

# **Strategic Fisheries Overview for the Bridge/Seton Habitat Management Area**

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**STRATEGIC FISHERIES OVERVIEW**

**FOR THE**

**BRIDGE/SETON HABITAT MANAGEMENT AREA**

***FINAL REPORT***

by Violet Komori<sup>1</sup>

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## EXECUTIVE SUMMARY

This strategic fisheries report provides an overview of the fisheries resources, biophysical features and land use issues that have affected or have the potential to affect fish production within the Bridge/Seton Habitat Management Area (HMA). Based on this background information, fisheries habitat management priorities and recommendations have been developed to guide future resource development and the management of fisheries resources. An accompanying document consisting of watershed summary profiles is being concurrently developed and provides a summary of this document in both hardcopy and database format.

The Bridge/Seton Habitat Management Area (HMA) is located on the west side of the Fraser River at Lillooet and encompasses 6500 square kilometers. Major salmon bearing watersheds include the lower Bridge River, Seton River, Yalakom River, Gates River, Portage River, and Cayoosh Creek. The Bridge/Seton HMA supports sockeye (*Oncorhynchus nerka*), pink (*Oncorhynchus gorbuscha*), chinook (*Oncorhynchus tshawytscha*) and coho (*Oncorhynchus kisutch*) salmon. Pink salmon are the most abundant species with a recent (1981-1992) average escapement of approximately 454,000 adults. Average sockeye escapement for the same period equals 35,000 and coho and chinook escapements have averaged 1240 and 760 respectively. In general, pink, sockeye and chinook escapements show an increasing trend when 1981-1992 averages are compared to historical averages (1969-1980). Conversely, coho escapement exhibits a declining trend.

Other fish species within the study area include steelhead/rainbow trout (*Oncorhynchus mykiss*), kokanee (*Oncorhynchus nerka*), bull trout (*Salvelinus confluentus*), dolly varden char (*Salvelinus malma*) and rocky mountain whitefish (*Prosopium williamsoni*). Trout, char and other fish species are widely distributed throughout the Bridge/Seton HMA but information on abundance and distribution is limited to steelhead escapement estimates in the Bridge River. Approximately 50-200 steelhead spawn in the Bridge River annually and Ministry of Environment, Lands and Parks (MELP), Kamloops Region has identified a conservation concern for this stock.

Hydroelectric power development on the Bridge and Seton Rivers and Cayoosh Creek has degraded salmon habitat through elimination of access to historical spawning and rearing areas, dewatering and alteration of flow regimes and reduction in natural rates of gravel recruitment. Periodic releases of high flows have increased suspended sediment loads, eroded spawning gravels and degraded riparian vegetation. Furthermore, hydroelectric development facilities are responsible for increasing natural mortality rates of returning adults and outmigrating juveniles.

The Bridge River hydro development is the third largest of BC Hydro's generating facilities and began in 1934 with an initial diversion of 30 cubic feet per second (cfs) overland through a tunnel to a power generating facility at Shalath located on the north shore of Seton Lake. Between 1946-1948, the Mission Dam was constructed at the outlet of Carpenter Lake,

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eliminating all access for anadromous fish species to the upper Bridge River watershed. In 1948, a second dam and power facility was constructed by BC Electric further upstream in the Bridge system at the outlet of Downton Lake and by 1954 diverted flows from the Bridge River to Seton Lake were increased to 2200 cfs. The water licenses carried no provision for the release of water for fisheries or any other purpose. In 1955, hydroelectric development in the Seton watershed included the construction of a diversion dam, powerhouse and tunnel in Cayoosh Creek and the completion of the Seton Dam by 1956. In 1960, the Mission Dam was replaced by the Terzaghi Dam and by 1967, diverted flows from the Bridge River to Seton Lake were increased to a final maximum of 5360 cfs. From Seton Lake, the majority of water is bypassed through a canal to the Seton generating station on the west bank of the Fraser River.

Placer mining and hard rock mining development is also responsible for the destruction of productive creek beds and riparian areas but mining activity has been significantly reduced since the 1970's within the Bridge River and Seton River watersheds. However, the potential for increased mining activity still exists and Alvino Mines and Resources Limited is currently in the process of re-opening the Bralorne/Pioneer gold mine.

Although percent logging of major watersheds is relatively low, known impacts of forest harvesting on fisheries values have occurred on a site specific manner rather than altering watershed based processes such as natural hydrologic regime. However, several drainages require further assessment to determine the extent of forestry related impacts on fisheries values. Linear development and agriculture have also had some impacts on fisheries values in the Bridge/Seton Habitat Management area.

Management priorities for the hydroelectric development in the Bridge/Seton HMA include the establishment of minimum flow releases through the Terzaghi Dam into the lower Bridge River. DFO has recommended a mean monthly flow release schedule for the Bridge River and suggests the construction of a suitable multi-level intake structure to release water of suitable quality and quantity. Another management priority in the Bridge River is to reduce the frequency and magnitude of spills from the Terzaghi Dam by increasing the buffer in the reservoir to account for the imprecision of hydrologic forecasting of run-off events. Primary management priorities in the Seton River are to restore a more natural hydrograph and to reduce the mortality of adults and juveniles during passage through the powerhouse and by impingement on the trashracks at the power plant. Other management priorities for the Seton River is to minimize delays of adult sockeye and pink at the Seton powerhouse tailrace and to minimize stranding of juvenile salmonids during downramping flows. Salmonid management and production can also be improved by facilitating access for large chinook through the fishway and replacing the fish counter at the Seton Dam.

In the Bridge/Seton HMA, there is concern that the increasing rate of forestry development may have negative impacts on the fisheries resource. Management recommendations include the assessment of road failures, slope failures, channel instability, increase sedimentation and

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degraded riparian areas through the application of the Watershed Assessment Procedure. Several sub-basins within the Gates River, Portage River, Cayoosh Creek , Yalakom River and the lower Bridge River have been prioritized for immediate assessment.

Another management priority in the Bridge/Seton HMA is the assessment of encroachment by urban, agriculture and mining development on salmon spawning and rearing habitat in the Gates River mainstem.

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## 1.0 INTRODUCTION

This strategic fisheries report provides an overview of the fisheries resources, biophysical features and land use issues that have affected or have the potential to affect fish production within the Bridge/Seton Habitat Management Area (HMA). Based on this background information, fisheries habitat management priorities and recommendations have been developed to guide future resource development and the management of fisheries resources in the Bridge and Seton watersheds. An accompanying document consisting of watershed summary profiles is being concurrently developed and provides a summary of the information within this document in both hard copy and database format.

The Bridge/Seton Habitat Management Area (HMA) is located on the west side of the Fraser River at Lillooet and encompasses 6500 square kilometers (Rood and Hamilton 1995). Major salmon bearing watersheds include the lower Bridge River, Seton River, Yalakom River, Gates River, Portage River, and Cayoosh Creek. (Fig 1). The Bridge/Seton HMA supports sockeye (*Oncorhynchus nerka*), pink (*Oncorhynchus gorbuscha*), chinook (*Oncorhynchus tshawytscha*) and coho (*Oncorhynchus kisutch*) salmon. Other fish species within the study area include steelhead/rainbow trout (*Oncorhynchus mykiss*), kokanee (*Oncorhynchus nerka*), bull trout (*Salvelinus confluentus*), dolly varden char (*Salvelinus malma*) and rocky mountain whitefish (*Prosopium williamsoni*).

Historical resource development activities have significantly impacted fisheries values within the study area. Hydroelectric power development and placer mining have degraded salmon habitat through the loss of adequate instream flows, loss of access to historical spawning and rearing areas, degradation of riparian areas, a reduction in natural rates of gravel recruitment as well as increased suspended sediment loads. Furthermore, hydroelectric development structures continue to increase natural mortality rates of returning adults and outmigrating juveniles. The rate of forestry development is increasing within the Bridge/Seton HMA but has had smaller impacts on the salmon resource relative to the existing impacts of hydroelectric and mining development.

Although some impacts of resource development activities on the fisheries resource are being addressed, several outstanding issues such as minimum flow releases from hydroelectric facilities need to be resolved in order to ensure the restoration and protection of fish and fish habitat. Therefore, the objective of this report is to document existing fisheries values as well as the extent of resource development activities in order to have sufficient information to develop effective management strategies that can minimize further impacts of resource development on the fisheries resource.

This report is based on the collection and summary of existing information from fisheries and land use management agencies. Information has been obtained from published literature as

well as from direct input of habitat biologists and technicians from the Department of Fisheries and Oceans (DFO) and the Ministry of Environment, Lands and Parks (MELP). Most of the physiographic and hydrologic information originates from Rood and Hamilton (1995).

## 2.0 FISHERIES RESOURCES

This chapter provides an overview of the fishery resources within the Bridge/Seton Habitat Management Area (HMA). Information on life history strategies, escapement trends, habitat use and future enhancement opportunities are summarized for sockeye, chinook, coho and pink salmon. A limited amount of information on trout and char species is also included. The purpose of the overview is provide fundamental information about fish stocks and their habitat use within the Bridge/Seton HMA. The key to preserving and rebuilding salmon stocks is to protect spawning populations and their freshwater habitat.

Pink are the most abundant salmon species in the study area with average annual escapements of over 450,000 and a maximum historical escapement of over 1.6 million (Table 1). Bridge/Seton pink stocks represented approximately 2.6% of the Fraser River pink escapement of 17 million fish between 1981-1991 (DFO 1995b). Sockeye are the second most abundant species with average escapements of 35,000 with a maximum historical escapement of 173,734. Coho and chinook stocks are also present in the Bridge/Seton HMA with an average escapement of 1250 for coho and 762 for chinook. Maximum historical escapements for coho and chinook equal 4,184 and 2,381 spawners respectively.

TABLE 1. 1981-1992 Average and (*historical maximum*) escapement by species (DFO 1994).

| System  | Sockeye                | Chinook           | Coho                 | Pink                           |
|---|------------------------|-------------------|----------------------|--------------------------------|
| Bridge River                                    | 466 (2500)             | 529 (956)         | 468 (1000)           | 48,013 (184,327)               |
| Yalakom River                                   | 164 (1200)             | 23 (450)          | 6 (250)              | 28 (2,000)                     |
| Seton River                                     | 44 (445)               | 73 (200)          | 79 (394)             | 383,879<br>(1,321,458)         |
| Portage River                                   | 8,792 (31,844)         | 137 (750)         | 135 (500)            | 10,427 (51,842)                |
| Gates River                                     | 16,054 (50,357)        | N/A (25)          | 523 (2000)           | 60 (1,277)                     |
| Cayoosh Creek<br>(included with<br>Seton River) |                        | N/A (N/A)         | 29 (40)              | 11,581 (50,638)                |
| <b>Total</b>                                    | <b>25,520 (86,346)</b> | <b>762 (2381)</b> | <b>1,240 (4,184)</b> | <b>453,988<br/>(1,611,542)</b> |

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## 2.1 Sockeye

Within the Bridge/Seton HMA, the majority of sockeye spawners return to the Gates River (62.9%) and Portage River (34.5%) systems. Relatively small runs of sockeye also return to the Seton River, Bridge River and Yalakom River (Table 2).

TABLE 2. Historical and Recent Escapement Trends for Sockeye (DFO 1994).

| System                | Historical Escapement<br>(1969-1980) | Recent Escapement<br>(1981-1992) | % of total<br>for HMA | Trend      |
|-----------------------|--------------------------------------|----------------------------------|-----------------------|------------|
| Bridge R.             | 70                                   | 466                              | 1.8                   | Increasing |
| Yalakom R.            | N/A                                  | 164                              | 0.6                   | Unknown    |
| Seton R/<br>Cayoosh C | N/A                                  | 44                               | 0.2                   | Unknown    |
| Portage R.            | 4286                                 | 8792                             | 34.5                  | Increasing |
| Gates R.              | 6127                                 | 16,054                           | 62.9                  | Increasing |
| <b>Total</b>          | 10,528                               | 25,520                           | 100                   | Increasing |

### 2.2.1 Life history

Fraser River sockeye stocks spawn from summer to autumn, mainly in tributaries to lakes, lake outlets or submerged lake beaches (DFO 1995a). Fry emerge from the gravel from mid-April to mid-May and immediately migrate to a lake where they spend the next year feeding primarily on zooplankton. The freshwater residency of the majority of Fraser River sockeye stocks is generally one year but occasionally two. During their second spring, most sockeye juveniles migrate to sea as smolts until they return to spawn at age 4 (DFO 1995a).

Most Fraser River sockeye stocks exhibit a four-year pattern of production characterized by one dominant year, followed by a sub-dominant year and then two years of relatively low returns (DFO 1995a). The dominant cycle year of the Gates River sockeye is the 1992 cycle whereas the dominant cycle line is not well defined in the Portage stocks. Both the 1992 and 1994 cycle lines show strong returns (DFO 1995a). All brood years in the Gates and Portage River stocks have been increasing in recent years (DFO 1995a).

The Gates Creek stock is an early summer run, migrating through the lower Fraser River from mid-July to mid-August and into Gates Creek from July 20 to Sept 5 (Fretwell 1979). Sockeye spawning peaks in Gates River during late August (DFO 1995a, FHIP 1988). Portage River sockeye are a late run stock and migrate through the lower Fraser in October, migrate into Portage River from September 2 to November 21 (Fretwell 1979) and peak spawning occurs during mid-November (DFO 1995a, FHIP 1992).

The Bridge River stock has similar run timing to Portage sockeye and spawning takes place from late August through early September (FHIIP 1992). It is suspected that Bridge River sockeye may be strays from other Fraser River stocks such as the Portage River or Chilko River, as the Bridge River system lacks accessible lake rearing habitat normally required by juvenile sockeye (Hirst 1991). However, Bridge River sockeye fry are known to rear in the Bridge River mainstem above the Yalakom confluence (Sheng 1996).

In general, fry emerge from early April to late May within the Bridge/Seton HMA. Juvenile studies in 1986 determined that emergence peaked during mid-April and was complete by mid-May in the Bridge River and Portage Creek (Matthew and Stewart 1987). After emergence, most Gates and Portage sockeye rear in Seton Lake for 1 year prior to migrating seaward as smolts (Groves and Higgins 1995, Geen and Andrew 1961). Gates Creek sockeye juveniles also utilize rearing habitat in Anderson Lake (Geen and Andrew 1961).

Most sockeye emigrate to sea as smolts in their second year between April and June. In Portage Creek, smolts were captured during their seaward migration from early April to late May, with peak smolt outmigration during late April (Matthew and Stewart 1987). Studies in the Seton River indicate that juvenile outmigration occurs between April and June and peaks during late April/early May (Fretwell and Hamilton 1983a).

### **2.2.2 Escapement and escapement trends**

Sockeye stocks in the Bridge/Seton HMA generally show an increasing trend in escapement (Fig 2). Between 1981-1992, total sockeye escapement averaged 35,238 fish whereas historical escapement between 1969-1980 equaled only 10,528 adults (Table 2). More specifically, the Bridge River, Portage River and Gates River all show an increasing escapement trend. In general, Portage River and Gates River sockeye stocks have been increasing since the construction of the Gates Creek spawning channel by the International Pacific Salmon Fisheries Commission (IPSFC) in 1968. The absence of historical data for the Yalakom River and Seton River/Cayoosh Creek makes it difficult to determine the escapement trend for these stocks. More detailed escapement information is provided in Appendix A.

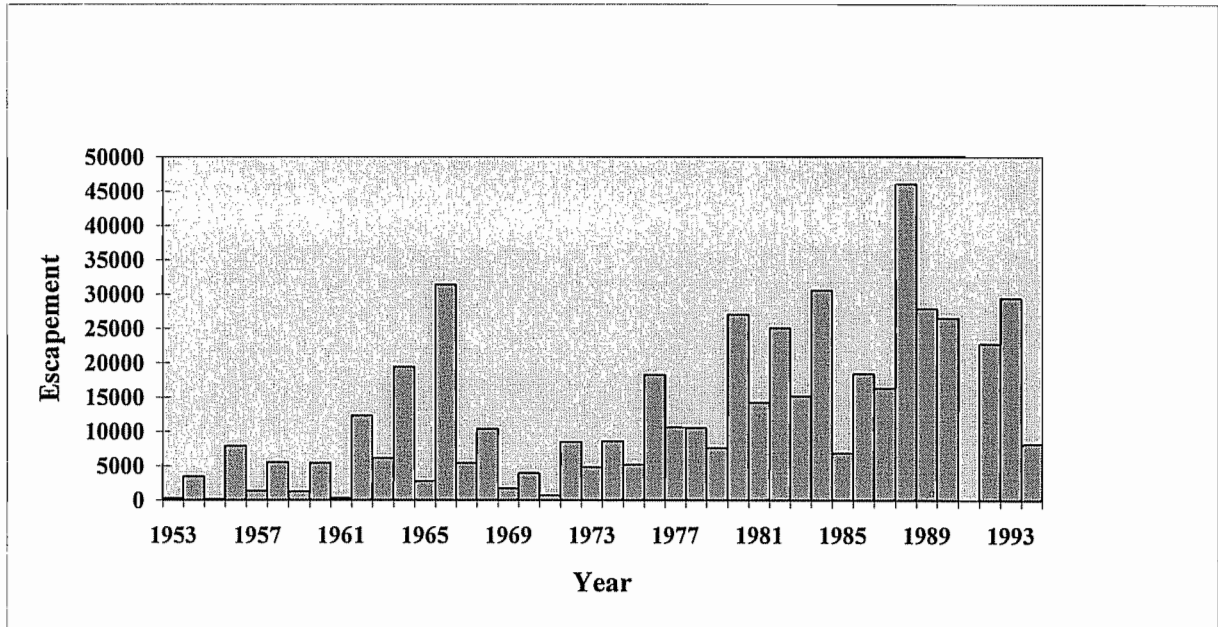


FIGURE 2. Total escapement estimates for Bridge/Seton sockeye stocks between 1953-1994 (Appendix A).

Historical maximum sockeye escapements exceed 50,000 in Gates River and are greater than 30,000 in Portage Creek. Historical maximum escapements are greater than 1,000 for the Bridge River, Seton River and Yalakom River (Fig 3). During 1981-1992, the average Portage returns equaled 8,792 with a maximum of 31,844 and Gates sockeye averaged 16,054 with a maximum of 50,357 (DFO 1994)(Table 1).

Escapement numbers are generally related to habitat capability and provide a relative index of stock strength, although other factors such as ocean survival and interception from commercial, sport and Native fisheries can affect the number of fish returning to spawn. The reliability of escapement data is highly variable, depending on the species, enumeration method used and variations in stream conditions. For example, the glacial waters of the Yalakom River make it difficult to visually estimate escapement values whereas the counting fence in the Gates River yields reliable escapement estimates (Lawrence and Cody 1996).

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### **2.2.3 Spawning and rearing habitat**

Within the Seton watershed, sockeye spawn primarily in Gates River and Portage Creek. The main spawning area for sockeye in the Gates River is the spawning channel located within 5 kilometers upstream of Anderson Lake. In the Bridge River, sockeye spawn in the mainstem from Camoo Creek to approximately 10 kilometers upstream of the Yalakom confluence (FHIIP 1992).

Seton Lake provides primary rearing habitat for sockeye juveniles while Anderson Lake also provides rearing habitat primarily for the Gates Creek stock (Geen and Andrew 1961). In the Bridge River, the lack of typical lake rearing habitat is absent and sockeye juveniles have been observed rearing in the mainstem (Sheng 1996).

