Strategic Review of Fisheries Resources for the Thompson Nicola Habitat Management Area

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This report represents a compilation and analysis of a wide variety of information sources. Fisheries production and fisheries habitat data were compiled from published and unpublished literature sources and from interviews with DFO and BC MELP staff.

Gordon Berezay (Ecolibrium Consulting Inc.) drafted the stock status (sections 2.1-2.4) for each salmon species and Alan Thomson prepared the steelhead/resident fish section (2.5). Bill Rublee and Wendy Chalmers (ARC Environmental Ltd.) compiled and prepared the original draft of the remaining sections (3,4,5) of the report that describes biophysical features, resource use and watershed management issues and recommendations. ARC Environmental Ltd. also gathered information from DFO, MELP and other agency staff. The primary published documents used included Sigma Engineering Ltd (1991) for biophysical descriptions and resource use components and Rood and Hamilton (1995) for hydrological information.

DFO personnel providing information included Gordon Kosakoski (Habitat Management Head, S.B.C. Interior), Mike Crowe (Habitat Biologist, Kamloops), Don Lawrence (Habitat Technician, Lillooet), and B. Rosenberger (Fisheries Management Biologist). MELP personnel interviewed included S. Maricle, (Fisheries Technician), R. Bison (Fisheries Biologist), P. Doyle (Water Management Branch, Head of Engineering), B. Grace (Impact Assessment Biologist, Kamloops). Additional contributors are listed in the Reference section (Personal Communications).

Alice Fedorenko edited the Fisheries Resources chapter (section 2) and Violet Komori edited the remaining sections (3,4,5) of the report. Final editing incorporated revisions and preparation for publication. Christine Davis Verrico (CDV Cartographic Services) prepared the map figures. We thank all those who critically reviewed the draft report or sections of the report including Gordon Kosakoski and Mike Crowe (DFO, Habitat Management), Lidia Jaremovic (DFO, Fraser River Action Plan) and Doug Lofthouse (DFO Enhancement Operations Division).

SUMMARY AND RECOMMENDATIONS

FISHERY RESOURCE

The Thompson-Nicola Habitat Management Area (HMA) includes the Thompson River from Kamloops to Lytton, as well as the Bonaparte River, Deadman River and Nicola River watersheds. Fisheries values in the Thompson-Nicola HMA are high. This HMA supports several species of salmon including chinook (*Oncorhynchus tschawytscha*), coho (*O. kisutch*), pink (*O. gorbuscha*) salmon, steelhead trout (*O. mykiss*) and small incidental populations of sockeye salmon (*O. nerka*). These species contribute to important First Nations, commercial and recreational fisheries. There are 22 resident fish species identified within the Thompson Nicola HMA and include rainbow trout (*Oncorhynchus mykiss*), bull trout (*Salvelinus confluentus*), kokanee (*Oncorhynchus nerka*), lake whitefish (*Coregonus clupeaformis*) and mountain whitefish (*Prosopium williamsoni*).

Since 1985, up to 800,000 pinks, 25,000 chinook, 5,000 coho as well as 3,500 steelhead trout have spawned annually in the HMA. The most important pink spawning habitat within the HMA is the mainstem Thompson River whereas the majority (50%) of chinook are produced in the Nicola River system. Major coho producers within the Thompson Nicola HMA are the Coldwater River and Deadman River.

Steelhead populations in the Thompson-Nicola HMA have been actively monitored since 1979. The largest producer of steelhead is consistently the Nicola River, followed by the Deadman, and Bonaparte Rivers. On average, 1061 steelhead return to spawn in the Nicola, 337 in the Deadman River, and 278 in the Bonaparte River.

Escapement Trends

Pink escapements have been increasing within the HMA and minimum overall escapements to the Fraser River have surpassed the goal of six million pink spawners since 1989. In recent years, chinook escapements have increased dramatically since 1990 with the return years 1994 to 1996 showing some of the largest escapements on record for the Nicola and Bonaparte Rivers. Consistent coho escapement data from the Deadman River show an alarming decline in recent years. All interior Fraser coho stocks are showing a similar declining trend which has been attributed to excessive exploitation rates, habitat loss and poor marine survival.

Salmon Enhancement

The key to rebuilding coho stocks is to increase and protect the yearly escapements and the productive capacity of the freshwater habitat. The Bonaparte fishway constructed in 1989, has allowed access to about 140 km of previously inaccessible spawning and rearing area. Until the factors controlling natural coho productivity in the Thompson Nicola HMA are better understood, hatchery enhancement may be used to support stocks of conservation concern.

The current focus of enhancement for chinook and coho production is habitat protection and restoration, along with opportunistic hatchery production. Natural summer low flow conditions that are exacerbated by water withdrawals for irrigation are prevalent throughout the Thompson-Nicola HMA. There is a need throughout the study area to ensure that adequate instream flows for salmonids are maintained. Habitat restoration projects include; riparian restoration (e.g., tree planting and cattle fencing), in-stream complexing (e.g., increased cover with root wads and vegetation), bank stabilization and developing of suitable off channel rearing sites, and screening of irrigation diversions. In addition to habitat restoration activities, chinook and coho production is augmented by the Spius Creek and Deadman River enhancement facilities.

There is no enhanced production of pink salmon in the HMA. However, in the last 10 years, the upstream fish passage at Hell's Gate has been facilitated by the construction of two low-flow fishways and the installation of lights on both river banks to facilitate night-time migration.

FISHERY MANAGEMENT ISSUES AND PRIORITIES

The primary goal is to conserve and continue to rebuild salmon stocks in order to increase their abundance and maintain genetic diversity. As well, an urgent conservation concern is to address declining coho stocks. A recent review of endangered stocks in B.C. identified extinct and threatened stocks. While stock aggregates (other than coho) were doing relatively well, the study concluded that a serious concern exists at the individual stock level, and that habitat preservation is a critical link in preserving native salmon stocks. For declining coho stocks, conservation measures must include a reduction in exploitation rates and the protection and restoration of fish habitat.

For coho salmon in the HMA, information on current stock status, habitat carrying capacity and life history is limited. Also for chinook salmon, the total productive capacity of the habitat is unknown. This information is essential for developing a comprehensive management plan for salmon stocks in the HMA. Research is also required to improve understanding of the factors regulating the production of chinook and coho salmon in interior streams.

HABITAT IMPACTS

Key habitat issues in the Thompson-Nicola HMA are related to increasing resource development pressures that result in cumulative impacts on fish habitat. Forestry and agriculture are the two primary resource development activities within the HMA. Other resource development activities include urban development, linear development, mining and a pulpmill.

Forestry Development

The salmon resource is dependent upon the preservation of freshwater habitat for spawning, incubation and rearing. The rate of cut and road construction can significantly impact fish habitat. Increased peak flows can occur when logging reaches approximately 20% of the total watershed area. Other potential impacts of forestry development include increased natural rates of landslide activity and surface erosion as well as degradation of riparian habitat.

Forestry is a major resource development activity in the Thompson-Nicola HMA. Historical and/or recent logging has occurred in most drainages within the study area. The upper watershed areas of the Nicola River, Spius Creek, Maka Creek, Coldwater River, Bonaparte River and Deadman River have been logged extensively. The total watershed area that has been harvested in the 8 major salmon watersheds within the HMA ranges from 10% in Spahomin Creek to 40% in the Bonaparte River. The rate of forest harvesting to 1991 was highest in the Bonaparte River (20%) and Maka Creek (25%). It should be noted that smaller tributaries of the Nicola, Coldwater, Bonaparte have not been assessed individually in terms of percentage watershed logged. Past harvesting activities within the Thompson-Nicola HMA have degraded riparian habitat which has increased sediment delivery and impacted instream habitat by reducing channel stability and the quality of spawning and rearing habitats.

The 1997 Level 1 Watershed Assessments for tributaries of the Nicola (including Guichon, Spius, Maka, Skuhun, Shakan), Coldwater (including Midday, Voght) and Spahomin Creek indicated moderate to high hazard indices for one or more parameters including peak flows, surface erosion and riparian vegetation (MOF 1997). In 1998, more detailed Level II Watershed Assessments will be conducted in those watersheds with the highest hazard indices and include the Coldwater River, Spius Creek, Maka Creek and Quilchena Creek.

Agricultural Activities

Within the Thompson-Nicola HMA, agricultural activity is intensive and concentrated along the lower, more productive reaches of most stream systems. Valley bottom areas are used for crop production and winter feeding, while upland areas are utilized for summer range activities.

Agricultural development has negatively impacted fisheries values in the Nicola River, Coldwater, Bonaparte River and the Deadman River watersheds. Environmental impacts within these systems include sedimentation, channelization, degradation of riparian habitat, degraded water quality, increased water temperatures, extremely low instream flows and channel degradation. Degradation of riparian areas has resulted in increased erosion, loss of shade and cover as well as the loss of pool and offchannel habitat. Loss of riparian vegetation has also been shown to increase river width and channel instability. Cattle feeding areas and cattle access to watercourses are the primary source for loading pollutants into surface and groundwater, thereby reducing water quality.

Water withdrawal for irrigation is one of the greatest problems associated with agricultural activities in the Thompson-Nicola HMA. High water use may be attributed to the arid climatic conditions and high irrigation demand. Current water management practices throughout most of the HMA do not allow for sufficient instream flows during low flow periods to support fisheries resources year round. Summer low flow problems are exacerbated by water withdrawals for irrigation in the Bonaparte River, Deadman River, Nicola River, Coldwater River and Spahomin Creek. Water use and low flow concerns were also noted in Shakan Creek, Skuhun Creek, Guichon Creek, and Clapperton Creek (tributaries of the Nicola River); Midday Creek, Voght Creek, and Brook Creek (tributaries of Coldwater River) and Cache Creek and Hat Creek (tributaries of the Bonaparte River.). The resulting low stream flows have impacted fish populations by reducing critical spawning, incubation and rearing habitat; impeded upstream fish access and increased summer water temperatures. Elevated water temperatures place salmonids at risk to physiological stress and diseases.

Urban and Linear Development

Urban development within the HMA includes: the western portion (33%) of the city of Kamloops, the District of Logan Lake, the City of Merritt, Cache Creek, Ashcroft, Clinton and Lytton. Urban development, such as residential and industrial construction has negatively affected fish habitat by the removal of riparian corridors, destruction and/or alteration of stream channels and restricting salmonid access by inadequate culvert placements.

The Thompson-Nicola HMA is traversed by a network of transportation and utility systems. Transportation corridors are concentrated in valley bottoms, adjacent to waterways and floodplain habitat. Major transportation routes include the Canadian Pacific Railway, the Canadian National Railway, B.C. Railway, the Trans Canada Highway 1, the Coquihalla Highway, B.C. Tel fibre optic line, B.C. Hydro major transmission lines as well as oil and gas pipelines owned by Westcoast energy, Trans Mountain Pipeline and B.C. Gas. Known impacts from linear development within the Thompson Nicola HMA includes extensive bank armoring with rip rap, the degradation of riparian habitat, a reduction in channel complexity, channelization, encroachment, bank erosion and bank degradation. The close proximity of highways and railways to major waterways creates a risk for chemical spills to enter the river and impact fisheries resources. Rock stabilization procedures and sidecast/ballasting materials generated during routine maintenance of roads and railways, have the potential to impact riparian and instream habitat.

Other Development

Active metal mines within the Thompson Nicola HMA includes Highland Valley Copper in the upper Guichon and Pukaist drainages. Highland Valley is the fifth largest open pit copper mine in the world. Significant impacts to resident fisheries values resulted from the Highland Valley Copper Mine development (Chan, pers. comm.). Between 1980 and 1984, 4 fish bearing lakes were drained in order to access underlying ore bodies. Two lakes supported wild, self sustaining rainbow trout stocks which were utilized as traditional food fishing sites by First Nations people. The remaining 2 lakes were stocked and supported a recreational fishery. Additional impacts include bioaccumulation of molybdenum in alfalfa crops utilizing water from Guichon Creek.

Other development within the Thompson-Nicola HMA includes the Weyerhaeuser Pulp Mill and the Kamloops Municipal Sewage Treatment Plan. Both contribute to the accelerated growth of algae and water quality in the Thompson River has been rated as fair.

WATERSHED MANAGEMENT PRIORITIES

DFO's Habitat Management objectives are: to achieve a net gain in the productive capacity of fish habitat; maintain the physical and biological diversity of fish habitat; and protect and restore watershed and stream channel integrity and stability. Management strategies must be developed at the watershed level and include the management of various regions (uplands, floodplain, riparian habitat, stream channel or lakes as an ecological unit. Watershed planning needs to address hydrological stability or recovery, stream channel integrity and the protection or re-establishment of a riparian corridor. Watershed plans must also address adequate instream flows for fish, protection of water quality from non-point sources and the protection of sensitive habitat. The major strategies for the protection, restoration and management of fish habitat in the HMA include:

- vigorous stewardship of the riparian zone and surrounding watershed to ensure the health of the ecosystem,
- implementation of best management practices for land use activities to prevent impacts on fish habitat and
- restoration of watersheds where cumulative impacts have occurred and fish habitat has been damaged.

Monitoring of the fishery resource and fish habitat is also a vital component. The key management strategies are summarized below. Stream-specific habitat management priorities are presented in the report.

Forestry Impacts: Manage watersheds for hydrological stability through maintenance of water quantity and quality and riparian protection

- Protect streamside and riparian areas by providing adequate leave strips (reserve zone) and riparian management area through application of the Forest Practices Code (FPC) on all salmon bearing streams as a minimum standard.
- Provide additional protection for sensitive salmon streams and those streams that have significant downstream effects (e.g., restrict harvesting and/or provide leave strips not specified in the Forest Practices Code such as on S4, S5 and S6 streams). On small fish bearing streams (S4), apply reserves and manage the riparian zone according to windthrow hazard guidelines to protect the integrity of leave strips. Non-fish bearing streams (S5 S6) may require leave strips to address downstream temperature, large woody debris, channel stability and water quality concerns.
- Conduct the appropriate level(s) of the Interior Watershed Assessment Procedure on all salmon bearing watersheds to assess hydrological impacts of past logging, identify restoration activities and prevent watershed impacts from further logging through harvest and road building restrictions, road deactivation, wider leave strips and revegetation of riparian areas.
- Defer logging in high risk watersheds to promote hydrological recovery
- Implement restoration activities such as road deactivation, bank stabilization and riparian planting.
- Focus on rehabilitation of riparian habitat and creation of refuge habitat such as off channel, side channel and overwintering ponds for fish habitat restoration.
- Input into the Timber Supply Review to ensure potential watershed level constraints on harvesting to prevent fisheries impacts are reflected in the determination of the Annual Allowable Cut for the timber Supply Area.
- Evaluate compliance and the efficacy of the Forest Practices Code in sustaining fish habitat by monitoring: riparian conditions in small fish bearing and non-fish bearing streams; streamflows and water quality; road construction and maintenance and assessing logging prescriptions.
- Increase monitoring of logging practices and promote Forest Practices Code standards for logging on private lands.

Agriculture/Settlement Impacts: Manage watersheds to maintain and restore riparian vegetation, channel stability and suitable temperatures; maintain the hydrologic regime of urban streams and control non-point source sediments and pollutants.

- Promote and implement long term solutions to channel stability problems by establishing a suitably wide riparian corridor that is 6-7 times the channel width to reduce rates of channel shifting, stabilize sediment deposits, reduce channel width and lower stream temperatures.

- Revegetate riparian habitat to assist in decreasing high summer water temperatures.
- Address private land issues and agricultural problems by educating ranchers and farmers on controlling direct cattle access to streams through livestock fencing programs, non-point source pollution and other issues concerned with ongoing fish habitat degradation.
- Develop watershed based plans to protect and restore riparian vegetation.
- Develop site specific remedial plans to rehabilitate severely disturbed sites by stabilizing banks using bioengineering techniques, planting vegetation and by fencing poorly vegetated areas to exclude livestock.
- Develop optimum planting techniques, species mix and bioengineering techniques for various types of river banks to promote rapid revegetation of actively eroding areas.
- Monitor the long term effectiveness of stream restoration activities in improving fish habitat.
- Apply DFO/MELP Land Development Guidelines, Stream Stewardship Guides for Urban Development and Agriculture and other relevant environmental guidelines that promote best management practices to minimize impacts of land development on fish habitat (e.g. setbacks from watercourses, waste management, stormwater management). Curtail urban development along the floodplain and on unstable fans.
- Work with the Department of the Environment, provincial and local governments to monitor and control non-point sources of water pollution including sediments, nutrients, contaminants, and stormwater and ameliorate contaminated sites.

Water Use Impacts: Manage watershed to conserve and improve instream fisheries flows for spawning and rearing salmonids

- Assess instream flow requirements for fish.
- Develop water management plans with provincial agencies, irrigation districts and water users to ensure adequate instream flows for fish through water conservation, licensing restrictions, flow agreements, groundwater regulation, streamflow and water use monitoring and storage opportunities.
- Optimize fisheries flow release schedules from regulated systems including the Nicola River, Deadman River and Bonaparte River.

Multiple Land Use Impacts: Manage watershed through the assessment and management of cumulative impacts on Crown and private lands

- Cooperative efforts are required of agencies, public and stakeholders to manage the watershed to address cumulative impacts and direct efforts toward watershed planning, restoration and ecosystem management.
- Continue partnerships with provincial government, local government, aboriginal communities and the public stakeholders to promote stewardship of land, water and riparian habitat on public and private land.
- Continue education, training and support to promote public understanding of the importance of watershed management and develop site specific standards for fish habitat protection when necessary.

A continuing need exists for inventory and research to identify critical fish habitat. There is also a need to increase understanding of fish life history, habitat capacity and utilization and limiting factors affecting salmon production.

Monitoring is an integral component of management strategies and should include improved monitoring of escapements of major stocks as well as small coho populations. In addition, it is also important to monitor habitat condition and assess whether a net gain in fish habitat is achieved. Monitoring should also include compliance monitoring and enforcement to ensure compliance to the Fisheries Act, the Forest Practices Code and other environmental standards and guidelines. Monitoring the effectiveness of management prescriptions is also essential. While the FPC provides guidelines for management of riparian areas, as well as other measures to address cumulative impacts, there is a need to evaluate the effectiveness of these measures to protect fish habitat.

There has been some improvement in understanding of fish habitat needs, stream processes, interactions between land uses and fish habitat, land management practices and restoration techniques. However, watershed specific information is limited and a conservative or risk averse approach to land use management is warranted if fish habitat is to be maintained and enhanced. Recent assessments indicate that the success of instream improvements and restoration techniques is limited. Consequently, the emphasis should be placed on the protection and restoration of stream integrity through watershed stewardship and the removal of or changes in land use activities that cause adverse impacts to riparian and aquatic ecosystems.

1.0 INTRODUCTION

The Thompson-Nicola Habitat Management Area (HMA) encompasses the Thompson River watershed from its confluence with the Fraser River upstream to the confluence of the North Thompson River (Fig 1). The Thompson-Nicola HMA has a drainage area of 17,600 km^2, equaling approximately 8% of the total Fraser River Basin. The climate of the Thompson-Nicola HMA is generally hot and dry, particularly in the lower elevations which contributes to low summer streamflows and high summer water temperatures.

Major watersheds include the Thompson River mainstem, the Nicola River, Deadman River and Bonaparte River. The Thompson River mainstem flows from Kamloops Lake for about 100 kilometers in a southwesterly direction and enters the Fraser River at Lytton. The remaining streams originate as confined, high gradient systems that flow through wide U-shaped valley bottoms into the Thompson River. The Nicola River flows northwest through Douglas Lake and Nicola Lake for 193 kilometers before entering the Thompson River at Spences Bridge. The Deadman River originates in a high plateau region south of Bonaparte Lake and enters the Thompson River near Savona. The Bonaparte River parallels the Deadman River to the east, joining the Thompson mainstem near Ashcroft.

The Thompson Nicola HMA supports several species of salmonids including chinook (*Oncorhynchus tschawytscha*), coho (*O. kisutch*), pink (*O. gorbuscha*) salmon and steelhead trout (*O. mykiss*). Since 1985, up to 800,000 pinks, 25,000 chinook 5,000 coho and 3,500 steelhead trout have spawned annually throughout the HMA. Pink salmon utilize the mainstem Thompson River for spawning and incubation. Chinook, coho and steelhead spawn and rear throughout the HMA (FHIIP 1992, Harding et al. 1994). The Thompson mainstem is a major migration corridor for salmon stocks returning to the North and South Thompson watersheds. As resource development within the watershed increases, so does the pressure on salmon spawning and rearing habitat. In order to conserve and rebuild salmon stocks in the area, strategies for the protection and restoration of the freshwater habitat must be developed and implemented.

Land use is intensive in this HMA with logging dominating headwater activities, and agriculture being the main activity on the benchlands and in the valley bottom areas. Historic logging has taken place along valley bottoms and lower benches along the lower reaches of watersheds above the Bunchgrass zone. More recently, logging activities have been occurring in the upper areas of the watersheds. Residential development is generally sparse, with aggregations occurring at Kamloops, Cache Creek, Ashcroft, and Merritt. Several smaller communities also exist along the river valley bottoms. Linear development within the HMA includes the Coquihalla Highway, the old Trans Canada highway, the

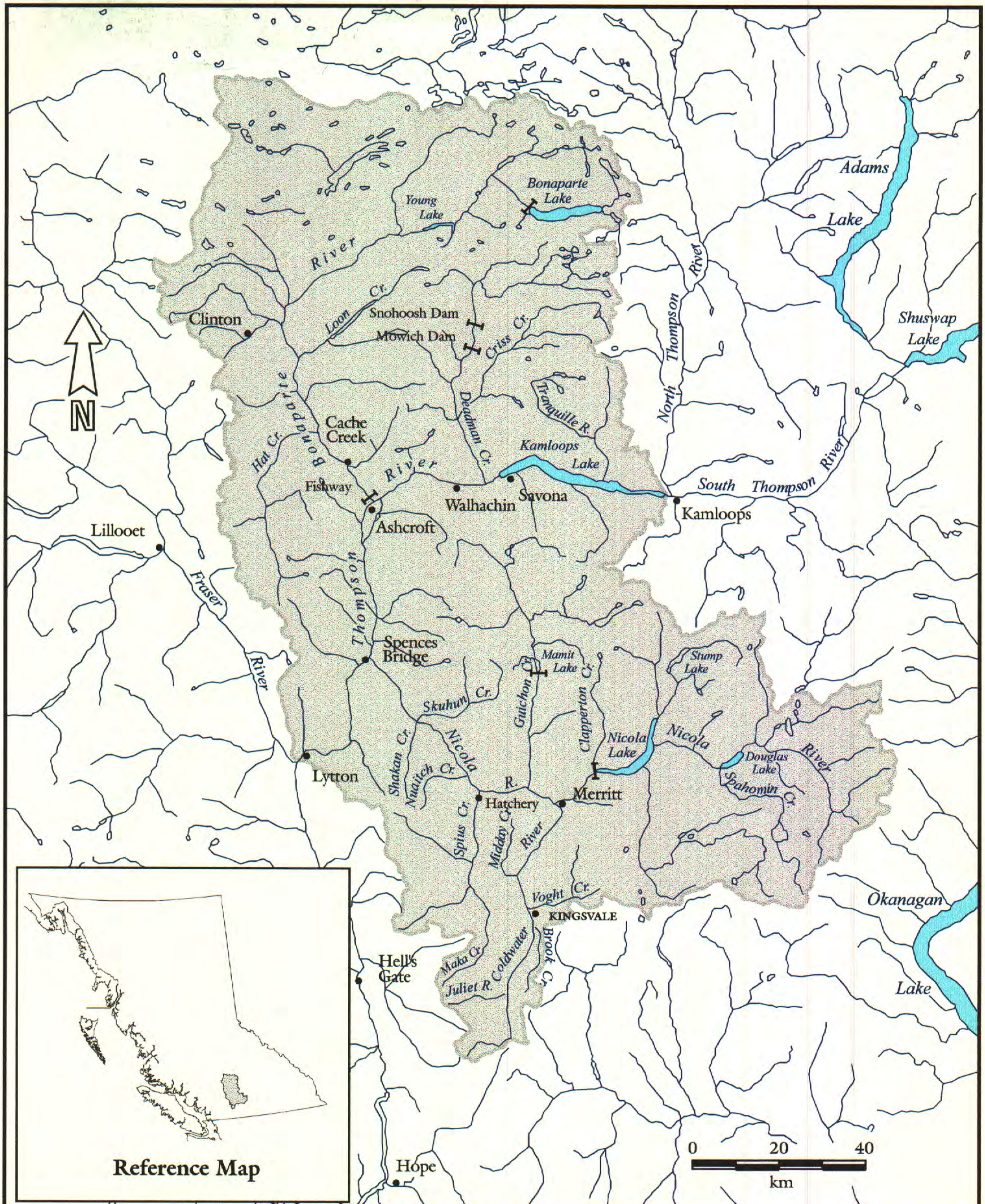


Figure 1. Thompson-Nicola Habitat Management Area.

Canadian National and the Canadian Pacific Railways which run along the Thompson River. Oil and gas pipelines, and B.C. Tel lightguide corridors have also been constructed through the Nicola and Coldwater valleys.

This report presents an overview of the fisheries resources, biophysical characteristics and land use issues for the Thompson Nicola HMA. Based on this information, fisheries habitat management priorities and strategies have been developed. This report provides common ground for initiating the cooperative development of a long term, sustainable resource development strategy for the Thompson Nicola HMA.

The information in the report is based on a compilation of existing information from fisheries and land use management agencies and published reports. In many cases, sections of an earlier study on the Thompson-Nicola HMA by Sigma Engineering Ltd. (1991), and a hydrology and water use study done by Rood and Hamilton (1995) have been incorporated into the report. Additional information was obtained through interviews with the Department of Fisheries and Oceans (DFO), Ministry of Environment Lands and Parks (MELP), and Ministry of Forests (MOF) personnel.

2.0 FISHERIES RESOURCES

The Thompson-Nicola basin supports pink, chinook and coho salmon, as well as steelhead trout. These contribute to important First Nations, commercial and recreational fisheries. There are also occasional reports of sockeye salmon in the Nicola and Deadman Rivers.

Ten-year average escapements of pink, chinook and coho salmon to the HMA are shown for the period 1951 to 1996 in Figure 2. During the 1980's, escapements averaged approximately 527,000 pinks, 6,000 chinook and 3,000 coho salmon; in recent years, chinook escapements have increased while coho escapements have declined (Append. A). Recent reports summarize the life history, stock description, harvest management, enhancement activities and production potential for each of the pink, chinook and coho salmon in the Fraser River system (Dept. Fish. Oceans 1995a, b, 1996). During 1985-1995, annual steelhead escapements have ranged between 1000-3500 fish within the HMA.

2.1 PINK SALMON

Historically, the upper Fraser pink salmon stocks represented the largest pink salmon population in the Fraser watershed (Ricker 1989). The Hell's Gate landslide of 1913 blocked virtually all upriver access to pink adults and nearly decimated the upper Fraser pink stocks. Subsequent remedial work and construction of fishways resulted in pink salmon returning to the streams in the area.

Currently, pink salmon are the most abundant species in the HMA, with the Thompson mainstem supporting virtually all of the production. The Thompson stock is the largest pink stock in the upper Fraser system, with up to 1.2 million spawners reported in 1981 (Append. A-1). Some pink spawning is also observed in the Deadman, Bonaparte and Nicola rivers (Williams et al. 1994, DFO 1992a); together these stocks contribute less than 2% to the HMA's total pink escapement (Append. A-1).

2.1.1 Life History

Pink salmon mature at age two, with the Fraser population returning to spawn on the odd year cycle. The Thompson River pink salmon return to the lower Fraser River by early September to early October (Hourston et al. 1965); peak spawning in natal streams is generally observed in early October (DFO 1992b). Fry emerge in March and April of the following year and migrate to sea immediately. The Fraser pink juveniles enter the Strait of Georgia from March to May (Healey 1980) and by fall emigrate to outside waters. Heard (1991) provides an overall summary of the pink salmon life history.

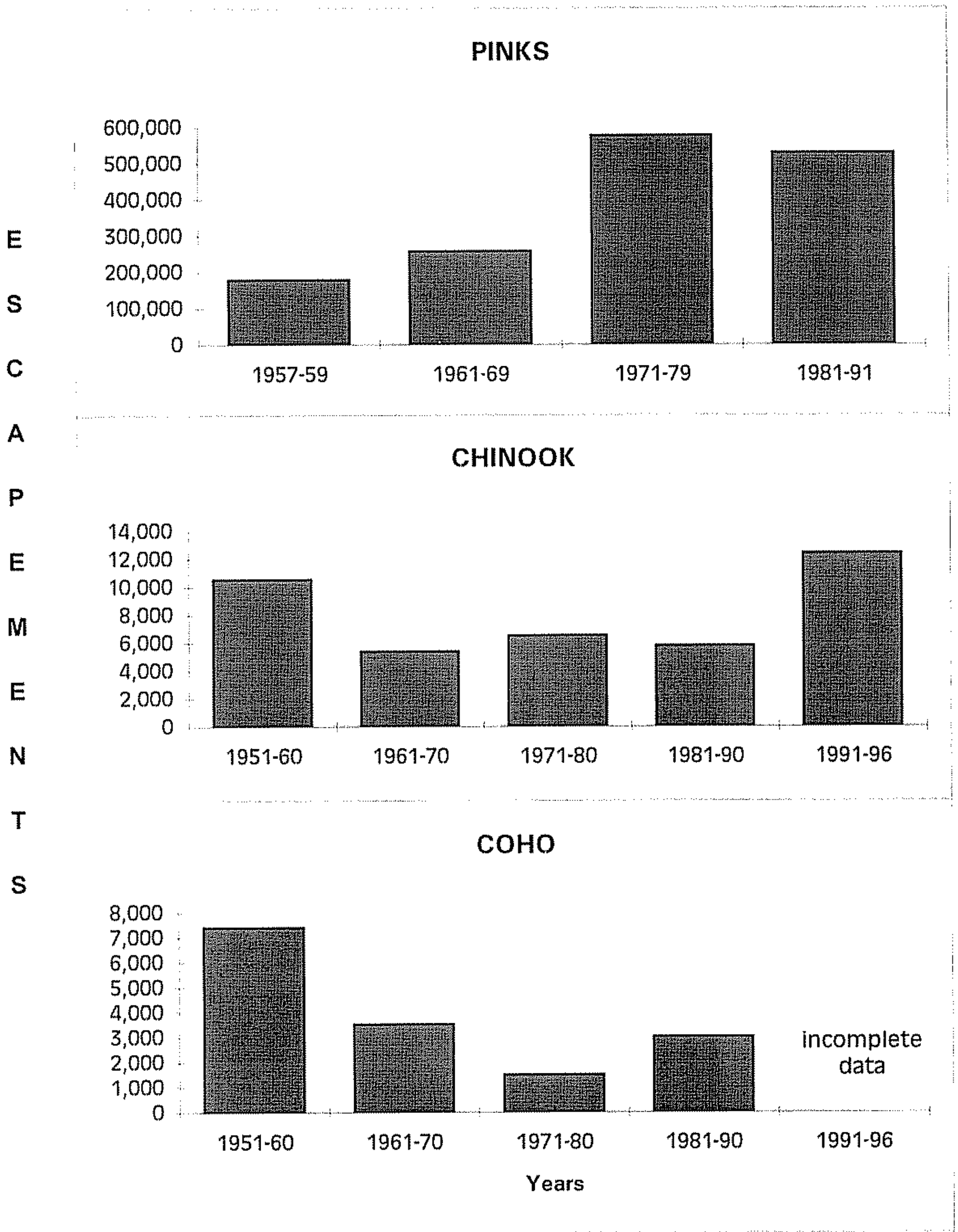


FIGURE 2. Ten-year average escapements of pink, chinook and coho salmon to the Thompson-Nicola HMA, 1951-1996 (Appendix A - pk esc unavail after 1991).

2.1.2 Spawning and Rearing Habitat

Spawning distribution of pink salmon in the HMA is shown in Figure 3. Spawning in the Thompson River occurs in small pockets from Kamloops Lake to the Nicola River confluence at Spences Bridge. A spawning survey on the Thompson mainstem in 1977 showed that the majority of pinks spawned downstream from Kamloops Lake to the confluence with the Deadman River (Morton 1978). Surveys conducted in 1983 indicated concentrated pink spawning also downstream of Kamloops Lake to Walhachin; all spawning areas downstream to Spences Bridge were mapped (Beniston and Lister 1984). Spawning occurred along the river margins, in riffles and back eddies, as well as in mid-channel, with concentrated spawning observed only in areas of small-sized gravel.

Freshwater rearing habitat is less important to pink juveniles than to chinook and coho juveniles which rear extensively in freshwater. The greatest limiting factor to pink juveniles may be the Strait of Georgia foreshore areas where the juveniles reside until about June before outmigrating to deeper waters (Healey 1980).

2.1.3 Catches, Escapements and Escapement Trends

No stock-specific catch information is available for pink salmon, and the Thompson pink population is managed as part of the early run stock group (i.e., upper Fraser / Thompson pink stocks). Canada harvests the majority (68%) of the Fraser River pink catch, mainly in the Johnstone and Juan de Fuca Strait net fisheries, while the U.S. harvests the remainder (Table 1). The Fraser River gillnet fishery takes only a small incidental catch (5% of total) during the directed sockeye fisheries.

TABLE 1. Catch distribution of Fraser River pink salmon by major commercial fishery, 1973-1991.*

FISHERY	% OF CATCH
Johnstone Strait	28
Canadian Troll	19
Juan de Fuca Strait	14
Fraser River	5
U.S. Fisheries	32
TOTAL	100%

* Pink stocks include all stocks in the Fraser system; data from Dept. Fish. Oceans (1995a).

