Consultative Committee Report

September 2003

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The Consultative Committee for the Bridge River Water Use Plan

Prepared by:

Compass Resource Management and BC Hydro

Bridge River Water Use Plan

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BC Hydro Contact:

Community Relations

Phone: 604 528-1600

Project Team:

Trade-off Analyst and Facilitator:	Lee Failing, Compass Resource Management and Graham Horn, Planit Management
Resource Valuation Task Manager:	Daryl Fields
Aboriginal Relations Task Manager:	Jack Edwards
Power Facilities Task Manager:	Terry Molstad
Power Studies Task Manager:	Paul Vassilev
Community Relations Task Manager:	Barry Wilkinson
Environment/Recreation Task Manager:	Paul Higgins
Environment/Fish Technical Coordinator:	Paul Higgins

Project Manager:

Sue Foster

Phone: 604 528-2737

Fax: 604 528-2905

E-mail: sue.foster@bchydro.com

This report was prepared for and by the Bridge River Water Use Plan Consultative Committee, in accordance with the *Water Use Plan Guidelines*.

The report expresses the interests, values and recommendations of the Consultative Committee and is a supporting document to BC Hydro's Bridge River Water Use Plan that will be submitted to the Comptroller of Water Rights for review under the *Water Act*.

The technical data contained within the Report was gathered solely for the purposes of developing the aforementioned recommendations, and should not be relied upon other than for the purposes intended.

Dedication

To Fraser Lang, Yalakom Community Council

The Bridge River Water Use Plan Consultative Committee would like to honour the memory of Fraser Lang who passed away in the summer of 2002. Fraser's participation on the Consultative Committee mirrored his love for the river and the life it bore. Fraser asked probing and often challenging questions, causing us to look deeper at the information or think harder about our own values. He spoke his mind and was open to learning as well as teaching. He safeguarded collaboration and ensured that all participants were respected and included in decisions. He contributed much. For some of us, our time with Fraser was all too short.

EXECUTIVE SUMMARY

A Water Use Plan (WUP) is a technical document that, once reviewed by provincial and federal agencies and accepted by the provincial Comptroller of Water Rights, defines how water control facilities will be operated. The purpose of a water use planning process is to develop recommendations defining a preferred operating strategy using a participatory process.

The Bridge River Water Use Plan consultative process was initiated in September 1999 and completed in December 2001. The consultative process followed the steps outlined in the 1998 *Water Use Plan Guideline*s. This report summarizes the consultative process and records the areas of agreement and disagreement arrived at by the Bridge River Water Use Plan Consultative Committee (CC). It is the basis for the Bridge River Draft Water Use Plan simultaneously submitted by BC Hydro to the provincial government and the Comptroller of Water Rights.

The Bridge River flows into the Fraser River near Lillooet. The Bridge River hydroelectric system is complex, comprised of:

- three impoundment dams; La Joie, Terzaghi and Seton;
- three reservoirs; Downton, Carpenter and Seton Lake;
- four generating stations; La Joie, Bridge No. 1, Bridge No. 2 and Seton.

In addition, a privately owned generating station, Walden North, is capable of diverting Cayoosh Creek water into Seton Lake Reservoir by means of a tunnel. All components of the system are connected so that changes in operations at one point in the system will affect water flows, operations and environmental impacts elsewhere in the system.

The Consultative Committee was comprised of thirteen members reflecting a variety of interests including: power, recreation, cultural use and heritage sites, fish, wildlife, water quality, socio-economic and First Nations. The Consultative Committee members represented local residents, environmental groups, BC Hydro, and federal and provincial agencies. The consultative process included numerous committee meetings to work through the steps outlined in the *Water Use Plan Guidelines.*

The Bridge River, Seton Lake Reservoir, Seton River and Cayoosh Creek are in the traditional territory of the Stl'atl'imx Nation. Participation by Stl'atl'imx in the Consultation Committee was not continuous throughout the water use planning process (see Section 2.2). However, Stl'atl'imx did attend all Consultative Committee meetings in steps 6 through 8 of the process.

The Consultative Committee explored issues and interests affected by the operations of BC Hydro's facilities and agreed to the following objectives for the Bridge River Water Use Plan:

- Fisheries: Maximize the abundance and diversity of fish in all parts of the system.
- Wildlife: Maximize the area and productivity of wetland and riparian habitat.
- Recreation and Tourism: Maximize the quality of recreation and tourism experience in all parts of the system.
- Power: Maximize the value of the power produced at the Bridge, Seton and La Joie facilities.
- Flood Management: Minimize adverse effects of flooding on personal safety or property.
- Dam Safety: Ensure that facility operations meet requirements of BC Hydro's Dam Safety Program.
- Water Supply/Quality: Preserve access to and maintain the quality of water for domestic and irrigation use.

Performance measures to show movement toward or away from these objectives were identified based on these objectives. Where possible, performance measures were modelled quantitatively. Operating alternatives were then developed to address the various objectives. In total, more than 20 alternatives were run through BC Hydro's operations model and their consequences for each objective were discussed by the Consultative Committee based on the agreed-to performance measures. Preferences and values were documented and areas of agreement sought.

With the exception of one member representing the community of Lillooet[1] (who abstained), Consultative Committee members agreed upon a single recommended operating alternative. The recommended alternative and the operating constraints are outlined in Section 9. As shown in Table 1 and Table 2, the recommended operating alternative includes new operating constraints, relaxation of existing licence constraints, physical works (i.e., a 5-year re-vegetation program) and an active adaptive management program.

[1] The Lillooet resident did indicate in post-meeting communications that he did not disagree with decisions of the Consultative Committee. Stl'atl'imx Nation members indicated a preference to be considered observers rather than Consultative Committee members and provided separate comments on the final outcome.

Table 1: Recommendations of the Bridge River Water Use Plan Consultative Committee

Decision	Description	Level of Support
Base Operating Strategy	Alternative N2-2P	Consensus with one abstention
Lower Bridge River Adaptive Management Program	Flow trials of 3-1-6 m^3/s over an 11-year period with monitoring of fish and wildlife responses	Consensus with one abstention
Seton Generating Station Upgrade	Recommend further study	Consensus with one abstention
Licence Changes	Remove licence restrictions on BR1/2 and SON diversions & La Joie	Consensus with one abstention
Monitoring Program	Implement combined fish/wildlife/water quality program	Consensus with one abstention
Review Period	11 years (at conclusion of flow trials) with check at 5 years to assess need to trigger an early Bridge River Water Use Plan	Consensus with one abstention
Monitoring Committee	Multi-party committee to oversee monitoring and nurture cooperative learning	Consensus with one abstention

The final recommendations for the Bridge River hydroelectric system reflect a balance between fish and wildlife interests in the reservoirs while protecting and enhancing like values in the rivers.

In the main reservoirs, flexibility was maintained although soft targets and guidelines were established. Specifically, minimum and maximum elevations were targeted to mitigate entrainment risks in Downton Reservoir and enhance fish and wildlife conditions in Carpenter Reservoir, respectively. A tension between fish and wildlife benefits became apparent in determining the final operating strategy, resulting in a recommendation for a five-year re-vegetation program to enhance riparian habitat in Carpenter Reservoir.

Maintaining flexibility in the main reservoirs was required in part to manage spills and flows in the three rivers: Middle Bridge River, Lower Bridge River and Seton River. Spill events were of most concern in the Lower Bridge River for fish, wildlife and monitoring reasons; consequently, the recommended operating strategy sets a priority to spill first at Seton River and limits spill events in the Lower Bridge River.

For the Middle Bridge River flow constraints were specified. Determining a flow regime in the Lower Bridge River proved more difficult. Because the Lower Bridge River did not until recently (2002) have regular flows, the understanding of flow needs and ecosystem response is extremely poor. The recommended adaptive management program is intended to improve that knowledge through base flow trials (of 3, 1 and 6 m^3/s) and associated monitoring and provide a basis for a flow prescription in the future.

For the Seton River, a flow shape and magnitude was specified. Operation of the Cayoosh Diversion was assumed to be open year round, but could be modified outside of the key flow mix period to facilitate agreements between Fisheries and Oceans Canada and the management of Walden North generating plant.

As noted in Table 1 the final recommendation of the Consultative Committee includes elimination of existing licence constraints at Bridge 1 & 2 Generating Stations, diversions constraints at La Joie and Seton and restrictions on turbine operations at Seton generating station. These changes all have positive environmental impacts while increasing power benefits. After these changes, power impacts did not vary significantly across the final set of alternatives considered by the Consultative Committee.

Relative to current operations, outcomes of the final recommendations are expected to benefit wildlife habitat, fish conditions, power generation, aesthetics and flood management. No interests are adversely affected by the change in operations.

Table 2: Expected Outcomes of Recommendations

Objective	Summary of Consequences
Flooding	- Reduction in flooding on all rivers, from expected frequency of four days (status quo) to zero (1 year out of 10)
Fish - DOW	- No change
Fish - MBR	- Improvements in whitefish egg survival
Fish - CAR	- 30% improvement in the fisheries index
Fish - LBR	- Reduction in spill frequency and duration on Lower Bridge River
	- Improvement in juvenile salmonid biomass (is a proxy for multiple instream benefits) from a 90% confidence interval of 500 to 1,200 up to 800 to 1,400
Fish - SONL	- No change
Fish - SONR	- Reduction in the frequency of significant negative impacts from operations from nearly 100% of years, to roughly 10% of years. Net effect expected to produce positive population level response in at least some species
	- Significant reduction (about 200 000 annually) in mortality from entrainment in turbines during peak sockeye outmigration; residual mortality at the dam remains at about 2% to 5%; no change to entrainment of outmigrants outside the peak window
Wildlife - DOW	- Preservation of Grizzly Flats
Wildlife - CAR	- Increase of about 500 hectares of new sedge-grass community on Carpenter Reservoir from Gun Creek to Tyax, and enhancements to willow community at upper end of Carpenter Reservoir
	- Improvements for wildlife that rely on sedge-grass and willow communities expected
Fish and Wildlife - Learning	- Implementation of the Lower Bridge River adaptive management program and the system monitoring program will provide key information about the impact of water management on fish and wildlife. This will provide greater certainty for future flow management decisions
Recreation/Aesthetics - CAR	- Increase of about 500 hectares of new sedge-grass community on Carpenter Reservoir from Gun Creek to Tyax
	- Improvements in aesthetics and dust control over about 500 ha

Objective	Summary of Consequences
Water Quality - SONL	- No change
Power	- Gain in annual revenues estimated at $1.8 million per year before monitoring program relative to current operations - Monitoring estimated at an average cost of $560,000 per year (undiscounted) over 11 years, ranging from about $352,000 to $813,000 in any particular year

In addition, the Consultative Committee reviewed the possibility of expanding the capacity of the Seton generating station, based on the availability of water, the desire to manage spills on Seton River and increased flexibility to other parts of the system. Consequently, the Consultative Committee recommended by consensus (with one abstention) that BC Hydro undertake within five years, a detailed feasibility study of an upgrade to Seton Generating Station.

Sources of uncertainty associated with each outcome were discussed by the Consultative Committee. Those most relevant to the decision process and to future decisions were addressed by the Consultative Committee's monitoring recommendations. The major components of the monitoring program support the Lower Bridge River adaptive management program, Carpenter Reservoir riparian vegetation and fish monitoring, and water quality. Specific programs for Downton Reservoir, Seton Lake Reservoir, Middle Bridge River and Seton River were also recommended.

The annual costs of the monitoring plan, including development of detailed terms of references and synthesis of monitoring results, vary from $352,000 to $813,000 with an overall average cost of $560,000 per year (undiscounted) over the period of the plan.

The Consultative Committee recommends that the Bridge River Water Use Plan be reviewed in 2012 at the conclusion of the adaptive management program (11 years). It further recommends that a formal review of the results of the monitoring programs be conducted after the fifth year of implementation. At that time, a recommendation may be forwarded to the Comptroller of Water Rights to trigger an earlier review of the Water Use Plan, if there is evidence of significant unexpected and unacceptable impacts from facility operations at that time.

It is recommended that a Monitoring Committee be formed consisting of representatives of:

- BC Hydro
- Fisheries and Oceans Canada
- Stl'atl'imx Nation
- Ministry of Water, Land and Air Protection
- Public representative (from existing Consultative Committee, if possible)

- Representative of local government (from existing Consultative Committee, if possible)

The Monitoring Committee's mandate should include:

- To review mid-term results and determine need for early Water Use Plan review (Year 5)
- To recommend improvements to monitoring programs within existing budgets (Year 5)
- To review LBR flow trial results (every 4 years)
- To support periodic communication with the public (annual)
- To oversee publication of monitoring reports (as needed, but as a minimum in years 5 and 10)
- To nurture cooperation and collaboration to improve the environmental database and to build common understanding (ongoing)

The task of the Bridge River Water Use Plan Consultative Committee revolved around a very complex hydroelectric system, one that encompasses three reservoirs, three rivers, three impoundment dams and four generating stations. Social, economic and environmental interests were also diverse, adding to the challenge of finding a balance among competing values. The Consultative Committee discovered synergies and some opportunities to modify operations that enhanced all interests simultaneously but it also had to contend with choices between fish, wildlife and recreation. The final result, supported by all (with one abstention), offers the potential to enhance all key objectives relative to current operations. It also builds the foundation for learning and productive communications among interested parties.

We submit this report as a true and comprehensive record of our deliberations and decisions.

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GLOSSARY

1 INTRODUCTION

1.1 Water Use Planning

Water use planning was introduced in 1998 as an approach to ensuring provincial water management decisions reflect changing public values and environmental priorities. A Water Use Plan is a technical document that, once reviewed by provincial and federal agencies and approved by the provincial Comptroller of Water Rights, defines how water control facilities will be operated. The purpose of water use planning is to understand public values and develop recommendations defining a preferred operating strategy using a consultative process. This consultative process is outlined in the *Water Use Plan Guidelines* (Province of British Columbia, 1998).

The Water Use Plan is intended to address issues related to the operations of facilities as they currently exist and incremental operational changes to accommodate other water use interests.[1] Water Use Plans are not intended to be comprehensive watershed management plans or to deal with water management issues associated with other activities in the watershed. Treaty entitlements and historic grievances from facility construction are specifically excluded from Water Use Plans, but can be considered as part of other processes (Province of British Columbia, 2000).

The Bridge River Water Use Plan consultative process was initiated in September 1999 and completed in December 2001. The purpose of the Consultative Committee Report is to document the consultative process and present recommendations of the Consultative Committee. The interests and values expressed in this report will be used by BC Hydro to prepare a draft Water Use Plan proposal for the Bridge River hydroelectric system. This report is a record of the water use issues and interests and the analysis of trade-offs associated with operating alternatives. This report ensures the Comptroller of Water Rights has comprehensive information from participants for use in decision-making. Both the Consultative Committee Report and BC Hydro's Bridge River Draft Water Use Plan will be submitted for review and approval to the Comptroller of Water Rights.

[1] The focus of a Water Use Plan is to determine how water could be allocated to accommodate different uses. However, there may be opportunities to undertake physical works as a lower cost substitute for changes in flow.

This document is structured as follows: The remainder of Section 1 describes the Bridge River system, the hydroelectric facilities and basic hydrology. Section 2 outlines the consultation process. Subsequent chapters follow the basic steps set out in the *Water Use Planning Guidelines*, namely:

- Section 3: Interests, Objectives and Performance Measures.
- Section 4: Studies.
- Section 5: Alternatives and Modelling.
- Section 6: Trade-off Analysis.

Section 7 describes the issue of adaptive management for the Lower Bridge River and Section 8 covers monitoring and sets out the recommended review period for the Bridge River Water Use Plan. Decisions are summarized in Section 9. Several appendices provide additional detail on specific issues.

1.2 The Bridge River System

The Bridge River is approximately 120 km long and flows southeast from the snowfields of Monmouth Mountain in the British Columbia Coast Range to join the Fraser River near Lillooet. The La Joie, Bridge River and Seton hydroelectric developments are collectively referred to as the Bridge River System. Downton Reservoir is impounded by La Joie Dam at the upstream end of the system. All releases from this facility discharge into the Middle Bridge River (MBR) to Carpenter Reservoir. Carpenter Reservoir is impounded by Terzaghi Dam.

From Carpenter Reservoir, water is diverted to the Bridge River Generating Stations (Bridge Generating Station No. 1 and Bridge Generating Station No. 2) via two tunnels through Mission Mountain. Spills from Carpenter Reservoir occur through spill release structures at Terzaghi Dam into the Lower Bridge River which subsequently joins the Fraser River.[1] Thus, spills at Terzaghi Dam remove water from a significant portion of the generating system.

The Bridge River Generating Stations discharge into the Seton Lake Reservoir. At Seton Dam, water is diverted along a 3.7 km power canal to the Seton Generating Station located on the banks of the Fraser River. Spills from Seton Lake Reservoir occur through release structures at Seton Dam into the Seton River, which subsequently joins the Fraser River upstream of the generating station and downstream of the Lower Bridge River.

[1] Low level outlets were installed in Terzaghi Dam in 2000 to enable release of 3 cms. Prior to that time, all (non-spill) water from Carpenter Reservior was diverted to the Bridge River Generating Stations.

For the purposes of the Bridge River Water Use Plan, objectives, performance measures and alternatives were defined for the following parts of the system:

- Downton Reservoir (DOW)
- Middle Bridge River (MBR): The Bridge River between Downton and Carpenter reservoirs
- Carpenter Reservoir (CAR)
- Lower Bridge River (LBR) - Bridge River between Terzaghi Dam and the Fraser River
- Seton Lake Reservoir (SONL)
- Seton River (SONR) - The Seton River between Seton Dam and the Fraser River.

Bridge River generating facilities include:

- La Joie Generating Station (LAJ): At the outflow from Downton Reservoir
- Bridge River Generating Stations No. 1 and No. 2 (Bridge GS No.1&2): At the outflow of Mission Mountain tunnels from Carpenter Reservoir into Seton Lake Reservoir
- Seton Generating Station (SON GS): At the outflow of the Seton power canal from Seton Dam

Therefore, the system comprises:

- three impoundment dams: La Joie, Terzaghi and Seton;
- three reservoirs: Downton, Carpenter and Seton Lake;
- four generating stations: La Joie, Bridge River No. 1, Bridge River No. 2 and Seton.

BC Hydro also has the licence and capacity to divert water made available at the tailrace of a privately owned generating station, Walden North, on Cayoosh Creek into Seton Lake Reservoir by means of a tunnel owned by BC Hydro. Cayoosh Creek discharges that are not diverted to the reservoir join Seton River approximately 500 m downstream of Seton Dam.

Figure 1-1 shows a schematic overview the Bridge River hydroelectric system. The following sub-sections provide more detailed in the system, starting at the "top" of the system, Downton Reservoir.

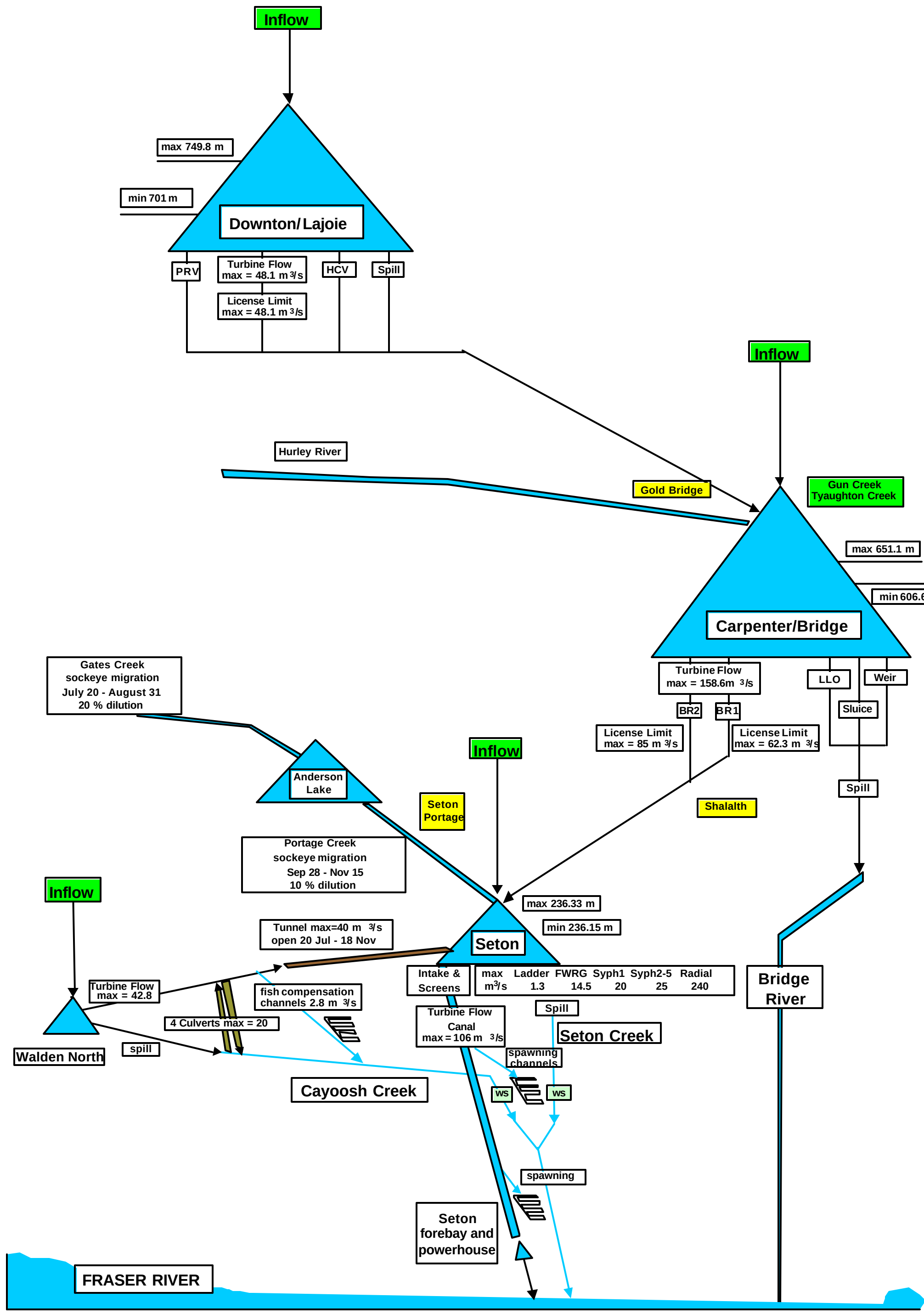

Figure 1-1: Components of the Bridge River Hydroelectric System

1.2.1 La Joie - Downton Reservoir

La Joie Dam is located near Goldbridge, upstream of the confluence of the Hurley and Bridge rivers. The original La Joie Dam was a low earthfill structure built in 1949. The reservoir was named in honour of pioneer surveyor Geoffrey Downton who, in 1912, first recognized the potential for power development. In 1955 the dam was raised to its current height and the powerhouse was completed in 1957. The dam is a rock fill structure with impermeable upstream face of shotcrete over timber.

Operating levels of Downton Reservoir are between 701.0 m and 749.8 m respectively. Since 1997, BC Hydro has attempted to limit drawdown to 710 m, however, lower levels provide the ability to accommodate dam safety, unavoidable maintenance work (e.g., repair of the upstream face) and to evacuate the reservoir as a safety meausure in anticipation of abnormally high snowmelt events. The nominal maximum elevation of 749.8 m represents sill elevation of a free overflow ogee shaped, side channel spillway at the left abutment of the dam. The normal maximum elevation is therefore exceeded whenever free crest spill occurs.

The La Joie Generating Station has a single vertical Francis unit with a rated head of 53.6 m. Maximum turbine discharge is currently limited by water licence to 48.1 m^3/s. Rated output of the unit is 22.4 MW. At reservoir elevations below 749.8 m any planned spills are discharged through two low level outlets equipped with energy dissipating hollow cone valves. The turbine is equipped with a pressure relief valve which is used to protect the penstock from high pressure by maintaining a penstock flow whenever the turbine is suddenly forced out of service. The valve is also used to establish flows to start unit and to maintain fish flows in Middle Bridge River.

As per the current System Operating Orders, Water Licence C12505 provides a total storage of 705.6 x 10^6 m^3 (572 000 acrefeet). Water Licence C23552 provides a total diversion of 48.1 m^3/s (1700 cfs).

Figure 1-2 shows historic (1984-2000) Downton Reservoir elevations and discharges from the La Joie Generating Station.

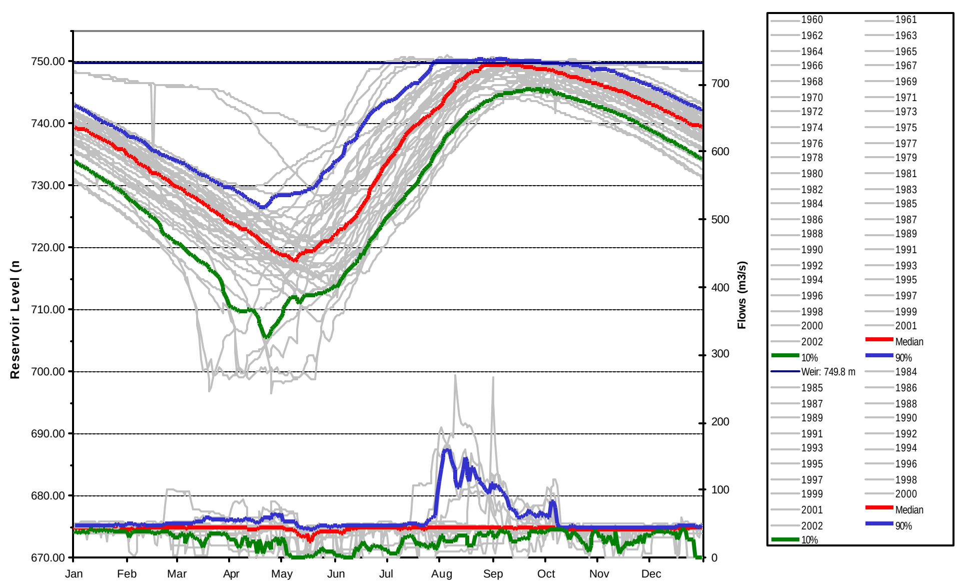

Figure 1-2: Downton/La Joie Historic Reservoir Elevations and Discharges - Summary of 1962-2002

Photo 1-1: La Joie Dam and Powerhouse

1.2.2 Bridge - Terzaghi - Carpenter Reservoir

Work began on this portion of the system in 1927 with the drilling of the first of two 5 km long tunnels through Mission Mountain. The Mission Dam initially built in 1948, was enlarged in 1960 and renamed Terzaghi Dam in 1965, in honour of Dr. Karl Terzaghi, the chief construction and design consultant. The dam is an earthfill structure.