### **2.2.4 Habitat productive capacities**

Sockeye spawning habitat in the Bridge/Seton HMA is currently underutilized. The Seton River has an estimated sockeye spawning ground capacity of 16,000 square meters of usable area with the potential to support 29,000 spawners (DFO 1995a) but recent escapements have averaged less than 100 adults (DFO 1994). The Gates River has approximately 8,360 square meters of natural sockeye spawning habitat which can accommodate 6700 female spawners (based on a spawning density of 0.79 females/per square meter) (Royal 1966). With the construction of the spawning channel, Gates River has the capacity for 12,000 spawners (FHIIP 1988) and escapements between 1981-1992 have averaged approximately 16,000 spawners (DFO 1994).

The rearing capacity of the Seton and Anderson Lakes exceeds the spawning capacity and has been estimated at 429,000 spawner equivalents (DFO 1995a). However, the introduction of cold, turbid water from the Bridge River is believed to reduce the productivity and potential rearing capacity of Seton Lake (Geen and Andrew 1961). Studies by Geen and Andrew (1961) and Cooper (1972) identified that Gates River sockeye fry from Anderson lake exhibited slower growth rates when compared to Gates River fry that had reared in Seton Lake.

### **2.2.5 Stock Management**

The interim spawning escapement goals for the Gates and Portage Creek sockeye runs are 21,000 spawners and 8,000 spawners for all cycle years respectively (DFO 1995a). These goals represent an increase of 5,000 spawners in the Gates River and no further increase in Portage Creek sockeye, over average escapement values recorded between 1981-1992.

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DFO has limited management action directed at Bridge/Seton sockeye stocks. The only stock within the Bridge/Seton HMA with transferable knowledge from a well studied index stock is the Gates sockeye run (DFO 1994). For the remaining stocks within the Bridge/Seton HMA, stock assessment data is either insufficient or of unknown quality for a comprehensive assessment. Although there are no directed commercial or sport fisheries on the Bridge/Seton sockeye stocks, Portage and Gates fish are incidentally captured in these fisheries.

Gates River sockeye are harvested in a direct Native gillnet fishery in Anderson Lake (Rosenberger 1996). On average 3-5 gillnets harvest approximately 60-80 sockeye over a period of one week, annually, for subsistence use. Native harvest of Portage Creek sockeye is not well documented but in years with a large run size, 40-50 sockeye are taken for food, social and ceremonial purposes. In general, the late timing of the Portage River sockeye does not coincide with the prime fishing season for local First Nations people. Therefore fewer Portage River sockeye are harvested by direct a Native fishery than Gates River sockeye. There is no Native sockeye fishery in Seton Creek (Rosenberger 1996).

#### **2.2.6 Enhancement and enhancement opportunities**

In 1968, a sockeye spawning channel was constructed in the Gates River to mitigate the effects of logging and other human activities (Cooper 1977). Although sockeye escapement has increased since the construction of the spawning channel, it was closed in 1995 and returning adults could only access natural spawning areas in the mainstem Gates River (Lawrence and Cody 1996). The Gates sockeye spawning channel was reopened in 1996 to accommodate a larger run size anticipated from the dominant brood year. Future operation of the spawning channel is undetermined (Rosenberger 1996). There are no other sockeye enhancement activities within the Bridge/Seton HMA.

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## 2.2 Chinook

Within the Bridge/Seton HMA, the majority of chinook are produced in the Bridge River (69%) and Portage River (18%). Small chinook stocks are supported in the Seton River and the Yalakom River (Table 3).

TABLE 3. Historical and Recent Escapement Trends for Chinook (DFO 1994).

| System        | Historical Escapement (1969-1980) | Recent Escapement (1981-1992) | % of total for HMA | Escapement Trend  |
|---------------|-----------------------------------|-------------------------------|--------------------|-------------------|
| Bridge River  | 125                               | 529                           | 69.4               | Increasing        |
| Yalakom River | 136                               | 23                            | 3.0                | Decreasing        |
| Seton River   | 44                                | 73                            | 9.6                | Increasing        |
| Portage River | 148                               | 137                           | 18.0               | Unchanged         |
| Gates River   | N/A                               | N/A                           |                    | N/A               |
| Cayoosh Creek | N/A                               | 4*                            | 0                  | N/A               |
| <b>Total</b>  | <b>453</b>                        | <b>766</b>                    | <b>100</b>         | <b>Increasing</b> |

\* calculated from escapement summary tables in Appendix A.

### 2.2.1 Life history

Fraser River chinook stocks are divided into spring, summer and fall runs based on their migration timing through the lower Fraser. Chinook stocks in the Bridge/Seton HMA belong to summer run timing stocks that migrate through the lower Fraser after July 15 (DFO 1995c). In the Bridge and Yalakom Rivers, chinook migration begins in mid-August and peak spawning occurs by early September (Jarvis and Stewart 1985b, FHIIP 1992). Chinook migration into Seton River and Portage Creek is slightly later than the Bridge River system with the peak of spawn occurring in early October. A second run in the Seton River chinook peaks in mid-November (Jarvis and Stewart 1985b, FHIIP 1992).

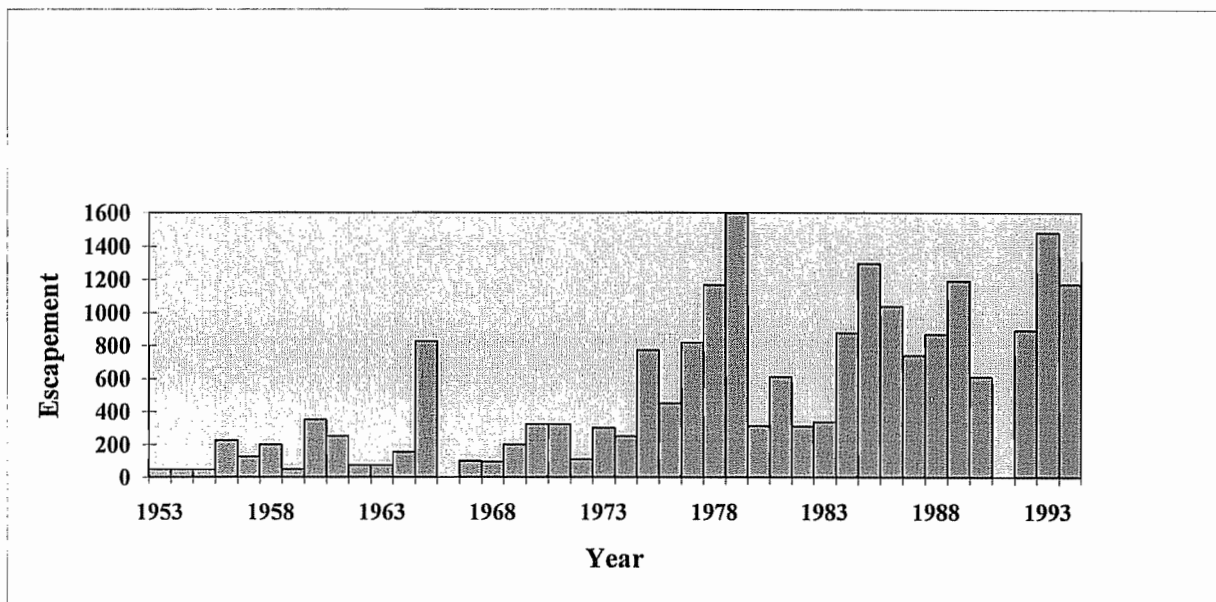
Chinook fry emerge from early April to the end of May in the Bridge River and Portage Creek (Matthew and Stewart 1987). Chinook juveniles in the Bridge/Seton HMA are mainly "stream-type" migrants and spend their first year rearing in freshwater (Matthew and Stewart 1987, Jarvis and Stewart 1985b). Juvenile assessments in the Bridge River suggest that the majority of chinook juveniles overwinter in the Bridge River for the majority of their freshwater rearing period rather than rearing in downstream waters (Stewart and Matthew 1984, Matthew and Stewart 1985). In Portage Creek, chinook fry likely overwinter in the Seton/Anderson Lake system and outmigrate during May and June during their second spring (Matthew and Stewart 1987).

Bridge River chinook emigrate as smolts from early April to early June with peak outmigration during mid-April (Matthew and Stewart 1985, Matthew and Stewart 1987). The majority of Bridge River chinook return as 4 year olds (52-64%) and occasionally 5 or 6 year olds (5-13%) or jacks (9-25%) (Matthew and Stewart 1987, Jarvis and Stewart 1985b).

Seton and Portage stocks have a larger proportion of chinook adults returning as five or six year olds (35-56%) than Bridge River stocks (FHIIP 1992). However, in most years, at least 50% of chinook return in their fourth year (Jarvis and Stewart 1985b). In the Seton River, there is some evidence that some chinook are “ocean type” juveniles and emigrate to sea in their first year, returning as four year olds (Jarvis and Stewart 1985b).

### 2.2.2 Escapement and escapement trends

Overall, annual chinook escapements to the Bridge/Seton HMA have shown an increasing trend to 1994 (Fig 4). In the Bridge River and Seton River, chinook escapements between 1981-1992 have shown an increasing trend when compared to escapement estimates from 1969-1980 (Table 3). Increasing escapement values are the result of decreasing incidental commercial catches of chinook as well as enhancement efforts directed at Fraser River chinook stocks. However, Yalakom chinook have shown a decreasing trend in escapement since the early 1980’s. Chinook escapement information in Cayoosh and Gates Creek is insufficient to determine escapement trends for these systems.



\* Escapement values equal 0 in 1991 as Portage and Bridge Rivers were unavailable

FIGURE 4. Total escapement estimates for Bridge/Seton chinook stocks (1953-1994) (Appendix A).

Historical maximum chinook escapement is greater than 500 in the Bridge River and Portage River and greater than 100 in the Yalakom and Seton Rivers (Fig 5). Between 1981-1992, average chinook escapements to the Bridge River represent 70% of the total chinook escapement to the Bridge/Seton HMA (Table 3).

Escapement numbers are generally related to habitat capability and provide a relative index of stock strength, although other factors such as ocean survival and interception from commercial, sport and Native fisheries can affect the number of fish returning to spawn. The reliability of escapement data is highly variable, depending on the species, enumeration method used and variations in stream conditions. For example, the glacial waters of the Yalakom River make it difficult to visually estimate escapement values whereas the counting fence in the Gates River yields reliable escapement estimates. In general, Bridge River chinook escapements show considerable annual variability (Stewart and Matthew 1984) and escapement estimates are difficult in the Yalakom due to the glacial nature of this system (Lawrence and Cody 1996). In Seton and Portage River, chinook estimates are also subject to a high degree of uncertainty (Lawrence and Cody 1996).

### **2.2.3 Spawning and rearing habitat**

Prior to the installation of the Mission Dam at the outlet of Carpenter Lake, chinook spawners migrated to the upper Bridge River watershed and known spawning areas included lower Tyaughton Creek and Ferguson Creek (Nielsen and Shepherd 1983). Chinook spawning is now limited to areas downstream of the Terzaghi Dam. Known chinook spawning habitat includes the Bridge River mainstem from Camoo Creek to approximately 10 kilometers upstream of the Yalakom confluence (Stewart and Matthew 1984) (Fig 6). The heaviest spawning occurs between the Horseshoe Bend upstream to the Yalakom confluence and light spawning occurs between Camoo Creek and Antoine Creek and from 1 to 7 kilometers upstream of the Yalakom confluence (Jarvis and Stewart 1995b). In the Yalakom River, coho and chinook spawning is scattered throughout but mainly occurs at Beaverdam Flats (FHIIP 1992).



FIGURE 6. Chinook spawning habitat upstream of Horseshoe Bend (photo by M. Sheng).

In general, chinook salmon are present in relatively low numbers upstream and downstream of the Seton Dam with slightly higher escapements being observed above the dam (Groves and Higgins 1995). In the Seton River mainstem, early chinook stocks spawn within a few hundred meters downstream of Seton Dam (Stalberg 1996). In Portage Creek, there is a moderate distribution of spawners from Whitecap creek upstream for 2 kilometers and scattered spawning between 1 and 4 kilometers upstream of the Seton Lake inlet (Jarvis and Stewart 1985b).

In the Bridge River, the upper wetted 12 kilometers provides rearing habitat for chinook, coho and rainbow trout (Lister and Beniston 1995). Chinook and coho prefer relatively low gradient side channel habitat while rainbow juveniles preferred higher gradient sites in riffles and cascades (Lister and Beniston 1995).

#### 2.2.4 Habitat productive capacities

Juvenile studies during the early 1980's suggested that rearing habitat in the Bridge River was underutilized by Pacific salmon in comparison to other regional streams which supported densities of 3.5 grams of fish per square meter. The useable rearing areas for all salmonids was estimated to be 158,000 square meters in the Bridge River below the dam (Stewart and Matthew 1984). In a more recent study by Lister and Beniston (1995), the uppermost 12

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kilometers of the wetted Bridge River below the dam was found to be very productive, supporting higher salmonid standing stock densities than the 2.5 km section below the Yalakom and the lower Seton River below the dam. Above the 12 kilometer reach in the mainstem Bridge River, the uppermost 5 kilometers of the Bridge River is dry below the Terzaghi Dam. Total salmonid standing stocks during a fall 1993 survey approximated 162,000 fish in the 12 kilometers of the Bridge River above the Yalakom, 18,000 in the 2.5 kilometers downstream of the Yalakom and 4,000 at Seton River (Lister and Beniston 1995). Furthermore, in comparison to salmonid densities in other streams outside the study area, chinook densities were rated as high, coho and 0+ rainbow densities were intermediate and rainbow parr densities were high. In terms of total biomass, the upper 12 kilometers of the Bridge River exceeds the majority of over 137 anadromous and resident trout stream reviewed (Lister and Beniston 1995). Estimates of the amount and type of rearing and available spawning habitat in lower Bridge River are discussed by Lister and Beniston (1995) in more detail.

In September 1994, DFO and MELP jointly conducted a juvenile assessment of the Yalakom River and identified potential habitat for an additional 23,000 chinook fry in order to reach full saturation of the mainstem below the partial obstruction at kilometer 15 in the mainstem (Griffith 1995). These estimates are based on large late summer fry captured during a September sampling period. Population estimates for all size classes appeared to be 25% of corresponding capability estimates derived from standing stock capability models in Griffith (1995).

DFO is in the process of determining the productive capacity of the Yalakom through a juvenile chinook salmon out-planting program. During 1993-1994, electrofishing was conducted monthly to determine the duration of the rearing period, out-migration timing and fish health from May 1993 to May 1994. Sampling was conducted both above and below the partial barrier prior to fry releases. Temperature data were collected in 1992 and 1993 to determine temperature ranges during spawning, incubation and rearing periods and biophysical habitat inventories were conducted to determine quality and quantity of available habitat (Conlin 1994). Final results of this study are not yet available.

DFO's assessment of the productive capacity of the Yalakom also suggests that the system could support more chinook if adults could consistently access the most productive habitat upstream of the partial barrier located 15 kilometers upstream of the Bridge River confluence (Conlin 1994). The partial barrier consists of large boulders which have eroded from the unstable hillside, creating a series of cascades for approximately 200 meters (Conlin 1994).

Another factor limiting the production of chinook in the Bridge River is the lack of adult holding pools which increases the vulnerability of adult migrants to predation by bears (Maricle 1996, Stalberg 1996).

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### **2.2.5 Stock Management**

Under the 1985 Pacific Salmon Treaty, Canada and the United States committed to halt declining chinook spawning escapements and attain by 1998, escapement goals established by each nation (DFO 1995c). In the Fraser River, interim rebuilding targets are based on doubling the average escapement numbers from 1979-1982. In general, chinook stocks have been rebuilt by reducing exploitation rates by 15% through management actions in ocean fisheries, particularly terminal sockeye and pink salmon fisheries (DFO 1995c). In the Bridge/Seton HMA, chinook escapements have reached their escapement target as returns have doubled from 366 during 1979-1982 to 789 between 1983-1994 (Appendix A).

All spring/summer run Fraser chinook stocks including Bridge/Seton chinook are harvested by an extensive range and gauntlet of fisheries (DFO 1995c). Recent coded wire information from 1991 Bridge River chinook indicate that 17% are captured by the northwest troll fishery, 45% by southwest troll and 38% by the sport fishery (DFO 1995d). Bridge/Seton chinook stocks are not managed on a stock specific basis and existing stock management data is unavailable or considered to be of insufficient quantity or quality for a comprehensive assessment.

The lower Bridge River is a popular sport and Native chinook fishing area for passing upper Fraser chinook stocks (Rosenberger 1996). Historical conflicts between Native and sport fishermen have been successfully resolved and the Bridge River Band is now conducting a creel survey for DFO and collecting an access fee from all sportfishing anglers (Rosenberger 1996). Currently, the sports fishery is open 2 days a week, for 4 weeks to yield an 8 day sports fishery prior to July 15 annually. No steelhead or Bridge River chinook stocks are harvested during this fishery (Rosenberger 1996).

### **2.2.6 Enhancement and future enhancement opportunities**

Enhancement activities in the Yalakom River began in 1948 when DFO's Fish Culture Branch improved access at kilometer 15 at the partial barrier (Nielsen and Shepard 1983). Chinook brood stock were collected from the Bridge River and eggs were planted near Beaverdam Creek between 1950-1952. Little enhancement work was done in the Bridge River system until 1980, when the Lillooet Rod and Gun Club started to raise and release chinook, coho and steelhead fry in the Bridge River as part of DFO's Public Involvement Program. By 1984, they constructed an incubation/early rearing facility at Texas Creek for coho, steelhead and chinook. By 1991, their capacity increased to 100,000 fry and outplants were generally released into the Yalakom River (Triton 1992). More details of fry release schedules are provided in Triton (1992).

Since 1991, B.C. Hydro has been enhancing Bridge River chinook stocks through a fry release program to mitigate for the 1991 and 1992 spills down the Bridge River from the Terzaghi Dam. All chinook fry originate from Bridge River stocks. B.C. Hydro released 51,000 fry in 1992, 120,344 fry in 1993 and 82,566 fry in 1994 into the Bridge River system (Sheng 1996). The majority of these juveniles are coded wire tagged or otolith marked and will therefore provide valuable life history information as well as commercial, sport and Native fishery interception rates. Coded wire tag information has already indicated that chinook adult returns may be further enhanced in the Bridge River system if hatchery facilities produced and released older (1+) fry. Older fry have a 0.14% survival rate compared to a 0.01-0.02% survival rate found in 0+ juveniles (DFO 1995d).

Historical habitat improvements for chinook, coho and steelhead in the Bridge River included the construction of 8 spawning platforms upstream of the Yalakom confluence in the early 1980s (Fig 7). This project was a joint effort by DFO, MELP and the Department of Highways during a road widening project. However, in 1982, flood release flows from Terzaghi dam transported a large proportion of the gravel downstream (Nielsen and Shepard 1983). Potential habitat enhancement projects in the Bridge River include the development of a spawning and rearing channel at Horseshoe Bend (Lawrence and Cody 1996, Triton 1992) and increasing rearing habitat by re-watering of the upper Bridge River through flow releases through Terzaghi Dam (Kosakoski and Stalberg 1996, Maricle 1996, Triton 1992).



FIGURE 7. Lateral view of Bridge River spawning platforms (photo by M. Sheng).

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## 2.3 Coho

The two main coho producing systems are the Gates River (42%) and the Bridge River (38%) within the Bridge/Seton HMA (Table 4). Smaller coho stocks are produced in the Yalakom River, Seton River, Portage River and Cayoosh Creek (DFO 1994).