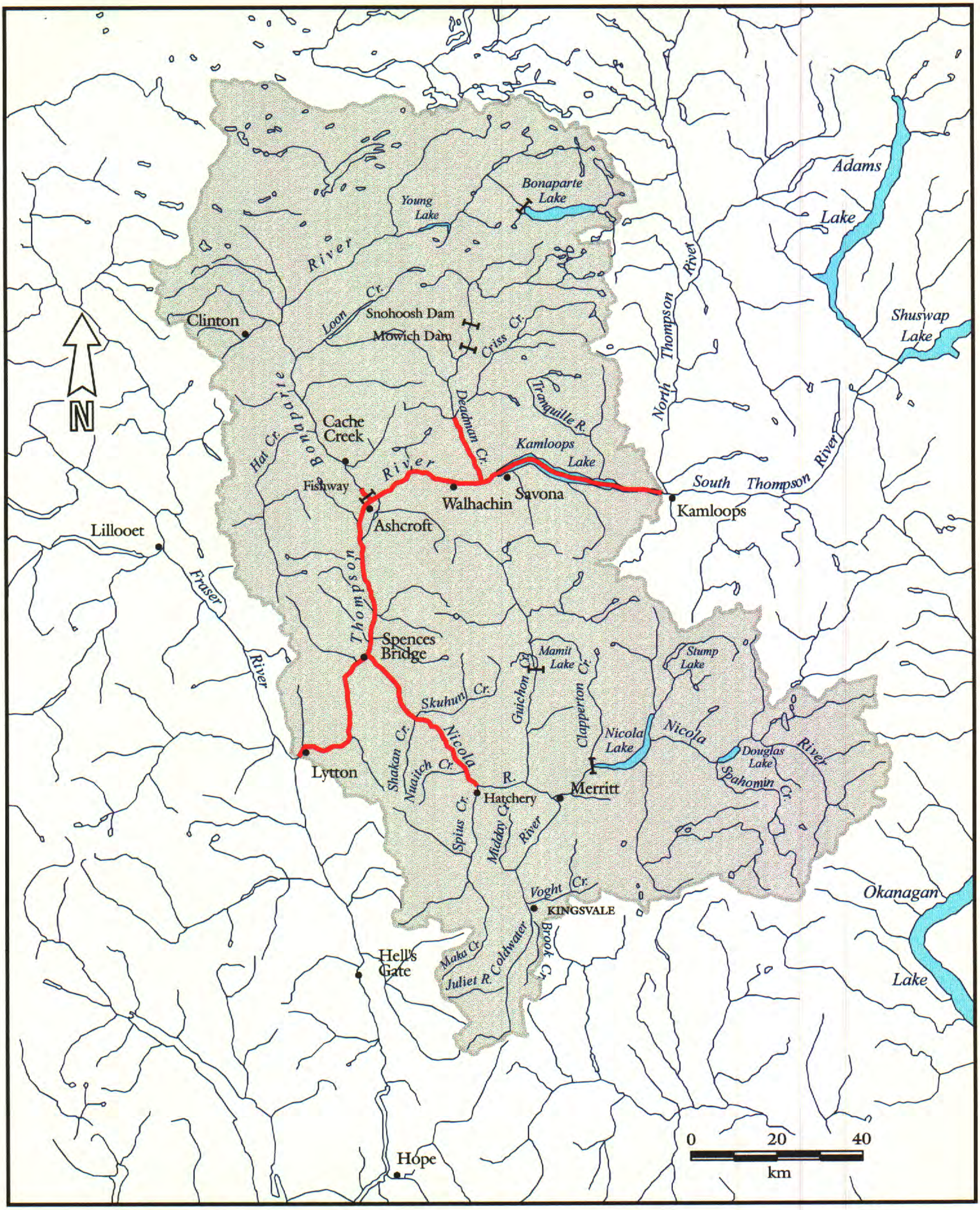


Figure 3. Known Pink Spawning Streams in the Thompson-Nicola HMA.

Since 1993, the First Nations fisheries have been managed to specific catch allocations by species, resulting in both directed and incidental salmon harvest. The majority of the native catch of Fraser pinks is taken between Mission and North Bend (MacDonald 1991); these fisheries likely target the Thompson and Seton River pink stocks.

Marine sport fisheries harvest pink salmon near major population centers (Vancouver and Victoria). In 1991, the total marine sport catch of pinks was estimated at approximately 275,000 pieces, greatly exceeding the previous annual catches of approximately 50,000 pieces. It is unknown what proportion of this catch is of the Thompson River origin. There are no freshwater sport catches of pink salmon.

Escapements to individual streams in the HMA are shown in Appendix A-1. The Thompson mainstem contributes over 98% to the total HMA pink return. The other stocks (Bonaparte, Deadman and Nicola) are minor and have no reliable escapement data. The Thompson pink escapements have increased during the 1960s and 1970s to a maximum of 1.2 million in 1981, then declined sharply to below 0.3 million in the later 1980s, increasing again in 1991 (Fig 4). The period of decline may be attributed in part to low flows in the Fraser Canyon during upriver migration and/or adverse environmental conditions during spawning and incubation period (Dept. Fish. Oceans 1995a). Since 1993, the DFO has ceased estimating pink spawning populations for individual streams and instead provides a total Fraser River estimate for pink salmon.

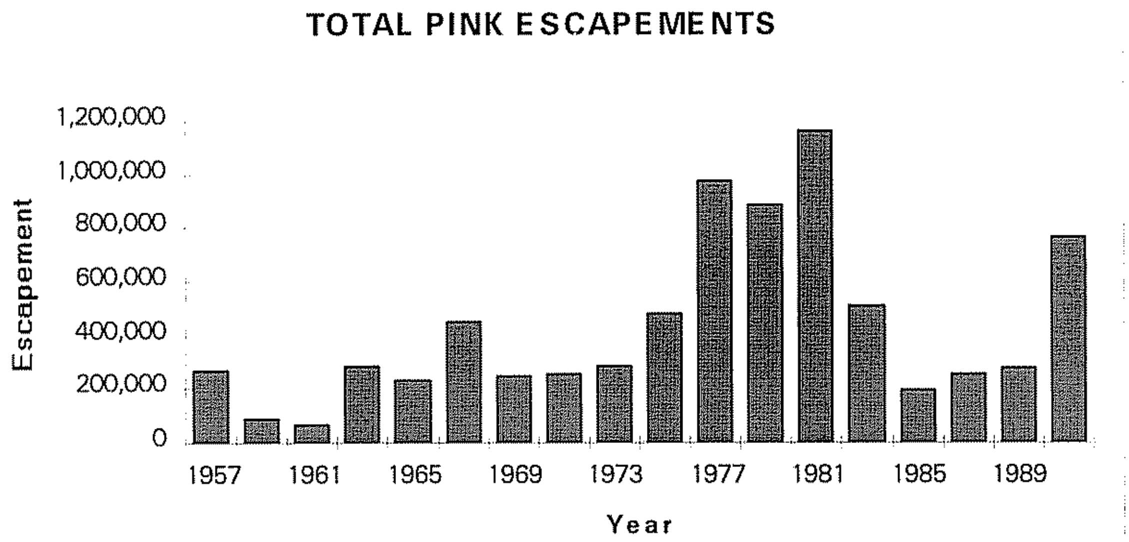


FIGURE 4. Pink salmon escapements to the Thompson-Nicola HMA, 1957-1991 (Appendix A-1).

2.1.4 Habitat Productive Capacity

The productive capacity of the Thompson pink salmon is uncertain. A stock-recruit analysis conducted on the combined Fraser pink stocks (since the catch could not be separated into discrete stock components) predicted an optimum escapement estimate of 7.6 million fish; this may be a conservative estimate due to the abnormally low return in 1987 (Dept. Fish. Oceans 1995a). A more reliable estimate of the rebuilding potential may be obtained by continuing to increase pink escapements to the Fraser system for several more cycles.

Several factors (not directly related to habitat productivity) may be limiting the future production of the upper Fraser pink stocks. Low water levels and the resultant high water velocities at the Hell's Gate and in the Fraser Canyon continue to obstruct upstream fish passage. Also, a gradual decrease in the body size of Fraser pinks has been observed due to selective harvesting in the gillnet fishery (Ricker 1989). In addition, the size of individual pink adults tends to be smaller in years of high returns (Pacific Salmon Commission 1988). These smaller adults likely have an even greater difficulty of traversing the Fraser Canyon area, and may also have less energy for reproduction, possibly leading to reduced stock productivity (Ricker 1989).

Additional information is required to clarify the relationship between the migration distance, fish size and fish productivity in order to determine the optimum spawning goals for the upper Fraser pink stocks. Also, additional habitat information is required (e.g., on spawning area, gravel quality, and incubation conditions) in order to develop an optimum escapement estimate for individual stock groups, such as the Thompson River.

2.1.5 Production Objectives

Natural production

Remedial work since the Hell's Gate landslide of 1913 and subsequent harvest management efforts have been aimed at rebuilding the Fraser pink stocks. Since 1983, the goal has been to achieve a minimum overall escapement to the Fraser system of six million pink spawners. This goal has been surpassed in recent years (1989, 1991, 1993, 1995, Woodey, pers. comm.) due in part to the DFO's policy of reducing the exploitation rates on Fraser pink stocks. The current exploitation rates are to be maintained until the present escapement levels are consistent and/or the maximum spawning levels can be determined.

Ricker (1989) considered the upper Fraser pink stocks to be the largest in the system prior to 1913. The present minimum escapement goal of six million pinks to the total Fraser basin may be low. A more accurate escapement target may be provided when a longer series of stock-recruit analysis data is acquired.

Enhanced production

There is no enhanced production of pink salmon in the HMA. However, in the last 10 years, the upstream fish passage at Hell's Gate has been facilitated through the construction of two low-flow fishways and the installation of lights on both river banks to facilitate night-time migration (McGechaen, pers. comm.).

2.2 CHINOOK SALMON

The Nicola River is the major chinook producer in the HMA (generally >3,000 spawners). Other important producers (>1,000 spawners) are the Coldwater, Deadman and Bonaparte rivers, with the latter stock exceeding 4,000 spawners in recent years (Append. A-2). The Spius Creek generally supports several hundred chinook spawners, while the Thompson mainstem (historically >1,000 spawners) has had no escapement records since 1976. Chinook are also present in Spahomin Creek and upper Nicola River above Nicola Lake, but consistent counts are not available (fence counts since 1990 in the upper Nicola show up to 67 chinook annually, Rosenberger, pers. comm.).

2.2.1 Life History

The Thompson-Nicola chinook return to spawn primarily at age four after two years of ocean rearing, with a portion returning at age three (scale analysis data, DFO unpubl.). The adults enter the lower Fraser from March to early July, based on coded wire tag (CWT) recoveries in the Albion test fishery and spawner presence in streams. Due to their early migration timing through the lower Fraser (by July 15), these stocks are managed as part of the spring (early run) stock group.

The Thompson chinook stocks migrate up-river more slowly than other Fraser chinook and may remain in the Fraser and Thompson mainstems for about two months (Schubert, pers. comm.). Chinook typically arrive in the Thompson River mainstem by mid June with peak spawning in the mainstem during the first two weeks of October (Rosenberger, pers. comm., Beniston 1985).

All Thompson chinook stocks exhibit a stream-type life history, with the juveniles overwintering in freshwater before entering the sea as yearlings (Healey 1991, Fraser et al. 1982). Fry emerge in the spring (Lewis and Komori 1989) and typically disperse throughout the natal streams; some remain to overwinter while a portion emigrates to the lower watersheds at this time (Scott and Olmsted 1985).

Lauzier and Taylor (1989) monitored the rearing densities of juvenile chinook in the Thompson mainstem above and below the Nicola River confluence. They observed that a portion of the Nicola subyearlings emigrated from that River by their first spring and likely reared in the lower Thompson mainstem until the following spring; the yearlings apparently outmigrated to sea around late March to early April.

Also in the Deadman River, a portion of the chinook underyearlings migrated downstream in late summer and likely overwintered in the Thompson mainstem (Starr MS 1979). The remaining juveniles apparently overwintered in the Deadman River, as indicated by early-season trapping of yearling chinook in that River (Olmsted et al. 1992).

2.2.2 Spawning and Rearing Habitat

Spawning habitat

Spawning distribution of chinook in the HMA is shown in Figure 5. Spawning In the Thompson mainstem is scattered from the Kamloops Lake outlet downstream to about 8 km above the Nicola River confluence, with spawners typically utilizing areas of gravel and cobble substrate on the inside bends of the river and in the upstream sections of riffles (Beniston 1985).

In the Nicola River, the majority of chinook spawn in the lower reaches, from the outlet of Coldwater River at Merritt to the Spius Creek confluence. Spawning in the Nicola also occurs above Merritt to the Nicola Lake Dam, and downstream of Spius Creek to the area of Dot Trestle; tributary spawning is observed in the Coldwater River (up to Kingsvale), Clapperton Creek and Spius Creek (up to Box Canyon) (Rosenberger, pers. comm., Scott and Olmsted 1985). Tributary spawning also occurs in the lower reaches of Spahomin Creek (Manuel and Grismer 1991).

Chinook spawn throughout the Deadman River, from the river mouth to about 15 km above the Criss Creek confluence (Starr MS 1979). In the Bonaparte River, chinook spawning has been confined prior to 1989 to a 3 km reach below the barrier to migration. Since the construction of a fishway in 1989, chinook spawning has extended along the 75 km reach of the lower Bonaparte River, mainly between Cache Creek and the confluence of Loon Creek, and at the mouth of Young Lake (Galesloot 1995, Diversified Ova Tech. Ltd. 1994). Chinook spawning has also been noted in the lower reaches of Hat Creek (tributary to the Bonaparte).

Rearing habitat

A detailed rearing habitat assessment is provided for the Coldwater River (Lauzier 1987, 1989, Beniston et al. 1988). Juvenile chinook generally utilize all habitat types (riffles, glides, shallow and deep pools), with a seasonal change observed in habitat preference; for example, the emergent fry were generally found in areas of lower velocity and gradient. Swales et al. (1986) observed that juvenile chinook overwintering in the Nicola and Coldwater rivers were generally most abundant in deep pools containing log debris.

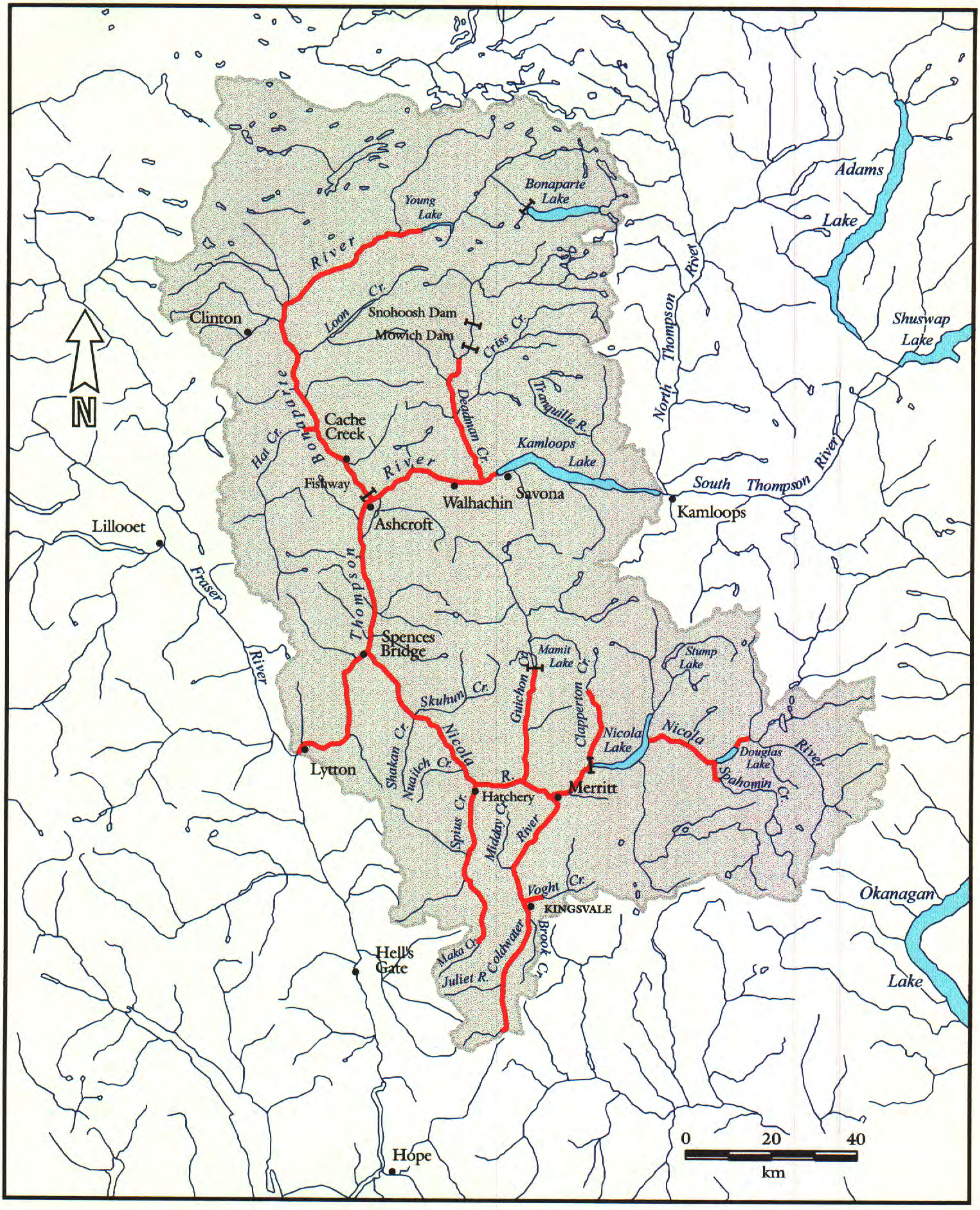


Figure 5. Known Chinook Spawning Streams in the Thompson-Nicola HMA.

Off-channel areas (side channels, minor tributaries, etc.) in the Coldwater River were not significantly utilized by underyearling chinook during any season (Beniston et al. 1988). However, Fleming et al. (1987) surveyed juvenile utilization of gravity-fed irrigation ditches in the Nicola and Coldwater rivers, and observed chinook fry moving into these ditches actively or passively throughout the summer (July and August study); those authors concluded that significant rearing opportunities existed for juvenile chinook in the off-channel sites, provided the juveniles did not become trapped at the dewatered sites.

Manuel and Grismer (1991) conducted summer/fall surveys on the small tributaries in the Nicola system and observed juvenile chinook only in the lower reaches of Guichon and Nuaitch creeks and in Midday Creek. These smaller tributaries likely provided summer rearing habitat only.
As in the Nicola system, the Deadman River system is utilized extensively by rearing chinook, with a portion of the juveniles remaining to overwinter (see above). Tredger (1980a) observed juvenile chinook throughout most of the Deadman River and in the lower reaches of Criss Creek during late August. The preferred habitats were similar to those observed in the Nicola River, with pools and glides, and abundant cover being critical for rearing.

No published information is available on chinook rearing habitat in the Bonaparte River. However, Tredger (1980b) assessed the potential rearing habitat for this river, based on chinook habitat in the Deadman River.

2.2.3 Catches, Escapements and Escapement Trends

Total catch estimates for the Fraser chinook are not available due to limited CWT recoveries. Table 2 shows the catch distribution for the Thompson stocks, based on available CWT data for the enhanced Nicola and Deadman chinook. Much of the harvest (44%) is taken in the Fraser gillnet fishery as incidental catch in the directed sockeye fisheries. Other important harvesters are the West Coast Vancouver Island troll (12%), Northern troll (11%), Georgia Strait sport (10%) and Juan de Fuca sport (9%) fisheries. The Alaska catch is minor (1%).

The Fraser in-river sport fisheries were terminated in 1980 due to low chinook returns, as indicated by the Fraser test fishery data (Schubert 1995). Since 1988, a limited sport fishery (about 100-300 catch ceiling) has been conducted in the lower Thompson near Spences Bridge. This fishery is supported by the Spius Creek Hatchery releases and takes primarily the Nicola-bound chinook, along with some passing chinook stocks (Rosenberger, pers. comm.).

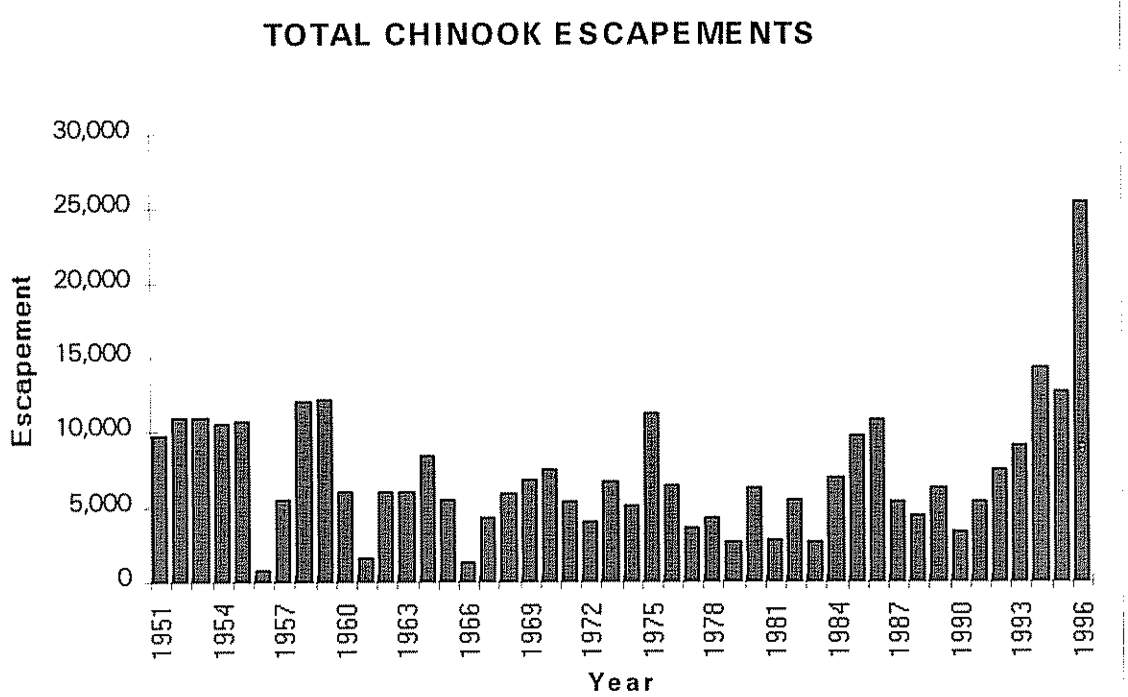
TABLE 2. Commercial and sport catch distribution of chinook salmon from the Thompson-Nicola HMA (no native fishery data).*

FISHERY	% OF CATCH
Fraser River Gillnet	44%
West Coast Vancouver Island	12%
Northern Troll	11%
Georgia Strait Sport	10%
Juan de Fuca Sport	9%
Juan de Fuca Net	5%
Johnstone Strait Net	3%
Northern Sport	3%
Georgia Strait Troll	1%
South Coast Troll	1%
ALASKA	1%
TOTAL	100%

* Based on CWT recoveries for Nicola and Deadman River chinook (1988-1994 data).

Catch data for the First Nations fisheries are not available due to lack of CWT sampling in these fisheries. The early return timing of these stocks would result in their presence through the directed chinook fishery prior to late June; the native fishing effort is then switched to sockeye salmon (Macdonald 1991). The majority (>80%) of the native catch of Fraser chinook is taken below North Bend, and the current harvest levels of the Thompson-Nicola chinook are believed to be low. Directed chinook harvesting in the Thompson River occurs primarily with rod and reel at the mouth of the Bonaparte River and Nicomen Creek; chinook are also harvested in the Bonaparte, Deadman and Nicola rivers by gillnet, weir and spearing (Rosenberger, pers. comm.).

Total chinook escapements to the HMA are shown for the period 1951-1996 in Figure 6 (Append. A-2). The Nicola River is the major chinook producer, contributing on the average over 50% to the system escapement. Total chinook escapements to the HMA have increased dramatically since 1990, with the return years 1994 to 1996 showing some of the largest escapements on record for the Nicola and Bonaparte rivers.



(no data for Thompson mainstem after 1976).

FIGURE 6. Chinook escapements to the Thompson-Nicola HMA, 1951-1996 (Append. A-2).

Under the Canada-U.S. Pacific Salmon Treaty of 1985, the two nations were committed to halt the decline in chinook escapements. Rebuilding goals were arbitrarily set at double the average escapements for the 1979-82 base period. The Chinook Technical Committee (CTC) goals were set at double the 1984 visual estimates. Stock rebuilding was to be achieved by reducing the exploitation rates by 15% in the ocean fisheries (troll, net, sport) through management actions.

Table 3 compares the mean annual stream escapements since 1971 with the interim escapement goals. All stocks have reached or exceeded the interim goals in recent years (1993-1996) except the Deadman stock which has not reached the CTC goal. The rebuilding trend may be attributed in part to enhancement efforts as most of the HMA stocks have been enhanced through hatchery production (see enhancement section). For the Bonaparte stock, the major increases since 1990 may be attributed to the construction of a fishway in 1989 which resulted in a greatly increased accessible fish habitat.

TABLE 3. Comparison of average chinook escapements to interim escapement goals by stream, Thompson-Nicola HMA. *

STREAM	AVERAGE ESCAPEMENTS				INTERIM ESCAPEMENT GOALS	
	1971-80	1981-90	1991-96	1993-96	Canada-U.S. Agreement (1985)	CTC Goals
Bonaparte R.	58	469	3,034	3,611	125	-
Deadman R.	152	673	886	1,211	463	3,252
Coldwater R.	611	847	1,140	1,296	1,005	1,196
Nicola R.	2,950	3,584	6,926	8,757	6,775	7,400
Spius Cr.	343	233	425	513	275	512
Thompson R.	2,417	n/r	n/r	n/r	-	-
TOTAL **	4,114	5,806	12,411	15,388	8,643	12,360

* Average escapements from Appendix A-2.
** Total excludes the Thompson River chinook due to incomplete escapement records.

Interim escapement goals: Canada-U.S. Treaty goals set at double the 1979-82 mean escapements; CTC (Chinook Technical Committee) goals set at double the 1984 visual estimates (except for Bonaparte River where production targets will be based on capacity returns in response to the fishway construction in 1989).

2.2.4 Habitat Productive Capacity

The total productive capacity of chinook habitat in the HMA is not known due to limited data. Studies have focused on the presence or absence of juveniles and spot abundance estimates, and hence do not provide total production estimates for the surveyed streams. Also the proportion of juveniles that leave their natal stream to rear in the lower watersheds is unknown. In addition, due to lack of accurate catch and escapement estimates, a stock recruit analysis for estimating optimal spawning levels is not possible at this time.

The overall productive capacity of the HMA is dependent on maintaining the spawning and rearing habitat. For the stream-type chinook in particular, a high quality rearing habitat is required throughout the year. Given the harsh winter conditions in the Thompson-Nicola region, the overwintering habitat may be critical to the overall smolt output in those streams where the overwintering component is significant. For example, Beniston et al. (1988) observed that in the Coldwater River, low flows during late summer and winter months may be the primary factor limiting juvenile chinook production. In the Deadman River, the scarcity of deep pools and cover reduces the amount of overwintering habitat (Olmsted et al. 1992).

Another major concern is that the Thompson chinook (and coho) stocks with their year-long dependency on the freshwater habitat, are especially vulnerable to impacts resulting from forestry, agriculture, industry and population growth in the HMA (e.g., loss of riparian vegetation, bank instability, siltation and high water temperatures) (Miles 1995, Millar et al. 1994).

2.2.5 Production Objectives

Natural production

The major objective of the DFO since 1980, has been to rebuild chinook runs by increasing escapements through reduced harvest rates. The actions included the closure in 1980 of the terminal Fraser gillnet fishery on chinook, the closure of in-river sport fisheries, and the Canada-U.S. Pacific Salmon Treaty (1985) initiatives which involved harvest rate reductions and catch ceilings in the marine fisheries (DFO 1991).

To date, most of the HMA chinook stocks have reached the interim escapement goals (Table 3), and a strong rebuilding trend is evident (Fig 6). Although the enhanced component is significant for most stocks (see below), a strong natural production is also apparent. For example, the Nicola chinook showed record-high escapements in 1996 (Append. A-2) despite low enhanced returns expected that year due to a partial BKD die-off of hatchery brood juveniles (Cross, pers. comm.).

To develop sound rebuilding goals for the HMA, a reliable estimate of the total productive capacity is required, along with improved escapement database and improved understanding of chinook population dynamics during the freshwater rearing phase.

Enhanced production

Two facilities (Spius Creek and Deadman River) have been operating in the HMA since 1984 and 1989, respectively. Currently, their combined production to catch and escapement is approximately 5,000 chinook adults (based on 1996 production targets, Cross, pers. comm.). The enhanced contribution to the HMA's chinook escapement is significant (e.g., 50-60% of the Nicola escapement prior to 1996, Cross, pers. comm.). In recent years, a portion of the chinook juveniles from the Spius Creek Hatchery have been transported to grow-out ponds on the Spahomin and Coldwater streams, for rearing and release.

The Spius Creek Hatchery, located about 0.5 km upstream of the Spius / Nicola confluence, presently enhances the Nicola, Coldwater and Spius Creek stocks. In addition, minor releases of the Bonaparte and Deadman chinook have been previously conducted. At present, only the yearling release strategy is being used due to its greater survival success compared to the underyearling release strategy. The total production to catch and escapement for this facility is currently approximately 4,300 adults annually (Cross, pers. comm.). The Deadman River Hatchery, located about 20 km upstream of the Deadman / Thompson confluence, is operated by the Skeetchestn Indian Band. This facility enhances the Deadman stock and presently has an estimated production to catch and escapement of approximately 500 chinook adults (Cross, pers. comm.).

2.2.6 Enhancement Activities and Opportunities

The major enhancement opportunities in the HMA are stream restoration projects including re-opening and developing side channels, fencing, bank stabilization (e.g., tree planting) and complexing of rearing habitat (e.g., root wads) to provide juvenile cover. Several such projects have been planned for the watershed through the Resource Restoration Division of the DFO, and include groundwater channels in the Nicola and Coldwater rivers, habitat restoration work in the Nicola River, bank stabilization and planting in Deadman Creek, and irrigation ditch screening in the Nicola River and Guichon Creek.

The Interior Wetlands Project between Nicola Lake and Merritt includes bank stabilization, riparian planting, fencing and groundwater channel development. The Nicola Watershed and Stewardship Fisheries Authority is a First Nations initiative that has completed several restoration projects on the Nicola, Bonaparte and Deadman rivers, including riparian restoration, tree revetments and other bank stabilization projects. Olmsted et al. (1992) have assessed the habitat enhancement strategies for the Deadman River.

The Bonaparte River fishway constructed in 1989, allows chinook to utilize the upper 140 km of the watershed. A water storage structure was installed at the Bonaparte Lake outlet in 1993 to augment low flows, and hence maintain incubation and rearing habitats, and potentially enhance this stock.

A number of improvements to the Nicola Dam are proposed, including fishway modifications, assessment of water release schedule, and assessment of cold water releases to the Nicola River.

2.3 COHO SALMON

Coho salmon are found throughout the HMA watersheds (Fig 7). The Coldwater and Deadman rivers support the largest coho populations, each exceeding 2,000 spawners in some years since the early 1980s (Append A-3). Spius Creek generally supports under 1,000 spawners, with smaller populations in the Nicola, Bonaparte and the Thompson mainstem (Append. A-3). Historical records indicate sporadic coho spawning in the Spahomin, Guichon and Clapperton creeks; however these are currently not assessed for adults (Rosenberger, pers. comm.).

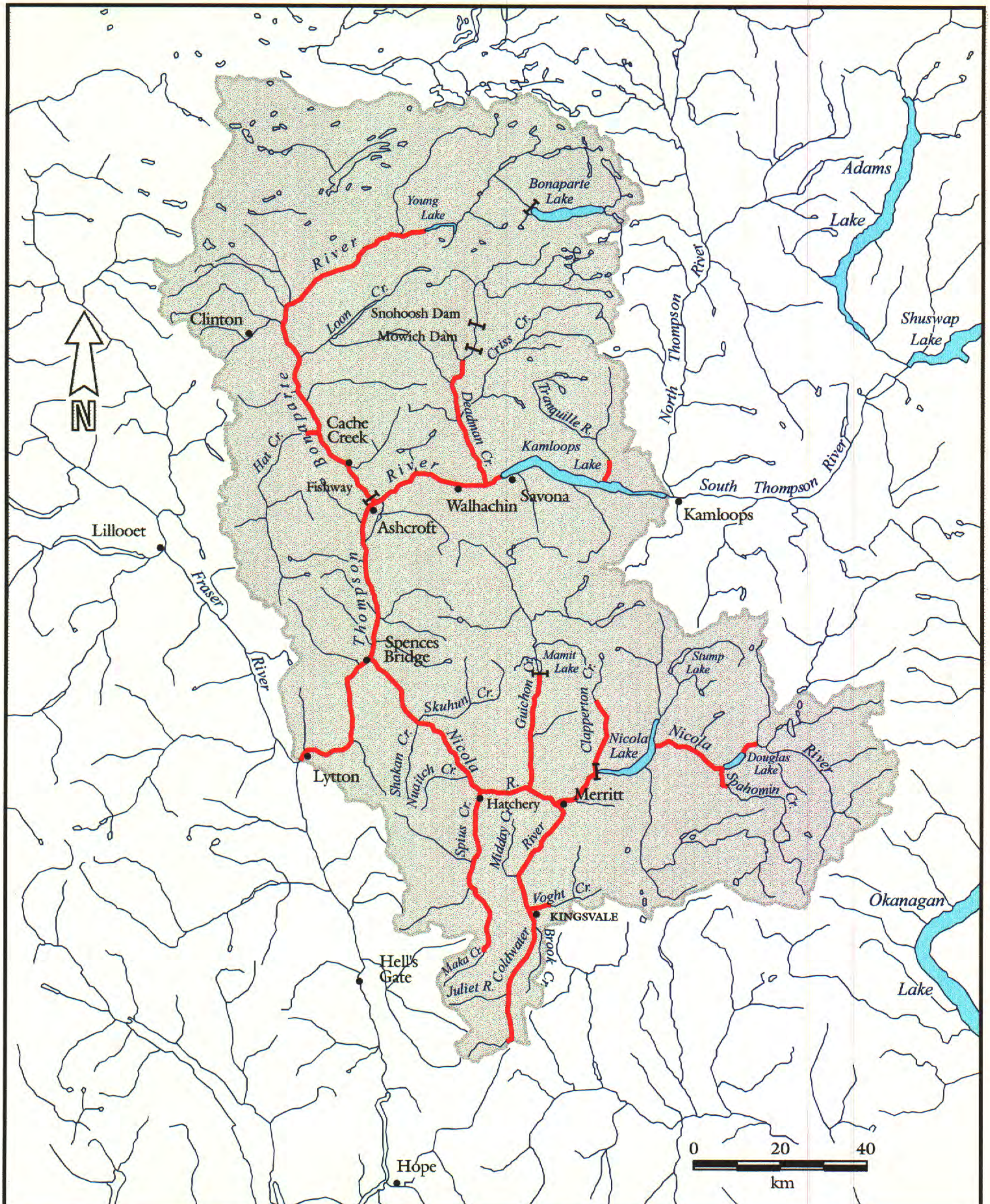


Figure 7. Known Coho Spawning Streams in the Thompson-Nicola HMA.

2.3.1 Life History

Coho return to spawn predominantly at age three (Fraser et al. 1982). The Thompson coho stocks enter the lower Fraser from about mid-August to late October, peaking in late September, based on catch per unit effort in the native fisheries and the Cottonwood test fishery (Schubert, per. comm.). Spawning in the Thompson-Nicola streams generally occurs from mid-October to early December; however, coho have been counted through the Deadman fence as early as August 22 (Rosenberger, pers. comm.).

Coho fry in the Thompson-Nicola generally emerge from late April to late June (Scott and Olmsted 1985) and spend one full year in freshwater before migrating to sea. Initial rearing generally occurs in natal streams, followed by a major downstream migration initiated in the winter months (Lauzier and Taylor 1989). The Thompson mainstem provides an important overwintering habitat for coho juveniles from the Nicola watershed. Scott and Olmsted (1985) observed a protracted (April to late June) downstream migration of Nicola coho yearlings, with peak migration occurring in the last two weeks of May. Yearling coho from the Fraser system enter the Strait of Georgia predominantly in May and June (Healey 1980).