Operating levels for Carpenter Reservoir are currently 610.0 m to 649.8 m. Below elevation 606.6 m, the two low level outlets at Terzaghi Dam are required to fully drain the reservoir. Current operations are planned to avoid frequent encroachment on elevation 648.9 m in order to preserve a 2.2 m flood buffer below the normal maximum elevation of 651.08 m.

Water can be spilled from Carpenter Reservoir by means of two sluice gates (sill elevation 641.7 m), by the two low level outlets (sill elevation 599.7 m) and by the overflow section of the spillway. In 1998, BC Hydro and Fisheries and Oceans Canada signed an interim agreement for the provision of minimum flow for the Lower Bridge River of an annual average discharge of 3 m^3/s. In order to deliver this flow BC Hydro undertook modifications of the low levels outlets and releases commenced 1 August of 2000. Prior to this, uncontrolled spills occurred periodically.

The Bridge River No. 1 and No. 2 generating stations each house four Pelton units and have licensed diversion capacities of 62.3 m^3/s and 85 m^3/s respectively. The Bridge River Generating Station No. 1 units are rated at 46 MW each, and the Bridge River Generating Station No. 2 units are rated at 61 MW each. Total rated generating capacity of the eight units is therefore, 428 MW.[1]

As per the current System Operating Orders, Water Licences C9265 and C19379 provide a total storage of 915.3 x 10^6 m^3 (742 000 acre-feet). Water Licences C9264, C22129 and C23626 provide a total diversion of 147.2 m^3/s (5200 cfs).

Figure 1-3 shows historic (1984-2000) reservoir elevations and discharges from Terzaghi Dam.

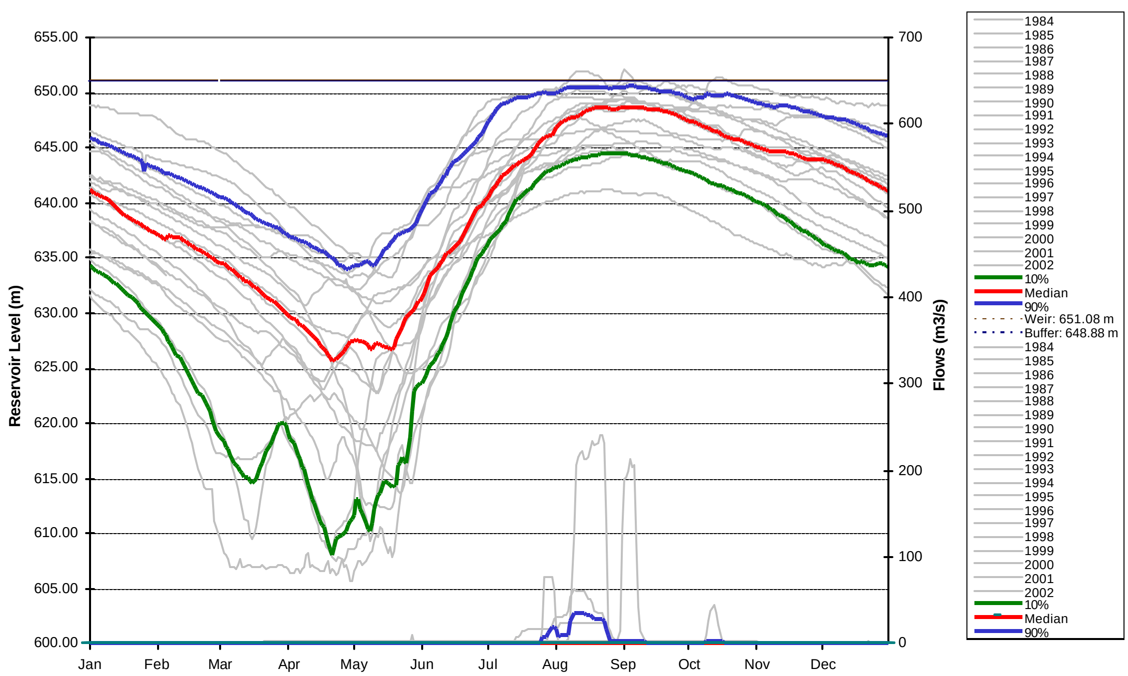

Figure 1-3: Carpenter/Bridge Historic Reservoir Elevations and Spills - Summary of 1984-2002

[1] These are nameplate ratings, actual performance may be higher.

Photo 1-2: Terzaghi Dam and Spillway

Photo 1-3: Bridge River Generating Station No. 1

1.2.3 Seton - Seton Lake Reservoir

Seton Dam is located 23 km downstream from the Bridge River generating stations. Seton Lake was dammed in 1953 to create the Seton Lake Reservoir. The project came into service in 1956.

Seton Lake Reservoir levels have a very narrow operating range between elevation 235.96 to 236.33 m. The reservoir is capable of providing daily flow regulation. Seton Dam is equipped with radial gate, five siphons, a fishwater release gate and a fish ladder. These release facilities are operated in various combinations during spills, and to provide fishery requirements.

At Seton Dam power flows are diverted from Seton Lake Reservoir through a gated intake structure into a 3.7 km long concrete-lined power canal. The canal delivers water to a small intake forebay. The intake forebay can be dewatered by closure of a radial gate. The Seton Generating Station has a single Francis unit with a rated output of 43.6 MW.

As per the current System Operating Orders, Water Licence 21712 provides for 10 000 acre-feet maximum daily diversion, which translates to a maximum daily diversion flow of 143 m^3/s (5040 cfs), and 2 606 284 acre-feet annual diversion, which translates to an average diversion flow of 102 m^3/s (3600 cfs). A flow of 11.3 m^3/s (400 cfs) is to be maintained in Seton River to provide water during the adult salmon migration period. During other times a flow of 5.7 m^3/s (200 cfs) is required to provide cover for incubating salmon eggs. There is no formal storage licence for Seton Lake Reservoir.

Figure 1-4 shows historic spills at Seton Dam.

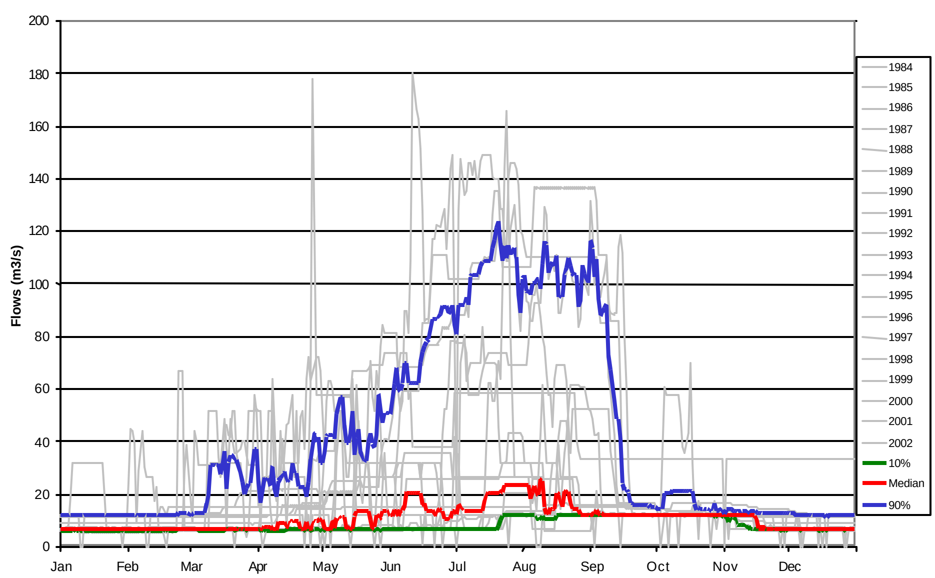

Figure 1-4: Seton Dam Spills - Summary of 1984-2002

Photo 1-4: Seton Dam

Photo 1-5: Seton Generating Station

1.2.4 Walden North

Walden North is owned by Aquila. The hydroelectric plant is located on Cayoosh Creek approximately 2 km upstream of the confluence with the Seton River. The plant is run-of-river. Discharges from Walden North Dam flows into Cayoosh Creek cross under the Seton canal and flows into Seton River downstream of Seton Dam. The canal traverses Cayoosh Creek by means of a concrete aqueduct.

Discharges from the Walden North plant can be diverted into Seton Lake Reservoir by means of 500 m long diversion tunnel. This diversion is required to facilitate the Gates Creek sockeye migration (20 July - 31 August) and the Portage Creek sockeye migration (28 September - 15 November). The fish migrations require a low concentration Cayoosh Creek water in Seton River to attract fish holding in the Fraser River and in the Seton Generation Station tailrace to encourage fish to continue upstream to migrate up Seton River. During the Portage sockeye migration the Cayoosh to Seton ratio is 20% or less and it is 10% or less for the Gates Creek migration.

Photo 1-6: Walden North

2 THE CONSULTATION PROCESS

The Bridge River Water Use Plan consultation process followed the steps outlined in the *Water Use Plan Guidelines* (Province of British Columbia, 1998). These steps, shown in Figure 2-1, represent a structured approach to decision-making.

2.1 Bridge River Water Use Plan Initiation and Scoping

The Bridge River water use planning process was publicly announced on 24 June 1999. The announcement advertisement ran in the Bridge River Lillooet News. In early June 1999, BC Hydro contacted agencies, organizations, industries, local governments, First Nations and other groups soliciting interest in the Bridge River Water Use Plan. Those contacted also suggested others in the community who may be interested. BC Hydro also responded to individuals who inquired about the ad or news release. In addition, a questionnaire was distributed to interested parties for input to the Bridge River Water Use Plan.

Step 1	Initiate a Water Use Plan process for the facility.
Step 2	Scope the water use issues and interests.
Step 3	Determine the consultative process to be followed and initiate it.
Step 4	Confirm the issues and interests in terms of specific water use objectives.
Step 5	Gather additional information on the impacts of water flows on each objective.
Step 6	Create operating alternatives to meet different interests.
Step 7	Assess the trade-offs between operating alternatives in terms of the objectives.
Step 8	Determine and document the areas of consensus and disagreement.
Step 9	Prepare a draft Water Use Plan and submit it to the Comptroller for regulatory review.
Step 10	Review the draft plan and issue a provincial decision.
Step 11	Review the authorized Water Use Plan and issue a federal decision.
Step 12	Monitor compliance with the authorized Water Use Plan.
Step 13	Review the plan on a periodic and ongoing basis.

Figure 2-1: Steps in the Water Use Planning Process

A public information and issues identification workshop was held on 16 October 1999. At this meeting, the consolidated information from the questionnaires, informal meetings, meetings with provincial and federal agencies, e-mail and phone conversations, was used to confirm the issues already identified and to provide an opportunity to raise new issues related to facility operations.

An *Issues Identification Report* (BC Hydro, 1999) was completed and submitted to the Comptroller of Water Rights to complete Step 2 of the *Water Use Plan Guideline*s. Key issues identified are the following:

- Power
- Fish
- Water Quality
- Recreation
- Cultural Use and Heritage Resources
- Socio-economic development
- Wildlife

A number of Information Sessions, Public Meetings and Open Houses were held at the following locations. All events were advertised in the local newspapers.

- Lillooet - 24 June 1999. Gold Bridge - 23 September 1999. Seton-Portage/Shalath - 5 October 1999.
- Gold Bridge - 18 April 2000.
- Seton-Portage/Shalath - 29 May 2000. Lillooet - 30 May 2000.
- Yalacom Community - 18 February 2001.
- Lillooet - 25 June 2001. Seton-Portage/Shalath - 26 June 2001. Gold Bridge - 26 June 2001.

Early in the process, the Consultative Committee Meetings were advertised in the Bridge River Lillooet News on the following dates:

- 22 November 1999
- 16 December 1999
- 31 January 2000
- 28 February 2000
- 8 and 9 May 2000

However, given that the newspaper advertisements did not attract people to the public meetings, this practice was discontinued. Other forms of communication including use of the web site, newsletters, forms of communication and announcement at public meetings were used.

2.2 First Nations Involvement

BC Hydro's Bridge River hydroelectric facilities are located in the traditional territory of the Stl'atl'imx Nation. Stl'atl'imx Nation territory is shown on Figure 2-2 as well as the eleven communities that make up the Nation.

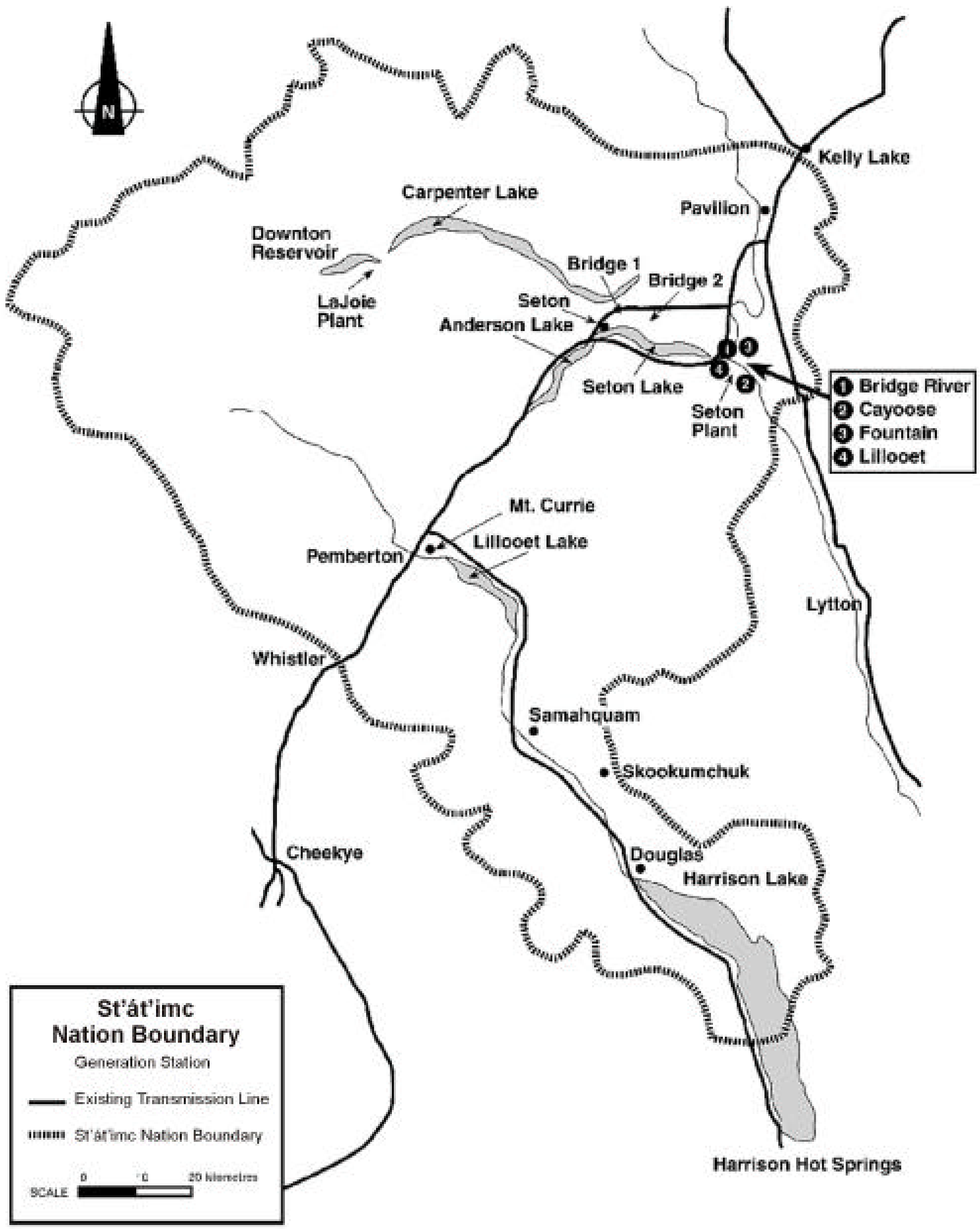

Figure 2-2: Map of Stl'atl'imx Nation Territory

Several of the Stl'atl'imx Nation communities have reserves on the Bridge and Seton Rivers and immediately adjacent to BC Hydro facilities. Stl'atl'imx Nation have asserted their claim to the ownership of this tribal territory since signing of the Declaration of the Lillooet Tribe on 10 May 1911.

Prior to the initiation of the Bridge River Water Use Plan, BC Hydro contacted Stl'atl'imx Nation representatives including the chair of the Stl'atl'imx Nation group involved in negotiations with BC Hydro (Stl'atl'imx Nation Hydro Committee) over past issues with BC Hydro. As a result, Stl'atl'imx Nation representatives attended the initial meetings of the Consultative Committee as observers. In addition, a separate table was established for Stl'atl'imx Nation, which met seven times (Table 2-1).

Table 2-1: Stl'atl'imx Nation Water Use Table Meetings and Major Tasks (to June 2000)

Water Use Plan Step	Meeting Date and Major Tasks	
Step 3	23 November 1999:	Confirm participants, review process, and develop participation agreement.
	17 December 1999:	Develop terms of participation agreement.
Step 4	13 January 1999:	Improve understanding of system operation, and preliminary objectives.
	1 February 2000:	Clarify issues and objectives, define preliminary performance measures.
	29 February 2000:	Clarify issues and objectives, refine performance measures; detailed review of fisheries issues and performance measures.
Step 5-6	20 March 2000:	Refine performance measures (wildlife, recreation/aesthetics); discuss opportunities to use Traditional Ecological Knowledge in Water Use Plan studies.
	7 June 2000:	Review study status to date and identify additional needs, Develop workplan to incorporate Traditional Ecological Knowledge; Discuss Stl'atl'imx Nation concerns with the Water Use Plan process.

In mid-2000, after the 7 June 2000 meeting, the Stl'atl'imx Nation Hydro Committee formally withdrew their participation in the Bridge River Water Use Plan and the First Nation table was discontinued pending a decision by the Stl'atl'imx Nation leadership about whether and in what capacity Stl'atl'imx Nation would participate. BC Hydro continued to provide updates on the Bridge River Water Use Plan and encourage their participation. As well, the Consultative Committee expressed their desire to have Stl'atl'imx Nation participate in the Bridge River water use planning process.

On 12 March 2001, a meeting was convened with Stl'atl'imx Nation to discuss their potential involvement in a Traditional Ecological Knowledge pilot project. Previous internal discussions on the Traditional Ecological Knowledge project had involved Stl'atl'imx Nation. On 1 May 2001, BC Hydro received a letter confirming Stl'atl'imx Nation's willingness to participate in the Bridge River Water Use Plan pending resolution of some outstanding issues including the opportunity to undertake a Traditional Ecological Knowledge pilot project. On 6 June, 13 September, and 9 October 2001, BC Hydro representatives met separately with Stl'atl'imx Nation to update and brief them on the Bridge River Water Use Plan in preparation for upcoming Consultative Committee meetings and to address any issues. Notes of these meetings were prepared and distributed to participants. Members of several Stl'atl'imx Nation communities including Xwisten (Bridge River), Tsalalh (Seton), Sekw'elw'as (Cayoosh Creek) and T'it'q'et (Lillooet) contributed to the Consultative Committee's discussions in September, October and December 2001.

Specifically on 10 and 11 October 2001, the Consultative Committee conducted a trade-off analysis to help in assessing preferences for various operating alternatives. Stl'atl'imx Nation were observers at this meeting. Two representatives of Stl'atl'imx Nation participated in this exercise and subsequent discussions, which resulted in the decision that the preferred alternative would be found by combining elements of two of the six short-listed alternatives. On 3 and 4 December 2001, the Consultative Committee met to make a final decision on a preferred operating alternative. Members from Stl'atl'imx Nation attended the two day Consultative Committee meeting as observers. They participated in discussions, but stated that they were not prepared at that time to indicate their support on a preferred operating alternative, monitoring program or other elements of the Consultative Committee's decisions. On 21 December 2001, Stl'atl'imx Nation met with BC Hydro to review and provide feedback on these items. Notes of that meeting were prepared and distributed to participants.

On 18 January 2002, Stl'atl'imx Nation sent a letter to Lee Failing, the Bridge River Water Use Plan facilitator indicating their concerns and in some cases support for the recommendations made by the Consultative Committee (Appendix I). A key concern raised in the letter was Stl'atl'imx Nation's views of full and informed consent for consultation and agreement which were listed in detail as an example (outlined in Section 6.6). The contents of the letter are documented in various sections of this report (e.g., Sections 6, 7, and 8).

On 4 October 2002, Stl'atl'imx Nation sent a letter to BC Hydro in response to the Draft Consultative Committee Report. The letter states that Stl'atl'imx Nation were participating in the Bridge River Water Use Plan as observers, not as Consultative Committee members.

Traditional Ecological Knowledge Study:[1]

On 27 July 2001, BC Hydro sent a letter to Stl'atl'imx Nation approving Phase 1 of a study project 'Exploring Traditional Stl'atl'imx Ecological Wisdom and its Application to Western Natural Resource Management Practices'. Phase 1 was identified as a literature review of oral testimonies collected as part of existing impact related research and a technical review workshop to enable traditional and western technical experts to review the data gaps and attempt to seek clarification from Knowledge Holders.

[1] The Stl’atl’imx Traditional Ecological Knowledge Study was part of a broader study sponsored by the First Nations Water Use Planning Committee and the interagency Resource Valuation and fisheries Advisory Teams to explore how Traditional Ecological Knowledge could be more effectively incorporated in Water Use Plans.

The Traditional Ecological Knowledge literature review and gap analysis report was completed in October 2001 and the results were presented to the Consultative Committee at the December 2001 meeting. In April 2002, the Traditional Ecological Knowledge workshop was held and focused on the data gaps associated with resident fish stocks in Seton Lake Reservoir. The workshop purpose and agenda is summarized in Appendix J2.

Funding for Phase 2 has not yet been requested or secured and whether it proceeds will depend on a number of factors including the results and success of Phase 1. Through development of a work plan and interviews, Phase 2 would attempt to seek clarification from Knowledge Holders and identify possible opportunities to improve future ecosystem knowledge and management systems. It would be directly related to one or more of the monitoring programs identified by the Consultative Committee.

The study project is expected to contribute to the overall understanding of Stl'atl'imx Nation's Traditional Ecological Knowledge and identify pathways for inclusion in BC Hydro's future water use planning processes for the Bridge River hydroelectric system.

2.3 Committee Structure, Members and Process

The Consultative Committee was initially comprised of 13 members (22 November 1999). As the process advanced, three members withdrew for one of the following reasons:

- Unable to continue their level of involvement due to other priorities. (Canjar)
- Change in responsibilities. (Kartha)
- Change in residence to outside the region. (Mayo)

No member who changed their status expressed unhappiness with the process. One new member joined in November 2000, representing the District of Lillooet. Two people received information, but did not attend as regular Consultative Committee members. Ten members actively completed the process on 3 and 4 December 2001, representing a variety of interests including: power, recreation, cultural use and heritage sites, fish, wildlife, water quality and socio-economic.

Technical issues related to fish, wildlife and recreation were addressed by the Fisheries and Wildlife Technical Committees which met throughout the process. A Recreation subgroup, including community members from outside the Consultative Committee, also met on several occasions to discuss recreational interests.

Appendix A contains a list of Consultative Committee members and alternates, as well as the members of the Fisheries and Wildlife Technical Committees.

2.3.1 Timeline and Milestones

The Consultative Committee met thirteen times between September 1999 and December 2001 to move through the steps outlined in the *Water Use Plan Guidelines*. Table 2-2 highlights meeting dates and main activities.

Between the Consultative Committee meetings, the Fisheries Technical Committee met twelve times. The Wildlife Technical Committee met four times to refine performance measures and discuss study design and findings. A Recreation subgroup met twice to clarify recreation issues, performance measures and studies.

Table 2-2: Consultative Committee Meetings and Major Tasks

Water Use Plan Step	Meeting Date and Major Tasks	
Step 4	4 November 1999:	Confirm participants, review process, and identify interests.
	22 November 1999:	Structure objectives.
	16 December 1999:	Improve understanding of system operation, and Water Use Plan process.
	31 January 2000:	Clarify issues and objectives, define preliminary performance measures.
	28 February 2000:	Clarify issues and objectives, refine performance measures.
Step 5-6	8 May 2000:	Prioritize studies and refine study scope.
	19 June 2000:	Review refined studies, generate preliminary alternatives.
Step 6-7	6 November 2000:	Conduct pilot trade-off analysis.
	6 March 2001:	Review study findings, Round 1 alternatives, refine performance measures and alternatives.
	1 May 2001:	Round 2 alternatives and trade-offs; refine performance measures and alternatives.
Step 7-8	19 September 2001:	Participants briefed on the short-listed alternatives and the nature of decisions that will be expected at next Consultative Committee meeting (information meeting only).
	10 October 2001:	Trade-off Analysis for Rounds 3 and 4 alternatives, Adaptive Management.
	3 December 2001:	Final Recommendations based on Round 5 alternatives; monitoring priorities, areas of agreement and degree of support.