TABLE 4. Historical and recent escapement for coho salmon (DFO 1994).

| System        | Historical Escapement (1969-1980) | Recent Escapement (1981-1992) | % total of HMA | Escapement Trend |
|---------------|-----------------------------------|-------------------------------|----------------|------------------|
| Bridge River  | 137                               | 468                           | 37.7           | Increasing       |
| Yalakom River | 40                                | 6                             | 0.5            | Decreasing       |
| Seton River   | 16                                | 79                            | 6.4            | Increasing       |
| Portage River | 155                               | 135                           | 10.9           | Unchanged        |
| Gates River   | 1042                              | 523                           | 42.2           | Decreasing       |
| Cayoosh Creek | N/A                               | 29                            | 2.3            | N/A              |
| <b>Total</b>  | 1,390                             | 1,240                         | 100            | Decreasing       |

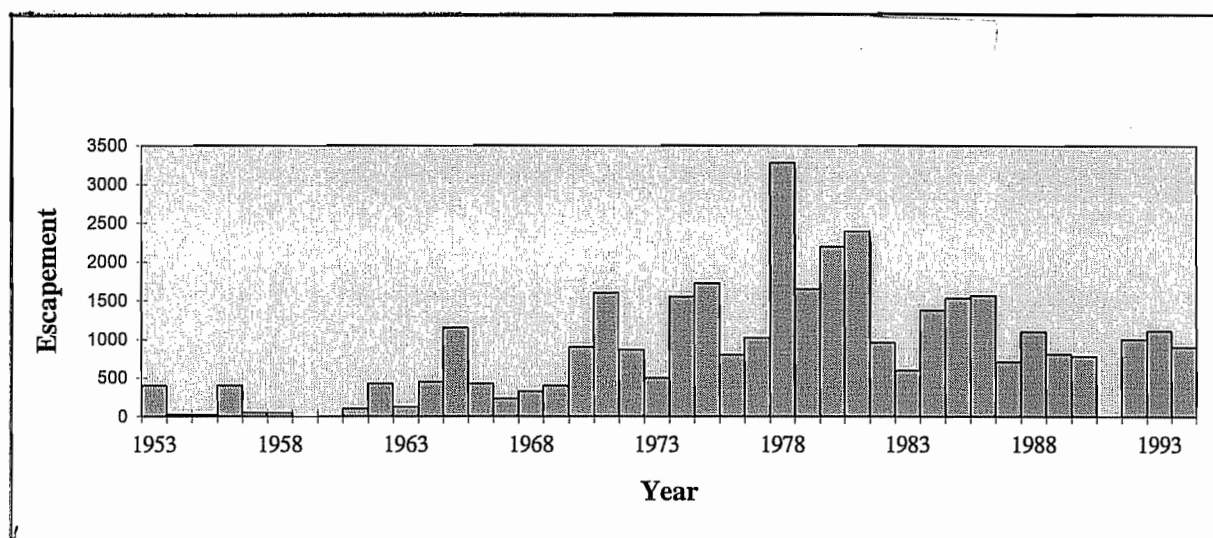
### 2.3.1 Life history

Within the Bridge/Seton HMA coho generally spawn from October to early January with peak spawning during late November/early December (Jarvis and Stewart 1985a, FHIIP 1992, Matthew and Stewart 1987). Coho adults return to the Seton River from late September through October and migrate into the Portage River during October (Jarvis and Stewart 1985a, Matthew and Stewart 1987, Jarvis and Stewart 1985a). The migration timing of Gates River coho varies but generally takes place from mid-September to late October.

Emergence of coho fry starts in April and continues into June (Matthew and Stewart 1987). In general, Bridge River coho overwinter in their natal stream (Stewart and Matthew 1984, Matthew and Stewart 1985). Similarly, Seton River fry rear locally in streams or in Seton Lake for 1 year prior to their seaward migration (Groves and Higgins 1995). Bridge River smolts migrate seaward between early April through early June (Matthew and Stewart 1985). The timing of outmigrating coho smolts from the Seton drainage is unknown (Groves and Higgins 1995). The majority of coho in the Bridge/Seton HMA spend 2 years in freshwater and one year in the ocean (Matthew and Stewart 1987, Jarvis and Stewart 1985a). A small proportion (7-8%) of Bridge and Gates coho spend 2 years at sea and return as four year olds (Matthew and Stewart 1987).

### 2.3.2 Escapement and escapement trends

Overall, the coho stocks in the Bridge/Seton HMA show a decreasing trend (Fig 8). More specifically, Gates River and Yalakom River coho shows a declining escapement trend whereas the Bridge River and Seton River coho appear to be increasing (Table 4). In Seton Creek, there have been slight increases in abundance of coho since the construction of the dam with yearly escapement estimates ranging from 50 to 2150 spawners. Since the 1980's there has been some reduction these numbers and recent coho escapements have ranged between 100-300 fish annually (Groves and Higgins 1995). The apparent decline in the abundance of wild Fraser coho is attributed to excessive exploitation rates, habitat loss and decreased marine survival of smolts (DFO 1996).



Gates and Bridge River escapement unavailable for 1991

FIGURE 8. Total escapement estimates for Bridge/Seton coho stocks (1953-1994) (Appendix A).

Historical maximum coho escapements exceed 500 for the Bridge River, Portage River and Gates River and over 100 in the Yalakom River and Seton River (Fig 9). The reliability of escapement data is highly variable, depending on the species, enumeration method used and variations in stream conditions. Coho salmon are inherently difficult to enumerate and coho escapement estimates are probably the most unreliable of all estimates for salmon species (DFO 1996).

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

In the Gates River, the heaviest spawning occurs within the 2 kilometer reach upstream of Spruce Creek. Light spawning occurs in the mainstem for 2 kilometers downstream of Spruce creek and very scattered spawning occurs for within a 3 kilometer reach at seven 7 mile creek (Jarvis and Stewart 1985a). Some coho spawning also takes place in low gradient areas of Anderson Lake tributaries such as D'Arcy springs. In D'Arcy Creek, the lowest one kilometer is suitable for coho spawners (Matthew and Stewart 1987, FHIIP 1988). In the Seton River, the main spawning area is approximately 1 kilometer downstream of Seton Dam (Matthew and Stewart 1987). In the Bridge River, coho spawn from Camoo creek upstream to approximately 10 kilometers upstream of the Yalakom River confluence (FHIIP 1992, Jarvis and Stewart 1985a).

### **2.3.4 Habitat productive capacities**

Little information is available regarding the productive capacity for coho within the Bridge/Seton HMA. In the Yalakom River, the availability of suitable rearing habitat is thought to be the limiting factor to coho as stream flows are often too swift or shallow. In addition to flow problems, adequate cover in the form of LOD or complex bank habitat is limited in both abundance and distribution (Griffith 1995).

### **2.3.5 Stock Management**

The production potential of Fraser River coho is difficult to assess due to the poor quality and incompleteness of escapement and exploitation data (DFO 1996). Improved data collection is necessary in order to assess the stock status of the coho population and the success of rebuilding strategies. Although the available information on Fraser River coho stocks is limited and incomplete, there are indications that the Fraser system can support more coho than current escapements (DFO 1996). The Department of Fisheries and Oceans is in the process of adopting a reliable system for monitoring spawning escapement and exploitation rates of key stocks in order to assess the stock status of Fraser River coho (DFO 1996).

There are no Native, commercial or sport directed fisheries on these stocks but significant interception by these fisheries are suspected. DFO's stock management program does not actively manage any of the coho stocks in the Bridge/Seton watershed.

### **2.3.6 Enhancement and enhancement opportunities**

For information on coho enhancement opportunities see chapter on chinook enhancement.

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## 2.4 Pink

Pink are the most abundant salmon species found in the Bridge/Seton HMA. The majority of pink are produced in the Seton River (84%) and to a lesser degree in the Bridge River (11%) (Table 5). Small pink salmon runs escape to Portage River, Cayoosh Creek, Yalakom River and Gates River. Escapement estimates for the Seton, Gates, Portage and Bridge River have averaged approximately 0.8 million for the 1983-1991 cycle years with a peak of over 1.5 million in 1991 (DFO 1995b).

TABLE 5. Historical and Recent Escapement Trends for Pinks (DFO 1994).

| System        | Historical Escapement (1969-1980) | Recent Escapement (1981-1992) | % of total for HMA | Escapement Trend  |
|---------------|-----------------------------------|-------------------------------|--------------------|-------------------|
| Bridge River  | 12,328                            | 48,013                        | 10.6               | Increasing        |
| Yalakom River | 167                               | 28                            | 0                  | Decreasing        |
| Seton River   | 138,429                           | 383,879                       | 84.5               | Increasing        |
| Portage River | 9,728                             | 10,427                        | 2.3                | Unchanged         |
| Gates River   | 122                               | 60                            | 0                  | Decreasing        |
| Cayoosh Creek | 11,245                            | 11,581                        | 2.6                | Unchanged         |
| <b>Total</b>  | <b>172,019</b>                    | <b>453,988</b>                | <b>100</b>         | <b>Increasing</b> |

### 2.4.1 Life history

Fraser River pink spawn primarily in odd years and are categorized as either early or late runs, depending on migration and spawn timing (DFO 1995b). Approximately 85% of the total return to the Fraser River belong to the early run pink and consist of stocks from the lower Fraser River, Thompson River and Seton Creek (DFO 1995b, IPSFC 1959).

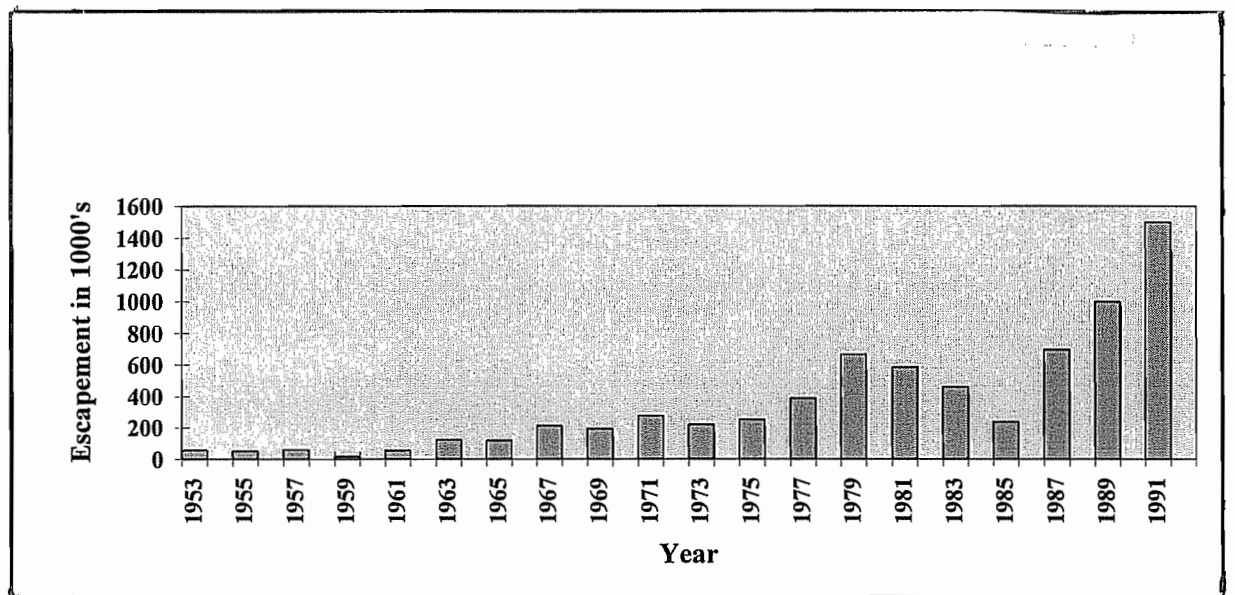
In the Bridge/Seton HMA, Seton pink adults migrate through the lower Fraser in mid-September and travel at a rate of 12 miles a day to the Seton River (Ward 1959). Pink spawning occurs in the Bridge River from mid-September to late October (Triton 1992). Pink spawning in Seton and Portage Creeks occurs from mid September to early November (Rosenberger 1996, FHIIP 1992, Triton 1992) and peaks in the Seton River during mid-October (DFO 1995b).

In general, Fraser River pink juveniles emerge in early spring and migrate immediately to the ocean (DFO 1995b). Seton Creek, Portage River and Bridge River fry emerge from late March to May and juvenile outmigration is complete by the end of May (Matthew and Stewart 1987). Pink rear in the Strait of Georgia until mid-summer, then migrate as far as the

Gulf of Alaska and rear for one year in the marine environment before returning to spawn as two year olds (DFO 1995b).

### 2.4.2 Escapement and escapement trends

Pink escapement to the Bridge/Seton HMA shows an overall increasing trend (Fig 10). During the early 1900s, 28 million pink salmon spawned in Seton Creek, Thompson River and Nicola River drainages. However in 1913, the Hell's gate rockslide completely blocked access upriver and significantly reduced the Fraser pink run. In 1946, the construction of the Hell's Gate fishway restored passage through the Fraser Canyon. Pink stocks were further rebuilt in Seton Creek during the 1960's through the construction of two spawning channels to compensate for loss of historical spawning habitat by the construction of the Seton Dam and Cayoosh Creek diversion (Fretwell 1989). In combination with enhancement and mitigation measures, exploitation rates were reduced and pink escapement to the Bridge/Seton HMA has been steadily increasing (DFO 1995b).



\*1993 data incomplete and not included

FIGURE 10. Total escapement estimates for Bridge/Seton pink stocks (1953-1991) (Appendix A).

Historical maximum pink escapements are greater than 500,000 in the Seton River and exceeded 50,000 in Portage River, Bridge River and Cayoosh Creek (Fig 11). Smaller pink escapements to Gates River and the Yalakom River have historically exceeded 1000 adults.

### **2.4.3 Spawning and rearing habitat**

In the Seton River, the majority of pink salmon spawn in the artificial channels constructed during the mid-1960's by the IPSFC (Groves and Higgins 1995). Some pink spawning also occurs upstream of the Seton dam in the Portage River and Gates River. In the Bridge River, pink spawn from the mouth to approximately 10 kilometers upstream of the Yalakom confluence, with highest densities reported downstream of Camoo Creek. Pink salmon also spawn in the lowermost 0.5 kilometer of the Yalakom River (FHIIP 1992).

### **2.4.4 Habitat productive capacities**

In the Seton River, the total productive capacity has been estimated at 900,000 adults (DFO 1995b). Pink stocks in the Seton and Bridge River watersheds have the potential to rebuild rapidly as indicated by the significant increases in the 1989 and 1991 escapements (DFO 1995b).

### **2.4.5 Stock Management**

Fraser River pink are managed as a single stock, based on in-season estimates of total run size with different exploitation rates applied to early and late run stock groups (DFO 1995b). The Seton and Thompson River pink are the 2 major stocks making up the early Fraser River pink run. Therefore, all Seton/Bridge pink stocks are managed as part of the early pink run (Rosenberger 1996). Bridge and Seton River pinks are also incidentally captured in the commercial sockeye fishery (Rosenberger 1996).

The total productive capacity of the Fraser River pink habitat is presently underutilized as suggested by the variable total returns in recent years (DFO 1995b). The total escapement goal for Fraser River pink salmon established by DFO is 6 million spawners and harvest management strategies will achieve this goal by reducing exploitation rates (DFO 1995b).

### **2.4.6 Enhancement and enhancement opportunities**

The first enhancement project for pink salmon in the Bridge/Seton HMA was the removal of a series of partial barriers in the lower Bridge River near the Fraser River confluence in 1963 (Nielsen and Shepherd 1983). Further efforts to increase current production of pink salmon occurred in 1961 and 1967, when two pink spawning channels were constructed in the lower Seton River (Fig 12). These channels were built by the IPSFC to compensate for the loss of historical spawning habitat by the construction of the Seton Dam and Cayoosh Creek diversion (Fretwell 1989).

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## 2.5 Trout and Char Species

The conservation and management of provincial fisheries values is guided by B.C. Environment's "Conserving our Resource" document (B.C. Environment undated). This provincial management strategy identifies issues and problems facing the fisheries and outlines comprehensive initiatives to ensure wise resource management, conservation and allocation. The four main strategic objectives of the program are to: conserve wild fish stocks, protect and manage fish habitat, serve the public interest and practice strong corporate management. More details on objectives and strategies are provided in B.C. Environment (undated).

Within the Bridge River HMA, trout and char species include steelhead trout and rainbow trout. Anadromous and resident populations of dolly varden char and bull trout may occur in the Bridge/Seton HMA but further studies are required to document this. Other salmonid species include rocky mountain whitefish and possibly lake whitefish (*Coregonus clupeaformis*) (Maricle 1996). In addition, kokanee are resident to Anderson, Seton, Carpenter, Downton and several other smaller lakes within the HMA.

### 2.5.1 Life history summary

A brief discussion of life history characteristics of bull trout, dolly varden char and steelhead/rainbow trout are summarized in the following section. For more detailed information on bull trout see Skeesick (1989).

Before 1978, dolly varden (*Salvelinus malma*) was known to have anadromous (dolly varden) and resident (bull trout) forms which were distinguished according to morphometric, meristic and osteological characteristics (Skeesick 1989). By 1985, electrophoretic research concluded that bull trout are more closely related to the arctic char than to eastern brook or lake trout (Skeesick 1989). Therefore dolly varden and bull trout are now considered to be 2 separate species.

#### **Bull trout**

Bull trout have three different life history strategies; resident, fluvial and adfluvial. Resident bull trout populations occupy headwater streams and are usually isolated from other fish populations by some type of physical barrier (Skeesick 1989). These isolated resident stocks often survive in cold headwater streams that are characterized by low productivity and a short growing season. As a result of these environmental conditions, these stocks tend to mature at an early age and are reduced in size and age (Skeesick 1989, Maricle 1996). Adults from fluvial populations are found in rivers and larger streams and will migrate up to 225

kilometers to spawn in smaller tributaries. Adfluvial stocks live mainly in lakes or reservoirs and may also undergo extensive spawning migrations.

In the Yalakom, fluvial bull trout populations spawn at Moose Flats and Beaverdam Flats. When they reach 3-4 years of age, they migrate into the Bridge River and Fraser River to feed (Maricle 1996). Bull trout are sensitive to temperature and do not regularly tolerate water temperatures exceeding 18 Celcius (Skeesick 1989).

Bull trout are characteristically a long lived species which is evidenced by the capture of a 25 year old bull trout (75 cm) in the North Thompson (Maricle 1996). They are late to mature and reach sexual maturity at 4-7 years of age (Skeesick 1989). Bull trout spawn in September/October with declining water temperatures and in a Washington study, spawning intensity peaked in water temperatures of 5-6 Celcius, at night (Skeesick 1989). Emergence occurs after 223 days in late April or May. Juvenile bull trout have specific habitat requirements and juveniles less than 100 mm are bottom dwellers and require shallow, slow backwater side channels or eddies. Yearling juveniles are found in deeper, faster waters than young of the year (Skeesick 1989). More detailed information on bull trout life history characteristics are documented in Skeesick (1989).

### **Dolly varden char**

Dolly varden are the most widely distributed salmonid in B.C. most often reside in rivers, lakes and remote headwater creeks (Carl et al 1977). They generally spawn in the fall between mid-August and early November. The first age of maturity is variable and may not occur until they are in their fifth year and/or approximately 20 inches long (Carl et al 1977). Dwarf headwater populations mature at a smaller size and often reach a maximum length of 12 inches. Both anadromous and resident populations of dolly varden may occur in the Bridge/Seton HMA (FHIIP 1992).