2.3.2 Spawning and Rearing Habitat

<u>Spawning habitat</u>

Coho spawning has been recorded in all the major watersheds of the HMA. In the Thompson mainstem, spawning is scattered from Kamloops Lake to the confluence with Nicola River at Spences Bridge (DFO 1992a). In the Nicola River, the main spawning areas were recorded between Spius Creek and Merritt (DFO 1992a), but no observations have been made in recent years. Coho also spawn throughout the Spius - Maka Creek watershed (DFO 1992a, Scott and Olmsted 1985). Sporadic assessments indicate coho spawning in the Guichon, Clapperton and Spahomin creeks.

Due to the unreliability of coho spawner counts (see section 2.3.3), juvenile assessments have been made in recent years to determine coho presence (Rosenberger, pers. comm.). Juveniles were observed in the upper Nicola (between Nicola and Douglas lakes, above Douglas Lake and in Spahomin Creek) and in the upper reaches of Guichon Creek (Manuel and Grismer 1991), as well as in the lower reaches of Nuaitch Creek. Fence counts in the upper Nicola indicate a population of under 50 coho spawners in that area since 1990 (Rosenberger, pers. comm.).

Coho spawn throughout the middle reaches of the Coldwater system (Scott and Olmsted 1985), extending above the confluence with Juliet Creek. Heaviest spawner concentrations are noted along a section about 2 km above Kingsvale.

Spawning in the Deadman River occurs above and below the confluence with Criss Creek, and along a 3 km stretch above the Thompson River confluence (Starr MS 1978). No coho juveniles were observed in Criss Creek which has a relatively high gradient and large substrate unsuitable for spawning (Tredger 1980a). That author observed some juveniles in the Deadman River below Mowich Lake suggesting some coho spawning in the upper Deadman reaches.

Prior to 1989, coho spawning in the Bonaparte River had been restricted to the lower 3 km reach. With the installation of the fishway, coho adults now migrate above the falls and disperse upstream.

Rearing habitat

In the Coldwater River, underyearling coho have demonstrated a strong preference for the off-channel habitat; this included smaller tributaries, beaver ponds, groundwater fed ponds, and channels and side channels connected to the mainstem; sections with heavy riparian and in-river cover were particularly favoured (Beniston et al. 1988). The winter distribution studies on coho juveniles in the Coldwater and Nicola rivers generally showed an extensive use of off-channel ponds, side channel, and back channels with groundwater influence; few juveniles were found in the mainstem during the winter months (Swales et al. 1986)

Coho juveniles in the Deadman River were observed from the Criss Creek confluence downstream to about 3 km above the Thompson River confluence (Starr MS 1979). Coho juveniles did not utilize the upper reaches above the Deadman-Criss Creek confluence probably due to a large crib dam across the River (about 2 km above Criss Creek) which impeded upstream access (Starr MS 1979).

While a portion of the Deadman coho overwinter in the natal stream, based on spring captures of yearlings at the river mouth, the majority migrate downstream and likely overwinter in the Thompson River; this is similar to the behaviour of coho in the Nicola and Coldwater systems. Overwintering habitat in the Deadman River may be limited by the availability of deep pool habitats with abundant cover (Olmsted et al. 1992, Tredger 1980a).

2.3.3 Catches, Escapements and Escapement Trends

The major harvesters of the Thompson-Nicola coho stocks, based on CWT data for the Coldwater River coho, are the West Coast of Vancouver Island troll fisheries (55% of catch) and the Strait of Georgia sport fishery (31% of catch) (Table 4). No CWT data are available for the native fisheries.

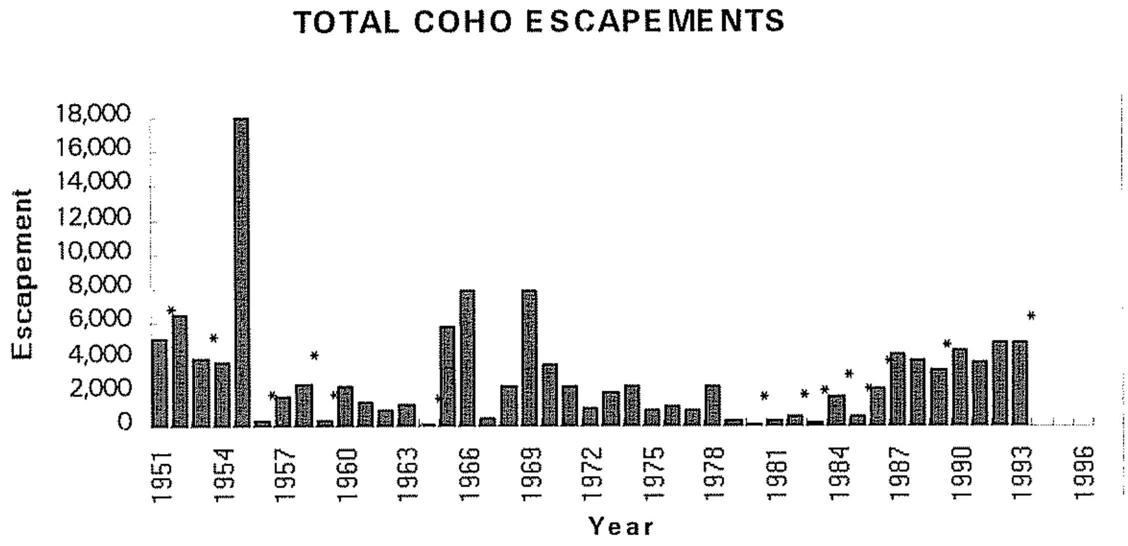
TABLE 4. Commercial and sport catch distribution of coho salmon from the Thompson-Nicola HMA (no native fishery data).*

FISHERY	% OF CATCH
Southwest Van. Is. Troll	43%
Northwest Van. Is. Troll	12%
Georgia Strait Sport	31%
Georgia Strait Troll	8%
Fraser River Gillnet	2%
Johnstone Strait Net	2%
South Central Troll	1%
Central Sport	1%
TOTAL	100%

* Based on CWT recoveries for Coldwater River coho (1988-1994 data).

The native catch of coho in the HMA is minor since the majority of the native catch of this species is taken in the lower Fraser between Mission and North Bend (Macdonald 1991). The Thompson in-river sport fishery has taken up to 200 coho annually; however, catches and effort have declined to low levels in recent years and all coho sport fisheries in the area were closed in 1996 (Rosenberger, pers. comm.). Some of the Thompson coho stocks likely continue to the intercepted in the lower Fraser River sport fishery.

Coho escapements to individual streams in the HMA are presented in Appendix A-3. The overall escapements are variable, ranging from <500 to around 5,000 spawners since 1970 (Fig 8). The coho escapement data must be viewed with caution since the records are often incomplete; in addition, the estimates unreliable due to poor stream access and poor visibility, late and protracted spawning period, inclement weather conditions, and lack of consistent enumeration methodology. These estimates include both the natural and enhanced production, and any trends in abundance may not reflect the health of the wild coho stocks (Dept. Fish. Oceans 1992b).



(most streams not surveyed after 1993; * data missing for 3 or more stocks)

FIGURE 8. Coho escapements to the Thompson-Nicola HMA, 1951-1993.

The Deadman River fence counts provide the only consistent escapement data for the HMA streams since the early 1980s (Append A-3, Rosenberger, pers. comm.). The Deadman returns show an alarming decline in recent years, from 1,561 coho spawners in 1991 to only 353 in 1996. A similar recent declining trend is observed for all the interior Fraser coho stocks with consistently monitored escapements (e.g., Eagle and Salmon rivers, DFO MS 1997, Rosenberger, pers. comm.). This declining trend parallels the decline in the overall coho abundance observed for the Lower Georgia Strait and Fraser River stocks (Dept. Fish. Oceans 1992b). The decline in the wild Fraser coho populations is attributed largely to excessive exploitation rates, habitat loss and poor marine survival (Dept. Fish. Oceans 1996).

2.3.4 Habitat Productive Capacities

The habitat productive capacity for coho salmon in the HMA is not available at present. To provide this estimate, all suitable spawning and rearing habitat must be quantified and the limiting factors identified. The major factors limiting coho production in the HMA include low flows in late summer and winter which may result in dewatered areas and high water temperatures (e.g., Coldwater River, Beniston et al. 1988), extreme water temperatures which may lead to sub-lethal and lethal rearing conditions (e.g., Nicola mainstem temperatures fluctuate between 20°C and 27°C during summer, Walthers and Nener 1997, Lauzier 1989), and scarcity of suitable rearing habitat (e.g., Coldwater River, Swales et al. 1986).

Agriculture, forestry and other activities in the Thompson-Nicola have seriously impacted the riparian cover and instream flows in most salmon producing streams, including the Nicola, Coldwater, Deadman and Bonaparte rivers; this has resulted in a loss of productive capacity (Miles 1995, Millar et al. 1994). Given the continued development pressures in this region, the protection and restoration of the spawning and rearing habitat is vital to the preservation of these stocks.

2.3.5 Production Objectives

Natural production

There are no defined escapement goals for the Fraser coho populations. These stocks are managed passively as part of the Strait of Georgia stock complex, based on six indicator streams none of which are located in the HMA (Rosenberger, pers. comm.). The uncertainty in the marine catch of coho by stock and the poor reliability of escapement data, prevent the estimation of coho exploitation rates. This in turn prevents the development of sound harvest management strategies to preserve and restore these stocks.

The apparent major decline in coho escapements to interior Fraser streams (see section 2.3.3) requires immediate action. Escapement estimates must be improved, and habitat capacities assessed by stock in order to develop strategic goals and plans. Further conservation measures must be developed and implemented immediately.

Enhanced production

The Spius Creek Hatchery, the largest coho facility in the HMA, began operation in 1984 and at present has an estimated production to catch and escapement of approximately 7,200 coho adults (Cross, pers. comm.). This facility serves to enhance primarily the Coldwater River stock through the release of fed fry to underutilized areas. In recent years, a portion of the hatchery juveniles (Coldwater stock) have been transported to grow-out ponds on the Spahomin Creek, for rearing and release. Enhancement efforts are also directed at the Spius Creek coho. The enhanced contribution to spawner abundance is not known since the escapement records are incomplete (Append. A-3).

The Deadman River coho have been enhanced since 1985 (DFO 1992b) through hatchery and side channel production efforts. At present, the combined production to catch and escapement is about 3,000 coho adults (Cross, pers. comm.). The recent major decline in coho escapements to this stream reflects the concerns regarding the overall decline in the Fraser coho population (see above).

2.3.6 Enhancement Activities and Opportunities

The key to rebuilding coho stocks is to increase and protect the spawning population and the productive capacity of the freshwater habitat. The Bonaparte fishway constructed in 1989, has allowed access to about 140 km of previously inaccessible spawning and rearing area. While the coho productive potential of the Bonaparte is unknown, a significant increase in this stock may be expected over time. Until the factors controlling natural coho productivity are better understood, hatchery enhancement may be used to support stocks of conservation concern.

Habitat protection and restoration projects include riparian restoration (e.g., tree planting and cattle fencing), in-stream complexing (e.g., increased cover with root wads and vegetation), development of suitable off channel rearing sites, and screening of irrigation diversions. Proposed restoration projects include a feasibility study on the Deadman to increase water capacity of Snohoosh Lake for minimum flow control, and placement of tree revetments; riparian restoration for the Bonaparte River. In the Nicola River, proposed projects include; cattle fencing along 15 km of river bank on both sides for the Nicola River; fishway modifications and fish counts at the Nicola Dam. Water flow and temperature issues in the Nicola watershed may be addressed through an improvement of water release schedules and a feasibility assessment study on transporting cool water by pipe below the dam as well as groundwater channel development for the Coldwater River.

2.4 Sockeye Salmon

Only occasional observations of sockeye spawners have been made in the Deadman and Thompson rivers (DFO 1992a), and the rearing sockeye in Kamloops Lake are presumed to be of North and South Thompson River origin (Fig 9). Stewart et al. (1989) and Beniston and Lister (1985) observed sockeye juveniles at nearshore sampling sites of Kamloops Lake until about late July and early August; subsequently, juveniles moved into deeper waters as nearshore surface temperatures reached sub-lethal levels. The extent to which Kamloops Lake provides sockeye rearing habitat in later months is unknown. The Thompson River provides an important migration route for major sockeye stocks to the South and North Thompson systems.

2.5 Steelhead and Resident Fish Species

There are 22 resident fish species identified within the Thompson Nicola HMA. Resident species include steelhead/rainbow trout (*Oncorhynchus mykiss*), bull trout (*Salvelinus confluentus*), kokanee (*Oncorhynchus nerka*), lake whitefish (*Coregonus clupeaformis*) and mountain whitefish (*Prosopium williamsoni*) and bull trout (*Salvelinus confluentus*). Although many resident species exist in the

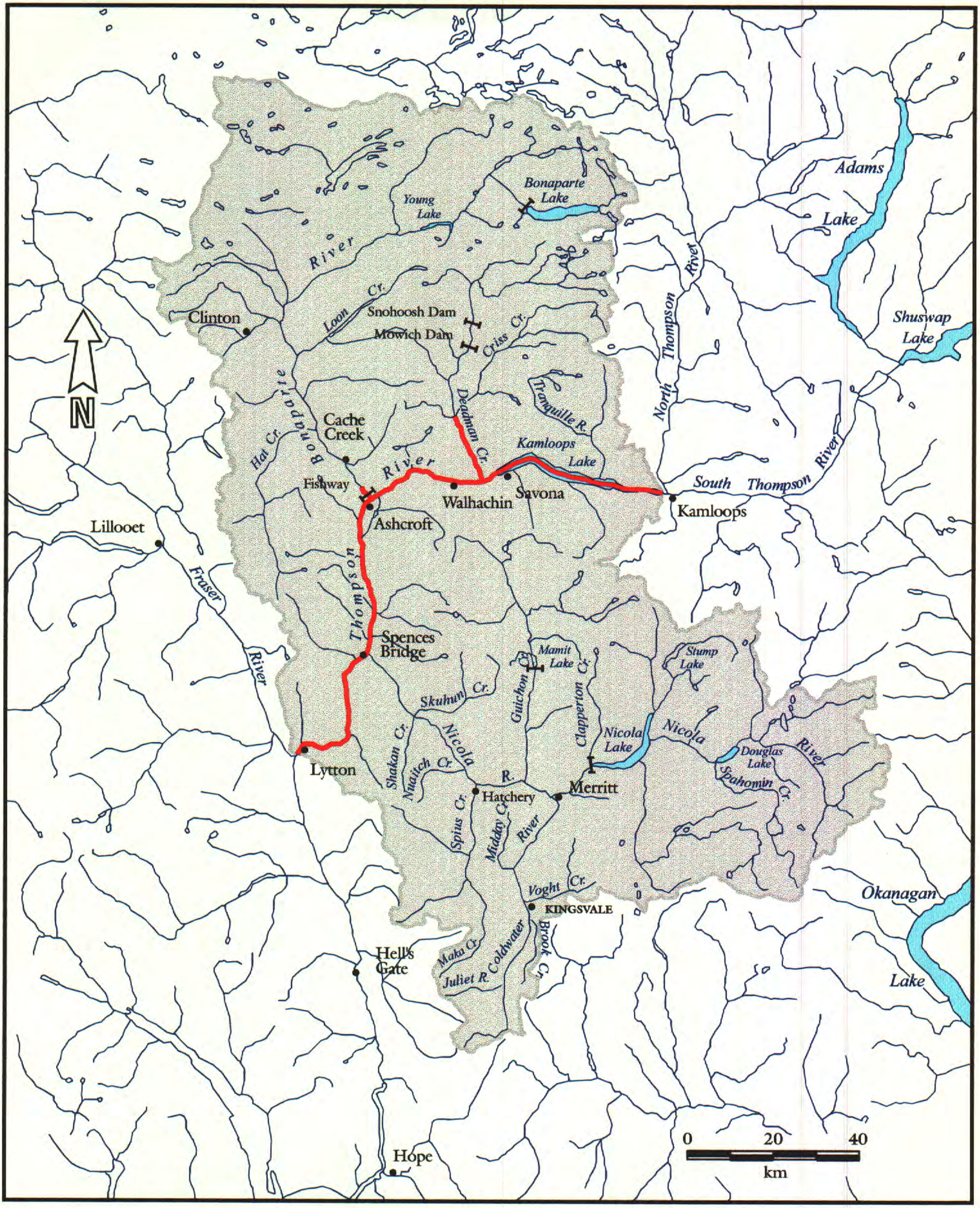


Figure 9. Known Sockeye Spawning Streams in the Thompson-Nicola HMA.

HMA, steelhead, rainbow trout, bull trout and kokanee are the most understood and actively managed. Relatively little is known of the remaining resident species found within the HMA.

The Thompson River and large tributaries including the Deadman and Nicola River is the second largest producer of steelhead (*Oncorhynchus mykiss)* in the Fraser River following the Chilliwack/Vedder system (Ptolemy, pers. comm). The Thompson River steelhead is the largest *interior summer run* stock and is world renowned (Caverhill, pers. comm). Steelhead trout distribution includes the Thompson, Deadman, Bonaparte, Nicola and Coldwater River systems, including Spius Creek and smaller tributaries (Fig 10a). These stocks provide recreational opportunities in the Thompson River and the lower Fraser steelhead fisheries. During 1985-1995, the annual steelhead escapements have ranged from approximately 1,000 to 3,500 spawners, with Nicola River being the dominant producer (Dept. Fish. Oceans MS 1996). The Thompson River may have been the primary producer of steelhead before significant habitat degradation took place in the headwaters of major tributaries (Ptolemy, pers. comm).

2.5.1 Life History

Steelhead trout inhabit all major tributaries within the Thompson-Nicola Habitat Management Area, including the Bonaparte, Deadman, and Nicola Rivers. These systems produce an average of 1675 steelhead annually (MELP, 1997). Several steelhead studies have documented that steelhead migrate into and spawn in all three major tributaries in April and May of each year. Upon emergence, the alevins remain in the gravel for approximately three months, after which the fry rear in both the major tributaries and the Thompson mainstem for two to three years (Harding et al, 1981; Renn, 1995). After 2 or 3 years, the steelhead smolts migrate down the Fraser River to the ocean and return to natal spawning grounds after three years in the oceans. A very small percentage return to spawn a second time. For example, 2% of spawners in the 1990 Bonaparte enumeration study had spawned the previous year (Maricle and McGregor 1990b). There are no studies indicating that steelhead spawn a third time in the Thompson-Nicola HMA.

Residualism of steelhead has been observed and studied on the Bonaparte River since a fish fence was installed in 1989. Residualism in steelhead is a poorly understood phenomenon where a smolt produced from anadromous stock remains in a freshwater environment throughout its life. The phenomenon has also been noted in other rivers in the HMA. Since it is believed that residualising only occurs in males, and that steelhead female to male ratios have increased between 1991 and 1995, it is probable that a greater number of steelhead are residualising in the Bonaparte River as well as in other local rivers (Renn 1995). This trend may be the result of steelhead stocking of local rivers, where rare

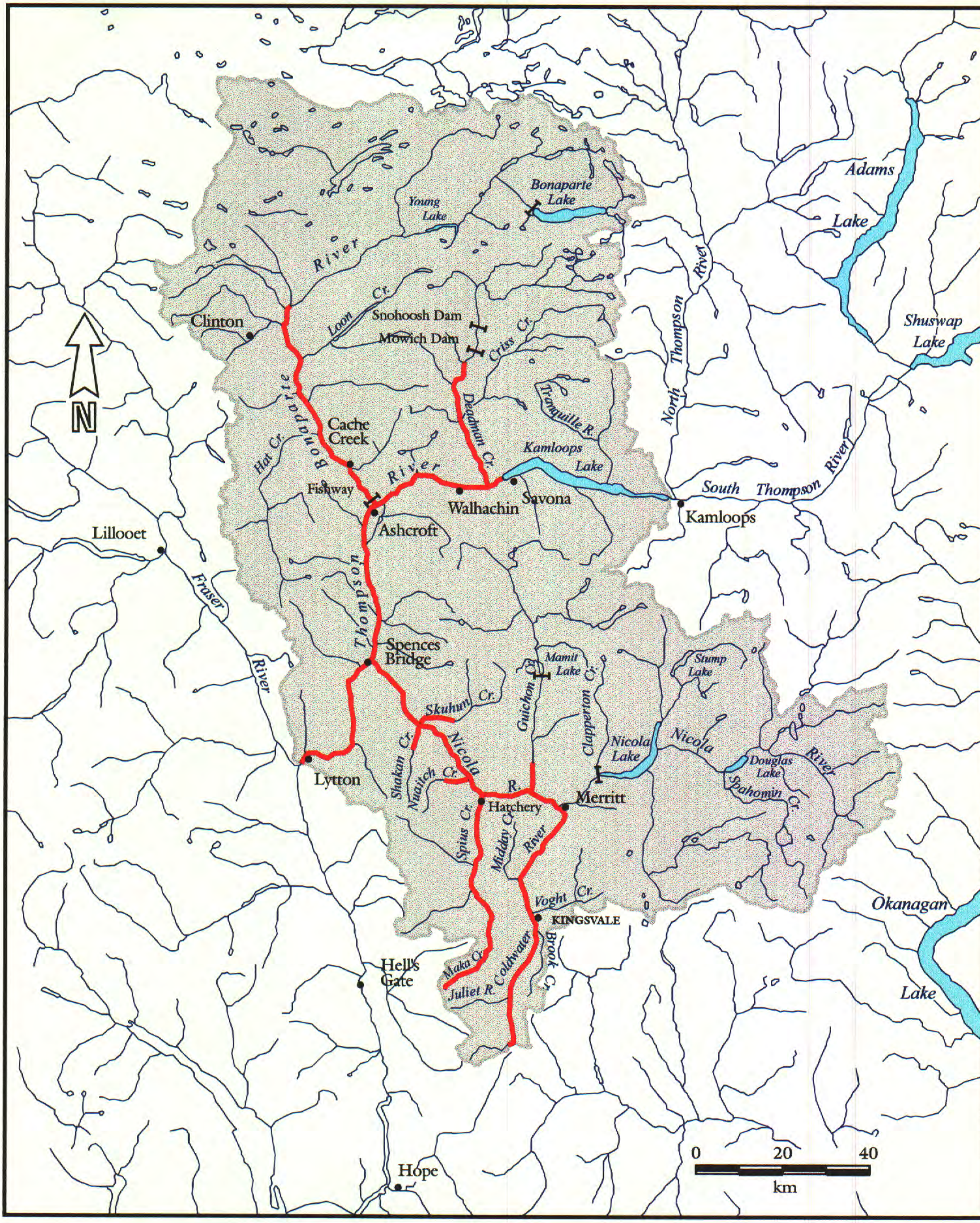


Figure 10a. Known Steelhead Spawning and Rearing Streams in the Thompson-Nicola HMA.

genetic traits are likely to be amplified, and the increased opportunity that precocious males have in mating with wild female steelhead (Renn 1995). In addition, juvenile male steelhead that grow rapidly before smolting time may not migrate to the ocean but instead remain in freshwater environments (Renn 1995).

2.5.2 Abundance and Distribution

Although many resident species exist in the HMA, steelhead, rainbow trout, bull trout (*Salvelinus confluentus*) and kokanee (*Oncorhynchus nerka*) are the most understood and actively managed. Relatively little is known of the remaining resident species found within the HMA (Table 5).

TABLE 5. Resident fish species documented in the Nicola River system (Scott et al., 1985; Sebastian, 1982; FHIIP, 1992).

Common Name	Scientific Name
bridgelip sucker	*Catostomus columbianus*
burbot cod	*Lota lota*
bull trout	*Salvelinus confluentus*
chiselmouth minnow	*Acrocheilus alutaceus*
Eastern Brook Trout	*Salvelinus fontinalis*
kokanee salmon	*Oncorhynchus nerka*
lake whitefish	*Coregonus clupeaformis*
leopard dace	*Rhinichthys osculus*
longnose dace	*Rhinichthys cataractae*
longnose sucker	*Catostomus catostomus*
mountain whitefish	*Prosopium williamsoni*
northern squawfish	*Ptychocheilus oregonensis*
Pacific lamprey	*Entosphenus tridentatus*
peamouth chub	*Mylocheilus caurinus*
prickly sculpin	*Cottus asper*
redside shiner	*Richardsonius balteatus*
river lamprey	*Lampretra ayresi*
slimy sculpin	*Cottus cognatus*
speckled dace	*Rhinichthys osculus*
steelhead, rainbow trout	*Oncorhynchus mykiss*
western brook lamprey	*Lampretra richardsoni*
white sucker	*Catostomus commersoni*

Steelhead populations in the Thompson-Nicola HMA have been actively monitored since 1979 (Fig 10b). The largest producer of steelhead is consistently the Nicola River, followed by the Deadman, and Bonaparte Rivers. On average, 1061 steelhead return to spawn in the Nicola, 337 in the Deadman River, and 278 in the Bonaparte River (MELP, 1997).

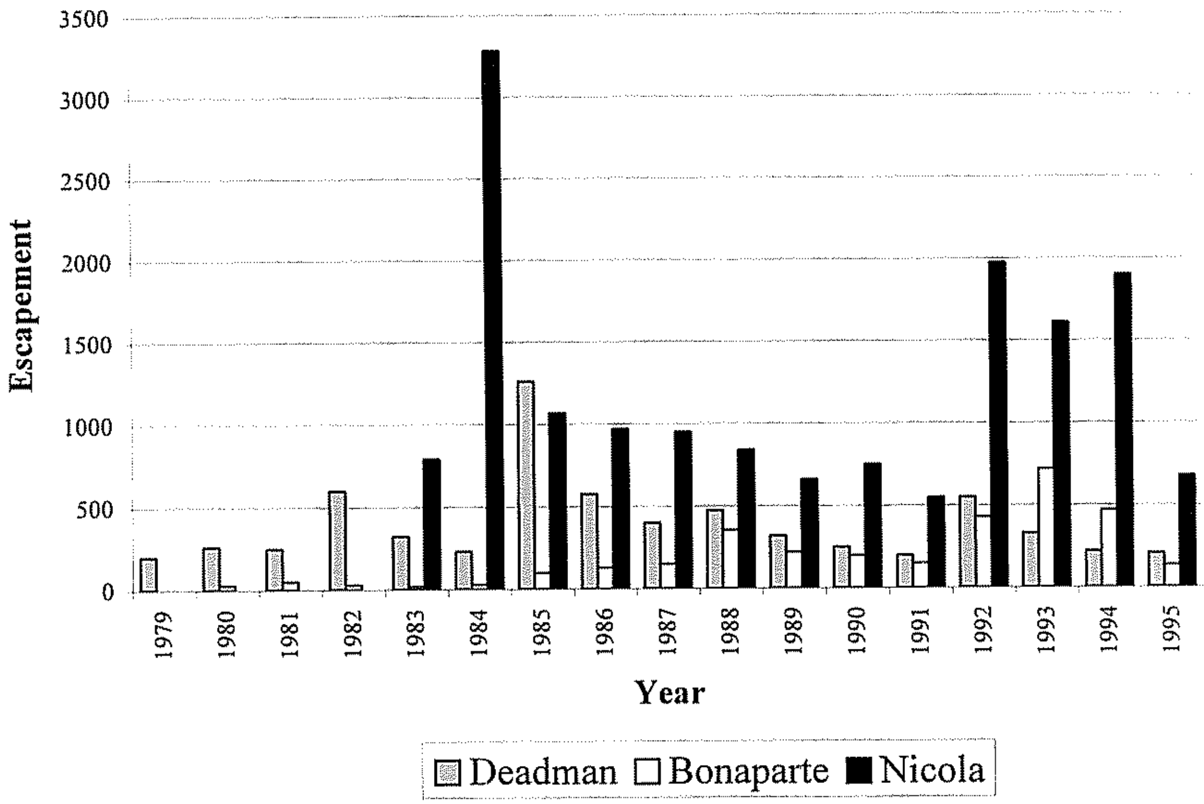


FIGURE 10b. Steelhead escapement to the Deadman River, Bonaparte River and Nicola River between 1979-1995.

In the Nicola River watershed the majority of steelhead are produced in the lower reaches of the Nicola River, and in Spius Creek and the Coldwater River (Bison, pers. comm). The majority (75%) of juvenile rainbow trout in the Nicola are assumed to be anadromous (Sebastian and Yaworski 1984). Rainbow trout become the dominant species in the headwater areas.

The Deadman River is also considered an important summer run steelhead spawning and rearing river. On average since 1979, 337 steelhead have returned to spawn in the Deadman River. Rainbow trout are also abundant throughout the watershed. A large number of resident rainbow trout from the Thompson River mainstem are believed to spawn in the Deadman River (Bison, pers. comm.). An isolated and largely pure strain of rainbow trout exists above Deadman River falls because stocking in the upper watershed has been minimal (Bison, pers. comm.).

The Bonaparte River has been a significant steelhead producer since a fishway was installed around an impassable fall 2.6 kilometers upstream of the Thompson River confluence. Annual discharge rates appear to determine steelhead distribution as well as spawning and rearing sites throughout the watershed.

Many other resident fish species inhabit the Nicola River watershed (Table 5). The most regionally important include mountain whitefish (*Prosopium williamsoni*), bull trout, kokanee, and burbot (*Lota lota*). Subadult bull trout have been captured in Nicola Lake, but their natal streams are unknown (Bison, pers. comm.).

Large populations of mountain whitefish are believed to inhabit pool and glide sections of the mainstem Nicola between Spius Creek and Nicola Lake (Sebastian, 1984). Bull trout are found in upper sections of Spius and Maka Creeks, and the Coldwater River upstream of Midday Creek. Bull trout densities are much lower than rainbow trout in the same reaches (Sebastian, 1984). The upper Bonaparte River watershed contains introduced Eastern Brook Trout (*Salvelinus fontinalis*), which are incompatible with native bull trout. The impact of the introduction of eastern brook trout on bull trout populations in not known at this time but is considered a management concern (Bison, pers. comm.). Burbot, chiselmouth (*Acrocheilus alutaceus*) and kokanee are found within Nicola Lake. Kokanee numbers in the lake are depressed due to angling pressure and low water levels in spawning streams (Bison, pers. comm.).

2.5.3 Spawning and rearing habitat

In the Nicola River watershed, the mainstem Nicola River, Spius Creek, Maka Creek, and Coldwater River produce the majority of steelhead (Figure 11). Although production capacity per unit area is greatest in the small tributaries such as Nuaitch, Guichon and Skukun Creeks (Sebastion 1984), they are not considered the most important steelhead producers due to the limited amount of suitable habitat. The majority of steelhead spawning is believed to occur downstream of Kingsvale in the Coldwater River. Steelhead production however appears to be limited by availability of quality parr rearing habitat in the Nicola River and the lower Spius Creek (Sebastion and Yaworski 1984). Due to parr habitat saturation in Nicola system, up to 25-30% of Nicola River steelhead may rear in the Thompson River (Sebastion and Yaworski 1984).

In the Deadman River steelhead spawn throughout the river (Tredger 1980). Overwintering survival of fry is considered low at 5-7% and is due to limited suitable rearing habitat. Low overwintering survival is believed to be the limiting factor of production (Tredger 1980). Due to the limited rearing habitat in the Deadman River, fry likely move into the Thompson River mainstem to rear.

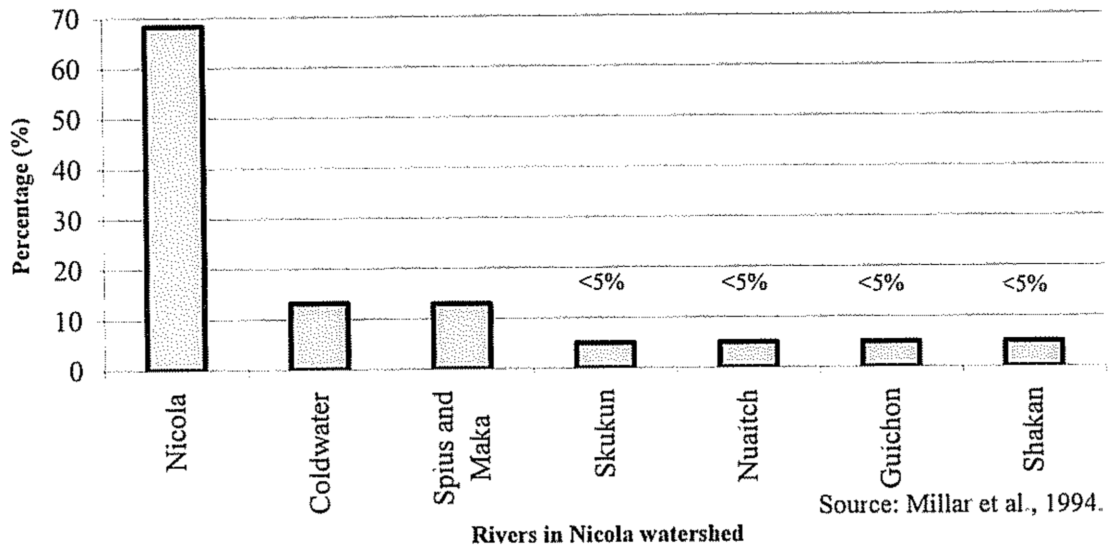


FIGURE 11. Relative contribution to steelhead production within the Nicola River watershed (Millar et al., 1994).

The Bonaparte River steelhead stocks spawn throughout the watershed, with some studies indicating that spawning takes place in the section 20-40 kilometers above the confluence with the Thompson River, and in the short 2.6 kilometer section downstream of the waterfall (Maricle and McGregor 1990a, Tredger 1980). Maricle and McGregor (1990b) determined that approximately 2% of the returning population are repeat spawners, and that the majority (80%) of spawners return at the age of five.

2.5.4 Stock enhancement and habitat restoration opportunities

In 1984, a hatchery was installed on Spius Creek to produce, among other species, steelhead smolts. Steelhead hatchery stock were outplanted in several local streams, including the Bonaparte and Deadman Rivers. However, recently the hatchery discontinued steelhead production, and rejuvenation of steelhead outplanting is not considered a current management objective (Bison, pers. comm.).

Habitat restoration activities have been ongoing since the early 1980's. The Department of Fisheries and Oceans, Ministry of Environment Lands and Parks, First Nations and private landowners are all currently involved in projects that involve restoring habitat, improving water quality, monitoring for land disturbances, enumeration and improving water supply and developing fish passage around barriers (Millar et al., 1994). Habitat enhancement options identified in the anadromous fisheries section will also benefit resident and steelhead stocks.

3.0 BIOPHYSICAL FEATURES

The Thompson-Nicola HMA falls into three physiographic land units within the Interior Plateau of the Canadian Cordillera (Holland 1976). Most of the Thompson-Nicola HMA is located within the Thompson Plateau. The most northern areas lie within the Fraser Plateau, and the headwaters of Spius Creek and Coldwater River originate in the Cascade Mountains (Figure 12a). Annual precipitation and snowfall values are low in Fraser and Thompson Plateau Units, but increase significantly in the southwestern portion of the Thompson-Nicola HMA in the Cascade Mountain area (Sigma Engineering Ltd. 1991).