3 INTERESTS, OBJECTIVES AND PERFORMANCE MEASURES

Step 4 of the *Water Use Plan Guidelines* requires the Consultative Committee to express the issues and interests confirmed by the group in terms of specific objectives and performance measures. In defining the objectives, the participants articulate what they are seeking to achieve through a change in operations while the performance measures indicate the specific measurable criteria the Consultative Committee will use to assess impacts of alternative operating regimes on stated objectives.

This section describes the objectives and performance measures developed for the Bridge River Water Use Plan. Section 3.1 documents the objectives and preliminary performance measures (summarized in Table 3-1). As new information was collected, performance measures were refined and modified. These changes are explained in Section 3.2 (summarized in Table 3-2). Section 3.3 documents the objectives and final performance measures and explains the consequence tables used to present the impacts of the alternatives (summarized in Table 3-3).

3.1 Objectives and Preliminary Performance Measures

The Consultative Committee identified the following objectives.

Fisheries: Maximize the abundance and diversity of fish in all parts of the system.

- Minimize direct operational impacts.
- Provide habitat conditions to maintain and enhance fish populations.
- Learn more about the impacts of hydroelectric operations on fish populations and habitat.

In the reservoirs, direct operational impacts that could affect the abundance and diversity of fish populations include entrainment into turbines, backwatering of tributaries flowing through the drawdown zone and stranding in isolated pools as a result of reservoir drawdowns, both of which may result in stress or mortality. In rivers, main concerns are related to mortality from rapid fluctuations in water levels and large or frequent spill events displacing eggs or juvenile fish.

Habitat conditions that could affect fish populations in reservoirs include littoral and pelagic productivity, which provide a source of food for various species, and access to tributary spawning habitat which affects reproductive success. In Seton Lake Reservoir, sediment laden water from the Bridge system diversions may affect habitat. In rivers, the effects of operations on spawning and juvenile habitat are a concern.

The Bridge River system was not managed for any "priority" species. As a result, the Bridge River Water Use Plan attempted to take a holistic approach to the Bridge system, rather than manage "priority" species. The Bridge River Water Use Plan focused on maximizing habitat conditions, and minimizing sources of direct mortality/stress as a means of improving both abundance and diversity. However, there is a great deal of uncertainty about the relationship between habitat/mortality factors and fish populations. Very early in the process technical experts emphasized the lack of good information linking operations to fish habitat and population response. As a result, the Consultative Committee set learning as an explicit objective of the Bridge River Water Use Plan. No performance measure was specifically defined; however the learning objective influenced decisions related to adaptive management on the Lower Bridge River and the prioritization of monitoring programs.

Fisheries performance measures are discussed in more detail in Appendix B.

Wildlife: Maximize the area and productivity of wetland and riparian habitat.

- Minimize direct operational impacts.
- Provide habitat conditions to maintain and enhance wildlife populations.
- Learn more about the impacts of hydroelectric operations on riparian vegetation.

The most significant effect of water use decisions on wildlife occurs through the effect of reservoir operations on riparian habitat. The frequency and duration of inundation will significantly affect the extent and type of vegetation communities that develop in the deltaic areas at the upper ends of Downton and Carpenter reservoirs and on several large tributary fans in these reservoirs. A large wetland area in Downton Reservoir known as Grizzly Flats was identified as an important wildlife area, and the desire to maintain suitable habitat conditions in the Downton Reservoir area for grizzly bears was noted to be consistent with regional planning priorities (Land Resource Management Plan process)[1]. On Carpenter Reservoir, recent operations have resulted in the development of vegetated areas in the "buffer zone," particularly the western-most end of the reservoir. This demonstrated the potential to create additional riparian vegetation, given a suitable reservoir regime.

[1] Refer to Ministry of Sustainable Resource Management for Lillooet Land Resource Management Plan for further information.

Similarly, on the Lower Bridge River and Seton River, the frequency and duration of inundation from high flow or spill events will affect riparian vegetation survival and wildlife populations that use the river.

Direct operational impacts on wildlife include spills which may displace stream-dependent wildlife (e.g., harlequin ducks, beavers, etc.), and rapid changes in water levels from ramping.

Recreation and Tourism: Maximize the quality of the recreation and tourism experience in all parts of the system.

- Maximize abundance and diversity of fish and wildlife.
- Maximize safety and aesthetic quality of recreational experiences.

The abundance and diversity of fish and wildlife are a key driver of recreational quality in the region. As such, performance measures for fish and wildlife were recognized as important from a recreation and tourism perspective.

- Multiple factors were considered under safety and aesthetic quality. Initial concerns included:
- Temperature and water clarity on Seton Lake, which affects safety and desirability of swimming and water related activities;
- Exposed mudflats and dust storms on Carpenter Reservoir, which affects visual quality and is seen as a deterrent to tourism potential;
- Boat access on Downton and Carpenter reservoirs, which could be affected if the Bridge River Water Use Plan resulted in significant changes in water elevations;
- Boating safety and shore access/aesthetics, specifically as affected by floating debris;
- Erosion of beaches and shoreline facilities and loss of beach area on Seton Lake Reservoir.

Power: Maximize the value of the power produced at the Bridge, Seton and La Joie facilities.

- Maximize revenues from power production.
- Preserve ancillary service capability.

Maximizing annual revenue from power production was the primary power objective. Preserving ancillary service capability was also identified. BC Hydro and the Province indicated a concern that if operational changes are proposed under the Bridge River Water Use Plan that could affect their capability to provide ancillary services,[1] then these service reductions would need to be explored and considered in decision-making.

Flood Management: Minimize adverse effects of flooding on personal safety or property.

- Minimize frequency and magnitude of spills of sufficient magnitude to affect people or property.

The flooding objective is related to the effects of operational spills on people or property. The region is not densely populated, but there are roads and some property that can be affected by large spills. This objective does not refer to catastrophic flooding from dam failures. It is also distinct from the effects of spills on fish and wildlife.

Dam Safety: Ensure that facility operations meet the requirements of BC Hydro's Dam Safety Program:

- Minimize the impacts of dam safety activities on other objectives.

Dam safety concerns were raised early in the process. Most concerns were related to understanding the risks associated with dam failures and improving the quality of communications and plans in the event of a failure. These were largely addressed by non-Water Use Plan BC Hydro regular operations meetings in the community concurrent with, but separate from, the Bridge River water use planning process. From a Bridge River Water Use Plan perspective, the key objective was to ensure that operating changes do not jeopardize dam safety. Some participants also recommended that if and when dam safety activities (e.g., maintenance, etc.) are required, a collaborative approach with management agencies should occur to minimize negative effects of emergency drawdowns.

Water Supply/Quality: Preserve access to and maintain the quality of water for domestic and irrigation supply.

- Prevent changes in contaminant levels or mobilization of contaminants that would adversely affect domestic or irrigation uses.

Water from the Seton River is a secondary source of domestic drinking water for the Village of Lillooet. Water from Seton Lake is also used by some local residents for drinking. Water use changes were not expected to result in changes to the supply (e.g., quantity) of water available, but concerns were raised about the quality of water. Specifically, concerns were related to the possibility of introducing or mobilizing contaminants from one part of the system to another

[1] Ancillary Services are the fundamental physical and electrical capabilities, mainly supplied by generators, needed to maintain the reliability of large and small interconnected power systems. They are essential services needed to match exactly the production of electric power with the demand for power, to transmit power from one location to another, to reduce the risk of outages and to expedite service restoration.

(e.g., from Downton or Carpenter reservoirs, into the Lower Bridge River or Seton Lake).

Other Issues

Road Safety: The Consultative Committee also discussed the possibility of an objective related to safety of road transportation around Carpenter Reservoir. The safety of this road was viewed by some as a significant issue that affects local quality of life, as well as tourism potential. However, after extensive discussion and exploration of the factors contributing to road safety, the Consultative Committee agreed that changes to the use of water will not significantly affect road safety. In March 2001, the local Reservoir Safety Committee (RSC) requested an opportunity to make a presentation to the Consultative Committee. On 16 May 2001, a letter was sent by the Bridge River Water Use Plan facilitator to the Chair of the Reservoir Safety Committee indicating that their request to present had been considered by the Consultative Committee and declined because road transportation issues including the important issue of road safety are not within the scope of water use planning; they are footprint as opposed to operating issues. These issues, while considered critically important by the Consultative Committee, could not be effectively addressed through water use changes.

On 22 October 2001, the Squamish Lillooet Regional District Board (SLRD) passed a resolution directing the RSC to attend the next Consultative Committee meeting to present their position on reservoir safety. On 19 November 2001, BC Hydro responded to the SLRD that the facilitator would review the SLRD resolution with the Consultative Committee at the next meeting to be held on 3 December 2001. If the Consultative Committee determined that there is value in hearing the RSC's presentation, then the item will be scheduled on 4 December 2001. No one from the SLRD attended the 3 or 4 December 2001, Consultative Committee meeting, as they felt they were not provided sufficient notice of the meeting.

At the 3 and 4 December 2001, Consultative Committee meeting, the road safety issue was further discussed. The Consultative Committee confirmed that the water use planning process was not the appropriate forum to deal with the issue. The Consultative Committee's mandate is to determine water allocations across all classes of water users and to review the consequence operational impacts to the Bridge River hydroelectric system.

Seton Lake Reservoir Erosion/Licence Compliance: The Consultative Committee extensively discussed issues related to erosion on Seton Lake Reservoir at several points in the process. However, after review of several technical reports, it was agreed that issues related to erosion cannot be addressed through water use changes. Separate processes exist for resolving those concerns are underway between landowners and BC Hydro. The related issue of a storage licence on Seton Lake Reservoir was also raised in the Consultative Committee.

However, after some discussion it was agreed that the wording of and compliance with licences was a matter directly for the Comptroller of Water Rights and outside the scope of the Bridge River Water Use Plan. Interested Consultative Committee members then communicated directly with the Comptroller.

Table 3-1 summarizes the interests, objectives and performance measures for the Bridge River Water Use Plan at the end of Step 4. Performance measures are specific to location, reflecting the unique factors affecting the objectives in each segment of the system.

Performance measures were modified after Step 5, on the basis of better information gained from studies. Changes to and definitions of the final performance measures are discussed in Section 3.2.

Table 3-1: Preliminary Performance Measures (to end of Step 4)

Interest	Objective	Location	Performance Measures
Fish	Maximize the abundance and diversity of fish in all parts of the system	DOW and CAR	- Littoral (shoreline) Productivity (grams carbon produced per year)
			- Pelagic (open water) Productivity (grams carbon produced per year)
			- Tributary Spawning Success/Backwater Risk (hectares backwatered)
			- Entrainment Risk (unitless)
			- Stranding Risk (hectares of isolated pools)
		SONL	- Spawning Success (tonnes sediment inflow per year)
			- Pelagic Productivity (tonnes carbon per year)
			- Entrainment Risk/Mortality
		MBR	- Adult Habitat (hectares, by species)
			- Juvenile Habitat (hectares, by species)
			- Spills (weighted index, reflecting frequency, magnitude, timing)
		LBR and SONR	- Spawning Habitat (hectares, by species)
			- Juvenile Habitat (hectares, by species)
			- Spills (weighted index, reflecting frequency, magnitude, timing)
			- Passage (Seton River only)
Wildlife	Maximize the area and productivity of wetland and riparian habitat	CAR and DOW	- Wildlife Habitat Index (hectares, by habitat type, weighted by habitat value to wildlife and summed to weighted index)
		LBR and SONR	- Wildlife Habitat Index (hectares, by habitat type, weighted by habitat value to wildlife and summed to weighted index)
			- Wildlife Spills (Weighted Index reflecting frequency, magnitude, timing; indicates instream displacement risks)

Interest	Objective	Location	Performance Measures
Recreation and Aesthetics	Maximize the quality of the recreation and tourism experience in all parts of the system	CAR and DOW	- Area of exposed mudflats (hectares) - Access to boat launch (# days per year)
		SONL	- Temperature change (degrees or degree-days) - Turbidity/clarity - depth of light penetration (metres) - Area of accessible beach (hectares) - Debris
Power	Maximize the value of the power produced at Bridge River and La Joie facilities		- Annual revenues ($ per year) - Availability of ancillary services (Reduced? - Yes/No)
Flood Management	Minimize adverse effects of flooding on personal safety or property	MBR LBR SONR	- Frequency or probability that water levels exceed those that will result in property damage
Dam Safety	Ensure that facility operations meet the requirements of BC Hydro's Dam Safety program		- Dam safety requirements met - Yes/No?
Water Supply/ Quality	Preserve access to and maintain the quality of water for domestic and irrigation supply	SONL LBR	- Risk of contaminant mobilization (metric to be determined)

3.2 Final Performance Measures

The performance measures listed above were used to prioritize studies. Upon completion of the studies, they were modified and used to assess the first two rounds of alternatives. As the process progressed, the list of active performance measures was iteratively reduced in number. Elimination of performance measures from the active list occurred for one or more of the following reasons:

- the performance measure was shown to be insensitive within the range of alternatives under consideration by the Consultative Committee;
- the performance measure was strongly and consistently correlated with another performance measure, such that one could serve as a proxy for both;
- the magnitude of impact was small relative to other performance measures;
- studies or analysis conducted through the course of the process demonstrated the impact described by the performance measure to be smaller than originally believed and hence not of significant concern;

- the ability of the performance measure to report even the correct direction of response was seriously questioned, such that an alternative measure was required.

The rationale for revising or removing performance measures from the active list is described below along with the final performance measures that were used to make trade-offs among final alternatives. The evolution of performance measures is summarized in Table 3-2.

3.2.1 Fish

Carpenter and Downton Reservoirs

Littoral Productivity (tonnes of carbon produced per year): This performance measure reports the total mass of carbon that is produced each year in the littoral zone of the reservoir. Exactly how fish abundance or diversity will respond to carbon is uncertain. However, it was generally assumed that higher levels of carbon production would contribute to higher abundance and diversity of fish.

Pelagic Productivity: Uncertainty exists around key food pathways for several fish species of interest. However, studies indicated that pelagic production was underutilized by the fish community in Carpenter, suggesting that operations need not be managed to increase it. In Downton Reservoir, conditions for rainbow trout were of particular concern, which rely most on littoral production. Thus littoral productivity was adopted as the performance measure for reservoir productivity in both reservoirs and pelagic productivity removed as an active performance measures.

Enstrainment Risk (unitless): Stranding and entrainment were both of concern. However, stranding in Downton and Carpenter reservoirs was found to co-vary strongly and consistently with entrainment. As a result, the Entrainment performance measure was changed (in name only) to Enstrainment, and it was used to represent risk factors associated with both stranding in isolated pools and entrainment. The higher the value of this performance measure, the greater the risk. In Carpenter and Downton reservoirs, enstrainment risk is a function of reservoir volume and discharge rate. The higher the volume and the lower the discharge rate, the lower the enstrainment risk. It follows then that lower volumes increase risk.

Tributary Spawning Success/Backwatering Risk (kilometres backwatered per year): This performance measure reports the tributary length in kilometres that is backwatered after spawning and before the end of the incubation period. It is calculated for Downton and Carpenter reservoirs for the spring spawning period for rainbow trout. Eggs that are backwatered in this period are at risk of mortality. Increases in the backwatering index can be interpreted as an increase in risk of egg mortality.

Carpenter/Downton Fish Index (scale of 0-100): The Fisheries Technical Committee weighted each of the above performance measures (Littoral, Enstrainment, Backwatering) for Carpenter and Downton reservoirs. Using these weights, a normalized weighted sum was calculated, resulting in a score on the CAR/DOW Fish Index of between 0 and 100 (0=bad; 100=good). This score represents a summary indicator of the relative ranking of the alternatives with respect to fish impacts. Appendix B1 contains a description of the methods and results of the fisheries performance measures weighting exercise.

Seton Lake Reservoir

Entrainment: Entrainment of fish at Seton Lake Reservoir turbines is a significant issue. However, studies and modelling indicated that entrainment can be significantly reduced by implementing a minimum of 25 m^3/s release at the dam during the peak sockeye smolt outmigration period. Further analysis showed that this flow could be provided at very small cost and with no negative impact on any other performance measure. It was agreed by consensus after Round 2 that all alternatives would be modelled with the 25 m^3/s minimum flow. As a result, all of the final alternatives perform equally with respect to entrainment at Seton Lake, and the performance measure was removed from the active list.

Pelagic Productivity and Spawning Success: The Pelagic Productivity and Spawning Success performance measures both vary inversely with sediment inflow, as does Water Quality. All three of these performance measures co-vary. It was agreed to use the Water Quality performance measure (see below) to represent concerns associated with Pelagic Productivity and shore Spawning Success.

Middle Bridge River

Fish performance measures originally included Juvenile Habitat, Adult Habitat and Spill Impacts. Across the range of alternatives under consideration, these performance measures did not vary and were removed from the active list. The potential risk of egg dewatering was identified as another impact of concern in the Middle Bridge River, and it was a factor in setting flow changes, discharge rates and timing at Round 5.

Lower Bridge River

Fish performance measures originally included Juvenile Habitat, Spawning Habitat and Spill Impacts. Due to lack of confidence in the ability of habitat performance measures to correctly report the direction of fish response, these performance measures were removed. The Fisheries Technical Committee was directed to develop an experimental program to test alternative flow regimes (adaptive management) rather than select a single flow regime on the basis of current information (see Section 6).

Spills (Yes/No): This performance measure, initially constructed as a weighted index reflecting frequency, magnitude and timing of spills, was not easy for participants to interpret. To use it effectively, it would have required modification. Given the decision to move toward an experimental approach in the river, this was not deemed necessary or useful. For the Rounds 4 and 5 trade-off analysis, the Consultative Committee set an upper limit on acceptable spills on the Lower Bridge River as follows.

- spills not to exceed 20 m^3/s, 50% of the time;
- spills not exceed 50 m^3/s, 10% of the time.

The performance measure used was simply a yes/no indication of whether the spill limit was respected. The limits represented upper limits beyond which an alternative would be clearly unacceptable, <u>not</u> limits below which it was agreed that there would be no impacts.

Juvenile Salmonid Biomass (kg/year): For evaluating the adaptive management program on Lower Bridge River, the performance measure used was a probabilistic estimate of Juvenile Salmonid Biomass (see Section 7 for more details). This performance measure was not used to select the base operating strategy, only to assist in designing the Adaptive Management program and evaluating its benefits.

Seton River

The Juvenile, Habitat and Spawning Habitat performance measures were initially proposed as good proxies for fish abundance and diversity in Seton River. After reviewing the first round of alternatives, the Fisheries Technical Committee reported lack of confidence that these habitat performance measures were reporting the correct direction of fish response, and acknowledged that any attempt to use these performance measures would overstate their degree of knowledge about what kind of flow regimes are good for fish in Seton River. What Fisheries Technical Committee members could say with confidence was that provided flows remained between 5 and 60 m^3/s, the most important factor affecting fish productivity was the shape of the hydrograph, with hydrographs more closely mimicking the natural hydrograph preferred. The habitat performance measures were therefore replaced by performance measures reporting the shape and magnitude of the hydrograph.[1]

[1] The effect of Seton fluctuations on potential shore spawining kokanee was discussed early in the process. Available information and First Nations knowledge suggests these are deep water spawners, not shore spawners (data gap).

Hydrograph Shape (0-1): This performance measure is an index that reflects the degree to which the shape of the hydrograph is similar to the shape of a natural, pre-regulation hydrograph. A higher score represents a better shape, which is expected to provide better spawning and rearing habitat as well as other cues important for fish productivity.

Hydrograph Magnitude (# weeks outside preferred bounds): Provided flow remains between 5 m^3/s and 60 m^3/s, the shape is the most important performance measure. However, once outside this range, there are negative habitat and displacement impacts. This performance measure tracks how frequently the flows on Seton River exceed these outer bounds.

Spill (weighted number of spill weeks): This performance measure reports the number of weeks per year that spills occur. Each spill event is weighted by the magnitude of flow (higher weight for higher flow) and weighted by season (higher weight for seasons when spills are more damaging).

Seton River Fish Impact Rating (Scale of 0-2):

The above three performance measures were subsequently aggregated using the professional judgement of Fisheries Technical Committee members into a Seton River Fish Impact Rating, which describes the expected net effect of the performance measures on fisheries abundance and diversity in Seton River.

0: Combination of recurring direct mortality risks and consistently degraded habitat year over year is expected to produce negative population-level responses in abundance for at least some species.

1: Improvements in habitat and/or mortality risks are expected (relative to "0"); but it is uncertain whether these are sufficient to produce positive population-level responses in abundance. Long term productivity and abundance of at least some species likely to remain depressed.

2: Significant negative impacts from operations are limited to roughly 10% of years. Net effect on habitat and fisheries productivity expected to produce positive population-level responses in abundance for at least some species.

Passage: It was agreed that the degree of compliance with Fisheries and Ocean's specifications for flow mix would be monitored and any significant differences across alternatives would be documented. However, differences across alternatives turned out to be small, and it was not used as a formal performance measure. The Consultative Committee agreed that provision of the flow mix must be a major consideration in the operation of the Cayoosh diversion in order to ensure appropriate cueing or signals to returning sockeye salmon. This is problematic early in the summer (July) when Cayoosh flows are still very high. The Fish Technical Subcommittee did not identify any passage problem for other fish species.

3.2.2 Wildlife

Carpenter Reservoir

Wildlife Habitat Index (sum of weighted hectares): This performance measure reports the weighted area of riparian habitat. It is calculated by estimating the area of each habitat type under each operating alternative, weighting that by the "habitat value index" for that habitat type, and summing over all habitat types (e.g., types include cottonwood forest, deciduous shrub, and sedge-grass-herb). The weights, which were determined by members of the Wildlife Technical Committee, are summarized in Appendix B3.

Downton Reservoir

A similar index was also developed for Downton Reservoir. This index was carried through to Round 4 alternatives. Within the narrow range of Round 5 alternatives, the Downton Reservoir wildlife index did not vary and so was not reported in Round 5. The preservation of Grizzly Flats was the single most important objective in Downton Reservoir from a wildlife perspective. At Round 5, it was verified that Grizzly Flats continued to be protected.

Lower Bridge River and Seton River

Two wildlife performance measures were used in the first two rounds of alternatives evaluation:

- Wildlife Habitat Index (sum of weighted hectares): As above.

- *Wildlife Spills (weighted index)*: This performance measure reports the frequency of a flood that would significantly disrupt wildlife using the instream area of the Lower Bridge River. In particular, floods of this size would inundate harlequin duck loafing areas, which have been identified as significant habitat features for this species.

After reviewing the results from the first several rounds of alternatives, the Consultative Committee recognized that the amount and quality of wildlife habitat (riparian vegetation) around Seton River was not large. It also recognized that:

- the fish performance measures on Seton River and Lower Bridge River serve as a good proxy for wildlife spills, and

- there was no significant variation in this measure in Round 4 alternatives.

As a means of simplifying the presentation of information on impacts, it was agreed to drop the wildlife habitat index and wildlife spill performance measures for Seton River from the active list of performance measures in Round 5.

3.2.3 Recreation and Aesthetics

Carpenter Reservoir

The Consultative Committee agreed that the most significant impact on recreation that could be addressed by water use decisions was aesthetic impacts from exposed mudflats and related dust events. Because Downton Reservoir is more remote, the aesthetic impacts at Carpenter Reservoir were felt to be of higher priority.

It was agreed that the *Wildlife Habitat Index* could be used as a proxy for recreational impacts, as an alternative with greater riparian vegetation would be both better for wildlife and better for recreation/aesthetics. However, when the detailed evaluation of alternatives was conducted at Round 5, it became apparent that there were trade-offs between aesthetics and wildlife benefits that were embedded in the index. A small area of cottonwood forest would score better from a wildlife perspective than a large area of grass, whereas the large grass habitat would be better for aesthetics. As a result, in Round 5, a separate performance measure was used to document the areal extent of summer green-up.

Greenup: The performance measure was defined as the eastern-most point of greenup and approximate height in centimetre of grass coverage (native sedge/grass/herb and/or planted fall rye).

Boat access and safety were initially considered on Carpenter and Downton reservoirs, however, early in the process it was agreed that operational changes should be determined on the basis of other objectives, and if negative effects on boat access and safety occur, then they should be addressed at that point. None of the short-listed alternatives affected boat access or safety.

Seton Lake

While there were a number of issues related to recreational quality that were explored in the Bridge River Water Use Plan process, studies and modelling found that none of them could be significantly affected by water use changes. Specifically:

- No operational alternatives were considered to change the water level on Seton Lake, therefore the beach area performance measure (calculated as a function of water level) was not useful for distinguishing among alternatives and was not used.

- A Step 5 debris study concluded that BC Hydro operations were not the sounce of debris thus there were no practical water use alternatives for debris management. Debris was not carried forward as a performance measure.

- Water clarity/turbidity co-varies directly with the water quality performance measure, since both are a function of sediment inflow. Significant changes were not observed across the alternatives.

The beach temperature performance measure initially proposed was intended to reflect the impact of the operation of the Cayoosh Diversion. From a recreation perspective, operations resulting in closure of cold water from the diversion during peak recreation season (June-August) would be preferred. However, the Consultative Committee agreed early in the process that operation (i.e., opening to ensure appropriate flow mix) of the diversion for the period from mid-July to end of August was necessary for the purpose of ensuring fish migration/homing. The Consultative Committee later agreed that for the remainder of the time the diversion should be operated to maximize fish benefits in the Cayoosh River (see Section 6.5). This choice implied a trade-off in favour of fish between flow mix for fish passage and cooler water temperatures for recreation at Seton beach for about 6 weeks in late summer. However, operation of the diversion to enhance fish benefits in Cayoosh is partial closure of the diversion for the period in question (i.e., June to mid-July) which reduces cold water from Cayoosh. Consequently, water temperatures at Seton Beach should be affected in a positive way, although the magnitude of impact is unknown.

