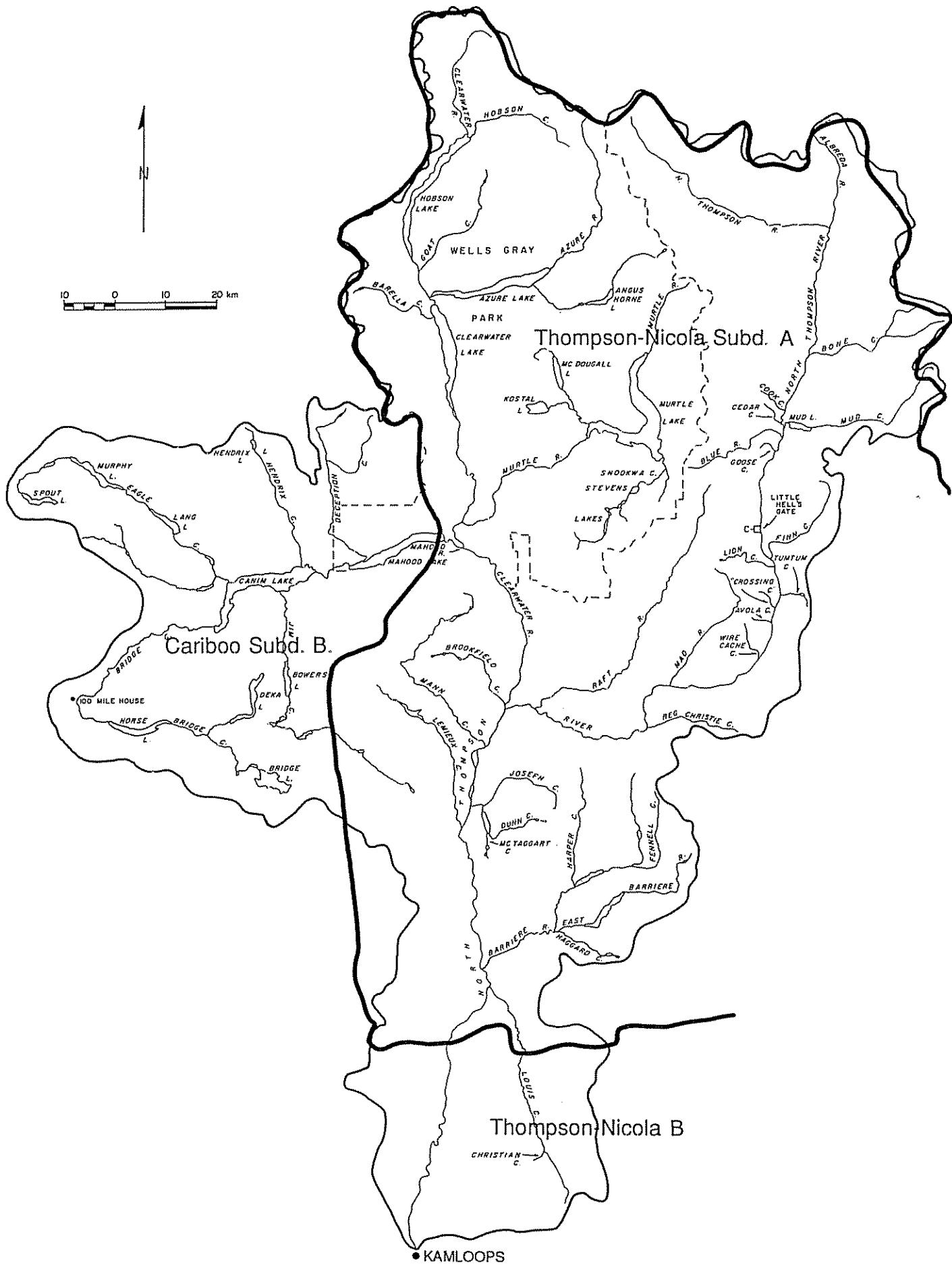


Figure 4.5

Agricultural subdivisions in the North Thompson HMA

Table 4.2 depicts recent regional trends in cultivation that were developed for CCSD statistics for the three agricultural subdivisions by Sigma Engineering Ltd. (1991). As is evident, agricultural activity within the Thompson-Nicola Subdivision A, where most salmon production occurs, was quite static over the 1976-1986 period. The total area of crop land has actually declined modestly (down 1.8%). Area reported as cultivated within Thompson-Nicola Subdivision B dropped significantly (down 17.3%) over the 1976-1986 period, while the Cariboo Subdivision B (Mahood and Canim Lake areas) had a 27% increase over the same period.

Estimates of potential agricultural development by the year 2010 were made for each watershed (Appendix C). These were based on Agricultural Land Reserve maps and the personal knowledge of the resource consultants used for the Sigma Engineering Ltd. (1991) study. Louis, Christian, McTaggart and Brookfield creeks are expected to show increases in improved farmland. Percentage increases exceed 1% of the total watershed area; an increase of 10 km<sup>2</sup> is expected for Louis Creek (1.9% increase) and 0.47 km<sup>2</sup> for Christian Creek (2.5% increase) (Appendix C).

Table 4.2 Trends in area (km<sup>2</sup>) of crop land in the North Thompson basin, 1976 to 1986 (data from Sigma 1991)

Subdivision	1976	1981	1986	1971-81	1976-81	1976-86
Cariboo B	13,660	19,459	17,380	42.5%	-10.7%	27.2%
Thompson-Nicola A	5,251	5,455	5,158	3.9%	-5.4%	-1.8%
Thompson-Nicola B	7,039	7,794	4,778	10.7%	-25.3%	-17.3%

#### Agricultural water use

Agricultural water use can be divided into the two main categories of irrigation and stock watering, the former representing nearly 90% of the total volume used. Agriculture is the highest consumptive water user of all the economic water use sectors, with irrigation consuming (i.e., not returning to the source stream) 78% of water withdrawn. Irrigation also represents a water use sector that substantially undervalues the resource. Water charges are artificially low, and irrigators typically pay based on irrigated area rather than actual volumes used. There is little incentive for demand management in agricultural water use, and efficiency of water use in irrigation (i.e., water reaching the crop, divided by the total water supplied) is approximately 35%. Additional problems related to agricultural use of water include lack of, or improper screening of, intakes, leakage and evaporation from irrigation canals, and the lack of gauging or metering of actual water use.

Table 4.3 depicts recent trends in the area of land irrigated, and shows the relationship between flood irrigation and total irrigation. Conversion from flood to sprinkler irrigation is of some interest, as it usually allows either more area to be irrigated using the same amount of water

or, alternatively, the same area to be irrigated using substantially less water. Although there has been a reduction in total irrigation in the Mahood/Canim area (Cariboo B), there has been an increase in flood irrigation from 47% to 54%, suggesting little conversion from flood to sprinkler irrigation in recent times. Further, the level of flood irrigation, approximately 50%, compared to 12% and 15% in the other units, suggests that there could be considerable water conservation achieved in this subdivision. In Thompson-Nicola A, where most salmon production occurs, almost all irrigation is by sprinklers (12% flood). In Thompson-Nicola B, which includes Louis Creek, the area irrigated decreased (down 4.8%) between 1981 and 1986. Some conversion from flood to sprinkler irrigation has occurred over this period, although use of flood irrigation has been below 20%.

Table 4.3. Trends in area (km<sup>2</sup>) of crop land irrigated from 1981 to 1986 (data from Sigma 1991)

Subdivision	1981			1986			81 to 86
	Total	Flood	Percent Flood	Total	Flood	Percent Flood	Change in total
Cariboo B	8,076	4,369	54.1%	7,442	3,517	47.3%	-7.9%
Thompson-Nicola A	3,957	479	12.1%	4,196	516	12.3%	6.0%
Thompson-Nicola B	5,021	764	15.2%	4,778	935	19.6%	-4.8%

#### Livestock densities

Livestock densities are often expressed in animal units per square km (AU/km<sup>2</sup>). One animal unit is equivalent to the manure production of a mature cow. Stocking densities for livestock in each watershed were obtained by using regional stocking rates and applying them to the estimated area of improved farmland. Two watersheds (Louis and Christian creeks) have estimated densities greater than 2 AU/km<sup>2</sup> (of watershed). By the year 2010, three watersheds (the above two, plus McTaggart Creek) may have livestock densities greater than 2 AU/km<sup>2</sup>. Stocking rates for most areas in the North Thompson HMA were 171 and 126 AU/km<sup>2</sup>, or less than 2 AU/ha of farmland (Sigma Engineering Ltd. 1991). The measurement of stocking densities provides an indication of potential problems of nutrient absorption into the watercourse. It is assumed that a stocking density of two animals/ha may be a reasonable standard for sustainability of water quality (Dorcey and Griggs 1991). This level of assessment, however, is not adequate to identify site-specific water quality and stream habitat degradation associated with concentration of cattle along the stream and at feedlots.

#### 4.2.4 Impacts on fisheries resources

Continued conversion to sprinkler systems for irrigation throughout the HMA is advised,

especially in the Cariboo Subdivision B, where water demand is a potential concern in the Mahood drainage, and Thompson-Nicola Subdivision B, where water demand is a major issue. Increases in crop land and stocking densities are relatively small; greatest projected increases are 1-2% by 2010. However, these are projected to occur in Louis and Christian creeks, where agricultural development and livestock access has resulted in a significant loss of riparian stream habitat (Photos 4.3, 4.4), bank destabilization, low water flows and reduced water quality. Even small developments in areas that could directly affect these drainages may aggravate existing problems, therefore no further water licences should be allowed and protection and restoration of riparian habitats is critical.

### **4.3 Population and Settlement, Recreation and Transportation**

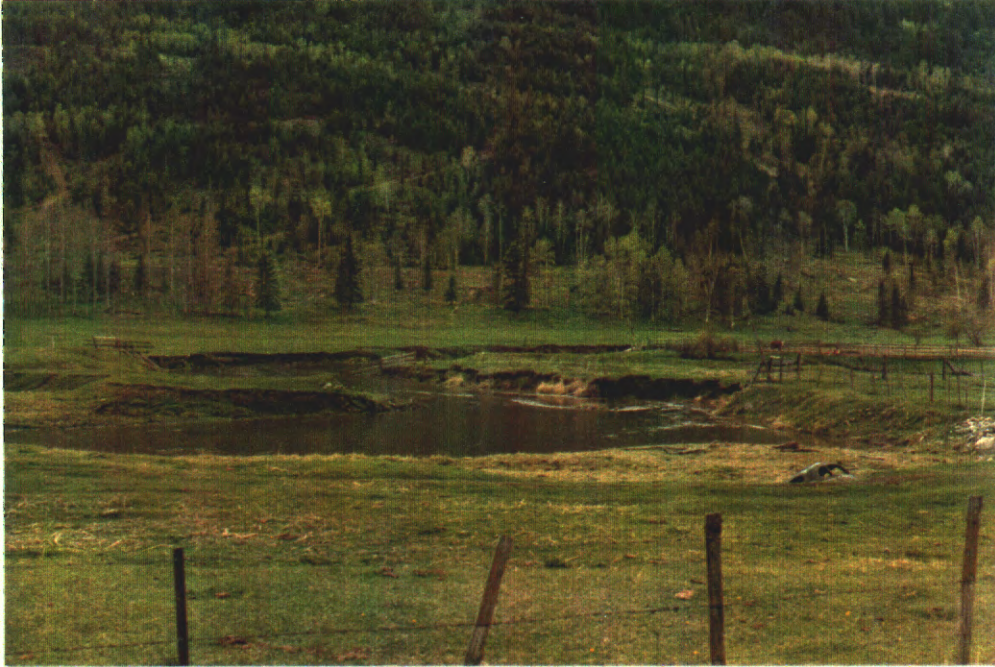
Of all proposed land uses, urban development will, in the long term, have the greatest permanent effect on fish and fish habitat. Urban spread from city centres can encroach and have a marked effect on the hydrologic stability of fish bearing streams, and the development of recreational properties on lake shores can reduce the quality of the sport fishing experience as well as water quality and the quality and quantity of lake shore habitats. Transportation corridors can adversely affect fish production, particularly along the North Thompson River. Channel crossings and stream encroachments can be detrimental to the quality and quantity of water and to instream and riparian habitats. Another concern is the potential for damage caused by toxic spills from the road, rail or pipeline.

#### **4.3.1 Existing resource use**

##### Population and settlement

The total population in the HMA is approximately 35,000, but it has fluctuated considerably over the past decade. In fact, a 4-5% decrease in population occurred through the mid-1980s, when the area experienced a pronounced and sustained economic recession. Estimated populations in the watersheds of the North Thompson HMA are shown in Appendix C.

Settlement is concentrated in two areas. The first closely parallels the corridor containing the North Thompson River, Yellowhead Highway and the C.N. Railway. The economy of this area is based primarily upon forestry, ranching and tourism. The only incorporated municipality in this portion of the HMA is the City of Kamloops (Westsyde and Rayleigh areas). Unincorporated settlement areas include Barriere/Louis Creek, Little Fort, Clearwater/Black Pool/Birch Island, Vavenby, Avola and Blue River. The narrow bottom land strip from Little Fort to Clearwater, particularly, is subject to increased residential and small acreage developments (MacDonald, pers. comm.).



**Photo 4.3** Louis Creek, loss of riparian and instream habitat due to agricultural land use (photo courtesy of M. Sheng).



**Photo 4.4** Lemieux Creek, loss of bank habitat on land cleared for agricultural use (photo courtesy of M. Sheng).

The second settlement area is around 100 Mile House. The District of 100 Mile House is an incorporated municipality with a population of approximately 1,600. There is considerable fringe development to the north and east of 100 Mile House, notably in the House, Bridge, 108 Mile and Canim Lake areas. This fringe development consists of small holdings that are occupied on a year-round basis, as well as recreational/residential developments occupied seasonally. Forestry, ranching and tourism are again the mainstays of the economy.

### Recreation

Recreation facilities within the HMA include more than 30 fishing lodges located throughout the area; resorts at Clearwater (Wells Gray) and 108 Mile Ranch; ski areas at Tod Mountain and Mt. Timothy; numerous provincial parks, notably Wells Gray Park, which occupies almost 5,000 km<sup>2</sup> within the Clearwater River watershed; approximately 60 forest service recreation sites; and golf courses at Clearwater and the 108 Mile Ranch.

The nature of these facilities demonstrates the importance of fishing and related outdoor activities (i.e., camping) as recreation pursuits within the North Thompson HMA. Wells Gray Provincial Park is the single largest recreation feature and provides opportunities for hiking, canoeing, backcountry skiing and other extensive recreation activities.

### Transportation / utilities

As noted above, the corridor parallel to the North Thompson River contains a number of transportation/utility features, including the Yellowhead Highway, C.N. Railway, B.C. Hydro lines, and pipelines. Other transportation/utility systems in the area include: Highway 24 (90 Mile to Little Fort); the northern portion of Highway 97 (Cariboo Highway); B.C. Rail; B.C. Hydro lines, and pipelines, all of which generally run parallel to Highway 97. The largest corridor project in the last decade was the twin tracking of the CN Railway along the North Thompson River (Federal Environmental Assessment Review Office 1985).

## **4.3.2 Projected developments**

### Settlement

Further settlement within the HMA will be located within existing settled areas. Policies of municipal and regional governments within the area have provided this direction to fulfil three main objectives. The first is to infill vacant residential, commercial and industrial lands within the urban and semi-urban settlement areas. From a planning standpoint, it is preferable to facilitate infill development, rather than expand the settlement area to include new development, if excess capacity already exists. The second is to utilize existing capacities in community service

systems (i.e., infrastructure, garbage collection, fire protection, etc.), rather than extend those systems, and the third is to centralize development in already defined areas, rather than scatter development throughout logging, rangeland and recreational resource areas.

Anticipated additional settlement includes infilling of residential development within the City of Kamloops and District of 100 Mile House, infilling small holdings and recreational/residential development surrounding the lakes in the 100 Mile House fringe area, and construction of a strand board plant in 100 Mile House. Despite this infilling policy, significant development in new areas continues.

### Recreation

Projected recreation developments include: an environmental centre at Clearwater; expansion of the 108 Mile Ranch to include a new golf course and condominium/accommodation developments; expansion of accommodations at Tod Mountain ski area; a possible provincial park in the Lac de Bois area northeast of Kamloops, and a new golf course in the Westsyde area.

### Transportation

The only transportation initiative planned is continued upgrading of the major highways that traverse the area. This includes the completion of upgrading of the Yellowhead Highway north of Kamloops and continued widening and upgrading of Highway 97 south of 100 Mile House.

#### **4.3.3 Impacts on fisheries resources**

The major impact on fisheries resources is the development of recreational and residential properties around many of the important sport fishing lakes. Such development leads to reduction in overall water quality, and reduction of shoreline and littoral area habitats due to brush clearing and establishment of docks and boat launching sites. As well, expansion of residential development from Little Fort to Clearwater threatens tributaries such as Brookfield Creek and floodplain as well as associated wetland areas adjacent to the North Thompson.

#### **4.4 Mineral Resources and Placer Mining**

##### **4.4.1 Regional overview of mineral exploration and development**

The HMA lies within the boundaries of the Kamloops, Lillooet and Clinton mining divisions of the South Central Mining District. Most of the HMA is contained in the Kamloops Mining Division, and there are small portions of the upper Mahood drainage within the Clinton and Lillooet Division (Figure 4 6).

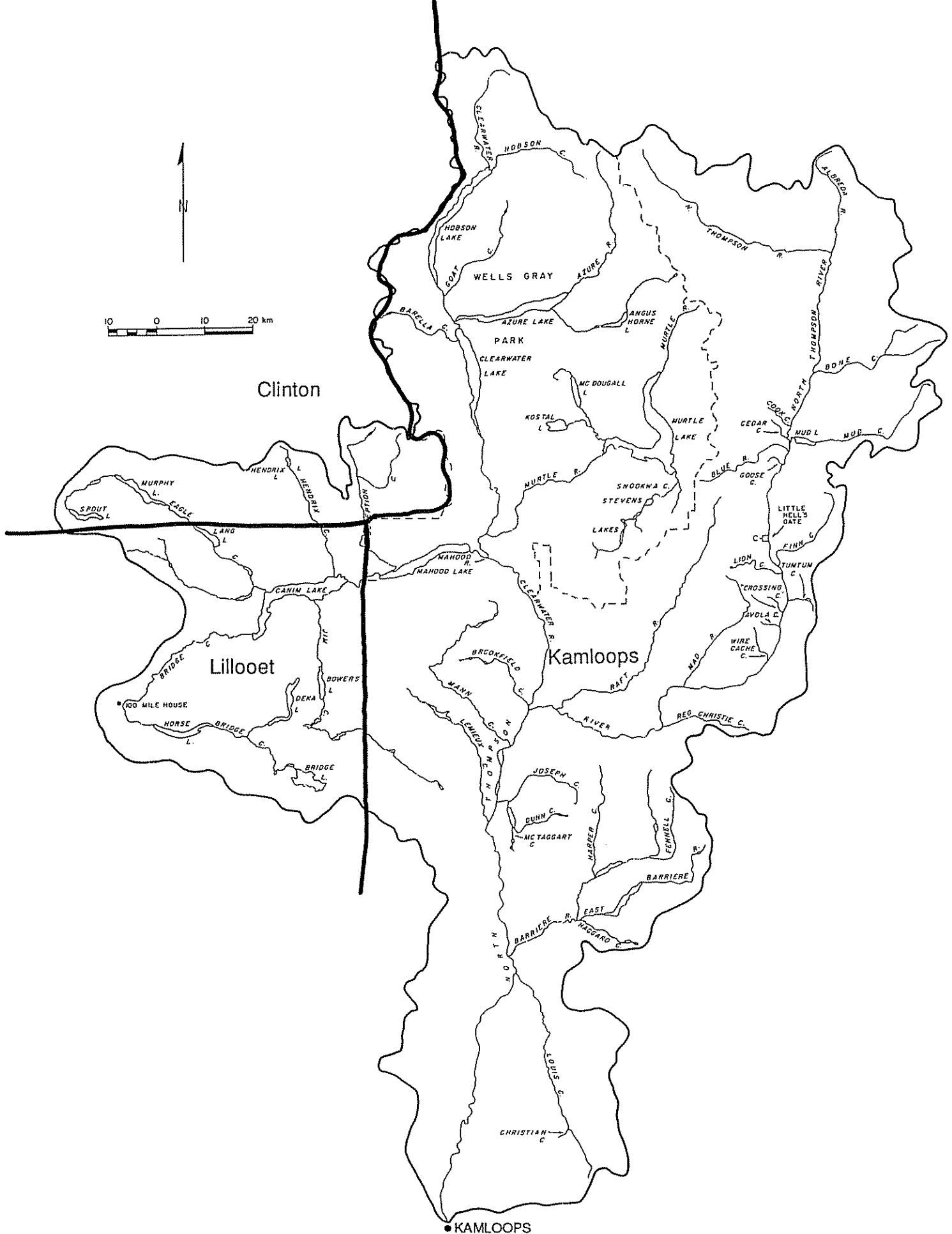


Figure 4.6 Mining divisions of the South Central Mining District in the North Thompson HMA

Most development/exploration activity within the South Central District in 1990 was within the Kamloops and Adams Lake areas. Steady increases in activity in these areas between 1988 and 1990 have been noted. Meyers and Hubner (1991) suggests that the prevailing strong base metal markets (particularly copper and zinc) will likely result in a continued high level of exploration, and possibly development, in these areas.

#### 4.4.2 Mineral resources and mining activity

No active mines are listed in the 1990 Mineral Exploration Review or the Mineral Resource Inventory maps for this area. There are four past producers listed on the inventory maps that are located in the Barriere (Energite and San - Pb,Ag), Joseph (Chidgrin - Ag,Pb) and Raft (Dimac - Wo,Wi) drainages. A total of 98 mineral interests have been recorded in the North Thompson HMA; these include 82 claims (within a 300 m radius), 12 prospects (within a 300-3200 m radius), and four deposits (general area). Mineral interests are concentrated in the Barriere River, Raft River, Lemieux Creek, Clearwater River, Louis Creek and East Barriere River drainages (Appendix C).

There was substantial exploration activity in this HMA during 1990. A summary of the main activities, as noted in the 1990 Mineral Exploration Review (Meyers and Hubner 1991), is presented in Table 4.4. The Zed and Birk properties are in the Barriere drainage; Birch is in the Clearwater drainage. The MC and Honeymoon properties are found along the mainstem North Thompson drainage. There may be significant exploration/development potential in the Mila property (North Thompson) and Cana property (Barriere).

Table 4.4. Summary of exploration activity in the North Thompson HMA during 1990

Property	Company	Interest	Activity
Birch	New Global	Zn,Pb,Ag	drilling
MC	Initial Dev.	Zn,Pb,Ag	drilling
Zed	Duchan Ent.	not known	surface expl
Honeymoon	Minnova	not known	GP,GC
Birk	Falconbridge	High - Pb,Zn,Cu	DD,GP,GC

There was placer mining activity in Barriere River, Louis Creek, and North Thompson River prior to 1945. Production was very low and there are no current placer interests recorded.

#### **4.4.3 Impacts on fisheries resources**

Adverse effects resulting from the leaching of heavy metals from former mine sites have been noted in Hendrix Creek, which is part of the Boss Creek/Canim Lake watershed. The damage was severe enough that the mining company was required to correct the problem (Lirette, pers. comm.). Major impacts of exploration and past mining activities on salmon bearing streams have not been reported (Panko, pers. comm.).