The productive capabilities of the lakes and streams throughout the HMA are governed by the physiography, climate and hydrology of the area. Physiography is the primary factor affecting the type and amount of lake and stream habitat present. Specific climatic conditions result from the interaction between the physiographic features and general climatic patterns of the southern interior.

The Biogeoclimatic Ecological Classification (BEC) is based on vegetation, climate and physical site characteristics (Lloyd 1990). Nine zones occur within the Thompson-Nicola HMA; Alpine Tundra (AT); Engelmann Spruce-Subalpine Fir (ESSF); Montane Spruce (MS); Sub-boreal Spruce (SBS); Interior Douglas Fir (IDF); Ponderosa Pine (PP); and Bunchgrass (BG) (Fig 12b).

3.1 PHYSIOGRAPHIC DESCRIPTIONS

<u>Thompson Plateau</u>

The Thompson Plateau encompasses the majority of the Thompson-Nicola HMA and includes the lower Bonaparte River, lower Deadman River, Nicola River and the mainstem Thompson River between Lytton and Kamloops Lake (Figure 12). Streams within this physiographic unit are low gradient channels within flat or rolling terrain. Watershed area is small to moderate with the largest drainage area being the Nicola River at 722,720 hectares.

The climate is generally characterized by low precipitation and limited snow pack which results in a shortened spring run-off period. Overall these streams are extremely productive and capable of significant fry and smolt production. However, low flows and warm water temperatures affect fish production through loss of summer rearing habitat. Average summer stream temperatures are known to exceed 18^{o}C, which is higher than the optimum rearing temperature for most stream-dwelling salmonids (Harding et al. 1994; Walthers and Nener 1997).

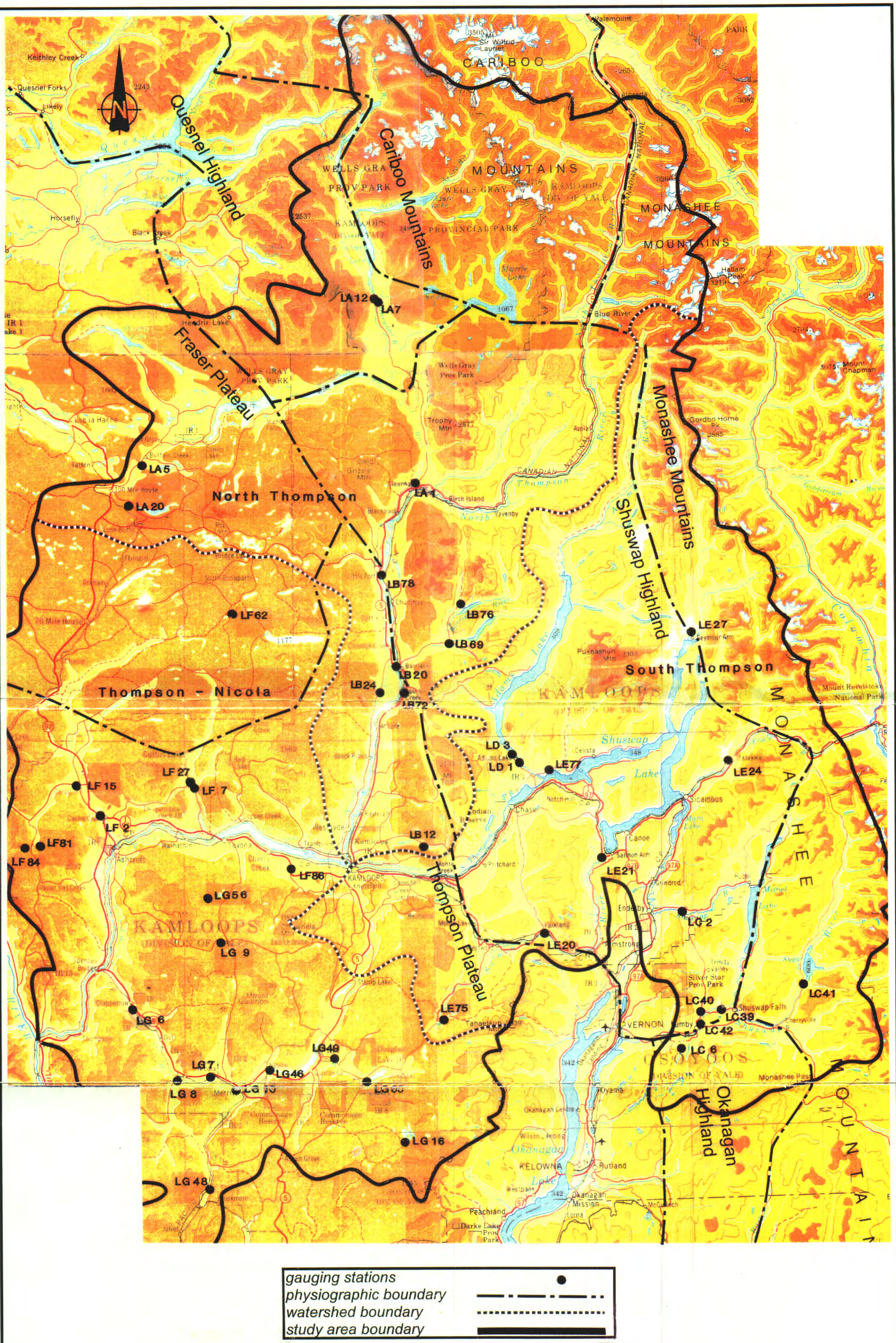


Figure 12a Physiographic land units (after Holland 1976) in the Thompson River Basin.

Source: Rood & Hamilton, 1995.

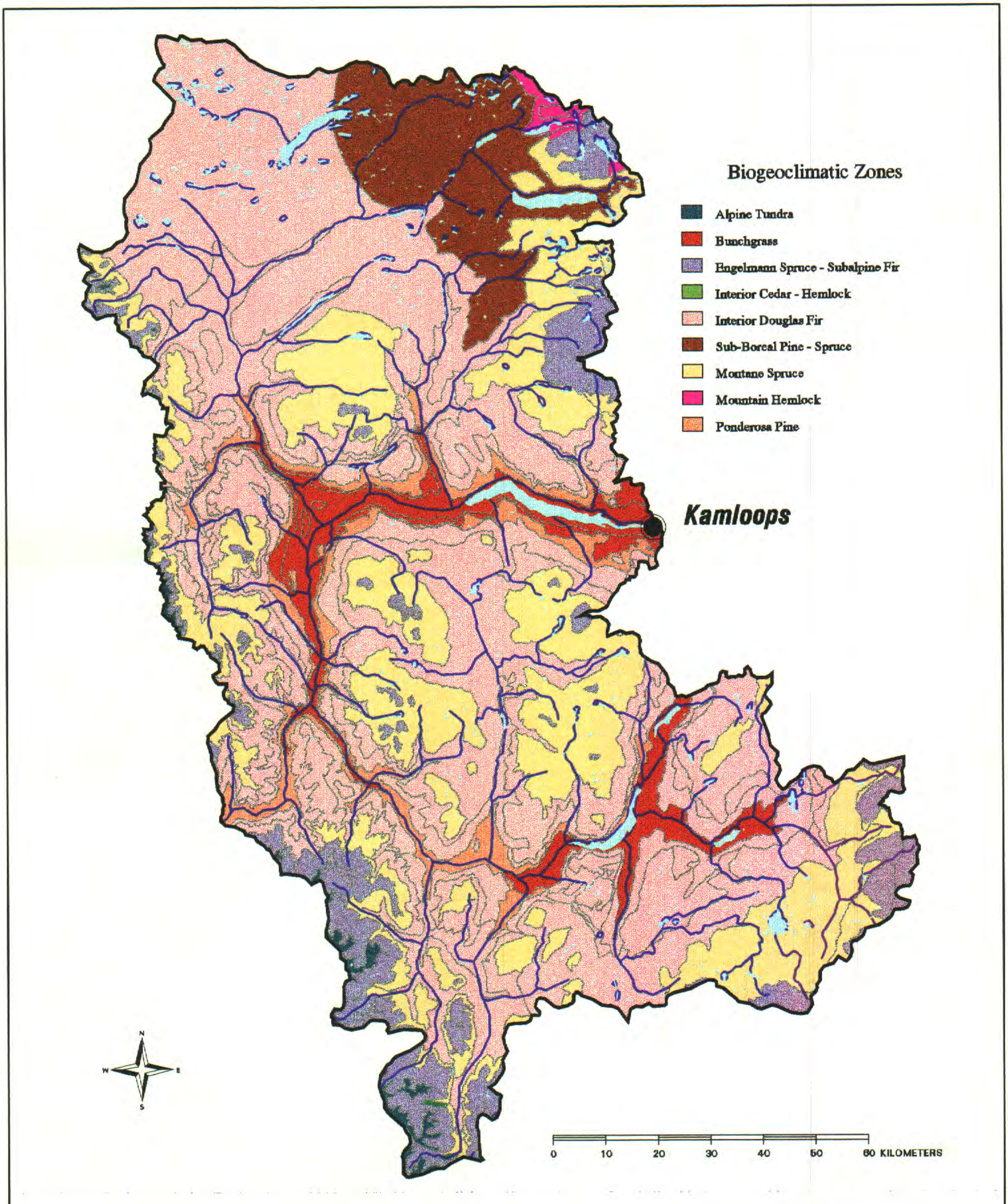


Figure 12b Generalized biogeoclimatic zones of the Thompson - Nicola HMA

Fraser Plateau

The Fraser Plateau includes the northern areas of the Thompson-Nicola HMA and the upper reaches of the Bonaparte River and the Deadman River (Figure 12a). This physiographic unit is characterized by irregular, rolling relief resulting from the presence of glacial features such as eskers and drumlins. As a result of the undulating terrain, hundreds of lakes and wetlands have been formed throughout the unit. Stream channels are usually small and connected to numerous wetlands and lakes. Spring runoff occurs early, and summer water temperatures are relatively warm. Because of the lack of relief, stream channels are usually stable and potential suspended sediment discharges generally occur only during spring runoff events. Numerous small watersheds may be subject to critical low flows in the late summer and fall.

Cascade Mountains

The southwestern portion of the Thompson-Nicola HMA lies within the Cascade Mountains (Figure 12a). This area is characterized by steep, mountainous relief and high gradient confined streams. The coastal influence results in high amounts of precipitation that can result in large freshets and high bedload movement along stream channels. Although only the headwaters of Spius Creek and the Coldwater River fall within this physiographic region, the climatic and hydrological characteristics of the Cascade Mountains affect the streams and rivers downstream.

3.2 REGIONAL HYDROLOGIC REGIME

The Thompson-Nicola HMA is geographically located in a transitional zone. The southwestern portion of the HMA has a wetter climate pattern with higher runoff rates in comparison with the northeastern region. The southwestern portion also displays typical coastal summer low flows, while northeastern areas of the HMA exhibit winter low flow characteristics (Sigma Engineering Ltd. 1991). Annual precipitation and resulting annual, peak and low flows in the Thompson-Nicola HMA are lower than in neighboring North Thompson and South Thompson drainages. Streamflow patterns reflect the more southerly and less mountainous nature of the Thompson-Nicola basin.

The Thompson River and Nicola River are characterized by a snow melt hydrograph where the annual peak flow event usually occurs in June (Sigma Engineering Ltd. 1991). The actual timing (ranging from May to July) and volumes of peak discharge are controlled by snowpack volume and weather conditions during the melt period (Watt 1989). These conditions can result in annual maximum instantaneous flows and localized high water levels. Winter thaw events and ice-jam flooding have been recorded on the Nicola River and the Coldwater River and impacts of ice flow on fish have been documented

(Doyle et al. 1993). The mainstem Thompson River has a stable lake-fed base flow during the winter months. Temperatures generally remain above 0° C below Kamloops Lake for most of the winter resulting in an ice-free reach (Sigma Engineering Ltd. 1991).

The Nicola system has the potential to develop ice cover from late November to March, and summer temperatures as high as 23° C in August. Both ice cover and high water temperatures can limit salmon production by decreasing the availability and quality of rearing and spawning habitat (Walthers and Nener 1997, Kosakoski and Hamilton 1982). Clapperton Creek, Guichon Creek and Skuhun Creek are identified as cool water contributors to the Nicola River mainstem and provide important local cool water refuge habitat for juvenile salmonids during the summer (Walthers and Nener 1997).

3.2.1 Hydrologic Analysis

A detailed analysis of flow characteristics of the salmon bearing streams in the HMA was prepared by Rood and Hamilton (1995). Appendix B summarizes the hydrology of these streams showing mean annual flow, mean summer monthly flows and mean 7-day low summer and winter flows (the lowest average flow for seven consecutive days), as well as total water licenses and licensed demand. Sensitivity indices were developed to indicate potential high water demand, low summer/winter flows, and high peak flows (Append. C). This appendix highlights the streams with indices in the top 25% of extreme values.

Low flow values indicate streams with steep recession curves during summer drought. Spius creek, Maka creek and the Coldwater River are most sensitive to summer low flow conditions whereas Spahomin creek and Bonaparte river are most sensitive to winter low flow conditions (Rood and Hamilton 1995). Other salmonid streams in the HMA, not included in this analysis, likely demonstrate similar summer drought trends as they are located in the same dry climatic zone, and are generally limited in headwater lake storage. These include tributaries of the Nicola River; (Skuhun Creek, Shakan Creek, Nuaitch Creek, Guichon Creek, Clapperton Creek) tributaries of the Coldwater River (Midday Creek, Voght Creek, Brook Creek,); tributaries of the Bonaparte River (Hat Creek, Cache C) and tributaries of the Thompson River (Tranquille River). Water withdrawals result in low flows and high summer temperatures in most salmonid streams in the HMA (see Water Use section).

Peak flow indices (ratio of mean annual flood to mean annual discharge) are also shown in Appendix B. Higher values indicate streams with potential ranges of peak flows that may affect stream channel stability. The Coldwater River and its tributaries are highlighted. Stability is, however, also affected by channel configuration, bed and bank material and channel gradient, which were not included in this analysis.

Three major flood events occurred during June/July 1990 within the study area with the largest flood estimated to be between a 1 in 200 - 500 year event, and the other two floods being 1 in 50 year events (Miles 1995, Doyle pers. comm. in Rosenau 1990). As a result of the flooding, severe erosion occurred within and adjacent to the river channel causing significant damage to properties along the Bonaparte River. Erosion effects were also thought to have severe impacts on the salmonid resources (Rosenau 1990). The late timing of the high water flood in 1990 may have resulted in loss of some natural steelhead recruitment in the Bonaparte River (Maricle and McGregor 1990b). In the Deadman River upstream of Criss Creek, the 1990 flood appeared to reduce the carrying capacity of juvenile salmonids in the Deadman watershed by about 30% (Olmsted et al. 1992). Because of the degree of bedload movement on this system, losses in natural steelhead recruitment were likely higher on this system than in the Bonaparte River system (Maricle and McGregor 1990b). However, despite the severity of the flood, Olmsted et al. (1992) found that many of the channel features and physical habitat characteristics remained relatively undisturbed or redistributed.

There are several systems in the Thompson-Nicola HMA where hydrology studies have been conducted. These studies have been prompted by conflicts over water use and include the Nicola, Deadman and Bonaparte Rivers. The hydrology of the Deadman River has been examined in detail in conjunction with the construction and management of the Snohoosh Dam storage structure (Hamilton 1974, Ward and Chiung 1991, Miles 1995). The hydrology of the Nicola River system has also been studied extensively (Kosakoski and Hamilton 1982, Bergman 1983, MELP 1983). The Nicola Basin Strategic Plan completed in 1983 analyzed water supply and demand in the Nicola basin and outlined water management objectives and options (MELP 1983).

4.0 RESOURCE USE

The following sections describe land and water use within the Thompson - Nicola HMA, and identify where development activities are affecting, or have the potential to affect fish, and fish habitat.

4.1 FORESTRY

The Thompson-Nicola HMA falls within the Kamloops and Cariboo Forest Regions and spans four forest districts; Merritt, Kamloops, 100 Mile House and Lillooet (Figure 13). Logging is a major resource development activity in the Thompson-Nicola HMA. Historical and/or recent logging has occurred in the upper watershed areas of most stream systems with the exception of Shakan and Nuaitch Creeks (Maricle, pers. comm., Todd, pers. comm.). Past harvesting activities within the Thompson-Nicola HMA have degraded riparian habitat along streambanks which has increased sediment delivery and impacted instream habitat by reducing channel stability and the quality of spawning and rearing habitats.

Recently harvested areas that exceed 20% of the total watershed area can result in changes in the annual hydrograph due to changes in snow accumulation and melt patterns and possible changes in sediment regime of the stream (Rood and Hamilton 1995). In general, water flows increase as a result of forest removal in proportion to the amount of canopy removed (Bosch and Hewlett 1982; Toews et al. 1992). In addition to the rate of cut, road construction and density also has a significant impact on sedimentation of streams.

4.1.1 Forest Resource Activity

Total percent logged and the recently logged areas (no revegetation) in each watershed on the HMA were estimated by Sigma Engineering Ltd. (1991) and are shown in Appendix D. These estimates are visual (based on 1990 satellite imagery) and may overestimate the actual Equivalent Clearcut Area (ECA) at the time; the latter takes into account the greenup and hydrological recovery. The above estimates, however, provide an indication of the risks of logging-related impacts to streams. Figure 14 and Table 6 show the major salmon bearing systems in the HMA that have had 20% or more of the drainage logged.

The upper watershed areas of the Nicola River, Spius Creek, Maka Creek, Coldwater River, Bonaparte River and Deadman River have been logged extensively. The percent watershed harvested has been estimated for 8 major salmon watersheds within the HMA and ranges from 10% in Spahomin Creek to 40% in the Bonaparte River (Table 6). The recent rate of forest harvesting (to 1991) was highest in the Bonaparte River (20%) and Maka Creek (25%). It should be noted that smaller tributaries of the Nicola, Coldwater, Bonaparte have

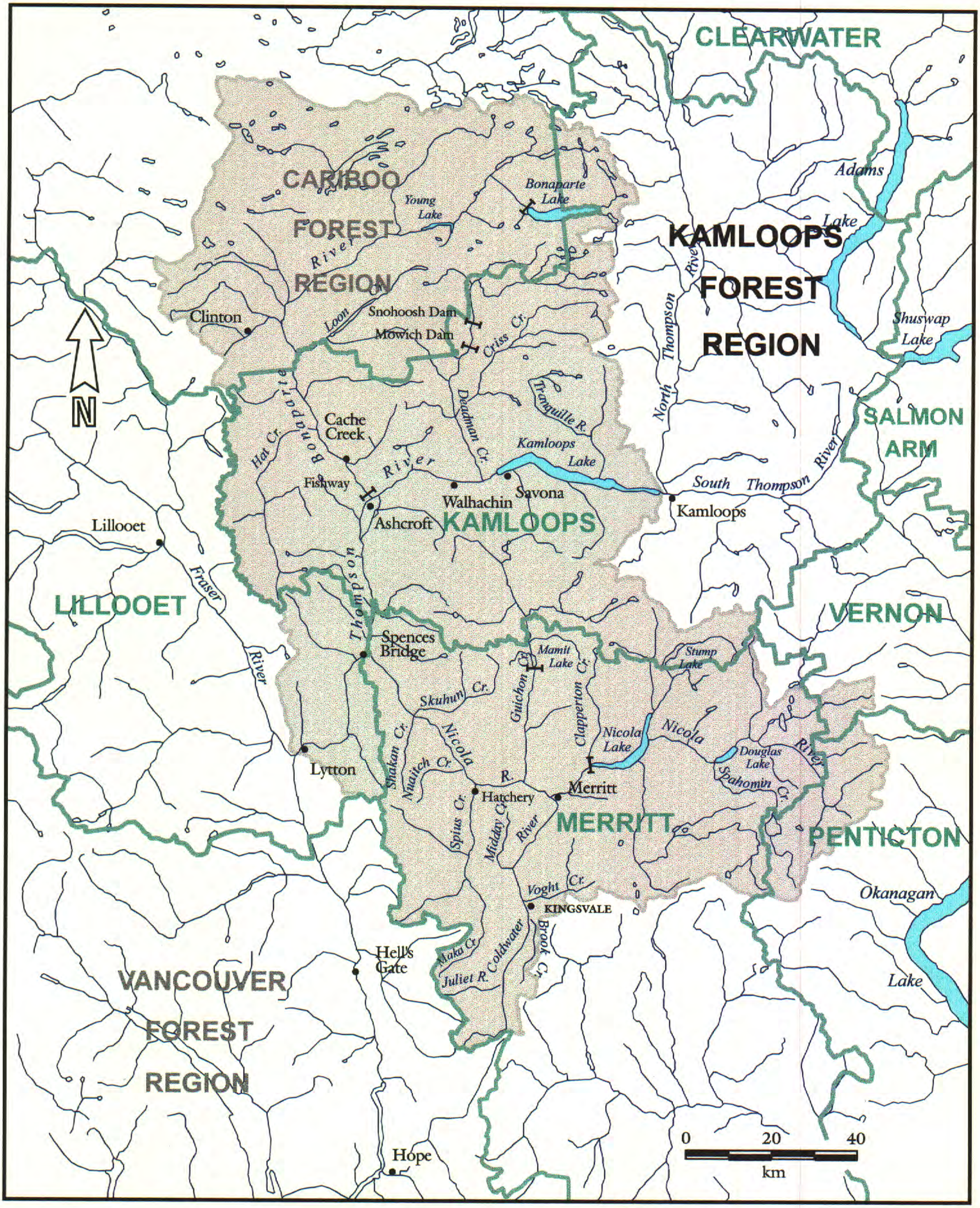


Figure 13. Forest Districts (Kamloops Forest Region) in the Thompson-Nicola HMA.

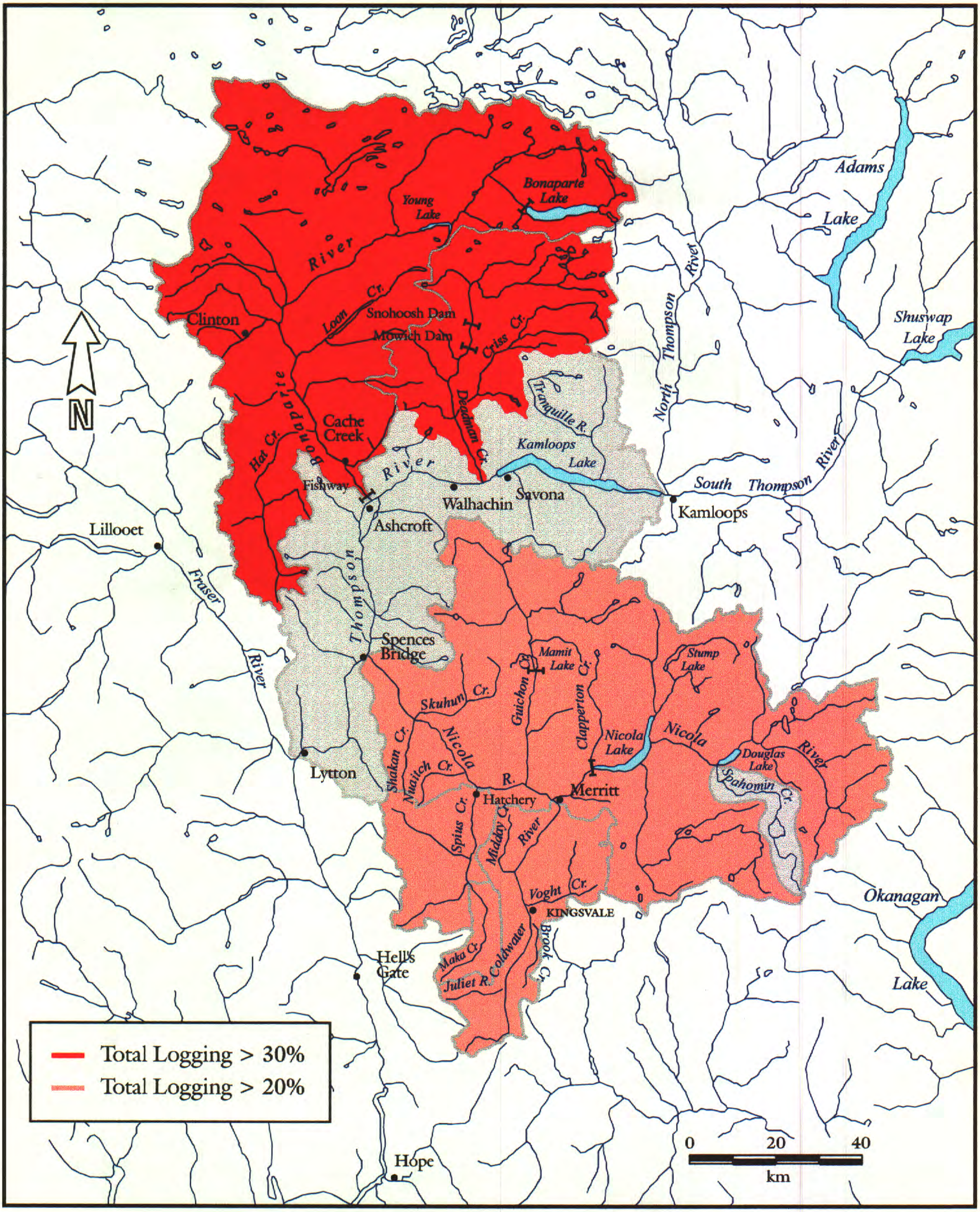


Figure 14. Watersheds with greater than 20% of their watersheds logged, Thompson-Nicola HMA.

not been assessed individually in terms of percentage watershed logged. Subbasins may be higher or lower than the average of the entire watershed.

TABLE 6. Forestry Impacts in the Thompson Nicola Habitat Management Area

Watershed Name	% Total Basin Logged *	% Recent Basin Logged *	Peak flow indices **	Surface erosion indices**	Riparian vegetation indices**
Thompson R.	9	4	.4	1	.1
Tranquille R.	N/A				
Deadman R.	30	10			
Bonaparte R.	40	20			
Cache Crk.	N/A				
Hat Crk.	N/A				
Nicola R.	26	10	0 - 0.6	0 - 1.0	0 - 1.0
Spahomin Crk.	10	5	0.2 - 0.6	0.5 - 1.0	0 - 0.9
Clapperton Crk.	N/A		0.4 - 0.7	1.0	0.3 - 0.9
Guichon Crk.	N/A		0.3 - 0.7	0.7 - 1.0	0.1 - 1.0
Spius Crk.	30	18	0.1 - 0.7	0 - 1.0	0 - 0.9
Maka Crk.	30	25	0.2 - 0.8	0.4 - 1.0	0 - 0.6
Skuhun Crk.	N/A		0.1 - 0.7	0.8 - 1.0	0 - 0.7
Shakan Crk.	N/A		0 - 0.9	0 - 0.7	0 - 0.1
Nuaitch Crk.	N/A				
Coldwater R.	35	5	0.4 -0.6	0.4 - 1	0.1 - 1
Midday Crk.	N/A		0.5 -1.0	0.1 - 1	0 - 1
Voght Crk.	N/A		0.3 -0.7	1	1
Brook Crk.	N/A				

* Sigma Engineering Ltd. 1991

**Range in hazard indices for peak flows, surface erosion and riparian vegetation from Level I Watershed Assessment results. Low hazard = <0.5, Moderate hazard = 0.5-0.7 and High hazard = >0.7

A more detailed analysis of the impacts of forest harvesting on watershed hydrology, river morphology and fish habitat is currently being conducted through the Interior Watershed Assessment Procedure. A Level I (reconnaissance level analysis) is intended to identify watersheds that may have impacts from cumulative effects of past forest harvesting or planned future harvesting. The Level I analysis determines the impacts of forest harvesting on changes to peak flows, potential for landslides, changes to the riparian buffer and the potential for accelerated surface erosion.

The Level I Watershed Assessments for tributaries of the Nicola (including Guichon, Spius, Maka, Skuhun, Shakan), Coldwater (including Midday, Voght) and Spahomin Creek indicated moderate to high hazard indices for one or more categories including peak flows, surface erosion and riparian vegetation (MOF

1997). Results from the Level I Watershed Assessment conducted by the Merritt Forest Service are summarized in Table 6. The range in indices for each category represents the range in results for each subbasin within major watershed areas. These results are preliminary and need to be verified by further field assessments. Level I Watershed Assessments will be completed in the lower Bonaparte River and the entire Deadman River watershed by March 1997 (Aird, pers. comm.). More detailed Level II Channel Assessments will be conducted in those watersheds with the highest hazard indices and include the Coldwater River, Spius Creek, Maka Creek and Quilchena Creek (Heller, pers. comm.).

4.1.2 Current Trends

Five-year development plans propose continued logging in the Bonaparte River, Deadman River as well as Spius and Maka Creeks in the Coldwater River watershed (Wall, pers. comm.). Several factors will influence the forest industry in the coming years as a result of current changes and a shift in resource use intensity. For example, harvesting practices that once concentrated on old growth timber are now shifting towards second-growth stands, lowering sustainable harvest levels. Also, the public is becoming more interested in non-timber resources and values, thus more emphasis is placed on managing for these uses. Furthermore, forested land is being withdrawn due to an increase in land requirements for agricultural, residential and industrial needs associated with population growth (Ministry of Forests 1994).

The Forest Practices Code (FPC) was brought into law in June 1995. The FPC provides legislation, regulations and guidelines that govern road building and logging practices, including provision for buffer strips in riparian zones of fish bearing streams. The FPC defines a riparian management area (RMA) as consisting of a reserve zone (for streams greater than 1.5 m in width) and a riparian management zone. No logging is permitted in reserve zones, while constraints may be placed on logging in management zones. The width of the RMA is determined by a stream riparian classification based on the presence of fish and the average channel width, as specified in the Riparian Management Guidebook (FPC British Columbia 1995). Stream classifications (S1-S6) and Best Management Practices are outlined in the Guidebook.

The FPC regulations also require that a watershed assessment be completed for all watersheds with high fisheries values. The Interior Watershed Assessment Procedure (IWAP) Guidebook outlines the method (FPC 1995). The assessment of hydrological impacts focuses on the potential for changes to peak flows, landslide events, accelerated surface erosion and changes to the channel riparian buffer. The Guidebook also provides a guide for interpretation and recommendations to be considered once the appropriate level of assessment is completed.

The provincial Watershed Restoration Program (WRP) initiated in 1994 (Slaney 1994), is a provincial initiative under the Forest Renewal British Columbia (FRBC), aimed at accelerating recovery through watershed restoration. The operational projects under the WRP include watershed assessment; impact inventories of the condition of roads, slopes, gullies, riparian zones, channels and fish habitat; prescription of treatments; and rehabilitation and monitoring. The FPC and WRP programs currently involve only provincial forests and does not include private forest lands, agricultural and urban lands.

WRP activities have been initiated in or are planned for most of the watersheds in the Thompson-Nicola HMA (Table 7). In addition to WRP activities, the Forest Practices Code requires that streams in the watershed be classified prior to harvesting activities.

TABLE 7. Forest Renewal Activity in the Thompson Nicola HMA (Epp, pers comm).

Watershed Name	FRBC activity (Y/N)	Proposed IWAP*,CAP,FHAP Sediment surveys, Road Assessments	Scheduled Operational Fish Inventories	Licensee	Contractor
Thompson R.	Y - In tribs	Y - In tribs	Y - In tribs		
Tranquille R.	Y		Y (1997)	Weyerhaeuser	Dobson/ Trumblay
Deadman R.	Y	Y (1997)	Y (1997)	Ainsworth	Proposed
Bonaparte R.	Y	Y (1997)	Y (1997)	Ainsworth	Proposed
Cache Cr.					
Hat Cr.	Y	Y (1997)	Y (1997)	Ainsworth	Proposed
Nicola R.	Y - In tribs	Y - In tribs			MOELP
Spahomin Cr.					
Clapperton Cr.	Y	Y			MOELP
Guichon Cr.	Y	Y		Ainsworth	Proposed
Spius Cr.	Y	Y - Overview		Aspen Planers	Borrett/Coast River
Maka Cr.	Y	Y - Overview		Aspen Planers	Borrett/Coast River
Skuhun Cr.	Y	Y			MOELP
Shakan Cr.	Y	Y			MOELP
Nuaitch Cr.	Y	Y			MOELP
Coldwater R.	Y - In tribs	Y - In tribs		Tolko	Borrett/Coast River
Midday Cr.	Y	Y - Overview		Tolko	Borrett/Coast River
Voght Cr.	Y	Y - Overview			MOELP
Brook Cr.	Y	Y - Overview		Tolko	Borrett/Coast River

*IWAP: Interior Watershed Assessment Procedure FHAP: Fish Habitat Assessment Procedure
CAP: Channel Assessment Procedure

4.2 AGRICULTURE

Agricultural development impacts fish habitat by decreasing stream bank stability, degrading riparian habitat and increasing erosion, sedimentation and water temperature regimes. Streamside vegetation moderates summer high water temperatures, provides cover for fish and contributes to bank stability and sediment control (Platts 1990). Unvegetated river beds are more susceptible to bank erosion than those with riparian vegetation (Beeson and Doyle 1995). Livestock access degrades riparian vegetation along streams, while runoff from feedlots and winter feeding and the use of pesticides and fertilizers reduces water quality in the receiving stream. In addition, water withdrawal for irrigation reduces instream flows and exacerbates high temperatures to the detriment of spawning and rearing fish and invertebrate populations.

4.2.1 Agricultural Activity

Within the Thompson-Nicola HMA, agricultural activity is intensive and concentrated along the lower, more productive reaches of most stream systems. Valley bottom areas are used for crop production and winter feeding, while upland areas are utilized for summer range activities.

Improved farmland area and livestock densities in the major salmon bearing watersheds of the HMA were estimated by Sigma Engineering Ltd. (1991). Appendix E shows these estimates for 1990 and give the predicted estimates for the year 2010. Table 8 lists those watersheds in the HMA with highest agricultural development. These watersheds also have relatively high livestock densities. It should be noted that although the percentage of watershed farmed is relatively low, agricultural activities are concentrated along stream channels and valley bottoms where fish values are the greatest and erosion and sedimentation problems can extend far downstream.

Agricultural development has negatively impacted fisheries values in the Nicola River, Coldwater River, Bonaparte River and the Deadman River watersheds. Environmental impacts within these systems include sedimentation, channelization, degradation of riparian habitat, degraded water quality, increased water temperatures, low instream flows and channel degradation which has resulted in the reduction of fisheries values (Millar et al. 1994; Miles 1995; Morantz and Haefele 1996) (Photo 1).