3.2.4 Power

Financial Value of Power Produced (Annual revenue in $ per year): This is the total value of the revenue that the province of British Columbia would receive from the combined operation of BC Hydro's Bridge River hydroelectric facilities under each operating alternative. For alternatives involving modifications to physical facilities, it is calculated net of the levelized annual cost of the upfront investment and ongoing operations and maintenance.

Through the initial rounds of alternatives, it was determined that the availability of ancillary services would not be affected. Consequently, this performance measure was removed from the active list.

Additional costs of physical works (e.g., planting) were documented under Power values.

3.2.5 Flood Management

Lower Bridge River and Middle Bridge River and Seton River

Flood Days (number of days of flood damage per year): For each river, an assessment was made of the flow rate that will cause property damage. This performance measure tracks the frequency that flow exceeds these thresholds. The thresholds selected were:

- Middle Bridge River: 283 m^3/s

- Lower Bridge River: 225 m^3/s
- Seton River: 225 m^3/s

3.2.6 Dam Safety

Dam safety requirements with provision for deep drawdowns as required for inspection and maintenance/repair were met in all alternatives. Consequently, this performance measure was not a distinguishing factor in determining a preferred operating alternative, and it was removed from the active list of performance measures.

3.2.7 Water Quality

Seton Lake

Sediment Load to Seton Lake Reservoir (tonnes suspended sediment per year): This performance measure reports the annual loading of suspended sediments in the water entering Seton Lake Reservoir from Carpenter and Downton reservoirs. This performance measure was originally thought to indicate the potential for metals contamination in Seton Lake Reservoir. However, the final consultant's report, which was released in fall of 2001, indicated that sediment from Carpenter and Downton reservoirs has lower levels of contaminants than exist in Seton. Consequently, most participants placed less importance on this effect. However, this performance measure is also a proxy for Pelagic Productivity and shore Spawning Success in Seton Lake Reservoir (as noted above under the fisheries performance measures above).

Table 3-2 summarizes the evolution from preliminary to final performance measures.

Table 3-2: Evolution of Performance Measures

Objective/ Location	Preliminary Performance Measures	Final Performance Measure	Explanation

Fish - DOW and CAR	- Littoral productivity
	- Pelagic productivity
	- Tributary spawning success/Backwater risk
	- Entrainment risk
	- Stranding risk
		- Index, composed of:
		  - Littoral productivity
		  - Tributary spawning/Backwater risk
		  - Enstrainment risk (combination performance measure for entrainment and stranding risk)
			- Impact of pelagic productivity small relative to other performance measures
			- Stranding and entrainment co-vary significantly

Objective/ Location	Preliminary Performance Measures	Final Performance Measure	Explanation
Fish - SONL	- Spawning success - Pelagic productivity - Entrainment risk	- Water quality performance measure used as proxy for spawning success and pelagic productivity	- Pelagic productivity and shore spawning co-vary with sediment inflow; water quality performance measure used as proxy - Entrainment performance measure insensitive after all alternatives adopted 25 m^3/s minimum flow at dam
Fish - MBR	- Adult habitat - Juvenile habitat - Spills	- Potential risk of egg dewatering (Round 5 alternatives only)	- Preliminary performance measures insensitive within range of alternatives
Fish - LBR	- Spawning habitat - Juvenile habitat - Spills	- Spills - Juvenile salmonid biomass (for evaluating adaptive management plan)	- Lack of confidence that habitat performance measures correctly reporting direction of response - Spill indicator difficult to interpret - Indicator removed in favour of an adaptive management program

Fish - SONR	- Spawning habitat
	- Juvenile habitat
	- Spills
	- Passage
		- Constructed scale, based on:
		  - Shape
		  - Flow magnitude
		  - Spills
			- Lack of confidence that habitat performance measures correctly reporting direction of response

Wildlife - DOW	- Wildlife habitat index	- Wildlife habitat index	
Wildlife - CAR	- Wildlife habitat index	- Wildlife habitat index (Protection of grizzly flats most important)	
Wildlife - LBR and SONR	- Wildlife habitat index - Wildlife spills	- River wildlife habitat index (Lower Bridge River only)	- Wildlife spills co-vary roughly with SONR and LBR fish spills. SONR wildlife value low within range of Round 4 alternatives, no significant variation
Recreation and Aesthetics - DOW	- Area of exposed mudflats - Access to boat launch	- Wildlife Habitat Index	- Initially, wildlife index and exposed mudflats closely correlated; subsequently, no change across alternatives, and the performance measure was not used - Boat access: Consultative Committee felt the Bridge River Water Use Plan should be determined by other performance measures, and if boat access is a problem, then consider physical works to address it

Objective/ Location	Preliminary Performance Measures	Final Performance Measure	Explanation
Recreation and Aesthetics - CAR	- Area of exposed mudflats - Access to boat launch	- Initially captured by wildlife habitat index - Area of green-up (added in Round 5)	- Initially, wildlife index and exposed mudflats closely correlated; subsequently, need for more specification where wildlife and aesthetic impacts diverge. - Boat access insensitive across range of short listed alternatives
Recreation and Aesthetics - SONL	- Temperature change - Turbidity - Accessible beach area - Debris		- Turbidity, beach area, debris not affected by alternatives - Temperature also insensitive within the range of alternatives once agreed that operation of Cayoosh should be driven by fish and result should be, if anything, a small improvement in temperature
Power	- Annual revenues - Ancillary services	- Annual revenues (net of capital costs) - Planting cost	- Ancillary services insensitive within range of alternatives - Costs of physical works (e.g., planting) included in Round 5 alternatives
Flooding - MBR, LBR, SONR	- Frequency or probability of property damage	- Frequency or probability of property damage (flood days) above specified threshold flows	
Dam Safety	- Dam safety requirements met		- All alternatives meet dam safety requirements
Water quality - SONL, LBR	- Risk of contaminant mobilization (metric to be determined)	- Suspended sediment load (SONL)	- No contaminant mobilization on LBR - Contaminant mobilization unlikely to be a major factor in SONL, but this performance measure remained a proxy for other impacts such as pelagic productivity and shore spawning

3.3 Summary of Objectives and Final Performance Measures

Table 3-3 documents the final active performance measures in the sample consequence table. The consequence table is the format used to plot various alternatives (A, B, C) against each performance measure. The performance measures shown are those used in evaluating the final two rounds of alternatives.

Table 3-3: Sample Bridge River Water Use Plan Consequence Table

Objective	Performance Measure	What's Good?	MSIC	A	B	C
Flood	Flood Days[1] (no. of days per year)	Less	5%			
Fish	Fish-Rivers: LBR Spill Summary (OK or NO)	OK	n/a			
	Fish-Rivers: SONR Summary (constructed scale)	More	n/a			
	Shape (constructed scale of 0-2)	More	n/a			
	Flow Magnitude (weeks/yr)	Less	n/a			
	Spills (weighted spill days)	Less	n/a			
	Fish-Reservoirs: DOW INDEX (0-100)	More	15%			
	Fish-Reservoirs: Littoral C (t/season): 25%	More	25%			
	Fish-Reservoirs: Enstrain (unitless): 55%	Less	10%			
	Fish-Reservoirs: Backwater (km): 20%	Less	10%			
	Fish-Reservoirs: CAR INDEX (0-100)	More	15%			
	Fish-Reservoirs: Littoral C (t/season): 50%	More	25%			
	Fish-Reservoirs: Enstrain (unitless): 35%	Less	10%			
	Fish-Reservoirs: Backwater (km): 15%	Less	10%			
Water Quality	Suspended Sediment Load to SONL (t/year)	Less	30%			
Wildlife	DOW Reservoir WL Habitat Index (weighted hectares)	More	10%			
	CAR Reservoir WL Habitat Index[2] (weighted hectares)	More	10%			
	Wildlife Habitat Area (ha) - sedge-grass-herb	More	n/a			
	Wildlife Habitat Area (ha) - deciduous shrub	More	n/a			
	Wildlife Habitat Area (ha) - cottonwood	More	n/a			
	Wildlife Habitat Area (ha) - fall rye	More	n/a			
	LBR WL Habitat Index (weighted hectares)	More	10%			
Recreation/ Aesthetics	Green-up (eastern-most limit and height of grass)	More	n/a			
Power	Total Annual Revenue ($M/yr)	More	2%			
	Annual Planting Costs ($M/yr)	Less	n/a			
	Annual Levelized Other Costs ($M/yr)	Less	n/a			
	Net Annual Revenue $M/75	More	2%			

1. Values reported here refer to the Worst Impact, 9 years out of 10. Median flood days equal zero under all alternatives.
2. Values reported here refer to Maximum values after 39 years in order to better represent the cumulative effect of wildlife development.

The following explanatory points help in interpreting the consequence tables used for the Bridge River Water Use Plan:

- The "What's Good" column of Table 3-3 is simply a guide to remind readers which direction of change is preferred on each performance measure. For example, all else being equal, fewer flood days would be preferred.

- The "MSIC" is the Minimum Significant Increment of Change. There is a significant amount of measurement, modelling error and expert judgement associated with the calculation of performance measures. The MSIC represents the minimum change in the performance measure value that one should see before concluding that there is a real difference in performance between alternatives. Note however, that the MSIC does not convey the uncertainty associated with whether or to what extent the habitat/mortality factor represented by the performance measure will result in a (for example) fish response observable at the population level. The MSIC was assigned by the fisheries biologists responsible for the fieldwork and modelling. Power MSIC was assigned by Resource Management staff at BC Hydro. Details of the factors considered in estimating the MSIC are included in Appendix B2.

- The percentages shown opposite some of the subcomponents of the fish indices are weights assigned by the Fisheries Technical Committee. They represent a simple average of the judgements of seven Fisheries Technical Committee members who assigned the weights based on their judgements of the contribution that each factor could make to the objective to maximize the abundance and diversity of fish (see Appendix B1). The net effect of the three weighted performance measures is summarized in the INDEX at the top of the grouping.

- Because there is significant variability in inflows across years, there is significant variability in performance across years. For each performance measure, two values were assessed - the median value (in 50% of years, the value will be this good or better) and the 90% value (in 90% of years, the value will be this good or better). The Consultative Committee agreed to ignore the very worst year, and to use the 90% figure as a representation of performance of an alternative under extreme conditions. There are two exceptions to this agreed upon approach. Wildlife habitat on the reservoirs demonstrates a clear increasing trend over time that is decadal in scale. The Consultative Committee agreed to use the maximum value after the full cycle of inflow sequences (39 years) as the main performance measure. A second exception is flooding. None of the alternatives show any flooding under median years, so the 90% statistic was used.

4 STUDIES

During the process of identifying issues, structuring objectives and developing performance measures, a number of questions were raised. Limited information was available to calculate performance measures upon which to base operational decisions. As a result, a number of studies were undertaken to improve the knowledge base on the Bridge River system.

At the conclusion of Step 4, the preliminary performance measures were used to develop a set of candidate studies for Step 5. An initial list, developed by various technical committees, included studies requiring a total investment of about $1.33 million. Studies were then prioritized according to the Proposed Process for Evaluating Studies Under Step 5 of Bridge River Water Use Plan outlined in Appendix C1 and reviewed by the Consultative Committee. The Consultative Committee recommended the studies shown in Table 4-1, which were implemented at a cost of $660,000.

A summary of the information collected during the Bridge River water use planning process is provided in Table 4-1. Key findings from the studies are outlined in more detail in Appendix C2.

Table 4-1: Summary of Studies and Key Findings

Study Title	Key Findings or Outcome
Pelagic Productivity Assessment	Field work and modelling to allow calculation of Pelagic Productivity; Pelagic in Carpenter Reservoir found to be underutilized, and the performance measure was dropped in favour of Littoral Productivity.
Littoral Productivity Assessment	Field work and modelling to allow calculation of Littoral Productivity and identify operating alternatives for improving littoral productivity. Resulted in the development of the M2 and M5 alternatives to maximize Carpenter Reservoir littoral production.
Tributary Drift Monitoring	Field work and modelling to allow calculation of total carbon budget.
Reservoir Productivity/Fish Food Assessment	Literature review to enable calculation of carbon production from biomass (in support of Pelagic and Littoral assessments above).
Entrainment - CAR/DOW	Engineering study found the "risky volume" to be small, except in the most extreme operating conditions. Simplified entrainment index accepted as a result.
Entrainment - SONL	A conceptual model to estimate the proportion of outmigrating smolts that pass through the Seton powerhouse (rather than Seton Dam) at various flow rates was developed. Key finding was that a flow of 25 m^3/s is expected to reduce turbine entrainment significantly. Subsequent modelling showed this to be low cost.
Reservoir Fish Stranding	Field work and modelling to allow calculation of the reservoir stranding performance measure.

Study Title	Key Findings or Outcome
Metals and Contaminants	Literature review, field sampling (sediment and fish tissue) and risk assessment conducted. Key findings: There are no apparent drinking water quality concerns (some aesthetic effects from iron and turbidity, but no health concerns). Although there are some elevated metals levels in sediments, they are unlikely causing ecological harm. There are no identifiable operating changes that could increase the risks associated with sediment contamination because upstream sediments are same or lower concentration than downstream. Mercury levels in bull trout in Carpenter Reservoir are elevated, and operating alternatives that increase vegetation in Carpenter Reservoir should trigger monitoring.
Tributary Spawning Success	Modelling to estimate the area of tributaries backwatered under different reservoir elevations.
Shore Spawning Success - SONL	Modelled impact on shore spawning as function of sediment inflow.
Spawning and Juvenile Fish Habitat - SONR, LBR	Physical habitat modelling was conducted; Low confidence in the outcomes resulted in changes to performance measures.
MBR History Study	Field study on abundance, distribution, and life history of resident fish species in Middle Bridge River and effects of flow reduction on habitat use.
MBR Flow/Habitat Study	Field study to quantify the functional relationship between flow and useable habitat; found habitat generally insensitive to flow due to compensating side channel habitat; however effects to insects and dewatering of potential spawning area remain uncertain.
Fish Spill Impacts Index	Developed system for weighting spills of different magnitude, duration and timing.
Riparian Habitat	Fields studies and modelling to characterize riparian vegetation communities in Carpenter and Downton reservoirs, Lower Bridge River and Seton River, and to parameterize a vegetation growth model.
Wildlife Spill Index	Developed system for weighting spills of different magnitude, duration and timing.
Harlequin Duck Studies	Field surveys were conducted to fill data gaps about nest site selection in relation to water levels and patterns of instream habitat use. This was used to set thresholds for the wildlife spill index.
Traditional Ecological Knowledge	Literature review to determine suitability of existing Traditional Ecological Knowledge documentation for use in Bridge River Water Use Plan. Found that existing documentation is inadequate. Workshop held in April 2002.
Floating Debris: SONL	Assessed the extent to which floating debris is an issue in Seton Lake Reservoir and to identify options for mitigation. Found that debris problem is small relative to other reservoirs and no operating alternatives will provide significant mitigation.
Water Clarity: SONL	Model was developed to predict the mean change in the depth of light penetration in Seton Lake Reservoir. This performance measure covaried with water quality and so the latter was used as proxy for water clarity.
Beach Area Index: SONL	Field survey of Seton beach was conducted to collect information needed to estimate change in beach area with change in Seton Lake Reservoir water level. Eventually it was found that there are no plausible opportunities to lower Seton Lake Reservoir, therefore beach area cannot be affected.
Temperature: SONL	Review of existing studies to estimate effects of the Cayoosh Creek discharge pipe on beach water temperature. Found some differences in summer temperature near Cayoosh Creek discharge. Mitigation options identified.
Property Damage Flood Frequency	Field studies and hydraulic modelling were conducted to estimate the threshold discharge at which property damage occurs.

Implementation of the Traditional Ecological Knowledge project was delayed due to discontinuity in the participation of the Stl'atl'imx Nation (see Section 2.2 in the water use planning process). Originally, the Traditional Ecological Knowledge project was scoped to provide input on tributary spawning, shore spawning and metals contamination issues. Upon the re-entry of Stl'atl'imx Nation into the process, it was revised to provide a critical review of suitability of existing Traditional Ecological Knowledge documentation for use in Bridge River Water Use Plan. A workshop was also conducted to elicit Traditional Ecological Knowledge on topics directly related to priority monitoring programs (e.g., resident fish populations in Seton Lake Reservoir). The workshop held in April 2002 included both traditional knowledge holders and scientists, and identified alignment in information, data gaps and anomalies and monitoring needs for future understanding of resident fish stocks.

5 ALTERNATIVES AND MODELLING

5.1 Overview of Models

Several models were used to predict the impacts of alternative operating strategies on the performance measures (Figure 5-1).

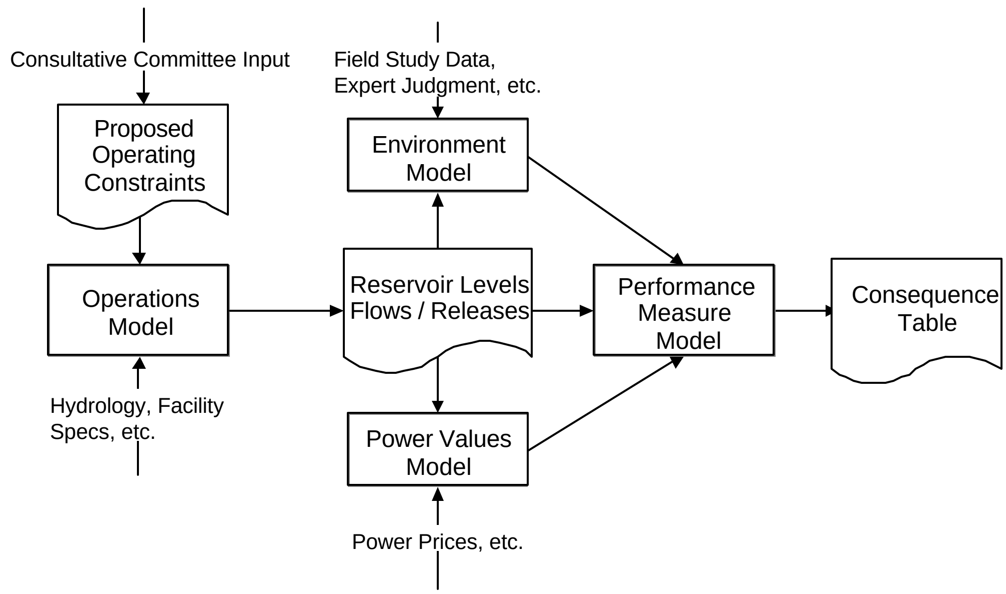

Figure 5-1: Overview of Bridge River Water Use Plan Models

Once the Consultative Committee developed an alternative to be modelled, the specified constraints were entered into an *Operations Model*. Software development for the operations model was centred on the AMPL and CPLEX commercial software packages. AMPL is a modelling language for mathematical programming which enables conversion of a problem from a "modeller's form" to the "algorithm's form." AMPL transforms a mathematical formulation to computer code. The transformed problem is solved by CPLEX, a package of mathematical solvers for linear and non-linear programming. The operations model optimizes facility operations for power production, within specified constraints. For the Bridge River hydroelectric system, it uses 39 years of inflow data. The primary output of the operations model is a set of data describing reservoir levels and releases from dams on each day of each year, along with daily power production. These data are used as input to two additional models.

The *Environment Model* is a Visual Basic program that simulates the dynamics of the performance measures. A series of Excel spreadsheets is used to store model parameters, physical characteristics of the system (e.g., reservoir surface area as a function of elevation, etc.) and the hydrologic scenarios (e.g., schedules of discharge and reservoir elevations associated with each alternative). Output (performance measures and various diagnostic indicators) can be viewed as data sets, time series graphs and/or maps. This model is used to calculate the environmental and social performance measures defined in Section 3.

Plant discharge flow data are also routed through a *Power Values Model* that takes information about energy prices, dispatchability, and plant characteristics to calculate the annual value of the power that will be produced under each alternative.

Additional information on power studies are available in the Draft Bridge River Water Use Plan Hydro Operations Studies (BC Hydro 2002).

5.2 Overview of Alternatives

Beginning in January 2001, the project team and Consultative Committee developed and reviewed five "rounds" of alternatives (Figure 5-2).

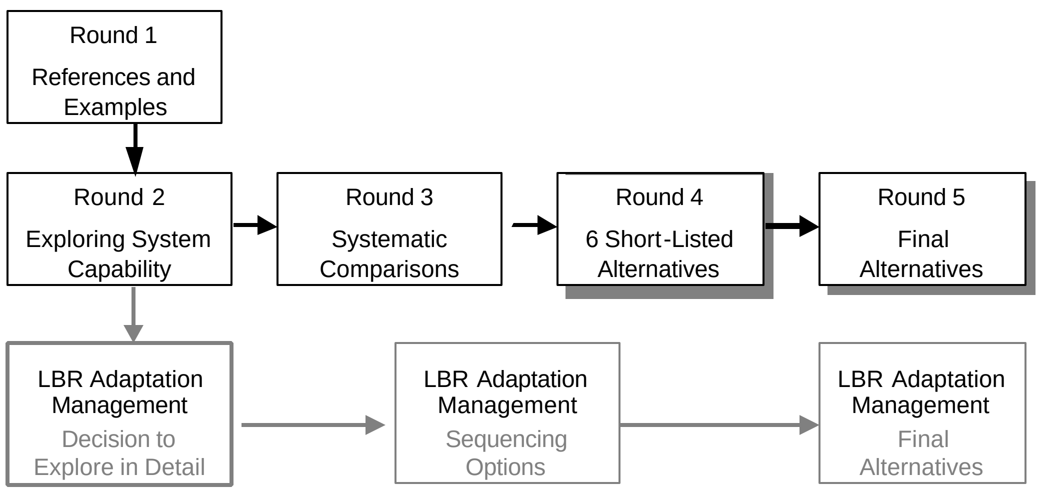

Figure 5-2: Summary of Alternative Development for Bridge River Water Use Plan

A list of the alternatives presented is included in Appendix D1. During Rounds 1-3 of the trade-offs, the Consultative Committee explored reference alternatives and different limits of capabilities of the system. The Consultative Committee also worked toward finding common ground, seeking win-wins, and continually improving the alternatives in ways that benefited multiple objectives/performance measures. Both alternatives and performance measures were narrowed over this period as the Consultative Committee came to understand what the key priorities were in the system and where the opportunities were to make changes. In Rounds 4 and 5, all of the technical improvements that could be made, had been made, and the choices made by the Consultative Committee in these rounds were largely based on fundamental value judgements.

The section below summarizes the nature of the alternatives explored at each round, and for Rounds 1 to 3, summarizes the key decisions made. Appendix D2 summarizes the findings from these early rounds of modelling. The trade-offs faced by the Consultative Committee and the value judgements and decisions it made in Rounds 4 and 5 are described in detail in Section 6.

Round 1: In the first round of alternatives, sample alternatives were prepared by the project team and presented to the Consultative Committee. In addition to three sample alternatives, Round 1 contained three "reference" case alternatives: A. Licence (operation as per current licence); B. Interim (continuation of current operations which includes voluntary/agreed to constraints on current licence); C. Modified Interim (current operation modified with removal of licence constraints).

Key Decisions:

- Remove licence constraints from operating alternatives. Three key constraints were removed: the maximum diversion volume to Seton generating station; individual licence restrictions at Bridge No. 1 and Bridge No. 2 generating stations; and diversion constraint at La Joie. Removal of the Seton restriction enables better management of spills down Seton River and increased generation of power. The removal of individual constraints at the Bridge plants enable joint management of the two plants (8 units) with consequent operating efficiencies, but no adverse environmental/social impacts. Relaxation of the La Joie constraint also enhances power values and increases flexibility to manage Middle Bridge River flows. In short, removal of these constraints improved opportunities for better water management in the system for all interests.

- Carry Alternative B (Interim) forward as the most useful reference case.

- Remove or modify several performance measures (see Section 3.2).

Round 2: After reviewing the reference and sample alternatives, the Consultative Committee created new alternatives, largely designed to explore system capabilities and interactions. These alternatives contained some very significant changes from the current operation (e.g., extremely limited range of operations of Carpenter Reservoir, etc.) and were useful in demonstrating the effect of significant constraints on up- or downstream effects.

Key Decisions:

- Modelling of fisheries performance measures on Lower Bridge River is unreliable even for reporting the correct direction of change. The Fisheries Technical Committee was directed to evaluate an adaptive management program for the Lower Bridge River that would involve a sequence of planned flow releases designed to test the response of fish to several flows. Concurrent with the development and evaluation of alternatives under Rounds 3, 4 and 5, the Fisheries Technical Committee and trade-off analysts conducted analyses to identify alternative test flow rates and sequencing/duration options, and to develop a probabilistic assessment of potential benefits (see Section 6 and Appendix G for details).

- Improvements in wildlife habitat around Carpenter Reservoir are a priority. However, the Consultative Committee set upper limits on spills down the Lower Bridge River within which these improvements should be sought. These limits were designed to provide the project team with an aid to designing alternatives that might be acceptable to the Consultative Committee. They represented upper limits beyond which an alternative would be clearly unacceptable (not limits below which it was agreed that there would be no impacts).

- Some negative environmental impacts occur because there is a bottleneck at Seton Generating Station resulting in uncontrolled spills at Seton Dam. The Consultative Committee requested to use the modelling capability developed under Bridge River Water Use Plan to assess the potential benefits from a capacity increase at Seton Generating Station. The Consultative Committee recognized that any recommendations with respect to facility upgrades would be recommendations for further study only. A more detailed feasibility study (beyond what could be undertaken under Bridge River Water Use Plan) would be required before any decision to upgrade could be taken.