#### **4.5 Water Use**

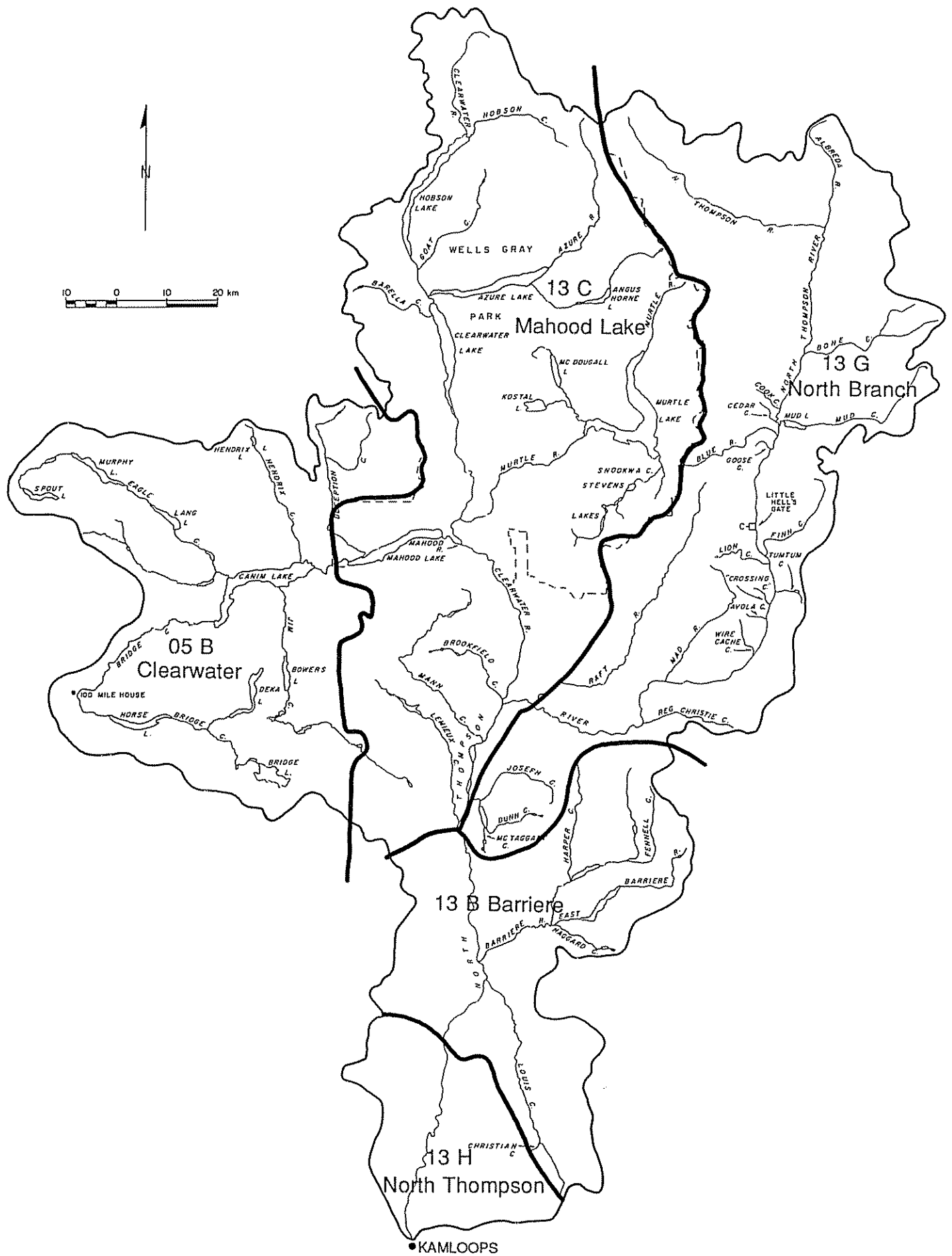
The water resources of the North Thompson HMA are vital to the fish and wildlife in the area and critical to the future of a variety of activities including agricultural, industrial, urban and recreational development. The pressure of development on water resources is considerable, as is indicated by the more than 2,000 water licences held in the HMA. This number represents approximately 9% of the 18,000 water licences held in the entire Fraser catchment (Dorcey and Griggs 1991).

As indicated in previous sections, irrigation is the biggest consumer of water in the HMA. In the North Thompson, chronic low flow problems in streams with high agricultural activity and water demand can reduce fish production by increasing summer stream temperatures above optimal levels for fish, reducing the useable area for salmonid spawning and rearing and impeding spawning migrations.

##### **4.5.1 Administration**

Water is licensed to individual users under the Water Act of the Province of British Columbia, and administered by the Water Management Division (WMD) of the B.C. Ministry of Environment, Lands and Parks. The WMD is subdivided into regions, districts, and precincts which do not necessarily follow watershed boundaries. The precincts for the North Thompson are shown in Figure 4.7.

The water allocation system shows little recognition of "instream" flow needs. Non-consumptive water uses, such as recreation, aesthetics and fish and wildlife habitat, have typically been undervalued and not accounted for in a supply-management-based system. Individual licence applications are reviewed by the regional Water Management Division staff, and a Regional Engineer's Report (RER) is prepared. The RER outlines the current application in the context of the total available flow and existing licences held on the stream and all upstream tributaries. A licence can be approved unconditionally, approved with conditions, or refused, and is classified according to its use. These RER documents are considered confidential (Zackodnick, pers. comm.) and consequently the detailed calculations of total available flow, cumulative existing



88 Figure 4.7 Water Management Division precincts in the North Thompson HMA

licences and flow remaining for further licensing or other uses are not available. This makes water planning by other basin users extremely difficult.

#### 4.5.2 Consumption and storage

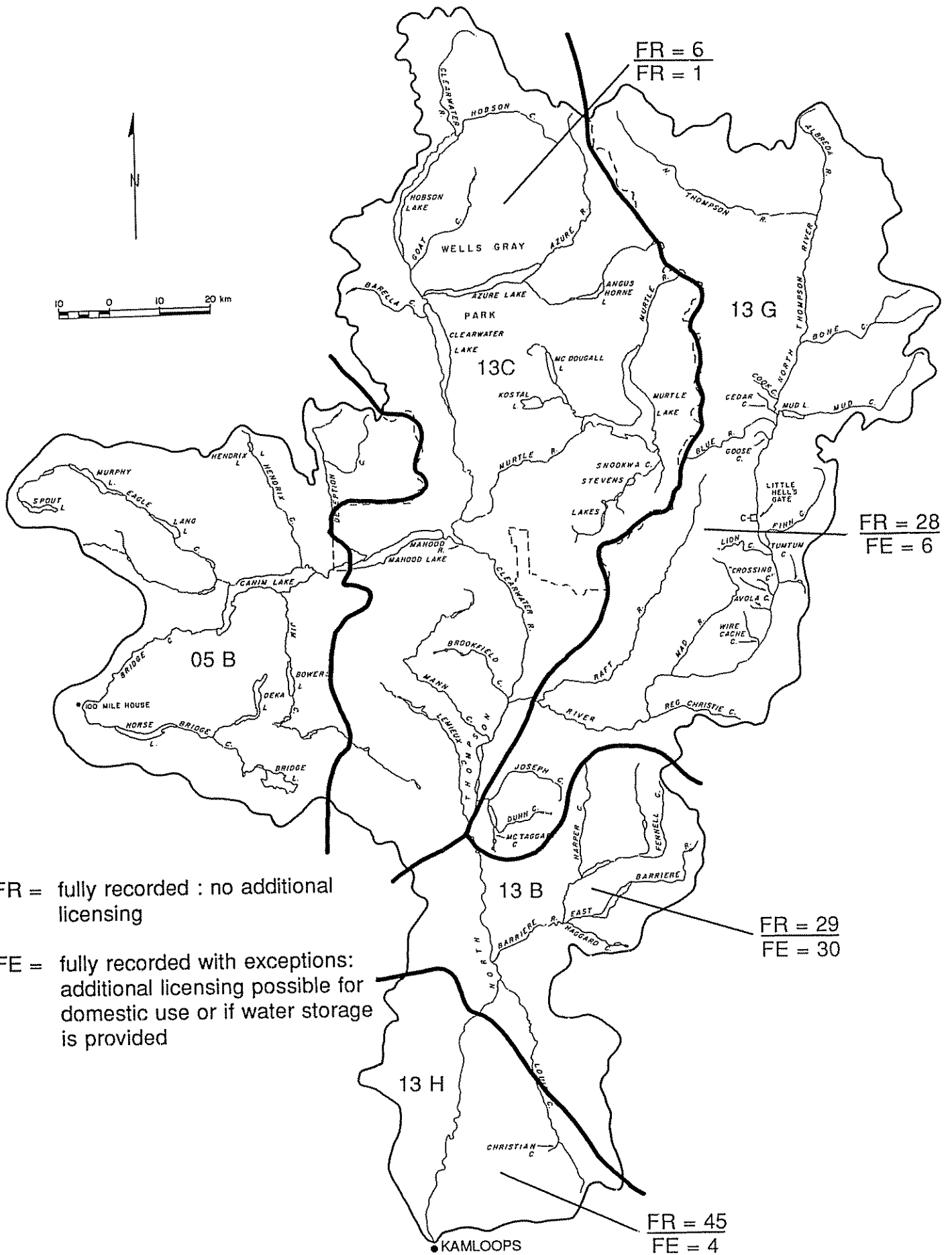
Most of the North Thompson licences are for domestic use and irrigation, which typically use smaller amounts of water than are used in power, storage and industrial licences. Agriculture is the major consumer of the water resource in the Thompson basin (Dorcey and Griggs 1991). In the North Thompson approximately 40% of the licences let are for the purpose of irrigation, and more than 51% of the licensed volume ( $>122 \times 10^6 \text{ m}^3/\text{year}$ ) is used for irrigation (Sigma Engineering Ltd. 1991).

Figure 4.8 shows that there are a greater number of fully recorded licences in the drier and more developed southern part of the HMA. Some of these fully recorded licences do provide for additional licensing, if it is for domestic use or if storage is provided.

Figure 4.9 shows the number of water storage licences in each Water Management Division precinct, for a total of over 180 water storage licences. As with water licences, the majority of storage licences are held in the southern end of the HMA, the area with the lowest total precipitation and the greatest urban and rural development. More than 90% of the water storage licences in the HMA are used for agriculture (Sigma Engineering Ltd. 1991).

While the total number of water storage and water licences is not a particularly good measure of the amount of flow licensed relative to total available flow, it provides a general indication of the degree of water use. Over 2,000 water licences are held in the HMA, which is 9% of the 18,000 water licences held in the entire Fraser catchment (Dorcey and Griggs 1991). A total volume of  $240 \times 10^6 \text{ m}^3/\text{year}$  is licensed in the North Thompson HMA, which is less than 0.3% of the  $91,792 \times 10^6 \text{ m}^3/\text{year}$  licensed in the Fraser watershed (Sigma Engineering Ltd. 1991). This disparity between number of licences and volume licensed can be attributed to agricultural water use (i.e., large number of licences with relatively small volumes of water).

An analysis of water demand on a stream-by-stream basis is provided in a study by Northwest Hydraulic Consultants Ltd. (1992). Flow characteristics and sensitivity indices are tabulated in Appendix C. Potential water demand (based on water licences) was calculated for each stream. Since stream flows for fish are of most concern during the low flow period in late summer and early fall, potential water demand in August and September was expressed as a percentage of low flows during that period (Table 3.1). The derived indices provide an indication of potential conflicts between irrigation use and instream needs for fish. Streams with relatively large water demand values (top 25%) are shown in Appendix C and include Louis, Lemieux, Christian, McTaggart, Mann, Mahood and Reg Christie creeks (Fig 4.10).



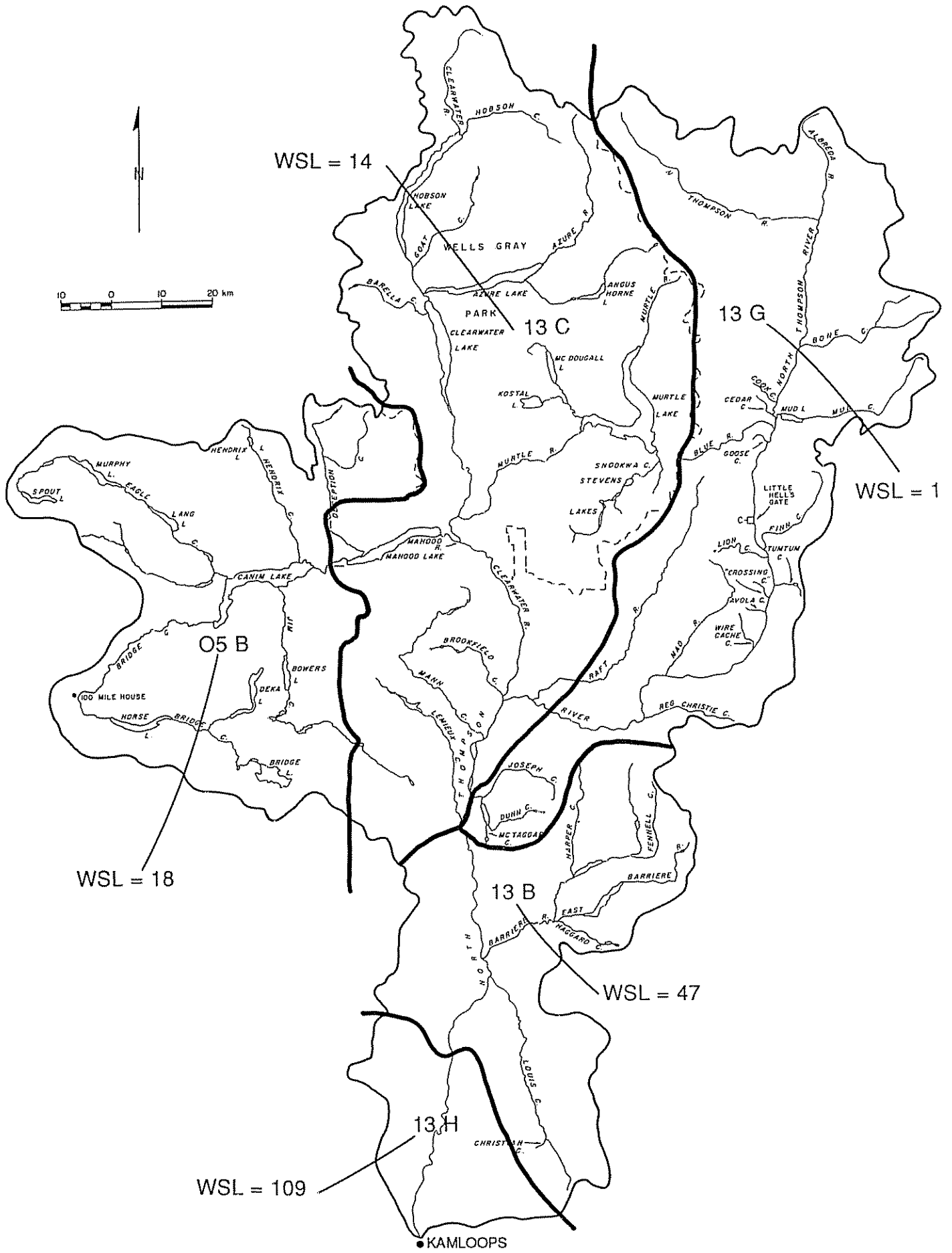
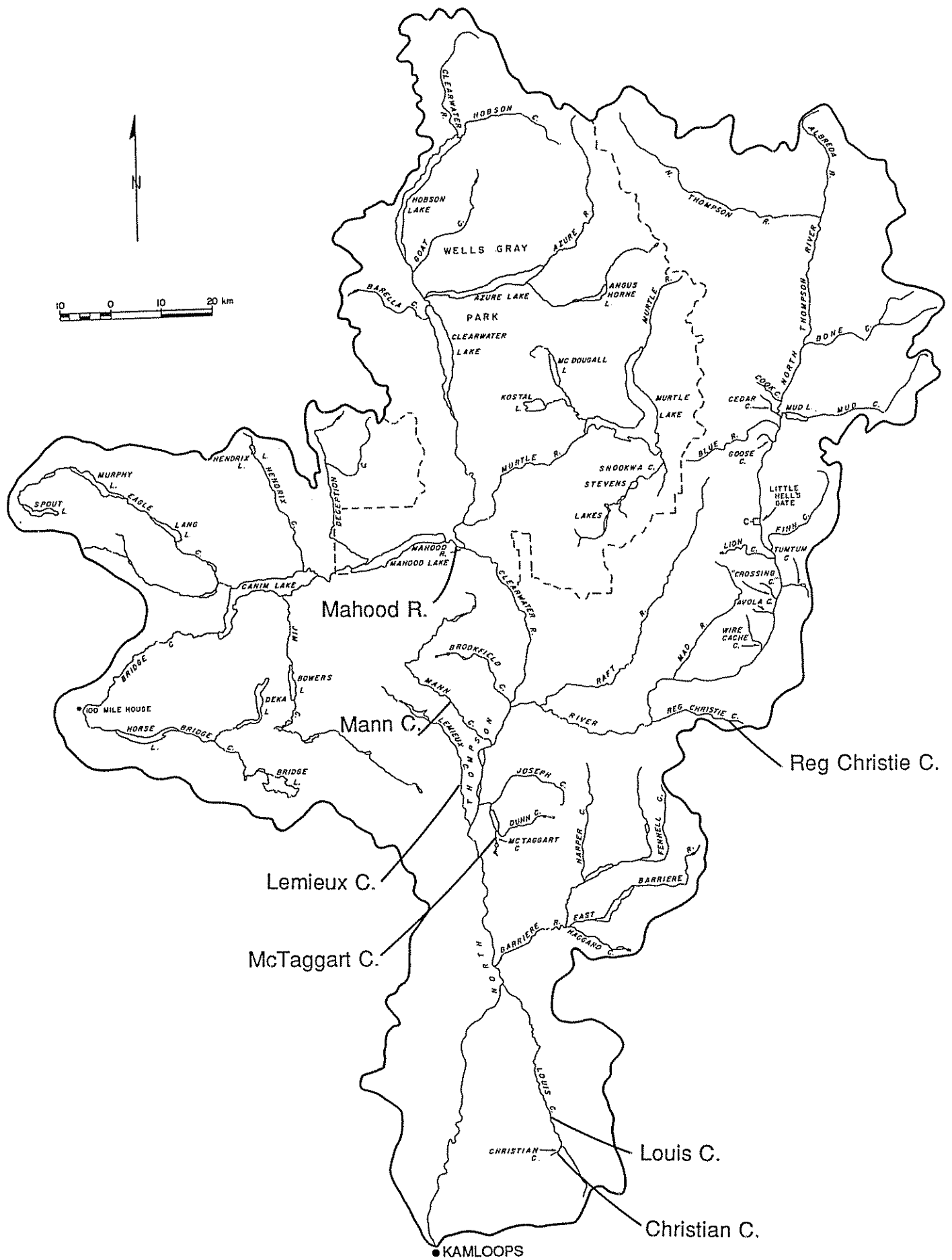


Figure 4.9 Number of water storage licences in the North Thompson HMA



92 Figure 4.10 Salmon streams in the North Thompson HMA with high potential water demand during the summer low flow period

Of the moderate-sized streams, Louis Creek, which is fully recorded, has by far the greatest potential water demand, amounting to 50% of the flow in average years and much higher percentages during droughts. Lemieux Creek has more moderate demands, although dewatering occurs along the river, seemingly as a result of a combination of local extractions and exchange of surface water with subsurface flow and groundwater. Roughly 50% of the total irrigation extractions have an associated storage licence in Lemieux Creek and Mann Creek. Potential water demands in Christian and McTaggart creeks are as great as, or exceed, typical low flows in these streams. While Mann, Mahood and Reg Christie show high potential demands based on water licences, the actual amount of water use may be overestimated. Low flow problems related to salmon have not been observed in these streams (Panko, pers. comm).

Streams that exhibit low flows with no present water demands include Tumtum, Lion, Goose, Cedar and Cook creeks. These are small drainages that have a steep recession curve during late summer and fall, indicated by indices of seven-day low flows (the lowest average flow for seven consecutive days) over the mean annual flow (Table 3.1) (Fig 3.6).

The watersheds in the HMA where conflict already exists between agricultural water use and instream uses are in the lower part of the drainage and include Louis, Christian and McTaggart creeks. Watersheds where future growth in agricultural activity is anticipated can be expected to show the greatest increase in water demand. The only way to increase agricultural growth where irrigation is required is to provide additional storage. Improved efficiency of irrigation through conversion from flood to sprinkler irrigation could effect some improvement in water use, as most of the irrigation systems in the HMA are still of the sprinkler type. The greatest increased water demand for agriculture can therefore be anticipated in the watersheds listed above, as well as in Brookfield Creek.

#### **4.5.3 Future trends**

##### Water demand

Increasing conflict over water resources in the HMA can be anticipated. Projected increases in agricultural activity and water uses, increased demand for dilution from industrial projects, and steadily increasing municipal demand will all continue to compete with fisheries and other water uses that require instream flows.

A major diversion project has been proposed by Multinational Water and Power Inc. to divert one million acre feet annually from the North Thompson by construction of a tunnel below Albreda River through to the Columbia River. This water would be piped from the lower Columbia system into Oregon and California (newspaper articles, Vancouver Province, June 6, 1991; Vancouver Sun, June 27, 1991). The B.C. government has an interim moratorium on water export

permits until 1994. Although no formal application has been made for the project, the proposal has raised a great deal of concern for fishery resources of the North Thompson River. The B.C. government is presently considering legislation to prohibit the large scale export of water.

#### 4.5.4 Water quality

Current water quality conditions in the basins in the HMA vary considerably, due to changing land and resource uses, differing climatic conditions and differing geologic conditions. This discussion highlights some of the current water quality conditions and problems within the major watersheds.

Water quality information is very limited. The North Thompson River mainstem from McLure to the confluence with the South Thompson River is discussed in a B.C. Environment, Lands and Parks water quality assessment report (Nordin and Holmes 1992). The water quality of this section of the river is considered to be good. There are no direct discharges to the river, but there are a variety of indirect discharges to groundwater. Nordin and Holmes (1992) identified three non-point problems in the lower North Thompson. These are storm sewer outfalls, housing development effects (nutrients from cottage development and ground contamination from sewage), and logging effects (problems with suspended solids). There was, however, insufficient data to quantify the impacts. The water quality of the North Thompson is similar to the South Thompson, except that it has higher colour and more suspended sediments. Nordin and Holmes (1992) also did a rough assessment of water quality changes over time. They did not consider the analysis to be a definitive test of trends over time, since sampling times were irregular. However, they felt that increases for some of the dissolved ions may be occurring. Phosphorous and nitrogen did not show any evident trends over time.

The only significant point waste discharge to salmon streams within the HMA is the DFO fish hatchery, which discharges into the Clearwater River. The waste discharge permit allows for a maximum of 21,600 m<sup>3</sup>/day. There is also a municipal sewage discharge of 910 m<sup>3</sup>/day allowed for the village of 100 Mile House (to Little Bridge Creek), but the actual discharge is much lower, as the effluent is primarily used for spray irrigation. A summary of waste discharge permits and the maximum possible daily loading for effluent permits are found in Appendix C.

A mosquito abatement program has been in operation between the mouth of the North Thompson and the Little Fort area. There are numerous back channels and wetlands throughout this area where mosquito abatement pellets are introduced each year. The position of DFO has been to control larvae only in areas not directly connected to the mainstem North Thompson. However, there has been little or no monitoring of this program, and actual impacts have not been documented (MacDonald, pers. comm.).

A number of basins within the HMA have high levels of recent logging activity, which has a non-point influence on water quality. Hetherington (1987) gives a general discussion of the impacts of recent logging activity on the water chemistry of streams. He states that the water chemistry of streams is altered after logging and, to a greater extent, after slash burning or wildfire. Studies in eastern and western Canada measured concentration changes (increase or decrease) of a number of parameters in forest streams after harvesting or burning had occurred. These parameters included calcium, magnesium, sodium, potassium, nitrogen, phosphorus, sulphate, chlorine, bicarbonate, organic substances, dissolved oxygen, colour, and pH (Hetherington 1987). Water chemistry changes have generally been relatively minor and short-lived (Hetherington 1987), with parameters usually returning to pre-disturbance conditions within three to five years. Recorded changes have, however, lasted as long as nine years in a coastal British Columbia stream (Feller and Kimmins 1984).

### Future trends

Future trends in water quality are dependent on a number of factors, including future resource uses such as agriculture, forestry and residential development, industrial development and expansion, and changing standards and regulations as set by the federal and provincial governments.

Non-point source pollution is considered to be the major future water quality problem in the HMA (Nordin and Holmes 1992). These sources affect larger areas and are more difficult to isolate and treat than point discharges. A potential point discharge problem is the proposed pulp mill for the Blue River/Clearwater area of the North Thompson River. However, this project is conceptual in nature and it is unlikely that it will ever proceed. Another pulp mill on the Thompson River system with a discharge into the river would be a great concern to the fisheries resource.

The major land use activity currently affecting water quality is forestry, and this is likely to continue. Increased sedimentation of streams is probably the greatest concern. As well, increased agricultural activity, such as introduction of additional feedlots or wintering areas for cattle, could affect water quality of salmon and trout streams.