Much of the riverbanks bordering agricultural areas are actively eroding, due to loss of riparian habitat and unimpeded cattle access to the river (Table 8, Photo 2). Within the lower sections of the Nicola River, only 3.5% of a total riverbank length of 234.2 kilometers is bordered by unimpacted vegetation (Morantz and Haefele 1996) (Photo 3) . The upper Nicola River above Nicola Lake has suffered extensive losses of riparian vegetation due to ranching activities

TABLE 8. Agricultural Impacts in the Thompson Nicola Habitat Management Area

Watershed Name	[a] AU/Km²	[b] Improved Farmland %	[c] Impact Rating- High/Low	
			[d] Water Quality	[e] Riparian Degradation
Thompson R.	1.77	0.85	L	L
Tranquille R.	n/a	n/a	L	H
Deadman R.	0.79	0.46	H	H
Bonaparte R.	0.78	0.51	H	H
Cache Crk.	n/a	n/a	H	H
Hat Crk.	n/a	n/a	H	H
Nicola R.	2.41	0.84	H	H
Spahomin Crk.	5.35	1.86	H	H
Clapperton Crk.	n/a	n/a	H	H
Guichon Crk.	n/a	n/a	H	H
Spius Crk.	0.51	0.18	H	n/a
Maka Crk.	0	0	L	L
Skuhun Crk.	n/a	n/a	n/a	n/a
Shakan Crk.	n/a	n/a	n/a	n/a
Nuaitch Crk.	n/a	n/a	n/a	n/a
Coldwater R	2.97	1.04	H	H
Midday Crk.	n/a	n/a	n/a	L
Voght Crk.	n/a	n/a	n/a	n/a
Brook Crk.	n/a	n/a	L	L

a) AU/Km2	Animal units per square kilometer. An animal unit is equivalent to one mature cow (Sigma Engineering 1991).
b) Improved farmland	Cultivated land including improved pasture (Sigma Engineering 1991).
c) High Impact Rating	(H) - Impacts are high and remediation is a priority as indicated by DFO (L) - Impacts are low at this time as indicated by DFO
d) Water Quality	Concern rating for water quality relating to sediment, nutrient inputs from cattle and/or fertilizers by MELP and/or DFO.
e) Riparian Degradation	Concern rating for the extent of riparian degradation caused by livestock and/or removal of riparian vegetation for crop production or agricultural development.

(Walthers and Nener 1997). In the Deadman River, there is a 30 kilometer reach downstream of Mowich Lake that has been significantly impacted by historical and present agricultural practices. Miles (1995) determined that 44% of the stream bank has no woody riparian vegetation and an additional 23% of the river bank has a riparian corridor less than half the width of the channel.

PHOTO 1. Degraded riparian habitat resulting from agricultural development along the Bonaparte River (Photo by G. Kosakoski).

PHOTO 2. Unrestricted cattle access to the Nicola River aggravates bank erosion in the Nicola River (Photo by M. Crowe).

PHOTO 3. Degraded riparian habitat resulting from agricultural activities has intensified bank erosion problems in the Nicola River (Photo by P. Doyle).

The loss of riparian vegetation has resulted in increased erosion, loss of shade and instream cover, and loss of pool and offchannel habitat. Loss of riparian vegetation has also been shown to increase river width and channel instability in those areas where riparian vegetation was removed (Miles 1995) A wider and shallower river can be expected to have warmer water temperatures, reduced number and size of pools, less undercut bank habitat and possibly lower minimum flows. In some areas of the Deadman River, channel widths have increased from 18 meters to 114 meters. Channelization has also reduced the number of back channel and wetland areas. Chinook and coho that rear for one year in freshwater are particularly vulnerable to these impacts.

Agricultural development has also degraded water quality within the Thompson Nicola HMA (Table 8). Surface runoff and contaminated groundwater seepage from feedlots, winter feeding ground contribute to high nutrient loads (John and Geier 1994) During spring runoff, phosphorus from fertilizers is also washed into streams, along with elevated coliform levels from animal wastes. Water quality is also impaired by increased bank erosion resulting from cattle access to streams. Livestock stocking densities provide an indication of potential problems of nutrient absorption into the watercourse.

A survey of agricultural practices in the Thompson Basin was conducted to identify runoff and contaminant sources. The inventory identified 103 sites of potential environmental impacts from agriculture (John and Geier 1994). Proximity of feeding areas and cattle access to watercourses were the most common practices of concern and were the primary source for the loading of pollutants to surface and groundwater.

Water withdrawal for irrigation is one of the greatest problems associated with agricultural activities in the Thompson-Nicola HMA. Current water management practices throughout most of the HMA do not allow for sufficient instream flows during low flow periods to support fisheries resources year round (Crowe, pers. comm.). Some of the irrigation within the Thompson Nicola HMA is by open ditches and inadequate screening in these ditches leads to entrainment of fish (Kosakoski, pers. comm.). Refer to the water use section for a more detailed discussion.

4.2.2 Current Trends

Agricultural activity within the Thompson-Nicola HMA has not changed significantly over the past two decades. In general the amount of area in crop land has declined whereas irrigation has increased slightly (6%) (Sigma Engineering Ltd. 1991). There has been some conversion from flood to sprinkler irrigation thereby allowing a greater area to be irrigated using the same amount or less water (Sigma Engineering Ltd. 1991). In many areas within the HMA, hay fields are being converted to grow ginseng as the return per acre can be significantly higher. Future growth in agricultural activity to 2010 is anticipated to be low within the Thompson-Nicola HMA (Sigma Engineering Ltd. 1991). The Coldwater, Spahomin and Nicola drainages are expected to have improved land percentages that will increase between 1-2% of the total watershed area (Sigma Engineering Ltd. 1991).

While the requirement for riparian reserve and management zones is regulated on Crown range lands by the Forest Practices Code, it does not apply to private agricultural land. Nevertheless, protection and restoration of riparian zones on salmon streams are a priority in protecting the fisheries resource. Protection and restoration of the riparian corridor, and improved instream flow and water quality will require the combined effort of government agencies, local communities and landowners. In order to minimize the impacts of agriculture on fisheries values, DFO has been working with ranchers to identify non-point sources of pollution and promoting alternative livestock management practices to prevent the on-going degradation of fish habitat within the study area (Crowe, pers. comm.). The re-establishment of riparian corridors by fencing and by revegetation and the screening of irrigation ditches is also being undertaken to restore fish habitats. The Stewardship Guide for Agriculture outlines strategies and practices to improve farming operations and protect fish habitat (Anon. 1997).

4.3 WATER USE

Water resources of the Thompson-Nicola HMA are vital to the fish and wildlife in the area. Pressure on the water resources in this HMA is immense as is indicated by over 2,499 water licenses held in this HMA which represents 14% of all water licenses within the Fraser River Basin (Dorcey 1991b). Over 50% of the streams in the Thompson-Nicola HMA have license restrictions (Sigma Engineering Ltd. 1991). This high water use may be attributed to the arid climatic conditions and high irrigation demand. Irrigated land in the Thompson-Nicola basin is the third highest in the entire Fraser watershed (Dorcey 1991b). The resulting low stream flows have impacted fish populations through reduced critical spawning, incubation and rearing habitat; impeded upstream fish access and increased summer water temperatures. Elevated water temperatures place salmonids at risk to physiological stress and diseases.

4.3.1 Agricultural Water Use

Appendix C shows for each watershed in the HMA the sensitivity indices for summer water demand (expressed as a ratio of summer water use over summer mean 7-day low flows) and indices for low flows (expressed as a ratio of 7-day low flows over mean annual flow). The most sensitive streams (those in the top 25% of extreme values for high water demand or low flows) are highlighted in Table 9. Low flow index values indicate streams with large water demands or with steep recession curves during summer drought. It should be noted that the accuracy of calculated indices may vary due to difficulties in estimating natural streamflows where low flows are controlled by storage.

Water demand is high for the Nicola River, Spahomin Creek, Spius Creek, Coldwater River, Deadman River and Bonaparte River ranging from 20% to 135% of the August 7 day low flows (Fig 15). Summer low flows were highlighted for the Coldwater River and Spius and Maka Creeks even though water demand was relatively low compared to the Nicola, Bonaparte and Deadman Rivers. Summer lows were 9% of the mean annual flow (Appendix C). Based on criteria developed by Tennant (1976), 10% of the mean annual flow in summer and winter is considered a poor base-flow for fish. To sustain good survival of aquatic life, 30% of the mean annual flow is recommended for streams. Although small tributary streams were not assessed individually, water use and low flow concerns were noted by agency staff for Shakan C, Skuhun C, Guichon C, and Clapperton C (tributaries of the Nicola River); Midday C, Voght C, and Brook C (tributaries of Coldwater R) and Cache C and Hat C (tributaries of the Bonaparte R.) (Table 9).

Most of the streams with large potential water demands are moderately large or large basins with developed storage. Storage licenses compensate for a variable portion of the irrigation licenses compensating for nearly all the irrigation

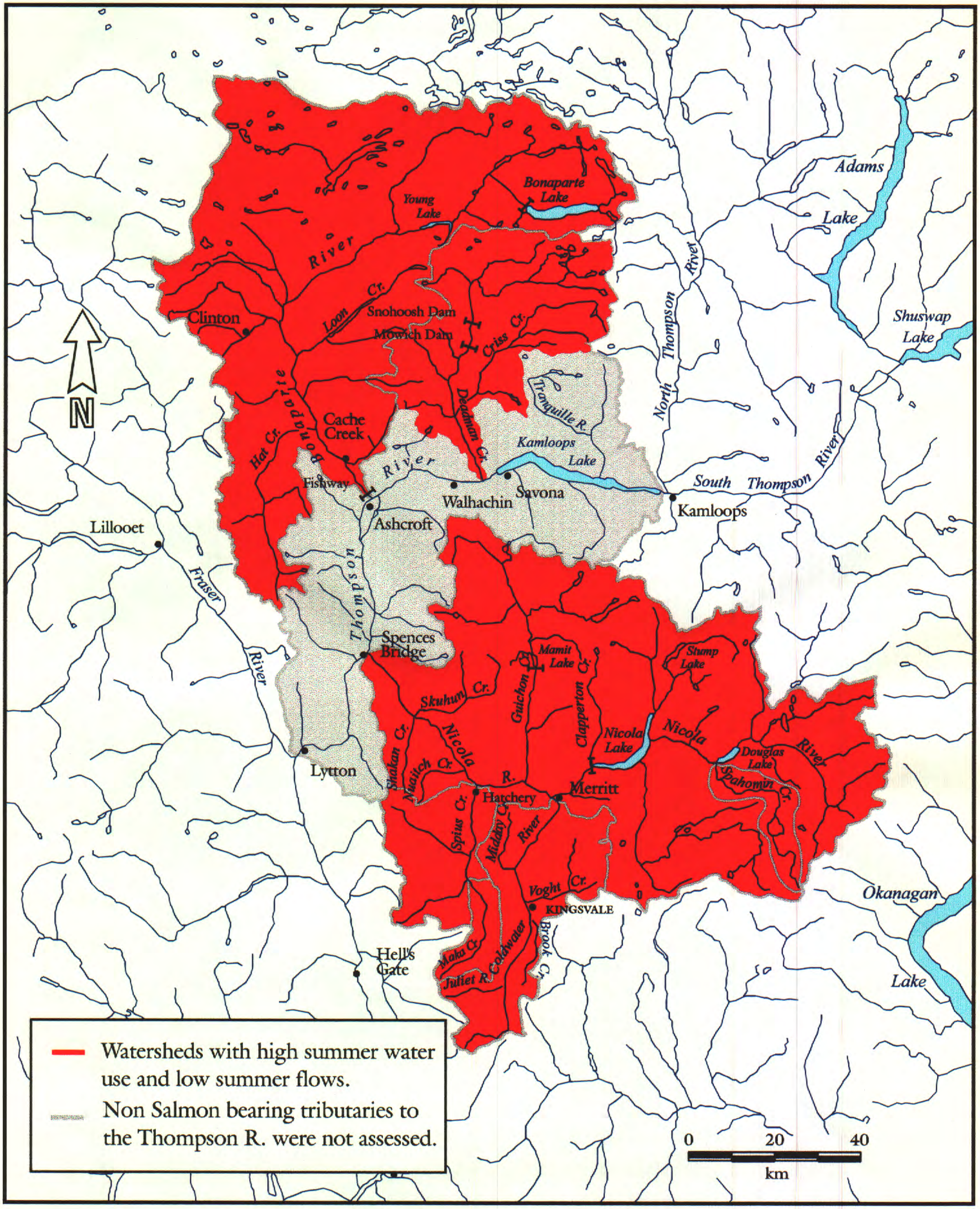


Figure 15. Watersheds with high level of concern related to water demand and low instream flows, Thompson-Nicola HMA.

licenses in the Nicola River to 24 % in the Bonaparte River (Rood and Hamilton 1995). Water is released for fisheries purposes in the Nicola, Deadman and Bonaparte Rivers to provide fish maintenance flows. Adequate flows are not, however, always available for fish (see next section). The Nicola, Spius, Bonaparte and Deadman Rivers are fully recorded (further licenses denied unless compensated by storage) by the Water Management Branch. The Coldwater River and Spahomin Creek, on the other hand, have few irrigation licenses with associated storage, large potential water demands, extreme low flows and have no restrictions on further licensing.

With respect to winter flows, the Bonaparte River and Spahomin Creek had the lowest values between 14-15% of the mean annual flow (Rood and Hamilton 1995). Low winter flows and ice cover can be a limiting factor for overwintering coho and chinook salmon.

Other impacts to fisheries values from agricultural use of water include lack of adequate screening on water intakes, entrapment of fish in irrigation canals, leakage and evaporation from irrigation canals.

TABLE 9. Water Use in the Thompson-Nicola HMA (Rood and Hamilton 1995).

Watershed	Summer Water Demand	Summer Low Flows	Winter Low Flows	Water use or low flow concerns*
Thompson R.				
Tranquille R.				
Deadman R.	X			
Bonaparte R.	X		X	
Cache C.				x
Hat C.				x
Nicola R.	X			
Spahomin C.	X		X	
Clapperton C.				x
Guichon C.				x
Spius C.		X		
Maka C.		X		
Skuhun C.				x
Shakan C.				x
Nuaitch C.				
Coldwater R	X	X		
Midday C.				x
Voght C.				x
Brook C.				x

* Tributary systems were not assessed by Rood and Hamilton but concerns were expressed by MELP staff.

4.3.2 Water Storage

Storage licenses are granted by the Water Management Branch for three purposes: power generation, irrigation and conservation. There are no B.C. Hydro projects within this HMA. Storage for conservation totals over 75 m^3/year, one of the highest totals in the Fraser Basin (Sigma Engineering Ltd. 1991). Most of these conservation licenses are held by DFO, Fish and Wildlife branch, MELP and Ducks Unlimited.

Major storage projects exist on the Nicola River, Guichon Creek, Deadman River the Bonaparte River. The Nicola Dam was built in 1927 for power and/or irrigation, but was no longer used to generate power by 1980. The dam was rebuilt in the mid 1980's to provide water storage for irrigation and maintenance flows for fish and is currently managed by DFO and MELP (Photo 4). Fish maintenance flows of 60 cfs are specified below the dam; 110 cfs downstream of Merritt and 200 cfs at the mouth (Kosakoski, pers. comm.). Minimum flows for fish are being provided approximately 80% of the time (Crowe, pers. comm.). Improvement in flow releases for fish depend on dredging the outlet channel to make full storage potential available and modifying the flow release schedule to optimize water management for fish. A second major dam structure within the Nicola River watershed occurs in Guichon Creek at the outlet of Mamit Lake to supply water to the Guichon Creek water users and the Nicola Mameet IR #1 (Crowe, pers. comm).

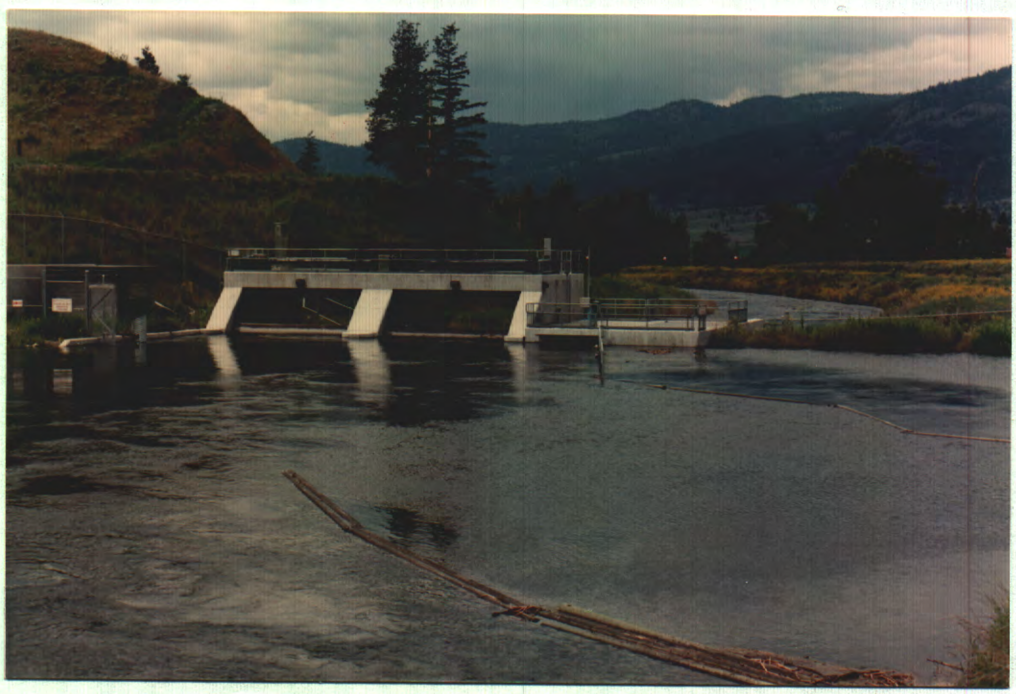


PHOTO 4. Downstream view of the Nicola Lake Dam, June 1990. (Photo by J. Patterson).

Deadman Creek has been used for irrigation since the 1920's (Sigma Engineering Ltd. 1991). Snohoosh Lake dam was constructed in the early 1970's to store water for irrigation and provide maintenance flows for fish. In its present condition the dam has a limited storage capacity and does not provide adequate attraction flows for steelhead in the spring (Crowe pers. comm.). At this time, minimum flows for fish specified in the Improvement District's water licence are not released until the minimum requirements for agriculture are met (Crowe pers. comm.) . DFO and MELP have conducted a feasibility study to identify options for upgrading the Snohoosh Lake Dam to increase storage and improve control for flow releases. Better flow monitoring is also required. There is also a second dam at the outlet of Mowich Lake for irrigation purposes (Crowe, pers. comm.).

A dam in the Bonaparte River was constructed 3 kilometers upstream of the Thompson River confluence at a 7 meter falls by B.C. Hydro to generate hydroelectric power. In 1988, a fishway was constructed to assist in the passage of salmonids over the remnant dam and the waterfall (Crowe, pers. comm.). In 1990, major repairs were completed at the fishway to repair damage from high flood flows. In the upper Bonaparte River, a flow control structure was built in 1993 at the outlet of Bonaparte lake to store water that would be used to augment instream discharges during low flow periods to maintain and preserve fish habitat (McGregor and Kosakoski 1996). A Conditional Water Licence was granted to MELP, Fisheries Branch to store 14,300 acre feet of water for conservation purposes which was to be released according to a rule curve and release schedule designed by the Water Management Branch. At this time, the existing rule curve and release schedule is inadequate in providing minimum downstream flow requirements for fish. Improvements could be made by implementation of an alternative rule curve and release schedule that would provide greater certainty of maintaining prescribed stream flows for fish (KPA Engineering 1994). Adequate stream flows for fish would also be achieved with additional live storage at the Bonaparte Dam (McGregor and Kosakoski 1996).

4.3.3 Water Quality

Water quality issues of concern include discharges from point and non-point sources. The Kamloops municipal sewage treatment plant and processing effluent from the Weyerhaeuser pulp mill are the two largest point source discharges into the Thompson River. Phosphorous loading (which stimulates algal growth in the Thompson River) from the sewage treatment plant has been reduced significantly over the last 12-15 years due to upgrades and modifications to the plant (Nordin and Holmes 1992). The sewage plant discharges part of the effluent by spray irrigation and rapid infiltration, and only discharges effluent directly into the river during May/June when the dilution is high (Sigma Engineering Ltd. 1991). However, there has been recent toxicity problems identified at the Kamloops Sewage Treatment Plant (Kosakoski, pers. comm). The growth of algae is still a concern and the water quality for the Thompson River has been rated as fair (MELP, 1996).

The chlorinated organic compounds contained in effluents from the Weyerhaeuser Pulp mill were also a concern and resulted in consumption advisories by the Ministry of Health when high concentrations of some pulpmill-related fatty acids were found in Kamloops Lake near Savona that resulted in fish tainting (Hatfield Consultants Ltd. 1996). Recent improvements at the pulpmill have resulted in reduced amounts of dioxins and furans (Nordin and Holmes 1992) and the advisory was lifted in 1994 (Nener and Werneck, in press).

Non-point discharges include septic tank discharges, storm sewer outfall, feedlots and cattle overwintering areas, fertilizers, pesticides, herbicides as well as siltation from forestry and linear development. Non point discharges can impact water quality by increased siltation, nutrient enrichment, increased metal concentrations and chemical additions to surface waters (MELP 1985). However, quantification of these impacts is difficult due to the widespread nature of these unregulated sources.

Water quality is affected by logging in the headwaters and intensive agricultural activities in the Nicola, Coldwater, Deadman and Bonaparte watersheds as described in the previous sections. Loss of riparian vegetation and cattle grazing has resulted in bank erosion and stream siltation. Runoff from feedlots particularly in the spring results in high levels of ammonia and BOD that can be toxic to fish. The Nicola River, contributes approximately 4% of the flow to the lower Thompson River, and is influenced by non-point source agricultural inputs along its length. The Nicola has relatively high concentrations of suspended sediment, fecal and coliform bacteria. Upstream of the Coldwater confluence, high turbidity is a problem during the irrigation season due to surface and groundwater runoff causing increased silt loads in the mainstem Nicola River (Photo 5). Water quality in the Bonaparte River has been rated fair because turbidity, suspended solids, fecal coliforms and growth of algae regularly did not meet acceptable levels (MELP 1994). Sources of contamination include agricultural operations and treated municipal sewage from Cache Creek and Clinton. The high number of recently logged cutblocks within Maka Creek and Bonaparte River watersheds are probable non-point influence on water quality (Sigma Engineering Ltd. 1991).

Water temperature is a key concern in most streams of the Thompson-Nicola HMA including the mainstem Thompson River which in turn has a warming influence of the Fraser River. Monitoring in the Nicola River has indicated that lethal water temperatures (>20%) are exceeded during the summer months both upstream and downstream of Nicola Lake (Walthers and Nener 1997).

PHOTO 5. High suspended sediment loads in the Nicola River (bottom) at the confluence of the Coldwater River. Note urban encroachment and the lack of natural riparian habitat (Photo by M. Crowe).

They also found high water temperatures in the Coldwater, Bonaparte and Deadman rivers. High water temperature affect the productivity and survival of adult spawners and juvenile salmon rearing in the system.

Some Thompson River tributaries drain highly mineralized areas and contain elevated metal levels (Nordin and Holmes 1992). The Nicola River has high metal concentrations, probably originating from the Guichon Creek watershed where copper and molybdenum are mined. Stumbles Creek, which enters the Nicola approximately four miles west of Guichon, has had high levels of copper and molybdenum during freshet when the creek flows past the Craigmont mines tailing pond (Little 1974). In 1990, B.C. Environment listed Ainsworth Lumber in Chasm, located near Chasm Creek in the Bonaparte River Watershed, as a contaminated site (copper arsenate) that was a pollution concern (Sigma Engineering Ltd. 1991).

4.3.4 Current Trends

Increasing conflict over water resources in the Thompson-Nicola HMA can be anticipated due to a projected increase in agricultural activity and municipal demand.

Identifying and controlling non-point discharges is a significant component of protecting future water quality in the Thompson Nicola HMA (Holmes 1990). Large direct discharges within the area, from the Weyerhaeuser Pulp Mill and the City of Kamloops sewage treatment plant can be managed by effluent treatment procedures. However, non-point discharges affect larger areas, are often difficult to isolate and manage (Holmes 1990).

Agricultural activities currently have water quality impacts in many of the watersheds including the Bonaparte River, Coldwater River, Deadman River, Nicola River and Spahomin Creek, and will likely continue to have an impact in the future (Sigma Engineering Ltd. 1991). Watershed specific water quality policy guidelines have been proposed by the B.C. Environment to protect present and future water uses (Swain 1986). However these guidelines have no legislation associated with them (Sigma Engineering Ltd. 1991).

Although the Forest Practices Code applies to Crown Forest Lands, there are no legislated requirements for riparian reserves on private lands. Changes is water management are also needed to address inadequate instream flows for fish. Water management plans need to be developed on a watershed basis to provide adequate maintenance flows for fish. A strategic review and water quality plan is being developed for the Fraser River Basin. This document outlines the key issues and recommendations for each subbasin including the Thompson-Nicola HMA (Nener and Werneck, in prep.).

4.4 POPULATION, SETTLEMENT, RECREATION AND TRANSPORTATION

Urban development, such as residential and industrial construction, and linear development has negatively affected fish habitat by the removal of riparian corridors, destruction and/or alteration of stream channels and banks. Transportation corridors are concentrated in valley bottoms, adjacent to waterways and floodplain habitat. The presence of roads and railway lines in close proximity to streams results in encroachments and ongoing maintenance impacts (eg. sidecasting debris into the stream) and also increases the risk of hazardous spills.

4.4.1 Population and Settlement

There are approximately 95,000 people living in urban centers within the Thompson Nicola HMA (Stats Canada 1996). Urban settlements within the HMA includes: the western portion (33%) of the city of Kamloops, the District of Logan Lake, the City of Merritt, Cache Creek, Ashcroft, Clinton and Lytton (Figure 16). Each of these communities is much smaller than Kamloops (76,394 total population), ranging from populations of 322 people in Lytton to 7,631 residents in Merritt. Semi-urban settlements within this HMA include: Savona, Colletville and Lower Nicola and Spences Bridge (Figure 16). Smaller

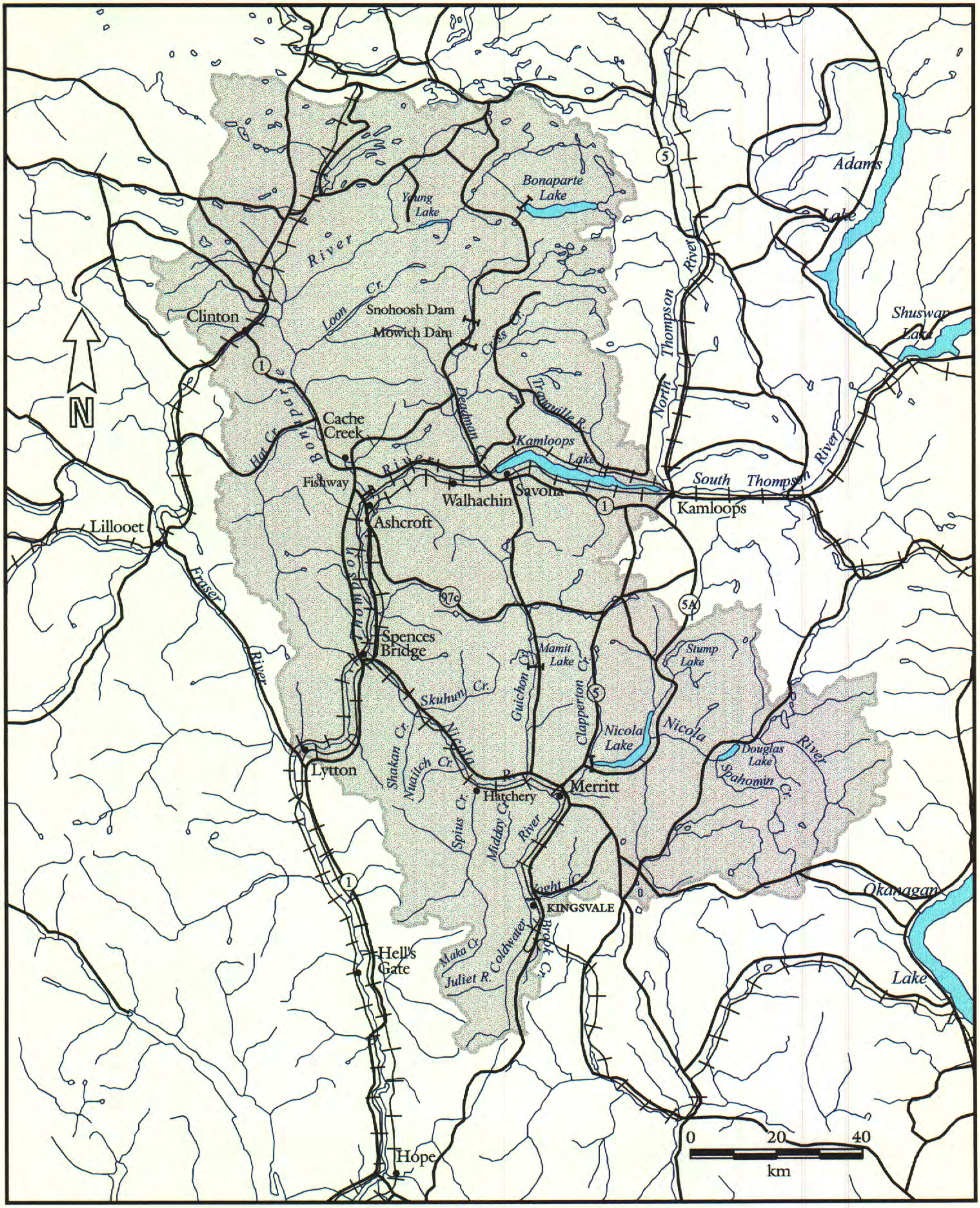


Figure 16. Urban Settlement and linear Development.

communities are located along the Trans Canada Highway west of Kamloops (ie. Cherry Creek, Skeetchestn Indian Band), in the Ashcroft/Cache Creek area and outhwest of Merritt in the Coldwater, Lower Nicola and Highway 8 corridor areas.

4.4.2 Recreation

Fishing lodges are the predominant form of recreational development within the Thompson-Nicola HMA. A total of 29 lodges are located in this HMA, 18 of which can be found in the Bonaparte River watershed (Sigma Engineering Ltd. 1991). The sports fishery is an important recreational activity in this area and includes a significant chinook and steelhead fishery at Spences Bridge. More than 1,000,000 angler days were reported for the Thompson-Nicola Region which accounts for more approximately 20% of the total angler days in the province (Chan, pers. comm.).

There are 9 resorts, numerous small provincial parks, recreational sites and golf courses also located within the Thompson-Nicola HMA. There are 6 MOF recreation sites within the Deadman River and Bonaparte River watersheds and in 1994 total user days for these sites equaled 9,229 (Eastwood, pers. comm.). Recreational use within the Nicola River watershed is very high with over 98, recreational user days recorded in 1994 (Kekula, pers. comm.).

4.4.3 Transportation and Utilities

The Thompson-Nicola HMA is traversed by a network of transportation and utility systems (Photo 6). Linear development is high along the Thompson River corridor and major transportation routes include the Canadian Pacific Railway, the Canadian National Railway, B.C. Railway, the Trans Canada Highway 1, B.C. Hydro major transmission lines as well as oil and gas pipelines owned by Westcoast energy, Trans Mountain Pipelines and B.C. Gas (Sigma Engineering Ltd. 1991). Secondary road systems are extensive at all municipal developments. Known impacts from linear development within the Thompson Nicola HMA include the degradation of riparian habitat, a reduction in channel complexity, channelization, encroachment, bank erosion and bank degradation.

Linear development along the Coldwater River includes the Coquihalla Highway, B.C. Tel fibre optic line, Trans Mountain Pipelines, Westcoast Energy oil/gas pipeline and a network of secondary roads. Impacts from the Coquihalla Highway, natural gas pipelines and other linear developments have had negative impacts on fish habitat in the upper Coldwater and its tributaries (Photo 6) (Fast 1990).

Linear development along the Thompson River includes the Trans Canada Highway, the CNR, the CPR, Trans Mountain Pipeline and Westcoast Energy

PHOTO 6. Linear corridor consisting of the Coquihalla Highway, abandoned railway, 2 oil/gas pipelines and the B.C. Tel fibre optic line have constrained the Coldwater River (Photo by M. Crowe).

gas/oil pipeline, hydro transmission lines as well as a network of secondary roads. Within the Thompson River corridor, linear development has resulted in extensive bank armoring with rip rap and encroachment of the river channel which has degraded near bank rearing habitat and resulted in the direct loss of spawning habitat (Grace, pers. comm., Lawrence, pers. comm., Hickey and Trask 1994). Bank stabilization techniques such as the placement of riprap, can result in an overall reduction of habitat diversity and reduce the quantity and/or quality of off-channel habitat and riparian vegetation. In addition, the close proximity of the highway and railways along the river creates a risk that chemical spills could enter the river and impact fisheries resources. Railway maintenance practices have resulted in railway and highway sidecast along portions of the streambank below Ashcroft (Lawrence, pers. comm.).

4.4.4 Current Trends

Recreational use is increasing within the Thompson Nicola HMA. Recreational user days at the Deadman and Bonaparte River forest service recreation sites has increased from 1,972 in 1988 to 9,229 in 1994 (Eastwood, pers. comm.). Within the Nicola River, recreational use has increased from over 66,000 user days in 1993 to over 98,000 user days in 1994 (Kekula, pers. comm).

Sportsfishing is also an increasing recreational activity and has increased from 870,000 angler days in 1990 to 1,000,000 angler days in 1995 (Chan pers. comm.). Increased recreational use within the Thompson Nicola HMA will likely require expansion and upgrading of existing highways.

4.5 MINERAL RESOURCES AND MINING ACTIVITY

4.5.1 Mining Activity

Active metal mines include Highland Valley Copper (HVC) which is the fifth largest open pit copper mine in the world and is located in the upper Guichon and Pukaist drainages (Sigma Engineering Ltd 1991). Afton Operating Corporation, resumed production in September 1994 but was closed again in May, 1997. Tailings recovery operations in the area include Craigmont tailings, at which tailings are being reworked for magnetite. The company has submitted a conceptual design to create a new tailings-storage dam which would allow the operation to continue for at least another 15 years (Schroeter 1996).

Advanced exploration and development projects in the HMA include a zeolite deposit near Cache Creek, B.C., and red shale deposits in the Hat Creek coalfield (Schroeter 1996). Past producers within the HMA include 23 closed mines in the Nicola drainage, and four closed mines in the Coldwater drainage (Sigma Engineering Ltd. 1991). There are also a number of non-producing properties near the confluence of the Coldwater and Nicola Rivers and in the vicinity of Nicola Lake.

There has been a moderate degree of exploration in this area during 1995 and a summary can be found in Schroeter (1996). Placer mining has several claims throughout the HMA, particularly in Shakan Creek, Cache Creek. There are recreational placer mine reserves at Tranquille River and Hat Creek.