- All subsequent alternatives will include a constraint of a minimum flow of 25 m^3/s down Seton River during peak smolt outmigration to minimize entrainment. This constraint delivers large benefits at very low cost. These entrainment results were discussed at length. The key finding of the study conducted is that entrainment mortality (calculated as the sum of mortality at the dam plus mortality at the turbines) can be reduced essentially to the mortality that occurs at the dam by maintaining flows at or above 25 m^3/s during the peak smolt outmigration period. This is a result of the assumption of an asymptotic relationship between fish passing at the dam and the flow passing at the dam (an assumption supported by data from two previous independent studies). While surprised and somewhat uncomfortable about the reliability of this conclusion, participants accepted that this represents the best estimate based on best available data. It was agreed that, if 25 m^3/s is maintained, turbine restrictions at Seton Generating Station are not required. Subsequent effort was focused on identifying means of reducing mortality at the dam, which remains significant. Means include routing protocols through discharge facilities with the lowest mortality rates first.

- Several performance measures were removed or modified, particularly Seton River fish performance measures (see Section 3.2).

Round 3: The Consultative Committee and project team identified nine alternatives designed to keep operations at Downton Reservoir and Middle Bridge River the same across all alternatives, and systematically test changes in operations at other facilities. This approach would allow comparability among the alternatives; operational alternatives at Middle Bridge River and Downton Reservoir would be considered in subsequent rounds. These alternatives introduced spill boundaries on Lower Bridge River developed in Round 2 discussions.

Key Decisions:

- Apart from power and fish value, changes in overall system performance from varying Lower Bridge River flows between 3 m^3/s and 10 m^3/s are small enough that it should be sufficient to conditionally select an operating alternative using 3 m^3/s as the nominal Lower Bridge River flow, and make a decision about Lower Bridge River flows independently from the base operating decision.

- Initial attempts to maximize littoral and riparian/wildlife habitat benefits around Carpenter Reservoir proved unsuccessful (i.e., the models predicted relatively minor benefits from the proposed operating changes). Through iterative testing, an operating strategy was defined that would maximize littoral and riparian productivity while respecting spill limits at Lower Bridge River.

Round 4: Alternatives were generated from a review of the Round 3 results from which six were selected to represent several different ways of operating the system within the bounds of choices and decisions made to that point. Choices between these alternatives were value-based. Choices depended on how the participants valued improvements in one performance measure relative to losses in another. Trade-offs, participant preferences and decisions at Round 4 are summarized in Section 6.

Round 5: Four final alternatives were presented. The differences between them are small (relative to the differences among Round 4 alternatives). Three of the alternatives (N2-2, O3-2, O4) were strictly operating alternatives representing different balances among objectives. The fourth alternative (N2-2P) included non-operational related feature of planting of fall rye to enhance riparian vegetation on Carpenter Reservoir - applied to Alternative N2-2.[1] As the decision hinged largely on riparian vegetation benefits on Carpenter Reservoir, both for wildlife and aesthetic objectives, the Consultative Committee reviewed detailed information on riparian vegetation types and their relative benefits for both wildlife and aesthetic objectives.

Trade-offs, participant preferences and decisions at Round 5 are summarized in Section 6.

[1] Consistent with the scope of the Water Use Plan program, planting is considered in lieu of reservoir management to secure wildlife/aesthetic benefits.

6 TRADE-OFF ANALYSIS

6.1 Overview of Structured Decision Process

At Step 7, Evaluate Trade-offs, a structured decision-aiding process was used in the Bridge River Water Use Plan to assist participants in making recommendations about operating alternatives that were informed, transparent and consistent with their values.

Decision methods can range from an intuitive ranking of alternatives through to a technically complex weighting and mathematical treatment. On the Bridge River Water Use Plan, a combination of direct ranking and weighting methods were used to provide the best mix of rigour, accountability and transparency. Once a short list of alternatives was developed (Round 4 alternatives) and their consequences understood, participants completed a questionnaire designed to assess their preferences using three methods: *direct ranking, swing weighting and paired comparison.* The purpose of this exercise was to help participants better understand and articulate their priorities and values across different objectives and alternatives. The results supported an interest-based dialogue and provided direction for decision-making; they did not dictate a specific outcome. Appendix F describes in detail the preference assessment methods and results. The Round 4 alternatives, consequences and decisions are described below.

6.2 Round 4 Alternatives and Consequences

Six alternatives were presented for detailed consideration by the Consultative Committee. They are summarized below. Table 6-1 contains the consequence table for the Round 4 alternatives.

M2 In this alternative, Carpenter Reservoir is significantly constrained. The minimum elevation occurs at about 632 m; the reservoir rises slowly over 637 m (a productive littoral area), up to a maximum of 647 m. This alternative provides the maximum improvement in both **wildlife habitat** and **littoral productivity** in Carpenter Reservoir that is achievable without violating the upper spill limits specified by the Consultative Committee for the Lower Bridge River. However, it was necessary to remove minimum elevation constraints on Downton Reservoir in order to maintain spill boundaries set for Lower Bridge River.

L2 In this alternative, Carpenter Reservoir is still constrained to remain below 647 m, but does not maximize littoral productivity over the bench at 637 m. This alternative provides **wildlife habitat** improvements on Carpenter Reservoir, but does not provide significant littoral benefits. No minimum reservoir elevation is set for Downton Reservoir.

M5 In this alternative, Carpenter Reservoir is constrained to rise slowly over the bench at 637 m (as in M2), but then rises to a maximum elevation of 648 m, with excursions above 648 m allowed up to 651 m for short periods. This alternative provides **littoral** benefits on Carpenter Reservoir, but does not provide significant wildlife habitat benefits. A minimum elevation of 718 m is maintained on Downton Reservoir.

N2 This alternative allows more **flexibility** in the operation of Carpenter Reservoir, the only constraint being a maximum of 648 m with excursions to 651 m allowable for up to 8 weeks. A minimum elevation of 718 m is maintained on Downton Reservoir.

I3 The capacity of Seton Generating Station is **upgraded**. The upgrade involves capital investments for a new powerhouse and related structural changes. The extra capacity is used to provide a firm Seton River hydrograph (11 and 36 m^3/s), but otherwise is used to maximize the power generation benefits from the upgrade.

B This strategy represents roughly how the system is currently operated, under the constraints as defined in the **current licence plus the interim flow agreement** to provide 3 m^3/s on Lower Bridge River. On Seton River, there is a "soft" constraint to try to approximate an 11 and 36 m^3/s hydrograph. There are no constraints other than licence constraints on any of the reservoirs (e.g., no reservoir fill profile on Carpenter Reservoir nor minimum elevation on Downton Reservoir).

All Round 4 alternatives incorporate a 3 m^3/s water budget on Lower Bridge River, and a minimum flow rate on Middle Bridge River of 600 cfs (17 m^3/s), which is allowed to reduce to a minimum of 200 cfs as required to maintain specified constraints on Carpenter Reservoir. On the Round 4 alternatives, no attempt was made to optimize flows in the Middle Bridge River, imposing only the 600 and 200 cfs constraints as initial guidelines for Round 4. The constraints noted above were relatively arbitrary. The Consultative Committee agreed that Middle Bridge River flows should be more fully explored and defined after the preferred operating regime was selected.

Flow options for the Lower Bridge River (adaptive management program) are reviewed in Section 7.

As shown in Table 6-1, a number of the performance measures carried forward for Round 4 were insensitive across most alternatives. For example, Flood Days vary by no more than 2 days in the worst 90% of years. With the exception of Alternative B, results do not vary significantly in terms of meeting Lower Bridge River Spill limits, Seton River Hydrograph, and River Wildlife Habitat. Water quality is also fairly invariant with the exception of Alternative I3. Differences in power values are also small across the six alternatives, often within the minimum significant increment of change. The most significant changes across alternatives appear in fish and wildlife measures for Carpenter and Downton reservoirs. These measures were the focus of discussions within the Consultative Committee.

Table 6-1: Round 4 Consequence Table

ACTUAL IMPACTS (Median Values, Except as Noted)										
Objective	Performance Measure	What's Good?	MSIC	Alternative M2	M5	L2	N2	I3	B
Flood	Flood Days * (no. days per year)	Less	5%	1	1	0	0	0	2
Fish	Fish-Rivers: LBR Summary (OK or NO)	OK	n/a	OK	OK	OK	OK	OK	NO
	Fish-Rivers: SONR Summary (constructed scale)	More	n/a	2	2	2	2	1	0
	Fish-Reservoirs: DOW INDEX (0-100)	More	15%	42	70	48	69	65	69
	Fish-Reservoirs: CAR INDEX (0-100)	More	15%	69	71	41	41	29	29
Water Quality	Suspended Sediment Load (t / year)	Less	30%	94	89	77	84	108	78
Wildlife	DOW Reservoir WL Habitat Index ** (weighted hectares)	More	10%	223	231	322	313	295	300
	CAR Reservoir WL Habitat Index ** (weighted hectares)	More	10%	759	522	758	520	602	600
	River WL Habitat Index (weighted hectares)	More	10%	48	48	48	48	48	33
Power	Annual Revenue ($M / yr)	More	2%	144	145	146	148	144	145

* Values reported here refer to the Worst Impact, 9 years out of 10. Actual median flood days equal zero under all alternatives.
** Values reported here refer to Maximum values in order to better represent the cumulative effect of wildlife development.

1. See Appendix E for a more detailed table of consequences, including Index subcomponents, and 90th percentile results.

From Table 6-1, some key observations about the individual alternatives relating to status quo (Alternative B) are:

- Alternative M2 is expected to provide the greatest ecological benefits for Carpenter Reservoir, with both significant littoral productivity (fish) and wildlife habitat improvements. However, this is achieved with a deterioration of both fish and wildlife conditions in Downton Reservoir caused by primarily by deeper drawdowns on Downton Reservoir (which are necessary to refill Carpenter Reservoir as specified while managing spills at Lower Bridge River). In other words, deeper drawdowns in Downton Reservoir are needed for flexibility as Carpenter Reservoir is managed more tightly.

- Alternative M5 provides expected littoral gains in Carpenter Reservoir with no increase in risk at Downton Reservoir for fish. However, these gains are made at the expense of wildlife habitat as those measures deteriorate in both Downton and Carpenter reservoirs relative to Alternative B.

- By contrast, Alternative L2 provides significant wildlife habitat benefits on Carpenter Reservoir (and maintains current wildlife conditions on Downton Reservoir), but results in a deterioration in littoral productivity for fish in Downton Reservoir and only a modest increase in Carpenter Reservoir.

- Alternative N2 results in unchanged or improved conditions for fish and wildlife in Downton Reservoir as a result of the minimum elevation. However, littoral productivity gains in Carpenter Reservoir are made at the expense of wildlife habitat in Carpenter Reservoir. In short, the higher elevations on Carpenter Reservoir in this alternative aid fish, but compromise the wildlife habitat provided by the current buffer.

- All of the alternatives outperform Alternative B on Flood days, Lower Bridge River Fish (Spills), Seton River Fish (Hydrograph) and River Wildlife Habitat. Reservoir Wildlife Habitat scores are moderate on Alternative B relative to other alternatives as are Fish Index scores in Downton Reservoir. However, the Fish Index score in Carpenter Reservoir is low under Alternative B.

The results clearly indicate limited capacity in the system to simultaneously maximize fish and wildlife objectives in both Downton and Carpenter reservoirs, while maintaining the previously set preferences on the Lower Bridge River (spills boundaries) and Seton River (hydrograph). Some key trade-off questions discussed by the Consultative Committee were:

- Alternatives L2 and M2 result in improvements in quality of wildlife habitat. However they do so at a potential ecological cost at Downton Reservoir (increased risk of entrainment) relative to all other alternatives. *Are the expected gains in Carpenter fish and wildlife worth the potential losses in Downton Reservoir?* Alternatives L2 and M2 also produce smaller financial benefits (relative to Alternative N2). *Are the gains in wildlife habitat and/or littoral productivity worth the foregone financial gains?*

- Under Alternative M5, do the gains in Carpenter littoral and protection of Downton Reservoir entrainment offset the lost opportunity to enhance/protect Carpenter wildlife habitat that exists in Alternatives M2, L2 and B?

- Are Lower Bridge River Spill levels and Seton River Hydrograph performance under Alternative B acceptable?

- Alternatives M2, M5, N2 and L2 deliver roughly equal performance on Seton River fish and wildlife. The improvement (from a score of 0 to 2 on the Seton River Summary Constructed Scale) is achieved at a cost of roughly $600,000 per year (relative to Alternative B). *Are the gains worth the costs?*

- Relative to Alternative B (continuation of status quo), all performance measures under Alternative N2 either stay the same or improve, with the exception of Wildlife Habitat on Carpenter Reservoir, which drops under Alternative N2 relative to Alternative B. *Are the gains on other performance measures worth foregoing gains on Carpenter vegetation?*

Are there opportunities to improve vegetation on Carpenter through non-operational initiatives?

- A minimum constraint on Downton Reservoir of 718 m imposes a cost of about $800,000 per year. *Are the gains for fisheries (e.g., reduced entrainment risk) worth the financial cost? Could this constraint be relaxed without significant ecological risk?*

Alternative I3 (increasing capacity at Seton by installing a new generating station) embodies a significant capital cost. As designed, it represents the most optimistic scenario for power revenues achievable under an upgrade (i.e., beyond delivering an improved hydrograph at Seton River, all water is used to generate power). Apart from meeting spill boundaries in Lower Bridge River and improving the Seton River hydrograph (relative to Alternative B), Alternative I3 shows little improvement in other performance measures. A different alternative that uses the extra capacity to improve environmental performance upstream on Carpenter and Downton reservoirs would result in a drop in power revenues relative to Alternative I3.

6.3 Round 4 Preference Assessment

Once all the impacts had been discussed, each participant completed a questionnaire designed to assess their preferences using the three different methods: direct ranking, swing weighting and paired comparison. The replies were then entered into a decision model, which in turn computed scores, compared rankings and generated outputs for each person as well as for the group as a whole.

Figure 6-1 shows the resulting weights by the swing weighting approach.[1] This weighting approach was generally the more favoured of the two weighting approaches. The performance measures are shown across the bottom with the weights on the vertical axis. The markers represent the weights for this particular Consultative Committee member and the vertical line represents the range of weights for all decision makers.

[1] The weights for the paired comparison could also be shown in the same way, but as the swing weighting was generally the more favoured of the two approaches, only this chart was shown in order to keep materials to a minimum.

CC Member	Respondent X

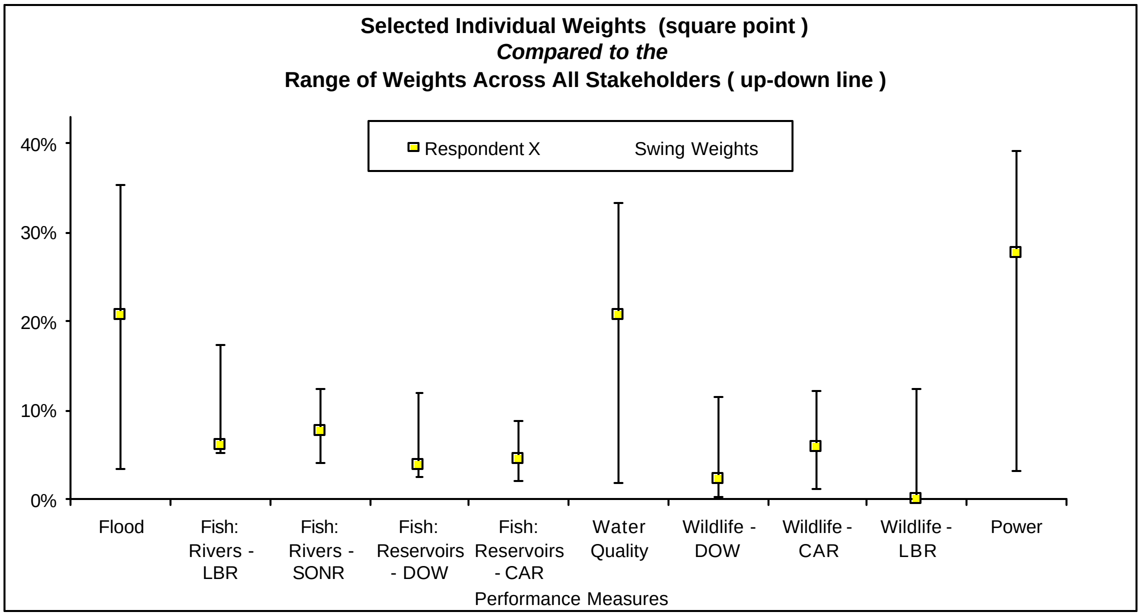

Figure 6-1: Example of Individual Weights for One Participant

Key messages to be drawn from the chart for this particular Consultative Committee member is that he/she feels that, across the magnitude of change estimated for this set of alternatives (i.e., the swing), Flooding, Water Quality, and Power are relatively important, whereas Lower Bridge River Wildlife is not. The other measures are moderately important to this Consultative Committee member. In its deliberations, the Consultative Committee used this chart format to probe differences in weights and the differences in values that they represent. Some of the reasons for significant differences in values include:

- Water Quality: A consultant's report indicated that the potential for increases in contamination in Seton Lake as a result of operating changes is likely negligible. However, the second impact from water quality is a potential to negatively affect fisheries. The significance of this effect is a large uncertainty, and results in the wide range of weights assigned.
- Flooding: Most participants weighted this low because the differences across alternatives was small and the potential for damage to people and property was also small. However, one participant admitted to difficulty separating out the more catastrophic impacts of a dam failure and the relatively minor damage to roads and buildings that this performance measure was really indicating.
- Power: The large range in weights for this performance measure is not surprising and reflects the diversity in participants – from local residents who view these impacts as small relative to the total annual revenues from the facility, to provincial representatives who are responsible for fiscal management.

Each Consultative Committee member was also provided with an overall summary of the participants' rankings by each method. Table 6-2 shows the Consultative Committee members across the top (numbered for anonymity) and alternatives down the side. For each alternative, a ranking is shown for each of the Swing, Paired Comparison and Direct methods.

Table 6-2: Group Ranking

Rank of Alternatives by Stakeholder and by Method

Alternatives	Weighting Method	CC Members 1	2	3	4	5	6	7	8	9	10	11	12
M2	Swing	4	4	3	3	2	2	4	3	2	4	3	4
M2	Paired Comparison	4	4	4	2	2	2	4	4	2	4	4	5
M2	Direct	4	4	1	3	3	3	4	2	1	4	2	2
M5	Swing	3	3	4	4	4	4	3	4	4	3	4	3
M5	Paired Comparison	3	3	3	3	4	4	3	3	4	3	3	3
M5	Direct	2	2	6	2	2	2	3	5	4	2	4	3
L2	Swing	1	1	1	1	1	1	2	1	1	2	1	1
L2	Paired Comparison	1	2	1	1	1	1	2	1	1	2	1	2
L2	Direct	3	3	3	4	4	4	2	4	3	3	3	4
N2	Swing	2	2	2	2	3	3	1	2	3	1	2	2
N2	Paired Comparison	2	1	2	4	3	3	1	2	3	1	2	1
N2	Direct	1	1	2	1	1	5	1	3	5	1	1	1
I3	Swing	5	5	5	5	5	5	5	5	5	5	5	5
I3	Paired Comparison	5	5	5	5	5	5	5	5	5	5	5	4
I3	Direct	5	5	4	5	5	1	6	1	2	5	5	5
B	Swing	6	6	6	6	6	6	6	6	6	6	6	6
B	Paired Comparison	6	6	6	6	6	6	6	6	6	6	6	6
B	Direct	6	6	5	6	6	6	5	6	6	6	6	6

Indicates an alternative with a rank = 1
Indicates an alternative with a rank = 2
Indicates an alternative with a rank = 6

Key observations are:

- Alternative B (i.e., the status quo) was not preferred by any participants by any of the methods.

- Alternative I3 was ranked second to last by most Consultative Committee members except for three people who ranked it high by the direct method. For one person this was because he felt the inclusion of capital costs resulted in an overstatement of the power impacts, and so he had discounted that performance measure. The other two liked it on a Direct basis because they felt that upgrading Seton Generating Station’s capacity made sense in concept and believed that the alternative had simply not been designed to take full advantage of the additional generating capacity for maximizing environmental benefits.

- Alternatives M2 and M5 received mid-range scores by most participants.

- Alternative N2 fared very well by the direct method, and was ranked second for most Consultative Committee members by the weighting methods.

- Alternative L2 fared very well for most Consultative Committee members by both weighting methods. However, most Consultative Committee members were not particularly in favour of Alternative L2 by the Direct Method. This was discussed as a group and was explained by two factors. First, the Alternative L2 Seton hydrograph (as it was shown on the wall charts during the session) appeared to be slightly worse than the hydrographs for other alternatives even though they were given equivalent scores by the Fisheries Technical Committee. This caused some people to give it a lower direct ranking. Second, Consultative Committee members who favoured wildlife habitat benefits had tended to lean immediately toward the "M" alternatives as their first choice, and those who favoured fish chose "N" alternative as their first or second choice. In other words, the fact that L2 was a "middle of the road" alternative caused it to be overlooked and generally pushed down in the Direct ranking. However, as the weighting exercise illustrated, virtually all members valued both objectives. This was not a case where participants were polarized in two distinct camps (fish versus wildlife), but rather one in which each participant sought a balance between two fundamentally important objectives. Thus all participants recognized the value of the compromise offered by Alternative L2, or a refinement thereof.

In sum, when participants stated their preferences directly, there was no clear common ground. However, by both of the indirect (weighting) methods, Alternatives N2 and L2 emerged as alternatives that rank first or second for nearly all Consultative Committee members.

6.4 Round 4 Areas of Agreement

After review and discussion of the results of the preference assessment exercises, the Consultative Committee concluded that:

- Alternative M2 has desirable environmental benefits on Carpenter Reservoir, but results in unacceptable environmental impacts on Downton Reservoir.

- While Alternative M5 is expected to deliver significant fisheries benefits on Carpenter Reservoir, it delivers no wildlife habitat benefits, an objective the Consultative Committee values highly. As a result, Alternative M5 was not preferred.

- Alternative B results in unacceptable performance on the Seton River Hydrograph and Lower Bridge River Spills and consequently is unacceptable from a fisheries perspective. However, it was agreed to carry this alternative forward as a reference case only.

- The protection provided to Downton Reservoir (entrainment) under Alternative N2 is likely more than adequate; the minimum elevation could be relaxed slightly. (This was based on reports of the Downton Technical Committee which noted population level impacts may begin to occur at El. 718 m but are much more significant at El. 710 m). Several Consultative Committee members noted the apparent resilience of Downton Reservoir fish populations given the history of severe drawdowns.

- The cost of providing the improved Seton River hydrograph is small relative to the improvements in fish productivity expected from it. Moving from a score of 0 to 2 is expected to result in a significant reduction in the risk of direct mortality and significant improvements in long term productivity.

The Consultative Committee therefore concluded that the preferred operating alternative would be found in a compromise between Alternatives N2 and L2. The Consultative Committee directed the project team to:

- Develop alternatives that seek a compromise between improvements on Carpenter wildlife habitat and Downton Reservoir/Middle Bridge River fish, while preserving downstream fish performance (Seton River hydrograph).

- Consider planting as an alternative to operational changes for achieving Carpenter wildlife benefits.

- Develop an alternative that assumes the Seton Generating Station upgrade capacity is used to deliver environmental benefits, rather than economic benefits.

These alternatives formed the basis of the Round 5 (Final) Alternatives.

Fisheries Technical Committee members on the Consultative Committee also noted that there are some differences in the Seton River hydrograph among alternatives, and requested the opportunity to revisit the scores given to the hydrographs in the final evaluation of alternatives.

The Consultative Committee agreed that final alternatives were to be modelled with inclusion of minimum flows on Middle Bridge River.[1] It was agreed that Middle Bridge River minimum flows should take precedence over maintaining minimum reservoir elevations in Downton Reservoir to benefit a diversity of fish species. However, first priority must remain the levels of performance on Lower Bridge River and Seton River achieved under Alternatives L2 and N2, recognizing the greatest diversity of fish, (both anadromous and resident) in those rivers.

6.5 Round 5 Alternatives and Consequences

Four final alternatives were presented for detailed consideration by the Consultative Committee in Round 5, along with one new alternative incorporating an upgraded Seton Lake Reservoir Generating station.

Final Operating Alternatives

The final four operating alternatives are summarized below.

Some common elements to all the Round 5 Final Alternatives include:

- Lower Bridge River: a 3 m^3/s water budget (to be refined in the adaptive management program) with maximum spills as specified by the Consultative Committee.
- Middle Bridge River/Downton Reservoir: a Middle Bridge River flow reduced to a maximum of 850 cfs during whitefish spawning and a minimum flow of 650 cfs on Middle Bridge River year round.[2]
- Seton River:
    - 25 m^3/s minimum flow release from dam during peak sockeye outmigration.
    - Nominal 11/36 to mimic shape, magnitude and spill frequency parameters (see Section 3.2.1).
    - Cayoosh: Open year round.
    - Throughout: All alternatives remove existing operating constraints (as described in Section 5.2).

[1] It was initially thought that egg dewatering would be covered by the origianl MBR performance measures. However, as these measures were shown to be insensitive across alternatives, the concern about egg dewatering suggested a trade-off with drawdowns on Downton Reservoir.

[2] A protocol, by which Middle Bridge River flows were moderated, at low Downton Reservoir elevations was discussed but not finalized as was timing of maintenance activities (and consequent flow changes) to avoid critical times for key species in Middle Bridge River. See Section 6.6.