Population growth within the HMA is expected to be moderate -- less than 2% over the next 20 years. Overall, increased loadings from sewage treatment plants and septic systems are not expected to be significant, but may continue in some areas where there are new housing developments.

Watershed-specific water quality objectives proposed by the B.C. Ministry of Environment, Lands and Parks also provide an indication of future water quality trends. These objectives are

proposed to protect present and future water uses, and are based on working criteria for water quality. They are only prepared for waterbodies and water quality characteristics that may be affected by current and foreseen future activities. Although the objectives have no legal standing, they can be considered policy guidelines for MELP resource managers, and as such are an indication of planned future water quality conditions. The B.C. Ministry of Environment, Lands and Parks also carries out programs to monitor how well the objectives are being met. Provisional water quality objectives are set only for coliforms to protect drinking water quality in the lower North Thompson. Overall, the majority of the changes in water quality that will affect North Thompson migratory fish will occur downstream of Kamloops.

#### 4.6 Air Quality

The analysis of the overall air quality in the Thompson River habitat management areas (HMAs) is taken from a discussion of the Southern Interior Region of B.C. Ministry of Environment, Lands and Parks. The Southern Interior Region boundaries do not coincide exactly with the watershed boundaries, but are close enough that general conditions would be similar. Only one ambient-air continuous-analyzer site, located in Kamloops, exists in the watershed. There are a number monitoring stations for dustfall and suspended particulate matter.

B.C. Ministry of Environment, Lands and Parks (1989) states that the majority of air quality problems in the Southern Interior Region are related to the forest products industry. Problem parameters include hydrogen sulphide (pulp mills), suspended particulate matter, and dustfall (sawmills). In 1989, Kamloops monitoring stations had measurements exceeding the 24-hour desirable standards 11% of the time, and the one hour desirable limits 5.5% of the time. Most of the Southern Interior Region is affected by smoke from slash burning and sawmill operations. Note that the air quality monitoring stations are usually located near industry sites where specific pollutants are expected. Since these stations are only set up near pollution sources, they are typical of industrial and/or urban areas but not of rural and undeveloped portions of the region.

In the 1970s B.C. Hydro began investigating the possibility of developing a coal-fired thermal electric power generating station in the Hat Creek Valley of south central B.C. This project has been indefinitely postponed by the B.C. Hydro and Power Authority since 1982, but, were it ever to go ahead, it has the potential to result in wet and dry acidic deposition in the downwind region. Servizi and Farrell (1985) investigated the buffering capacity and alkalinity of 32 salmon streams downwind of the proposed project in order to determine their sensitivity to acidic inputs. Streams in the North Thompson HMA with low alkalinities include Finn Creek and Blue and Raft rivers. The buffering of these streams was considered inadequate to ensure protection against acid deposition, so the impact of the Hat Creek project on these streams would be considerable, should it go ahead.

## **5.0 WATERSHED MANAGEMENT ISSUES AND RECOMMENDATIONS**

The watersheds in the North Thompson Habitat Management Area (HMA) are influenced by a variety of landscapes and climatic conditions, as described in Section 3.0. Landforms range from broad plateaus to steep mountainous terrain, while climatic conditions range from some of the driest areas in the province to areas with above-average levels of precipitation. Rivers and streams are products of their drainage basins and are affected not only by physical and hydrological conditions, but by land use practices within the watershed. Many of the activities discussed in Section 4.0, including logging, road building, agriculture, grazing, irrigation and residential developments, can affect fish habitat by altering or degrading the river riparian ecosystem. Land and water use activities can affect fish habitat by altering water quantity, channel morphology, sedimentation, erosion, substrate quality and water quality. The severity of the impact will not only depend on the activity, but on the sensitivity and resilience of the stream and its watershed.

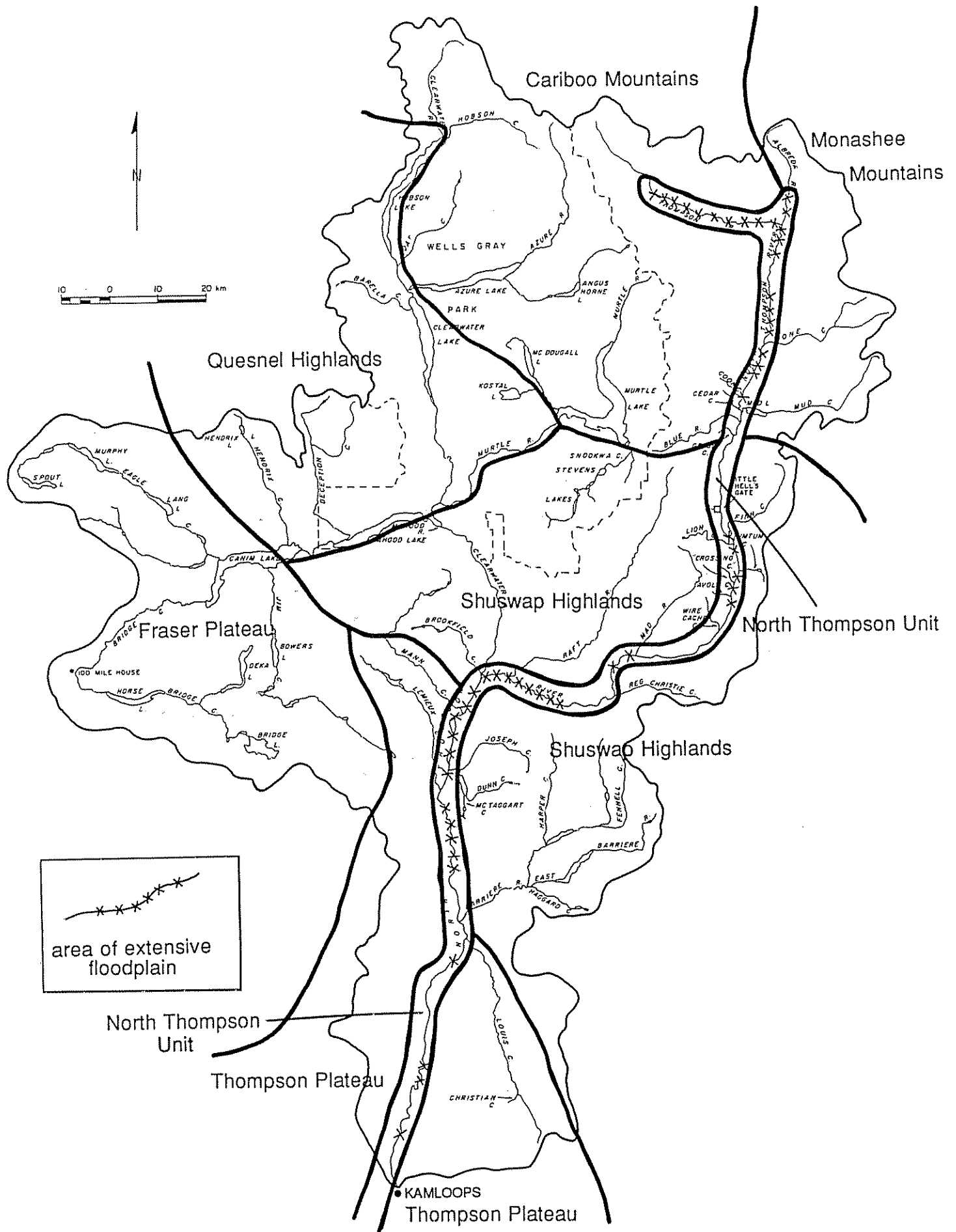
The fish habitat management priority in the Basin is to ensure protection of the fisheries resource by protecting and managing the river riparian zone or floodplain. Firstly, proper land management practices must be promoted to maintain the integrity of the stream and its riparian zone and to prevent impacts on spawning and rearing fish. As well, the natural water and sediment regime and riparian communities need to be restored in watersheds where impacts have already occurred and continue to damage fish habitat.

Based on an assessment of the physical and hydrological characteristics of the North Thompson River, it was determined that the physiographic units (Holland 1976) could provide a suitable basis for the discussion of watershed management issues and priorities. The North Thompson River Valley, including the floodplain and adjacent valley slopes, was included as a separate unit. Holland's (1976) original physiographic units have therefore been revised, and the modified units are shown in Figure 5.1. These physiographic units closely approximate the planning units used for the Kamloops Resource Area Management Plan (Figure 5.2).

### **5.1 North Thompson River Valley**

#### **5.1.1 Description**

The North Thompson River Valley extends from its junction with the South Thompson River, near Kamloops, to its headwaters, upstream of Albreda River (Figure 5.1). Although there are salmon-bearing tributaries to the North Thompson that could be considered to be within the North Thompson unit, they are discussed as watersheds in the physiographic unit containing their headwaters.



98 Figure 5.1 Physiographic land units in the North Thompson HMA, modified for watershed summaries

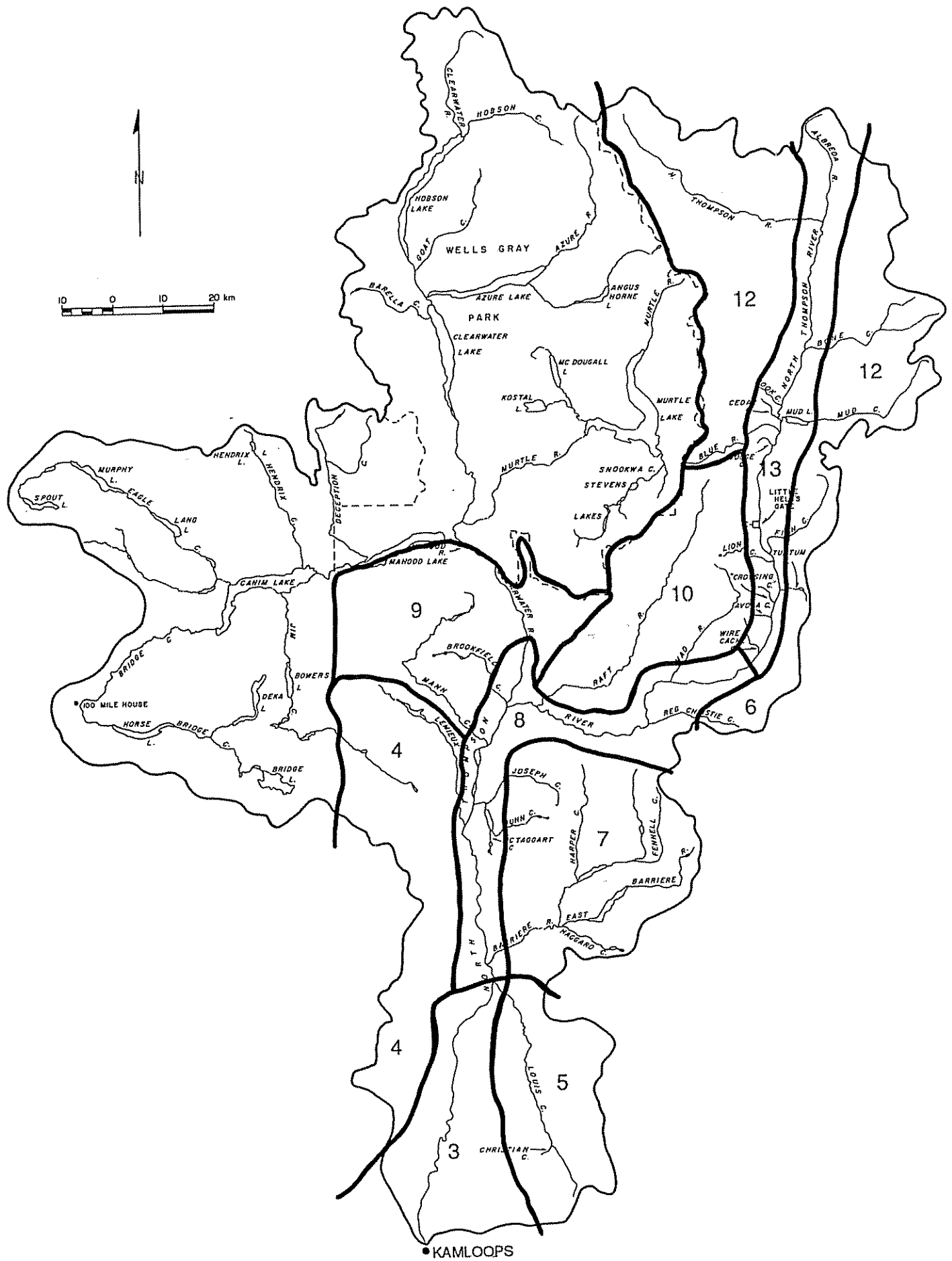


Figure 5.2 Kamloops resource management plan resource units in the North Thompson HMA

The mainstem North Thompson supports the second-largest chinook spawning population in the North Thompson HMA. Unlike the Clearwater River, chinook escapements in the North Thompson are not increasing. They have averaged just under 2,000 fish over the last decade. Significant numbers of coho (avg. 774) also spawn in the mainstem. It should be noted, however, that the North Thompson is turbid due to glacial runoff and that escapement counts may be underestimating actual numbers. Juvenile sampling indicates that there is high use of the North Thompson for chinook and coho rearing, and many of these fish are thought to have migrated out of adjacent tributary streams (Scott et al. 1982b; Whelen and Lister 1985). Rainbow trout, bull trout and mountain whitefish are the main sport species found in the North Thompson, but, due to the high level of glacial sediment in the river, it is not reputed to be a good sport fishing stream. However, sport fishing does occur at the mouths of many of the clearer tributaries, such as the Clearwater River.

Salmon habitats in the North Thompson include the main river channel, sidechannels, floodplain, wetlands, and the fans and confluences of a multitude of minor and major tributary streams. The main areas of floodplain, including wetlands and low terraces, are shown in Figure 5.1, and include sections from Barriere River to Raft River, Mud River to Bone Creek, and Albreda River to Adolph Creek. The major spawning area is from Little Fort to Vavenby (Figure 2.5). The North Thompson mainstem provides very important summer and winter rearing habitat for chinook. The wetlands and small tributaries were found to be highly used by coho in the summer and provide rearing habitat for coho that spawn in the tributaries, as well as for mainstem coho.

Potential impacts on fish habitat in the North Thompson are related to the transportation corridor and to agricultural and residential developments. During construction of the CN Twin Tracking project, for example, compensation had to be made at a number of sites where encroachment on fish habitat occurred. It is critical that stream crossings be properly designed and constructed in order to maintain access for rearing fish. Agricultural activity can also affect or eliminate wetlands which are very important rearing areas for coho as well. Non-point source pollution can also damage these habitats and must be controlled. Increased residential and small acreage developments from Little Fort to Clearwater may affect fish habitat in the mainstem and floodplain of the North Thompson River. There is major dyking proposed for the lower 24 km of the North Thompson that could also affect mainstem and offchannel fish habitat. The proposal to divert water from the North Thompson to the Columbia system would have very serious impacts on the North Thompson River and its fishery resources.

### **5.1.2 Management priorities**

The North Thompson River not only provides a migration route for salmon, but provides major spawning and rearing habitat for chinook and coho salmon. Protection of the North Thompson River with its associated wetlands and sidechannels as well as the lower reaches of

small tributaries is a primary concern. These areas provide important spawning and/or rearing habitat and can be extremely sensitive to impacts from land use activities. A habitat management and enhancement strategy should be developed and implemented for the North Thompson Valley. Failure to provide proactive protection for many offchannel habitats will result in their longterm degradation by human activity. Habitat management priorities include the following:

- Classification, mapping and assessment of all existing habitat and historic stream channels is required. Historic stream channels and riparian and floodplain habitats that retain their connections to the river, or have access to the mainstem need to be identified. The spawning and/or rearing habitat potential of small tributaries to the North Thompson also need to be identified. This data can then be used to create a comprehensive plan for the protection and restoration of existing habitat, and the creation of new habitats. At present, such an assessment is required to assess the proposed dyking projects in the lower North Thompson below Hefley.
- Compensation wetland habitat developed by CN at the mouths of Peddie and Cook creeks (Photos 5.1 and 5.2) should be assessed to determine potential production of these sites and, hence, their success and applicability in other areas.
- Inventory work should be initiated to better assess adult and juvenile chinook and coho utilization of the North Thompson mainstem and offchannel habitats. Particularly, greater attention should be paid to coho in the upper North Thompson, where escapement and basic inventory data are very limited.
- Work should be continued to assess the potential for improving passage at Little Hell's Gate Falls (Photo 2.2), which has been identified as a partial barrier to coho and, to a lesser extent, chinook salmon. This would ensure fish access to rearing areas in the upper watershed and tributaries, including Albreda River. A feasibility study has been proposed for 1993.
- The feasibility of improving flows in the Birch Island sidechannel, a major coho spawning area, should be assessed. The natural build-up of gravel at the entrance of the sidechannel is reducing flows through the channel affecting coho spawning habitat (Panko, pers. comm).

## 5.2 Thompson Plateau Watersheds

### 5.2.1 Description

The Thompson Plateau extends along both sides of the North Thompson River from Kamloops to Little Fort (Figure 5.1).

The salmon-producing streams in this section are Louis, Christian, Lemieux and Mann creeks. There are a large number of highly productive trout-producing lakes, including Heffley, Paul, Knouff and Badger on the east side of the Thompson, and Noble, Isobel, Dunsapie and Totunkwa on the west side. These lakes support a lot of angling activity and provide important sport fisheries, and many of the west-side lakes have wild trout stocks and semi-wilderness locations.

Chinook salmon spawn and rear in Louis and Lemieux creeks; from 1981 to 1990, the average chinook escapements were 11 fish for Lemieux Creek and 126 for Louis. Significant coho populations are found in Louis Creek and its tributary, Christian Creek, as well as in Lemieux and Mann creeks. The 1981 to 1990 average coho escapements for Louis and Lemieux creeks were 700 and 615, respectively. Escapements to Mann Creek for the same period averaged 46.

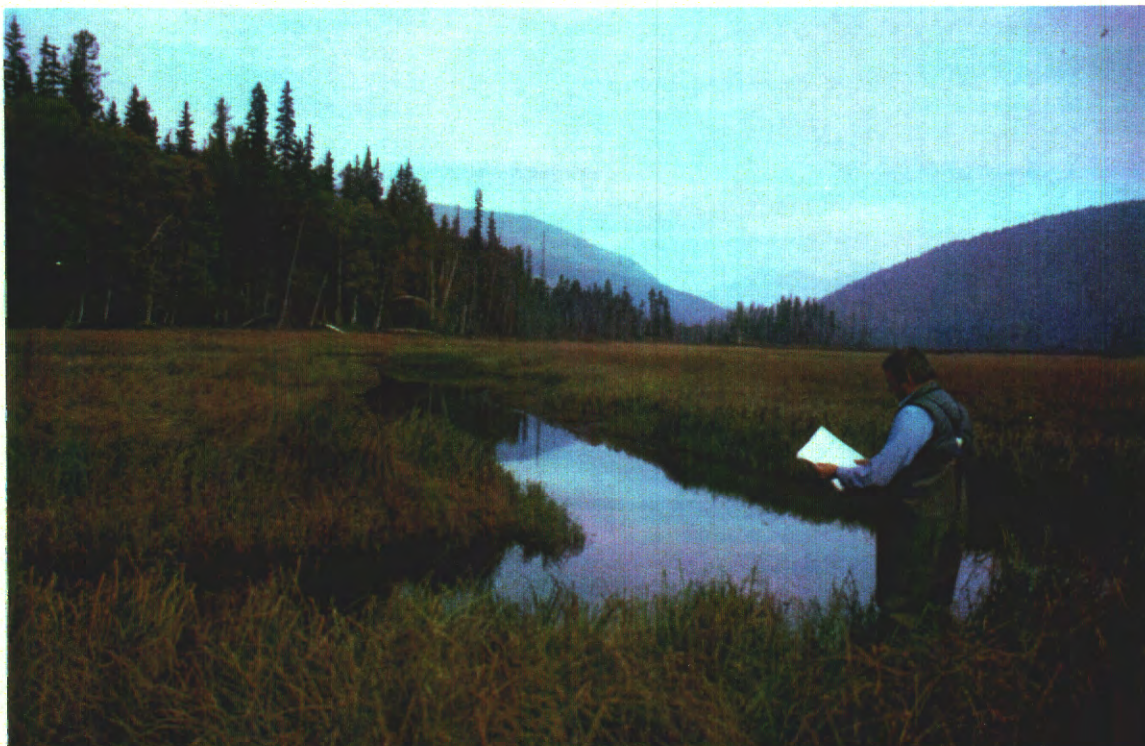
Most stream channels in this unit are laterally stable; unstable valley walls and hillslopes are restricted to the tributary streams in Louis Creek and the upper ends of Mann and Lemieux creeks. The Thompson Plateau's annual precipitation is 400-500 mm and annual snowfall is below 120 mm, the lowest in the HMA. Water withdrawal, water storage and fisheries instream flow requirements are in conflict throughout the unit, due to low precipitation and high agricultural water use. As well, agricultural development around streams and livestock access results in the loss of riparian vegetation and deterioration of water quality. Proximity to Kamloops subjects this area to increased pressure from the development of residential and recreational properties. Water quality and shoreline habitats around important trout-producing lakes have been, and will continue to be, adversely affected by this development.

### 5.2.2 Management priorities

The main management priority for streams of the Thompson Plateau is to maintain adequate instream flows for fish migration, spawning and rearing. In addition, riparian zone management is essential to protect and restore fish habitat. Riparian vegetation helps to maintain stable banks by preventing erosion and sedimentation; provides cover for fish; provides shade, thus lowering stream temperatures; and contributes nutrients to the stream. Agricultural activity and livestock grazing and watering have degraded the riparian zone and destabilized the banks in many stream reaches.



**Photo 5.1** Peddie Creek wetlands showing the location of the CN Twin Tracking encroachment (photo courtesy of G. Kosakoski).



**Photo 5.2** Cook Creek wetlands adjacent to the North Thompson (photo courtesy of G. Kosakoski).

Serious water shortage problems in many of these streams result from the water allocation system that does not recognize instream flow needs. The revised Water Act (now being drafted) must recognize water uses for fish, recreation and other non-consumptive uses to avoid these conflicts. Management priorities are to:

- assess instream flow needs for fish and establish fisheries flow agreements to optimize instream flows (a process to assess instream flows has been drafted by DFO);
- develop a process for dealing with the management of limited water resources during drought conditions;
- assess storage opportunities to ameliorate existing problems and reduce conflicts;
- re-allocate unused water licences to instream uses;
- promote water conservation through increased efficiency, by changing from flood to sprinkler irrigation;
- promote the need for the Water Management Branch to regulate groundwater use, since it can affect stream flows;
- promote agricultural and grazing practices that protect the river/riparian system; and
- identify sites and develop programs to rehabilitate riparian vegetation and stabilize banks.

### Louis Creek

Louis Creek, a coho and chinook stream, has been affected over the years by agricultural and forestry development, and could be subject to increasing demands for water for irrigation and domestic use in the future. Much of the riparian edge vegetation has been removed, due to agricultural activity (Photo 4.3). Despite hatchery augmentation of Louis Creek stock at the Dunn Lake hatchery, coho escapements appear to be declining. Production of Louis Creek coho and chinook is likely affected by low water flows and degraded habitat, particularly in low flow years (Ptolemy 1982). Management of Louis Creek should include the following:

- Water storage on Eileen and McGillvray lakes has been proposed to augment existing stream flows. A detailed hydrologic study, including a review of storage

options on Eileen and McGillvray lakes, should be completed so that instream flow alternatives can be assessed.

- An inventory of riparian vegetation should be conducted and a riparian restoration program should be implemented to compensate for losses due to intensive agricultural development. Fencing and bank stabilization projects have been proposed by MELP and the North Thompson Indian Band.
- Further study of the habitat capacity of Louis Creek is required. A project to determine fish utilization and rearing densities in various habitat types is being undertaken. This will also assist in determining whether further hatchery augmentation is desirable.
- Twenty-one percent of the Louis Creek drainage has been logged, which is a level at which hydrological impacts from additional logging could occur. Unstable valley walls identified in the tributaries to Louis Creek should be carefully assessed and prescriptions drawn up before additional logging is approved.
- The project to expand ski facilities at Tod Mountain must be assessed to ensure that it does not affect water quality in Louis Creek. Clearing and road building near Tod Mountain has resulted in sediments being released into the stream.