### **Steelhead/Rainbow trout**

Steelhead and rainbow trout differ in morphology and their tendency towards being anadromous or resident species. Steelhead trout are anadromous whereas rainbow trout are resident. Adult steelhead remain in fresh water for 2-3 years and return to spawn after 2-3 years at sea (Hart 1973). Unlike other salmon species, steelhead may return to spawn a second or third time.

Bridge River steelhead are a summer run stock which migrates into the Fraser during late summer/early fall and overwinter in the Fraser River. They migrate into the Bridge River during high spring flows and spawn from late March to early June (Hebden 1981). Approximately 65% of the Bridge River steelhead spend 2 years rearing in freshwater

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afterwhich they migrate to sea and return to spawn as 4 year olds. The remainder spend an extra year in freshwater and return as 5 year olds (Hebden 1981). Seton River and Cayoosh steelhead are also summer run stocks and the majority of juveniles rear in freshwater for 3 years (Hebden 1981).

### **Kokanee**

Kokanee are resident sockeye salmon that have diverged from an anadromous life history to a freshwater existence (Burgner 1991). A second form of kokanee are “residual” sockeye which are progeny of anadromous parents (Burgner 1991). Resident forms are smaller (18-30 cm) than anadromous stocks and spawn during the fall in streams or along the shoreline of lakes.

### **2.5.2 Abundance and distribution**

Trout, char, kokanee and other fish species are widely distributed throughout the Bridge/Seton HMA (Fig 13). However, information on the abundance of trout and char species in the Bridge/Seton HMA is limited to steelhead escapement estimates in the Bridge River. In general, the distribution of kokanee is known whereas distribution information for rainbow trout and bull trout is incomplete (Maricle 1996). The following section summarizes known distributions for kokanee, trout and char species.

Approximately 50-200 steelhead spawn in the Bridge River annually and this stock has been identified as a conservation concern by B.C. Environment (Hebden 1981, Maricle 1996). The Yalakom, lower Bridge River and Cayoosh Creek also provide suitable habitat for steelhead within the Bridge/Seton HMA. In the Yalakom River, steelhead utilize most of the mainstem river and are believed to pass over the partial barrier during early spring flows. In the Bridge River, steelhead spawn throughout the system (Maricle 1996, FHIIP 1992, Stewart and Matthew 1984). The presence of steelhead in Cayoosh Creek is documented but no steelhead above the dam have been observed (Groves and Higgins 1995). During the spring of 1995 and 1996, fourteen steelhead were radiotagged by B.C. Hydro to determine the destination of migrating adults (Maricle 1996). Study results identified that twelve steelhead moved into the Bridge River system to spawn, of which one spawned in the Yalakom River (Maricle 1996).

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Known bull trout populations have been identified in Duffy Lake and associated tributaries, Gates River, Tyaughton Creek, Tyaughton Lake, Gun Lake/Lajoie Lake and tributaries, and the Yalakom River (Table 6). Many other bull trout population exist but have not been documented to date (Maricle 1996). Bull trout are distributed throughout the Yalakom River mainstem to headwater areas (Griffith 1995). Headwater populations are allopatric and resident while fluvial-adfluvial bull trout populations are present between the first and second obstruction on the mainstem (Griffith 1995). In the Yalakom River, bull trout stocks have been identified by MELP as a conservation concern and production is limited primarily by pressure from sportfishing (Griffith 1995). As a result, fishing regulation for 1996 have been reduced from 2 fish day (any size) to 1 fish per day greater than 60 cm (Maricle 1996).

Rainbow trout are widely distributed throughout the study area and populations have been verified in headwater areas of Cayoosh Creek, Gates River, Slim Creek, Tyaughton Creek and the Yalakom River (Fig 13). Large rainbow trout up to 2.5 kilograms are known to migrate into Gates and Portage Creek from Anderson and Seton Lakes to spawn (FHIIP 1988). Additional information on known fish distributions are summarized in Table 6 (Triton 1992).

Kokanee are found in most large lakes and reservoirs within the study area. Kokanee populations have been documented in Anderson Lake, Birken Lake, Carpenter Lake, Downton Lake and Gun Lake (Fig 13). Kokanee spawn in Portage Creek, the outlets of Downton Lake, Gun lake and La Joie Lake and along the shores of Carpenter Lake (FHIIP 1992).

### **2.5.3 Enhancement opportunities**

The limiting factor for bull trout, steelhead and rainbow trout in the Bridge River is amount of available rearing habitat. Increasing minimum flows through the Terzaghi Dam could enhance trout populations by increasing rearing habitat (Maricle 1996).

In the Yalakom below the partial barrier located approximately 15 kilometers upstream of the Bridge River, the 1994 standing stock of all salmonid populations is approximately 25% of the corresponding capability estimates for all species (Griffith 1995). Therefore, good enhancement opportunities exist for chinook and steelhead fry outplants according to Griffiths (1994). Potential enhancement opportunities for rainbow trout, chinook and bull trout include the release of an additional 20,000 late summer yearlings (steelhead and resident rainbow trout combined) below the partial barrier (Griffith 1995). To accommodate the restoration of resident rainbow trout stocks and the preservation of bull trout, Kamloops Regional Fish and Wildlife recommends that all future fry releases should be restricted to the lower river downstream of partial obstruction at 18 kilometer (Griffith 1995). For declining resident rainbow trout stocks, a complete angling closure should be implemented in the Yalakom River (Griffith 1995).

TABLE 6. Known Distribution of trout, char, kokanee and some resident fish species in the Bridge/Seton HMA (FHIIP 1992 and those listed).

| System/Lake   | Species                             | Comments  |
|---|-------------------------------------|---|
| Carpenter Lake  | RT, BT,<br>KO, DV*,<br>MWF          | Kokanee introduced Kootenay Lake (Triton 1992)<br>-prickly sculpin, red sided shiner, long nose suckers<br>and Pacific lamprey also present (Triton 1992) |
| Seton Lake  | RT, BT,<br>KO, DV*,<br>MWF,<br>LWF* | Turbid due to diversion from Carpenter Lake to Seton<br>Lake (Maricle 1996)   |
| Anderson Lake   | RT, DV,<br>LWF*                     | (Maricle 1996)  |
| Tyaughton Creek                                       | RT, BT                              |   |
| Spruce Lake   | RT                                  | Self recruiting population  |
| Tyaughton Lake  | RT                                  | Spawning habitat in Crane Creek and at lake outlet  |
| Mud, Grizzly and<br>Noaxe Lakes                       | RT                                  | Low numbers of fish and thus considered to have<br>potential for fish stock enhancement   |
| Hurley River,<br>Cadwallader Creek                    | BT, RT                              |   |
| Sucker, MacDonald,<br>Fish, Kingdom and<br>Mead Lakes | RT                                  | Self sustaining populations   |
| Marshall, Liza Lakes                                  | RT                                  | Self recruiting populations   |
| Downton Lake  | RT, BT,<br>KO, MW                   | Turbid due to inflow of glacial sediments.  |
| Gun and Lajoie Lakes                                  | RT, BT, KO                          | Self sustaining populations of RT and BT, also stocked<br>with RT and KO to support local sport fishery (Acres<br>1990 in Triton 1992)                    |
| Penrose, Upper and<br>Lajoie Creek                    | KO, RT                              | (D.B. Lister and Assc 1988).  |
| Gun Creek, Walker<br>Creek                            | RT, BT                              | Important spawning area at mouth of Gun Creek and<br>Walker Creek. Walker Creek is an important nursery<br>stream for BT (Triton 1992)                    |
| Pearson and Mowson<br>Ponds                           | Brook trout,<br>RT                  | Do not contain self recruiting populations, stocked<br>annually to support recreational fisheries (Acres 1990<br>in Triton 1992)                          |

\* may exist but unconfirmed by MELP

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### 3.0 BIOPHYSICAL FEATURES

It is important to discuss the physiography, climate and hydrology of the Bridge/Seton HMA as these biophysical characteristics can influence the distribution, abundance and productive capabilities of aquatic and terrestrial systems (Harding et al 1994). The combined effects of physiography and climate are classified into 2 major systems based on physiographic characteristics (physiographic regions) or ecological attributes (ecoregions). Much of the physiographic, climatic and hydrological information has been extracted from Rood and Hamilton (1995).

#### 3.1 Physiographic Regions

The majority of the Bridge and Seton HMA lies within the Coast Mountains physiographic region except for the northeast portion of the Yalakom River which belongs to the Interior Plateau (Rood and Hamilton 1995) (Fig 14). Physiographic regions are further divided into 3 sub-regions within the Bridge/Seton HMA. The Pacific Ranges lie to the southwest of Carpenter Lake/Seton Lake area, the Chilcotin Ranges are northeast of Carpenter Lake/Seton Lake and the Camelsfoot Range occupies the northwest side of the Yalakom River (Rood and Hamilton 1995). The following physiographic sub-region descriptions for the Chilcotin Ranges and the Pacific Ranges originate from Rood and Hamilton (1995);

*The Chilcotin Ranges are an eastern subdivision of the Coast Mountains composed largely of sedimentary and volcanic rocks. The Yalakom River flows along the Yalakom Fault, separating the Camelsfoot and Chilcotin Ranges. The highest peaks in the Chilcotin Ranges are about 2800 meters and located in the upper Yalakom.*

*The Pacific Ranges of the Coast Mountains are formed in granitic stocks and extend southeastward from Bella Coola to the Fraser Valley. In the vicinity of the Bridge River there are a number of peaks which are 3300 meters in elevation. Many of these have an alpine appearance as they projected above the Cordilleran ice sheet which reaches elevations of about 2500 meters while lower peaks were rounded by glacial erosion. Extensive ice-fields remain along the crest of the Pacific Ranges and the Bridge Glacier in the upper Bridge River watershed covers about 140 square kilometers. Snow avalanches, debris slides and debris flows are important sources of debris to tributary streams within the Pacific Ranges. Many of the larger streams have a braided pattern, particularly downstream of glaciers where they receive large quantities of coarse sediment. In the Bridge River, this glacial debris is deposited in a large delta at the head of Downton Lake.*

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### **3.2 Biogeoclimatic zones**

The current system of ecosystem classification divides the landscape into ecologically meaningful management units, based on vegetation, climate and physical site characteristics (Lloyd et al 1990). The biogeoclimatic classification system was developed by Dr. V.J. Krajina during the 1970's and has been adopted and revised by the B.C. Forest Service and renamed the Biogeoclimatic Ecosystem Classification (BEC). The BEC divides the landscape into biogeoclimatic zones (BGCZs) that are relatively uniform in composition, structure and properties of both the biotic and abiotic environments and their interactions (Pojar 1983). The BEC organizes our knowledge about ecosystems and provides a common framework for developing integrated resource management strategies (Lloyd et al 1990).

In the Bridge/Seton HMA, biogeoclimatic zones generally follow elevational boundaries with the lower Bridge/Seton area being slightly warmer and drier than the rest of the HMA. Conversely, sections of upper Cayoosh and the south of Anderson Lake are somewhat cooler and wetter than the rest of the study area (Fig 15). Six BGCZs occur within the Bridge/Seton HMA: Ponderosa Pine (PP), Interior Douglas Fir (IDF), Montane Spruce (MS), Englemann Spruce-Subalpine Fir (ESSF), Coastal Western Hemlock (CWH) and Alpine Tundra (AT) (MOF 1992).

### **3.3 Surficial Geology**

There is limited information available on the quaternary geology or the surficial geology of the Seton/Bridge study area. Detailed surficial geology information is limited to the vicinity of dams and powerhouses (Rood and Hamilton 1995).

### **3.4 Regional Hydrology**

The natural hydrologic characteristics have been significantly disturbed by hydroelectric development in both the Seton River and the Bridge River watersheds. Snowmelt is the main source of streamflow and annual peak flows generally occur in June with some variability according to snow pack volume and weather conditions during May-July (Rood and Hamilton 1995).

In the Chilcotin ranges, annual run off is about 200 millimeters with approximately 50% of the annual runoff occurring in May, June and July (Rood and Hamilton 1995). June through Sept have high evapotranspiration rates and therefore little rainfall contributes to streamflows. A maximum daily rainfall of 114 millimeters was recorded at Lillooet in June and maximum rainfall near 60 millimeters have been recorded at Bralorne in July and September (Rood and Hamilton 1995). These intense summer storms are infrequent but may produce flooding after

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the snowmelt season. Annual minimum flows typically occur under ice cover between December and April though in dry summers minimum discharges in small watersheds may occur in July, August or September. In larger watersheds, the minimum discharge nearly always occurs in the winter (Rood and Hamilton 1995).

In the Pacific Leeward Ranges, 80% of the precipitation falls from October to April in the form of rain at lower elevations and snow at higher elevations. Rainstorms that cross the Coast Mountains occasionally produce large floods from August through October. Monthly flows typically decline rapidly after August and annual minimum discharges occur under ice-cover from December through March (Rood and Hamilton 1995).

Rood and Hamilton (1995) developed a sensitivity indices to determine the most sensitive streams from a hydrologic basis. Within the Bridge/Seton HMA, the Bridge River and Cayoosh Creek are the most sensitive systems (Rood and Hamilton 1995). The Bridge River is sensitive to water demands during summer low flows as the maximum daily summer use equals 9% of the mean summer low flows in August. In general, the Bridge River above the Yalakom is subject to problems with low flows as water is derived from springs, groundwater inflows and small tributaries. On Cayoosh Creek, hydrologic concerns include both summer and winter 7 day low flows. Summer and winter low flows are currently less than 10% of the mean flows, which is likely the result of upstream diversion and power production (Rood and Hamilton 1995).

### **3.5 Climate**

Annual normal precipitation in the Bridge/Seton HMA varies considerably from the east to west portion of the study area. The dry interior climate of Lillooet receives annual precipitation levels of 300 to 400 millimeters whereas the upper watershed area of both the Bridge and Seton Rivers in the Coast Mountains receives annual precipitation levels of 2,000 millimeters (Rood and Hamilton 1995).

The Southern Chilcotin Range includes portions of the Yalakom and Bridge River. This area has mean annual temperatures of 9 degrees Celsius in Lillooet. January is the coldest month with mean temperature of -5.6 degrees Celsius with extreme minimum temperatures of -26 Celsius whereas July is warmest with mean temperature of 21 Celsius and extreme maximum temperature of 40 Celsius. Annual precipitation ranges from 300 to 400 millimeters with the greatest amount of precipitation from November through January and the least amount of precipitation from May through July. About 17% of total precipitation falls as snow at Lillooet but increases with elevation to about 40% at Bralorne. The greatest monthly snowfall totals occur in December and January and snow accumulates through to April or May.

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The Pacific Leeward Ranges include the Seton watershed and the upper Bridge River drainage area. Winter temperatures are slightly warmer than Lillooet whereas summer temperatures are cooler. The annual normal precipitation is 1100 millimeters with 25% of the total falling as snow (Rood and Hamilton 1995). Total precipitation and the portion falling as snow increases substantially with elevation.

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## 4.0 REGIONAL RESOURCE USE

The extent of resource development activities and their impact on fisheries values is discussed in the following section. Hydroelectric development has had the single largest long-term impact on fisheries values within the Bridge/Seton HMA. Historical placer mining and hard rock mining development has also been responsible for the destruction of productive creek beds and riparian areas but mining activity has been significantly reduced since the 1970's. Impacts to fisheries values from forestry development have been more site specific relative to hydro development and mining activities. Other resource development activities within the study area that have negatively affected salmonid production include linear development and agriculture.

### 4.1 Forestry

#### 4.1.1 Administration

Forestry is the main industry providing economic activity within the Lillooet Timber Supply Area (TSA) (MOF 1995). The Bridge/Seton HMA belongs to the Lillooet Timber Supply Area (TSA) with the exception of Gates River which is managed as part of the Squamish TSA (MOF 1993). The Lillooet TSA encompasses a total area of 1,124,000 hectares with approximately 25% of the total land base available for timber harvesting under current management practices (Fig 16) (MOF 1993). Non-forest land accounts for 43% of the total landbase, 10% is environmentally sensitive, non-Crown land represents 10% and the remaining 12% is not economical to harvest at this time.

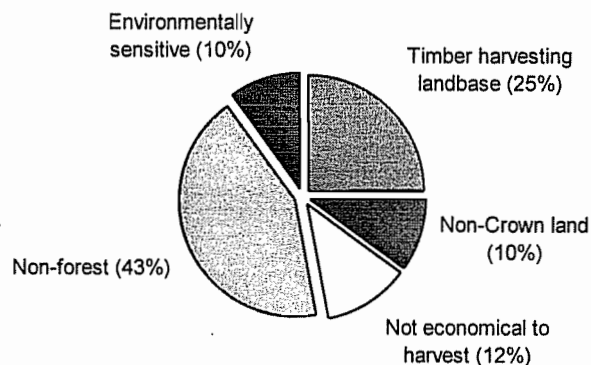


FIGURE 16. Breakdown of Lillooet TSA (MOF 1993).

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The total volume of standing timber within the TSA is approximately 49 million cubic meters of which 47 million cubic meters is currently of merchantable age. The operable area is dominated by spruce, Douglas-fir and lodgepole pine stands.

The major licensee in the Bridge/Seton HMA is Ainsworth Lumber Company with a small proportion of the available timber managed by MOFs Small Business Program (Fig 17) (Georgeson 1996). Ainsworth Lumber and Bridgeside Higa Forest Industries both operate sawmills in Lillooet (MOF 1995).

#### **4.1.2 Current development and future trends**

Less than 10% of the total watershed area is logged within salmon bearing streams located in the Bridge/Seton HMA (Rood and Hamilton 1995). Cayoosh Creek has the highest percentage logged within the study area and logging has been concentrated in Gott and Downton Creeks. Proposed harvesting over the next 5 years equals 1 to 2% in most salmon bearing drainages except for the Yalakom where proposed development will equal 6% of the total watershed area (Rood and Hamilton 1995).

However, the percentage of the total watershed logged can be misleading as the total percentage watershed logged may be low but if forest harvesting activities are concentrated in a small number of sub-basins, drainage specific problems with hydrology, terrain stability or channel stability can negatively impact fisheries values (Table 7). Unfortunately, information on the percentage logged by sub-basin area is unavailable at this time (Georgeson 1996). In addition to harvest history, detailed terrain mapping can minimize road construction and forestry development on steep, unstable slopes. Currently, terrain mapping is only available for a limited portion of the TSA (MOF 1995). The current hydrologic and geomorphologic condition of high priority sub-basins can be determined through the application of the Forest Practices Code Watershed Assessment Procedure.

The current allowable annual cut (AAC) for the Lillooet TSA is 650,000 cubic meters. Given current management assumptions, the Timber Supply Analysis shows the current annual allowable cut (AAC) can be maintained for another 30 years without reducing future harvest levels below the predicted long term level. After 30 years, the harvest begins to decline at 8% per decade until the long-term harvest level is reached in the ninth decade when the Long Run Sustained Yield is equal to 400,000 cubic meters (MOF 1993). However, the TSA analysis does not account for additional reductions to the AAC for biodiversity protection, riparian areas, wildlife habitat and recreation areas as outlined in the Forest Practices Code and the Protected Areas Strategy. Therefore, both the AAC and the LRSY may be further reduced after the impacts from the FPC and the PAS have been incorporated into timber supply analyses.