4.5.2 Current Trends

Current information suggests that mining related impacts are relatively small due to limited mining activity in proximity to fish bearing streams throughout the HMA. However significant impacts to resident fisheries values resulted from the Highland Valley Copper Mine development (Chan, pers. comm.). Between 1980 and 1984, 4 fish bearing lakes were drained in order to access ore bodies. Two lakes supported wild, self sustaining rainbow trout stocks which were also utilized as traditional food fishing sites by First Nations people. One of these lakes, Lake Quiltanton, supported diverse riparian habitat and provided high value wildlife habitat as well as fish habitat. The remaining 2 lakes were stocked and supported a recreational fishery. The lake system flowed into Witches Brook which was diverted, dammed and dewatered, resulting in losses to both fish and wildlife habitat. Existing impacts from Highland Valley Copper Mine include increased copper and molybdenum levels in downstream waters and in fish (Sigma Engineering Ltd 1991). Additional impacts include bioaccumulation of molybdenum in alfalfa crops utilizing water from Guichon Creek. The mine has 15 more years of operation and active reclamation of tailings ponds has restored fish habitat. The loss of fish and wildlife habitat by the development of Highland Valley Copper Mine resulted from an agreement signed between the provincial government and the mining company (Cominco) in 1975. An active water quality monitoring program is being conducted by the provincial government.

5.0 WATERSHED MANAGEMENT ISSUES AND RECOMMENDATIONS

The Thompson-Nicola HMA has a drainage area of approximately 17,600 km^2 and encompasses a number of distinct geographic land regions and climatic zones (Sigma Engineering 1991). Most of the HMA is located in very dry climatic zones with the exception of the south-west portion of the HMA where streams originate in the Cascade Mountains and exhibit coastal streamflow patterns. Hydrological characteristics, landforms and stream processes vary greatly throughout the study area and thereby affect the sensitivity of stream habitat to physical disturbances in the watershed.

Fish production in riverine systems is influenced by natural conditions such as river morphology and water quality, as well as impacts associated with resource activity. Land and water use activities within the Thompson-Nicola HMA have affected fish habitat by altering riparian ecosystems, water quantity, channel morphology, sedimentation, erosion, substrate quality, water quality and water temperature. Changes in the physical processes of a watershed often result in the degradation of fish habitat and ultimately a loss in the productive capacity of the system. The severity of the impact from activities, such as logging, agriculture or urbanization, will depend on the existing stability of the watershed, the sensitivity of the habitat values and the severity and duration of the event.

The priority in managing fish habitat in the HMA is to ensure protection of the fisheries resource by protecting and managing the stream ecosystem including the uplands, riparian zones and floodplains of rivers and lakes. DFO has defined seven measurable and achievable goals in order to sustain fisheries values (Table 10). Proper land management practices must be promoted to maintain the integrity of the streams and lakes and prevent impacts on spawning and rearing fish. In watersheds where land use impacts have already occurred and continue to damage fish habitat, the natural water and sediment regimes and riparian ecology needs to be restored. Beschta et al. (1994) observed that the removal of land use activities that cause adverse impacts to riparian and aquatic ecosystems are of the highest priority if restoration is to be accomplished; furthermore, restoration alone cannot substitute for vigorous stewardship of riparian systems and their surrounding watersheds.

Within the Thompson Nicola HMA, there are concerns for impacts to fish habitat as a result of resource development activities (Table 11). The current state of watersheds is the result of past and present practices on Crown and non-Crown lands that have resulted in cumulative impacts on fish habitat. Most salmon bearing watershed in the HMA have logging development in upland areas and agricultural development in the lower watershed. Studies in the interior indicate that clearcutting, road building, land clearing and cattle grazing have significantly impacted streams by channelization and degradation of riparian vegetation.

TABLE 10. Measurable and achievable goals for sustainable fisheries development (O. Langer in Harding et al. 1994).

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1. **Avoid irreversible human induced alterations to fish habitats.** Alterations to fish habitat that reduce its capacity to produce fish populations and cannot be reversed within a human generation will be avoided.
2. **Maintain the genetic diversity of fish stocks.** No fish stock, however small, will be arbitrarily eliminated and where possible, efforts to conserve and rebuild small and remnant stocks will be made.
3. **Maintain the physical and biological diversity of fish habitat.** Physical and biological diversity of habitat provides fish with an opportunity to adopt alternative life history strategies, thereby providing protection from natural habitat variation.
4. **Provide a net gain in productive capacity through proper habitat management.** Ecological limits control productive capacity of a stream system. Natural and self-sustaining productions systems are preferred over semi-natural, artificial or non-self sustaining systems.
5. **Maximize the value of commercial, sport and aboriginal fisheries.** All market and extra-market values are to be considered, and measured in a away that permits comparison of competing users of the fisheries resources.
6. **Maximize the non-consumptive values of the fisheries resources.** Intangible and cultural values associated with fishery resources are to be given due consideration in decision making.
7. **Distribute fishery net benefits in a fair and equitable manner.** Local communities are to be involved in the decision-making process pertaining to habitat conservation, enhancement, and restoration and particularly who is to benefit and who is to pay.

These streams require restoration and considerable time for recovery and are vulnerable to further development. Therefore, it is vital that land and water management practices in these watershed be improved and past impacts addressed.

Monitoring escapement to salmon stream throughout the HMA is also imperative to managing the stocks and ensuring adequate spawner returns. Intensive ocean harvesting rates need to be reduced. This is of particular concern regarding the rebuilding of coho stocks which are in serious decline.

TABLE 11. Streams with concerns for impacts due to forestry, agriculture, urbanization, linear development, industrial development in the Thompson-Nicola HMA.*

STREAM	Forestry	Agriculture	Urban	Linear	Industrial
Thompson R.			X	X	X
Tranquille R.		X			
Deadman R.	X	X			
Bonaparte R.	X	X			
Cache C.		X	X		
Hat C.	X	X			
Nicola R.	X	X	X		
Spahomin C.		X			
Clapperton C.		X			
Guichon C.		X			
Spius C.	X	X		X	
Maka C.	X				
Skuhun C.	X	X			
Shakan C.					
Nuaitch C.					
Coldwater R.	X	X	X	X	X
Midday C.		X			
Voght C.		X			
Brook C.					

*Based on information in sections 4.0 and 5.0

The purpose of this chapter is to identify management issues and recommendations by watershed. The Thompson-Nicola HMA will be divided into the following drainages and discussed as follows :

1. The Thompson River mainstem from the confluence of the North and South Thompson River to the Fraser River/Thompson River confluence at Lytton.
2. Deadman River watershed
3. Bonaparte River watershed
4. Nicola River watershed (except for the Coldwater River)
5. Coldwater River watershed

A major management priority for all watersheds within the Thompson-Nicola HMA is to ensure protection of the fisheries resources by protecting and managing the river riparian zone or floodplain, and ensuring water quality and quantity are maintained at adequate levels. Proper land management practices must be promoted in order to maintain the integrity of the streams and riparian zones and prevent impacts on spawning and rearing habitat. In addition, there is a need to inventory fish and assess fish habitat for a number of salmon streams within the HMA.

5.1. Thompson River

Significant populations of pink, chinook and coho spawn in the Thompson River mainstem upstream of Ashcroft. Pink are the most abundant species in the HMA with the Thompson mainstem supporting virtually all of the population. The Thompson mainstem provides rearing and overwintering habitat for juvenile chinook and coho for the North and South Thompson as well as Thompson salmon stocks. The Thompson also supports steelhead and rainbow trout. Several studies on salmonid rearing and spawning habitat in the Thompson mainstem were completed as part of the proposed CN Twin Tracking project between 1984-1987 (Beniston and Lister 1987, Lister 1987, Beniston et al 1985, Beniston and Lister 1985, Beniston and Lister 1984).

The mainstem Thompson River is also a major migration corridor for adult and juvenile salmon of the entire Thompson watershed including the North Thompson and Shuswap systems. Adult salmon passage problems due to natural river hydraulics are known to occur in the Thompson Canyon downstream of Spences Bridge and in the Black Canyon below Ashcroft. Slide debris in the Black Canyon could adversely impact river hydraulics and hinder fish passage. An ongoing monitoring program and the development of a contingency response plan currently addresses concerns for fish passage problems through the Black Canyon should a major slide occur (AGRA 1996). Increased mortality of salmonids can occur when elevated summer water temperatures exceed the optimum temperature of 15 C. Temperatures of up to 20 C were measured in the mainstem Thompson River at Spences Bridge (Walthers and Nener 1997). Water temperatures during the summer of 1994 at Savona also indicated that temperatures exceeded 20 C in the mainstem Thompson River at Savona (Lauzier et al., 1995).

Resource development activity along the Thompson River corridor includes linear development, agriculture, urban development and forestry. Linear development along the Thompson River includes the Trans Canada Highway, the CNR, the CPR, Trans Mountain Pipeline and Westcoast Energy gas/oil pipeline, hydro transmission lines as well as a network of secondary roads. Within the Thompson River corridor, linear development has resulted in extensive bank armoring with rip rap and encroachment on the river channel which has degraded near bank rearing habitat and resulted in the direct loss of spawning habitat (Grace, pers. comm., Lawrence, pers. comm., Envirowest 1994). Bank stabilization techniques such as the placement of riprap, can result in an overall reduction of habitat diversity and reduce the quantity and/or quality of off-channel habitat and riparian vegetation. In addition, the close proximity of the highway and railways along the river creates a risk that chemical spills could enter the river and impact fisheries resources (Photo 7). Railway maintenance practices have resulted in railway and highway sidecast along portions of the Thompson River (Lawrence, pers. comm.) (Photo 8). In 1997, a CPR compensation project near Ashcroft created spurs and placed spawning gravels in compensation for the impacts of stabilization works.

Agricultural activities include livestock pasturing, ginseng, hay and fruit production along benchlands of the Thompson River. Impacts from this activity are localized to sites where riparian habitat has been degraded. There is also some concern over increased levels of pesticides and nutrients from ginseng farming (Grace, pers. comm., Matthew, pers. comm.).

Urban development includes the city of Kamloops at the east end of Kamloops Lake and smaller communities of Wallachin, Savona, Ashcroft, Spences Bridge and Lillooet along the mainstem Thompson River. Stormwater runoff and effluent discharges from the City of Kamloops Sewage Treatment Plant and the Weyerhaeuser pulp mill have the potential to degrade water quality in the mainstem Thompson River (Envirowest 1994, Grace, pers. comm.). Over the past several years, phosphorous loading from the sewage plant has been reduced (Nordin and Holmes 1992). However, warm water effluent containing chlorinated compounds continues to be released from the Weyerhauser Pulp Mill.

There has been extensive forestry development in the tributaries to the Thompson River watershed. Logging related impacts include sediment loading and increased turbidity and is most evident downstream of the Nicola River confluence (Sigma Engineering 1991). Hazard index scores based on watershed assessments indicate impacts from logging include surface erosion problems in Thompson River Face Units (MOF, 1997).

Management Objectives

To maintain a migratory corridor for upstream Thompson River salmon stocks and to protect pink, chinook, coho and steelhead spawning and rearing habitat in the mainstem Thompson River through management of the foreshore and tributary streams.

Management Strategies

- Investigate opportunities to provide more low velocity holding and rearing habitats for fry during late spring and early summer in the mainstem Thompson River

PHOTO 7. Potential for chemical spills to occur due to close proximity of the Trans Canada Highway 1 and railway lines to the Thompson River downstream of Spences Bridge (Photo by G. Kosakoski).

PHOTO 8. Widening the railway track with material sidecasted in the Thompson River upstream of the Nicola River confluence (Photo by G. Kosakoski).

Management Strategies (con't)

- Develop off-channel habitat at the oxbow near Walachin (Andrew et al. 1986); open up oxbow (inlet blocked by CN fill) and construct spawning and rearing channel upstream to provide additional habitat and more flow to oxbow.
- Develop and implement guidelines for routine maintenance of roads and railways including rock stabilization and disposal of sidecast and ballasting materials to prevent impacts on fish habitat.
- Request that user groups including CNR, CPR and BC Rail develop contingency plans for possible hazardous chemical spills associated with linear development within the Thompson River corridor (Lawrence, pers. comm.). Ensure emergency cleanup and containment facilities are available for accidental spills from railways and highways.
- Continue monitoring of water quality, effluent discharges and sediments introduced into the river and identify non point sources of sediments and contaminants to ensure maintenance of water quality
- continue to monitor major water intake screens to ensure that fish are not being entrained
- Protect and restore riparian vegetation along the mainstem river and tributaries that have been impacted by urbanization, agriculture, and linear development
- Promote watershed stewardship in the ranching community to protect the riparian corridor, instream fish flows and water quality of the mainstem and tributary streams on crown and private lands. Assess potential impacts of the use of herbicides and pesticides in Ginseng production
- Apply the Land Development Guidelines as a minimum for urban development and Best Management Practices outlined in Stewardship Guides for Planners and for Agriculture
- Continue to monitor and enumerate Thompson River stocks in particular coho.

5.1.1 Kamloops Lake

The North and South Thompson Rivers flow into Kamloops Lake. Kamloops Lake is 27 kilometers in length, 143 meters deep and encompasses an area of 56,000,000 m^2. The substrate is primarily fine material and the banks are predominantly bedrock (Hatfield Consultants Limited 1996). Kamloops Lake is an important and productive nursery area for South Thompson chinook stocks and North and South Thompson River sockeye stocks. It is also a migratory corridor for pink, coho, chinook and sockeye salmon adults moving upstream, and smolts migrating to the ocean from upstream populations. Fry rear along the littoral zones of the east end of Kamloops Lake and move offshore as water temperatures rise through June (Stewart et al. 1989). Sockeye move out to deeper water to take up a pelagic lifestyle, while chinook salmon appear to remain near the lake margins.

Development is concentrated at the east end of the lake where the City of Kamloops is located. Additional urban development occurs at Savona located on the west end of the lake with an additional low density community along the north shore. The Canadian Pacific and Canadian National Railway lines follow the north and south shores of the Lake. The lakeshore is precipitous and rocky over much of its length with lower gradient littoral zones are located along the east and west ends.

Water quality in Kamloops Lake is influenced by effluent from the Weyerhaeuser Pulp Mill, the City of Kamloops Sewage Treatment Plant and stormwater runoff from the City of Kamloops (Envirowest 1994, Grace, pers. comm.). Agricultural activities along the northeast end of the lake may also affect water quality in localized areas. Numerous water studies conducted in Kamloops Lake over the past 2 decades suggest that there has been little change in water quality over this period (Nordin and Holmes 1992). However, there is an indication that community structure of the zooplankton community may be changing (Ward 1964; Bechtel 1979, Anderson 1981, Weyerhaeuser 1974). A recent study found that the concentration of some pulpmill-related resin/fatty acids in Kamloops Lake sediments increased along the downstream axis of the lake, with the highest concentrations near Savona, B.C. (Hatfield Consultants Ltd. 1996).

Recreational values in Kamloops Lake may be considered low because of the lack of accessibility, good bathing beaches, and effluent discharges from the Sewage Treatment plant and Weyerhaeuser Pulp Mill. However, some recreational fishing occurs. A development proposal has been submitted for the Six Mile Ranch Property and consists of a marina, golf course and subdivision. Acceptance of the proposal would require removing the property from the ALR. Protection of fish habitat would require sediment control during development, storm water management and minimal disturbance to foreshore habitat (Kosakoski, pers. comm).

Management Objectives

To protect foreshore habitat and maintain or improve the water quality of Kamloops Lake and the Thompson River mainstem

Management Strategies

- Continue to monitor water quality as recommended by Water Quality in BC (MELP 1993b).
- Monitor effluent from Weyerhauser pulpmill to ensure compliance with their waste discharge permits.
- Conduct foreshore inventory and mapping of Kamloops Lake to identify sensitive habitat areas and develop guidelines for protection of fish habitat. Apply the Land Development Guidelines as a minimum for lakeshore development.

5.1.2 Tranquille River

Tranquille River has a drainage area of 59,600 hectares and flows in a southerly direction, entering Kamloops Lake near the City of Kamloops. Tranquille River provides spawning and rearing habitat for coho salmon and anadromous access is restricted to the lower 5 kilometers by a series of falls. A fishway was constructed to facilitate migration past the water diversion below the falls but successful passage by anadromous species is unknown (Matthews, pers. comm., Crowe pers. comm.).

Agricultural development is concentrated along the valley floor and upland benches of both the upper and lower portions of the watershed. Erosion and compaction of streambanks has occurred in localized areas in the upper portion of the watershed. Tranquille River is a lake fed system with 3 storage dams constructed for agricultural use. Typical of interior systems, Tranquille River has low summer water flows and therefore water withdrawals for resource use have the potential to negatively affect instream values.

Forestry development has also occurred in the Tranquille watershed but the level of concern regarding the impacts to fisheries values has been rated as low. Other development within the drainage includes one small scale recreational placer mine, 2 forest service recreation sites, a secondary road along the river and a railway across the lower river. Settlement in this area is primarily low density and includes a large psychiatric facility and hobby farms.

Management Objectives

To reduce increased sedimentation and riparian degradation from agricultural development and ranching, ensure maintenance flows for fish and address channel instability problems from past forest harvesting practices.

Management Strategies

- Conduct a Fish Habitat Assessment Procedure for the Tranquille River watershed to identify fish species at risk, provide a quantitative description and evaluation of fish habitat conditions and identify opportunities for rehabilitation.
- Increase coho production through a fry outplant program (Matthews, pers. comm.).
- Promote stream stewardship by community groups to develop a watershed management plan to restore riparian corridors, ensure instream flows for fish and improve water quality.
- Assess the existing water control structure at the Padova city water intake to ensure maintenance flows for fish are being maintained.
- Conduct IWAP to assess and address impacts of forest development activities.

5.2 Deadman River

The Deadman River has high fisheries values, supporting chinook, coho and pink salmon and steelhead trout (Galesloot 1995, Olmsted et al. 1992.). The Deadman River is recognized as an important producer of chinook and coho, with average annual escapements of 1000 and 2000 spawners respectively. Sockeye salmon are known to utilize the system intermittently (FHIIP 1992). Upstream passage of pink salmon is limited by a falls located 5.1 km upstream of the mouth whereas other salmonids can access and additional 50 km of river upstream of the falls to the dam at Snohoosh Lake. Salmonid enhancement initiatives on Deadman Creek include a chinook and coho salmon hatchery operated by the Skeetchestn Indian Band and counting fences for chinook, coho and steelhead.

Forestry and agriculture are the two primary resource development activities in the Deadman River watershed. An estimated 30% of the total watershed area of the Deadman River has been logged (Sigma Engineering 1991). Logging activity has concentrated in the middle and upper portions of the watershed with more recent logging concentrated along the northwest and eastern boundaries of the watershed (Miles 1995). However, it in unlikely that the current level of clearcut logging would cause a significant increase in snow and/or rain generated peak flows in the mainstem Deadman River upstream of Criss Creek or in Criss Creek. This is due to the small percentage of both watersheds that have been clearcut logged and most cut blocks located on relatively gentle terrain. There is also flow regulation from the lakes (Cheng 1990 in Miles 1995). Only 1.2% of

Criss Creek and 2.1% of the watershed upstream of the WSC gauge Deadman River above Criss Creek has been logged since 1985.

Agriculture has negatively impacted channel stability and reduced fisheries productivity (Miles 1995, Fast 1990). Agricultural activities within the Deadman River watershed have resulted in decreased channel length, decreased back channel habitat, bank erosion, increased sediment transport and channel aggradation (Miles 1995, Kosakoski, pers. comm., Maricle, pers. comm). In order to decrease erosion rates, bank protection and mitigation works have been conducted (Photo 9).

Water demand is high for the Deadman River equaling 91% of 7 day summer low flows (Rood and Hamilton 1995). Deadman River has been used for irrigation since the 1920's (Sigma Engineering Ltd. 1991). Snohoosh Lake dam was constructed in the early 1970's to store water for irrigation and provide maintenance flows for fish. In its present condition the dam has a limited storage capacity and does not provide adequate attraction flows for steelhead in the spring (Crowe, pers. comm.). At this time, minimum flows for fish specified in the Improvement District's water licence are not released until the minimum requirements for agriculture are met (Crowe pers. comm.) . DFO and MELP have conducted a feasibility study to identify options for upgrading the Snohoosh Lake Dam to increase storage and improve control for flow releases. Better flow monitoring is also required. There has also been a second dam constructed at the outlet of Mowich Lake for irrigation purposes (Crowe, pers. comm.).

Downstream of Mowich Lake there is a 30 kilometer reach of the Deadman River that is wider and laterally unstable where agricultural practices (since 1949) have degraded riparian areas. Miles (1995) determined that 44% of the stream bank has no woody riparian vegetation and an additional 23% of the river bank has a riparian corridor less than half the width of the channel. In some areas channel widths have increased with one site increasing from 18 meters to 114 meters. Increased channel widths likely result in increase water temperatures, a reduction in the number and size of pools, less undercut bank habitat and potentially smaller minimum flows (Miles 1995:x). Off channel habitat has also been reduced by stream channelization.

During June, 1990, a 1-in-178 year flood event occurred in the Deadman River mainstem upstream of Criss Creek (Fig 10)(Miles 1995). This flood appeared to reduce the carrying capacity of juvenile salmonids in the Deadman watershed by about 30% (Olmsted et al. 1992). Because of the degree of bedload movement on this system, losses in natural steelhead recruitment were likely higher on this system than in the Bonaparte River system (Maricle and McGregor 1990b). However, despite the severity of the flood, Olmsted et al. (1992) found that many of the channel features and physical habitat characteristics remained relatively undisturbed or redistributed. Furthermore, they suggested that in some

PHOTO 9. Rip rap placement in the Deadman River where bank protection and mitigation works have occurred to reduce erosion rates (Photo by G. Kosakoski).

PHOTO 10. The June 1990 flood in the Deadman River destroyed the Deadman River hatchery (Photo by J. Patterson).

cases the quantity and quality of fish habitat may have increased, although discharges of fines into the watershed may have contributed to infilling of former pool habitat (Olmsted et al. 1992).

Management Objectives

Management objectives for the Deadman River include conservation and rebuilding salmon stocks, particularly coho. It is also a priority to re-establish a vegetated riparian corridor to restore channel stability, improve water quality and reduce elevated summer water temperatures. Additional objectives are to manage storage and water releases to meet fish flow requirements.

Management Strategies

- Continue enhancement of Deadman River chinook and coho through the Deadman and Spius hatcheries and support wild stock conservation and rebuilding programs as well as habitat protection and restoration (Crowe, pers. comm.)
- Develop a riparian management plan to protect and re-establish a vegetated riparian corridor that will allow riparian vegetation to re-stabilize the channel banks. The width of the corridor should be determined on a site specific basis as a function of present channel stability and how this will change over time (Miles 1995). The riparian corridor should vary from 3-7 channel widths, depending on morphological characteristics (Miles 1995).
- Fence riparian areas to prevent grazing damage and restrict access by cattle to a few designated sites (Miles 1995).
- Control local areas of rapid bank erosion through the use of appropriate bio-engineering techniques and avoid the use of rip-rap. The need for bank stabilization should be reduced once a riparian corridor is established (Miles 1995).
- promote initiatives to purchase or lease land or provide some other form of compensation to land owners to protect or restore riparian habitat (Miles 1995).
- Continue to support the Skeetchestn Indian Band and their efforts to enhance salmon production and restore fish habitat through revegetation and fencing programs, and operation of the fish hatchery
- Determine the feasibility of constructing groundwater channels to help manage low flow problems
- Develop a water use plan with Improvement District, Water Management and the community to include better flow monitoring, groundwater management,

storage opportunities and flow regulation (during average and dry years) to ensure adequate instream flows for fish.

- Determine the feasibility of upgrading Snohoosh Dam to increase storage capacity to provide attraction flows for steelhead and maintenance rearing flows for juvenile salmonids (Crowe, pers. comm.).
- Conduct IWAP to assess impacts on past logging activities to identify restoration needs and provide recommendations to avoid impacts of further logging

5.3 Bonaparte River

The Bonaparte River enters the Thompson River at Ashcroft, B.C. Major tributaries to the Bonaparte River include Cache Creek, Hat Creek and Loon Creek.

The Bonaparte River supports chinook, coho and pink salmon as well as steelhead and rainbow trout (Maricle and McGregor 1990a, 1990b, Bison 1992). The Bonaparte is an important producer of chinook within the HMA with an average of 1000 spawners annually. Chinook escapement to the Bonaparte River is increasing and in 1997, the highest historical escapement of 11,080 fish was recorded (Rosenberger, pers. comm.). Salmon habitat on the Bonaparte River was historically limited to the lower 2.6 kilometers due to a 7 meter falls near the mouth. Construction of a fishladder in 1989 allowed anadromous fish to access an additional 140 kilometers of habitat and chinook, coho and steelhead stocks are increasing as a result of fishway construction (Galesloot 1995, Crowe 1993, R. Bison unpubl. data) (Photo 11).

Resource use in the Bonaparte watershed is dominated by forest harvesting activities in the upper watershed and agricultural development in the lower watershed along the plateau above the Thompson River Valley. Approximately 40% of the total watershed area has been logged with 20% of the basin in a recently logged state (Sigma Engineering 1991). Sedimentation from extensive logging road networks and forest harvesting has resulted in compaction of gravels in the lower reaches of the system which in turn reduces habitat values for both spawning and rearing salmonids (Maricle, pers. comm.). Removal of the riparian vegetation and alteration of stream hydrology has likely had negative impacts on the downstream reaches (Kosakoski, pers. comm, Lawrence, pers. comm.; Todd, pers. comm.).

Agricultural activity is extensive from Cache Creek to Loon Creek and primarily consists of cattle ranching and crop production (Photo 12). Cattle grazing and watering in riparian areas has resulted in bank erosion, channel stability problems and compaction of gravel due to increased sedimentation (Photo 13). Removal

PHOTO 11. Overhead view of the Bonaparte River fishway constructed in 1989 (Photo by M. Crowe).

PHOTO 12. Extensive agricultural development in the Bonaparte River includes crop production and cattle ranching (Photo by M. Crowe).

of riparian vegetation for crop production and unlimited access to the stream by cattle has resulted in bank erosion and increased sediment delivery to the stream. A significant loss of groundwater channels has occurred from agricultural practices (Galesloot, pers. comm.)

Conflict exists between agricultural use of water and instream uses especially during summer and early fall during low flow periods. Summer water use equals 98% of the August summer 7 day low flow (Rood and Hamilton 1995). Low flow problems also exist during the winter when average 7 day low flows equal 14% of the mean annual flow (Rood and Hamilton 1995). Water supply estimates are insufficient for licensed irrigation use on the Bonaparte River, Hat and Scottie Creeks (MELP 1985).

PHOTO 13. Impacts of agricultural development in the Bonaparte River near Cache creek includes the degradation of riparian habitat, bank erosion problems, and decreased water quality (Photo by M. Crowe).

Three major flood events occurred during June/July 1990 in the Bonaparte River with the largest flood estimated to be between a 1 in 200 - 500 year event, and the other two floods being 1 in 50 year events (Miles 1995, Doyle, pers. comm. in Rosenau 1990). As a result of the flooding, severe erosion occurred within and adjacent to the river channel causing significant damage to properties along the Bonaparte River. Restoration and/or protection work included bridge reconstruction, log jam removal and streambank revetments where subsequent erosion had the potential to further impact property and the existing infrastructure. Erosion effects were also thought to have severe impacts on the salmonid resources (Rosenau 1990). The late timing of the high water flood in 1990 may have resulted in loss of some natural steelhead recruitment (Maricle and McGregor 1990b).

Urbanization includes the villages of Cache Creek, Clinton and Loon Creek in addition to rural development. Within Cache Creek, bank protection works have resulted in channelization, a reduction in channel complexity and degradation of riparian vegetation.

Other activities within the Bonaparte River drainage include recreational development on Bonaparte Lake, residential development at Loon Lake and Ainsworth Lumber at Chasm (Sigma Engineering Ltd. 1991; MELP 1993a). Water quality in the Bonaparte has been rated fair because turbidity, suspended sediments, fecal coliforms and algal samples have not met acceptable levels on a regular basis (MELP 1985). Low dissolved oxygen in Loon Lake is likely the result of eutrification (MELP 1994).

Management Objectives

To re-establish a vegetated riparian corridor that will enable riparian vegetation to re-stabilize the channel. It is also an objective to restore groundwater channels and to improve water quality. Management objectives include investigating water storage opportunities and to providing maintenance flows for fisheries values.

Management Strategies

- Develop a riparian management plan to protect and re-establish a vegetated riparian corridor that will allow riparian vegetation to re-stabilize the channel banks. The width of the corridor should be determined on a site specific basis as a function of present channel stability and how this will change over time (Miles 1995).
- Fence riparian areas to prevent grazing damage and restrict access by cattle to a few designated sites (Miles 1995).
- Control local areas of rapid bank erosion through the use of appropriate bio-engineering techniques and avoid the use of rip-rap. The need for bank stabilization should be reduced once a riparian corridor is established (Miles 1995).

- promote initiatives to purchase or lease land or provide some other form of compensation to land owners to protect or restore riparian habitat (Miles 1995).
- Develop a water use plan with Water Management Branch and water users that includes an analysis water supply and licensing, instream fish flow requirements, flow monitoring requirements, groundwater regulation, storage opportunities and review flow release strategies to optimize flows for fish.
- Restrict further licensing of water in the Bonaparte River and tributaries unless supported by storage and/or alternate water supply.
- Implement rule curve and release schedule designed by KPA Engineering that would provide greater certainty of maintaining prescribed stream flows for fish.
- Investigate additional live storage at the Bonaparte Dam as well as in other lakes in the drainage (McGregor and Kosakoski 1996).
- Conduct IWAP to assess impacts on past logging activities to identify restoration needs and provide recommendations to avoid impacts of further logging. Restore off-channel habitats to enhance fish habitat values
- Continue to support Bonaparte Indian Band salmonid enhancement and restoration initiatives on private property, such as the ongoing habitat restoration and riparian revegetation projects from Hat Creek to Loon Lake (Morgan 1993)
- Enhance salmonid stocks, and investigate the need to construct a second fishway at the Bonaparte Dam to facilitate rainbow trout fry migration (Crowe, pers. comm.)
- Apply the Land Development Guidelines as a minimum for future development in Cache Creek, Clinton, Loon Creek and other urban centers.
- Continue to monitor chinook and coho and their habitat utilization upstream of the fishway

5.3.1 Cache Creek

Cache Creek flows into the Bonaparte River approximately 11 kilometers upstream of the Bonaparte/Thompson River confluence. Since the construction of the Bonaparte fishway in 1989, it is likely that the lowermost 100 meters of Cache Creek is utilized by juvenile coho salmon (Crowe, pers. comm.).

The village of Cache Creek is located at Cache Creek/Bonaparte River confluence. Approximately 1 kilometer of Cache Creek is channelized and armored through the town with most of the streamside vegetation removed. A series of culverts located approximately 250 meters from the mouth of Cache Creek within the village of Cache Creek is likely restricting upstream migration of salmonids (Crowe, pers. comm., Maricle, pers. comm.). Upstream of the culverts is high quality fish habitat that could support anadromous stocks.

Extensive agricultural development has occurred along the bench above Cache Creek and in valley bottom areas of Cache Creek. Riparian vegetation has been degraded from cattle grazing and trampling of stream banks, resulting in increased sediment delivery and high summer water temperatures (Lawrence, pers. comm.). Natural low flows in late summer and fall are exacerbated by water withdrawals for agricultural purposes.

Management Objectives

To determine whether fish access is limited by the culvert through Cache Creek and to restore riparian habitat to reduce sedimentation and elevated water temperatures. It is also a management objective to maintain adequate instream flows for salmonids.

Management Strategies

- Improve fish passage through the culvert located in the Village of Cache Creek
- Restore instream habitat and riparian corridors that have been negatively impacted by urban and agricultural development
- Promote stream stewardship initiatives with Village of Cache Creek and communities to protect and revegetate riparian areas, maintain adequate instream flows, and improve water quality by restricting livestock access to the creek and controlling runoff from the Village of Cache Creek

5.3.2 Hat Creek

Hat Creek flows into the Bonaparte River halfway between the Villages of Cache Creek and Clinton. Access to Cache Creek and Hat Creek by anadromous species was facilitated by the construction of the Bonaparte fishway in 1989 although beaver dam obstructions exist throughout Hat Creek (Lawrence, pers. comm.). Tredger (1980) speculated that chinook juveniles and steelhead utilize this system.

Resource development within the Hat Creek watershed includes forestry, agriculture and urban development. Significant forestry development has occurred in the headwater area of Hat Creek and future harvesting potential is high (Fast 1990, Maricle, pers. comm, Todd, pers. comm, Lawrence, pers. comm.).

Significant agricultural activity has also occurred within lower Hat Creek drainage. Extensive agriculture is occurring at the Hat Creek Ranch along the Bonaparte River valley bottom with less intense agricultural activity occurring in the upper watershed (Todd, pers. comm., Matthews, pers. comm., Lawrence, pers. comm.). Impacts to fish habitat include the degradation of riparian habitat by cattle access and increased sedimentation and nutrient loading from winter confined livestock areas through Hat Creek Ranch. Water withdrawals for irrigation exacerbate natural summer low flow problems and high water temperatures. Grazing and crop production has increased sediment delivery to the creek.

Urbanization in the Hat creek watershed is limited to the Hat Creek Guest Ranch and a small Native Reserve (Lawrence, pers. comm.). Additional resource development activities include a placer mine recreational reserve and Highway 99 in the lower portion of the watershed (MEMPR 1995).

Management Objectives

To restore and protect riparian habitat from agricultural development and to assess and restore habitat degradation resulting from forestry development on the fisheries resource.

Management Strategies

- conduct IWAP to assess impacts of past logging, identify restoration needs and prevent further impacts
- restore upslope areas through road deactivation and slope stabilization that have been negatively impacted by forest harvesting and agricultural practices
- Restore riparian vegetation and fence cattle away from streams
- Determine whether beaver dams are restricting access by salmonids
- promote stream stewardship initiatives to educate stakeholders on the importance of riparian habitat Develop a stream demonstration project at the Hat Creek historical site to educate the public on stream habitat values
- Inventory and monitor salmon populations and habitat utilization and assess potential for enhancement by stocking the upper watershed with coho fry

5.4 Nicola River

The Nicola River mainstem originates west of Kelowna, B.C. and flows 193 kilometers to the Fraser River at Spences Bridge (Morantz and Haefele, 1996). Salmon producing tributaries to the Nicola River include the Coldwater River, Spius Creek, Maka Creek, Guichon Creek, Spahomin Creek and Clapperton Creek. Important steelhead producing systems within the Nicola River watershed include Skuhun Creek, Shakan Creek and Nuaitch Creek, Spius/Maka Creeks, Guichon Creek, the Coldwater River and the mainstem Nicola from Spences Bridge to Merritt.