### Lemieux Creek

Lemieux Creek is a significant coho stream and also produces a small number of chinook. Spawning grounds are ice free, which may increase the productivity of this stream. Spawning escapements in the last two decades have been approximately 600 fish, about one half of historical averages. Escapement in 1991 was relatively large, at 1,400 coho. Chinook escapement is generally 25 fish or less.

Lemieux Creek is subject to water demands and agricultural pressures similar to those at Louis Creek and exhibits low summer and fall flows. Dewatering occurs in a large reach of the stream, which limits the amount of rearing area available. It can be dry at the mouth in some years, limiting access to spawning grounds (Hutton et al. 1983). The following are identified fisheries management priorities:

- Water storage has been licensed at Taweel Lake by MELP to protect the water supply for fisheries use in Lemieux Creek. A detailed hydrological study should be completed jointly with MELP to determine the feasibility of storage development on Taweel Lake and improving instream flows. A feasibility study is proposed by SEP.

- A riparian habitat inventory and riparian vegetation restoration program should be undertaken. A fencing and bank stabilization project is proposed by SEP.

### Mann Creek

Mann Creek produces coho and a few chinook, providing good spawning and rearing habitat in the lower end (below highway) (Hutton et al. 1983). Coho escapements have averaged about 50 fish in the last two decades but, historically, escapements have been 200-400 fish. Limited information is available for Mann Creek, but the following issues have been identified:

- Mann Creek was identified as having potential low-flow problems due to heavy water demand. Low-flow problems have not, however, been noted since existing water licences are not being used (Panko, pers. comm.). Any further licence applications, however, should be assessed for potential problems, and fisheries instream flows determined .
- Lower Mann Creek (downstream of the highway crossing) has been noted to have bank instability problems (Kosakoski, pers. comm.). Future development in this area should be carefully assessed.

### Lakes

One of the major concerns throughout this unit is the increased access to wilderness fishing lakes created by logging operations. Development of acceptable logging access and the visual impacts of clearcutting around lakes must be addressed.

### Other streams

Specific information is not available about the many smaller stream systems that produce or rear trout (and, perhaps, small quantities of salmon). However, all watersheds in the Thompson Plateau are subject to similar low flow, water demand and valley wall stability concerns, and the same concerns and management goals prescribed for Louis, Lemieux and Mann creeks will apply across the Thompson Plateau.

## 5.3 Shuswap Highland Watersheds

### 5.3.1 Description

The Shuswap Highlands, the largest physiographic unit in the HMA, extend across the centre of the HMA and form a transition zone between the Fraser and Thompson plateaus and the Cariboo and Monashee mountains (Figure 5.1).

Many of the salmon-producing streams and lakes are found in this unit, including Barriere, Dunn, Raft, and lower Clearwater rivers, as well as a number of smaller tributary streams in the North Thompson Valley. This unit accounts for all of the sockeye production in the HMA, almost all the chinook production except for the upper Clearwater River, and the largest proportion of coho production.

The primary sockeye spawning areas are in the Barriere system (Fennell Creek) and Raft River. Escapements to Fennell Creek have ranged from 858 to 26,932 over the past five cycle years, while Raft runs have increased to 19,000 in the 1988 dominant cycle. Chinook spawning streams, including Clearwater and Raft rivers and Finn Creek, account for 75% (6,205) of the chinook spawning in the HMA from 1981 to 1990. Over the same period, coho escapements to the Shuswap Highlands have averaged 4,000 fish, which represents over 60% of the coho run in the HMA.

There are a number of large and important high-use angling lakes in the Barriere and Dunn Creek drainages. In the more northerly section of the unit, the density of lakes and level of use is much reduced. Important trout fisheries are also found in the Clearwater and Mahood rivers.

Valley walls are generally unstable throughout the lower elevations of most systems. This is more pronounced in the northern half of the unit, and valley instability is less of an issue in Barriere and Dunn creeks, compared to creeks between Clearwater River and Blue River. Hillslope stability is of concern throughout the unit, although in most cases valley wall failures will have greater impact on fisheries resources than will hillslope failures. Most of the tributary streams have short reaches of narrow and laterally unstable floodplains and commonly have major unstable fans at the confluence with the North Thompson. Raft River is exceptional among tributaries, with long reaches of laterally unstable floodplain in its upper watershed, while the Clearwater is exceptionally stable.

The Shuswap Highlands are subject to annual precipitation of 450 mm in the Barriere and Dunn Creek drainages, and 500-800 mm in the area north of Clearwater. Snowfall is similar, with averages of 100 cm in the Barriere area, and up to 120 mm to 400 cm north of Clearwater. This

range of precipitation is reflected in the biogeoclimatic zones, where river valleys in the southern end are in the dryer Interior Douglas Fir zone, compared to the upper valleys found in the wetter Interior Cedar Hemlock zone.

Many of the small streams in this unit have the potential for critical summer low flows, including McTaggart, Tumtum and Lion creeks. Reg Christie and McTaggart creeks and Mahood River were identified as subject to potential high water demand, based on existing water licences. Agricultural development in this unit occurs in the Barriere and Clearwater rivers, and Joseph, Dunn and Brookfield creeks. The key concerns are the potential loss of stream bank and riparian habitats, and potential impacts on water quality. Extensive logging is proposed over the next five years for the Barriere River drainage and for the major tributaries to the North Thompson north of Clearwater. All salmon-bearing watersheds within this unit have been more than 20% logged. These present levels of logging, and the greater levels of snow pack in the northern end of this unit, suggest that rate-of-cut is a concern. Higher snow pack zones indicate that effects of clearcutting on hydrology can be greater and regeneration on these sites is slower. Terrain instability, including stream channel, hillslope and valley walls, requires that specific attention be paid to road and drainage development.

### 5.3.2 Management priorities

Management priorities in many streams of the Shuswap Highlands are related to reducing the impacts of logging activities. Many concerns are presently being addressed. A joint committee including MELP, MOF and DFO is developing a watershed assessment procedure for determining land and stream sensitivities to logging, and "Interior Fish, Forestry and Wildlife Guidelines" are being developed for logging practices in two ecoprovinces in the Interior. These initiatives will develop procedures for determining the impacts of rate-of-cut on a watershed, methods of assessment and protection of streamside vegetation and debris, and methods for de-activation and stabilization of logging roads. In conjunction with the development of these guidelines, a study is underway in Finn Creek as part of a "Local Resource Use Plan" to determine the effect of present level-of-cut, now at 20%, on chinook spawning habitat in lower Finn Creek (Kosakoski, pers. comm.). Based on the problems and concerns with logging in this HMA, it is recommended that:

- watershed assessments to determine cumulative watershed impacts (using the methodology developed by the joint committee) be conducted on all streams with clearcut area approaching and exceeding 20%, prior to approval of additional logging to ensure streams are adequately protected from logging impacts;
- an inventory of fish and fish habitat be conducted, particularly in the upper watershed and tributaries where information on habitat and fish utilization is limited;

- research on the effects of logging in interior streams be initiated;
- major emphasis be placed on identification and mapping of channel and terrain instability problems for use in potential impact assessment;
- impact monitoring programs be initiated to monitor sediments and watershed stability on selected streams;
- Interior Fish, Forestry and Wildlife guidelines be developed and implemented for the protection of streams in the HMA, particularly for the Shuswap Highlands physiographic unit. Guidelines should address rate-of-cut, streamside management zones and classification of salmon streams and sensitive habitats; and
- monitoring be required following implementation of guidelines, to assess their effectiveness as well as industry compliance.

#### Barriere River system

The Barriere River system is an important chinook, coho and, particularly, sockeye salmon producer, and includes the Barriere River and its tributaries, and Harper, East Barriere and Haggard creeks. The Central Interior Tribal Fisheries Program conducted a number of surveys of coho and chinook production in the Barriere system (Stewart and Matthew 1984, 1985; Matthew and Stewart 1985; and Jarvis and Stewart 1985). Chinook and coho spawning in the Barriere River is largely concentrated immediately below North Barriere Lake. Scattered chinook spawning also occurs downstream to the confluence of the East Barriere River. The studies suggested that Barriere River provided more suitable habitat for chinook than coho, and could likely support an increase in the number of chinook. The average escapement in the last two decades has been less than 100 fish. However, historical records to 1951 indicate that the Barriere River was never a big chinook producer. The maximum escapement was 400 fish and often fewer fish were observed.

Coho spawning and rearing is limited to the lake outlet. Average 10-year escapements in the Barriere River have been under 400 fish. A large percentage of coho production in the Barriere system occurs in Fennell Creek (Barriere River above North Barriere Lake). Fennell Creek is a low gradient stream and abundant pools, glides and edge cover make it a productive coho stream. Additional rearing may also occur in North Barriere Lake. Fennell Creek may be unique in the North Thompson in that most production (i.e., spawning, rearing and overwintering) occurs instream. Escapements since 1981 in Fennell Creek have averaged 500 fish. The above studies suggested that the East Barriere was limited for chinook production and was better suited for coho. Coho production occurs below East Barriere Lake and slough; habitat is characterized by beaver dams, log jams, and overhanging vegetation, providing suitable spawning and rearing

habitat for coho.

Major production of sockeye occurs in Fennell Creek (maximum of 27,000 spawners in the dominant cycle) and spawning areas are well-utilized. A small population (less than 100 on average) also spawns below the lake and there may be some potential to enhance this stock as well.

Future forestry development and its impact on existing and potential fisheries resources is the primary concern, and the following specific issues have been noted:

- Most watersheds in the Barriere system, including Fennell Creek, the most important sockeye spawning stream in the HMA, have had at least 30% of their areas logged. Northwest Hydraulic Consultants Ltd. has identified Fennell and Haggard creeks and Barriere River as having the potential for high peak discharges relative to mean flow. Watershed assessments should be conducted to ensure that present and future rates-of-cut do not adversely affect fish habitat.
- The potential loss of habitat in the small tributaries to the Barriere Lakes as a result of logging is of concern. This has potential impacts on the spawning and rearing habitat for resident species in these tributaries, and also applies to the backwater and floodwater channels of the Barriere River.
- It has been noted that Leonie Creek, a tributary to the lower Barriere River, and also the mainstem of the Barriere River about 10 km upstream of the mouth, have major valley wall and hillslope stability problems. Bedload and suspended sediment from these sources is thought to be contributing to habitat degradation in the lower end of the river (MacDonald, pers. comm.). Possible remedial actions and net benefits to fish production should be assessed.
- The lower end of the valley (from the confluence with the North Thompson River to where the East and West Barriere join) is subject to hobby farming, resulting in bank stability problems. There are some erosion problems now at the lower end of the system, and these are expected to increase and become major problems in the future. There are also many resorts and residences around the Barriere Lakes that are contributing to the degradation of habitat.

All of these concerns require assessment of existing impacts and the development of remedial and protection strategies such as fencing, bank stabilization and riparian restoration.

### Dunn Creek system

The Dunn Creek system, including Joseph and McTaggart creeks, is a major coho producing system. The chinook run is minor and the sockeye run no longer exists. Most coho spawning occurs in Dunn Creek at the outlet of Dunn Lake. Rearing downstream of the lake is limited and coho likely emigrate to the North Thompson to rear. A small number of coho also spawn in McTaggart Creek. McTaggart is a groundwater/lake-fed stream flowing into Dunn Lake. The marshy outlet of McTaggart Lake provides good habitat for coho rearing and overwintering, but is limited by its small area. Coho production in the Dunn system has been augmented by the Dunn Lake hatchery, which produces coho smolts for release in Dunn, Lemieux and Louis creeks. An escapement of over 1,500 coho was recorded in 1991.

- Joseph, Dunn and McTaggart watersheds have all had more than 20% of their areas logged. Little or no logging is planned for the Dunn drainage for 1993 to 1996. However, Dunn Lake is the water source for the Dunn Lake hatchery, and maintenance of water quality is a concern for future logging activities.
- McTaggart Creek has the potential for critical seven-day low flows and is also subject to high summer water demand (Northwest Hydraulic Consultants Ltd. 1992). It is a coho rearing and spawning stream, and the lake and marsh area has potential for additional coho production (SISS Files). No further consumptive water licences should be approved in this stream unless it can be proven that there will be no impacts as a result.
- The McTaggart Lakes area is a rapidly developing area for hobby farms. Setback or buffer strips to protect the stream are required, and water quality should also be monitored. The region from Dunn Lake to the confluence with the North Thompson River has been recommended by a local conservation group for protected area status.
- Assessment of hatchery production and straying problems at the Dunn Lake facility should be continued.
- Since the system has limited salmon spawning area, projects to develop a spawning channel and spawning platforms in Joseph Creek have been identified by SEP and SNTC (Shuswap Nation Tribal Council) as having enhancement potential.

### Clearwater River system

The Clearwater River is the major chinook spawning system in the North Thompson. It

also contains coho and a large population of rainbow trout. The upstream limit of salmon migration is Bailey's Chute (approx. 56 km). There is a canyon and chute at approximately 7 km that may be a difficult point of passage. Because most of the Clearwater drainage is within Wells Gray Park, there are few concerns about land use development. There is also a recreational corridor between the town of Clearwater and the park, in which there is some logging, but it is rigorously controlled. The Clearwater also has "reserved" (no water licensing) status. There is concern related to development in the Mahood Creek drainage, a Clearwater tributary, which includes the Bridge, Jim and Eagle Creek systems. Logging and land development for agriculture and recreation are the key concerns. Only the lower river below Mahood Lake up to an impassable falls is used by salmon, and these activities have not had an impact to date. Although there are several large water licences on the Mahood River and a potentially high water demand, most of the water licences are above the lake and effects on downstream low flows have not been observed (Panko, pers. comm.).

- Assessment of the falls at 7 km to determine the extent of obstruction and the feasibility of improving passage is recommended.
- A sidechannel used for coho spawning near the hatchery needs to be improved, to allow for adequate flows and flushing of gravels (Panko, pers. comm.).
- Development of a protection plan for resident species in the Mahood River requires an assessment of the potential impacts of increased logging, agriculture, and recreational and urban development on the water quality and water supply to the Mahood drainage. This is discussed in greater detail under the Fraser Plateau unit, where most of the Mahood drainage is located.

### Brookfield Creek

Brookfield Creek is known as a coho stream, although escapements have not been recorded for the past 19 years. Coho escapement records have never exceeded 75. Coho and chinook fry have recently been sampled in the stream (Griffith 1993). Debris and siltation that may come from two old sawmill operations, now closed, may be limiting the use of this stream by salmon (Panko, pers. comm.). Forty percent of the Brookfield drainage is logged and additional logging could affect hydrology and fish/fish habitat. Brookfield Creek has the potential for increased agricultural activity (Sigma Engineering Ltd. 1991) and increased water demand. Further, the lower end is in an area of increasing residential development, which is a major concern for the protection of fish and fish habitat. Therefore:

- an assessment of Brookfield Creek should be made to determine ways to protect and restore the fisheries resources.

### Reg Christie Creek

Reg Christie supports a limited coho run that averages 25 fish, although runs of 200 coho have been observed. Production for salmon is limited to the lower end. Twenty percent of Reg Christie is logged, and additional logging could affect fish and fish habitat. As well, Reg Christie was identified by Northwest Hydraulic Consultants Ltd. as having a potentially high summer water demand. Therefore:

- assessment of instream fisheries maintenance flows is required, should there be further licence applications. Adequate instream flows need to be maintained for fish production.

### Raft River

Raft River is a major sockeye salmon producing stream in the North Thompson (maximum escapements of 19,000 fish) and also produces relatively large populations of chinook and coho. Average chinook escapements over the last 10 years have been about 500 fish, which is about double the average in the previous two decades. Average coho escapements have been about 400 fish since 1970, which is about one half of their historical numbers. All production occurs in the lower 4.7 km, below a 5.5 m waterfall barrier that prevents further upstream migration.

- Forty percent of the Raft River drainage has been logged; a watershed assessment is required to determine past and future effects of logging.
- Above the barrier, there is more than 30 km of high-quality habitat available that is suitable for salmon production (Stewart et al. 1983). Feasibility of the barrier removal and enhancement options, including headwater stocking, should be assessed.

### Wire Cache, Avola, Crossing and Tumtum creeks

These streams are small tributaries to the North Thompson near Avola that support small coho runs (less than 100 fish). All of the spawning and rearing occurs in the lower reaches, usually the fan area, in or adjacent to the North Thompson River floodplain. These small streams may also provide rearing for coho from the North Thompson or upstream tributaries.

- Potential effects of further logging are of concern, since 25-40% of these watershed areas are logged. The most productive reaches are laterally unstable; 10 m green-up may be required, due to heavy snow packs. Hillslope and valley wall instability issues are also of major concern in any future logging plans for these streams.

- Tumtum has been identified as one of the small drainages that is subject to low flows, although there are no water licences.

### Lion and Finn creeks

These are two of the smaller but more productive streams in this northerly portion of the Shuswap Highlands. In both cases, chinook and coho salmon have access to the lower 5 km of stream. Lion Creek exhibits stable flows and ice-free conditions. Coho spawning habitat is well utilized and escapements in the last decade have averaged about 1,000 coho. Lion Creek is considered to have excellent rearing habitat, although juveniles are believed to rear downstream in the North Thompson River as well. Lion Creek usually supports fewer than 25 chinook (Photo 5.3).

Finn Creek supports a relatively large population of chinook. Escapements appear to be increasing, with a recent 10-year average of 1,155 fish, which approximates averages in the early records. Coho escapements, however, have declined; only 200 coho were reported for 1981-90 compared with 1,850 for the 1951-60 period.

Total logging in Lion Creek and Finn Creek was estimated to be 40% and 35% respectively, and both streams are located in areas of moderately unstable valley walls and stream channels (Sigma Engineering Ltd. 1991). Logging in Finn Creek was deferred pending a hydrological study by the Ministry of Forests that is now completed. There is the possibility for development (by SEP) of several side channels near the mouth, below the highway, where there seems to be a good groundwater supply. There is also a land reserve for a hatchery, but there are no plans for immediate development.

- Issues of rate-of-cut and channel and hillslope stability were studied in the Finn Creek watershed. Channel and hillslope instability in this stream is a key issue; a protected zone (downstream of the falls to the mouth) where logging will not be permitted has been designated to protect the spawning grounds in the lower river. A key management strategy is to ensure that the equivalent clearcut area (ECA) does not exceed 20%. (ECA in Finn Creek was calculated to be 15% at the present time.)
- Habitat suitable for salmon production is available above the falls on Finn Creek and may be an enhancement opportunity.
- Present high rate-of-cut in Lion Creek and its large coho escapement warrant an assessment to ensure that the stream is not being adversely affected by logging and will be protected from impacts in the future.

## **5.4 Cariboo and Monashee Mountain Watersheds**

### **5.4.1 Description**

The Cariboo and Monashee Mountains are located at the northern end of the HMA (Figure 5.1). Chinook salmon are known to be present only in Blue River, the upstream extent of their migration, and account for less than 1% of the total North Thompson escapement. Coho are found in Albreda and Blue rivers and Goose, Cedar and Cook creeks, and account for 19% of the North Thompson coho escapement. Both species are found in the North Thompson mainstem as well (Section 5.1). Mud River and Mud Lake are known as major spawning and rearing areas for bull trout, and all of the large lakes in Wells Gray Park contain substantial populations of rainbow trout, many of them supporting trophy rainbow fisheries. As well, some trout, bull trout and whitefish angling occurs at the junctions of many of these tributary streams with the mainstem North Thompson.

The Monashee and Cariboo mountains are characterized by steep, jagged ridges. Valley walls are steep and precipitous, with evidence of numerous slides and avalanche areas. Valley bottoms in the Monashee Mountains tend to be moderately confined by the valley walls, with a moderate degree of stream instability. In the Cariboo Mountains, the valleys have been well glaciated, resulting in moderately steep valley walls; valley wall slopes tend to be relatively stable. Valley bottoms are generally wide, with a moderate degree of lateral channel movement and evidence of associated erosion. This unit has the highest annual precipitation and snowfall in the HMA, with 800 mm of precipitation per year and 400+ cm of snowfall. However, small streams such as Cook, Cedar and Goose creeks are still subject to potential low summer flows (Northwest Hydraulic Consultants Ltd. 1992). Potential peak flows were not identified by Northwest Hydraulic Consultants Ltd. (1992) as a concern, most likely because the higher mountain elevations are not subject to major rain-on-snow events.

Five-year plans include logging in many of the tributaries. Most logging is quite recent and the total area cut is still relatively low for most streams, although Goose Creek has had 45% of its watershed logged. Due to the unstable nature of many of the stream channels, rate-of-cut will be a major concern as logging proceeds because of the presence of high snow packs and the possible requirement for 10 m green-up for hydrological recovery in some of these areas (Toews et al. 1992).

### **5.4.2 Management priorities**

Coho salmon is the species of major concern in this area. Information on the distribution and utilization of the mainstem and northern tributaries is very limited for this portion of the North Thompson. Management priorities include investigating the coho utilization and carrying

capacity of the upper watershed and tributaries such as the Albreda River. Small streams that provide some spawning or provide primarily rearing in their lower reaches also need to be identified. Some streams in this area, including Bone, Pyramid, Foghorn and McDougall were identified as having potential spawning and/or rearing habitat in the CN studies (Whelen and Lister 1985). Ensuring access to these areas by improving passage at Little Hell's Gate on the North Thompson is also a management priority.

#### Cedar, Goose and Cook creeks

These three are relatively small coho streams. Cook Creek has had average escapements of 70 fish for the past 10 years. All three streams have good coho-rearing habitat, but have limited area. These three small watersheds have extreme low flow indices, although there are no water licences on these streams. The area logged varies from 3% (Cedar), to 25% (Cook), to 45% (Goose).

- Determination of acceptable rates-of-cut and the protection of steep, unstable hill slopes and valley walls is required for all of these streams.
- These streams already exhibit low flow problems and no water licenses should be approved unless there will be no impact on instream fisheries flows.
- Wetland compensation habitat developed at CN Twin Tracking encroachment sites at Cook and Peddie creeks should be assessed to determine fish utilization and potential development of similar habitats in other areas.

#### Blue River

Blue River supports a small run of chinook salmon (avg. 20) and a moderate coho salmon run (avg. 235); approximately 17 km of the stream is accessible to salmon (Photo 5.4). The area of watershed logged is 15%.

- Logging activity should be monitored on a site-specific basis; a complete watershed assessment would be required as the area of watershed logged approaches 20%.
- Development of a sidechannel for coho rearing (below the Highway) has been identified as an enhancement opportunity (Panko, pers. comm.).

#### Albreda River

The Albreda River, located near the headwaters of the North Thompson, is the farthest upstream tributary known to contain coho salmon. Coho escapements have been recorded since

the 1970s. The average escapement from 1980 to 1991 was 850, and a maximum of 2,300 coho were recorded in 1989. It appears that the Albreda is a very productive coho stream, but very little data on utilization of the stream is available. Fifteen percent of the watershed has been logged. There are no water demands at present; however, the proposed North Thompson water diversion may have a significant impact on the Albreda system.

- Additional fish and habitat inventory is required to assess coho utilization of the system; to estimate habitat capacity to determine what, if any, enhancement opportunities are present in this system; and to respond to logging plans and other developments.
- Bank instability problems have been noted on the Albreda River, some of which are associated with an existing railway encroachment (Kosakoski, pers. comm.).

## 5.5 Quesnel Highland Watersheds

### 5.5.1 Description

The Quesnel Highlands lie to the northwest of the Shuswap Highlands and are bordered to the east by the Cariboo Mountains (Figure 5.1). Tributaries and drainages to the north side of Mahood Lake originate in this physiographic land unit.

Chinook and coho salmon are found only in the upper Clearwater River. The upper Clearwater Lake and River and the Murtle River are known for superb rainbow trout fisheries.

The area has a moderate relief between elevations of 1,500 and 2,000 m. The summits are typically rounded from glaciation, with steep valley walls. Steep, unstable areas and slides are typical on many valley wall slopes. Valley bottoms tend to be narrower than in the adjoining Cariboo Mountain unit and there is a lower degree of lateral channel activity. Stream channels are generally entrenched between valley walls and there is little or no lateral instability. Most streams are bounded by unstable valley walls. Due to the rounded and reduced relief of the mountains, there are few locations where hillslope failures can enter directly into a stream channel. This is a relatively high precipitation zone, with annual precipitation of 600-800 mm, and annual snowfall of 160-280 cm; however, peak flows have not been identified as a concern.