TABLE 7. Total percentage watershed logged in salmon bearing watersheds (Rood and Hamilton 1995).

| System        | % total logging | % recent logging | Comments   |
|---------------|-----------------|------------------|--|
| Bridge River  | 6               | 4                | Tyaughton Creek = 10% logged   |
| Yalakom River | 6               | 2                | Increasing rate of cut in this watershed. Impacts to riparian habitat have occurred in side drainages such as La Rochelle Creek. Mainline is a source of mudslides/debris flows.   |
| Seton River   | 3               | 3                | Highway 99 encroaches Seton River.   |
| Portage River | 3               | 2                | Forest harvesting has been concentrated in Whitecap and McGillivary Creeks where channel stability problems and slope stability problems have been observed. Debris slides and cross-stream skidding has impacted riparian habitat in both drainages.            |
| Gates River   | 2               | 2                | Forest development has been concentrated in Halymore and Blackwater Creeks   |
| Cayoosh Creek | 9               | 5                | Existing slope failures and increased siltation in Gott Creek and Downton Creek. Rate of cut is increasing in Blowdown Creek and most side drainages are developed to some degree. Potential exists for hydrologic impacts when examined at the sub-basin level. |

#### 4.1.3 Impacts on the fisheries resource

In order to assess the existing impacts of forestry development on fisheries values a more detailed evaluation of the current state of forestry development in the Bridge/Seton HMA is needed. Existing development can be evaluated at the sub-basin level by the Watershed Assessment Procedure (WAP). Watershed assessments can provide necessary information to determine the extent of forestry impacts on fish habitat and DFO has established the following priority list for watersheds requiring a watershed assessment (in decreasing order of importance): Bridge River below the Terzaghi Dam, Yalakom River, Portage River (Whitecap and McGillivary Creeks), Gates River (Halymore and Blackwater), Cayoosh Creek and the upper Bridge River (Lawrence and Cody 1996).

In the Bridge River, upon completion of the first pass in Yankee Creek, some silt delivery from road construction is having moderate impacts to fisheries values (Lawrence and Cody 1996). Within the Bridge River watershed, Carpenter Lake buffers the impacts of forest harvesting activities in the upper watershed on downstream salmon habitat. However, in the upper Bridge River watershed, Hurley Creek is extensively logged and warrants further

investigation to determine the forestry related impacts on resident fisheries values. In the Yalakom River, logging is the major resource development activity as evidenced by a network of old roads and second growth stands.

Within the Seton watershed, major slope failures have deposited large quantities of coarse cobbles into Portage River, narrowing the channel and causing erosion of opposite bank (Rood and Hamilton 1995). In Gates Creek, historical logging and sawmilling has damaged sockeye spawning habitat (Royal 1966). Also within the Gates watershed, hydrologic impacts from forest development in both Halymore Creek and Blackwater Creeks should be examined in more detail by conducting a Watershed Assessment Procedure (Lawrence and Cody 1996). In the lower Seton River, the Ainsworth Mill has resulted in the loss of valuable riparian habitat (Fig 18).

In the Cayoosh drainage, the rate of cut is increasing in Blowdown Creek and most side drainages are developed to some degree. Impacts to the natural hydrologic regime may be detectable at sub-basin level and should be further investigated by conducting a Watershed Assessment Procedure (Lawrence and Cody 1996). In Gott and Downton Creeks, there are existing slope failures and increased siltation from forest harvesting activities (Lawrence and Cody 1996).



FIGURE 18. Ainsworth Mill located on the lower Seton (Photo by M. Sheng).

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## **4.2 Agriculture**

### **4.2.1 Existing Use**

One of the most extensively developed areas for agriculture is the Gates floodplain where small farms are concentrated along the Gates mainstem (Lawrence and Cody 1996). However, in general farming and ranching occur on a small scale within the Lillooet TSA (MOF 1995). The lowermost 7 kilometers of the Yalakom River is sparsely developed with residential and agricultural development (Griffith 1995). The upper Bridge River has limited agricultural potential but some areas are used by commercial operators to graze horses (Chandler 1996).

The largest agricultural employer is Chai-Na-Ta Ginseng Products in the Lillooet area (MOF 1995). The ginseng operation is four years old and employs 40 people on a seasonal basis. Since ginseng can only be grown for 7 years in the same soil due to accumulation of toxins, there is uncertainty whether the ginseng operation will continue to operate in the Lillooet area after this crop (MOF 1995).

### **4.2.2 Impacts on fisheries resource**

Originally providing spawning habitat for 150,000 sockeye, historical agricultural activities degraded salmonid habitat in the Gates River to the extent that only two short stretches of lower river were suitable for spawning (Royal 1966). Current impacts from agricultural activities are limited to the Gates River floodplain where hayfields, pastures and barns are encroaching into riparian areas and rearing habitat and likely increasing suspended sediment loads (Lawrence and Cody 1996). The Gates River has also been riprapped through agricultural areas to control bank erosion and has subsequently reduced the integrity of riparian habitat. In the past, agricultural practices have drained swamp complexes that once provided good rearing habitat for salmonids (Lawrence and Cody 1996).

## **4.3 Urban and Linear Development**

### **4.3.1 Overview**

A total of 5680 people live within the Lillooet TSA (MOF 1995). Primary communities in the Bridge/Seton HMA include Lillooet, Bralorne and Gold Bridge as well as the Bridge River, Cayoosh and Lillooet Native Reserves (MOF 1995). Lillooet is located at the Seton/Fraser confluence and provides residence for 1782 people (Fig 19) (MOF 1995). Lillooet is a forest dependent community with 25% of the population being directly employed by the forest industry. Both Bralorne and Gold Bridge are small communities with less than 100 people and located near the south end of Carpenter Lake. Tourism is the primary source of employment in both towns (MOF 1995).

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The Bridge/Seton study area has an extensive network of roads and most headwater areas are accessible by road (Fig 19). Within the Bridge River watershed, major road systems include Highway 40 connecting Gold Bridge to Lillooet and numerous logging/mining roads throughout the Yalakom River, Tyaughton Creek, Hurley River and Cadwallader Creek. In the Seton drainage, Highway 99 connects Lillooet to Pemberton and a railway, powerline and a logging mainline road are located along the north side of Anderson Lake. There is also a road and railway along Portage Creek and railway along the north side of Seton Lake (Fig 20).

#### **4.3.2 Impacts on fisheries resource**

Impacts to the fisheries resource along Highway 40 in the Bridge River include regular sidecasting of ditch debris and accumulated scree into riparian areas. In addition, the use of calcium chloride appears to be reducing survival and growth of riparian vegetation (Lawrence and Cody 1996).

Within the Seton drainage, urban development on private land in the Gates River near D'arcy includes stream channelization and loss of rearing habitat (Lawrence and Cody 1996). Furthermore, bulldozing for flood protection and powerline construction/maintenance has further reduced the suitability of spawning habitat in the Gates River (Royal 1966, Lawrence and Cody 1996). Fish habitat in the Gates River has also been further degraded by channel confinement from the railway and riprap along stream margins that has reduced the growth of natural riparian vegetation (Lawrence and Cody 1996). Private land development has also degraded or eliminated riparian habitat along the Portage River mainstem (Lawrence and Cody 1996).

Impacts to fish habitat from linear development in the Seton drainage include stream encroachment and degraded riparian habitat from the construction and maintenance of Highway 99. Fisheries values have also been impacted by B.C. Rail's maintenance program which regularly sidecasts ditch debris and discards old tracks and ties into Seton and Anderson Lakes (Lawrence and Cody 1996). The close proximity of the railway to the lakes increases the potential for hazardous waste spills and rockslides into the lake and river. Furthermore, the mainline logging road is poorly maintained and has created problems with increased siltation and restricted access to tributary streams (Lawrence and Cody 1996).

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## **4.4 Tourism and Recreation**

### **4.1 Existing use**

Tourism is becoming increasingly important in the Lillooet TSA as a result of improved highway access by the Duffey Lake Road (Highway 99) from the Whistler ski resort area. The number of tourists traveling to Lillooet increased by 57% between 1991 and 1992 (8860 visits in 1991 and 13,880 visits in 1992) (MOF 1995). With the abundance of scenery and varied landscape, the Lillooet TSA offers tourists and recreationists many outdoor opportunities. Key tourism activities include:

- fishing (particularly for steelhead, sturgeon, trout and salmon);
- hunting (big horn sheep, mule deer and mtn goats);
- mountain climbing, hiking, mountain biking, camping, trail riding and nature viewing;
- white water rafting and
- backcountry skiing and snowmobiling (MOF 1995)

There are approximately 200 cabins and a boat launch that are used seasonally on Gun Lake (Chandler 1996). Tyaughton Lake has a large resort area with 40 cabins, private campground and a Forest Service campsite. Recreational development at Lajoie Lake is limited to a small day use tourist resort (Chandler 1996).

Numerous sportfishing opportunities in the Bridge/Seton HMA include: chinook at the mouth of Bridge River; kokanee on Seton, Anderson, Carpenter and Gun lakes; rainbow trout on most lakes and bull trout in the Hurley River, Marshall Creek and Gun Creek. The Fraser River mainstem provides a high value sturgeon fishery (Maricle 1996).

#### **4.4.2 Impacts on fisheries resource**

The impacts of recreational activities on fisheries values is limited to overfishing of bull trout in Kwoiek Lake. Problems with overfishing can be addressed through the sportfishing regulations and fishing in Kwoiek Lake should be restricted to a catch and release fishery (Maricle 1996).

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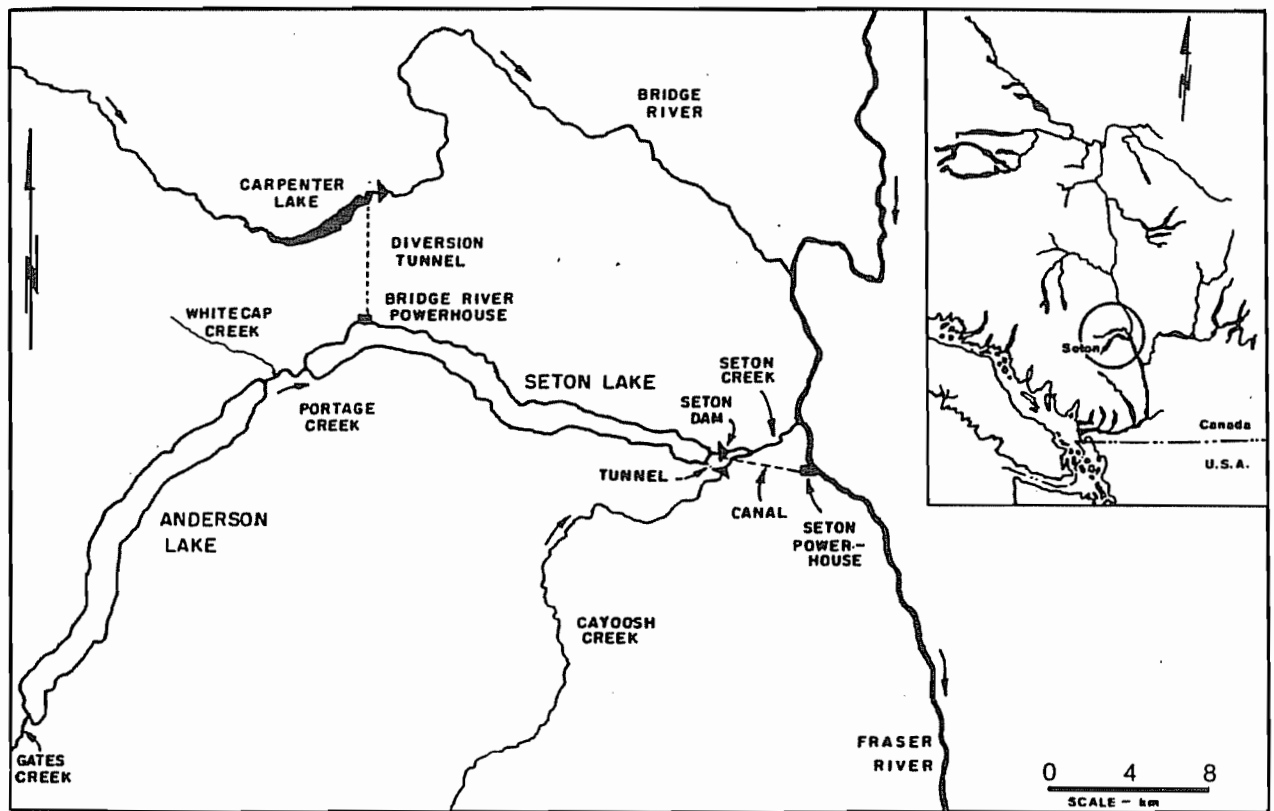
## 4.5 Hydro Development

### 4.5.1 Overview

Hydroelectric development has had the single largest impact of all resource development activities on fisheries resources within the Bridge/Seton HMA. The Bridge River hydroelectric development is the third largest of B.C. Hydro's generating facilities and consists of three dams, two tunnels and a canal between the Bridge River and the Fraser River via Seton Lake (Fig 21).

The history of hydroelectric development in the Bridge/Seton system began in 1934 with an initial diversion of 30 cubic feet per second (cfs) from Carpenter Lake (Bengeyfield 1982, Triton 1992). The water was diverted through a tunnel to a power generating facility at Shalath located on the north shore of Seton Lake (Fig 22). Between 1946-1948, the Mission Dam was constructed at the outlet of Carpenter Lake and eliminated all access to spawning and rearing habitat in the upper Bridge River. Upon completion of the Mission Dam, diversion flows from the Bridge River to Seton Lake were increased to 1,000 cfs (Table 9). In 1948, a second dam and generating plant was constructed by B.C. Electric at Lajoie Falls located at the outlet of Downton Lake (Hirst 1991) (Fig 23). In 1953, B.C. Electric obtained a conditional water license to divert a total of 5400 cfs from the Bridge River. *The water licenses carried no provisions for the release of water for fisheries or any other purpose* (Hirst 1991). By 1954, diverted flows from the Bridge River to Seton Lake were increased to 2200 cfs.

In 1955, a diversion dam, powerhouse and tunnel were constructed in Cayoosh Creek to divert additional flows into Seton Lake (Geen and Andrew 1961) (Fig 24). In 1956, the Seton dam was completed (Fig 25) and in 1960, the Mission Dam was replaced by the Terzaghi Dam. There is no power generating facility at the Terzaghi Dam as flows continue to be diverted through 2 five kilometer tunnels to a power generating facility at Shalath on Seton Lake. From Seton Lake, the majority of water is bypassed through a canal to the Seton generating station on the west bank of the Fraser River (Hirst 1991)(Fig 21). After completion of the Terzaghi Dam in 1967, diverted flows were increased to a final maximum of 5360 cfs (Triton 1992)(Fig 26).



Seton-Anderson Lake system in relation to the Fraser River watershed.

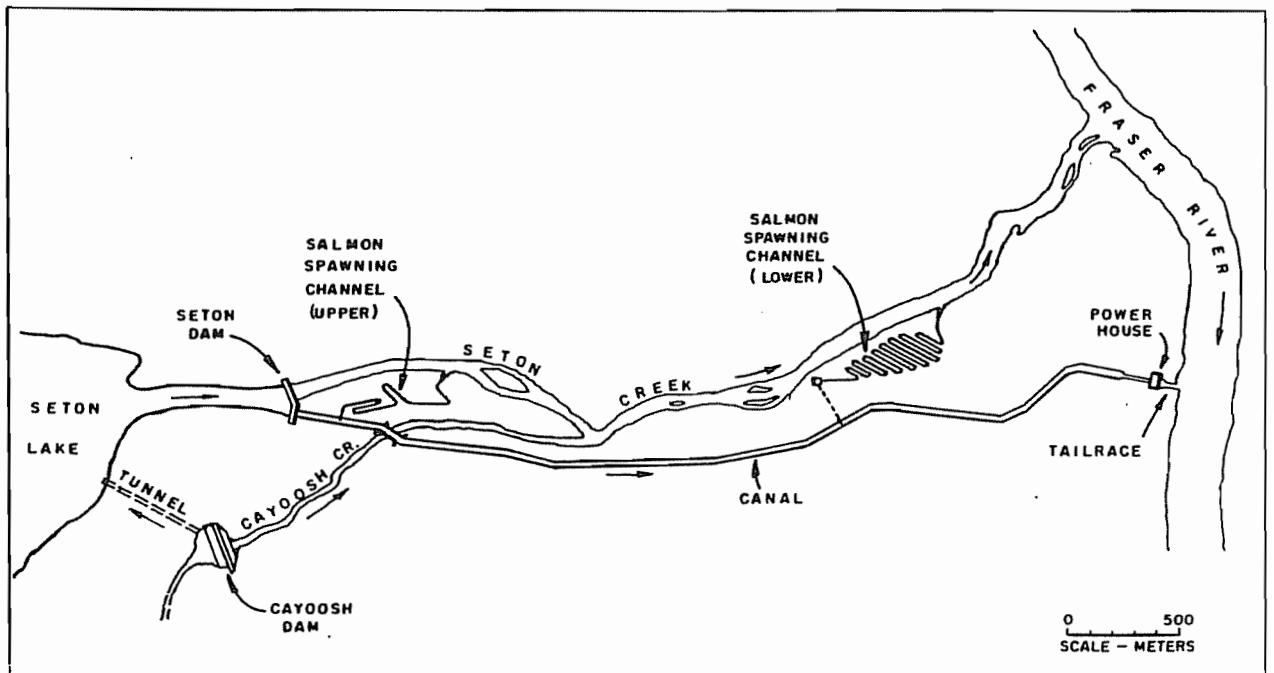


FIGURE 21. Diagram of Bridge/Seton hydroelectric development (Fretwell 1989).