Fisheries values in the Nicola River watershed are extremely high, with strong runs of chinook, coho, pink salmon and steelhead (Scott and Olmsted 1985). The Nicola River is a major producer of chinook with an average of 3,000 spawners annually, representing 50% of the overall escapement to the HMA. Chinook escapement reached a historical peak of over 16,500 fish in 1996 (Rosenberger, pers. comm.). Coho and chinook salmon spawn and rear primarily between Spius Creek and Merritt while pink salmon and steelhead trout utilize the lower reaches of the river (CRES 1996, Lauzier and Levings 1991, Scott and Olmsted 1985). Existing information indicates that wild fish stocks in the Nicola River watershed have been declining since the early 1980s (FHIIP 1992; Millar et al. 1994). Chinook, coho and steelhead stocks have been enhanced through hatchery operations since 1984 (Millar et al. 1994). Spius Creek hatchery has been outplanting juveniles into the Coldwater River, the Nicola River, Spius Creek, the Bonaparte and Deadman Rivers (FHIIP 1992). Outplanted juveniles originate from broodstock collected from each system.

The most severe impacts to the fisheries values in the Nicola watershed have resulted from agricultural activities in the lower reaches and forestry development in the headwaters of the Nicola River and tributaries. Much of the riverbank bordering agricultural areas is actively eroding, due to removal of riparian vegetation combined with unimpeded cattle access to the river. Within the lower sections of the Nicola River, only 3.5% of a total riverbank length of 234.2 kilometers is bordered by unimpacted vegetation (Morantz and Haefele 1996) (Photo 14). The upper Nicola River above Nicola Lake has suffered extensive losses of riparian vegetation due to ranching activities (Walthers and Nener, 1997). Although fish maintenance flows are specified for the Nicola dam, adequate flows for fish are only provided 80% of the time in the mainstem downstream of Nicola Lake dam (Crowe, pers. comm.).

High summer water temperatures in the Nicola River from late June through August, are the result of natural climatic conditions combined with agricultural, ranching, urban and linear development activities (Walthers and Nener 1997). The loss of overhanging riparian vegetation can increase water temperatures over a prolonged period resulting in physiological stress, behavior changes or

PHOTO 14. Degraded riparian habitat and active bank erosion in the Nicola River, April 1994 (Photo by M. Crowe).

mortality in fish (Barton et al. 1985, Morantz and Haefele, 1996). Temperature problems on the Nicola River have been further compounded by withdrawal of large volumes of water for irrigation and other uses with over 50% of the summer flow volume being removed by licensed withdrawals (Rood and Hamilton 1995). A 1994 study by Nener and Walthers (1997) identified that maximum temperatures in late July in the Nicola River reached 29 degrees Celcius and average weekly temperatures in July and August exceeded the preferred temperature for migrating salmonids. Adult whitefish and juvenile coho mortalities as a result of increased water temperatures were observed (Crowe, pers. comm.). Results from the 1994 temperature monitoring program by Walthers and Nener (1997) indicated that water temperatures likely limit salmon production in the Nicola River.

Water quality is also affected by agricultural development in the Nicola River valley. The Nicola River, contributes approximately 4% of the flow to the lower Thompson River, and is influenced by non-point source agricultural inputs along its length. The Nicola has relatively high concentrations of suspended sediments and fecal coliform bacteria. Large cattle operations reduce water quality through surface runoff from over-wintering feed areas located adjacent to surface water or irrigation ditches (MELP 1983). Upstream of the Coldwater confluence, high turbidity is a problem due to bank erosion and surface runoff causing increased silt loads in the mainstem Nicola River (Photo 15).

PHOTO 15. Discharge of high sediment loads into the Nicola River from an irrigation ditch (Photo by G. Kosakoski).

PHOTO 16. Degraded instream and riparian habitat resulting from private land logging in the Upper Nicola River near Douglas Lake (photo by G. Kosakoski).

Agricultural activities have also channelized sections of the Nicola River which has resulted in the loss of channel complexity and off channel high water refuge habitat (Kosakoski, pers. comm., Maricle, pers. comm.). Channelization and water diversions on the Nicola River upstream of Nicola Lake have severely impacted salmonid productivity (Fast 1990). Some farmers and ranchers still use an open-ditch irrigation system, which results in large amounts of water being lost to ground seepage and evaporation. Juvenile and adult salmonids become entrapped and die in unscreened ditches during periodic dewatering during the summer (Fleming et al. 1987).

Forestry development was initiated in the Nicola Valley in the early 1900's and 26% of the total watershed areas was logged by 1991 (Sigma Engineering 1991). Forest harvesting activities are concentrated in the upper portions of Spius Creek, Maka Creek and the Coldwater River where over 30% of the total basin area has been logged based on 1990 Landsat imagery analysis. In Maka Creek, over 25% of the basin has been considered to be "logged recently" as no evidence of vegetation was observed during the 1991 analysis of Landsat imagery (Table 13).

Forestry harvesting within the Nicola River watershed has resulted in altered hydrologic patterns including increased peaks flows, degraded riparian habitat, increased bank erosion and increased surface erosion and subsequent sedimentation in the mainstem Nicola River (Millar et al. 1994, MOF 1997, Doyle, pers. comm., Kosakoski, pers. comm.) (Photo 16). A watershed assessment completed on the Nicola River watershed during 1996/1997 identified evidence of significant impacts to surface erosion, riparian habitat and/or peak flows from past forest harvesting activities in the Nicola River mainstem, Coldwater River, Spius Creek, Guichon Creek, Clapperton Creek, Quilchena Creek, Spahomin Creek, Skuhun Creek, Shakan Creek (MOF 1997). The cumulative impacts of forestry activities will be further assessed through a more intensive Level II Channel Assessment in the Coldwater River, Spius Creek and Maka Creek watersheds by March 1997 (Heller, pers. comm.).

Residential development in the Nicola Valley is moderate, with the City of Merritt and other smaller residential centers such as Douglas Lake, Quilchena, Nicola, Coutlee, Lower Nicola and Canford are located along the River corridor. Transportation and utility corridors, and residential developments have restricted drainage patterns and have resulted in loss of riparian areas and channelization of the river (Crowe, pers. comm.). Roads and railway lines are located with 20 meters for 12% of the length of the Nicola riverbank (Morantz and Haefele 1996). Some water quality concerns regarding the seepage of sewage from the City of Merritt into the river were reduced by the construction of a rapid infiltration basin (RIB) in 1984. The construction of the RIB resulted in significant improvements in water quality (Grace 1987). Mining and industrial effluent loadings are also a concern and include elevated copper and molybdenum levels in Guichon Creek (Chan, pers. comm., Millar et al. 1997).

One freeze up and two severe mid-winter breakups since 1984 have had adverse effects on fisheries resources of the Nicola River system (Doyle et al. 1993). Freeze-up and ice jamming at the Nicola Lake outlet resulted in extremely low flows through a major spawning reach with probable losses of salmon eggs (Doyle et al. 1993). Ice jams can result in fisheries losses due to scouring of gravels and a loss of eggs as well as forcing fish out of overwintering areas. Changes in hydrologic patterns in upslope areas of the drainage have compounded this type of event. Two large breakups also moved large volumes of channel bed and bank material, leaving fish stranded on the floodplains (Doyle et al. 1993). Ice jamming in the Nicola River also causes extensive flooding in Merritt (Photo 17).

Photo 17. Extensive flooding in Merritt from ice jamming in the Nicola River (Photo by G. Kosakoski).

Restoration initiatives are being carried out by DFO, First Nations groups, the Nicola Watershed Community Roundtable, and the Interior Wetlands Programs. These groups are involved in a variety of projects focusing on bank stabilization, riparian planting, livestock fencing, with objectives to increase habitat complexity, control sediment loads, reduce summer water temperatures and maintain adequate fisheries flows. A complete list of current fisheries related projects and initiatives in the Nicola River is outlined in Millar et al. (1997).

Management Objectives

In the Nicola watershed, management objectives include the conservation and rebuilding of salmon stocks particularly coho stocks, the restoration of riparian and instream habitat and improvement of water quality (reduced temperature, sediment and nutrients). This includes re-establishing a vegetated riparian corridor, restoring channel stability, increasing channel complexity and controlling runoff from cattle overwintering areas. Lastly, efforts to improve fish conditions should focus on increasing the efficiency of irrigation systems and optimizing the use of water storage on Nicola Lake.

Management Strategies

- Develop a riparian management plan to protect and re-establish a vegetated riparian corridor that will restore riparian vegetation and over time, provide a longterm solution for re-stabilizing channel banks and decreasing summer water temperatures. The width of the corridor should be determined on a site specific basis as a function of present channel stability and how this will change over time (Miles 1995).
- Promote initiatives to purchase or lease riparian lands and provide other incentives to landowners to protect riparian zones
- Continue to fence riparian areas to prevent grazing damage and restrict access by cattle to a few designated sites (Miles 1995).
- Continue to control local areas of rapid bank erosion through the use of appropriate bio-engineering techniques and avoid the use of rip-rap. The need for bank stabilization should be reduced once a riparian corridor is established (Miles 1995).
- Actively participate in the Merritt Forest District Interior Watershed Assessment and Implementation Plan to assist in identifying and addressing the impacts of forestry development on peak flows, surface erosion and riparian habitat degradation. Conduct Level II Interior Watershed Assessment Procedure where necessary.

- Optimize flow releases from the Nicola Dam by completing dredging of the outlet to maximize storage potential.
- Improve efficiencies of irrigation distribution systems by replacing remaining ditch irrigation systems in the upper and mainstem Nicola River to a more efficient pipeline or sprinkler system.
- Control nutrient loading into the Nicola mainstem by reducing surface runoff from cattle overwintering areas into irrigation ditches and tributaries.
- Develop and restore groundwater channels and off-channel habitat to provide high water refuge habitat and critical overwintering habitat
- Address private land issues and agricultural problems by educating ranchers and farmers on controlling direct cattle access to streams through livestock fencing programs, non-point source pollution and other issues concerned with ongoing fish habitat degradation (M. Crowe, pers. comm.)
- Curtail urban development along the floodplain and develop a management plan for the watershed to protect fish habitat. Apply the Land Development Guidelines as a minimum for the protection of riparian habitat (Lawrence, pers. comm.)
- Continue restocking programs for Nicola, Coldwater and tributaries. Efforts to enhance coho and chinook stocks in the upper Nicola include building a second imprinting pond (similar to that on Spahomin Creek) on the Nicola River itself (Crowe, pers. comm.)
- Assess effectiveness of the one fish ladder, as a second one on the other side of the Nicola Dam may be needed to further enhance fry migration
- Investigate the feasibility of constructing a dam at the outlet to Douglas Lake to provide regulated flows to upper Nicola River. Investigate the feasibility of cold water releases from Nicola Lake during the summer.

5.4.1 Spahomin Creek

Spahomin Creek flows into the Nicola River at the west end of Douglas Lake. The lower reaches of Spahomin Creek support chinook and coho salmon. Escapement has been low over the last decade with less than an average of 10 fish annually for the entire upper Nicola. The Nicola Watershed Stewardship Fisheries Authority has been actively involved in development of fish habitat improvement projects and fish enhancement initiatives (Millar et al. 1997). Two smolt imprinting ponds for coho and chinook have been constructed at Spahomin Lake to increase the survival of juveniles released by the Spius Creek hatchery program.

Agricultural activity is the primary resource use in the Spahomin River watershed. Impacts of agricultural activities include degraded streambank and riparian areas from unimpeded access by cattle to streams and extremely low summer flows that are exacerbated by water withdrawals for irrigation. Rood and Hamilton (1995) identify that the total demand equals 135% of the summer 7 day low flows and 50% of the mean August flow. Therefore, agricultural activities are negatively impacting water quality and quantity in the Spahomin watershed and there is an increased demand for hay production in the lower 3 to 4 kilometers (Millar et al. 1997, Doyle, pers. comm., Todd, pers. comm.).

Forestry development is concentrated in the southern portion of the watershed and approximately 10% of the total watershed area was logged by 1990 (Sigma Engineering 1991). Results from the 1996 Level I Watershed Assessment showed high indices for surface erosion and riparian degradation (MOF 1997) but impacts on fisheries values from forestry development have been low in comparison to agricultural activities.

Management Objectives

Two primary management objectives for the Spahomin watershed are to restore riparian habitat and protect streambanks from further erosion. Equally important is the management of water withdrawals to ensure maintenance flows for fish are maintained and high summer water temperatures are reduced. Another management objective is to continue salmon enhancement efforts to assist the recovery of chinook and coho stocks.

Management Strategies

- Restore and protect riparian corridors and streambanks through the use of set-back fencing for cattle.
- Promote efficient use of water in order to minimize problems with low flows and high water temperatures.
- Continue to support salmonid enhancement programs run by the NWSFA including outplanting of coho and chinook fry and monitoring the success of imprinting ponds on Spahomin Creek.
- Conduct a Level II IWAP to further assess impacts of logging, identify restoration needs and prevent further impacts

5.4.2 Clapperton Creek

Clapperton Creek enters the north side of the Nicola River immediately downstream of Nicola Lake and provides one of the few cold water sources for the Nicola system (Crowe, pers. comm.). Coho and chinook are presumed to use Clapperton Creek but have not been enumerated (NWSFA 1996, Kosakoski, pers. comm.). However, juvenile salmonids are known to rear at the confluence of Clapperton Creek and the Nicola River (Kosakoski, pers. comm.). Steelhead have been observed in the system and passage of fish is difficult approximately 3 km from confluence during low flows (Crowe, pers. comm.).

Agriculture is the major resource development activity in the Clapperton Creek watershed. At one time, the Nicola Ranch diverted Clapperton Creek into irrigation ditches resulting in very low flows on a regular basis but is now required to maintain minimum flows in Clapperton Creek mainstem for fish (Crowe, pers. comm.). In addition, irrigation ditches have recently been screened to minimized stranding of juvenile and adult salmonids. Other impacts from agricultural development occur when cattle graze along the river banks and result in bank instability, sediment and organic inputs (Lawrence, pers. comm.).

A Level I IWAP was conducted in the Clapperton Creek watershed in 1996 and results identified high hazard indices for surface erosion, riparian habitat and peak flows (MOF 1997). Further assessment through a Level II Channel Assessment is required.

Management Objectives

One of the primary management objectives for Clapperton Creek is to maintain adequate instream flows for fish which will also sustain this system as a valuable cool water source flowing into the mainstem Nicola River. It is also a priority to rebuild coho stocks and restore riparian habitat that has been degraded by agricultural and forestry activities.

Management Strategies

- Improve instream flows by switching the 2 major diversion points for irrigation at the lower end of Clapperton Creek to the Nicola River downstream of the Clapperton/Nicola confluence. The existing alternative intake on Nicola Lake has the potential to negatively affect chinook spawning habitat between the Nicola Lake outlet and Clapperton Creek.
- Limit water diversions on benchland area in lower Clapperton Creek as excessive diversion and ground percolation create 'silt boils' in the Middle Nicola. Elimination of silt boils would improve water quality (suspended sediments) and increase the quality of spawning and rearing habitat in the mainstem Nicola River.
- Assess the potential for additional headwater storage. Increased flows resulting from switching points of diversion or increased storage could help

reduce high temperatures in the Nicola River and improve fisheries productivity (MELP 1983).

- Conduct a Level II IWAP to assess the extent of surface erosion, riparian degradation and changes to peak flows
- Protect and restore riparian corridors through the development of a riparian management plan and the use of set-back fencing.
- Outplant coho fry in the upper reaches.

5.4.3 Guichon Creek

Guichon Creek joins the Nicola River approximately 10 kilometers downstream of the City of Merritt. Guichon Creek is a potentially productive steelhead system and could provide good habitat for chinook and coho salmon and rainbow trout (DFO 1994, Maricle, pers. comm., Crowe, pers. comm.). Although the Nicola Watershed Stewardship and Fisheries Authority (NWSFA) has operated a fish fence on Guichon Creek in the past few years, streamflows have been very low and no chinook or coho have been enumerated (Crowe, pers. comm.). However, coho spawners have been observed and documented in the system (Crowe, pers. comm.).

Agricultural development is extensive in the Guichon Creek watershed. Large agricultural water withdrawals exceed any licensing agreements by at least 10 fold (Crowe, pers. comm.). Much of the irrigation is by open ditches and no screening of 4 major ditches leads to entrainment and stranding of juvenile and adult salmonids (Kosakoski, pers. comm.). The dam located at Mamit Lake is impassable to anadromous salmon but is used by downstream users as a headgate to fill irrigation ditches and results in the lack of control of waterflow regimes (Crowe, pers. comm., Todd, pers. comm.). In addition, some water is diverted from the headwater area into Tunkwa and Leighton Lakes for ranching activities in that valley. Water diversion also occurs in the lower reaches where Stumbles Creek parallels Guichon which increases low flow problems in this system (Crowe, pers. comm.). A fishway at the Mamit Lake Dam was being considered, but was given low priority because of the instream flow issues (Crowe, pers. comm.). Other impacts from agricultural development on the fisheries resource includes increased water temperatures due to low flows, surface runoff from cattle operations and some riparian degradation in the lower river (Crowe, pers. comm., Maricle, pers. comm.).

Forest harvesting has occurred upstream of Mamit Lake and in 1980 a forest fire removed forest cover east of Mamit Lake. A Level I Watershed Assessment indicated moderate to high hazard indices for surface erosion, riparian habitat and peak flows (MOF 1997).

Urban development includes the District of Logan Lake, a subdivision downstream of Mamit Lake, a Native reserve in lower Guichon Creek and rural settlements throughout the watershed. The headwater area of Guichon Creek is a Community Watershed (Province of B.C. 1995). Tunkwa and Leighton Lakes provide trophy rainbow trout fishing areas as well as water storage for irrigation (Todd, pers. comm., Province of B.C. 1995). Linear development is limited to Highway 97C paralleling portions of Guichon Creek and secondary roads in the upper drainage (MSBTC 1994).

Significant impacts to resident fisheries values resulted from the Highland Valley Copper Mine development (Chan, pers. comm.) (Photo 18). Between 1980 and 1984, 4 fish bearing lakes were drained in order to access ore bodies. Two lakes supported wild, self sustaining rainbow trout stocks which were also utilized as traditional food fishing sites by First Nations people. One of these lakes, Lake Quiltanton, supported diverse riparian habitat and provided high value wildlife habitat as well as fish habitat. The remaining 2 lakes were stocked and supported a recreational fishery. The lake system flowed into Witches Brook which was diverted, dammed and dewatered, resulting in losses to both fish and wildlife habitat. Existing impacts from Highland Valley Copper Mine include increased copper and molybdenum levels in downstream waters and in fish (Sigma Engineering Ltd 1991). Additional impacts include bioaccumulation of molybdenum in alfalfa crops utilizing water from Guichon Creek (Chan, pers. comm). The mine has 15 more years of operation and active reclamation of tailings ponds has partially restored degraded fish habitat. The loss of fish and wildlife habitat by the development of Highland Valley Copper Mine resulted from an agreement signed between the provincial government and the mining company (Cominco) in 1975. An active water quality monitoring program is being conducted by the provincial government.

Management Objectives

The primary management objective for Guichon Creek is to provide maintain flows for fish by ensuring adequate instream flow releases from the Mamit Lake Dam and replacing ditch irrigation systems with pipeline systems. Another objective in Guichon Creek is to minimize stranding of juvenile and adult salmonids in irrigation ditches.

PHOTO 18. Highland Valley Copper Mine in upper Guichon and Pukaist drainages (Photo by G. Kosakoski).

Management Strategies

- Manage instream flow releases from the Mamit Lake Dam to maintain adequate flows for fish. Include downstream water withdrawals in the instream flow calculations.
- Manage water flow problems by replacing ditch irrigation systems with pipeline systems.
- Improve instream flows by switching some major diversions from the lower end of Guichon Creek to the mainstem Nicola River. Where available, financial incentives could be used to support the additional pumping costs (MELP 1983).
- Develop a water use plan with the Water Management Branch and local users to improve the efficiency of irrigation systems, review licensing and examine storage opportunities.
- Minimize stranding of juvenile and adult salmonids. There are 4 major irrigation ditches which originate in the Mameet Reserve (2 Native and 2 non-Native) that require screens.

- Educate landowners on fish habitat degradation due to current agricultural practices through stewardship initiatives and promoting best management practices. Support the Guichon Irrigation Project which is part of the Nicola Valley Enhancement and Education Project which has developed irrigation system improvements to eliminate fish entrapment and stranding.
- Conduct Level II IWAP to identify restoration needs for upslope areas and prevent further impacts of logging
- Although riparian habitat is relatively intact, develop a riparian management plan with agencies and stakeholders to ensure protection of riparian habitat.
- BC Environment should continue to monitor water quality (specifically copper and molybdenum levels) within and downstream of the Highland Valley Copper Mine (Millar et al. 1997)

5.4.4 Spius Creek and Maka Creek

Spius Creek flows west into the Nicola River near Canford and is the second largest tributary to the Nicola next to the Coldwater River. Maka Creek, a major tributary to Spius Creek, is a high energy system with high bedload movement. Most of the river is confined except for lower reaches where channel gradient decreases and lateral instability increases (Sigma Engineering 1991). Ice jamming can occur in Spius Creek when thaws and rain on snow events result in flow increases during periods of ice cover. Both summer and winter low flows in Spius Creek have extreme sensitivity ratings (Rood and Hamilton 1995). Spius Creek likely contributes cooler water to the Nicola system during hot summer periods (Sigma Engineering Ltd. 1991).

Spius Creek and Maka Creek support coho and chinook salmon as well as steelhead trout (FHIIP 1992; Millar et al. 1997). In terms of salmonid production, Maka Creek is the most important tributary to Spius Creek and supports chinook salmon (Jarvis and Stewart 1985a). Fish reared at Spius Creek hatchery have been outplanted into the Coldwater River, the Nicola River, Spius Creek, the Bonaparte and Deadman Rivers since 1984 (Millar et al. 1997, FHIIP 1992).

Forestry development is extensive with over 30% of the total watershed area logged in both Spius and Maka Creeks (Sigma Engineering Ltd. 1991). There is an extensive logging road network in the upper Spius Creek which is susceptible to surface erosion and increased sediment inputs to downstream fish habitat (MOF 1993). Logging and road construction are suspected to have altered flow regimes and increased sedimentation in both systems (Kosakoski, pers. comm., Maricle, pers. comm.). A Level I Watershed Assessment conducted in 1996 identified high indices for peak flows, surface erosion and degraded riparian habitat in Maka Creek and Spius Creek (MOF 1997, Millar et al. 1994). Peak flows in Maka Creek have also been affected by a large cutover area that was deforested by a fire in 1962 which has not recovered (Jarvis and Stewart 1985a). Other impacts of forestry development includes habitat degradation at stream crossings, loss of channel complexity and historical logging practices which have degraded sensitive riparian habitat (Miller et al 1994).

Agricultural development is concentrated in the lower reaches of both drainage systems and have altered flow regimes and water quality, degraded riparian habitat, increased sedimentation and increased bank instability (Millar et al. 1994; Lawrence, pers. comm., Todd, pers., comm., Maricle, pers. comm.). Water withdrawals for irrigation also have the potential to decrease naturally low summer streamflows.

Management Objectives

To restore hydrologic stability and to stabilize roads and upslope areas in order to reduce existing sedimentation problems, particularly in Maka Creek. Another objective for Spius Creek and Maka Creek is to restore riparian habitat that has been impacted by logging in both drainages and agricultural development in lower Spius Creek.

Management Strategies

- A Level II IWAP will be conducted by March 1997 to identify restoration needs for upslope areas and prevent further impacts of forestry development on altered flow regimes, increased sedimentation, and degraded riparian areas.
- Use IWAP and FHAP inventory information to identify restoration objectives for upslope areas to enhance fish habitat values and fish use of watershed. Determine opportunities for the development of groundwater fed, off channel rearing habitat.
- Restore riparian corridors and reforest upslope areas in Spius Creek
- Develop a riparian management plan for lower Spius Creek through agricultural areas in cooperation with other resource users. Educate ranching and farming groups on habitat degradation resulting from current agricultural practices and promote stewardship and best management practices
- Support salmonid enhancement initiatives to conserve and rebuild stocks including the coho, chinook and steelhead fry release program operated by the Spius Creek hatchery since 1984

- Inventory fish stocks and conduct a habitat assessment of Maka Creek to determine utilization by salmonids

5.4.5 Skuhun Creek, Shakan Creek, and Nuaitch Creek

Skuhun Creek flows west into the Nicola River approximately 15 kilometers upstream of Spences Bridge. Shakan Creek is a tributary to the Nicola which enters the river from the west across from Skuhun Creek, approximately 15 km upstream from Spences Bridge. Falls located on Shakan Creek, 3 km. upstream of the mouth of the Nicola restrict fish access to further upstream habitat. Nuaitch Creek is a small stream that enters the Nicola River from the west, approximately 4 km downstream of Spius Creek (NWSFA 1996).

All three watersheds are a provincial concern as they are important steelhead producers (Maricle, pers. comm.; NWSFA 1996). Chinook and coho salmon likely utilize the lower reaches of these tributaries as rearing habitat (Lawrence, pers. comm.). Chinook, coho, rainbow trout and bull trout were captured in Nuaitch Creek (NWSFA 1996).

Forestry and agricultural development are the two primary resource development activities in Skuhun Creek. Logging activities in the headwaters of Skuhun Creek have likely affected peak flows (Maricle, pers. comm.). Water runoff from logging roads and improperly maintained culverts have increased natural sediment inputs into Skuhun Creek (Todd, pers. comm.). The 1997 Level I Watershed Assessment results indicate a high hazard rating index for surface erosion and moderate indices for peak flows and riparian impacts (MOF 1997). Agricultural activity occurs in the lower reaches of Skuhun Creek. Water withdrawal for irrigation withdrawals compounds natural summer low flow conditions resulting in decreased habitat availability and high summer water temperatures. Irrigation ditches in the Skuhun Creek watershed are screened to prevent access by fish (Todd, pers. comm.).

Land use in Nuaitch Creek watersheds is relatively small, with some agricultural activity in the lower reaches (Maricle, pers. comm., Todd, pers. comm.). Agricultural development includes cattle grazing and cultivation of alfalfa crops in the lower Nuaitch. Some logging has occurred in the headwaters of Nuaitch Creek, but current impacts of forest harvesting on fisheries values appears to be minimal (Maricle, pers. comm.). However, the Level I Watershed Assessment results indicate a moderately high hazard rating for surface erosion (MOF 1997).

Shakan Creek is in a relatively pristine condition with little logging activity to date (Maricle, pers. comm., Todd, pers. comm). However, the Level I Watershed Assessment results indicate moderate to high ratings for surface erosion and riparian degradation (MOF 1997). Future forestry development is imminent as the area has already been charted to a logging company. There is limited agricultural development in lower Shakan Creek and consists primarily of cattle grazing and crop production. Water withdrawals for irrigation may be contributing to low summer flows (Maricle, pers. comm).

Management Objectives

Management objectives for Skuhun Creek, Nuaitch Creek and Shakan Creek are to maintain adequate instream flows for fish, protect riparian habitat and stabilize upslope terrain to minimize sedimentation problems in Skuhun Creeks.

Management Strategies

- Identify and restrict licensing of instream flows for fisheries values and determine whether a more efficient irrigation system could be employed in Skuhun Creek. Develop a water management plan for Skuhun Creek to ensure maintenance flows for fisheries are sustained and to promote efficient use of water.
- Conduct Level II Interior Watershed Assessment to identify the extent of impacts and identify restoration needs for riparian and upslope areas.
- Inventory fish and fish habitat values in Skuhun Creek to assist in determining fish habitat restoration objectives
- Collect baseline fisheries and habitat data on Shakan Creek to identify and record habitat conditions on an undisturbed system. Identify sensitive habitat features.
- Assess and map habitat and riparian habitat in Nuaitch and Shakan Creek
- Develop stock enhancement plans in co-operation with local First Nations and resource users
- Continue to implement the screening of irrigation ditches to prevent fry access (Crowe, pers. comm., Todd, pers. comm.).

5.5 The Coldwater River

The Coldwater River, originates in the northeastern slopes of the Cascade Mountains and flows into the Nicola River at Merritt. The river has a relatively low to moderate gradient stream (average 0.6% gradient), with channel widths varying from 2 to 25 meters. Major tributaries to the Coldwater River include Midday Creek, Voght Creek and Brook Creek. These tributaries have low to moderate gradients in their lower reaches with upslope areas becoming steep and mountainous (Fig 17).

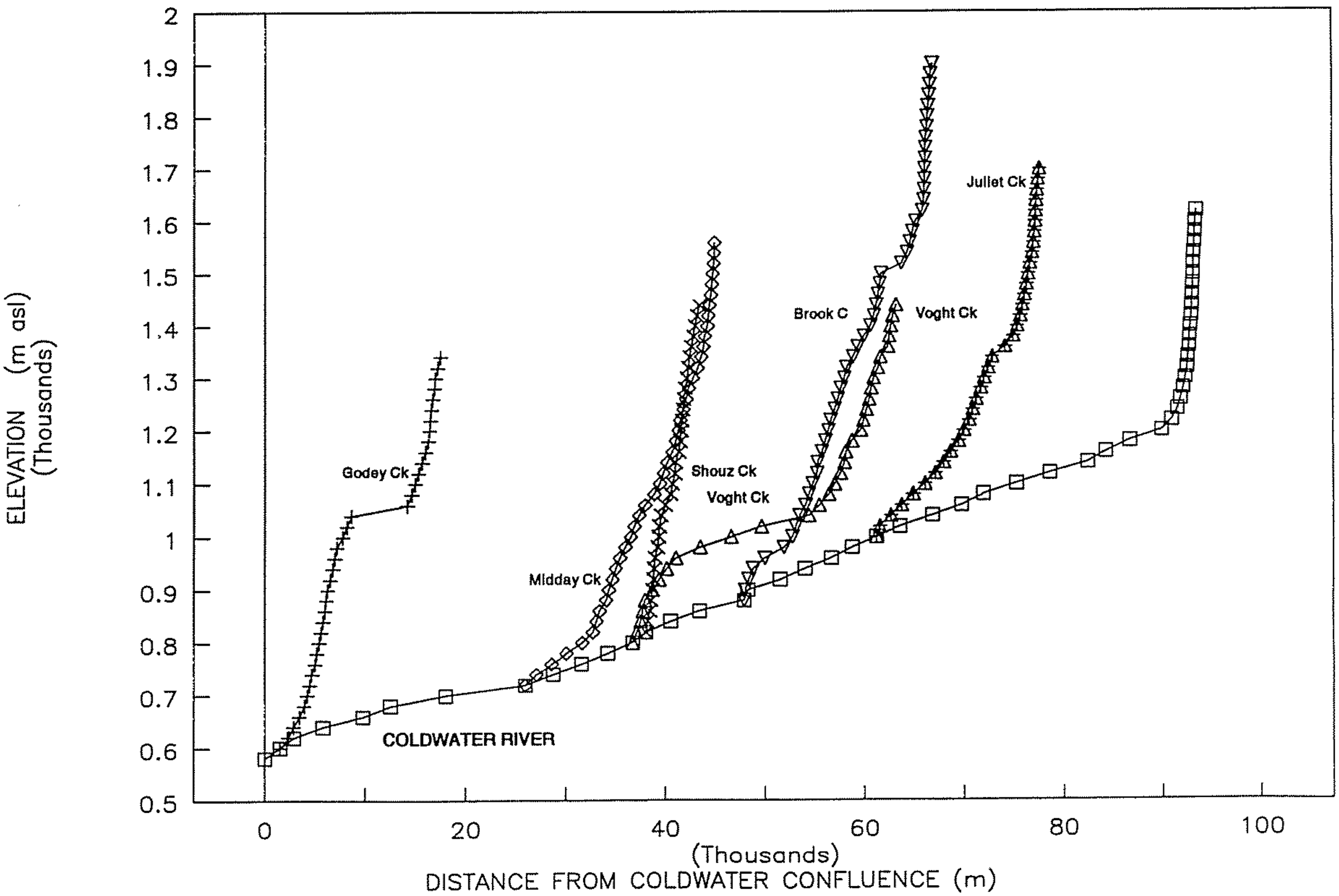

FIGURE 17. Long profile of the Coldwater River and tributaries (Miles 1997).

The Coldwater River is recognized as a very important salmon producing system and supports coho, chinook and steelhead stocks (FHIIP 1992). The Coldwater River supports one of the largest coho runs within the Thompson-Nicola HMA with an average escapement of 2000 coho annually. Coho spawn throughout the middle reaches extending above the confluence with Juliet Creek (Scott and Olmsted 1985). Heaviest coho spawner concentrations occur approximately 2 kilometers upstream of Kingsvale. The Coldwater River is also an important producer of chinook with an average of 1000 spawners annually. Chinook spawning has been observed from the Nicola/Coldwater confluence to above Kingsvale. The Coldwater River is also a primary producer of steelhead with the majority of spawning habitat located downstream of Kingsvale.

Limitations to fish production in the Coldwater watershed include extremely low summer flows where the average 7 day summer low flow equals 9% of the mean annual flow (Rood and Hamilton 1995). Summer low flows reduce the available rearing habitat in the middle and upper Coldwater River (CRES 1996). Ice flows and ice jams resulting from run-off from large rain events during the winter also have the potential to destroy incubating eggs and rearing salmonids, degrade riparian areas and destabilize stream banks and stream bottom sediments (Doyle, 1993, CRES 1996) (Photo 19).

PHOTO 19. Ice flow in the Coldwater River (Photo by G. Kosakoski).

Fish production is also limited by highly consolidated substrate materials in the Coldwater River, resulting from the natural geological formation consisting of glaciofluvial and lacustrine deposits combined with relatively low river gradient. The abundance of fines in the river can reduce spawning and incubation success, depress benthic invertebrate production and reduce over-winter survival of salmonids (CRES 1996). Another limiting factor to salmon production is the lack of instream habitat diversity between Merritt and Kingsvale which consists primarily of shallow riffle-glide habitat (Wightman 1979).

Agricultural and urban development has resulted in local encroachments, channel instability and degradation of fish habitat in the lower and middle river. Uncontrolled cattle access to the river is a major cause of riparian zone damage and bank erosion (Morantz and Haefele, 1996). A study conducted by Miles (1997) determined that 65.5% of riparian vegetation bordering the Coldwater

River downstream of the Coquihalla Highway Bridge was either moderately or severely impacted (Fig 18). Water withdrawal by agricultural activities for irrigation amplifies low flow problems by further reducing the available rearing habitat, increasing water temperatures and increasing the incidence of fry stranding in off channel habitats (Morantz and Haefele 1996, Harding et al 1981). Average water temperatures during 1994 exceeded 21 Celcius in July and August and reached 29 Celcius during the last week of July, well above the lethal tolerance range for Pacific salmonids (Walthers and Nener 1997).

Forestry is another primary resource development activity in the Coldwater River. Over 35% of the Coldwater watershed has been logged (estimated from 1990 Landsat imagery) and harvesting has been concentrated in upper headwater areas and tributary watersheds (Miles 1997, Sigma Engineering 1991). Forestry development in combination with fire history has resulted in local encroachments, slope instability problems and accelerated sediment production (Miles 1997). The 1997 Level I Watershed Assessment results revealed high hazard indices for surface erosion, riparian habitat and peak flows (MOF 1997). The cumulative impacts of forestry activities will be further assessed through a more intensive Level II Channel Assessment which is scheduled for March 1998 (Heller, pers. comm.).