The final alternatives explored opportunities to manage for incremental fish and wildlife performance gains; that is, after the above constraints were satisfied.

N2-2 This alternative is a refinement of Alternative N2. Relative to Alternative N2, the main change is a relaxation of the constraints on elevation of Downton Reservoir. Alternative N2 had a 718 minimum elevation constraint on Downton Reservoir. In order to achieve this, Middle Bridge River flows often dropped below 250 cfs. Alternative N2-2 holds Middle Bridge River flows at a minimum of 650 cfs, and as a result elevations in Downton Reservoir drop to (and sometimes slightly below) 710 m. The modelled constraints on Carpenter Reservoir are the same as Alternative N2, namely targeting a maximum of 648 m with excursions to 651 m allowable for up to 8 weeks. As shown in the resulting hydrographs (see Appendix E), this target is frequently violated in order to maintain the higher priority constraints downstream. Performance measure results incorporate this frequency. The model results also indicate that Carpenter Reservoir elevations are not expected to drop below 615 m, mitigating the entrainment concern.

O3-2 This alternative is a refinement of Alternative L2. Alternative L2 delivered good wildlife habitat benefits on Carpenter Reservoir, but caused relatively high entrainment risks at Downton Reservoir. The Consultative Committee requested an alternative that would provide most of the wildlife habitat benefits in Carpenter Reservoir, but reduce the entrainment risks in Downton Reservoir. Alternative O3-2 maintains a maximum elevation of 647 m on Carpenter Reservoir, with excursions up to 651 m allowable for up to 8 weeks duration (versus no excursions as in Alternative L2). As with Alternative L2, there is no minimum on Downton Reservoir, however, the more flexible profile for Carpenter Reservoir coupled with different flow constraints on Middle Bridge River result in fewer deep drawdowns than under Alternative L2.

O4 This is also a refinement of Alternative L2. It maintains a firm elevation of 647 m in Carpenter Reservoir (no excursions) and so provides slightly more wildlife habitat benefit than Alternative O3-2. However, it fails to respect the minimum flow requirements in Middle Bridge River. Therefore it is clear that to achieve the wildlife habitat benefits in Carpenter Reservoir, it is necessary to accept either increased risk of egg dewatering in the Middle Bridge River or entrainment risk in Downton Reservoir.

N2-2P Alternative N2-2P is identical to Alternative N2-2, except that fall rye is planted in Carpenter Reservoir from the Gun Creek to Tyax Junction. This increases the wildlife habitat index to roughly the same value as for Alternative O3-2. However, there are some trade-offs: Alternative O3-2 delivers more cottonwood forest; Alternative N2-2P delivers more sedgegrass/fall rye.

I4 As in Alternative I3, the capacity of Seton Generating Station is upgraded through addition of a new generating plant. The extra capacity is used to provide a 718 m minimum elevation on Downton Reservoir and to meet constraints on Carpenter Reservoir that are designed to improve both littoral productivity and wildlife habitat. These constraints are the same as those applied in the Round 4 Alternative M2. Both the Carpenter Fish Index and Carpenter Wildlife Habitat Index are highest under this alternative.

In designing Alternative N2-2P, the Consultative Committee explored several planting options: (a) planting the area to Minto, (b) to Tyax, and (c) to Tyaughton Creek. Initial concerns were expressed about differences between native vegetation and planted fall rye (native being much preferable to fall rye) and about the need for planting in perpetuity. It was confirmed through consultation with revegetation experts that it is expected that a planting program of three to 5 years would create the soil conditions necessary to establish a native vegetation zone and that continued planting is expected to be unnecessary.

The Consultative Committee rejected the option to plant to Tyaughton Creek as it was expected that the success of native species in the most eastern end of this zone would be low due to the long duration of inundation. Planting to Minto only (Option a) was rejected because there are significant economies of scale in planting, and Option b: planting to Tyax allows an area nearly 300% of the size of Option (a) to be planted at 160% of the cost.

The Consultative Committee agreed by consensus (with one abstention) that the planting option should consist of a 5-year period of planting fall rye over about 500 hectares (roughly to Tyax) with some planting of perennials (willows) in appropriate locations, for a total maximum cost of $80,000 per year over 5 years.

The possibility of adding planting to the "O" alternatives was rejected because the longer inundation periods would undermine establishment of native vegetation and dust control and aesthetics benefits are not significant (i.e., the "O" alternatives have shorter inundation at the very upper levels, but longer inundation at mid-levels around Gun Creek and Tyax). The suggested planting program is described in Appendix D3.

Table 6-3 contains the consequence table for the Round 5 Final Bridge River Water Use Plan alternatives. Appendix E provides for more detailed results, including Index subcomponents, 90th percentile results and a full set of hydrographs for each segment of the system. The hydrographs illustrate water flow and storage under the selected constraints based on historical inflow. As Alternative I4 does not affect the operating regime recommendation in this Bridge River Water Use Plan, it is discussed separately in Section 6.7.

Table 6-3: Round 5 Consequence Table for Final Bridge River Water Use Plan Alternatives

ACTUAL IMPACTS (Median Values, Except as Noted)								
				Alternative				
Objective	Performance Measure	What's Good?	MSIC	B	N2-2	O3-2	O4	N2-2P
Flood	Flood Days * (no. of days per year)	Less	5%	4	0	1	1	0
Fish	Fish-Rivers: LBR Summary (OK or NO)	OK	n/a	NO	OK	OK	OK	OK
	Fish-Rivers: SONR Summary (constructed scale)	More	n/a	0	2	1	1	2
	Fish-Reservoirs: DOW INDEX (0-100)	More	15%	67	67	68	66	67
	Fish-Reservoirs: CAR INDEX (0-100)	More	15%	39	51	54	53	51
Water Quality	Suspended Sediment Load * (t / year)	Less	30%	131	125	160	173	125
Wildlife	CAR Reservoir WL Habitat Index ** (weighted hectares)	More	10%	1121	1108	1201	1307	1208
Aesthetics	Green-up (eastern-most point)	More	n/a	Gun Creek	Gun Creek	Gun Creek	Gun Creek	Minto 40-80 cm; Tyax 30 cm
Power	Total Annual Revenue ($M / yr)	More	2%	145	147	146	146	147
	Annual Planting Costs ($M/year) ^	Less	n/a					0.042
	Net Annual Revenue ($M / yr)	More	2%	145	147	146	146	147

* Value reported is the Worst Impact, 9 years out of 10. Median flood days equal zero under all alternatives.
** Value reported is the Maximum value in order to better represent the cumulative effect of wildlife development.
^ Value reported is the levelized annual cost of the 5-year planting program.

Notes to Table 6-2:

1. A unit change has been made to the calculation of littoral productivity and the wildlife habitat index since Round 4. This change results in different scores being recorded for Alternatives B, N2 and I3 in Round 5 versus Round 4. This changes the value of the performance measure, but does not change the relative rank of each alternative with respect to that performance measure. The unit change was made in response to updated environmental information.
2. The Consultative Committee reviewed planting options in Alternative N2-2P (a) to Minto, (b) to Tyax, and (c) to Tyaughton Creek. They selected (b). Here we present Planting Option N2-2P (b) only.

As in Round 4, several performance measures do not vary significantly across alternatives,[1] including:

- Flood days
- Lower Bridge River Summary
- Carpenter and Downton Reservoirs Fish Index

Power values also vary within a small range. In contrast to the previous set, Round 5 alternatives vary little with respect to the fish performance measures in either Downton Reservoir or Carpenter Reservoir. Downton Reservoir wildlife performance measure is also insensitive. The key differentiating factors in the Round 5 results are: Seton River Fish, Carpenter Reservoir Wildlife and Aesthetics as measured by the area of green-up. Some differences were also noted in 90th percentile data for Seton Lake water quality.

After a review of Table 6-3, the Consultative Committee focused its deliberations on the key trade-offs outlined in Table 6-4 below.

[1] Note that Alternative B is included as a reference case only, having been eliminated from further consideration in Round 4.

Table 6-4: Summary of Key Trade-offs

	B	N2-2	03-2	04	N2-2P
CAR WILDLIFE (Wildlife Habitat Index)	1121	1108	1201	1307	1204
CAR AESTHETICS (Green-up)	Gun	Gun	Gun	Gun	Tyax
SONL WATER QUALITY * (Sediment)	131	125	160	173	125
SONR FISH (Hydrograph Score)	0	2	1	1	2
POWER (Net Revenue)	145	147	146	146	147
CAR FISH (Local Littoral Benefit)					Yes
MBR/DOW FISH (Entrainment, Minimum Flow)				No	

* Value shown is the 90% percentile value. Differences in median values across alternatives are not significant.

In sum:

- When planted, Alternative N2-2P delivers a Wildlife Habitat Index value equal to Alternative O3-2. Alternative O4 continues to deliver the best wildlife performance, primarily through increased cottonwood habitat.
- Alternative N2-2P produces about an additional 500 hectares of green-up each summer on Carpenter Reservoir (from Gun Creek to Tyax), which will improve aesthetics and dust control. While initially planted fall rye, this should lead to the establishment of native vegetation over much of this area within 5 years.
- There is no change in sediment loading to Seton Lake Reservoir across the alternatives in median years. However, in the worst 10% of years, the sediment inflows to Seton Lake are higher under the "O" alternatives, likely due to extended duration at lower elevations in Downton Reservoir.
- There is little difference across alternatives in power values (within the MSIC of 2%).
- Under Alternatives N2-2 and N2-2P, the Seton River hydrograph scores a "2," meaning that significant negative conditions occur in roughly only 10% of years, which is expected to produce a positive population response in at least some species. The O alternatives score a 1, which significantly reduces direct mortality risks (e.g., stranding, dewatering), but high spills in a large number of years is expected to constrain productivity.

In addition to the performance measures, two impacts unique to Alternatives N2-2P and O4 were identified:

- In Carpenter Reservoir, it is expected that the planting of fall rye under Alternative N2-2P will increase littoral productivity in the area immediately adjacent to the planted area. The boost in productivity is expected to be quite significant, locally, but not significant, with respect to the entire reservoir productivity.

- Alternative O4 is unable to meet the minimum flow targets on Middle Bridge River or minimum elevation targets on Downton Reservoir. As a result, there is an increased risk of egg dewatering in Middle Bridge River or entrainment in Downton Reservoir relative to other alternatives.

Finally, it was also noted that although all alternatives meet the maximum spill limits on Lower Bridge River set by the Consultative Committee, Alternatives O3-2 and O4 result in slightly longer duration of spills relative to Alternatives N2-2 and N2-2P.

Some of the key trade-offs, uncertainties and points of discussion that affected the Consultative Committee's decisions are summarized below:

- *How significant would the effect of Alternative O4 be on Middle Bridge River/Downton Reservoir Fish?* Alternative O4 delivers the greatest amount of cottonwood forest at Carpenter Reservoir, an outcome highly valued by some participants. However, to achieve that, it must violate either minimum flows in Middle Bridge River or minimum elevation targets in Downton Reservoir. There is considerable uncertainty about how significant the effect of these violations would be on fish populations. There is a belief by some that fish in Downton Reservoir and Middle Bridge River can persist or rebound from fairly severe conditions. However, the frequency and magnitude of violations under Alternative O4 would be worse than those experienced historically and thus adoption of Alternative O4 was considered risky.

- How likely is it that the willow/cottonwood community will develop under Alternatives O4 or O3-2? How large would the community be? It was noted that while modelling of grass and willow communities is fairly accurate, the assumptions used to estimate cottonwood progression were more uncertain. It was also noted that most of the increase in cottonwood under Alternatives O3-2 and O4 results from an increase in biomass in areas with some existing cottonwood, rather than from a large increase in the spatial extent of cottonwood forest. Cottonwood forest was assigned the highest wildlife value (the greatest benefit for the most species). Cottonwood forest also provides habitat year round. In comparison, other habitat types offer seasonal (summer) wildlife support.

- *How significant is the difference between a score of "1" versus "2" on the Seton River Fish Index?* Some participants felt so strongly about achieving a score of "2" on Seton River Fish, that they could not support alternatives with a score of only "1." However, there were significant differences of opinion among Fisheries Technical Committee members when assigning scores to the hydrographs delivered under each alternative. Several Fisheries Technical Committee members acknowledged that there are large uncertainties about the extent to which the fish response across the alternatives would differ. Because alternatives that constrain Carpenter Reservoir (in order to achieve environmental improvements there) result in failure to achieve a score of "2" on Seton River Fish Index, this uncertainty clearly affects Bridge River Water Use Plan decision-making.

- *How important is the effect of occasional increases in annual sediment loading in Seton Lake Reservoir?* The consultant's report on metals/contaminants found that while increased sediment loading originates from Downton Reservoir or Carpenter Reservoir into Seton Lake Reservoir (or Lower Bridge River) it would not be expected to increase risks associated with contamination, because the Downton and Carpenter sediments are at equal or lower concentrations than those already in Seton Lake Reservoir. Similarly the report found that drinking water quality posed no health concerns although it was acknowledged there were some aesthetic issues (elevated iron, turbidity). Participants generally accepted the findings of the report. However, this performance measure is also a proxy for some fisheries effects – namely, pelagic productivity and shore spawning. It is clear that turbidity in Seton Lake Reservoir has increased as a result of the interbasin transfer from Carpenter Reservoir. It is not clear to what extent this turbidity increase affects fish productivity in Seton Lake Reservoir. Further it is not clear whether an operating alternative that results in higher sediment inflows in the worst 10% of years (Alternatives O3-2 and O4) would have any incremental negative impacts.

- *How significant is the increase in vegetated area under Alternative N2-2P and the aesthetic benefits that will result?* Under Alternatives N2-2 and O3-2, grass coverage is expected to extend to about Gun Creek (with some additional sparse coverage to lower elevations). In contrast, under the planted Alternative N2-2P, fall rye would grow to a height of 40-80 cm over the area extending from Gun Creek to Minto (about 175 hectares) and to a height of about 30 cm over the area extending from Minto to Tyax (about 500 hectares). This would have benefits for wildlife, and also aesthetic benefits (e.g., visual quality, dust control) which would improve the tourism appeal of the area and appeal to local residents.

- *How significant is the effect of fall rye grass on littoral productivity? How will fish respond to this production?* Studies have shown that fall rye has an additional benefit in that it contributes to localized littoral productivity. That is, Alternative N2-2P is expected to provide benefits to fish using the littoral areas immediately adjacent to the planted area. It is not clear to what extent this will enhance fish production. In the end, the potential benefit of planting to fish was not a major driver of the decision to adopt planting, but was recognised as an expected secondary benefit.

Sensitivity to Future Decisions About Cayoosh Diversion

The Walden North plant is located on Cayoosh Creek approximately 2 km upstream of the confluence with the Seton River. Discharges from Walden North into Cayoosh Creek can be diverted into Seton Lake Reservoir by means of a diversion tunnel. This diversion is required to accommodate the Gates Creek sockeye migration (20 July - 31 August) and the Portage Creek sockeye migration (28 September - 15 November). The sockeye migrations require a dilution of Cayoosh Creek with water from Seton River so that the fish do not delay their migration at the Seton powerhouse.

Aquila and Fisheries and Oceans Canada and Ministry of Water, Land and Air Protection have initiated discussions about the preferred way to operate the Cayoosh Creek diversion to maximize benefits to both the Seton River fisheries (Gates and Portage sockeye migrations) and instream fish habitat in Cayoosh Creek itself. These discussions were not yet complete when the Consultative Committee reached the conclusion of its deliberations.

All model runs for the operating alternatives specify the Cayoosh Creek Diversion as open year round. The diversion is required to be fully open during the flow mix periods noted above. However, alternatives for the non-flow mix window that Fisheries and Oceans Canada and Aquila are exploring include fully closing the diversion outside the flow mix window, and partially closing the diversion outside the flow mix window. The Consultative Committee discussed these alternatives and identified the following implications of closing or partially closing the diversion outside the flow mix period:

- Advantages: Some improvement in the Seton River hydrograph due to reduced spills; Improved temperatures at Seton beach (up to mid-July); Improved conditions for fish habitat in Cayoosh Creek.

- Disadvantages: Loss of power generation at BC Hydro Seton and Aquila Walden North power plants.

In order to determine whether the Consultative Committee's decisions would be affected by decisions about Cayoosh Creek diversion operation, "bounding" model runs were conducted. Table 6-5 shows the impact of various Cayoosh Creek Diversion operations on Alternative O3-2 (see columns labelled O3_2closed and O3_2half closed). Alternative O3-2 was chosen as it was expected that it (along with O4) would be the most sensitive to changes at Seton River.

As expected, closing the diversion outside the flow mix period would lower power values while improving the Seton River hydrograph. It was concluded that these impacts would be marginal, as well as consistent across all operating alternatives, and thus would not materially affect the performance measures or the selection of an operating alternative. Effects on recreational quality (beach temperature) are better under a fully closed alternative, but both fully and partially closed are improvements over current, and neither addresses recreational quality after mid-July.

After reviewing these outcomes, the Consultative Committee concluded that its decision will be robust with respect to the range of plausible operations on Cayoosh Creek and so the Committee did not feel it needed to provide any recommendations.

Table 6-5: Sensitivity of Results to Cayoosh Operation and Lower Bridge River Flows

ACTUAL IMPACTS: (Median Values, Except as Noted)

Objective	Performance Measure	What's Good?	MSIC	O3-2		O3_2Closed		O3_2HalfClosed	
				Median (over 40 years)	Worst (9 years out of 10)	Median (over 40 years)	Worst (9 years out of 10)	Median (over 40 years)	Worst (9 years out of 10)
Flood	Flood Days * (no. days per year)	Less	5%	1	1	0	0	0	0
Fish - SONR	Fish-Rivers: SONR Summary (constructed scale)	More	n/a	1	1	1-2		1-2	
	Shape (0-1)	More		0.9	0.8	0.8	0.8	0.8	0.8
	Flow Magnitude (wks / yr)	Less		2.0	10.0	2.0	6.0	2.0	9.0
	Spills (weighted spill days)	Less		18.0	31.0	17.0	27.0	17.0	30.0
Fish - DOW	Fish-Reservoirs: Littoral C (t / season): 25%	More	25%	4.9	3	5.4	4	4.9	3
	Fish-Reservoirs: Enstrain (unitless): 55%	Less	10%	4.1	8	4.3	8	4.2	8
	Fish-Reservoirs: Backwater (km): 20%	Less	10%	3.0	4	2.9	4	2.9	4
Fish - CAR	Fish-Reservoirs: Littoral C (t / season): 50%	More	25%	19.4	16.0	20.0	17.1	19.7	16.6
	Fish-Reservoirs: Enstrain (unitless): 35%	Less	10%	8.4	9.0	8.7	9.3	8.4	9.0
	Fish-Reservoirs: Backwater (km): 15%	Less	10%	6.9	8.4	7.0	8.4	7.0	8.4
Water Quality	Suspended Sediment Load (t / year)	Less	30%	86	160	83	162	88	158
Wildlife	CAR Reservoir WL Habitat Index ** (weighted hectares)	More	10%	1201	1151	1187	1144	1155	1110
	Wildlife Habitat Area (ha) - sedge-grass-herb	More		240	214	251	224	250	219
	Wildlife Habitat Area (ha) - deciduous shrub	More		130	112	134	115	132	113
	Wildlife Habitat Area (ha) - cottonwood	More		327	290	304	272	273	239
	Wildlife Habitat Area (ha) - fall rye	More		0	0	0	0	0	0
Power	Total Annual Net Revenue ($M / yr)	More	2%	146	127	145	126	146	127

* Values reported here are the Worst Impact, 9 years out of 10. Median flood days equal zero under all alternatives.
** Values reported here refer to Maximum values in order to better represent the cumulative effect of wildlife development.

6.6 Round 5 Areas of Agreement

Recommended Operating Strategy

Upon conclusion of its deliberations, each Consultative Committee member was asked to indicate his/her support for each of the Round 5 alternatives. Definitions of degrees of support were:

- Endorse: Strong Support
- Accept: Support with reservations
- Block: Do not support

Both "Endorse" and "Accept" are indications of support. An "Accept" usually means the member believes that there is a better alternative, but this one meets minimum needs or expectations. The Consultative Committee agreed that a consensus decision is one that is not blocked by any party.

Consultative Committee support for Round 5 alternatives is summarized in Table 6-6.

Table 6-6: Summary of Support for Round 5 Alternatives

Alternative	Endorse	Accept	Block	Abstain
N2-2	Joe	Brett Caverly Delling Kroeker Lang Mullen Dalmer	Hall Macfarlane	Ingram
O3-2		Brett Delling Joe Kroeker Lang	Caverly Hall Macfarlane Mullen Dalmer	Ingram
O4		Brett Delling Joe Kroeker Lang	Caverly Hall Macfarlane Mullen-Dalmer	Ingram
N2-2P	Brett Caverly Delling Hall Joe Kroeker Lang Macfarlane Mullen-Dalmer			Ingram

Note: Affiliations of individuals are provided in Appendix A. In addition, Rod Louie and the following chiefs of the Stl'atl'imx Nation were present: Mike Leach, Garry John, Perry Redan and Bradley Jack.

Based on an earlier discussion and agreement by the Consultative Committee (see Section 6.5), the Alternative N2-2P is defined as a 5-year period of planting fall rye over about 500 hectares (roughly to Tyax) with some planting of perennials (willows) in appropriate locations, for a total cost of $80,000 per year for 5 years.

Individuals who "blocked" alternatives in Table 6-6 provided the following reasons:

- Alternative N2-2: Blocks reflect a belief that the incremental cost of the proposed planting program under Alternative N2-2P is so small that a decision to forego the opportunity for significant environmental improvements would be unacceptable.

- Alternatives O3-2 and O4: Blocks reflect a concern that the residual impacts of a "1" on Seton River fish performance measures will not sufficiently address the current concerns related to fish productivity on Seton River.

Reasons for the Endorsements in Table 6-7 were:

- Alternative N2-2P: All participants felt that this alternative represents an improvement over current operations. While some had initially hoped for larger environmental gains in the reservoirs, the exploration of alternatives had demonstrated that such alternatives would have unacceptable consequences in the rivers for fish and wildlife habitat. Participants felt that the process had explored all reasonable alternatives, that the analysis of impacts was thorough, and that the Alternative N2-2P represents a good balance among all the objectives, in particular between fish and wildlife interests.

- Alternative N2-2: One participant felt that even without planting, the Alternative N2-2 was a substantial improvement over current operations. However, most felt that the incremental cost of Alternative N2-2P was so small relative to the benefits that they simply could not strongly support N2-2.

Lillooet resident, Don Ingram chose not to declare his preferences, but did confirm that he was satisfied with the information that had been provided in the process. In subsequent communication (D. Fields, 3 May 2002), Mr. Ingram indicated he did not disagree with the recommendation of Alternative N2-2P.

As observers, Stl'atl'imx Nation (Chief Mike Leach, Chief Garry John, Chief Perry Redan, Chief Bradley Jack, Rodney Louie and Desmond Peters Jr.) indicated that they had not had time to review the alternatives and their implications with their communities. However, Chief Perry Redan of Sekw'elw'as and representing Stl'atl'imx Nation advised that he was:

- encouraged by the scope of the results of the water use planning process;

- pleased to see the extent to which the process encouraged information exchange and dialogue among the parties; and

- impressed with the results that were put on the Consultative Committee table.

Chief Perry Redan of Sekw'elw'as expressed concern that planned or emergency water releases be accompanied by a communications protocol to avoid stranding fishermen on the rocks in the Bridge River.

Stl'atl'imx Nation later provided comments on certain steps that they feel are required to obtain "full and informed consent." The letter in its entirety is presented in Appendix I. Relevant extracts from that letter include:

- informed and notified of any plans/proposal contemplated by Government agency(ies);
- reach agreement on participation in all aspects of proposed activities, depending on the nature of the proposed activity;
- where consultation is part of a process, a parallel process with the Stl'atl'imx Chiefs Council may be required, as the Stl'atl'imx Chiefs Council is not defined as a stakeholder;
- resources for meaningful participation is required, both for Chiefs and/or technical support;
- technical support is required to review reports and studies that are proposed or require review;
- legal review may be required, including a review of the proposed process/project;
- all communities impacted will require involvement in final decision/ratification;
- timing of proposed process/project must consider limitations of community/tribe to respond;
- decision-making process should be separate from stakeholders, if consultation;
- approach to process/project must consider holistic nature or approach and any linkages to other similar activities;
- others as identified by participants at the start/during the process;

The above is a partial list, provided by Stl'atl'imx Nation for example purposes only.

The Stl'atl'imx Chiefs Council also noted that it has concerns with revised or renewed licences. Since Alternative N2-2P involves revisions to existing licences, Stl'atl'imx Chiefs Council expects these current issues to be resolved before changes to licences are made.

Recommended Procedures for the Operating Strategy

Once the basic operating alternative was selected, there remained a number of detailed operating procedures that needed to be specified in order to operationalize the selected constraints. Given the detailed and technical nature of these procedures, the Consultative Committee delegated their resolution to the fisheries agencies and BC Hydro representatives. At time of writing, they were being developed and will be included in the draft Bridge River Water Use Plan submission or BC Hydro's Operating orders. They include:

- specification of the Seton River hydrograph;
- specification of the Lower Bridge River hydrograph;
- management of flows at Middle Bridge River when Downton Reservoir elevations are low;
- flow ramping including fish salvage;
- spill sequencing; and
- management of Cayoosh Creek dilution.

6.7 Alternatives with an Upgraded Seton Generating Station

The Round 5 upgrade alternative (I4) is summarized in Table 6-7, along with the Reference case (B) and the upgrade alternative presented in Round 3 (I3).