Because most of this unit is within Wells Gray Park, there are few land use issues. However, there is logging in the Deception Creek drainage -- outside of Wells Gray Park -- which drains into Mahood Lake.



Photo 5.3 Lower Lion Creek (photo courtesy of M Sheng).

Photo 5.4 (below) Blue River downstream of the Highway Bridge (photo courtesy of L. Jaremovic).



## 5.5.2 Management priorities

The fisheries management objective for Wells Gray Park is to protect existing wild stocks of resident fish species and to maintain the present populations by regulation and gear restrictions. It is a B.C. Parks policy, in Wells Gray Park, to disallow enhancement or removal of barriers to increase the distribution of salmon or trout stocks (Sinclair, pers. comm.).

## 5.6 Fraser Plateau Watersheds

### 5.6.1 Description

The Fraser Plateau lies to the west of the Thompson Plateau (Figure 5.1) and contains the upper reaches of the Mahood system and the Canim Lake drainage.

Salmon are not found in this section of the Fraser Plateau. However, this area contains well in excess of 150 trout-fishing lakes, providing a range of angling experiences. For the most part, these are rainbow trout lakes, but lake trout and bull trout are also present.

The Fraser Plateau has a low, gently rolling relief between elevations of 1,200 and 1,600 m. Valley walls tend to be relatively stable, due to the low relief. Similarly, drainage channels are of low gradient, with low to moderate incidence of bank erosion along the valley bottoms. There are only isolated stability problems in this unit, owing to the small and low gradient drainage areas of many of the watersheds, the numerous wetlands located throughout most drainages, the moderate relief of the hills and the stable valley walls.

Annual precipitation ranges from 400-600 mm, and annual snowfall ranges from 100-160 cm. Low summer stream flows tend to be a general problem in this unit.

There has been extensive logging in this unit; 40% of the total Mahood drainage area has been logged (Sigma Engineering Ltd. 1991). Continued forestry development has greatly increased access into areas that were not formerly accessible by road and logging will continue throughout this area for the next five years. Water use is presently a problem in some areas and water demand will continue to increase. In particular, water storage could be a significant problem for lake fisheries because draw-down on lakes and reservoirs causes the loss of the littoral area around the shore, which dramatically alters the summer and fall rearing capacity of a lake. Extensive agricultural development occurs throughout the Fraser Plateau, most of which is related to beef cattle ranching and hay production. Most of the water demand is related to these agricultural activities. Within the Fraser Plateau, the major population centre is 100 Mile House. Residential and recreational housing is now developing from this centre out into the HMA. The main concerns are increased water demand and development of sub-divisions and recreational

property around lake shores. Protection of these aquatic environments is a key management issue, and is being actively pursued by the B.C. Ministry of Environment, Lands and Parks.

### **5.6.2 Management priorities**

There are a number of fisheries production objectives for resident species in this unit, ranging from protecting many lakes from logging and road access in order to maintain a wilderness experience and trophy fisheries, to establishing highly stocked put-and-take type fisheries. These issues are common to the whole area, but are more critical near 100 Mile House. In areas where lakes are subject to logging or recreational property development, lake shore management guidelines are being developed in order to protect viewscales and riparian habitat (Lurette, pers. comm.). A large portion of the sport fishery is dependent on hatchery stocking programs -- these systems are not quite as sensitive to land-based development.

Some of the specific areas of concern within this unit are caused by heavy agricultural water demands, especially in the Bridge and Bradley Creek areas. Bradley Creek is currently under application for a water reserve as a means of protecting the resident fishery. Moreover, forestry developments in the Eagle and Jim Creek watersheds are becoming a cause for concern. Residential developments and subdivisions, if not checked, will cause cumulative harm and result in eutrophication problems. The potential for long-term eutrophication problems is great, and the input of nutrients from agricultural, recreational and urban developments is a major concern. Baseline water chemistry data is presently being collected (Lurette, pers. comm.). Some of the lakes in this area, such as Bridge and Sheridan lakes, have very low turnover rates (100-250 years).

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## APPENDIX A - SALMON ESCAPEMENTS

### Tables

Sockeye escapements by year  
Sockeye escapements by cycle years  
Chinook escapements by year  
Coho escapements by year

### Bar Graphs

Sockeye escapements to Fennell Creek and Raft River, 1951 to 1992  
Chinook escapements to Clearwater and North Thompson rivers, 1951 to 1991  
Coho escapements to the North Thompson River, 1951 to 1991  
Coho escapements to Lemieux and Louis creeks, 1951 to 1991  
Coho escapements to Barriere River and Fennell Creek, 1951 to 1991  
Coho escapements to Dunn Creek, 1951 to 1991  
Coho escapements to Lion Creek, 1951 to 1991

Sockeye escapements to the North Thompson River system

Year	Barriere River	Clearwater River	Fennell Creek	N. Thompson River	Raft River	Total
1951	108	N/O	N/O	N/O	8,561	8,669
1952	N/O	N/O	N/O	N/O	15,617	15,617
1953	N/O	N/O	N/O	N/O	7,909	7,909
1954	N/O	N/O	N/O	N/O	9,995	9,995
1955	97	N/O	N/O	N/O	5,081	5,178
1956	2	N/O	N/O	N/O	9,037	9,039
1957	38	N/O	N/O	N/O	6,881	6,919
1958	N/O	N/O	5	N/O	10,215	10,220
1959	203	N/O	27	N/O	10,210	10,440
1960	23	N/O	N/O	1,208	5,553	6,784
1961	335	N/O	N/O	225	7,301	7,861
1962	14	N/O	N/O	90	7,613	7,717
1963	92	N/O	439	70	8,724	9,325
1964	85	N/O	146	38	5,201	5,470
1965	104	N/O	N/O	N/O	6,624	6,728
1966	4	N/O	N/O	46	6,250	6,300
1967	16	N/O	920	N/O	1,303	2,239
1968	275	N/O	954	N/O	8,121	9,350
1969	40	N/O	52	N/O	5,593	5,685
1970	2	N/O	9	270	4,474	4,755
1971	5	N/O	1,300	888	840	3,033
1972	94	342	1,931	465	11,151	13,983
1973	22	N/O	205	N/O	2,729	2,956
1974	4	N/O	243	343	2,396	2,986
1975	N/O	N/O	4,127	123	2,664	6,914
1976	85	N/O	4,090	500	8,684	13,359
1977	16	N/O	355	1,372	648	2,391
1978	N/O	N/R	675	N/O	2,500	3,175
1979	N/O	18	15,590	1,009	1,780	18,387
1980	133	4	8,437	36	5,418	14,028
1981	N/O	N/O	2,113	N/O	873	2,999
1982	N/O	N/O	1,139	N/O	2,992	4,131
1983	N/O	N/O	5,018	750	2,857	8,625
1984	86	18	11,021	31	19,098	30,366
1985	N/O	N/O	1,620	1,883	3,638	7,141
1986	20	N/O	6,120	72	2,120	8,338
1987	75	N/O	16,871	800	1,512	19,258
1988	452	N/O	26,932	550	19,857	47,791
1989	0	N/O	4,037	180	1,647	5,864
1990	100	N/O	11,898	N/O	630	12,628
1991	293	N/O	20,466	N/O	464	21,311
1992	250	N/O	9,174	171	8,242	18,055
Average						
1951-60	79	N/O	16	1,208	8,906	9,077
1961-70	97	N/O	420	123	6,120	6,543
1971-80	51	121	3,695	592	3,881	8,122
1981-90	73	2	8,065	427	5,522	14,714

Summary of escapements to major sockeye spawning streams in the North Thompson, by the four cycle years (\* denotes the dominant cycle year)

YEAR	SOCKEYE ESCAPEMENTS					RAFT
	N.THOMPSON	BARRIERE	FENNELL	CLEARWATER		
1951			0		0	
1955	0	97	0		0	5,081
1959	0	203	27		0	10,210
1963	70	92	439		0	8,724
1967	0	16	920		0	1,303
1971	888	5	1,330		0	840
1975	123	75	4,127		0	840
1979	1,009	40	15,590		0	2,857
1983	750	0	5,018		0	2,857
1987	800	75	16,871		0	1,512
1991		293	20,466			464
1952*					0	
1956		2	0		0	9,037
1960	1,208	23	0		0	5,553
1964	38	85	146		0	5,201
1968	0	275	954		0	8,121
1972	465	94	1,931	342		11,151
1976	500	85	4,090		0	8,684
1980	36	133	8,437		4	5,418
1984	31	86	11,021		18	19,098
1988	550	277	26,932		200	19,857
1992	171	250	9,174			8,242
1953	0	0	0		0	7,909
1957	0	38	0		0	6,881
1961	225	335	0		0	7,301
1965	72	104	0		0	6,624
1969	0	40	52		0	5,593
1973	0	22	205		0	2,729
1977	1,372	16	355		0	648
1981	600	0	2,113		0	873
1985	1,883	40	1,620		0	3,638
1989	100	16	858		0	1,907
1954		0	0		0	9,995
1958		0	5		0	10,215
1962	90	14	0		0	7,613
1966	46	4	0	25		6,250
1970	270	2	9		0	4,474
1974	343	4	243		0	2,396
1978	200	0	675		0	2,500
1982	0	0	1,139		1	2,992
1986	72	20	6,120		0	2,126
1990		100	11,898		0	630

# Chinook escapements to the North Thompson River system

Year	Barriere River	Blue River	Clearwater River	Dunn Creek	Finn Creek	Lemieux Creek	Lion Creek	Louis Creek	McTaggart Creek	Mad River	Mahood River	Mann Creek	Raft River	North Thompson River	Total
1951	75	N/R	1,500	N/R	400	75	N/R	200	N/R	25	N/R	N/R	400	750	3,425
1952	N/R	N/R	200	N/R	400	25	N/R	200	N/R	N/R	N/R	N/R	400	400	1,625
1953	400	N/R	N/R	N/R	3,500	400	N/R	750	N/R	N/R	N/R	N/R	1,500	3,500	10,050
1954	25	N/R	N/R	N/R	1,500	200	N/R	750	N/R	N/R	N/R	N/R	200	3,500	6,175
1955	400	N/R	1,500	N/R	400	N/O	N/R	400	N/R	N/R	N/R	25	400	N/R	3,125
1956	N/O	N/R	N/R	N/R	1,500	N/O	N/R	400	N/R	N/R	N/R	N/R	400	N/O	2,300
1957	25	N/R	3,500	N/R	1,500	75	N/R	400	N/R	N/R	N/R	N/R	1,500	N/R	7,000
1958	25	N/R	3,500	N/R	1,500	25	N/R	750	N/R	N/R	N/R	N/R	200	N/R	6,000
1959	200	N/R	1,500	N/R	750	N/O	N/R	750	N/R	N/R	N/R	N/R	400	250	3,850
1960	25	N/R	629 a	N/R	25	25	N/R	400	N/R	N/R	N/R	N/R	200	1,750 b	2,954
1961	25	N/R	6,500 b	N/R	22	N/O	N/R	400	N/R	N/R	N/R	N/R	200	1,750 b	7,897
1962	75	N/R	4,500 b	N/R	750	75	N/R	400	N/R	N/R	N/R	N/R	200	1,500 b	7,500
1963	75	N/R	1,500	N/R	750	N/O	N/R	400	N/R	N/R	N/R	N/R	200	N/R	2,925
1964	200	N/R	750	N/R	200	N/O	N/R	75	N/R	N/R	N/R	N/R	400	2,500	4,125
1965	400	N/R	750	N/R	750	N/O	N/R	N/O	N/R	N/R	N/R	N/R	750	3,500	6,150
1966	25	N/R	1,500	N/R	400	N/O	N/R	25	N/R	N/R	N/R	N/R	400	1,500	3,850
1967	N/O	N/R	1,500	N/R	500	N/O	N/R	100	N/R	N/R	N/R	N/R	200	1,500	3,800
1968	N/O	N/R	750	N/R	500	N/O	N/R	75	N/R	N/R	N/R	25	25	750	2,125
1969	50	N/R	1,500	N/R	750	N/O	25	25	N/R	N/R	N/R	N/R	200	1,500	4,050
1970	25	N/R	1,500	N/R	750	N/O	N/R	25	N/R	N/R	200	N/R	75	1,500	4,075
1971	10	N/R	1,500	N/R	750	N/O	N/R	200	N/R	N/R	136	N/R	200	1,000	3,796
1972	50	N/R	1,200	N/R	300	25	25	200	N/R	N/R	150	N/R	250	1,400	3,600
1973	N/O	N/R	1,500	N/R	500	N/O	N/R	50	N/R	N/R	500	N/R	260	1,000	3,810
1974	10	N/R	1,200	N/R	650	N/O	N/R	40	N/R	N/R	300	N/R	140	1,000	3,340
1975	10	N/R	1,200	N/R	296	N/O	N/R	54	N/R	N/R	179	N/R	121	750	2,610
1976	75	N/R	1,550	N/R	400	25	25	200	25	N/R	200	N/R	250	2,500	5,250
1977	10	N/R	2,750	N/R	525	N/O	N/R	60	N/R	N/R	425	N/R	230	2,250	6,250
1978	10	N/R	3,000	N/R	700	N/O	30	75	N/R	N/R	450	N/R	200	2,500	6,965
1979	15	15	1,500	N/R	425	N/O	N/R	20	N/R	N/R	260	N/R	175	1,200	3,610
1980	15	20	2,500	N/R	600	10	2	45	10	N/R	150	N/R	200	750	4,302
1981	100	N/O	3,000	N/R	1,000 c	15	N/O	110	N/R	N/R	200	N/R	200	2,250	6,875
1982	N/O	N/R	3,000	N/R	850	5	15	150	N/R	N/R	250	12	375	2,500	7,157
1983	65	N/R	4,000	N/R	700	10	N/O	20	N/R	N/R	300	2	175	2,500	7,772 d
1984	75	15	2,800	N/R	1,500	11	2	100	N/R	N/R	400	N/R	500	1,200	6,603
1985	50	75	3,800	N/R	1,300	25	N/O	250	N/R	N/R	250	N/R	525	1,500	7,775
1986	5	20	5,500	5	1,300	25	15	150	N/R	N/R	500	N/R	700	2,500	10,720
1987	50	50	3,000	N/O	1,300	N/O	N/O	25	N/O	N/R	300	N/O	650	2,500	7,875
1988	100	55	6,300	12	1,600	10	N/O	80	N/R	N/R	700	N/R	800	2,000	11,657
1989	260	20	2,200	4	900	10	N/O	325	N/R	N/R	180	N/R	700	1,000	5,599
1990	100	30	7,320	N/R	1,100	N/O	10	50	N/R	N/R	500	10	650	1,500	11,170
1991	50	N/O	2,219	N/R	460	N/O	12	10	N/R	N/R	20	N/O	355	2,183	5,309
Average															
1951-60	147	N/R	1,747	N/R	1,148	118	N/R	500	N/R	25	N/R	25	560	1,915	4,650
1961-70	109	N/R	1,975	N/R	537	75	25	169	N/R	N/R	200	25	265	1,600	4,650
1971-80	23	18	1,790	N/R	515	20	21	94	18	N/R	275	N/R	203	1,435	4,353
1981-90	81	33	4,092	5	1,155	11	4	126	0	N/R	358	0	518	1,945	8,320

a. Chatwin et al 1961  
 b. Chatwin et al 1962

c. Scott et al 1982a  
 d. Includes 10 in Dunn Creek.

## Coho escapements to the North Thompson River system

Year	Barriere River System						Clearwater System					Dunn System			
	Albreda River	Avola River	Barriere River	E Barriere River	Pennell Creek	Haggard Creek	Blue River	Cedar Creek	Clearwater C	Brookfield C	Maheod River	Cook Creek	Crossing C	Dunn Creek	McHugh C
1951	N/R	N/R	400	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	400	N/R
1952	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
1953	N/R	N/R	750	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
1954	N/R	N/R	200	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
1955	N/R	N/R	1,500	N/R	N/R	N/R	N/R	N/R	3500	N/R	N/R	N/R	N/R	N/R	N/R
1956	N/R	N/R	750	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
1957	N/R	N/R	25	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
1958	N/R	N/R	750	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
1959	N/R	N/R	750	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
1960	N/R	N/R	200	N/R	N/R	N/R	N/R	N/R	28	N/R	N/R	N/R	N/R	N/R	N/R
1961	N/R	N/R	750	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	25	N/R
1962	N/R	N/R	750	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/O	N/R
1963	N/R	N/R	75	N/R	N/O	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/O	N/R
1964	N/R	N/R	400	N/R	N/O	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/O	N/R
1965	N/R	N/R	1,500	N/R	750	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	750	N/R
1966	N/R	N/R	400	N/R	25	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	200	N/R
1967	N/R	N/R	200	N/R	N/O	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	200	N/R
1968	N/R	N/R	400	N/R	200	N/R	N/R	N/R	N/R	75	N/R	N/R	N/R	75	N/R
1969	N/R	N/R	750	N/R	200	N/R	N/R	N/R	N/R	25	N/R	N/R	N/R	200	N/R
1970	N/R	N/R	750	N/R	1,500	N/R	N/R	N/R	N/R	25	N/R	N/R	N/R	750	75
1971	N/R	N/R	463	191	432	N/R	N/R	N/R	N/R	2	N/R	N/R	N/R	310	32
1972	N/R	N/R	400	75	750	N/R	N/R	N/R	N/R	25	N/R	N/R	N/R	367	65
1973	N/R	N/R	350	65	120	N/R	N/R	N/R	2,000	N/R	N/R	N/R	N/R	500	50
1974	6	N/R	620	40	290	N/R	300	N/R	2,000	N/R	35	N/R	N/R	390	2
1975	N/R	N/R	300	60	90	N/R	250	N/R	400	N/R	25	N/R	N/R	350	20
1976	N/R	N/R	300	25	75	N/R	25	N/R	N/R	N/R	N/R	N/R	N/R	400	20
1977	440	N/R	420	18	380	N/R	510	15	1,500	N/R	10	N/R	N/R	530	65
1978	180	5	400	110	360	N/R	600	15	400	N/R	12	60	N/R	700	80
1979	290	N/O	400	120	600	30	600	175	400	N/R	5	60	N/R	400	40
1980	325	N/O	50	25	40	5	300	40	100	N/R	N/O	10	N/R	210	10
1981	500	N/O	350	60	100	N/O	300	30	200	N/R	N/O	45	N/R	550	35
1982	550	N/O	450	75	450	25	450	30	200	N/R	N/O	50	N/R	500	35
1983	1,000	40	250	100 n	496 a	N/O	350	90	N/R	N/R	N/O	100	40	149 a	15
1984	N/O	N/O	714 n	239 n	534 a	1	N/O	N/O	N/R	N/R	N/O	N/O	N/O	1050 a	20
1985	N/R	N/R	360 b	180 b	534 c	N/R	N/O	N/O	N/R	N/R	N/O	N/O	N/O	868 b	65
1986	N/R	N/R	100	250	1,250	5	N/O	N/O	50	N/R	5	55	10	425	60
1987	800	N/O	500	N/O	500	N/O	500	80	50	N/R	N/R	200	5	1,250	N/O
1988	850	N/O	600	225	800	N/R	250	N/R	150	N/R	N/O	25	10	700	20
1989	2,300	N/O	175	160	60	4	450	60	120	N/R	N/O	70	N/O	375	N/R
1990	800	10	N/R	N/R	200	N/R	50	20	100	N/R	N/R	100	N/R	1,400	N/R
1991	50	20	N/R	N/R	N/R	N/R	20	N/O	N/O	N/R	N/R	10	N/R	1,574	N/R
Average															
1951-60	N/R	N/R	592	N/R	N/R	N/R	N/R	N/R	1,764	N/R	N/R	N/R	N/R	400	N/R
1961-70	N/R	N/R	598	N/R	535	N/R	N/R	N/R	N/R	42	N/R	N/R	N/R	314	75
1971-80	230	6	371	73	308	18	369	61	971	14	17	43	N/R	416	38
1981-90	850	6	389	143	500	5	235	34	124	N/R	1	66	9	727	31

n Systematic survey (Jarvis and Stewart 1985).

b Systematic survey (unpublished).

c Fence count (unpublished).

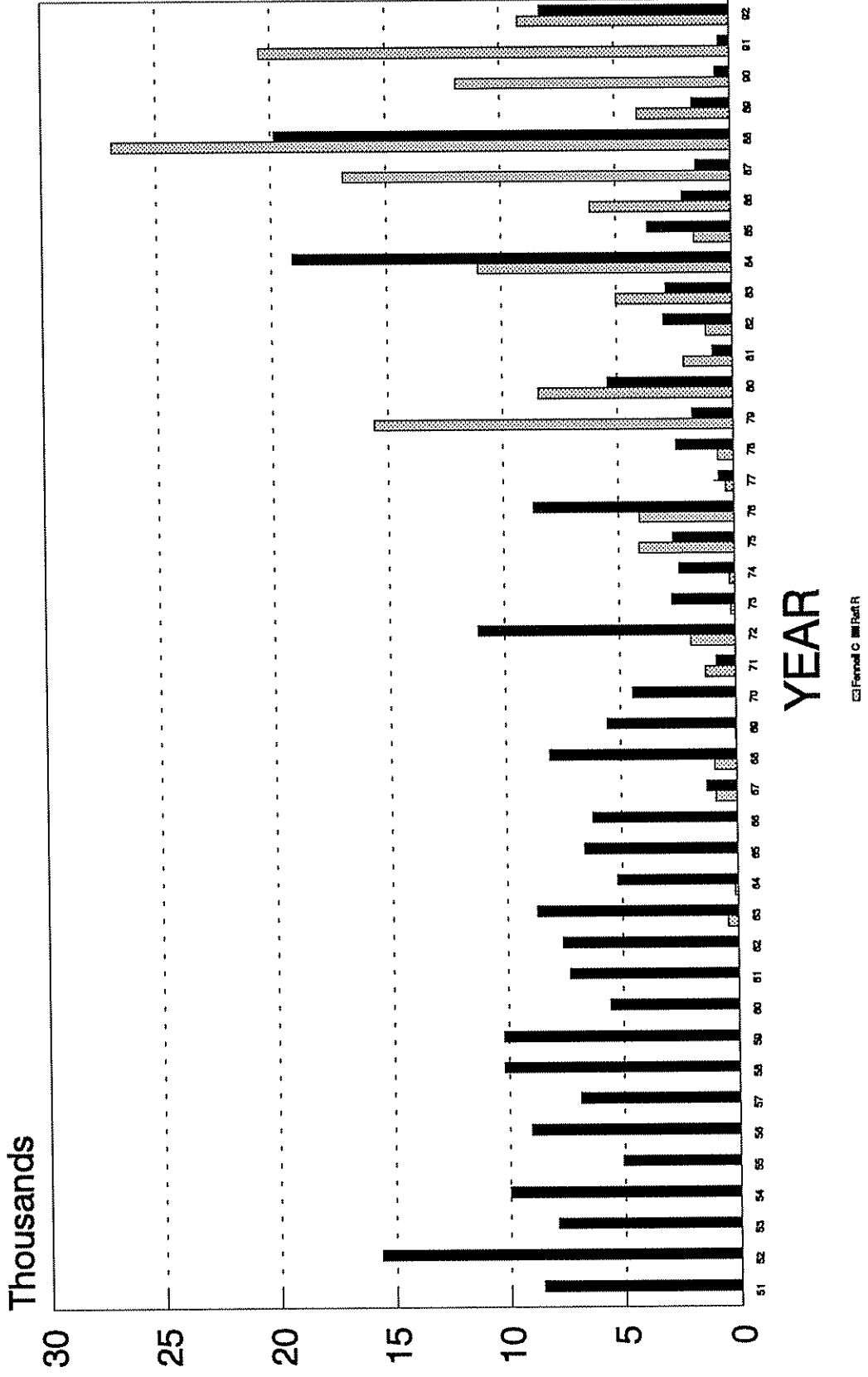
Coho escapements to the North Thompson River System, continued