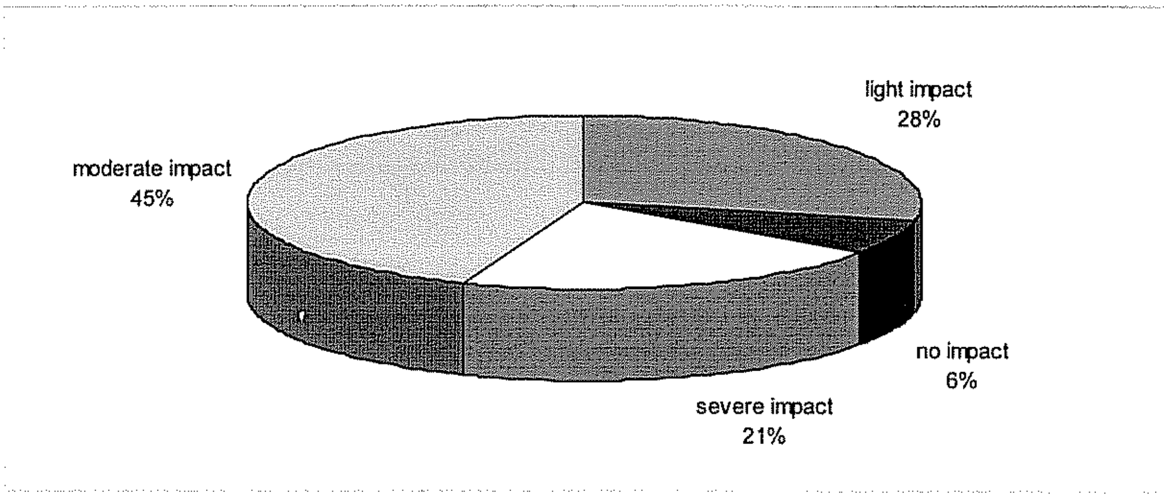

FIGURE 18. Relative condition of riparian vegetation bordering the Coldwater River downstream of the Coquihalla Highway Bridge (Miles 1997).

Linear development within the Coldwater River drainage includes the Kettle Valley Railway, the Coquihalla Highway, Trans Mountain Pipeline, West Coast Energy oil/gas pipeline, the B.C. Telephone Fibre Optic right of way and a network of secondary roads. The Coquihalla Highway was completed in 1986 and closely parallels the upper Coldwater River between the Coquihalla Highway bridge and Kingsvale (Figs 19, 20). The construction of the Coquihalla Highway involved placement of rip rap bank protection and/or alteration of the stream channel by diversion at 15 sites along the river mainstem (Beniston and Lister 1992). River diversions required extensive armoring of the channel banks at each bridge crossing and channelization of the river upstream and downstream of the bridge site (CRES 1996) (Photo 20).

To mitigate anticipated impacts of highway construction on juvenile and adult habitat, the BC Ministry of Transportation and Highways installed habitat improvement structures at 12 mainstem sites and 6 off channel juvenile rearing and overwintering channels (Photo 21) (Beniston and Lister 1992). A total of 99 instream structures consisting of rip rap, single boulder, boulder clusters along banks or mid channel, rock spurs and large woody debris were constructed in the Coldwater River (Miles 1995).

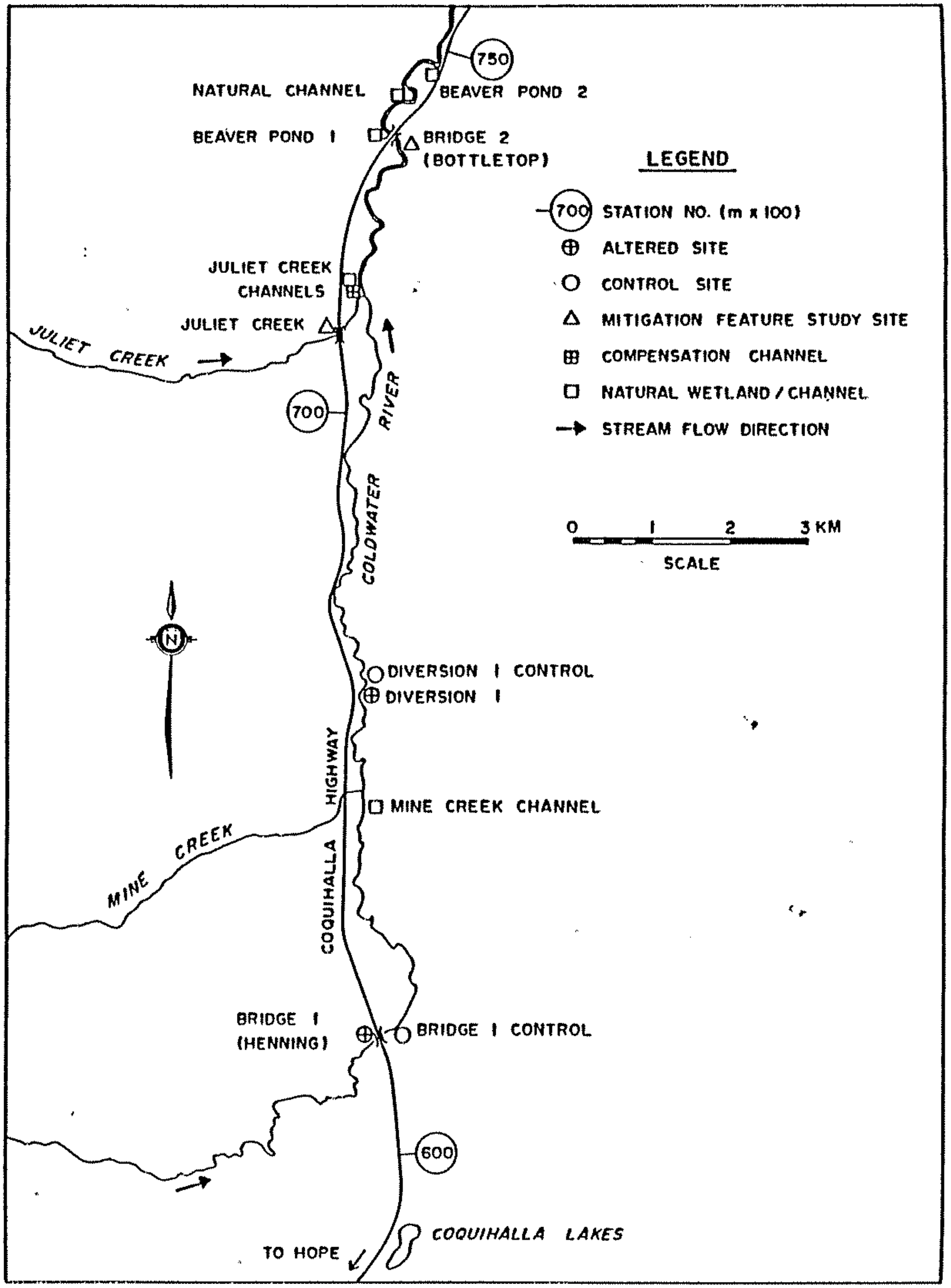

FIGURE 19. Study site locations and altered sites in the upper Coldwater River (Beniston and Lister 1992).

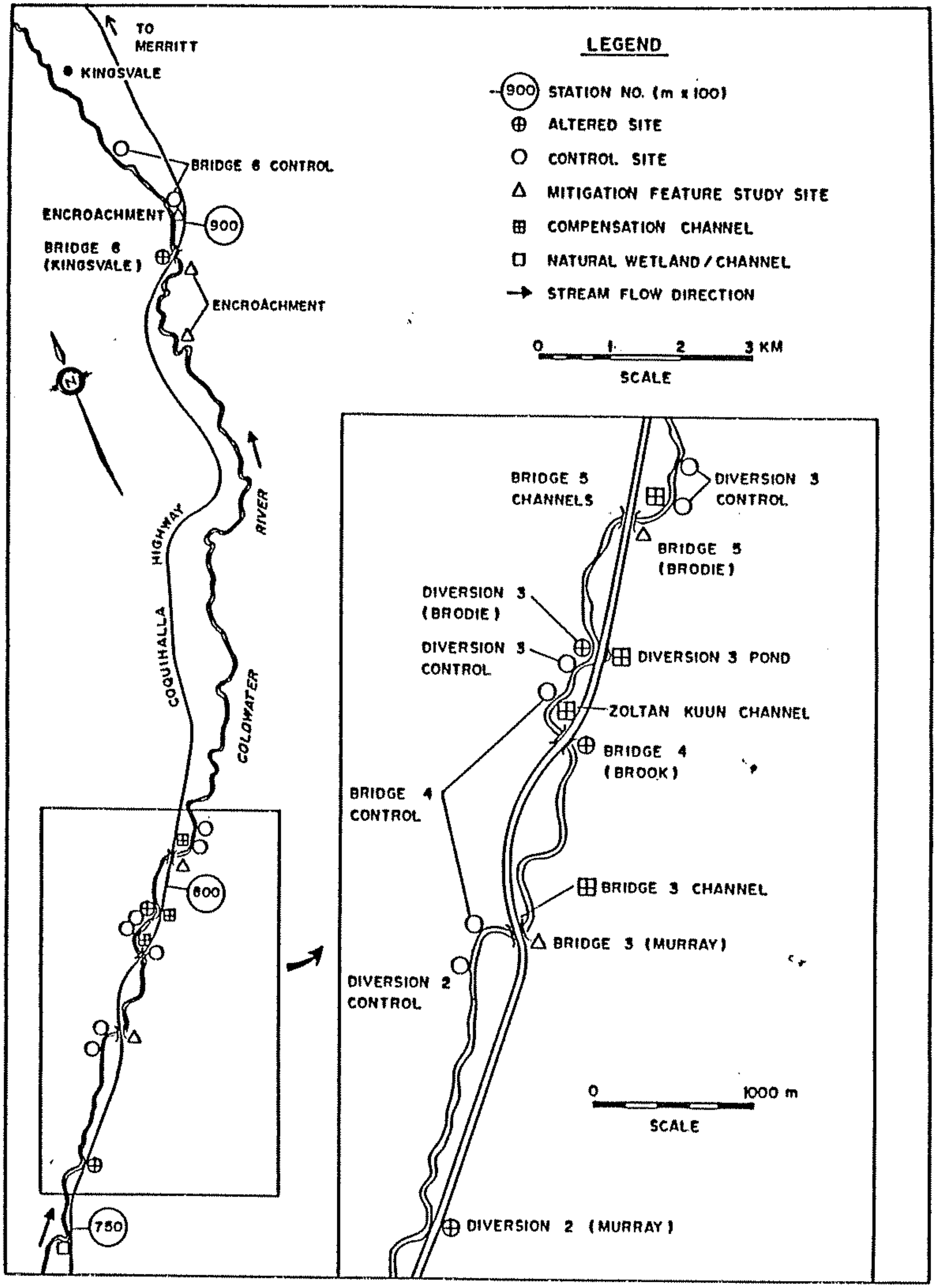

FIGURE 20. Study site locations and altered sites in the lower Coldwater River (Beniston and Lister 1992).

PHOTO 20. Coquihalla Highway bridge crossing showing river diversion and placement of rip rap along channelized stream section (Photo by G. Kosakoski).

PHOTO 21. Zoltan Kuhn compensation ponds off the Coldwater River (Photo by G. Kosakoski).

The rearing capability of the compensatory off channel habitat constructed was adequate to offset the negative impacts of highway construction on mainstem habitat capability but the 1990 flood event reduced the biological performance of these restoration works (Beniston and Lister 1992). The 1990 flood was the largest event in 25 years with a return period of approximately 35 years (Miles 1992). In 1995, another significant flood event occurred with a flood magnitude thought to be slightly smaller than the 1990 event (Miles 1996). The impacts of the 1995 flood event and other peak flow events since 1990 on the biological performance of compensatory works have not been assessed.

An analysis of structure performance by Miles (1992) identified that there has been a progressive net loss in structure performance over time. The physical behavior of instream structures was monitored for 8-14 years with 5% of the structures in the Coldwater River were either washed away, buried or no longed located within the low water channel. In addition, 78% of the structures lost 50% of their material following a 35-49 year return period flood (Miles 1995). Given a high failure rate of 40-60 percent, Miles (1995) suggests that a more successful method for long term river restoration is to re-establish the processes which form fish habitat rather than to artificially create specific habitat features, control further impacts, ensure the channel has space to store introduced sediment and re-establish riparian vegetation within an unconstrained flood plain.

Management Objectives

The main management objective for the Coldwater River drainage is to restore lost habitat values by re-establishing a vegetated riparian corridor, restoring off channel habitat and increasing habitat complexity throughout the system. It is also a priority to increase salmon stocks and continue longterm monitoring and mitigation of impacts resulting from construction of the Coquihalla Highway.

Management Strategies

- Continue to provide input into the Merritt Forest District Interior Watershed Assessment and Implementation Planning process. Review results of 1998 Level II Channel Assessment to assist MOF in addressing the impacts of forestry development on fisheries values.
- Map and inventory riparian areas. Develop and implement a riparian management plan that will assist in re-establishing a vegetated riparian corridor between Kingsvale and Merritt. The width of the corridor should be determined on a site specific basis as a function of present channel stability and how this will change over time (Miles 1995).
- Conduct further post-flood assessments of highways to document the longterm physical and biological performance of mitigation structures.

- Monitor and control sediments from the Coquihalla highway to increase water quality
- Continue to develop restoration/enhancement activities on the Coldwater River including the development and restoration of access to off-channel habitat to increase habitat complexity.
- Investigate the feasibility of streambank stabilization initiatives using bioengineering techniques in a high energy system and monitor performance
- Continue chinook and coho fry stocking programs from Spius hatchery to conserve and rebuild stocks
- Work with local stakeholders groups, the Nicola Valley Stewardship Fisheries Authority, Tolko Industries and MOF to develop a stewardship program to continue restoration/enhancement activities and develop off-channel habitats on the Coldwater River.

5.5.1 Midday Creek, Voght Creek, and Brook Creek

Midday Creek enters the Coldwater approximately 25 kilometers upstream of the Nicola-Coldwater confluence. Manuel and Grismer (1991) observed juvenile chinook in the lower reaches of Midday Creek during the summer/fall and likely utilize this habitat for summer rearing only. Upstream fish passage in Midday Creek is blocked by an irrigation dam and reservoir located 2 kilometers upstream of the Coldwater-Midday confluence (CRES 1996). A second barrier consisting of a Ducks Unlimited water storage dam is located 6 kilometers upstream of the Coldwater-Midday confluence (CRES 1996). Agricultural activity is high in lower Midday Creek and water withdrawals for agricultural purposes contribute to summer low flow problems during August and September (Todd, pers. comm., Wightman 1979). Some forestry development has occurred in Midday Creek and Watershed Assessment results indicate moderate to high hazard indices for peak flows, surface erosion and riparian condition (MOF 1997).

Voght Creek flows into the Coldwater River at Kingsvale approximately 10 km upstream of Midday Creek and. Access by anadromous species is limited to the first 0.85 km of the stream due to an impassable waterfall (Wightman 1979). This stream also has typically low flows by August as a result of irrigation water withdrawals (Wightman 1979). Forestry development is taking place in the upper watershed with some historical logging along the creek in the lower portion of the watershed. The 1997 Watershed Assessment results identify high hazard indices for surface erosion and riparian (MOF 1997). Other impacts of resource development on fish habitat includes the introduction of salts and road gravels into Voght Creek by the Coquihalla Highway.

Brook Creek flows into the Coldwater River approximately 3 km upstream of Kingsvale. Lower Brook Creek has a low gradient with sand/silt substrates up to a series of beaver dams located 3 kilometers upstream of the Brook Creek/Coldwater confluence. The upper reaches of Brook Creek have a steeper gradient with cobble/boulder (CRES 1996). Forestry development is active in the upper portion of the watershed but Brook Creek was not included in the 1997 Watershed Assessment program. There is a low level of concern for forestry development at this time. There is little agricultural development and no large water withdrawals but naturally low summer flows are characteristic to this system. The community of Brookmere is located in lower Brook Creek and utilize the system as a community water supply (Todd pers. comm.).

Current fish and fish habitat inventories for these drainages are limited. Therefore, fish inventories and habitat assessments are required to describe fish communities and to define the factors limiting production.

Management Objectives

The primary management objectives for these tributaries are to assess fish populations and existing habitat conditions and to establish maintenance flow requirements for fish. Also important is to assess and restore impacts to fisheries values resulting from forestry and agricultural development.

Management Strategies

- Develop maintenance flow requirements for fish in Midday Creek and Voght Creeks through a water management committee consisting of stakeholders and agency personnel
- Determine current fish utilization in these tributaries and inventory instream and riparian habitat.
- Conduct Level II IWAP's in Midday and Voght Creeks to identify restoration needs for upslope areas and prevent further logging impacts
- Monitor and control sediments from the Coquihalla highway to control water quality
- Explore the opportunity to stock upstream reaches of tributary systems to enhance salmon stocks (CRES 1996)
- Upgrade culverts located in irrigation ditches in lower Midday Creek to eliminate fish passage problems
- Continue efforts to construct and monitor groundwater channels in Midday Creek to supply important off channel habitat for coho and to a lesser extent, chinook and rainbow/steelhead.

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Appendix A-1. Pink salmon escapements to the lower Thompson River and tributaries, 1957-1991.*

Year	Bonaparte River	Deadman River		Nicola River	Thompson River, lower	TOTAL
1957	814	629		1,560	266,329	269,332
1959	3	n/o		806	86,342	87,151
1961	8	8		216	69,179	69,411
1963	1,706	101		1,196	282,240	285,243
1965	1,750	39		894	230,364	233,047
1967	2,070	n/o		385	448,032	450,487
1969	900	52		n/o	247,896	248,848
1971	614	122		772	255,880	257,388
1973	939	n/o		1,300	281,146	283,385
1975	1,448	2,324		6,853	467,019	477,644
1977	611	185		988	971,157	972,941
1979	1,128	86		1,981	882,207	885,402
1981	1,503	419		910	1,159,922	1,162,754
1983	793	601		4,100	502,339	507,833
1985	73	120		265	192,747	193,205
1987	0	359	a	928	250,270	251,557
1989	608	565		2,122	276,996	280,291
1991	1,914	1,616		n/r	763,916	767,446
Average						
1957-59	409	629		1,183	176,336	178,556
1961-69	1,287	50		673	255,542	257,552
1971-79	948	679		2,379	571,482	575,488
1981-91	815	613		1,665	524,365	527,459

* Data from Fraser River Division database.
Estimates for individual streams not available after 1991.
Abbreviations used: n/o and n/r - no numerical estimate available.

a Counted through a weir operated by the Skeetchestn Indian Band.

Appendix A-2. Chinook escapements to the lower Thompson River and tributaries, 1951-1996*.

			Nicola River System				
Year	Bonaparte River	Deadman River	Coldwater River	Nicola River	Spius Creek	Thompson River, lower	TOTAL
1951	400	25	750	7,500	400	750	9,825
1952	25	400	1,500	7,500	1,500	n/o	10,925
1953	400	750	770	7,100	1,200	750	10,970
1954	400	400	1,500	7,500	750	n/r	10,550
1955	200	750	1,500	7,500	750	n/r	10,700
1956	75	750	n/r	n/r	n/r	n/r	825
1957	25	25	400	3,500	75	1,500	5,525
1958	75	750	200	7,500	25	3,500	12,050
1959	200	750	200	7,500	25	3,500	12,175
1960	n/o	750	200	3,500	25	1,500	5,975
1961	n/o	200	200	400	n/o	750	1,550
1962	75	750	200	3,500	25	1,500	6,050
1963	25	750	200	3,500	25	1,500	6,000
1964	25	200	160	4,500	40	3,500	8,425
1965	n/o	200	200	3,500	75	1,500	5,475
1966	n/o	25	100 a	500	20	750	1,395
1967	25	n/o	200	2,500	25	1,500	4,250
1968	15	20	250	3,600	25	2,000	5,910
1969	20	20	250	4,000	75	2,500	6,865
1970	20	25	750	3,500	750	2,500	7,545
1971	20	25	350	2,000	500	2,500	5,395
1972	10	10	100	1,500	400	2,000	4,020
1973	150	200	1,000	2,800	500	2,000	6,650
1974	25	100	300	2,100	500	2,000	5,025
1975	100	250	1,500	4,500	850	4,000	11,200
1976	30	200 a	500	3,500 a	200	2,000	6,430
1977	n/r	150 a	600	2,700	150	n/r	3,600
1978	50	280 a	750	3,100	80	n/r	4,260
1979	n/r	50	300	2,300	50	n/r	2,700
1980	75	250	710	5,000	200	n/r	6,235
1981	25	25	200	2,500 b	100	n/r	2,850
1982	150	600	800	3,750	200	n/r	5,500
1983	20	162 c	547 c	1,800	102 c	n/r	2,631
1984	800	1,626 d	598 d	3,700	256 d	n/r g	6,980
1985	800	1,066 a	2,061 a	5,800	100	n/r	9,827
1986	993	945 b	2,100 a	6,500	350	n/r	10,888
1987	275	499 b	550	3,500	475	n/r	5,299
1988	525	1,013	220	2,490	150	n/r	4,398
1989	724	571	1,040	3,500	500	n/r	6,335
1990	380	225	350	2,300	100	n/r	3,355
1991	2,100	232	325	2,500	248	n/r	5,405
1992	1,659	241	1,332	4,028	250	n/r	7,510
1993	1,500	1,200	1,500	4,000	900	n/r	9,100
1994	4,283	1,591	275	7,970	150	n/r	14,269
1995	4,157	540	1,050	6,543 e,f	500	n/r	12,790
1996	4,504	1,511	2,358	16,516 e,f	500	n/r	25,389
Average							
1951-60	200	535	780	6,567	528	1,917	10,526
1961-70	29	243	251	2,950	118	1,800	5,391
1971-80	58	152	611	2,950	343	2,417	6,530
1981-90	469	673	847	3,584	233	n/r	5,806
1991-96	3,034	886	1,140	6,926	425	n/r	12,411

cont'd

*Data from Fraser River Division; 1991-1996 data from B. Rosenberger (pers. comm).
Abbreviations used: n/o and n/r - no numerical estimate available.

a. Systematic survey (unpubl.).
b. Fence count, systematic survey (unpubl.).
c. Systematic survey (Stewart and Matthew MS 1985).
d. Systematic survey (Jarvis and Stewart MS 1985a).
e. Mark recapture estimates for Nicola River chinook were approximately 11,000 for 1995 and 11,500 for 1996.
f. Nicola chinook escapement includes upper Nicola River (43 chinook in 1995, 16 chinook in 1996).
g. Over 500 chinook spawners estimated in the Thompson River in 1984 (Beniston 1985).

Appendix A-3. Coho escapements to the lower Thompson River and tributaries, 1951-1996.*

Year	Bonaparte River	Deadman River	Nicola River System: Coldwater River	Nicola River System: Nicola River	Nicola River System: Spius Creek	Thompson River, lower	TOTAL
1951	75	n/r	3,500	n/r	1,500	n/r	5,075
1952	25	3,500	1,500	750	750	n/r	6,525
1953	3,500	200	n/r	n/r	n/r	200	3,900
1954	1,500	750	750	n/r	750	n/r	3,750
1955	n/r	3,500	7,500	3,500	3,500	n/r	18,000
1956	n/r	400	n/r	n/r	n/r	n/r	400
1957	n/r	200	750	750	25	n/r	1,725
1958	n/r	1,500	n/r	750	200	n/r	2,450
1959	n/r	400	n/o	n/o	n/o	n/r	400
1960	n/r	1,500	400	400	25	n/r	2,325
1961	n/r	750	400	200	25	n/r	1,375
1962	n/r	400	75	400	25	n/r	900
1963	n/r	750	75	400	25	n/r	1,250
1964	n/r	75	n/o	50	n/o	n/r	125
1965	25	1,500	750	3,500	75	n/r	5,850
1966	75	400	5,000	2,000	200	200	7,875
1967	n/r	n/o	100	25	25	300	450
1968	n/r	20	1,000	1,000	50	300	2,370
1969	50	20	5,000	2,500	75	200	7,845
1970	25	50	750	1,000	1,500	250	3,575
1971	20	50	500	750	800	200	2,320
1972	15	25	250	200	400	150	1,040
1973	10	100	1,000	300	400	200	2,010
1974	10	50	1,000	500	500	250	2,310
1975	10	25	200	250	250	150	885
1976	20	35	200	400	300	200	1,155
1977	n/r	50	300	400	200	n/r	950
1978	n/r	100	1,500	350	400	n/r	2,350
1979	n/r	30	150	150	25	n/r	355
1980	n/r	n/o	75	n/o	n/o	n/r	75
1981	n/r	20	70	285	n/o	n/r	375
1982	n/r	n/r	300	300	25	n/r	625
1983	n/r	n/r	200	n/o	n/o	n/o	200
1984	n/r	1,688 a	n/r	n/r	n/r	n/r	1,688
1985	n/r	611 b	n/r	n/r	n/r	n/r	611
1986	n/r	390 b	1,477 b	n/r	300	n/r	2,167
1987	25	2,176 b	1,600 b	n/r	375	n/r	4,176
1988	n/o	1,722 b	2,000	n/o	100	n/r	3,822
1989	n/r	231 b	2,500	n/o	527	n/r	3,258
1990	100	273 b	3,000	n/o	1,000	n/r	4,373
1991	31	1,561 b	1,500	n/o	663	n/r	3,755
1992	10	1,225 b	3,000	n/r	600	n/r	4,835
1993	n/r	n/r	4,000	n/r	860	n/r	4,860
1994	n/r	747 b	n/r	n/r	n/r	n/r	- d
1995	n/r	573 b	n/r	49 c	n/r	n/r	- d
1996	n/r	353 b	n/r	4 c	n/r	n/r	- d
Average							
1951-60	1,275	1,328	2,400	1,230	964	200	7,397
1961-70	44	441	1,461	1,108	222	250	3,525
1971-80	14	52	518	367	364	192	1,506
1981-90	63	889	1,393	293	388	n/r	3,025
1991-96	- e	892	- e	- e	- e	n/r	- e

cont'd

Appendix A-3 Footnotes.

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*Data from Fraser River Division; 1991-1996 data from B. Rosenberger (pers. comm).

Escapements include wild and enhanced river spawners only (i.e., hatchery broodstock and hatchery surplus excluded).

Abbreviations used: n/o and n/r - no numerical estimate available.

a. Systematic survey (Jarvis and Stewart MS 1985b).
b. Based on fence counts (unpubl.).
c. coho escapements to upper Nicola River (Rosenberger pers. comm).
d. No totals given since most streams not surveyed.
e. The 1991-1996 averages not provided since most streams not monitored in recent years.

Appendix B. Hydrology of salmon streams in the Thompson Nicola HMA (Rood and Hamilton 1995).

Stream Name	WSC Gauge No.	Basin Area (mouth) (km^2)	Logged Area Recent (km^2)	Logged Area Older (km^2)	Improved Farmland (1990) (km^2)	Total Water Licenses Domestic (g/day)	Total Water Licenses Irrigation (ac-ft)	Total Water Licenses Waterworks (g/day)	Total Water Licenses Industrial (g/day)	Total Water Licenses Conservation (cfs)	Licensed Demand (L/s) Aug	Licensed Demand (L/s) Sept	Licensed Demand (L/s) Feb	Naturalized Flows (m^3/s) Mean Annual	Naturalized Flows Mean Flood	Mean Monthly Aug	Mean Monthly Sept	Mean 7-day Flow Summer	Mean 7-day Flow Winter
Thompson R	08LF051	55665	2313.4	2909.3	150.4									759	2650	981.00	444.00		
Nicola R	08LG006	7227	727.1	1180.9	60.7	222,400	72,669	2,342,203	12,898,501	408.6	9317	5916	814	22.7	180	16.67	11.77	10.25	5.06
Spius Ck	08LG008	780	138.9	95.2	1.4	6,500	1,664	0	0	0	195	117	0	9.33	80.9	1.85	1.41	0.98	1.56
Maka Ck		217	54.2	10.8	0	-					0	0	0	2.6	22.5	0.51	0.39	0.24	0.43
Coldwater R	08LG010	915	45.7	274.5	9.5	40,350	5,804	2,000,703	3,000	3	787	515	108	7.42	74.3	2.02	1.53	1.16	1.37
Spahomin Ck	08LG060	237	11.9	11.9	4.4	500	4,405	0	20,000	237	517	310	1	0.62	3.77	1.03	0.40	0.38	0.09
Bonaparte R	08LF002	5390	1078.1	1078.1	27.4	108,900	30,238	2,696,262	4,157,290	0	3905	2489	366	4.51	20.8	8.45	4.91	4.00	1.00
Deadman R	08LF027	1497	149.7	299.5	6.9	32,001	11,436	0	5,000	11.1	1340	805	2	2.85	24	2.98	2.16	1.48	0.49

1. Gauge numbers indicate that flow characteristics were calculated from WSC gauging records.
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 water extractions.

Appendix C. Sensitivity Indices -- Thompson Nicola HMA (Rood and Hamilton 1995).

Stream Name	Status	SUMMER WATER USE Index 1 Aug Use/ Sum Q7L2	Index 2 Sept Use/ Sum Q7L2	Index 3 Aug Use/ mean Aug	Index 4 Sept Use/ mean Sept	LOW FLOWS Index 5 Sum Q7L2/ QAA	Index 6 Win Q7L2/ QAA	PEAK FLOW Index 7 Q2/ QAA	LOGGING Index 8 Recent/ Basin	Index 9 Total/ Basin
Thompson R								3	4%	9%
Nicola R	FR	91%	58%	56%	50%	19%	19%	8	10%	26%
Spius Ck	FR	20%	12%	11%	8%	9%	17%	9	18%	30%
Maka Ck		0%	0%	0%	0%	9%	17%	9	25%	30%
Coldwater R		68%	45%	39%	34%	9%	17%	10	5%	35%
Spahomin Ck		135%	81%	50%	78%	11%	15%	6	5%	10%
Bonaparte R	FR	98%	62%	46%	51%	33%	14%	5	20%	40%
Deadman R	FR	91%	55%	45%	37%	23%	17%	8	10%	30%

- 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, RNW, refused, no water.
- 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 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.
- Indices expressed as percentages except 7, which is a direct ratio.

Most Sensitive Streams in the Thompson Nicola HMA (Rood and Hamilton 1995)

Water Demand [1]	*Summer Low Flows*	*Winter Low Flows*	*Recent Harvesting*
1 to 4	*5*	*6*	*8*
Nicola River	Spius Creek	Spahomin Creek	Maka Creek
Spahomin Creek	Maka Creek	Bonaparte Creek	Bonaparte River
Bonaparte Creek	Coldwater River		
Deadman River			
Coldwater River			

1. All streams with demands over 60% of summer 7 day low flows

Appendix D. Forest Inventory of Thompson - Nicola HMA Salmon Streams (Sigma Engineering Ltd 1991)

Gazetted Name	Watershed Code	Total Area (km2)	Non-forested (km2) (% total)	Potentially Forested (km2) (% total)	Recently Logged (km2) (% total)	Older Logging (km2) (% total)	Total Logged (km2) (% total)	Forest Remaining (km2) (% total)
Thompson R	02	17632.50	3718.70	13913.80	2313.40	2909.30	5222.70	8691.10
			21.09	78.91	13.12	16.50	29.62	49.29
Watershed exterior to tributaries of interest		3517.60	1055.30	2462.30	351.80	351.80	703.60	1758.70
			30.00	70.00	10.00	10.00	20.00	50.00
Nicola R	02-2500	7227.20	1741.00	5486.20	727.10	1180.90	1908.00	3578.20
			24.09	75.91	10.06	16.34	26.40	49.51
Watershed exterior to tributaries of interest		5294.70	1588.40	3706.30	529.05	794.20	1323.25	2382.60
			30.00	70.00	10.00	15.00	25.00	45.00
Spius C	02-2500-250	780.20	34.60	745.60	138.90	95.20	234.10	511.50
			4.44	95.56	17.80	12.20	30.00	65.56
Watershed exterior to tributary of interest		563.40	28.20	535.20	84.50	84.50	169.00	366.20
			5.00	95.00	15.00	15.00	30.00	65.00
Maka C	02-2500-250-300	216.80	6.50	210.30	54.20	10.80	65.00	145.30
			3.00	97.00	25.00	5.00	30.00	67.00
Coldwater R	02-2500-360	914.90	45.80	869.10	45.70	274.50	320.20	548.90
			5.00	95.00	5.00	30.00	35.00	60.00
Spahomin C	02-2500-670	237.40	83.10	154.30	11.90	11.90	23.80	130.50
			35.00	65.00	5.00	5.00	10.00	55.00
Bonaparte R	02-5000	5390.40	808.60	4581.80	1078.10	1078.10	2156.20	2425.60
			15.00	85.00	20.00	20.00	40.00	45.00
Deadman R	02-7000	1497.30	104.80	1392.50	149.70	299.50	449.20	943.30
			7.00	93.00	10.00	20.00	30.00	63.00

Appendix E. Agricultural Inventory of Thompson Nicola HMA Salmon Streams (Sigma Engineering Ltd 1991).

Gazetted Name	Watershed Code	Total Area (km2)	1976 Improved Farmland (km2) (% total)	est.1990 Improved Farmland (km2) (% total)	max.2010 Improved Farmland (km2) (% total)	est.1990 Animal Units (AUs) (AUs/km2)	max.2010 Animal Units (AUs) (AUs/km2)	Census Code (CCSD)	1976-86 % Change, Farmland (%)	AUs/km2, 1986 Farmland (AUs/km2)
Thompson R	02	17632.5	162.41	150.42	202.76	31272	41124	na	na	na
			0.92%	0.85%	1.15%	1.77	2.33			
Nicola R	02-2500	7227.2	57.49	60.71	73.87	17424	21201	TNC	4.0%	287
Nicola L, Douglas L, Barton L			0.80%	0.84%	1.02%	2.41	2.93			
Spius C	02-2500-250	780.2	1.32	1.39	1.45	400	417	TNC	4.0%	287
			0.17%	0.18%	0.19%	0.51	0.53			
Maka C	02-2500-250-300	216.8	0	0.00	0.00	0	0	TNC	4.0%	287
Murray L			0.00%	0.00%	0.00%	0.00	0.00			
Coldwater R	02-2500-360	914.9	8.97	9.47	11.66	2719	3347	TNC	4.0%	287
			0.98%	1.04%	1.27%	2.97	3.66			
Spahomin C	02-2500-670	237.4	4.19	4.42	5.45	1270	1563	TNC	4.0%	287
			1.76%	1.86%	2.29%	5.35	6.59			
Bonaparte R	02-5000	5390.4	31.69	27.39	37.12	4190	5679	TND	-9.7%	153
Bonaparte L, Young L			0.59%	0.51%	0.69%	0.78	1.05			
Deadman R	02-7000	1497.3	9.08	6.88	11.30	1177	1932	TNB	-17.3%	171
Mowich L, Snohoosh L, Skookum L, Deadman L, Allie L			0.61%	0.46%	0.75%	0.79	1.29			