TABLE 8. Timetable of hydroelectric developments in the Seton-Bridge System (Originated from Bengeyfield 1982 + additional references).

| Year    | Activity  |
|---------|---|
| 1934    | First Bridge River diversion of 30 cfs into Seton Lake  |
| 1948    | Construction of Lajoie Dam at a set of impassable falls at the outlet of Downton Lake and construction of a low temporary dam at the outlet of Carpenter Lake by B.C. Electric Company Water (Nielsen and Shepherd 1983, Hirst 1991). The Mission Dam at Carpenter Lake completely blocked passage of anadromous salmonids migrating to the upper Bridge River (Nielsen and Shepherd 1983). |
| 1948-52 | DFO's Fish Culture Branch undertook spawner salvage operations, concentrating on the Tyaughton chinook run. Eggs were outplanted in Gates Creek, Portage Creek and Yalakom River. No financial assistance provided by BCE. DFO improved passage in Yalakom River at kilometer 18 and constructed an eyeing station at the Mission Dam in 1950. (Nielsen and Shepherd 1983).                 |
| 1949    | Bridge River diversion of 1000 cfs into Seton Lake  |
| 1952    | Lajoie Dam increased in height by 16 m to a total of 85 meters, total length was 1034 meters (Nielsen and Shepherd 1983).   |
| 1954    | Bridge River diversions of 2200 cfs   |
| 1955    | Diversion dam and tunnel constructed in Cayoosh Creek   |
| 1956    | Completion of the Seton River hydroelectric development consisting of the Seton Dam, penstocks and a power generating facility located on the Fraser River (IPSFC 1959)   |
| 1958    | Tailrace delay of pink salmon report by Andrew and Geen (1958)  |
| 1960    | Construction of 55 meter high Terzaghi Dam, 2.4 kilometers downstream of the temporary Mission Dam. Flows into the Bridge River were completely cut off except under flood conditions (Nielsen and Shepherd 1983). Final Bridge River diversions of 4500 cfs  |
| 1961    | Logging and mining began in the Yalakom watershed (Nielsen and Shepherd 1983)   |
| 1961    | First (upper) Seton Creek pink salmon spawning channel constructed, Limnological changes in Seton Lake reported by Geen and Andrew (1961)   |
| 1963    | Application for major placer mining lease covering the lower 21 km of the BR refused on the basis of provincial and federal fishery concerns and upheld by the Minister of Mines and Petroleum Resources (Nielsen and Shepherd 1983)  |
| 1963    | IPSFC improved passage for pink salmon in lower BR mainstem   |
| 1967    | Second Seton Creek pink salmon spawning channel constructed. Bridge River diversion flows increased to 5360 cfs (Triton 1992).  |
| 1968    | Cayoosh Creek diversion dam breached and abandoned in Sept, Gates Creek sockeye spawning channel constructed  |
| 1972    | Tailrace delay of sockeye noted by IPSFC  |

TABLE 8. Timetable of hydroelectric developments in the Seton-Bridge System *continued* (Originated from Bengeyfield 1982 + additional references).

|           |   |
|-----------|---|
| 1978      | B.C. Fish and Wildlife requested that B.C. Hydro establish a continuous minimum flow regime downstream of the Terzaghi Dam. B.C. Hydro's response was that this was not economically or mechanically feasible (Nielsen and Shepherd 1983) |
| 1978      | Eight spawning platforms constructed between km 39-44, upstream of Yalakom confluence as joint DFO, BCFW and Dept of Highways project during road widening (Nielsen and Shepherd 1983).   |
| 1979      | Cayoosh Creek diverted with temporary dam (Sept - Nov)  |
| 1980      | Cayoosh dam operated Jul 29 - Dec 12  |
| 1981-1992 | Cayoosh dam operated (Stalberg 1996).   |
|           | Permanent dam and 450 meter concrete-lined diversion tunnel links the forebay of Cayoosh Creek dam to Seton Lake  |
| 1991-1992 | Uncontrolled spills over Terzaghi Dam in both years causing significant impacts to downstream fish and fish habitat.  |
| 1992-1994 | B.C. Hydro conducting mitigative chinook fry release program in the Bridge/Yalakom system.  |
| 1993      | Carpenter Lake Reservoir maximum operating level was reduced by 2.2 meters, reducing spill frequency from 1:3 year event to a 1:5 year frequency (Stalberg 1996).   |

One of the most important differences between the Seton project and the Bridge River development is that the conditional water license for the Seton facility incorporated clauses that stipulated minimum spill discharges of 400 cfs during adult sockeye migration and 200 cfs at other times (Hirst 1991). Conversely, there were no minimum flow releases established for the Terzaghi Dam. In addition, the Seton dam was constructed with the minimum requirements for fish provided with the understanding that additional facilities necessary to maintain fisheries values would be examined after the plant was in operation (Andrew and Geen 1958, Hirst 1991). Another major difference between the two facilities is the provision for access by anadromous salmonids through the Seton Dam (Fig 24) by a fishway whereas the Terzaghi Dam eliminated all access of anadromous fish upstream of the dam.

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## **4.5.2 Impacts to the fisheries resource in the Seton watershed**

### ***Destruction of pink spawning habitat***

The first significant alteration of the pink salmon spawning habitat occurred in 1955 when Seton Creek was diverted from its original channel at the dam site to the completed spillway section of the dam and the forebay of the dam was raised 12 feet to permit operation of the fishway (IPSFC 1959). The increased depth of water coupled with dredging between the dam and Seton Lake destroyed approximately 25,000 square meters of the best spawning habitat between Seton Dam and Seton Lake (IPSFC 1959). An additional loss of 11,000 square meters of spawning habitat in the original channel was compensated by an equal amount in the newly excavated spillway channel (IPSFC 1959).

### ***Reduced productivity in Seton Lake***

The diversion of glacial Bridge River and Cayoosh Creek waters into Seton Lake caused limnological changes in Seton Lake and Seton Creek (Geen and Andrew 1961). Reduced temperatures and dissolved mineral content as well as increased turbidity and flushing rate have been documented in Seton Lake. As well, plankton production appeared to be greatly reduced, primarily the result of a pronounced increase in turbidity (Geen and Andrew 1961). A positive impact of damming Seton Lake has been decreased water temperatures through pink spawning areas in Seton Creek (Geen and Andrew 1961).

### ***Delays at the Seton Powerhouse tailrace***

Sockeye and pink spawners are attracted to the tailrace of the Seton powerhouse, causing delay and injury (Fretwell 1989). The first evidence of serious problems caused by this attraction to the tailrace was noted in 1973 when the Gates Creek sockeye escapement was significantly reduced and a high incidence of head injuries was observed in sockeye spawners (IPSFC 1976). Sockeye preferred to remain in the discharge from the powerhouse because they were attracted to homestream waters from Seton Lake (IPSFC 1976). Cayoosh water is distinctly different from Seton Lake discharge being significantly higher in conductivity, turbidity, alkalinity, hardness, calcium sulphate and fluoride (Fretwell 1980). Sockeye failed to migrate upstream in Seton Creek unless the proportion of homestream water (Seton Lake outflow) was increased to at least 80% for early summer-run (Gates Creek) and at least 90% for the late summer-run (Portage Creek) (Fretwell 1989). The required concentration of homestream water was obtained by diverting Cayoosh Creek to Seton Lake for a portion of the year and occasionally it was also necessary to increase the spill discharge at Seton Dam (Fretwell and Hamilton 1983b). Pink salmon were not affected as severely as sockeye and corrective measures for sockeye are sufficient to avoid serious pink salmon delay and injury (Fretwell 1989).

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***Impingement of adults and juveniles on trashracks immediately in front of the powerhouse and coarse screens located at the upstream end of the power canal***

Salmonids are frequently reported to ascend the fishway into Seton Lake and then attempt to return down the power canal. Access to the power canal is limited by the placement of coarse screens at the upstream end of the power canal during pink spawning years only. Without the coarse screens to limit access, fish descending the power canal become impinged on the debris that accumulates on the trashracks in front of the powerhouse. Evidence of increased natural mortality as a result of the entrapment in the power canal is supported by observation of salmonids within the power canal. In the spring of 1995, a green steelhead was observed in the forebay and on July 4, 1995, 39 live green chinook and one dead chinook were found in the forebay (Stalberg 1996). On October 17, 1991, approximately 50 pre-spawn pink salmon were also observed in the forebay (Stalberg 1996). Another significant recurring problem occurs when outmigrating sockeye smolts, pink fry, chinook fry, rainbow trout as well as mountain whitefish, squawfish, red-sided shiners, suckers and sculpins are impinged on accumulated debris at the powerhouse trashracks (Hirst 1991, Stalberg 1996).

***Mortality of migrating juveniles from passage through powerhouse and dam***

Migrating juvenile sockeye salmon from Seton Lake either pass through the Seton Dam spillway into Seton Creek or through the powerhouse. Theoretical estimates based on adult escapement counts from 1981-1990 indicate that the average number of smolts that pass through the plant each year is 1.6 million (Groves and Higgins 1995). Downstream trapping studies confirm that more than 90-98% of the fish are currently routed through the powerhouse and exposed to impacts of turbine passage (Fretwell and Hamilton 1983a). B.C. Hydro estimates the mortality rate for juveniles migrating through the turbine passage is 17% (Groves and Higgins 1995). However, this mortality estimate for the turbines does not account for significant losses of fish killed or injured in the debris associated with the trashracks (Stalberg 1996).

There are also mortalities associated with Seton Dam. An operating constraint of the Seton facility is to set the fishwater release gate in an overshot position from April 1 to June 30 (Stalberg 1996). This allows juveniles to pass through the release gate by moving over the structure with a 0% mortality rate documented for sockeye smolts (Fretwell 1980). The overshot position reduces the potential for fish to abrade themselves on the concrete sill, be caught in turbulence, avoid pressure change and minimize the impact upon the deflector grill located immediately downstream from the sluice gate (Stalberg 1996). When the fishwater release gate is set at an undershot position, mortality rates range from 7.4% to 10.3% (Andrew and Geen 1958, Fretwell 1980). The fishwater release gate is then set to an undershot position after June 30 to facilitate upstream adult migrants. However, chinook smolts are known to migrate out of the system after the end of June (Stalberg 1996).

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### ***Stranding of salmonid adults, juveniles and eggs***

Rapid downramping of flows by hydroelectric facilities result in stranding of adults and juvenile salmonids and de-watering incubating eggs. In September 1991, additional flows being spilled in the order of several thousand cubic feet per second were shut off through an immediate closure of the gate (Nelson 1997). The resulting decrease in water levels stranded pink adults and dewatered pink eggs (Stalberg 1996). Stranded juvenile trout and salmon species were also observed after the daytime downramping of the Seton River on January 17, 1993 at an average rate of stage change of 12 centimeters per hour. Visual surveys of exposed un-imbedded gravel and cobble bars produced an estimate of 1 fish stranded per 20 square meters of substrate (Bradford et al 1995). Flow decreases during winter months may pose special problems in salmonid streams because rearing juveniles associate closely with either cover or substrate when water temperatures drop below 4 to 8 degrees Celcius. The total stage change during the day is also a determining factor in whether or not salmon are stranded (Stalberg 1996). In general, the rate of decreased flows can strand fish whereas the magnitude of flow changes can affect the viability of spawn (Stalberg 1996).

### ***Uncontrolled spills in Cayoosh Creek***

Uncontrolled spilling into Cayoosh Creek has reduced the available spawning gravels for pink and coho salmon. Spills generally occur when the power plant has an unplanned shutdown or during freshet or winter storm events when the total discharge is greater than the capacity of the tunnel to Seton Lake which equals 1400 cfs (Stalberg 1996). Another problem related to uncontrolled spills is the rapid rate at which the flow is returned through the powerhouse which has resulted in stranding of salmonids (Stalberg 1996).

In 1993, a spawning and rearing channel was constructed as compensation by Walden Power Partnership and ESI Power-Walden Corporation. The channel was designed to provide spawning habitat for coho and pink salmon and rearing habitat for rainbow trout, steelhead, chinook and coho (Stalberg 1996). The spawning channel was not functioning from a biophysical perspective due to sedimentation problems during the winter, bank instability and the lack of adequate riparian cover and function (Kosakoski and Stalberg 1996). The channel was reconstructed and operational by the summer of 1996.

### ***Uncontrolled spills over the Seton Dam***

Peak flows have increased in the Seton River by as much as 40% due to sudden discharges over the spillways and through the radial gate (Hirst 1991). There is limited storage on Seton Lake therefore floods on Gates River and Portage River create spills over Seton Dam into the Seton River (Hirst 1991, Rood and Hamilton 1995). Excessive reductions in the rate of flow delivered to Seton Creek after unscheduled spills have stranded and killed salmonids (Stalberg

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1996). Erosion problems have arisen in Seton River around 1,000 cfs but the extent of erosion is dependent on ramping rates (Stalberg 1995).

#### ***Loss of fish habitat from reduced flows over Seton Dam***

The major habitat component affected by the Seton Creek hydroelectric development is the spawning habitat downstream of the Seton Dam (Hirst 1991). The reduction of flow below the dam to 200-400 cfs has reduced the amount of spawning habitat, representing a loss of about 10% of spawning area available (IPSFC 1959). Historically, the average annual outflow of the Seton River was approximately 660 cfs. A recent instream flow study has been funded by B.C. Hydro at the request of DFO (Triton 1996a).

Pink, sockeye, coho and chinook salmon have been observed using the Seton Creek spawning beds when their upstream migration is delayed as a result of minimum flows released over the Seton Dam (Hirst 1991). There is also a lack of gravel recruitment to the Seton River and as high flows have displaced gravels to downstream areas, there has been a reduction of gravels near the dam without replacement (Stalberg 1996).

#### **4.5.3 Impacts to the fisheries resource in the Bridge River**

Construction of the Terzaghi Dam has severely reduced and degraded spawning and rearing habitat of anadromous salmonids in the Bridge River. In the original water licence, the Bridge River watershed was dedicated to power generation without any request made of the company for compensation due to the loss of fishery resources. Historically, chinook were recorded to have spawned in lower Tyaughton Creek while sockeye and coho spawners utilized the upper Bridge and Hurley Rivers in the mid-1920's (Nielsen and Shepherd 1983). The impoundment of the Bridge River and diversion of all flows except flood peaks has severely altered the salmon production system below Terzaghi Dam (Hirst 1991). Specific quantitative data are not available on the negative impacts to the salmon resource, but the following are likely:

#### ***Loss of spawning and rearing habitat above the Terzaghi Dam***

The major impact of hydro development was the completion of the Mission Dam in 1948 which eliminated access for migrating salmon destined for spawning areas upstream of the dam.

#### ***Uncontrolled spills over Terzaghi Dam***

Since 1961, there has been a spill release on average once every three years. The largest spills have occurred as a result of severe rainstorms when Carpenter Lake reservoir was near full pool level. There were three spill events during 1991, the maximum spill event released

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between 7000-8000 cfs into the lower Bridge River (Stalberg 1996). During 1992, a spill event occurred with a discharge of approximately 2100 cfs. The 1991 spill mobilized large quantities of sediment, eroded riparian vegetation, damaged spawning habitat and deposited sediment along the river (Kosakoski and Stalberg 1996, Rood and Hamilton 1995). Fish were killed during the reduction of flows and similar impacts were observed as a result of the 1992 spill with recently created spawning platforms also degraded (Stalberg 1996). Elevated sediment levels during a spill event also resulted from the inundation of placer settling ponds by flood flows as was observed during the 1992 spill event (Stalberg 1996).

Additional impacts of the Bridge River spills include the effects of elevated suspended sediment levels on the feeding efficiency of invertebrates and availability of interstitial invertebrate habitat. Increased sediment levels can also reduce stream productivity, damage gill tissues in fish, reduce the availability of preferred juvenile salmonid habitat and reduce growth rates in fish (Stalberg 1995).

In 1993, as a result the past impacts of spill damage on fish habitat, B.C. Hydro lowered the maximum target operating level of the Carpenter Lake reservoir by 2.2 meters. This provided a greater buffer for the reservoir during heavy rainfall and uncontrolled spills at the Terzaghi Dam were reduced from an average spill rate of 1 in 3 years to 1 in 5 years (Stalberg 1996).

#### ***Reduction in mainstem spawning and incubation areas***

With the completion of the Terzaghi Dam in 1960, flows into the Bridge River from Carpenter lake were eliminated and approximately 5 kilometers of the upper Bridge River below the dam were seasonally dewatered (Sheng 1996)(Fig 27a, 27b). Pre-impoundment flows in the Bridge River had a mean annual maximum discharge from 250 to 350 cubic meters per second and a mean annual minimum discharge of 15 cubic meters per second (Hirst 1991). In 1964, up to 1000 sockeye and some chinook spawned below the Terzaghi Dam during a spill which rapidly dried up during the incubation period (Nielson and Shepherd 1983). In 1991 and 1992, salmonids spawned during a spill event in an area that became dewatered during the incubation period (Stalberg 1996).

Requests from DFO and the provincial Fisheries Branch for water releases through Terzaghi Dam over the years have been rejected by B.C. Hydro because of the perceived high costs of the forgone power generation and the lack of a suitable outlet for continuous flow releases in Terzaghi Dam (B.C. Hydro 1982). However, ongoing studies and current negotiations between B.C. Hydro, DFO and MELP are striving to determine a strategy to ensure adequate instream flows for the restoration of fish and fish habitat in the Bridge River. A recent instream flow study has been funded by BC Hydro (Triton 1996b) and a review of this study as well as the current water licensing system has been conducted by DFO (Chilibeck 1996). DFO has suggested a flow release schedule which is listed in section 5.1.2.

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***Attraction of adults to the Bridge River tailrace***

Between 1949 and 1953, chinook adults were observed to be gathering at the Bridge River tailraces on Seton Lake at Shalath (Nielsen and Shepard 1983). This may be a continuing problem, especially for pink salmon from the lower Bridge River which subsequently home to Seton Lake. No information on the current extent of such straying is available at this time (Hirst 1991).

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## **4.6 Mineral Resources and Placer Mining**

There has been extensive historical mining exploration and development activities in the Bridge/Seton HMA that has caused the destruction of salmonid habitat. Placer and hardrock mining within the study area has had the second highest impact to the fisheries resource.

### **4.6.1 Regional overview of mining exploration and development**

Mining was historically a major industry for Gold Bridge, Bralorne and several smaller communities in the Lillooet TSA. During the 1850's, people traveled to the Bridge River area in search for gold and by 1880, gold was discovered on the Hurley River and Cadwallader Creek. The trend continued until 1930 when the Bralorne mine became the largest gold producing mine in Canada (Chandler 1996). By 1971, gold mining had slowed down and the Bralorne-Pioneer mine was shut down (MOF 1995).

Primary mineral deposits in the Bridge/Seton HMA are gold, silver, copper and zinc although limestone, mercury, tungsten, and jade have also been mined (MOF 1995, Chandler 1996). In the area surrounding Lillooet, semi-precious gems such as rhodonite, garnet, magnesite and jade can be found. (MOF 1995).

### **4.6.2 Current Trends**

Mineral exploration still occurs on a small scale within the Bridge/Seton HMA. There are approximately 30 people currently working in mining-related industries in the TSA but mining activity is increasing (Smith and Cathro 1995, MOF 1995). There are no metal mines currently operating in the Bridge/Seton HMA but Alvino Mines and Resources Limited is currently in the process of re-opening the Bralorne-Pioneer deposit on Cadwallader Creek (MOF 1995, Madu 1996). The Bralorne-Pioneer mine has substantial reserves remaining with an estimated 965,240 tonnes of ore grading at 9.4 grams of gold per ton (Triton 1992). In addition, numerous placer mining lease applications for small scale operations are received and approved on the Bridge River.

The upper Bridge River has one of the densest concentrations of mineral showings, prospects and past producing mines in the province (Chandler 1996). Exploration has revealed 24 potential mineral occurrences in the area of which three are developed prospects, that have sufficient information to evaluate potentially mineable commodities. These occurrences are located in the headwaters of Holbrook Creek, the south side of Poison Mountain in the Yalakom River and the headwaters of Blue Creek. The remaining 21 occurrences as classed as showings or prospects and have not been well researched at this time (Triton 1992). The region upstream of Terzaghi Dam has 72 showings, 40 prospects, 15 developed prospects and 19 past producers. The main concentration of mineral occurrences and activities are in the

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upper Carpenter Lake area, particularly along the Hurley River, Cadwallader Creek, Traux Creek and Steep Creek (Triton 1992).

The majority of staked placer claims and leases above Terzaghi Dam are located along Cadwallader Creek, Hurley River and along the Bridge River between Downton Lake and Carpenter Lake (Fig 28). Within the last 10 years, placer mining activity has been authorized in the Hurley River, Marshall Creek, Relay Creek and Tyaughton Creek. Most of these claims and leases have approved notices or work but mining activity has not necessarily been undertaken (Triton 1992).

#### **4.6.3 Impacts on fisheries resources**

##### ***Reducing water quality in adjacent watercourses***

The most significant effects of gold mining and processing in the Bridge River area includes the release of residual cyanide in the waste water from the cyanidation process, hydrospheric emissions of arsenic and other heavy metals, suspended solids in waste waters and atmospheric emissions of arsenic, sulfur and tellurium compounds associated with the arsenopyrite ores (Ripley et al 1978 in Triton 1992). Water samples taken during the 1980's identified that drainage from the Bralorne mine and the Congress mine contained high levels of iron, arsenic and sulphate (Chandler 1996). Water samples taken from Carpenter Lake in 1981, 1987 and 1988 also contained concentrations of cadmium, copper and mercury that exceeded provincial water quality guidelines for the protection of aquatic life (Chandler 1996).

##### ***Blocking access to spawning or rearing habitat***

In Cadwallader Creek, the construction of water diversion dams for mineral processing and river channel alteration has the potential to restrict access to potentially productive resident salmonid habitat (Triton 1992).