Year	Finn Creek	Goose Creek	Lemieux Creek	Lion Creek	Louis Creek	Mad River	Mann Creek	Raft River	Reg Christie Creek	North Thompson River	Tumtum Creek	Wire Cnche Creek	Total
1951	200	N/R	75	400	400	25	N/R	200	N/R	N/R	N/R	N/R	2,100
1952	N/R	N/R	1,500	N/R	1,500	75	400	3,500	200	N/R	N/R	N/R	7,175
1953	3,500	N/R	3,500	1,500	1,500	N/R	N/R	750	200	1,500	N/R	N/R	13,200
1954	N/O	N/R	1,500	400	3,500	N/R	N/R	N/R	N/R	1,500	N/R	N/R	7,100
1955	N/O	N/R	3,500	200	7,500	N/R	200	1,500	75	N/R	N/R	N/R	17,975
1956	N/O	N/R	750	N/O	750	N/R	N/O	200	200	N/R	N/R	N/R	2,650
1957	N/R	N/R	750	200	750	N/R	N/O	1,500	25	N/R	N/R	N/R	3,250
1958	N/R	N/R	75	200	750	N/R	N/O	75	N/O	N/R	N/R	N/R	1,850
1959	N/R	N/R	400	400	400	N/R	200	200	200	N/R	N/R	N/R	2,650
1960	N/R	N/R	400	3,500	1,500	N/R	N/O	25	N/O	N/R	N/R	N/R	5,653
1961	200	N/R	1,500	7,500	1,500	N/R	200	750	N/O	N/R	N/R	N/R	12,425
1962	200	N/R	750	7,500	1,500	N/R	75	75	N/O	N/R	N/R	N/R	10,850
1963	200	N/R	200	1,500	750	N/R	25	25	N/O	N/R	N/R	N/R	2,775
1964	75	N/R	750	3,500	200	N/R	25	1,500	N/O	N/R	N/R	N/R	6,450
1965	1,500	N/R	3,500	1,500	1,500	N/R	400	1,500	N/O	750	N/R	N/R	13,650
1966	400	N/R	1,500	750	750	N/R	200	750	200	N/R	N/R	N/R	5,175
1967	200	N/R	750	500	400	N/R	N/O	200	N/O	N/R	N/R	N/R	2,450
1968	400	N/R	750	1,000	1,500	N/R	75	750	75	N/R	25	N/R	5,325
1969	400	N/R	1,500	1,500	1,500	N/R	25	750	25	N/R	75	N/R	6,950
1970	200	N/R	1,500	1,500	1,500	N/R	75	750	25	N/R	N/O	N/R	8,650
1971	179	N/R	1,500	1,810	3,327	N/R	143	750	17	N/R	42	N/R	9,198
1972	25	N/R	400	650	2,500	N/R	25	550	25	200	30	N/R	6,087
1973	50	N/R	725	2,250	700	N/R	90	450	30	N/R	65	N/R	7,445
1974	90	N/R	850	700	4,000	N/R	55	700	N/O	2,000	6	N/R	12,084
1975	15	N/R	400	600	1,200	N/R	8	500	N/O	1,500	6	N/R	5,724
1976	10	N/R	200	550	1,100	N/R	25	350	60	N/R	N/O	N/R	3,130
1977	6	N/R	650	650	2,200	N/R	60	350	8	1,500	10	N/R	9,322
1978	100	N/R	600	2,300	1,300	N/R	20	250	20	300	10	N/R	7,762
1979	15	N/R	200	250	1,400	N/R	N/O	120	5	125	4	N/R	5,149
1980	25	N/R	180	300	700	N/R	20	90	10	100	4	N/R	2,554
1981	110	N/R	550	700 a	950 a	N/R	N/O	110	15	300	N/O	N/R	4,905
1982	25	N/R	400	1,200	750	N/R	20	200	15	90	25	100	5,640
1983	450	20	295 b	1,000	200	N/R	45	250	5	125	50	150	5,221
1984	N/R	N/R	1,528 b	1,150	700	N/R	110	900	25	700	25	N/O	7,769
1985	N/R	N/R	377 a	1,100	650 c	N/R	N/R	N/R	N/O	100	25	25	4,295
1986	200	N/R	850	1,500	1,000	N/R	60	800	25	500	80	45	7,380
1987	280	N/R	N/O	500	1,525	N/R	60	400	N/O	500	N/O	N/O	7,070
1988	450	N/R	950	1,500	600	N/R	60	650	15	600	N/O	60	8,515
1989	150	N/R	600	650	500	N/R	15	170	22	680	25	130	6,716
1990	20	N/R	600	600	110	N/R	N/R	50	200	774	26	50	5,110
1991	N/O	N/R	1,408	230	416	N/R	N/R	200	24	667	N/O	N/O	4,619
Average													
1951-60	1,850	N/R	1,245	850	1,855	50	267	883	150	1,500	N/R	N/R	6,350
1961-70	378	N/R	1,270	2,675	1,110	N/R	122	705	81	750	50	N/R	7,470
1971-80	52	N/R	571	1,006	1,843	N/R	50	411	21	818	20	N/R	6,816
1981-90	201	10	615	1,000	700	N/R	46	392	32	437	26	62	6,262

a Systematic survey (Jarvis and Stewart 1985)

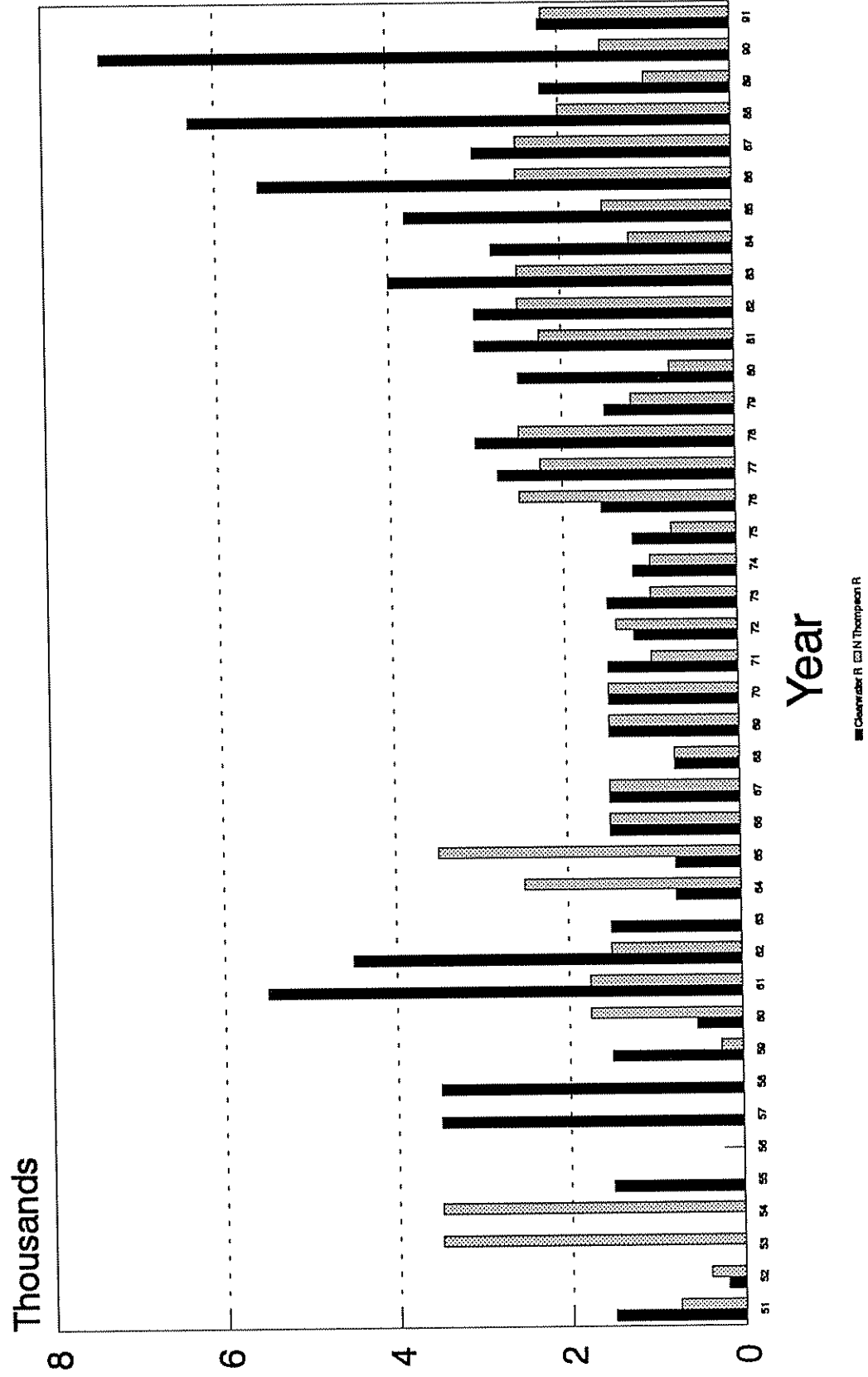
b Systematic survey (unpublished)

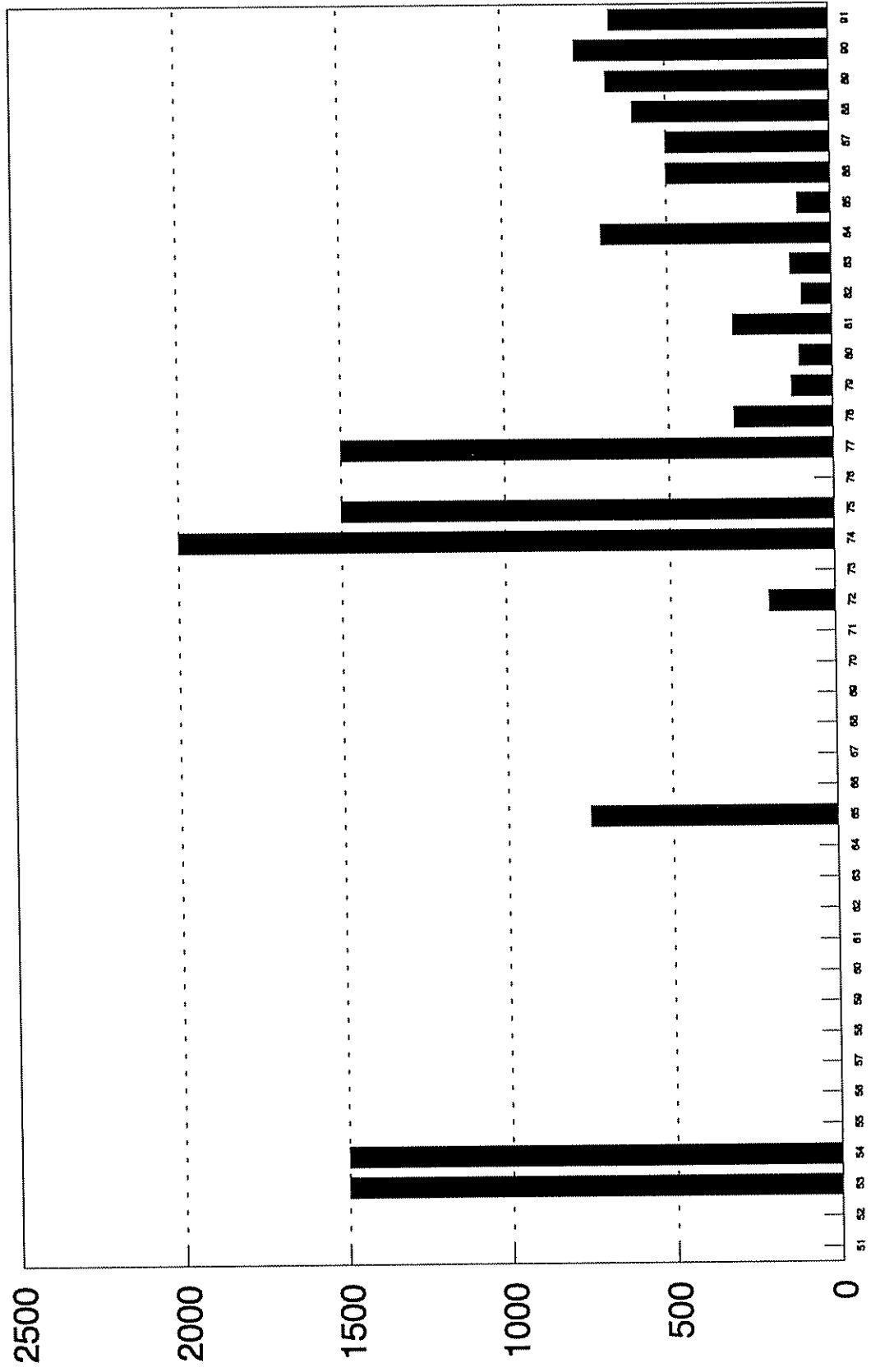
c Fence count (unpublished)



Sockeye escapements to Fennell Creek and Raft River, 1951 to 1992

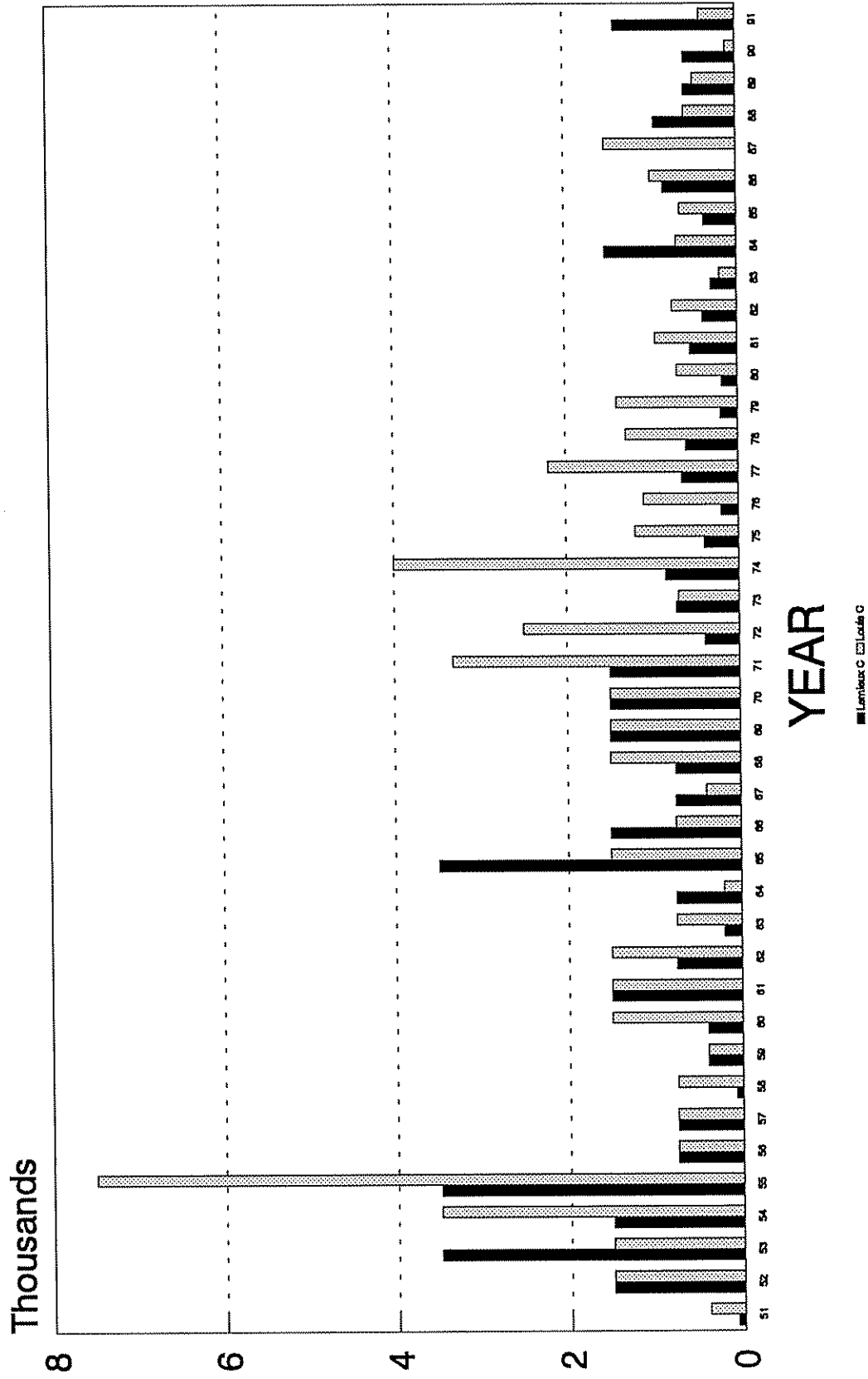
Chinook escapements to Clearwater and North Thompson rivers, 1951 to 1991

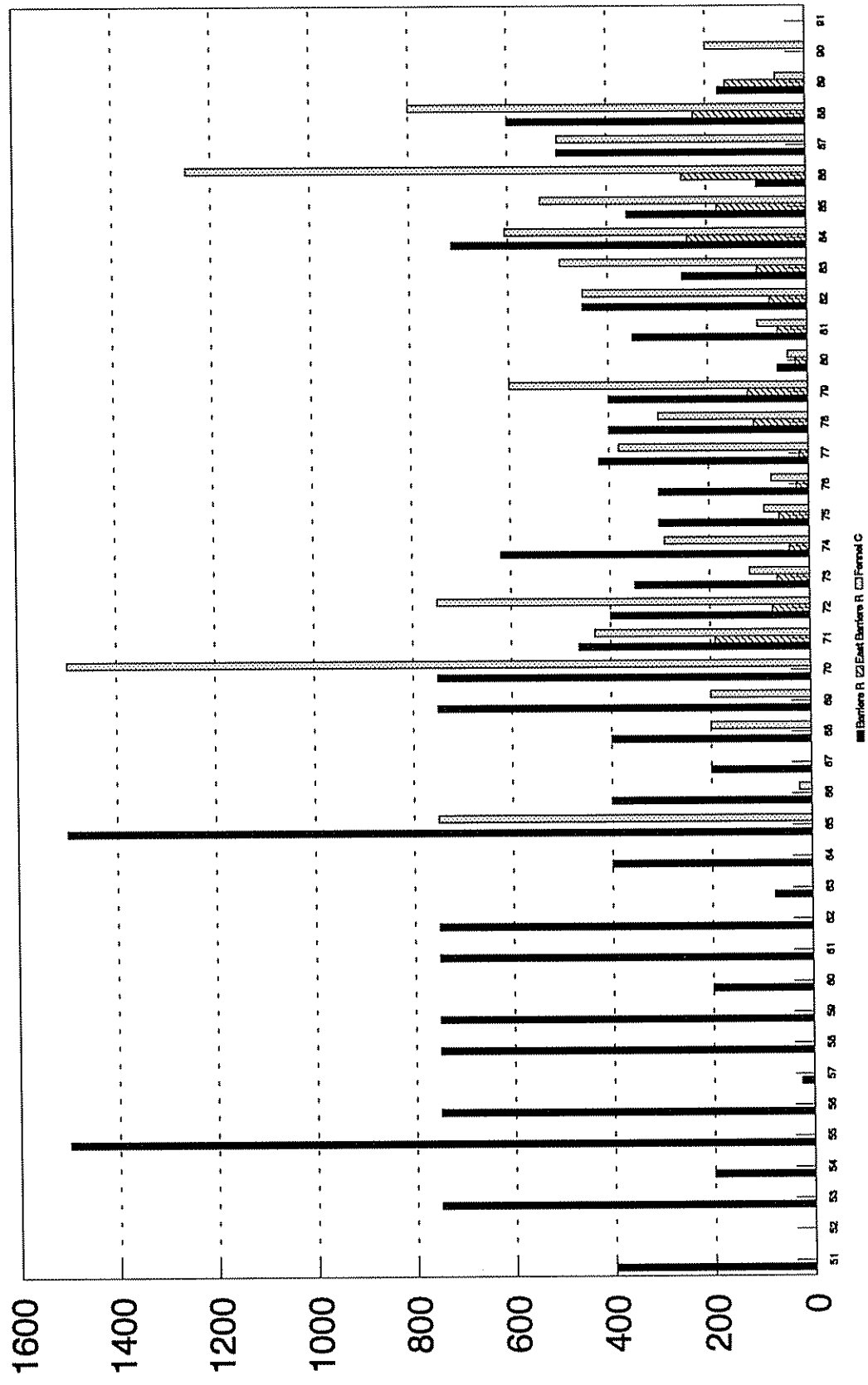




Coho escapements to the North Thompson River, 1951 to 1991

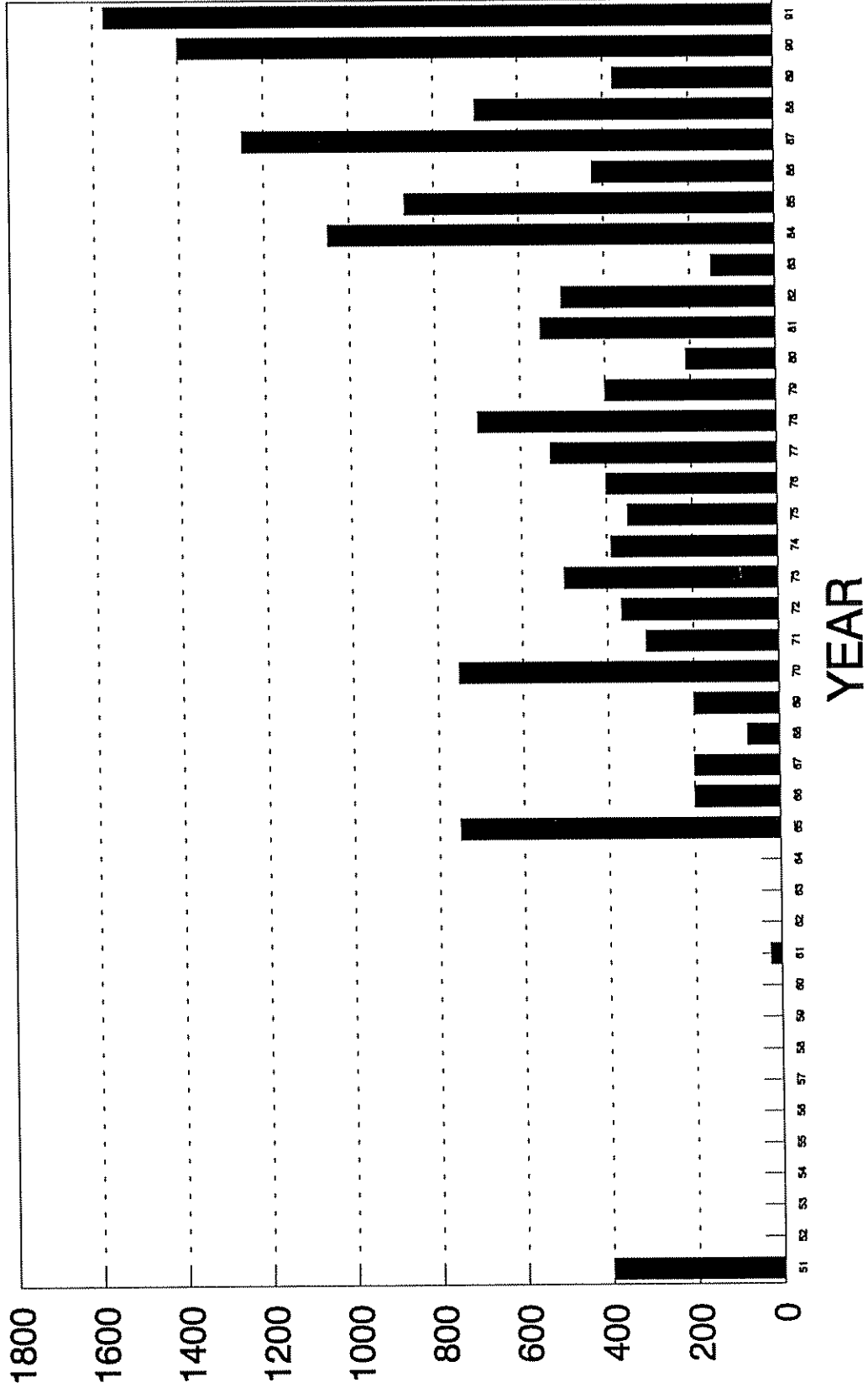
Coho escapements to Lemieux and Louis creeks, 1951 to 1991