Table 6-7: Round 5 Consequence Table for Seton GS Upgrade Options

ACTUAL IMPACTS (Median Values, Except as Noted)						
Objective	Performance Measure	What's Good?	MSIC	Alternative B	I3	I4
Flood	Flood Days * (no. of days per year)	Less	5%	**4**	**0**	**0**
Fish	Fish-Rivers: LBR Summary (OK or NO)	OK	n/a	**NO**	**OK**	**OK**
	Fish-Rivers: SONR Summary (constructed scale)	More	n/a	**0**	**1**	**1**
	Fish-Reservoirs: DOW INDEX (0-100)	More	15%	**67**	**63**	**69**
	Fish-Reservoirs: CAR INDEX (0-100)	More	15%	**39**	**38**	**76**
Water Quality	Suspended Sediment Load * (t / year)	Less	30%	**131**	**173**	**174**
Wildlife	CAR Reservoir WL Habitat Index ** (weighted hectares)	More	10%	**1121**	**1110**	**1352**
Aesthetics	Green-up (eastern-most point)	More	n/a	**Gun Creek**	**Gun Creek**	**Gun Creek**
Power	Total Annual Revenue ($M / yr)	More	2%	145	150	146
	Annual Levelized Capital Costs ($M/year)	Less	n/a		6.15	6.15
	Net Annual Revenue ($M / yr)	More	2%	**145**	**144**	**140**

* Value reported is the Worst Impact, 9 years out of 10. Median flood days equal zero under all alternatives.
** Value reported is the Maximum value in order to better represent the cumulative effect of wildlife development.

1. A unit change has been made to the calculation of littoral productivity and the wildlife habitat index from Round 4. This change results in different scores being recorded for Alternatives B, N2 and I3 in Round 5 versus Round 4. This changes the value of the performance measure, but does not change the relative rank of each alternative with respect to that performance measure. The unit change was made in response to updated environmental information. The performance measure values reported here for Alternatives B and I3 are calculated using the updated units.

Alternatives I3 and I4 demonstrate a range of ways in which additional capacity at Seton Generating Station can be used to enhance performance. Under I3, the additional capacity was used to maximize power production while providing improvements to Seton River fish. Under Alternative I4, the additional capacity was used to maximize environmental performance on Carpenter Reservoir. The intention under Alternative I4 was also to improve the Seton River hydrograph to a score of "2;" however it was not quite achieved. Further modelling would be required to optimize the use of the additional capacity. Notwithstanding, the Consultative Committee felt that it had adequate information to assess a recommendation to pursue feasibility studies of an upgrade at Seton Generating Station.

Benefits of the "I" alternatives include the ability to achieve improved environmental performance, possibly creating the opportunity in the future to find an operating strategy that allows improvements in Carpenter Reservoir wildlife habitat and fish performance measures, as well as maintenance of the Seton River fish performance measures. With the existing infrastructure, trade-offs between them are more significant.

Concerns about Alternatives I3 and I4 included the high capital cost of the upgrade, and relatively poor rate of return on investment (a net annual loss rather than a gain). However, some participants questioned whether the cost calculation had correctly accounted for the residual value of the facilities after the amortization period. Further, it was felt that since BC Hydro had relied on existing information to prepare the financial analysis, a full feasibility study that explores alternative ways to provide the additional capacity and uses updated market information may deliver a more favourable economic evaluation.

In terms of trade-offs, Alternative I4 delivers superior environmental performance relative to other alternatives. The primary drawback is the financial cost. However, some participants felt that the benefits outweigh the costs and that Alternative I4 would be preferred once modified to deliver a Seton River hydrograph with a score of "2." Other members are not convinced that Alternative I4 is superior, noting for example that it increases the sediment load to Seton Lake Reservoir relative to other alternatives. However, all participants agreed that the "I" alternatives have been shown to have enough merit to warrant more detailed investigation.

The Consultative Committee unanimously agreed on the following recommendation as part of the Bridge River Water Use Plan:

- On the basis of the potential to achieve a better balance among objectives, BC Hydro should undertake a detailed feasibility study of an upgrade to the Seton Generating Station within 5 years.

- Recognizing that other facility upgrades may have similar or greater benefits, BC Hydro should concurrently examine other facility upgrades elsewhere in the Bridge River system.

It was emphasized that this recommendation should not in any way undermine the strength of the selected alternative (N2-2P). Alternative N2-2P is viewed as an superior operating strategy. Nonetheless, difficult trade-offs were required, and it is apparent that facility upgrades could in some cases create more flexibility to achieve environmental, as well as power, objectives. Feasibility studies for upgrades should be conducted not only under assumptions designed to maximize power or economic performance (e.g., Alternative I3), but also to achieve environmental improvements (e.g., Alternative I4 with modifications to deliver a "2" on Seton River).

In a letter to the facilitator (18 January 2002), the Stl'atl'imx Chiefs Council indicated that it has concerns with the elevation of water storage in Seton Lake Reservoir, and questions the right of BC Hydro to store water in Seton Lake Reservoir, as there is presently no licence for storage. This matter has been raised with the Comptroller of Water Rights directly by Stl'atl'imx Nation, but is relevant to the recommendations regarding Seton Generating Station upgrades. Stl'atl'imx Nation would be particularly interested in studies of a Seton Generating Station upgrade if it resulted in the possibility of altering Seton Lake Reservoir water levels.

7 LOWER BRIDGE RIVER ADAPTIVE MANAGEMENT

At Round 2, the Consultative Committee directed the Fisheries Technical Committee to develop a detailed proposal for an active adaptive management program on the Lower Bridge River. Active adaptive management involves testing multiple alternative water management policies in order to resolve uncertainty about the benefits of each alternative and improve the quality of future water management decisions.

7.1 Introduction

Background

The lack of continuous flow releases from the Terzaghi Dam into the Lower Bridge River has been a long standing concern of the public, First Nations, and regulatory agencies. As a result, the resolution of instream flow management is considered an important component of the Bridge River Water Use Plan. Instream flow studies (1993-1995) and ecological monitoring (1996-present) have improved scientific understanding about baseline conditions in the Lower Bridge River aquatic ecosystem. However, they have not provided sufficient scientific understanding needed to provide reliable predictions about the impacts of instream flow releases on the productivity of the aquatic or riparian components of the ecosystem.

In 1998, an agreement between BC Hydro Fisheries and Oceans Canada (associated with litigation regarding 1991-92 dam operations) specified that an experimental instream flow release and monitoring program be developed and implemented in an attempt to resolve uncertainty about response of the aquatic ecosystem to reservoir releases. Continuous instream flow releases for the purpose of testing the response of the aquatic ecosystem to flow changes were initiated from Terzaghi Dam on 1 August 2000 with a water budget of 3 m^3/s. The agreement specified that an experimental flow release program was to continue until a Bridge River Water Use Plan was developed for the Bridge-Seton watershed. As described below, the deliberations of the Consultative Committee confirmed the need for a continued test program.

Rationale for Adaptive Management on LowerBridge River

Consideration of an experimental flow release program on the Lower Bridge River is based on the existence of two competing hypotheses about the response of fish to flow:[1]

- Alternative H1: High flows are better for fish
- Alternative H2: Low flows are better for fish

Alternative H1 reflects the hypothesis that higher flows will increase the quantity of habitat (wetted area) without significantly reducing its quality (especially for juveniles). Under this hypothesis, higher flows are believed to be better for cueing migrations of anadromous salmonids, improving the hydraulic conditions for spawning (depth, velocity), and more effectively performing a subset of the functions of a natural hydrograph (i.e., riffle scouring, provide habitat diversity), all without significantly reducing the availability of suitable juvenile habitat. Alternative H2 reflects the hypothesis inferred from physical habitat modelling for Lower Bridge River, which is that while the quantity of wetted area increases under higher flows, the increased velocities will have a detrimental impact on the quality of habitat, with a net negative impact on fish populations.

The Lower Bridge River is viewed as an important fish (salmon and steelhead) producing stream, and the opportunities to enhance productivity in this river are highly valued. On the other hand, the cost of releasing water at Lower Bridge River is relatively high and the financial costs of incorrectly assuming a strongly positive fish response to higher flows could be high.

Instream flow assessment/modelling methods have been utilized to make predictions about habitat availability and use. However, subsequent monitoring studies have contradicted model predictions. Therefore, the Fisheries Technical Committee and Consultative Committee had no information to reliably determine which of the above hypotheses is correct. Based on the potential of an adaptive management approach to reduce uncertainty, improve fish response and avoid high cost/low benefit flow alternatives, in May of 2001 (at Round 2), the Consultative Committee deliberated and recommended that the Fisheries Technical Committee develop a detailed proposal for an adaptive management program on the Lower Bridge River.

A variety of questions and concerns were raised and discussed. It was then agreed that the adaptive management program needs to be carefully designed and evaluated against a non-experimental flow alternative. The following analysis describes this process of refinement and more detailed assessment.

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[1] Relevant assumptions include: 1) that habitat is a limiting factor to fish productivity/biomass; 2) that the appropriate shape of the hydrograph is relatively certain, and it is changes in the base water budget that is the primary determinant of fish response.

7.2 Alternatives Considered

The adaptive management program consists of two components, a test flow release program and a monitoring program. This section briefly describes the design alternatives that were considered for the test flow release program, the decisions made by the Consultative Committee about the scope of the test flows, and the specifications of the program that was evaluated in detail. Monitoring plans for the adaptive management program are included in Section 8.

Test Flows and Hydrograph Shape

The Fisheries Technical Committee began its analysis by considering test flow releases between 1 m^3/s and 10 m^3/s, and ultimately considered test flows of 1 m^3/s, 3 m^3/s, 6 m^3/s, and 9 m^3/s in detail. All flow treatments were based on an annual water budget that is shaped to a pre-determined naturalized hydrograph developed by the Fisheries Technical Committee. This range of flows reflects the alternative hypotheses about the response of fish to increasing flows (i.e., H1: Low flows (1-3 m^3/s) will be better for fish; and H2: High flows (6-10 m^3/s) will be better for fish).

Treatment Duration

After an analysis of possible design parameters, it was agreed that each flow test should be implemented for four consecutive years. This would allow estimation of variation in the key response indicators due to natural variation and measurement error, and allow short term lag responses to be observed, if they exist (see Appendix G).

Titration Design

In the first program design considered in detail by the Fisheries Technical Committee and Consultative Committee, the first test flow was to be 3 m^3/s, the second 6 m^3/s, and then a post-Water Use Plan Fisheries Technical Committee would decide whether to go up to 9 m^3/s or down to 1 m^3/s based on the findings (See Appendix G2). This was called the "titration design." However, after reviewing the possible shapes of the functional relationships between flow and biomass, it was noted that this design could fail to test 1 m^3/s, even when a peak in biomass may occur there. Given the possibility of a win-win at 1 m^3/s (high biomass at low cost), it was agreed that the program design should explicitly include a 1 m^3/s flow release.[1] The titration design was rejected.

[1] Similarly, it was believed plausible that a threshold effect could cause a situation where biomass does not increase significantly from 3 to 6, but does increase significantly from 6 to 9. The design would also fail to detect that state of nature.

Maximum Test Flow

After reviewing the first round of costs and benefits, the Consultative Committee concluded that it would be premature to commit to a test flow of 9 m^3/s. The financial costs of a 9 m^3/s release are high, and based on current information, the potential for biomass gains is very uncertain. Further, given the duration of the trials, an adaptive management program involving three test flows would take 11 years to complete (treatment one is into its second year of implementation already). The Consultative Committee concluded that by then, there may be new information about biological impacts, significant changes in the value of power and importance of power produced at the Bridge River hydroelectric facilities, and changes in the trade-offs that people are willing to make between power and ecosystem benefits.

Test Flows and Sequencing

Therefore, it was proposed that the adaptive management program for the Bridge River Water Use Plan should include three test flow releases at 3, 1, and 6 m^3/s. The rationale for each test flow includes:

1. 3 m^3/s: This is a continuation of the current flow regime, for which 1 year of data has already been collected.

2. 1 m^3/s: One of the competing hypotheses suggests that a win-win may exist at or around 1 m^3/s. That is, it is possible that high biomass (and corresponding instream benefits) may be achieved at low cost. As a result, this flow warrants testing.

3. 6 m^3/s: This flow rate is the lowest flow that will adequately test the hypothesis that high flows are better.

These flows should be considered as the first three test flow releases, after which a stable flow could be selected or other (e.g., 9 m^3/s) releases could be tested.

The Consultative Committee agreed that the sequence of implementation should be 3 m^3/s first (since the first year at 3 m^3/s is complete), followed by 1 m^3/s, and then 6 m^3/s in order to minimize the present value of the costs. A review will occur before establishing the flow regime after 6 m^3/s (see Figure 7-1).

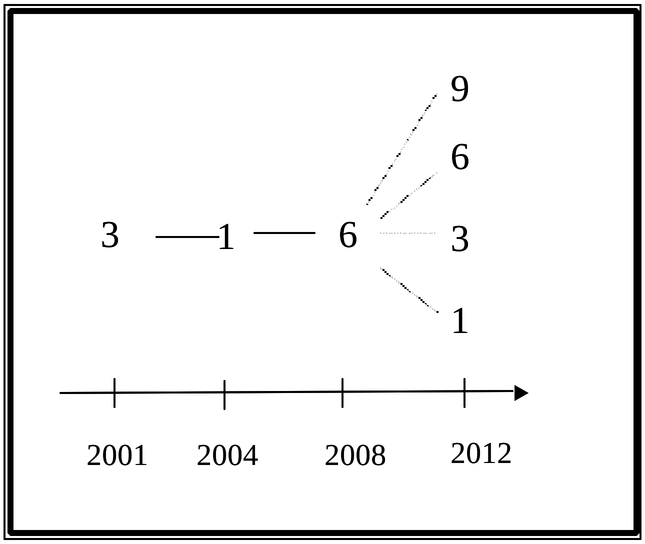

Figure 7-1: Proposed Flow Sequencing

Decision Rules

The Consultative Committee also considered adopting a decision rule that could give a post-implementation management committee the authority to halt the trials after the 1 m^3/s test flow under certain outcomes (e.g., if the observed biomass increment at 1 m^3/s was sufficiently high that the probability of achieving substantially greater gains at higher flows would be low). Had the decision about which flow to select been a single-attribute decision (e.g., based on juvenile salmonid biomass alone), then setting such a decision rule would likely have been possible and desirable. However, it became apparent that Consultative Committee members would want to review multiple attributes of performance before making a decision to conclude the trials. Specifically, there were significant concerns that the impact of the flow tests on riparian vegetation be considered. Also, a second evaluation criterion for fisheries was identified by the Fisheries Technical Committee (e.g., spawning habitat/success). The Consultative Committee concluded that the development of an *a priori* decision rule that could be implemented by a small group of decision makers was likely unworkable, given the multiple attributes involved. Instead, the Consultative Committee recommends that all three flows be tested followed by a broad multi-party review of operations. See Appendix G2 for further discussion of the decision rule(s) that were considered.

The Consultative Committee agreed that within the flow ranges proposed (1 m^3/s to 6 m^3/s) and based on the benefits of the program outlined (see Section 7.4 and Figure 7-2), the incremental cost of the experimental program relative to the status quo release of 3 m^3/s was small and justified.

The evaluation results presented in Section 7.3 are based on the 3-1-6 m^3/s sequence, without decision rules.

7.3 Method of Evaluation

Criteria for Evaluating the Fish Response

The Fisheries Technical Committee agreed that the primary ecological criterion against which each test flow would be evaluated is "juvenile salmonid biomass," aggregated over the total length of the Lower Bridge River (Reaches 1 through 4). That is, the ranking of flow regimes (from a fisheries perspective) would be based on their impact on total juvenile salmonid biomass. It was agreed that this criterion would be used both for an *a priori* evaluation to guide the selection of an appropriate experimental design, and for post-implementation evaluation to guide the selection of an ongoing flow regime.[1]

Juvenile salmonid biomass is used as the evaluation criterion because it is a good integrator of instream flow effects. It is assumed that if salmonid biomass is increasing, then there are benefits to a wide range of species using instream habitat in Lower Bridge River. Therefore, salmonid biomass is a useful criterion for discriminating among flow alternatives (i.e., a flow regime that is best for salmonid biomass is likely best for overall instream ecosystem health), but the true magnitude of benefits from selecting the correct flow regime is understated by the reported increment in salmonid biomass.

The Fish Technical Subcommittee recognized that other secondary indicators would support inferences derived from the juvenile salmon biomass measure.

Assessing the Expected Value of Information from the Experiment

To determine the value of the experimental approach, four questions were addressed:

- How large is the uncertainty?
- Does the uncertainty have the potential to affect a management decision?
- Does the experiment have the ability to reduce the uncertainty?
- Do the long-term benefits outweigh the costs?
- To address these questions, the Bridge River Water Use Plan trade-off analysts:
    - Elicited technical judgements from experts about the likely range in biomass across the proposed flow ranges, under each competing hypothesis;

[1] A second criterion for post-implementation evaluation was later identified as salmonid spawning habitat. However, it was not assessed as part of this *a priori* evaluation.

- Elicited value judgements from Consultative Committee members about whether water management decisions are likely to change, given the estimated costs and the potential range of benefits across the test flows;

- Elicited technical judgements from experts about the probability that the experiment will correctly predict the real state of nature (i.e., judgements about the ability of the experiment to discriminate between the hypotheses);

- Summarized the expected financial costs and biomass benefits of various policies, including selecting (without experimentation) flows of 1, 3, 6 and 9 m^3/s, and selecting the experimental approach outlined above.

The costs of each water management policy are the financial costs associated with a) the release of water (which, if released, is not available for generation) and b) the monitoring costs. The benefits are the expected change in juvenile salmonid biomass, and related instream/ecosystem benefits for which this measure is a proxy. Assessing the cost of the adaptive management trials is complicated by the fact that the flow regime that will ultimately be selected is currently unknown. Assessing the benefits is complicated by the fact that the fish response to flow is unknown. The framework used to assess costs and benefits is therefore a probabilistic one, based on expert judgements and "expected" values. The key findings are summarized below. Some of the underlying detail is presented in Appendix G1.

7.4 Results

Figure 7-2 summarizes the results of the evaluation. For each hypothesis (i.e., Hypothesis 1 = "high flows are good" and Hypothesis 2 = "low flows are good"), experts provided an interval within which they are 90% confident that the biomass value will fall. These estimates are represented by the far outer bounds marked as dotted lines in Figure 7-2. When taken together, the aggregate 90% confidence band (for both hypotheses and both experts combined) is narrower. This is represented by the solid horizontal line for each alternative. It is narrower because the hypotheses and the judgements of the two experts overlap. In sum, we are 90% confident that the true value for biomass for each alternative will fall along the solid line.

Although the Consultative Committee ultimately decided to recommend a 3-1-6 m^3/s program in the Bridge River Water Use Plan, it chose to conduct its evaluation based on the longer 25-year time frame, which includes the option to explore 9 m^3/s in the future. With a 25-year horizon, costs and benefits are dependent on the flow choice after 6 m^3/s. Consequently, the cost estimate is uncertain and presented as an "expected value." Costs of the selected program over the (shorter) Bridge River Water Use Plan period are discussed in Section 7.5.

From Figure 7-2, three key observations are:

1. Biomass results: Relative to all of the single flow options, the proposed flow trials have a slightly higher expected value for biomass.

2. Specifically, the test flow option shifts the 90% confidence interval for biomass to the right. Under a 1 m^3/s flow, there is a 90% confidence of getting between 500-1200 kg of biomass. But under the experiment, there is a 90% confidence of getting between 800-1400 kg of biomass. In other words, the flow trials are expected to increase the upside potential in terms of biomass (i.e., information about more flows increases the ability to find the preferred level), and reduce the downside risk of a poor biomass outcome.

3. Costs: The flow trials option is expected to cost $800,000 more per year than the 3 m^3/s option, but less than the other two higher flow options. However, the range of possible costs within this expected value depends on the flow that follows 6 m^3/s. The vertical line for the experiment shows a range of total levelized annual costs ranging from a low of roughly $2 million per year in the event that a low flow (1 m^3/s) is ultimately chosen, up to a high of roughly $5 million, which would occur only in the event a high flow (9 m^3/s) is ultimately chosen.[1]

   Had the decision rule been adopted that allowed halting the experiment at 1 m^3/s if a certain level of biomass had been obtained, the incremental cost of the experiment would have been reduced by an expected value of $450,000 (to $350,000 from $800,000). It would not change the upper and lower bounds of the vertical bar.

[1] Although the cost of a 9 m^3/s flow is about $8 million per year (see Figure 7-2), these costs would not be incurred until much later and for only part of the 25 year horizon.

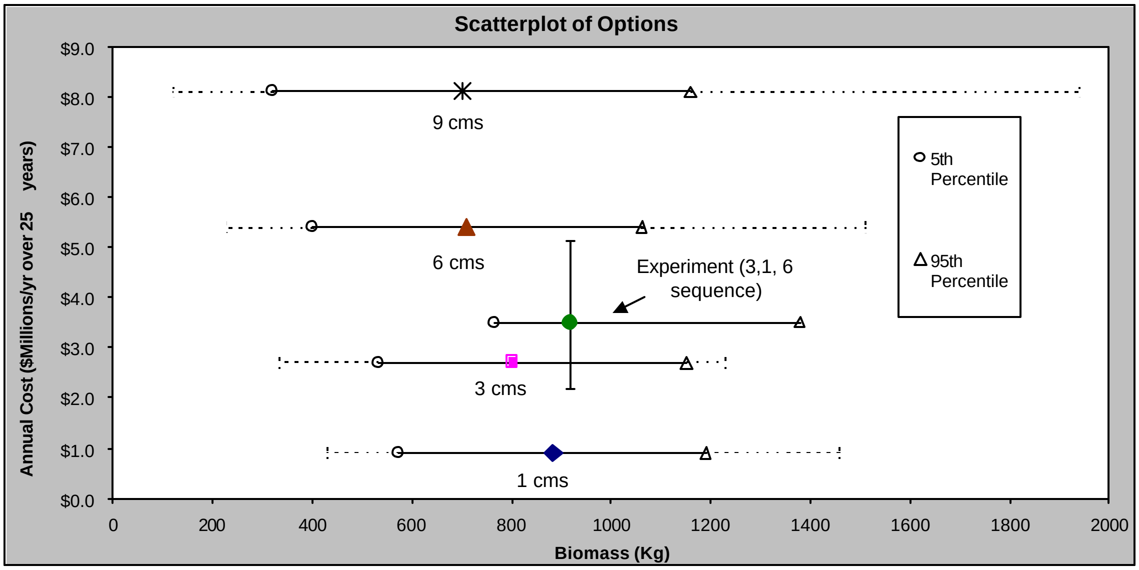

Figure 7-2: Expected Financial Costs and Juvenile Salmonid Biomass Under Alternative Flow

7.5 Incremental Costs and Benefits of the Recommended Adaptive Management Program

In this section, the costs and benefits of the specific Bridge River Water Use Plan recommendation are presented. Unlike the 25 year analysis, the cost associated with the finite 3-1-6 m^3/s program can be projected with some certainty. All the Rounds 4 and 5 operating alternatives were modelled with a 3 m^3/s discharge on the Lower Bridge River. Therefore, the incremental cost of the Lower Bridge River adaptive management program is calculated relative to 3 m^3/s.

On a levelized basis, relative to the current 3 m^3/s discharge, the incremental cost is $350,000 per year for the next 11 years. The possibility of incurring any additional costs will be debated at the conclusion of the experiment on the basis of better information about the benefits associated with each flow regime.

The expected biomass and 90% confidence intervals for biomass for each of the Rounds 4 and 5 operating alternatives *without* the adaptive management program are as reported in Figure 7-2 under 3 m^3/s. With the adaptive management program, there is an improvement in expected value and a reduction in the risk of a poor biomass outcome. Table 7-1 summarizes consequences of Alternatives B, N2-2P and N2-2P with the adaptive management program.

Table 7-1: Effect of Lower Bridge River Adaptive Management on Consequences of N2-2P

ACTUAL IMPACTS: Median Values (except for *, ** and ***)						
Objective	**Performance Measure**	**What's Good?**	**MSIC**	**Alternative**		
				B	**N2-2P**	**N2-2P with AM**
Flood	Flood Days * (no. of days per year)	Less	5%	**4**	**0**	**0**
Fish	Fish-Rivers: LBR Summary (OK or NO)	OK	n/a	**NO**	**OK**	**OK**
	Fish-Rivers: LBR Biomass *** (kg)	more	n/a	**500-1100**	**500-1100**	**800-1400**
	Fish-Rivers: SONR Summary (constructed scale)	More	n/a	**0**	**2**	**2**
	Fish-Reservoirs: DOW INDEX (0-100)	More	15%	**67**	**67**	**67**
	Fish-Reservoirs: CAR INDEX (0-100)	More	15%	**39**	**51**	**51.4**
Water Quality	Suspended Sediment Load * (t / year)	Less	30%	**131**	**125**	**125**
Wildlife	CAR Reservoir WL Habitat Index ** (weighted hectares)	More	10%	**1121**	**1208**	**1208**
Aesthetics	Green-up (eastern-most point)	More	n/a	**Gun Creek**	**Minto 40-80 cm; Tyax 30 cm**	**Minto 40-80 cm; Tyax 30 cm**
Power	Total Annual Revenue ($M / yr)	More	2%	145	147	147
	Annual Planting Costs ($M/year) ^	Less	n/a		0.042	0.042
	Annual Levelized AM Costs ($M/year) ^^	Less	n/a			0.360
	Net Annual Revenue ($M / yr)	More	2%	**145**	**147**	**147**

* Value reported is the Worst Impact, 9 years out of 10. Actual median flood days equal zero under all alternatives.
** Value reported is the Maximum value in order to better represent the cumulative effect of wildlife development.
*** Value reported is the 90% confidence interval for the 25-year program.
^ Value reported is the levelized annual cost of the 5-year planting program.
^^ Value reported is the incremental levelized annual cost of the 11-year 3-1-6 program.