##### ***Physical alteration of stream channel/riparian habitat***

Placer operations have the potential to disturb channel substrate as well as channel form and bank structure. For example, fish habitat in Ferguson Creek habitat was destroyed by placer mining operations during the 1940s and 1950's (Nielsen and Shepherd 1983, Hirst 1991). Furthermore, large areas within the channel of the Bridge and Yalakom Rivers have been, and continue to be impacted by placer mining operations dating from the previous century (DFO 1962). Placer mining has also disturbed several small sections of riparian habitat in lower Cayoosh Creek (Lawrence and Cody 1996).

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## 5.0 WATERSHED MANAGEMENT PRIORITIES AND RECOMMENDATIONS

Management priorities and recommendations have been developed for each salmon bearing watershed within the Bridge/Seton HMA. Management priorities for each drainage area are numbered and recommendations associated with the management priority have corresponding numbers. **Priorities numbers do not reflect the importance of one priority over another.**

### 5.1 Bridge River

#### 5.1.1 Description

The Bridge River originates in the ice fields of the Coast Mountains and flows east for 154 kilometers before entering into the Fraser River 5 kilometers north of Lillooet. The Bridge River watershed consists of two reservoirs and 5 major tributaries; Tyaughton Creek, Gun Creek, Hurley River, and Cadwallader Creek in the upper watershed and the Yalakom River in the lower river. The largest tributary is the Yalakom River which flows into the Bridge River about 26 kilometers upstream of the Fraser and contributes about 66-90% of the lower Bridge River flows (Nishimura et al 1995b, Stewart and Matthew 1984). Known salmonid species in the Bridge River include: sockeye, coho, pink and chinook salmon, steelhead trout, rainbow trout, dolly varden, lamprey and rocky mountain whitefish (FHIIP 1992, Lister and Beniston 1995). The lower Bridge River is confined to a narrow valley downstream of Terzaghi Dam, partly cut in bedrock but often incised into glacio-lacustrine and glacio-fluvial deposits (Fig 29a, 29b). Ravelling of unconsolidated sediments on steep, high banks that are undercut by the Bridge River and failures in small tributary gullies are important sources of sediment (Rood and Hamilton 1995:4).

Both the Bridge and Yalakom Rivers carry high silt loads derived from slides, glacial outwash deposits, run-off from deforested areas, highway construction, placer mining operations and glacial flour from higher elevations (Hirst 1991). Of particular concern in the Bridge River watershed is the construction of the Terzaghi Dam which has severely reduced and degraded spawning and rearing habitat for anadromous salmonids. Historically, chinook spawners were recorded in lower Tyaughton Creek while sockeye and coho spawners were known to utilize the upper Bridge and Hurley Rivers during the mid-1920's (Nielsen and Shepherd 1983). In addition to hydroelectric development, gold mining activities in the Bridge River continue to potentially have negative impacts on remaining salmonid populations (Hebden 1981). The fisheries values in the Bridge River are slowly being restored by DFO, MELP and B.C. Hydro as well as local community groups and First Nations people.

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### **5.1.2 Management priorities and recommendations for the Bridge River**

#### **Management Priority #1: To establish minimum flow releases for Terzaghi Dam.**

Year round fish releases at Terzaghi Dam would increase the availability of salmonid habitat downstream of the dam. Year round flow releases would also provide a buffer for inflows into the reservoir thereby minimizing the rate of return for spill releases (Stalberg 1995). Releasing water to the lower Bridge River rather than into Seton Lake may reduce turbidity and flushing rates in Seton Lake and result in increased phytoplankton productivity and fish production in Seton Lake. Finally, a flow release through Terzaghi Dam is a start towards restoring the structure and function of natural ecosystem characteristics of the Bridge River below the Terzaghi Dam (Stalberg 1995). The lack of continuous release facilities in the Terzaghi Dam is a major obstacle to improved water management for salmon (Hirst 1991).

Overall salmonid habitat in the Bridge River will be gained by increasing the wetted channel. At this time, overstream cover and instream habitat are limited and restoration of riparian vegetation could also enhance the productivity of the system. However, there is some concern that additional flows from Carpenter Lake may decrease the current productivity of the lower Bridge River downstream of Terzaghi Dam (Sheng 1996). Therefore, there may be tradeoffs between maintaining current salmonid productivity and re-establishing a naturalized flow regime in the lower Bridge River.

#### **Recommendations:**

Recommendation 1-1: Develop a suitable multi-level intake designed to release water of suitable quality and quantity through a flow release structure in the Terzaghi dam for long-term use.

Recommendation 1-2: Propose a range of flow releases that would set a flow regime that represents the pre-development hydrograph and determine the resulting effects on juvenile salmonid spawning and rearing habitat (Table 9). These flow releases provide a starting point and will require refinement over time.

Recommendation 1-3: Re-structure the Bridge River channel below Terzaghi Dam to a more natural configuration that will accommodate the proposed flow regime.

TABLE 9. DFO's proposed instream fisheries flows for the Bridge River (Chilibeck 1996).

| Month       | Proposed instream fisheries mean monthly flow releases (m <sup>3</sup> /s) | Proposed instream fisheries mean monthly flow releases (cfs) |
|-------------|--|--|
| January     | 12   | 424  |
| February    | 12   | 424  |
| March       | 12   | 424  |
| April       | 20   | 706  |
| May         | 30   | 1059   |
| June        | 36   | 1271   |
| July        | 30   | 1059   |
| August      | 22   | 777  |
| September   | 22   | 777  |
| October     | 20   | 706  |
| November    | 12   | 424  |
| December    | 12   | 424  |
| Average MMF | 20   | 706.3  |
| Total       | 630,720,000 m <sup>3</sup>   |  |
|             | 511,533 ac-ft  |  |

**Management Priority #2: Collect comprehensive data on habitat availability and utilization, life history characteristics, adult escapement, juvenile standing stocks and juveniles survival rates**

To determine the impacts of increased flows to the Bridge River below the dam, it is critical to have comprehensive baseline information on the abundance of fish as well as the availability and current utilization of habitat. Although several fish studies have been conducted in the lower Bridge River, many lack the sampling intensity required to produce statistically significant results.

Recommendation 2-1: Construct and operate a counting fence in mainstem as close to confluence with Fraser River as practical.

Recommendation 2-2: Identify and quantify habitat types in the Bridge River mainstem below the dam downstream to Fraser River. Establish index sites in representative rearing habitat and conduct standing crop assessment annually (Nishimura et al 1995a).

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Recommendation 2-3: Continue a coded wire tag recovery program to collect statistically significant life history information and determine exploitation rates on salmon (Nishimura et al 1995b).

**Management Priority #3: To reduce the frequency and magnitude of spills from the Terzaghi Dam.**

Recommendation 3-1: Determine a range of reservoir maintenance levels and their corresponding spill frequency rates. Identify an acceptable frequency of spill releases. Minimize the potential for uncontrolled spills over the dam by increasing the buffer in the reservoir to account for the imprecision of hydrologic forecasting of run-off events (Kosakoski and Stalberg 1996).

Recommendation 3-2: Propose a range of flow releases to evaluate what levels of freeboard in Carpenter Lake are created and compare the effects of minimum flow releases on spill frequencies over the Terzaghi Dam (Stalberg 1995). Monitor operational procedures and flow releases in order to adaptively improve these operations to the benefit of the salmon resource; results, successes and failures should be carefully documented so that other regulated river systems can benefit from the accrued experience (Hirst 1991).

**Management Priority 4: Determine the current rate of forestry development at the sub-basin level**

Recommendation 4-1: Forest licensees and/or the MOF should assess the existing degree of forestry development through the Watershed Assessment Procedure. Evidence of logging induced impacts on fisheries values in Tyaughton Creek, Hurley River and Cadwallader Creek have been noted by DFO which have been identified as priority areas for further assessment. A watershed assessment should be conducted on all sub-basins with either watershed based rate of cut concerns or site specific problems including terrain instability, increased sedimentation, channel instability or extensive riparian development.

**Management Priority 5: Ensure that future placer mining claims in the Bridge River have minimal impacts to instream and riparian fisheries values.**

Recommendation 5-1: Develop a watershed specific set of operating guidelines for placer mining in the Bridge River. These operational guidelines should include direction for minimum setbacks, requirements for stream crossings and restoration requirements.

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## 5.2 Yalakom River

### 5.2.1 Description

The Yalakom is 56 kilometers in length and provides the majority of accessible stream length for salmonids within the Bridge River system. The Yalakom is the principle source of natural, unregulated flows below the Terzaghi Dam (Griffith 1995, Nishimura et al 1995b, Stewart and Matthew 1984) (Fig 29). The Yalakom supports spawning populations of pink, chinook, coho and sockeye salmon, steelhead trout, rainbow trout, bull trout, mountain whitefish (*Prosopium williamsoni*), longnose dace (*Rhinichthys cataractae*) and Pacific lamprey (*Entosphenus tridentatus*) (Griffith 1995).

The stream gradient in the Yalakom is generally very steep, averaging 2.5% over the 15 kilometers most commonly utilized by anadromous salmonids below the partial barrier. The typical annual hydrograph closely follows the cycle of highland snowmelt runoff causing water temperatures to be lower than regional averages. Discharge in the Yalakom River varies from 1.4 to 28.1 cubic meters per second (Hebden 1981). The torrential nature of this stream, low average temperatures and limited fish habitat reduces the production potential in the Yalakom River. However, fish sampling by DFO identified that overwintering hatchery released chinook fry were in above average condition (Conlin 1994).

A partial barrier 15 kilometers upstream of the Bridge River confluence has restricted upstream salmon migration at some flow levels into sections of the Yalakom River that contain the most suitable spawning and rearing habitat. The natural barrier consists of large boulders which have eroded from an unstable hillside that has created a series of cascades for approximately 200 meters (Conlin 1994). At present, salmon migration to the upper sections of the river is believed to be flow dependent and probably improves at lower flows when pools and chutes are present in the section of river containing the barrier (Conlin 1994).

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## 5.2.2 Management priorities and recommendations for the Yalakom River

### **Management Priority 1: Ensure the increasing rate of forestry development will not negatively impact the fisheries resource.**

Recommendation 1-1: Rood and Hamilton (1995) have assigned a high sensitivity index in the Yalakom basin for logging to 1997, relative to other streams in the HMA. The current percentage of the watershed area harvested by biogeoclimatic zone at a sub-basin level should be determined. Field reconnaissance should be conducted in all drainages where hydrological impacts from forestry are suspected. Problems associated with degraded riparian areas, slope failures, road construction/maintenance problems or channel stability should be evaluated further through the watershed assessment procedure. Evidence of logging induced impacts on fisheries values in La Rochelle warrants further assessment immediately.

Recommendation 1-2: The development of a riparian management plan is needed to assist in the protection of fish and fish habitat. The Yalakom is characterized with a large proportion of S5 and S6 streams which require site specific prescriptions for riparian management than that provided in the Forest Practices Code Riparian Management Guidebook (Lawrence and Cody 1996).

Recommendation 1-3: Slope stability problems associated with the Yalakom mainline can be addressed through improved maintenance practices, improved drainage design and stabilization of sideslopes.

Recommendation 1-4: Minimize road construction/harvesting activities in areas where ultramafic rock is present. The ultramafic rock is covered 25 centimeters of volcanic ash which shields the unproductive properties of this rock. There were concerns that disturbance of the ash cover through road building could expose the ultramafic rock and result in leakage of toxic levels of nickel and chromium into the watershed. However, recent research indicates that there is a low risk of toxic leakage (MOF 1995).

### **Management Priority 2: Develop a salmonid enhancement plan for the Yalakom River in conjunction with MELP, B.C. Hydro and other interested stakeholders such as local community groups and First Nations people.**

The plan should identify the goals of the enhancement program, and include details on quantity, species and release location and timing. The plan should identify further studies required to effectively enhance salmonid stocks in the Yalakom and Bridge River system. At the present time, MELP is concerned that improved passage over the partial barrier located 15 kilometers upstream of the Bridge River confluence may displace bull trout populations in the upper Yalakom. Bull trout stocks do not appear to compete well with other salmonid species

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and are therefore vulnerable to immigration of other species. They have evolved the ability to live in habitats where salmon could not survive, such as glacial waters with low productivity. Bull trout have been identified as a conservation concern in the Yalakom River (Maricle 1996).

Recommendation 2-1: Prior to further out-planting of chinook juveniles above the partial barrier at 15 kilometer, DFO and MELP should determine future enhancement levels to ensure the survival of resident species (Conlin 1994).

Recommendation 2-2: Conduct further reconnaissance work to assess chinook migration above the partial barrier. Further assessment is needed to determine what is required to improve fish passage through the barrier (Conlin 1994).

### **5.3 Seton River**

#### **5.3.1 Description**

The Seton-Anderson system discharges into the Fraser River at Lillooet, approximately 200 miles upstream of the Fraser River estuary (Geen and Andrew 1961). The watershed is composed of two large oligotrophic lakes (Anderson and Seton) which are fed primarily by steep gradient tributaries and hydroelectric diversions (Groves and Higgins 1995). Anderson Lake has one major tributary, Gates Creek at southwestern end of the lake. At the outflow of Anderson lake is Portage Creek which flows northeast into Seton Lake. Except in the spring when local inflows are high, the primary source of water into Seton Lake originates from the hydroelectric diversion at Shalath where up to 153 cubic meters per second of water is diverted from the Bridge River on a year round basis. A second smaller diversion of up to 40 cubic meters per second originates from Cayoosh Creek near the outlet of Seton Lake (Groves and Higgins 1995). Glacial silt is present in both Seton Lake and Seton Creek that persists throughout the year (Hebden 1981).

In the past, there were numerous negotiations between B.C. Hydro, the former International Pacific Salmon Fisheries Commission (IPSFC) and DFO to develop a set of operating recommendations for the plant directed towards maintaining pink and sockeye stocks (Hirst 1991). Further negotiations with BC Hydro in conjunction with MELP are required in order to adequately safeguard spawning and incubating salmon in Seton Creek, to permit efficient passage of adult salmon into Seton lake and to facilitate passage of outmigrating salmonid juveniles.

The Seton River is 4.5 kilometers in length and provides spawning and rearing habitat for sockeye, coho, pink and chinook salmon, steelhead/rainbow trout, dolly varden and rocky mountain whitefish. Chinook and coho spawning is concentrated within 1 kilometer of Seton

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Dam and odd year pink escapements of up to 1 million fish utilize the 2 artificial spawning channels (FHIIP 1992).

### **5.3.2 Management priorities and recommendations for the Seton River**

#### **Management Priority 1: To reduce passage of salmonids through the powerhouse and reduce impingement of fish on the trashracks.**

Problems with smolt passage through the powerhouse turbines and impingement on trashracks debris remains to be overcome. Approximately 1.6 million pink fry are estimated to pass through the plant each year (Groves and Higgins 1995). Studies have indicated that strobe lights and sound deterrents (pneumatic poppers and hammers) may be effective in directing fish away from intakes (Hirst 1991). Adult salmonids are also known to move into the powerhouse canal with an unquantified percentage moving through the turbines (Stalberg 1996).

Recommendation 1-1: Prevent mortality of salmonid juveniles and adults by placing permanent screens at the upstream end of the power canal (Kosakoski and Stalberg 1996).

Recommendation 1-2: As an interim measure until screening is implemented, clean the trashracks at the power plant at shorter intervals in order to reduce mortality of outmigrating juveniles (Kosakoski and Stalberg 1996).

Recommendation 1-3: As an interim measure until screening is implemented, restrict adult access into the power canal by placing coarse screens in position annually between August through December. If possible, position them for a greater portion of the year to prevent steelhead and bull trout from moving down into the tailrace (Kosakoski and Stalberg 1996).

#### **Management Priority 2: Reduce adult sockeye and pink delays at the tailrace of the Seton powerhouse.**

Recommendation 2-1: Continue to monitor whether the proportion of homestream water (Seton Lake outflow) equals at least 80% for early summer run Gates sockeye and at least 90% for late summer run Portage Creek sockeye (Fretwell 1989). Monitor fish passage using the fish counter in the Seton dam in conjunction with visual counts of sockeye in the Fraser River tailrace. If fish are holding in the tailrace, the number of fish counted through the fishway should significantly decline (Stalberg 1996). An improved fish counter is required as the existing one is frequently out of order during the sockeye migration period and counts in the tailrace are subjective.

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**Management Priority 3: Minimize stranding of juvenile salmonids during downramping flows**

Recommendation 3-1: Minimize problems associated with ramping flows by researching and applying adequate ramping rates and timing schedules that are suitable for a broad range of salmonid species (Kosakoski and Stalberg 1996). The total stage change throughout the day should not be excessive (Stalberg 1996). Fish stranding can be minimized by reducing flows at night and by slow rates of change (Bradford et al 1995).

**Management Priority 4: Identify and establish adequate fisheries maintenance flow releases through Seton Dam for salmonids**

B.C. Hydro operates 200 cfs (November 16-July 19) and 400 cfs (July 20-November 15) flow scenarios for Seton River (Stalberg 1995). The 200 and 400 cfs flow regime has been assessed for the last 2-3 years but an acceptable fisheries maintenance flow required to protect fisheries values has not yet been determined (Kosakoski and Stalberg 1996).

Recommendation 4-1: Develop a water release schedule through a joint committee between fisheries agencies and B.C. Hydro to approximate a natural hydrograph with increased minimum flows to Seton River (Kosakoski 1994, Stalberg 1995).

**Management Priority 5: Reduce the mortality of outmigrating sockeye smolts in the powerhouse turbines.**

Recommendation 5-1: As an interim measure until proper screening is achieved, BC Hydro's ten day annual maintenance shutdown should be scheduled during late April to early May. The shutdown would then coincide with the peak downstream migration period for sockeye smolts. Upon resumption of power generation, the discharge should continue to follow the natural hydrograph pattern of the creek and satisfy steelhead spawning requirements (Stalberg 1996).

**Management Priority 6: Maximize utilization of spawning and rearing habitat within the Seton watershed.**

Recommendation 6-1: Improve access for large chinook through fishway (Lawrence and Cody 1996).

Recommendation 6-2: Modify pink spawning channels to provide year-round rearing habitat for chinook, coho and steelhead. Modifications include complexing, riparian re-vegetation, addition of rootwads and LOD for cover and removal of stop logs to allow access by juveniles (Lawrence and Cody 1996).

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Recommendation 6-3: Return gravels to the Seton River downstream of the dam (Stalberg 1996).

**Management Priority 7: To accurately enumerate adult spawners passing through the Seton Dam.**

Recommendation 7-1: Replace and/or redesign the fish counter at Seton Dam to permit accurate enumeration and allow unrestricted passage of migrating salmonids. The existing fish counter is frequently out of order.

**Management Priority 8: Reduce the impacts of railway and road maintenance on aquatic and riparian habitat.**

Recommendation 8-1: Develop an acceptable maintenance program to eliminate problems associated with sidecasting of debris, excessive use of calcium chloride, stream encroachment, rockslides, hazardous waste spills and siltation in conjunction with the Ministry of Highways and B.C. Rail

## **5.4 Cayoosh Creek**

### **5.4.1 Description**

Cayoosh Creek is 74 kilometers long and empties into the Seton River approximately 2.5 kilometers above the Fraser River. The average annual discharge varies from 3.6 to 83 cubic meters per second. In 1993, Cayoosh contributed 5% in summer and 12% during the fall to total Seton River flows (Lister and Beniston 1995). Cayoosh Creek provides spawning and rearing habitat to sockeye, coho, pink and chinook salmon, steelhead trout, rainbow trout, dolly varden char and rocky mountain whitefish (FHIIP 1992). The distribution of anadromous species is limited by a hydroelectric diversion dam located 1.6 kilometers upstream of the Seton confluence, which creates a total barrier for migrating adults. A waterfall located at 2.6 kilometers poses a natural barrier to anadromous migration (FHIIP 1992).