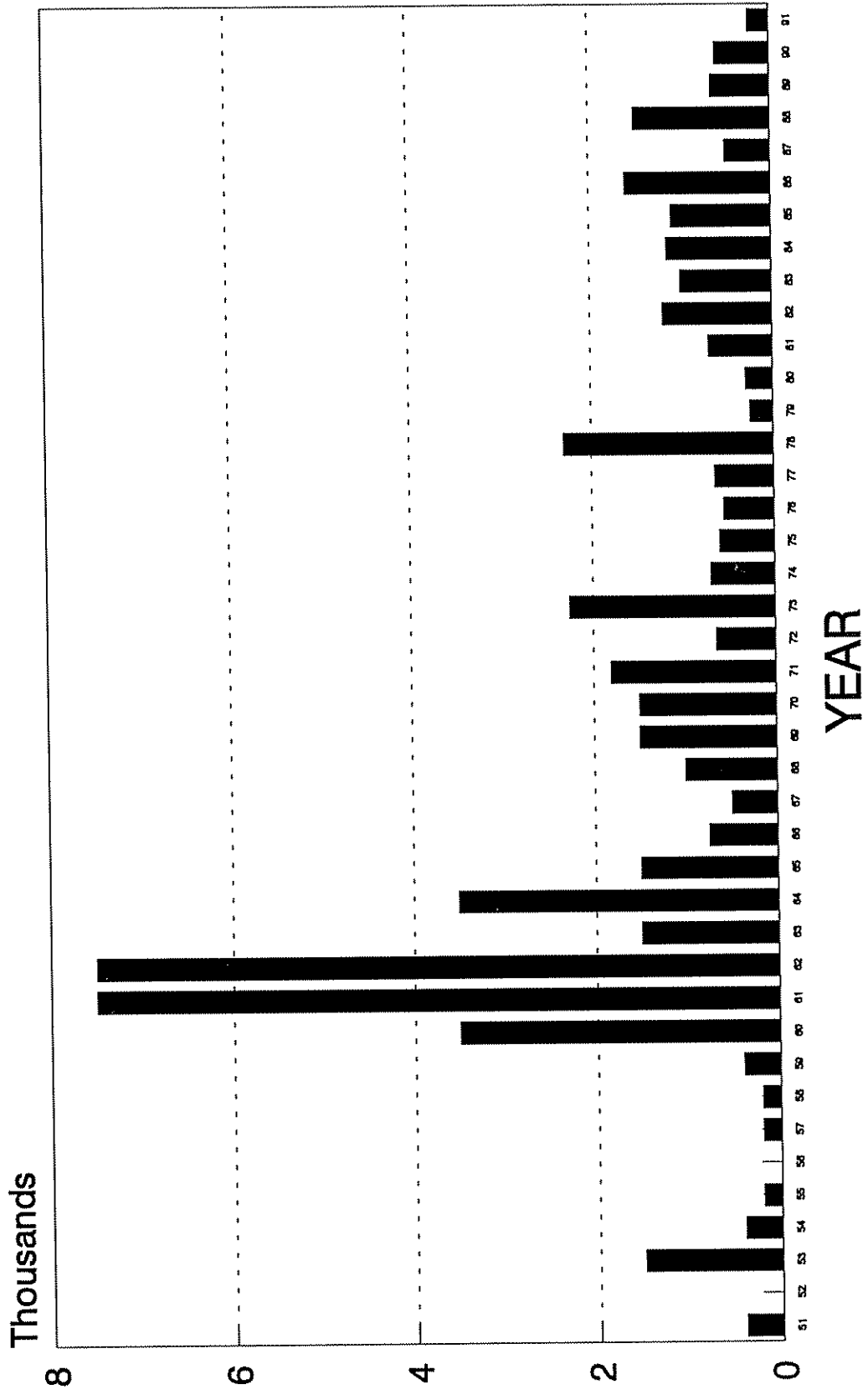




Coho escapements to Barrier River and Fennell Creek, 1951 to 1991

Coho escapements to Dunn Creek, 1951 to 1991





Coho escapements to Lion Creek, 1951 to 1991

## **APPENDIX B - PHYSIOGRAPHIC AND BIOGEOCLIMATIC DESCRIPTIONS**

Physiographic unit descriptions  
Biogeoclimatic zone descriptions  
Ecoprovinces of British Columbia

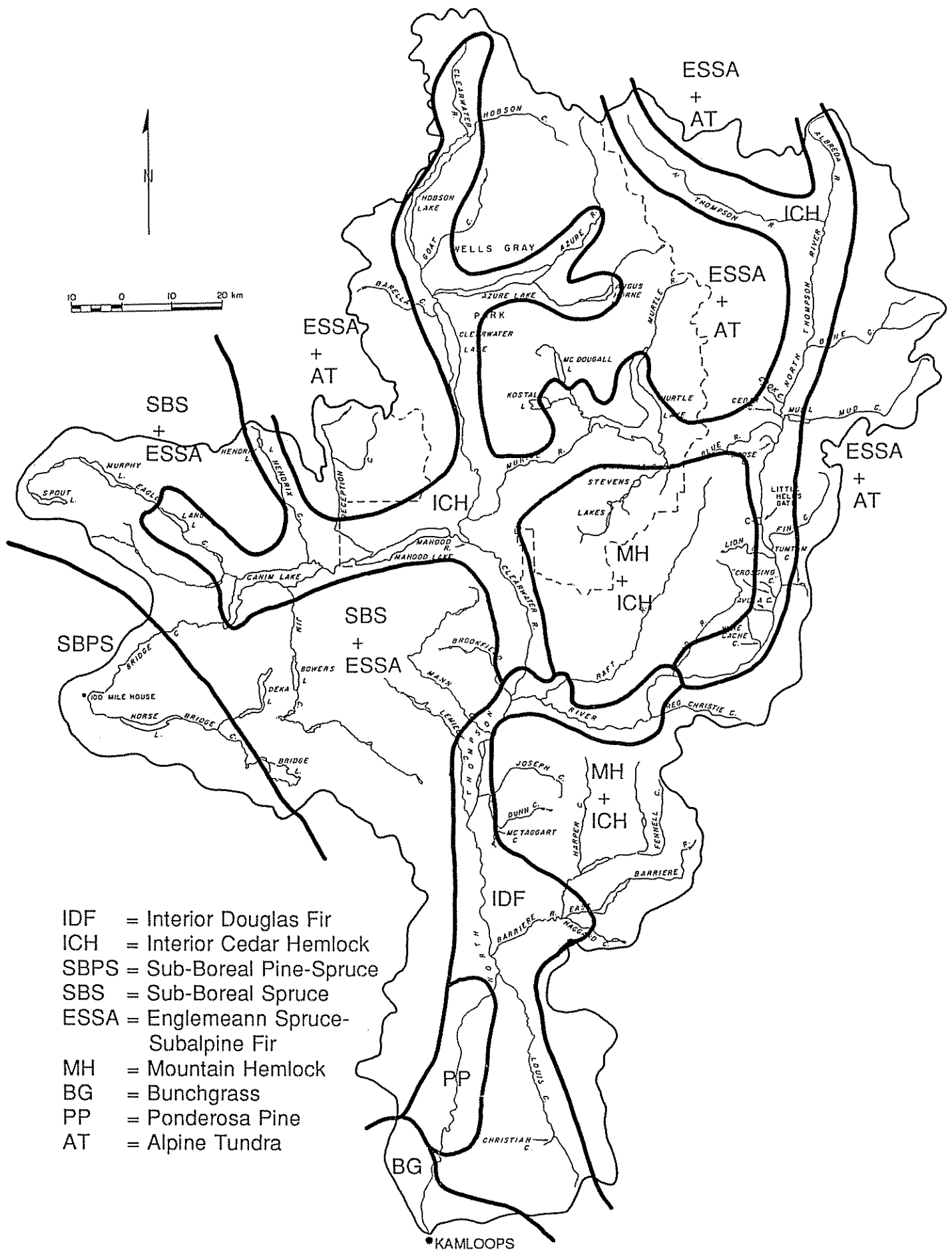


**Physiographic Unit Descriptions**

<p><b>Thompson Plateau</b></p>	<p>This unit forms a gradual transition into the Shuswap Highlands to the east, and the Fraser Plateau to the west. The unit encompasses the lower reaches of the North Thompson River and the mainstem Thompson River, from its Fraser River confluence upstream along the South Thompson, mid-way between Kamloops and Shuswap Lake.</p> <p>The unit is characterized by a gently rolling upland with low relief between elevations of 1200 and 1500 m. Glaciation has left a thick mantle of drift material over bedrock and there are numerous drumlin-like formations created by ice movement. There are extensive deposits of white silt visible along the river valleys that are remnants of former glacial lakes, although now only a moderate number of small lakes are found throughout this unit.</p> <p>Within this unit, the mainstem North Thompson is bounded by benches. Tributaries to the North Thompson generally emerge from the highlands, cutting through steep benches above the mainstem river valleys. Gulling and localized stream bank erosion are common.</p> <p>This unit contains the three driest biogeoclimatic units in the entire HMA.</p> <p>Salmon spawning streams in this unit are <b>Louis, Christian, Lemieux</b> and <b>Mann</b> creeks.</p>
<p><b>Fraser Plateau</b></p>	<p>This unit lies to the west of the Thompson Plateau. The upper reaches of the Mahood system and the Canim Lake drainage are located in this unit.</p> <p>The unit has a low, gently rolling relief between elevations of 1200 and 1600 m. Unlike the Thompson plateau, the unit is undissected and there are no high benches. There are volcanic formations throughout much of the area and steep escarpments along the drainages are common. Glacial drift has been deposited over most of the plateau, with only minor outcrops of bedrock. Eskers and drumlin-like formations provide most of the relief.</p> <p>Valley walls tend to be relatively stable in this unit, due to the low relief. Similarly, drainage channels are of low gradient with low to moderate incidence of bank erosion along the valley bottoms.</p> <p>There are no salmon streams in this unit. The major streams are <b>Bridge</b> and <b>Canim</b> creeks.</p>

<p><b>Shuswap Highlands</b></p>	<p>This is the largest physiographic unit in the HMA. It is clearly bounded to the east by the Monashee Mountains, with a more gradual transition to the Thompson Plateau in the west. The northern section is bounded by the Quesnel Highland and Cariboo Mountain land units.</p> <p>Elevations are between 1500 and 2100 m with a gentle to moderate sloping relief. The plateau is dissected by the Clearwater and North Thompson rivers. Glaciation has rounded the mountainous areas, resulting in moderate upland relief. Valley walls are commonly steep due to glaciation.</p> <p>Instability along the lower valley walls is common in this region. The valley walls are generally more stable in the headwater areas.</p> <p>Salmon spawning streams in this unit are <b>Fennell, Haggard, Dunn, Joseph, McTaggart, Brookfield, Reg Christie, Wire Cache, Avola, Crossing, Tumtum, Lion and Finn</b> creeks, and <b>Barriere, East Barriere, Clearwater, Mahood and Raft</b> rivers.</p>
<p><b>Monashee Mountains</b></p>	<p>This unit includes only the northeast corner of the North Thompson HMA.</p> <p>The area has a high relief with elevations of between 1700 and 3000 m, and is mountainous, with sharp peaks and jagged ridges. Cirque glaciation has occurred throughout the area. Peaks in the southern portion are somewhat rounded compared to those in the northern portion.</p> <p>Lakes are not prevalent in this land unit; high elevation cirque lakes are most common. Valley walls are steep and precipitous, and there is evidence of numerous slides and avalanche areas. Valley bottoms tend to be moderately confined by the valley walls, with a moderate degree of stream instability.</p> <p>Salmon spawning streams in this unit are the <b>Albreda and North Thompson</b> rivers.</p>

<p><b>Cariboo Mountains</b></p>	<p>This unit is bounded to the east by the Monashee Mountains, to the south by the Shuswap Highlands and to the west by the Quesnel Highlands. The upper North Thompson mainstem and Clearwater drainages originate in this unit.</p> <p>The area is characterized by steep, jagged mountain ranges lying north and south between elevations of 2400 to 3300 m; Mount Sir Wilfred Laurier (3560 m), located at the headwaters of the North Thompson River, is the highest peak.</p> <p>The valleys have been well glaciated, resulting in moderately steep valley walls; valley wall slopes tend to be relatively stable. Valley bottoms are generally wide, with a moderate degree of lateral channel movement, and associated erosional processes are evident.</p> <p>Salmon spawning streams in this unit are <b>Blue, Cedar, Cook and Goose</b> creeks.</p>
<p><b>Quesnel Highlands</b></p>	<p>This unit lies northwest of the Shuswap Highland and is bordered to the east by the Cariboo Mountains. Eastern tributaries and drainages to the north side of Mahood Lake originate in this unit.</p> <p>The area has a moderate relief between elevations of 1500 and 2000 m. The summits are typically rounded from glaciation, with steep valley walls. Steep, unstable areas and slides are typical on many valley wall slopes. Valley bottoms tend to be narrower than in the adjoining Cariboo Mountain unit and there is a lower degree of lateral channel activity.</p> <p>The salmon spawning stream in this unit is the <b>Upper Clearwater River</b> and trout streams are <b>Deception</b> and <b>Hendrix</b> creeks.</p>



- IDF = Interior Douglas Fir
- ICH = Interior Cedar Hemlock
- SBPS = Sub-Boreal Pine-Spruce
- SBS = Sub-Boreal Spruce
- ESSA = Englemeann Spruce-Subalpine Fir
- MH = Mountain Hemlock
- BG = Bunchgrass
- PP = Ponderosa Pine
- AT = Alpine Tundra

Generalized biogeoclimatic zones of the North Thompson HMA

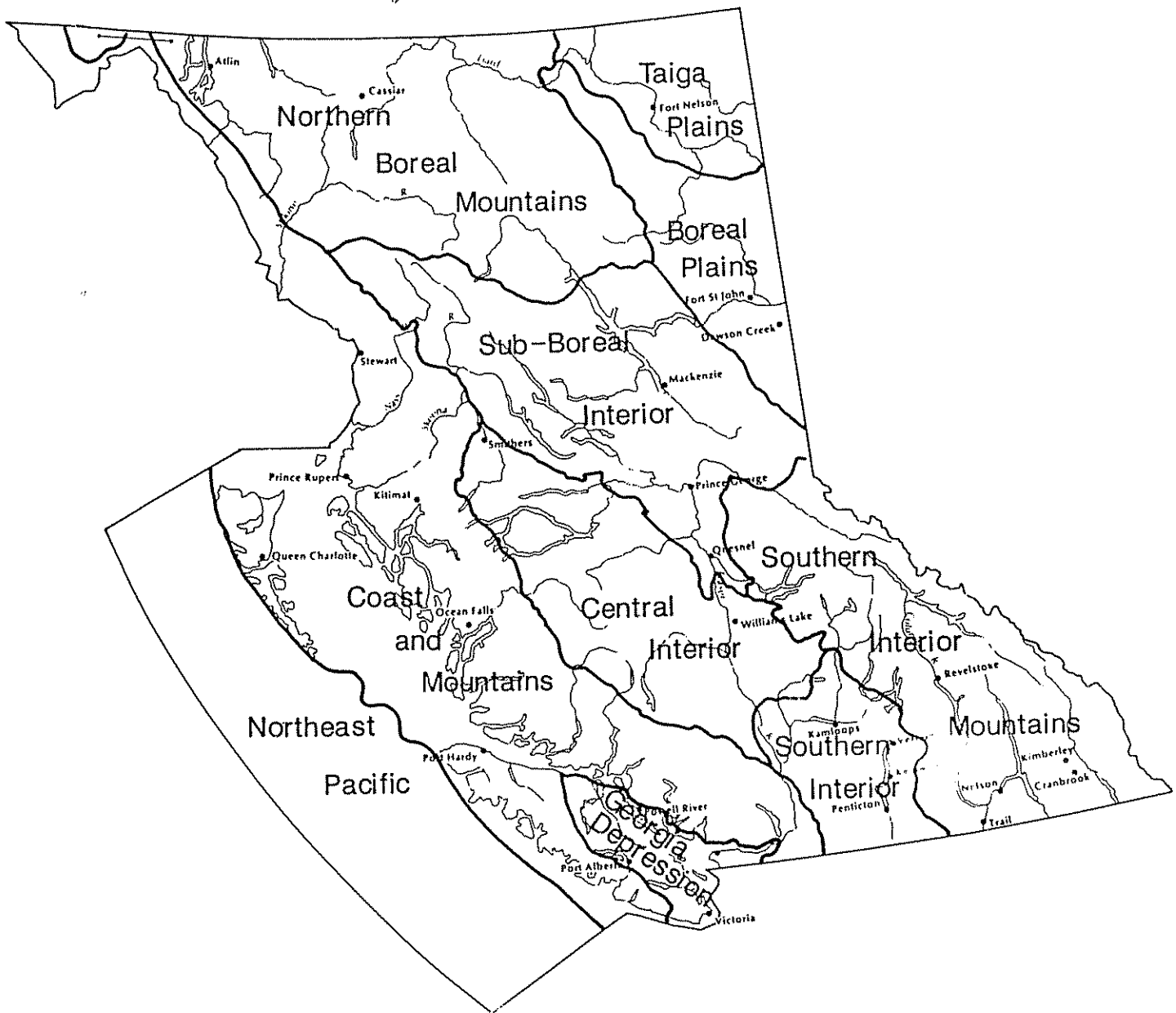
## Biogeoclimatic Zones

The biogeoclimatic ecological classification (BEC) is a hierarchical classification of ecosystems based on vegetation, climate and physical site characteristics. The BEC is a modification by the B.C. Ministry of Forests staff (Lloyd et al. 1990) of the classification system developed by Dr. V.J. Krajina in the 1960s and 1970s.

A biogeoclimatic zone represents a geographical area with a homogeneous macroclimate. Because of the mountainous nature of the Thompson River basin, biogeoclimatic zones tend to occur as elevational bands that represent significant differences in climate. Nine zones occur within the Thompson basin: Alpine Tundra (AT); Engelmann Spruce-Subalpine Fir (ESSF); Montane Spruce (MS); Sub-Boreal Spruce (SBS); Sub-Boreal Pine-Spruce (SBPS); Interior Cedar-Hemlock (ICH); Interior Douglas-fir (IDF); Ponderosa Pine (PP) and Bunchgrass (BG). General zonal characteristics are as follows (Lloyd et al. 1990):

<b>Bunchgrass Zone</b>	The Bunchgrass zone is non-forested grassland. In the North Thompson HMA, it occurs only at lower elevations (250-1000 m) in the Thompson Plateau (physiographic unit) near the junction of the North and South Thompson Rivers. Warm to hot, dry summers, and moderately cold winters with little snowfall are typical.
<b>Ponderosa Pine Zone</b>	In the North Thompson HMA, the Ponderosa Pine zone occurs as a thin band along the lower elevations (335-900 m) of the lower North Thompson River, in the Thompson Plateau. This unit has the warmest growing season and lowest precipitation of all the forested zones, and a large growing season moisture deficit.
<b>Interior Douglas Fir Zone</b>	The Interior Douglas Fir zone, the second warmest, and the driest forest zone, dominates the low to middle elevations (360-1450 m) of the southern Interior Plateau. Summers are characteristically warm and dry, and there are significant moisture deficits during the long growing season. Winters are cool, with low to moderate snowfall. Within the HMA, this unit is found primarily in the Thompson Plateau (physiographic unit), along the North Thompson River Valley from Kamloops to Vavenby. A small pocket is also found around the north side of Canim Lake.
<b>Montane Spruce Zone</b>	Montane Spruce is a forested zone which occurs at middle elevations (1100-1600 m) of the south-central Interior Plateau, in an elevational band between the Interior Douglas Fir and Engelmann Spruce Sub Alpine Fir zones. Summers are moderately short and warm, and winters are cold, with moderate snowfall. Moisture deficits can occur in the growing season. A small portion of the Thompson Plateau is in the Montane Spruce zone.

<p><b>Sub-Boreal Spruce Zone</b></p>	<p>Sub-Boreal Spruce is a forested zone which dominates the low to middle elevations (1000-1450 m) of the gently rolling plateaus of the central interior. The southeastern extent of the zone lies west of the North Thompson River, within the Fraser Plateau (physiographic unit). Summers are relatively warm and moist, and winters cold and snowy. Short moisture deficits are common during the growing season.</p>
<p><b>Sub-Boreal Pine-Spruce Zone</b></p>	<p>Sub-Boreal Pine-Spruce is a forested zone which is found on the high plateau of the west central interior, in the rain shadow of the coastal mountains. Summers are warm and dry, and winters cold and dry, resulting in forests of generally low productivity. There is a small area of this zone in the Fraser Plateau west of Canim Lake.</p>
<p><b>Interior Cedar-Hemlock Zone</b></p>	<p>Interior Cedar-Hemlock, a forested zone, has the most suitable climate for tree growth in the interior. It is found at low to middle elevations (660-1400 m) in the interior wet belt, east of the Okanagan and Thompson River Valleys. Summers are warm and moderately dry, while winters are cool and wet. Summer moisture deficits are minimal. All river valleys north of the town of Clearwater, the Cariboo and Monashee Mountains and the Quesnel and Shuswap Highlands are included in this zone.</p>
<p><b>Englemann Spruce-Subalpine Fir Zone</b></p>	<p>The Englemann Spruce-Subalpine Fir zone is the highest elevation of forested zone in south-central B.C., ranging from 1275-2050 m. Summers are short and cool and winters are long and cold, with a high snow cover. Frosts are common during the growing season. This zone is found mainly in the Cariboo and Monashee Mountains and the higher elevation areas of the Quesnel and Shuswap Highlands.</p>
<p><b>Alpine Tundra</b></p>	<p>The Alpine Tundra is a high elevation, non-forested zone with an extremely harsh climate. In the southern Interior, it is generally found at elevations greater than 2000 m. Summers are cold and windy, and winters are very cold, long and snowy. This unit is located predominantly in the Cariboo and Monashee Mountains.</p>



Ecoprovinces of British Columbia (from Demarchi et al. 1990)

## APPENDIX C - RESOURCE USES

Forest inventory of salmon bearing watersheds in the North Thompson HMA  
Agricultural inventory of salmon bearing watersheds in the North Thompson HMA  
Human population estimates for salmon bearing watersheds in the North Thompson HMA  
Mineral interests in salmon bearing watersheds in the North Thompson HMA  
Summary of waste discharge permits for salmon streams in the North Thompson HMA  
Maximum possible daily loading from effluent permits in the North Thompson HMA  
Drainage and flow characteristics for salmon streams in the North Thompson HMA  
Sensitivity indices for salmon streams in the North Thompson HMA

Forest inventory of salmon bearing watersheds in the North Thompson HMA (reproduced from Sigma Engineering Ltd. 1991)

Gazetted Name	Watershed Code	Total Area (km <sup>2</sup> )	Non-forested (km <sup>2</sup> ) (% total)	Potentially Forested (km <sup>2</sup> ) (% total)	Recently Logged (km <sup>2</sup> ) (% total)	Older Logging (km <sup>2</sup> ) (% total)	Total Logged (km <sup>2</sup> ) (% total)	Forest Remaining (km <sup>2</sup> ) (% total)
North Thompson R	04	20742.20	3992.90	16749.30	2511.90	2211.10	4723.00	12026.30
Watershed exterior to tributaries of interest			19.25	80.75	12.11	10.66	22.77	57.98
Louis C	04-0600	5506.70	1376.70	4130.00	605.70	770.90	1376.60	2753.40
Watershed exterior to tributary of interest			25.00	75.00	11.00	14.00	25.00	50.00
Christian C	04-0600-150	526.50	26.10	500.40	32.10	77.10	109.20	391.20
Barriere R	04-0700	507.80	4.96	95.04	6.10	14.64	20.74	74.30
Watershed exterior to tributaries of interest			25.40	482.40	30.50	71.10	101.60	380.80
East Barriere R	04-0700-070	18.70	5.00	95.00	6.00	14.00	20.00	75.00
Watershed exterior to tributary of interest			0.70	18.00	1.90	5.60	7.50	10.50
Haggard C	04-0700-070-010	1150.80	4.00	96.00	10.00	30.00	40.00	56.00
Fennell C	04-0700-150	722.40	89.90	1060.90	113.80	225.70	339.50	721.40
Lemieux C	04-1200	318.30	7.81	92.19	9.89	19.61	29.50	62.69
Joseph C	04-1300	226.80	72.20	650.20	72.20	144.50	216.70	433.50
Watershed exterior to tributary of interest			10.00	90.00	10.00	20.00	30.00	60.00
Dunn C	04-1300-010	91.50	15.40	302.90	36.50	59.00	95.50	207.40
McTaggart C	04-1300-010-010	226.80	4.84	95.16	11.45	18.55	30.00	65.16
Mann C	04-1400	290.70	13.60	213.20	22.70	45.30	68.00	145.20
Watershed exterior to tributary of interest			6.00	94.00	10.00	20.00	30.00	64.00
Watershed exterior to tributary of interest			1.80	89.70	13.70	13.70	27.40	62.30
Watershed exterior to tributary of interest			2.00	98.00	15.00	15.00	30.00	68.00
Watershed exterior to tributary of interest			2.20	107.90	5.50	22.00	27.50	80.40
Watershed exterior to tributary of interest			2.00	98.00	5.00	20.00	25.00	73.00
Watershed exterior to tributary of interest			54.50	0.00	45.40	45.40	90.80	309.10
Watershed exterior to tributary of interest			12.00	88.00	10.00	10.00	20.00	68.00
Watershed exterior to tributary of interest			21.10	238.20	25.50	34.60	60.10	178.10
Watershed exterior to tributary of interest			8.15	91.85	9.83	13.36	23.19	68.66
Watershed exterior to tributary of interest			10.80	143.20	23.10	15.40	38.50	104.70
Watershed exterior to tributary of interest			7.00	93.00	15.00	10.00	25.00	68.00
Watershed exterior to tributary of interest			10.30	95.00	2.50	19.20	21.70	73.30
Watershed exterior to tributary of interest			9.80	90.20	2.40	18.20	20.60	69.60
Watershed exterior to tributary of interest			9.30	75.00	2.50	14.30	16.80	58.20
Watershed exterior to tributary of interest			11.00	89.00	3.00	17.00	20.00	69.00
Watershed exterior to tributary of interest			1.00	20.00	0.00	7.40	7.40	12.60
Watershed exterior to tributary of interest			5.00	95.00	0.00	35.00	35.00	60.00
Watershed exterior to tributary of interest			5.80	284.90	72.70	29.10	101.80	183.10
Watershed exterior to tributary of interest			2.00	98.00	25.00	10.00	35.00	63.00