### **5.4.2 Management priority and recommendations for Cayoosh Creek**

**Management Priority 1: To restore salmonid spawning and rearing habitat by minimizing uncontrolled spills over the Cayoosh Dam.**

Recommendation 1-1: Establish seasonal diversions and/or partial diversions of Cayoosh flows into Seton Lake as year round diversions of Cayoosh Creek may result in excessive flows into Seton River and insufficient flows into Cayoosh Creek at certain times of the year

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(Kosakoski 1994). Seasonal diversion of Cayoosh Creek should closely simulate the natural hydrograph (Stalberg 1995).

Recommendation 1-2: Ensure more natural flows are maintained in lower Cayoosh Creek by implementing seasonal diversions that comply with concentration limitations of Cayoosh to Seton flows in the Seton River during the sockeye migration period. At the present time, only 20 to 40 cfs is retained in a short section of the channel from the dam to the compensation channel (Kosakoski and Stalberg 1996).

**Management Priority 2: Determine the current impacts of forestry development at the sub-basin level.**

DFO has identified site specific logging induced impacts on fisheries values in Blowdown Creek, Downton Creek and Gott Creek.

Recommendation 2-1: Licensees and/or MOF should determine the extent of forestry development and the site specific impacts on fisheries values in Blowdown, Downton and Gott sub-basins through a watershed assessment procedure or riparian habitat assessment.

**Management Priority 3: Address unresolved operational issues associated with the power plant on Cayoosh Creek.**

Recommendation 3-1: Design and implement an efficient bypass system for diverting creek flows back to Seton lake tunnel in the event of a power outage during the Gates and Portage Creek sockeye migration period between July 20 and November 15.

Recommendation 3-2: Replace or repair the old dysfunctional turbine to divert flows at speed-no-load into the tailrace to reduce the discharge spilled into the creek during power outages.

Recommendation 3-3: Stabilize the berm in the forebay to prevent future failures and degradation of downstream water quality through increased sedimentation.

## **5.5 Portage River**

### **5.5.1 Description**

The Portage River drains Anderson lake, flows for 5.8 kilometers and discharges into Seton Lake. Discharge rates are variable and range from 3.7 to 59.1 cubic meters per second. The Portage Rivers support sockeye, coho, pink, chinook, kokanee and rainbow trout. In 1991, there were a number of debris flows and slides on the north side of Anderson and Seton

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Lakes. Whitecap Creek experienced some major failures and deposited large quantities of coarse cobbles on its fan and the main river (Rood and Hamilton 1995).

### **5.6.2 Management priorities and recommendations for Portage River**

**Management Priority 1: Determine the current rate of forestry development at the sub-basin level.**

Recommendation 1-1: Conduct a reconnaissance to assess existing forestry development and perform a watershed assessment procedure or riparian habitat assessment on those drainages showing significant levels of terrain instability, increased sedimentation, channel instability or degraded riparian habitat. Evidence of logging induced impacts on fisheries values in Whitecap Creek and McGillivray Creek warrants further assessment immediately.

## **5.6 Gates River**

### **5.6.1 Description**

Gates River originates at Gates Lake and drains into the upper end of Anderson Lake, dropping about 600 feet in 9 miles. Total stream length is 15 kilometers of which 14 kilometers has potential anadromous use and supports sockeye, coho, rainbow trout, bull trout and dolly varden (Matthew and Stewart 1987). Fast main channel velocities generally limit juvenile salmonid rearing habitat to extreme edges in most reaches and discharge varies from 1.7 cubic meters per second in winter to 32.9 cubic meters per second in summer (Hebden 1981).

Resource development activities including logging, sawmilling, highway, railway, powerline and bulldozing has removed bedload materials and channelized the stream. Furthermore, development of adjacent lands has also caused severe deterioration of this stream (Royal 1966).

### **5.6.2 Management priorities and recommendations for Gates River**

There have been several years of above average annual peak flows causing floods on Gates River and landowners have been repairing damage to stream banks and removing jams in the river (Rood and Hamilton 1995).

**Management Priority 1: Assess the extent of encroachment by urban development, agriculture, forest and mining development on salmon spawning and rearing habitat in the Gates River mainstem.**

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Recommendation 1-1: Identify restoration techniques to urban and industrial developments that are most beneficial to maintain long-term channel integrity and stability.

**Management Priority 2: Determine the current rate of forestry development at the sub-basin level**

Recommendation 2-1: Conduct a reconnaissance to assess existing forestry development and perform a watershed assessment procedure on those drainages showing significant levels of terrain instability, increased sedimentation, channel instability or extensive riparian development. Evidence of logging induced impacts on fisheries values in Halymore and Blackwater Creek warrant further assessment immediately.

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**APPENDIX A. Historical Escapement Data for the Bridge/Seton HMA**

## A.1 Historical Escapement for Sockeye

| Year | Seton R | Portage R. | Gates R | Cayoosh C | Bridge R | Yalakom R |
|------|---------|------------|---------|-----------|----------|-----------|
| 1953 | 25      | 200        | 74      | unk       | unk      | 0         |
| 1954 | 25      | 3379       | 45      | unk       | unk      | 0         |
| 1955 | 25      | 43         | 77      | unk       | unk      | 0         |
| 1956 | 25      | 25         | 7807    | unk       | unk      | 0         |
| 1957 | 25      | 40         | 891     | unk       | unk      | 400       |
| 1958 | 200     | 4791       | 61      | 445       | unk      | 0         |
| 1959 | 76      | 572        | 582     | unk       | unk      | 25        |
| 1960 | 0       | 0          | 5413    | unk       | unk      | 0         |
| 1961 | 25      | 23         | 248     | unk       | 0        | 25        |
| 1962 | 200     | 11935      | 159     | unk       | 0        | 25        |
| 1963 | 6       | 2011       | 4113    | unk       | 0        | 0         |
| 1964 | 0       | 9          | 19396   | unk       | 0        | 0         |
| 1965 | 75      | 981        | 1642    | unk       | 25       | 25        |
| 1966 | 25      | 31343      | 65      | unk       | unk      | unk       |
| 1967 | 10      | 4025       | 1138    | unk       | 256      | 0         |
| 1968 | 0       | 86         | 10113   | unk       | 142      | 25        |
| 1969 | 0       | 963        | 777     | unk       | 0        | 0         |
| 1970 | 0       | 3873       | 78      | unk       | 0        | 0         |
| 1971 | 0       | 281        | 426     | unk       | 0        | 0         |
| 1972 | 0       | 190        | 8323    | unk       | 0        | 0         |
| 1973 | 0       | 3963       | 795     | unk       | 32       | 0         |
| 1974 | 0       | 8476       | 70      | unk       | 54       | 0         |
| 1975 | 0       | 3175       | 1982    | unk       | 0        | 0         |
| 1976 | 0       | 1042       | 17133   | unk       | 74       | unk       |
| 1977 | 439     | 7610       | 2582    | unk       | 54       | 0         |
| 1978 | 0       | 9978       | 258     | unk       | 300      | 0         |
| 1979 | 30      | 3575       | 3826    | unk       | 200      | 0         |
| 1980 | 75      | 1800       | 25088   | unk       | 125      | 0         |
| 1981 | 25      | 5855       | 4670    | unk       | 2500     | 1200      |
| 1982 | 25      | 23867      | 930     | unk       | 300      | 0         |
| 1983 | 30      | 7747       | 7394    | unk       | 14       | 0         |
| 1984 | 70      | 1551       | 28801   | 6         | 200      | 0         |
| 1985 | 50      | 1703       | 4578    | 6         | 502      | 50        |
| 1986 | 0       | 14291      | 3572    | 0         | 540      | 0         |
| 1987 | 40      | 6820       | 9417    | 0         | 40       | 0         |
| 1988 | 75      | 1068       | 50357   | 0         | 0        | 0         |
| 1989 | 63      | 8082       | 19672   | 63        | 90       | *         |
| 1990 | 125     | 18479      | 6887    | 0         | 1050     | *         |
| 1991 | NI      | 12202      | NI      | NI        | NI       | *         |
| 1992 | 5       | 2795       | 19672   | NO        | 357      | *         |
| 1993 | 380     | 4000       | 18000   | 80        | 7000     | *         |
| 1994 | 250     | 2500       | 4358    | 69        | 1020     | *         |

\* data unavailable and assumed to have little affect on total sockeye escapements to the Bridge/Seton HMA

NO: stream surveyed, none observed, NI: not inspected

References: 1956-1988: Gates and Portage River (DFO 1995a except 1988 Gates: DFO 1994), 1953-1955, 1989: Gates and Portage River (FHIIP 1992, FHIIP 1989), 1990-1994 All Streams: Lillooet stream files (BC 16s), 1990-1996 Portage sockeye, 1989-1994 Seton Creek: DFO Kamloops BC 16 summary sheet.

## A.2 Historical Escapement for Chinook

| Year | Seton R | Portage R. | Gates R | Cayoosh C | Bridge R | Yalakom R |
|------|---------|------------|---------|-----------|----------|-----------|
| 1953 | 25      | unk        | 0       | unk       | unk      | 25        |
| 1954 | 25      | 25         | NO      | unk       | unk      | NO        |
| 1955 | 25      | 25         | NO      | unk       | unk      | unk       |
| 1956 | 200     | 25         | NO      | unk       | unk      | unk       |
| 1957 | 25      | 25         | 0       | unk       | unk      | 75        |
| 1958 | 0       | 200        | 25      | unk       | unk      | unk       |
| 1959 | 25      | 25         | NO      | unk       | unk      | NO        |
| 1960 | 75      | 200        | NO      | unk       | unk      | 75        |
| 1961 | 25      | 200        | NO      | unk       | 0        | 25        |
| 1962 | 25      | 25         | 0       | unk       | 0        | 25        |
| 1963 | 25      | 25         | NO      | unk       | 0        | 25        |
| 1964 | 50      | 80         | 0       | unk       | 0        | 25        |
| 1965 | 75      | 750        | 0       | unk       | unk      | NO        |
| 1966 | 0       | NO         | 0       | unk       | unk      | unk       |
| 1967 | 25      | 50         | 0       | unk       | 0        | 25        |
| 1968 | 25      | 20         | 0       | unk       | unk      | 50        |
| 1969 | 25      | 100        | 0       | unk       | 0        | 75        |
| 1970 | 25      | 150        | 0       | unk       | 0        | 150       |
| 1971 | 25      | 200        | 0       | unk       | 0        | 100       |
| 1972 | 10      | 50         | 0       | unk       | unk      | 50        |
| 1973 | 50      | 50         | 0       | unk       | 0        | 200       |
| 1974 | 25      | 25         | 0       | unk       | 0        | 200       |
| 1975 | 25      | 200        | 0       | unk       | 100      | 450       |
| 1976 | 30      | 70         | 0       | unk       | 300      | 50        |
| 1977 | 70      | 500        | 0       | unk       | 200      | 50        |
| 1978 | 150     | 250        | 0       | unk       | 500      | 170       |
| 1979 | 20      | 100        | 0       | unk       | 200      | NO        |
| 1980 | 75      | 75         | 0       | unk       | 75       | unk       |
| 1981 | 30      | 100        | 0       | unk       | 400      | 80        |
| 1982 | 50      | 150        | 0       | unk       | 80       | 30        |
| 1983 | 24      | 70         | 0       | unk       | 210      | 30        |
| 1984 | 157     | 138        | 0       | NO        | 582      | NO        |
| 1985 | 114     | 225        | 0       | 0         | 956      | unk       |
| 1986 | 105     | 98         | unk     | unk       | 836      | unk       |
| 1987 | 65      | 50         | unk     | 0         | 600      | 25        |
| 1988 | 75      | 125        | unk     | 0         | 638      | 30        |
| 1989 | 115     | 330        | unk     | NO        | 744      | NO        |
| 1990 | 60      | 175        | unk     | NO        | 375      | *         |
| 1991 | 35      | unk        | unk     | 35        | NI       | *         |
| 1992 | 42      | 50         | unk     | NO        | 800      | *         |
| 1993 | 150     | 330        | unk     | 50        | 950      | *         |
| 1994 | 100     | 150        | unk     | unk       | 920      | *         |

\* information not available

References: 1953-1989 FHIIP (1992),  
1990-1994: Lillooet stream files (BC 16's)

### A.3 Historical Escapement for Coho

| Year | Seton R | Portage R. | Gates R | Cayoosh C | Bridge R | Yalakom R |
|------|---------|------------|---------|-----------|----------|-----------|
| 1953 | 0       | 0          | 400     | unk       | unk      | 0         |
| 1954 | 0       | 0          | 25      | unk       | unk      | 0         |
| 1955 | 0       | 0          | 25      | unk       | unk      | 0         |
| 1956 | 0       | 0          | 400     | unk       | unk      | 0         |
| 1957 | 25      | 25         | 2       | unk       | unk      | 0         |
| 1958 | NO      | 25         | 25      | unk       | unk      | 0         |
| 1959 | NO      | NO         | 0       | unk       | unk      | 0         |
| 1960 | 0       | 2          | NO      | unk       | unk      | 0         |
| 1961 | 0       | 25         | 75      | unk       | 0        | 0         |
| 1962 | 0       | 25         | 400     | unk       | 0        | 0         |
| 1963 | 25      | 25         | 75      | unk       | 0        | 0         |
| 1964 | 16      | 30         | 400     | unk       | 0        | 0         |
| 1965 | NO      | 400        | 750     | unk       | unk      | 0         |
| 1966 | 0       | 25         | 400     | unk       | unk      | 0         |
| 1967 | 5       | 25         | 200     | unk       | 0        | 0         |
| 1968 | 0       | 125        | 200     | unk       | unk      | 0         |
| 1969 | 0       | 100        | 300     | unk       | 0        | 0         |
| 1970 | 0       | 150        | 750     | unk       | 0        | 0         |
| 1971 | 0       | 100        | 1500    | unk       | 0        | 0         |
| 1972 | 15      | 100        | 750     | unk       | unk      | 0         |
| 1973 | 0       | 100        | 400     | unk       | 0        | 0         |
| 1974 | 0       | 50         | 1500    | unk       | 0        | 0         |
| 1975 | 0       | 25         | 1500    | unk       | 100      | 100       |
| 1976 | 20      | 80         | 400     | unk       | 250      | 50        |
| 1977 | 30      | 500        | 400     | unk       | 50       | 40        |
| 1978 | 30      | 500        | 1500    | unk       | 1000     | 250       |
| 1979 | 70      | 0          | 1500    | unk       | 80       | NO        |
| 1980 | 25      | 150        | 2000    | unk       | 25       | unk       |
| 1981 | 45      | 150        | 1500    | unk       | 700      | NO        |
| 1982 | 150     | 40         | 500     | unk       | 240      | 30        |
| 1983 | 30      | 80         | 250     | unk       | 240      | NO        |
| 1984 | 91      | 219        | 584     | 40        | 443      | unk       |
| 1985 | 394     | 337        | 475     | 30        | 291      | unk       |
| 1986 | 30      | 70         | 1250    | 40        | 170      | unk       |
| 1987 | 35      | 100        | NI      | 25        | 550      | unk       |
| 1988 | 50      | 175        | NI      | 20        | 850      | unk       |
| 1989 | 20      | 195        | NI      | 25        | 568      | unk       |
| 1990 | 55      | 150        | 150     | 30        | 400      | unk       |
| 1991 | 25      | 100        | unk     | 25        | NI       | unk       |
| 1992 | 68      | 6          | unk     | 20        | 900      | unk       |
| 1993 | 60      | 150        | unk     | unk       | 900      | unk       |
| 1994 | unk     | unk        | unk     | 50        | 850      | unk       |

REF: 1953-1989: (FHIIP 1992)  
 1990-1994 Cayoosh Creek, Gates and Bridge Rivers: Lillooet stream files (BC 16s)  
 1989-1996 Portage Creek: Kamloops DFO Summary Sheets  
 1990-1994 Seton Creek: Kamloops DFO Summary Sheets

#### A.4 Historical Escapement for Pink

| Year | Seton R   | Portage R. | Gates R | Cayoosh C           | Bridge R | Yalakom R |
|------|-----------|------------|---------|---------------------|----------|-----------|
| 1953 | 50,000    | 7,500      | 0       | unk                 | unk      | 0         |
| 1954 |           |            |         |                     |          |           |
| 1955 | 50,000    | 400        | 0       | unk                 | unk      | 0         |
| 1956 |           |            |         |                     |          |           |
| 1957 | 58,810    | 2,010      | 0       | NO                  | NO       | 0         |
| 1958 |           |            |         |                     |          |           |
| 1959 | 14,887    | 52         | 0       | NO                  | 1,201    | 13        |
| 1960 |           |            |         |                     |          |           |
| 1961 | 52,019    | 1,550      | 0       | NO                  | 1,895    | NO        |
| 1962 |           |            |         |                     |          |           |
| 1963 | 107,484   | 8,013      | 0       | 537                 | 6,422    | 0         |
| 1964 |           |            |         |                     |          |           |
| 1965 | 88,046    | 5,931      | 0       | 614                 | 23,657   | 0         |
| 1966 |           |            |         |                     |          |           |
| 1967 | 197,578   | 7,822      | 0       | NO                  | 6,547    | 0         |
| 1968 |           |            |         |                     |          |           |
| 1969 | 180,011   | 1,092      | 0       | NO                  | 13,034   | 0         |
| 1970 |           |            |         |                     |          |           |
| 1971 | 262,534   | 1,456      | 0       | 4,545               | 8,817    | 0         |
| 1972 |           |            |         |                     |          |           |
| 1973 | 179,691   | 13,983     | 0       | 1,336               | 23,718   | 0         |
| 1974 |           |            |         |                     |          |           |
| 1975 | 208,193   | 28,454     | 0       | 1,541               | 10,803   | 2000      |
| 1976 |           |            |         |                     |          |           |
| 1977 | 331,844   | 16,904     | 0       | 9,412               | 25,800   | 0         |
| 1978 |           |            | 96      |                     |          |           |
| 1979 | 498,874   | 51,842     | 1277    | 50,638              | 65,759   | NO        |
| 1980 |           |            | 88      |                     |          |           |
| 1981 | 519,393   | 18,733     | 0       | NO                  | 43,940   | NO        |
| 1982 |           |            |         |                     |          |           |
| 1983 | 371,882   | 10,202     | 0       | 36,746              | 41,909   | NO        |
| 1984 |           |            |         |                     |          |           |
| 1985 | 163,337   | 4,116      | 0       | 6,620               | 61,755   | 100       |
| 1986 |           |            |         |                     |          |           |
| 1987 | 590,261   | 21,117     | *       | 37,705              | 44,200   | 125       |
| 1988 |           |            |         |                     |          |           |
| 1989 | 872,460   | 21,096     | *       | combined with Seton | 104,000  | unk       |
| 1990 |           |            |         |                     |          |           |
| 1991 | 1,321,458 | unk        | *       | *                   | 184,327  | *         |
| 1992 |           |            |         |                     |          |           |
| 1993 | unk       | 4,000      | *       | *                   | 52,000   | *         |
| 1994 |           |            |         |                     |          |           |

\* information not available

REF: 1953-1989: FHIIP 1992

1990-1994: Lillooet office stream files (BC 16s)

1991 Seton: DFO 1994

1991 Bridge: DFO 1995b