Forest inventory of salmon bearing watersheds in the North Thompson HMA (reproduced from Sigma Engineering Ltd. 1991)

Gazetted Name	Watershed Code	Total Area (km <sup>2</sup> )	Non-forested (km <sup>2</sup> ) (% total)	Potentially Forested (km <sup>2</sup> ) (% total)	Recently Logged (km <sup>2</sup> ) (% total)	Older Logging (km <sup>2</sup> ) (% total)	Total Logged (km <sup>2</sup> ) (% total)	Forest Remaining (km <sup>2</sup> ) (% total)
Clearwater R	04-1500	10551.10	2119.70	8431.40	1315.70	804.00	2119.70	6311.70
Watershed exterior to tributaries of interest			20.09	79.91	12.47	7.62	20.09	59.80
Brookfield C	04-1500-020	5544.40	1361.10	4083.30	54.40	54.40	108.80	3974.50
		91.90	25.00	75.00	1.00	1.00	2.00	73.00
			3.70	88.20	18.30	4.60	22.90	65.30
			4.00	96.00	20.00	5.00	25.00	71.00
Maheed R	04-1500-160	4914.80	737.20	4177.60	1228.70	737.20	1965.90	2211.70
			15.00	85.00	25.00	15.00	40.00	45.00
Raft R	04-1700	757.30	37.90	719.40	189.30	113.60	302.90	416.50
			5.00	95.00	25.00	15.00	40.00	55.00
Reg Christie C	04-2800	75.60	1.50	74.10	11.30	3.80	15.10	60.00
			2.00	98.00	15.00	5.00	20.00	79.00
Mad R	04-3200	227.10	4.50	222.60	45.40	45.40	90.80	131.80
			2.00	98.00	20.00	20.00	40.00	58.00
Unnamed C	04-4210	11.30	0.20	11.10	4.00	0.00	4.00	7.10
			2.00	98.00	35.00	0.00	35.00	63.00
Avola C	04-4400	5.20	0.10	5.10	0.00	2.10	2.10	3.00
			2.00	98.00	0.00	40.00	40.00	58.00
Unnamed C	04-4600	9.70	0.20	9.50	2.40	0.00	2.40	7.10
			2.00	98.00	25.00	0.00	25.00	73.00
Tumtum C	04-4700	24.10	0.50	23.60	2.40	1.20	3.60	20.00
			2.00	98.00	10.00	5.00	15.00	83.00
Lion C	04-4800	46.30	0.90	45.40	9.30	9.30	18.60	26.80
			2.00	98.00	20.00	20.00	40.00	58.00
Finn C	04-5000	133.50	5.30	128.20	33.40	13.40	46.80	81.40
			4.00	96.00	25.00	10.00	35.00	61.00
Goose C	04-5850	8.90	0.20	8.70	2.20	1.80	4.00	4.70
			2.00	98.00	25.00	20.00	45.00	53.00
Blue R	04-6000	275.00	68.80	206.20	19.20	22.00	41.20	165.00
			25.00	75.00	7.00	8.00	15.00	60.00
Cedar C	04-6150	11.40	1.10	10.30	1.10	1.70	2.80	7.50
			10.00	90.00	10.00	15.00	25.00	65.00
Cook C	04-6200	11.20	2.20	9.00	1.10	1.70	2.80	6.20
			20.00	80.00	10.00	15.00	25.00	55.00
Albreda R	04-7800	406.30	162.50	243.80	28.50	32.50	61.00	182.80
			40.00	60.00	7.00	8.00	15.00	45.00

Agricultural inventory of salmon bearing watersheds in the North Thompson HMA (reproduced from Sigma Engineering Ltd. 1991)

Gazetted Name	Watershed Code	Total Area (km <sup>2</sup> )	1976.00 Improved Farmland (km <sup>2</sup> ) (% total)	est. 1990 Improved Farmland (km <sup>2</sup> ) (% total)	max. 2010 Improved Farmland (km <sup>2</sup> ) (% total)	est. 1990 Animal Units (AUs) (AUs/km <sup>2</sup> )	max. 2010 Animal Units (AUs) (AUs/km <sup>2</sup> )	Census Code (CCSD)	1976-86 % Change Farmland (%)	AUs/km <sup>2</sup> 1986 Farmland (AUs/km <sup>2</sup> )
North Thompson R	04	20742.2	89.76	91.55	115.37	11200	14355	na	na	na
Louis C	04-0600	526.5	0.43%	0.44%	0.55%	0.54	0.69	TR8	-17.3%	171
Christian C	04-0600-150	18.7	1.65%	1.25%	1.90%	2.14	3.26	TR8	-17.3%	171
Barriere R	04-0700	1150.8	0.43	0.33	0.47	2.99	4.33	TNA	-1.8%	126
North Barriere L, Saskum L	04-0700-070	318.3	1.67	1.74%	2.51	205	0.27	TNA	-1.6%	126
East Barriere R	04-0700-070-010	91.5	0.00	0.00	0.00	0.00	0.00	TNA	-1.8%	126
East Barriere Lake	04-0700-070-010	110.1	0.00	0.00	0.00	0.00	0.00	TNA	-1.8%	126
Haggard C	04-0700-150	454.4	0.05%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
South Barriere Lake	04-0700-150	259.3	1.72	1.68	2.24	211	0.62	TNA	-1.8%	126
Fennell C	04-1200	105.3	0.38%	0.37%	0.45%	0.46	0.53	TNA	-1.8%	126
Lentaux C	04-1300	21.0	0.28	0.27	0.42	0.33	0.50	TNA	-1.8%	126
Tawael Lake	04-1300-010	290.7	0.11%	0.11%	0.16%	0.13	0.20	TNA	-1.8%	126
Joseph C	04-1300-010	10551.1	0.27%	0.26%	0.40%	0.33	0.50	TNA	-1.8%	126
Dunn C	04-1300-010-010	91.9	0.28	0.27	0.42	0.33	0.50	TNA	-1.8%	126
Dunn Lake	04-1400	757.3	1.33%	1.30%	2.00%	1.64	2.52	TNA	-1.8%	126
Holteggart C	04-1500	75.6	0.00	0.00	0.00	0.00	0.00	TNA	-1.8%	126
Holteggart Lakes	04-1500	227.1	0.00%	0.00%	0.00%	0.00	0.00	na	na	na
Mann C	04-1500-020	91.9	31.65	36.79	37.35	4004	4075	na	na	na
Haina Lake	04-1500-020	4914.8	0.30%	0.35%	0.35%	0.38	0.39	TNA	-1.8%	126
Clearwater R	04-1500-160	757.3	0.82	0.80	1.07	101	134	na	-1.8%	126
Hurtle Lake	04-1700	75.6	0.85%	0.87%	1.16%	1.10	1.46	na	27.2%	108
Brookfield C	04-1700	405.3	29.90	35.09	35.09	3789	3789	CB	-1.8%	126
Grizzly Lakes, Reflector Lake	04-2800	227.1	0.61%	0.71%	0.77	0.77	0.77	TNA	-1.8%	126
Hahood R	04-2800	5.2	0.65	0.63	0.98	0.80	1.23	TNA	-1.8%	126
Hahood Lake, Centim Lake	04-3200	11.3	0.05%	0.08%	0.13%	0.11	0.16	TNA	-1.8%	126
Raft R	04-4210	275.0	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
Reg Christie C	04-4400	8.9	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
Mad R	04-4600	24.1	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
Unnamed C	04-4700	46.3	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
Avola C	04-4800	133.5	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
Unnamed C	04-5000	8.9	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
Tumtum C	04-5850	275.0	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
Unnamed Lake	04-6000	11.4	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
Liton C	04-6150	11.2	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
Finn C	04-6200	405.3	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
Goose C	04-6200	405.3	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
Blue R	04-7800	405.3	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
Cedar C	04-7800	405.3	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
Cook C	04-7800	405.3	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126
Albreds R	04-7800	405.3	0.00%	0.00%	0.00%	0.00	0.00	TNA	-1.8%	126

Human population estimates for salmon bearing watersheds in the North Thompson HMA (reproduced from Sigma Engineering Ltd. 1991)

GAZETTED NAME	POPULATION	
	Existing	Projected
North Thompson River (T)	33,775	34,365
North Thompson River (S)	20,330	20,665
Louis Creek (T)	125	125
Louis Creek (S)	75	75
Christian Creek	50	50
Barriere River (T)	1,600	1,630
Barriere River (S)	1,600	1,630
East Barriere River (T)	0	0
East Barriere River (S)	0	0
Haggard Creek	0	0
Fennell Creek	0	0
Lemieux Creek	100	105
Joseph Creek (T)	0	0
Joseph Creek (S)	0	0
Dunn Creek (T)	0	0
Dunn Creek (S)	0	0
McTaggart Creek	0	0
Mann Creek	0	0
Clearwater River (T)	11,375	11,555
Clearwater River (S)	2,750	2,800
Brookfield Creek	250	255
Mahood River	8,375	8,500
Raft River	0	0
Reg Christie Creek	0	0
Mad River	0	0
Unnamed Creek	0	0
Avola Creek	125	130
Unnamed Creek	0	0
Tumtum Creek	0	0
Lion Creek	0	0
Finn Creek	0	0
Goose Creek	0	0
Blue River	150	155
Cedar Creek	0	0
Cook Creek	0	0
Albreda River	0	0

(T) Total (Refers to the entire watershed including salmon spawning tributaries)

(S) Sub-Total (Refers to the watershed exclusive of salmon spawning tributaries)

Mineral interests in salmon bearing watersheds in the North Thompson HMA (reproduced from Sigma Engineering Ltd. 1991)

DRAINAGE	Total # Mineral Interests	Prime Mineral Interests	Total # of Claims (less than a 300 m radius)	Total # of Prospects (300 to 3200 m radius)	Total # of Deposits (3200 m or greater radius)
North Thompson					
Louis	8	Cu,Pb,Ag	7	1	0
Christian	0				
Barriere	23	Cu,Pb,Mo	22	0	1
Haggard	8	Cu,Ag,Pb	7	1	0
Fennell	0				
Lemieux	14	Cu,Mo,Au	13	1	0
Joseph	3	Ag,Cu,Pb	3	0	0
Dunn	0				
McTaggart	0				
Mann	4	Cu,Pb,Ag	4	0	0
Clearwater	10	Au,Mo,Hg	4	6	0
Brookfield	0				
Mahood	0				
Raft	22	Pb,Zn,Cu	16	3	3
Crossing	0				
Reg Christie	2	Cu,Mo	2	0	0
Mad	1	W,Mo,Cu	1	0	0
Wire Cache	0				
Avola	0				
Tumtum	0				
Lion	1	Cu,Mo,Ag	1	0	0
Finn	1	Zn,Pb	1	0	0
Goose	0				
Blue	1	Mi	1	0	0
Cedar	0				
Cook	0				
Albreda	0				





Maximum possible daily loading from effluent permits in the North Thompson HMA (reproduced from Sigma Engineering Ltd. 1991)

Gazetted Name	Watershed Code	Name	Receiving Water	Permit #	Parameter	Maximum Loading (kg/d)
North Thompson R	04	Clearwater Improvement Dist	N Thompson R	PE 330	BOD TSS	9 12.3
Clearwater R	04-1500	Dept of Fisheries and Oceans, Clearwater	Clearwater R	PE 7243	BOD NFR	216 108

BOD - 5 day Biological Oxygen Demand

TSS - Total Suspended Solids

NFR - Non-Filtrable Residue

Drainage and flow characteristics for salmon streams in the North Thompson HMA (reproduced from Northwest Hydraulic Consultants Ltd. 1992)

Stream Name	WSC Gauge No.	Basin Area (mouth) (km <sup>2</sup> )	Logged Area Recent (km <sup>2</sup> )	Logged Area Older (km <sup>2</sup> )	Improved Farmland (1990) (km <sup>2</sup> )	Domestic (g/day)	Irrigation (ac-ft)	Total Water Licenses		Conservation (c/s)	Licensed Demand (Us)			Naturalized Flows in the Salmon Streams (m <sup>3</sup> /s)					
								Waterworks (g/day)	Industrial (g/day)		Aug	Sept	Feb	Annual	Mean Flood	Mean Monthly	Aug	Sept	Summer
N. Thompson R		20742	25119	22111	9155									450.0	1890	408.09	270	205	78
Louis Creek	LB072	526	32.1	77.1	6.59	32,000	4,703	122,000	182,998	0.6	552	332	1	2.7	23.4	176	134	105	0.57
Christian Ck		19	1.9	5.6	0.33	3,500	950	0	500	0.6	111	67	0	0.1	0.9	0.11	0.07	0.07	0.003
Barriere R	LB020	1151	13.8	225.7	1.63	70,500	2,710	2,002,500	24,000	0	326	199	9	14.1	94.9	7.68	5.32	3.85	2.62
E. Barriere R.		318	36.5	59	0	45,500	313	2,500	500	0	37	22	0	3.9	41.0	1.31	0.97	0.68	0.42
Haggard Ck		92	13.7	13.7	0	4,500	32	0	0	0	4	2	0	1.1	19.0	0.45	0.36	0.2	0.14
Fennell Ck		110	5.5	22	0	500	0	0	0	0	0	0	0	1.4	27.2	0.34	0.36	0.15	0.12
Lemboux Ck	LB078	454	45.4	45.4	1.68	11,000	921	0	1,182,103	0	113	70	5	2.9	22.1	1.74	1.12	0.78	0.58
Joseph Ck		259	25.5	34.6	0.27	7,000	800	5,000	0	1.07	94	56	0	6.4	53.4	3.43	2.94	1.87	0.79
Dunn Ck		105	2.5	19.2	0.27	500	272	0	0	0.07	32	19	0	2.6	21.6	1.41	1.27	0.69	0.33
McTaggart Ck		21	0	7.4	0.27	500	231	0	0	0	27	16	0	0.1	1.0	0.06	0.04	0.03	0.01
Mam Ck	LB050	295	72.7	29.1	0	9,000	731	40,000	27,500	0	86	52	0	3.0	29.8	1.37	1.20	0.60	0.33
Clearwater R	LA001	10551	1315.7	604	35.79	123,800	10,921	2,270,900	161,988	10.3	1289	778	11	220.0	988.0	290.3	78.3	50.36	22.4
Brookfield Ck		92	18.3	4.6	0.8	0	52	10,000	30,000	0	6	4	0	1.7	15.5	0.42	0.34	0.19	0.14
Mahood R	LA008	4915	1228.7	737.2	35.09	86,900	9,332	4,060,000	124,466	0.3	1111	674	19	33.7	166.0	24.6	16.6	12	7
Rait R		764	189.3	113.6	0.63	2,500	879	0	1,500	0	103	62	0	15.2	116.6	4.42	3.75	2	1.1
Reg Christie Ck		76	11.3	3.8	0	1,000	342	0	0	0	40	24	0	1.5	10.8	0.50	0.42	0.22	0.15

1. Shading indicates gauged salmon streams.
2. Logged areas, improved farmland, mean annual flows and mean annual flood from Sigma (1991).
3. Total water licences for each salmon stream expressed in imperial units, as provided by Water Management Branch.
4. Reference for all data in table is the mouth of the salmon stream.
5. Licensed demands (L/s) calculated from total water licences as described in body of report.
6. Naturalized flows are estimates of those that would occur in the absence of all upstream regulation and water extractions.

Drainage and flow characteristics for salmon streams in the North Thompson HMA (reproduced from Northwest Hydraulic Consultants Ltd. 1992)

Stream Name	WSC Gauge No.	Basin Area (mouth) (km <sup>2</sup> )	Logged Area		Improved Farmland (1990) (km <sup>2</sup> )	Domestic (g/day)	Lic. Total Water Licences		Conservation (cfs)	Licensed Demand (L/s)			Naturalized Flows in the Salmon Streams (m <sup>3</sup> /s)					
			Recent (km <sup>2</sup> )	Older (km <sup>2</sup> )			Irrigation (ac-ft)	Waterworks (g/day)		Aug	Sept	Feb	Mean Annual	Mean Flood	Mean Monthly Aug	Mean Monthly Sept	Mean 7 day Low Summer	Mean 7 day Low Winter
Mad R		227	45.4	45.4	0	0	0	0	0	0	0	0	4.5	42.2	0.98	0.74	0.49	0.31
Unnamed Ck (04-4210)		11	4	0	0	0	0	0	0	0	0	0	0.2	2.0	0.07	0.06	0.025	0.023
Avola Ck		5	0	2.1	0	0	0	45,000	0	0	0	0	0.1	0.9	0.03	0.03	0.011	0.011
Unnamed Ck (04-4600)		10	2.4	0	0	0	0	0	0	0	0	0	0.2	1.9	0.06	0.06	0.02	0.02
Tumtum Ck		24	2.4	1.2	0	0	0	0	0	0	0	0	0.5	4.5	0.10	0.08	0.035	0.033
Lion Ck		46	9.3	9.3	0	0	0	0	10	0	0	0	0.9	8.6	0.17	0.14	0.069	0.061
Finn Ck		134	33.4	13.4	0	500	0	0	2.7	0	0	0	4.7	39.1	1.19	1.01	0.58	0.32
Goose Ck		9	2.2	1.8	0	0	0	0	0	0	0	0	0.3	2.6	0.02	0.014	0.005	0.008
<b>Blue E</b>	<b>LB038</b>	<b>275</b>	<b>19.2</b>	<b>22</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>200,000</b>	<b>5,000</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>9.7</b>	<b>80.3</b>	<b>7.21</b>	<b>4.93</b>	<b>3.17</b>	<b>1.21</b>
Cedar Ck		11	1.1	1.7	0	1,000	11	0	0	0	1	0	0.4	3.2	0.07	0.066	0.025	0.023
Cook Ck		11	1.1	1.7	0	1,000	0	0	0	0	0	0	0.4	3.2	0.09	0.09	0.034	0.028
Albreda R		406	28.5	32.5	0	500	0	0	1,000	0	0	0	14.3	118.6	3.37	2.68	1.89	0.87

1. Shading indicates gauged salmon streams.
2. Logged areas, improved farmland, mean annual flows and mean annual flood from Sigma (1991).
3. Total water licences for each salmon stream expressed in imperial units, as provided by Water Management Branch.
4. Reference for all data in table is the mouth of the salmon stream.
5. Licenced demands (L/s) calculated from total water licences as described in body of report.
6. Naturalized flows are estimates of those that would occur in the absence of all upstream regulation and water extractions.

Sensitivity indices for salmon streams in the North Thompson HMA (reproduced from Northwest Hydraulic Consultants Ltd. 1992)

Stream Name	Status	SUMMER WATER USE				LOW FLOWS			PEAK FLOWS		LOGGING	
		Index 1 Aug Use/ Sum Q7L2	Index 2 Sept Use/ Sum Q7L2	Index 3 Aug Use/ mean Aug	Index 4 Sept Use/ mean Sept	Index 5 Sum Q7L2/ QAA	Index 6 Win Q7L2/ QAA	Index 7 Q2/ QAA	Index 8 Recent/ Basin	Index 9 Total/ Basin		
N. Thompson R		-	-	-	-	49	18	5	12	23		
Louis Creek	FR	52	32	31	25	26	21	9	6	21		
Christian Ck	FR	164	99	98	99	1	3	9	10	39		
Barriere R		8	5	4	4	26	19	7	10	29		
E. Barriere R.		5	3	3	2	17	11	10	11	30		
Haggard Ck		2	1	1	1	17	12	17	15	30		
Fennell Ck		0	0	0	0	11	9	20	5	25		
Lemieux Ck		14	9	6	6	24	20	8	10	20		
Joseph Ck		5	3	3	2	28	12	8	10	23		
Dunn Ck		5	3	2	2	26	13	8	2	21		
McTaggart Ck	PWS	103	62	47	45	9	9	9	0	35		
Mann Ck		14	9	6	4	18	11	10	25	35		
Clearwater R	RES	3	2	0	1	23	10	4	12	20		
Brookfield Ck		3	2	1	1	11	8	9	20	25		
Mahood R		10	6	5	4	33	21	5	25	40		
Raft R		5	3	2	2	13	7	8	25	40		
Reg Christie Ck		18	11	8	6	13	10	7	15	20		

1. Status refers to restrictions noted by the Water Management Branch: FR, fully recorded with exceptions for storage; RES, reserved, no licencing; PWS, possible water shortages.
2. Aug and Sept Use are total demands in these months; Sum and Win Q7L2 are summer and winter mean 7 day low flows; mean Aug and Sept are mean August and September monthly flows; QAA is mean annual flow; Q2 is the mean annual flood; Recent and Total are recent and total logging areas in the basin; Basin is basin area above the mouth.
3. Indices expressed as percentages except 7, which is a direct ratio.
4. Shading indicates salmon streams with most extreme values for the various indices. The most extreme 25% are shown for indices 1 to 6; values of Index 7 exceeding 10 are shaded; and values of Index 8 exceeding 20% are shaded.

Sensitivity indices for salmon streams in the North Thompson HMA (reproduced from Northwest Hydraulic Consultants Ltd. 1992)

Stream Name	Status	SUMMER WATER USE				LOW FLOWS			PEAK FLOWS			LOGGING	
		Index 1 Aug Use/ Sum Q7L2	Index 2 Sept Use/ Sum Q7L2	Index 3 Aug Use/ mean Aug	Index 4 Sept Use/ mean Sept	Index 5 Sum Q7L2/ QAA	Index 6 Win Q7L2/ QAA	Index 7 Q2/ QAA	Index 8 Recent/ Basin	Index 9 Total/ Basin			
Mad R		0	0	0	0	11	7	7	9	20	40		
Unnamed Ck (04-4210)		0	0	0	0	11	11	11	9	36	36		
Avola Ck		2	2	1	1	11	11	11	9	0	42		
Unnamed Ck (04-4600)		0	0	0	0	10	10	10	9	24	24		
Tumtum Ck		0	0	0	0	7	7	7	9	10	15		
Lion Ck		0	0	0	0	8	7	7	9	20	40		
Finn Ck		0	0	0	0	12	7	7	8	25	35		
Goose Ck		0	0	0	0	2	3	3	8	24	44		
Blue R		0	0	0	0	33	12	12	8	7	15		
Cedar Ck		5	3	2	1	6	5	5	8	10	25		
Cook Ck		0	0	0	0	9	7	7	8	10	25		
Albreda R		0	0	0	0	13	6	6	8	7	15		

no licencing; PWS, possible water shortages.

- Aug and Sept Use are total demands in these months; Sum and Win Q7L2 are summer and winter mean 7 day low flows; mean Aug and Sept are mean August and September monthly flows; QAA is mean annual flow; Q2 is the mean annual flood; Recent and Total are recent and total logging areas in the basin; Basin is basin area above the mouth.
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