7.6 Areas of Agreement

- After a review of the costs and benefits, the Consultative Committee concluded that:
- In light of the high costs and uncertain benefits, testing of 9 m^3/s should be deferred until such time as better information is available
- Within the biomass ranges and financial costs noted in Figure 7-2, it is plausible that the preferred flow release on Lower Bridge River may be as low as 1 m^3/s or as high as 6 m^3/s. Therefore testing of 3 m^3/s, 1 m^3/s and 6 m^3/s is justified.
- A fixed sequence is preferable to a sequence guided by interim decision rules.
- Provision should be made to allow the 1 m^3/s test flow to be increased to 1.5 m^3/s should there be inadequate wetting of Reach 4 at 1 m^3/s.
- Monitoring programs must be designed to evaluate the benefits and risks of the test flows to both fish and wildlife.

- Coordination between the flow trials and physical enhancement works in the region must be coordinated so that enhancements works do not confound the trials, and so that the flow trials do not unduly restrict opportunities to conduct enhancement work. This coordination (and, where necessary, priority setting) would be undertaken on a case-by-case basis.

With respect to the fourth bullet above, some concern was raised about the 1 m^3/s flow rate and whether it would adequately wet some sections of Reach 4. It was agreed that those responsible for the flow test would observe the river at the start of the 1 m^3/s flow release and make a decision about whether the water budget should be 1 or 1.5 m^3/s. Should an increase to 1.5 m^3/s be necessary, the total additional cost of the 0.5 m^3/s flow for that 4-year period would be about $1.8 million. In levelized terms, this would equal $170,000 per year over the 11 year program proposed for the Bridge River Water Use Plan.

With respect to the concern about the possibility that the adoption of the adaptive management program would overly restrict opportunities for physical enhancements, the Consultative Committee had extensive discussions. Stl'atl'imx Nation in particular expressed that they could not support the adaptive management program if it overly restricted enhancement opportunities. The Consultative Committee explored enhancement opportunities, and identified a number of opportunities that would not confound the adaptive management program, including opportunities in downstream reaches of Lower Bridge River, as well as in other parts of the system beyond Lower Bridge River. A collaborative approach to both the flow trials and enhancement planning was agreed to among Stl'atl'imx Nation, Fisheries and Oceans Canada, Ministry of Water, Land and Air Protection and BC Hydro. It was agreed that this collaboration will allow for sufficient activity in both areas without confounding the results of the flow trials (and hence, the value of information from those trials in determining appropriate long term flows). It was suggested that the quality and quantity of enhancement opportunities be assessed at different flows (a possible project under the Bridge/Coastal Restoration Program).

At the conclusion of its deliberations, Consultative Committee members were asked to indicate their preferences for alternative flow regimes on the Lower Bridge River. These are summarized in Table 7-2. From Table 7-2, it is apparent that the only flow regime with a high degree of support is the proposed adaptive management program.

Table 7-2: Support for Lower Bridge River Flow Alternatives

Alternative	Endorse	Accept	Block	Abstain
3-1(1.5)-6 m^3/s	Brett Caverly Delling Hall Joe Kroeker Lang Macfarlane Mullen-Dalmer			Ingram
Fixed 1 m^3/s		Brett Delling Joe Kroeker Mullen-Dalmer	Caverly Hall Lang Macfarlane	Ingram
Fixed 3 m^3/s	Lang	Brett Caverly Delling Joe Kroeker Mullen-Dalmer	Hall Macfarlane	Ingram
Fixed 6 m^3/s		Caverly	Brett Delling Hall Joe Kroeker Lang Macfarlane Mullen-Dalmer	Ingram
Fixed 9 m^3/s			Brett Caverly Delling Hall Joe Kroeker Lang Macfarlane Mullen-Dalmer	Ingram

Reasons for endorsement included:

- The ecological attributes of the Lower Bridge River are highly valued by all participants and it is believed that there is a significant opportunity to enhance ecological values through flow manipulations. However, there is currently insufficient understanding of how the river would respond to flow changes to be able to make recommendations with confidence.
- Some participants also recognized the high financial costs of releasing water in the Lower Bridge River. The cost of being wrong is high, therefore it is valuable to reduce the chance of adopting a high flow when

a low flow would be better for fish, or when the incremental gains from a higher flow are not worth the costs.

- The flow ranges being tested are all very plausible future flows, since more expensive high flow options have been eliminated or deferred. The information from the program will therefore be directly relevant to future decisions.

- Relative to the status quo (a release of 3 m^3/s), the incremental expected cost of the adaptive management program, particularly for the first 11 years proposed here, is seen as small and far outweighed by the potential benefits.

- The monitoring programs are well designed and are expected to deliver useful information for selecting among flow options at the conclusion of the trials.

- This is an important opportunity for institutional learning about a new and very different way to manage fisheries.

- It is an excellent opportunity for relationship building among BC Hydro, government agencies, First Nations and stakeholders.

The endorsement of all participants was contingent on appropriate monitoring programs to ensure that defensible inferences can be drawn from the program. Endorsement of some participants was also contingent on an appropriate monitoring program for wildlife and riparian vegetation.

Blocks at a fixed 1 m^3/s reflect a high degree of concern that implementing a 1 m^3/s flow is risky. Although experts placed a slightly higher probability on the hypothesis that low flows are good, there remains a significant probability that low flows will result in reductions in biomass that some parties would view as unacceptable.

Blocks at a fixed 3 m^3/s reflect a belief that the incremental cost of the proposed adaptive management program is so small that a decision to forego the opportunity for significant improvements in knowledge that will aid future water management decisions would be irresponsible.

Blocks at a fixed 6 m^3/s reflect high degree of concern about the risk that increasing flows to 6 m^3/s could result in reductions in biomass and riparian quality and other negative wildlife impacts, that some parties would view as unacceptable. Further, given the high financial costs, there is too much uncertainty about the benefits.

Blocks at a fixed 9 m^3/s reflect both concern about the potential for negative impacts on fish and wildlife/riparian vegetation as well as concerns that the benefits may not justify the costs.

One party abstained. Goldbridge Resident Don Ingram indicated he did not disagree with the adaptive management approach as recommended (In telephone communication, D. Fields, 30 May 2002).

In a letter to the facilitator dated 18 January 2002, Stl'atl'imx Nation (observers) noted that the monitoring and adaptive management programs will need to consider Stl'atl'imx Nation capacity building and that the involvement of the Stl'atl'imx Chiefs Council is critical. Stl'atl'imx Nation expressed concern about committing to the long term (11 years) monitoring without the opportunity to change the flow rates proposed for testing based on the new information gathered in the preceding phase of the test. They also reiterated their interest in ensuring that the conduct of adaptive management trials do not jeopardize Stl'atl'imx Nation's ability to implement enhancement activities and to realize the capacity building benefits from those activities.

8 MONITORING AND REVIEW

8.1 Approach to Identifying Monitoring Programs

Early in the process, participants recognized the need to improve the understanding of the impact of operations on the objectives, particularly fish and wildlife objectives. Throughout the process, uncertainty affected many of the deliberations, both at the technical level (Fish and Wildlife Technical Committees) and at the Consultative Committee table.

These uncertainties affected the final water use decisions. For example, several participants preferred Alternative M2 alternative at Round 4 and the "O" alternatives at Round 5. What prevented adoption of these alternatives was concern about their impact on Seton River Fish (a score of "1" versus "2") and/or their impact on Downton Reservoir/Middle Bridge River (high entrainment risk and/or reduced minimum flow). The impact assessments that were used in this process were based on a number of uncertain assumptions, the resolution of which could alter participants' preferences. In addition, there were significant uncertainties affecting the calculation of other performance measures that, if resolved, could alter participants' preferences and hence decisions.

Uncertainties fall into three categories:

- Assumptions that, while uncertain, could be made with a relatively high degree of confidence and/or little consequence to water management decisions. No further investment is required to reduce these uncertainties.

- Assumptions that had an explicit impact on the Consultative Committee's final deliberations and preferences (e.g., the relationship between Seton River hydrograph and fish response, relationship between Downton Reservoir entrainment/Middle Bridge River minimum flows and fish response). These uncertainties had a very visible impact on the decision.

- Assumptions that influenced choices of the Consultative Committee throughout the process and that, within a range of plausible values for uncertain variables, could alter future decisions. In some cases, for example, participants put very low weight on a performance measure because the uncertainty was high. As a result, these measures were not as visible in the final deliberations. However, they may be equally capable of altering future decisions.

A monitoring program was developed to address the latter two types of uncertainties.

The Consultative Committee evaluated all proposed monitoring programs using the Water Use Plan program principles and evaluation templates. Key considerations for the Consultative Committee in prioritizing programs included:

- Information derived from the monitoring program must have the potential to change a future water management decision.
- The program must have the potential to deliver real learning; it must be designed in a way that delivers information of sufficient quality to discriminate among competing hypotheses.
- The program must be cost-effective; it must be shown that various methods of achieving the learning objectives have been considered and the most cost-effective alternative selected.

8.2 Monitoring Recommendations

The Consultative Committee conducted four steps to reach its recommendations:

1. Technical resources (principally the Fisheries Technical Committee) developed a list and rationale for twenty-six proposed monitoring activities. Each proposal was initially screened to exclude proposals which were unlikely to contribute useful data for assessing the effectiveness of operating changes or provide basis for better decisions in the future. These preliminary proposals are summarized in Appendix H1.
2. Monitoring proposals were evaluated by Fisheries Technical Committee members using a simple qualitative ranking system to determine the overall value they would provide.
    - The *Importance Scale* reflects both a) the importance of the resource; and b) the extent to which the information is expected to influence a future decision. 1 indicates highest importance; 5 is lowest.
    - The *Learning Scale* reflects the degree of learning that will be expected from implementing the monitoring programs. A score of 1 = fine quantitative discrimination among hypotheses; 2 = quantitative discrimination among hypotheses; 3 = quantitative discrimination among hypotheses to draw defensible weight of evidence among some hypotheses; 4 = likely to draw qualitative comparison or weak inferences about competing hypotheses; and 5 = poor inferential capability.
    - The *Overall Rank* reflects a) the importance of the resource; b) the extent to which the information is expected to influence a future decision; c) inferential quality of the program; and

d) cost-effectiveness. 1 indicates the highest priority and 5 is the lowest.

Scores were averaged across six members of the Fisheries Technical Committee and presented to the Consultative Committee as the basis for further discussion.

3. The Consultative Committee reviewed the proposed monitoring programs and made consensus decisions on the components of the program that should be included, modified, or be excluded from the proposed monitoring plan. The Consultative Committee's comments are summarized in Appendix H2. As a consequence of the Consultative Committee's review, five programs were dropped, two were enhanced and nine referred back to the Technical Committees for further modification or refinement.

4. The Technical Committees reviewed the Consultative Committee's comments, resulting in:

   - 12 programs dropped;
   - 3 programs combined into 1; and
   - 11 programs maintained and refined.

5. Detailed proposals for each recommended program were developed.

The final prioritized list of proposed monitoring programs with their respective importance, learning and overall scores are presented in Table 8-1. The annual cost of monitoring program range from about $352,000 (Year 11) to $813,000 (Year 1) with an average overall no change cost of about $560,000 per year over the 11 year period of the plan. Detailed descriptions of the recommended programs, which incorporate the modifications requested by the Consultative Committee, are included in Appendix H2.

The Consultative Committee agreed by consensus that the monitoring plan should be included in the Bridge River Water Use Plan as a package, but that the detailed evaluations and discussions of each program should also be sent to the Comptroller of Water Rights as further information (see Appendix H).

Table 8-1: Recommended Environmental Monitoring Programs

Number	Proposed Component of the Monitoring Plan	Importance	Learning	Overall Score[1]	Estimated Average Cost ($000 per year over 11 yr period) undiscounted	Total Cost ($000) (undiscounted)
1	Lower Bridge River Aquatic Monitoring	1.00	1.00	1.00	164	1806
2	Carpenter Reservoir Riparian Vegetation Monitoring	1.20	3.00*	1.40	18	199
3	Lower Bridge River Adult Salmon and Steelhead Enumeration	1.40	2.00	1.60	95	1044
4	Carpenter Reservoir and Middle Bridge River Fish Habitat and Population Monitoring	1.60	1.20	1.60	63	698
5	Downton Reservoir Riparian Vegetation Monitoring	1.60	2.40	1.60	8	86
6	Seton Lake Reservoir Aquatic Productivity Monitoring	1.60	2.40	2.00	27	300
7	Downton Reservoir Fish Habitat and Population Monitoring	2.40*	1.60	2.00	40	444
8	Seton Lake Reservoir Resident Fish Habitat and Population Monitoring**	2.20	2.80	2.20	45	500
9	Seton River Habitat and Fish Monitoring	1.75-2.60*	2.25-3.6*	2.25-2.6	44	483
10	Carpenter Reservoir Productivity Model Validation and Refinement	2.40	2.20	2.80	27	300
11	Lower Bridge River Riparian Vegetation Monitoring	3.00*	3.50*	3.25	13	145
12	Bridge-Seton Metals and Contaminant Monitoring Program	3.00*	3.50*	3.25	15	160

* Scores marked with an asterisk were recommended for review by the Consultative Committee. Specific comments are documented in Appendix H2.

** This component combines elements of three original proposals: redd dewatering, gravel scour/movement, and juvenile habitat assessments proposed for Seton. Rank reflects highest rank of the original proposal.

8.3 Review Period

The Consultative Committee considered the following options for Bridge River Water Use Plan review:

- *Full Bridge River Water Use Plan after 11 years:* This timing coincides with the conclusion of the Adaptive Management flow trials. Other monitoring results would also be available. The Bridge River Water Use

[1] For explanation of scores, see text above. Generally "1" indicates high importance/learning/overalls, with "5" the lowest score.

Plan process would follow the *Water Use Plan Guidelines* and involve the range of interests.

- *Focused Bridge River Water Use Plan after 5 years:* The intent of this option is to take advantage of early monitoring results and make changes outside Lower Bridge River. The possibility of a smaller group convening at this time to make such decisions raised concern about adequate involvement of all values. It was noted that the system is interconnected, and a Bridge River Water Use Plan that does not include Lower Bridge River may be of limited value.

- *Full Bridge River Water Use Plan after 11 years with a mid-point "check":* The intent of the mid-point check (after 5 years) is to use available monitoring information to assess whether a full Bridge River Water Use Plan should be triggered before 11 years. The default would be to continue with the stated Bridge River Water Use Plan until Year 11. A recommendation for a full Bridge River Water Use Plan would be based on significant unexpected impacts of the selected operating regime; however, a specific decision rule was not discussed. The mid-term check would involve representatives of various interests and the public, although it may be smaller than the current Consultative Committee.

The Consultative Committee agreed by consensus (with one abstention) to the third option as noted below:

> *"The Consultative Committee recommends that the Bridge River Water Use Plan be reviewed at the conclusion of the Adaptive Management program; i.e., 2012.[1] It further recommends that a formal review of the results of the monitoring programs be conducted by a Monitoring Committee after the fifth year of implementation. The Monitoring Committee may make a recommendation to the Comptroller of Water Rights at that time to trigger an earlier review of the Bridge River Water Use Plan, if it perceives evidence of unexpected and unacceptable impacts from facility operations at that time."*

In a subsequent letter (dated 18 January 2002), the Stl'atl'imx Nation indicated that the Stl'atl'imx Chiefs Council generally agree with a review of the water use planning process upon completion of the adaptive management program after 11 years, with a mid-term review after 5 years. Also D. Ingram, who abstained during the Committee decision, later indicated that he did not disagree with the Consultative Committee's recommendations.

[1] The first phase of adaptive management plan is underway under the interim flow. Consequently, the 11 years is taken as of 2001.

8.4 Monitoring Committee

The Consultative Committee recommended by consensus that a Monitoring Committee be formed, whose membership should include:

- BC Hydro
- Fisheries and Oceans Canada
- Stl'atl'imx Nation
- Ministry of Water, Land and Air Protection
- Public representative (from existing Consultative Committee, if possible)
- Representative of local government (from existing Consultative Committee, if possible)

The mandate of the Monitoring Committee would be:

- To review mid-term results and assess need to recommend an early Bridge River Water Use Plan review (Year 5).
- To recommend improvements to monitoring programs within existing budgets (Year 5).
- To review Lower Bridge River flow trial results (every 4 years).
- To support periodic communication with the public (annual).
- To oversee publication of monitoring reports (as needed, but as a minimum in Years 5 and 10).
- To nurture cooperation and collaboration to improve the environmental database and to build common understanding (ongoing).

The Monitoring Committee should meet at least annually and/or at key monitoring milestones.

In a letter to the facilitator (18 January 2002), the Stl'atl'imx Chiefs Council indicated that:

- The Stl'atl'imx Chiefs Council want to see this Monitoring Committee become part of the cooperative approach that is presently being reviewed by the Stl'atl'imx Chiefs Council, BC Hydro and Fisheries and Oceans Canada with the intent to formalize a working relationship on most of the fisheries projects/programs in the Bridge System.
- Capacity building and management are key issues of the proposed Cooperative Fisheries Agreement. The monitoring program must consider this, and the involvement of the Stl'atl'imx Chiefs Council is critical.

- Metal contamination and ongoing monitoring of heavy metals in Seton Lake remains a critical concern of the Stl'atl'imx Chiefs Council.

- Spill response and the development of emergency plans is also important, particularly in the Lower Bridge River where fishing in the river is common.

9 SUMMARY OF DECISIONS AND OUTCOMES

The Consultative Committee, made up of representatives of local residents and government, First Nations, federal and provincial agencies, BC Hydro and environmental groups, explored a wide range of alternative operating regimes for the system. They explored impacts to fish, power, wildlife, recreation, flood and water quality across the system as well as relative values. The Consultative Committee concluded its deliberations with seven recommendations which had full support of all, but one member who abstained.

The seven recommendations include a base operating strategy that encompasses a balance across wildlife and fish conditions. Linked with the operating strategy is removal of some current licence restrictions that impose constraints on power operations with no environmental or social benefits. Indeed, removal of these constraints reduce the cost of the recommended operating plan. The recommendations also recognize the uncertainties remaining in managing the system, including the lack of understanding of flow impacts in the Lower Bridge River (for which an adaptive management program is recommended) and the need to track impacts of recommended changes in water management (as covered in a monitoring program). Finally, recommendations account for a continued role for interested parties through the recommendations for a review period for the Bridge River Water Use Plan and for a Monitoring Committee.

The Consultative Committee's recommendations are summarized in Table 9-1.

Table 9-1: Recommendations of the Consultative Committee

Decision	Description	Level of Support (1)
Base Operating Strategy	Alternative N2-2P	Consensus with one abstentions
Lower Bridge River Adaptive Management Program	Flow trials of 3-1-6 m3/s over an 11-year period with monitoring of fish and wildlife responses	Consensus with one abstention
Seton Generating Station Upgrade	Recommend further study	Consensus with one abstention (2)
Licence Changes	Remove licence restrictions on BR1/2 and SON La Joie diversion	Consensus with one abstention
Monitoring Program	Implementation of combined fish/wildlife/water quality program	Consensus with one abstention (3)
Review Period	11 years (at conclusion of flow trials) with check at 5 years to assess need to trigger an early Bridge River Water Use Plan	Consensus with one abstention (4)
Monitoring Committee	Multi-party committee to oversee monitoring and nurture cooperative learning	Consensus with one abstention

1. Don Ingram does not disagree with any recommendations of the Consultative Committee (personal communication. D. Fields, 3 May 2002).
2. Note: Stl'atl'imx Nation indicated support for examining an upgrade if the opportunity to reduce Seton Lake levels was possible.
3. Note: Stl'atl'imx Nation expressed interest in being a party to the monitoring information tracking and the decisions that flow from that information.
4. Note that Stl'atl'imx Nation later indicated general support for the proposed review period.

The operating specifications of Alternative N2-2P are summarized in Table 9-2.

Table 9-2: Operating Specifications for Recommended Base Operating Strategy

Area	Specifications
DOW	- "Soft" minimum elevation of 710 m; this target will be relaxed in order to manage Middle Bridge River minimum flows as specified in subsequent procedure.
	- Remove licence restriction on diversion at La Joie
MBR	- Minimum flow of 650 cfs year-round
	- Maximum flow of 850 cfs from mid-October to mid-December
CAR	- Target maximum elevation of 648 m with allowance for inundations to 651 m for up to 8 weeks duration (frequent violations of inundation period (50% of the time expected))
	- 5-year riparian planting program involving planting of roughly 500 hectares of rye grass (about Gunn Creek to Tyax), and, if feasible, localized willow plantings at a maximum cost of $80,000 per year over 5 years.
LBR	- Planned flow releases (3 m^3/s-1 m^3/s-6 m^3/s) as per adaptive management plan
BR1&2	- Remove licence restrictions on unit operations
SONL	- No change
SONR	- Nominal 11/36 hydrograph; to mimic the shape, magnitude and spill frequency parameters of a preferred hydrograph[1]
	- 25 m^3/s minimum flow release at dam during peak smolt outmigration (Dates: 1 April to 30 June)
	- Spill Priority: If spills are necessary, spill first at Seton River.
SON GS	- Remove licence restriction on diversion annual volume
	- Remove restrictions on turbine operations related to entrainment
Cayoosh	- Maximum diversion through the tunnel year round except as specified by Fisheries and Oceans Canada for fisheries requirements in Cayoosh Creek and Seton River

At time of writing, a number of procedures were being developed to operationalize the alternative.

[1] Provided flow remains within 5-60 m^3/s, similarity of shape to a natural pre-regulative hydrograph is most important, spill frequency also considered. Operating constraints to meet these specifications will be refined inprocedures.

The Consultative Committee's support for the base operating alternative is robust across the range of flows to be explored in the adaptive management program. It is also believed to be robust across the different possible operations of the Cayoosh Diversion outside the flow mix period, which is to be finalized upon agreement between Aquila and Fisheries and Oceans Canada.

Based on the consensus recommendations, BC Hydro will draft a Water Use Plan and submit it to the Comptroller of Water Rights for consideration. If accepted, the operating constraints will form the basis of regulatory compliance.

9.1 Expected Benefits of Committee Recommendations

Expected benefits of the N2-2P operating strategy and associations recommendations are summarized in Table 9-3.

While challenged to balance objectives across different reservoirs, the consultative process identified a final operating alternative that sustains or contributes to each objective. No interest is adversely affected relative to current (Alternative B) operations. The most notable improvements are in the areas of:

- Flooding
- Fish (Carpenter Reservoir, Lower Bridge River, Seton River)
- Wildlife (Carpenter Reservoir)
- Recreation/Aesthetics (Carpenter Reservoir)
- Learning (Lower Bridge River and throughout the system)

Changes in power values are small (positive but within modelling error) relative to current operations as a result of the relaxation of licence restrictions. Water quality is not expected to be affected, however the monitoring program provides for confirmation of that as well as increased learning about how changes in operations impact water quality in Carpenter Reservoir, and Lower Bridge River and Seton Lake Reservoir. Although performance will vary year by year, the above results are expected to hold over a range of hydrologic conditions over time.

Table 9-3: Expected Outcomes of the Recommended Alternative

Objective	Summary of Consequences
Flooding	- Reduction in flooding on all rivers, from expected frequency of four days (status quo) to zero (1 year out of 10)
Fish - DOW	- No change
Fish - MBR	- Improvements in whitefish egg survival
Fish - CAR	- 30% improvement in the fisheries index

Objective	Summary of Consequences
Fish - LBR	- Reduction in spill frequency and duration on Lower Bridge River - Improvement in juvenile salmonid biomass (is a proxy for multiple instream benefits) from a 90% confidence interval of 500 to 1,200 up to 800 to 1,400
Fish - SONL	- No change
Fish - SONR	- Reduction in the frequency of significant negative impacts from operations from nearly 100% of years, to roughly 10% of years. Net effect expected to produce positive population level response in at least some species - Significant reduction (about 200 000 annually) in mortality from entrainment in turbines during peak sockeye outmigration; residual mortality at the dam remains at about 2% to 5%; no change to entrainment of outmigrants outside the peak window
Wildlife - DOW	- Preservation of Grizzly Flats
Wildlife - CAR	- Increase of about 500 hectares of new sedge-grass community on Carpenter Reservoir from Gun Creek to Tyax, and enhancements to willow community at upper end of Carpenter Reservoir - Improvements for wildlife that rely on sedge-grass and willow communities expected
Fish and Wildlife - Learning	- Implementation of the Lower Bridge River adaptive management program and the system monitoring program will provide key information about the impact of water management on fish and wildlife. This will provide greater certainty for future flow management decisions
Recreation/Aesthetics - CAR	- Increase of about 500 hectares of new sedge-grass community on Carpenter Reservoir from Gun Creek to Tyax - Improvements in aesthetics and dust control over about 500 ha
Water Quality - SONL	- No change
Power	- Gain in annual revenues estimated at $1.8 million per year before monitoring program relative to current operations - Monitoring estimated at an average cost of $560,000 per year (undiscounted) over 11 years, ranging from about $352,000 to $813,000 in any particular year

9.2 Additional Comments

At the meeting conclusion, all Consultative Committee members spoke about the process, the project team, other Consultative Committee members, and the overall results. Comments include:

- Fisheries and Oceans Canada representative: This is really a great result. We should all be really happy. The Bridge River Water Use Plan exceeds my expectations. All members need to publicly support what has been chosen and what they have accomplished. We need to communicate to our constituents and honour the arrangements.

- Ministry of Water, Land and Air representative: Thanks to the BC Hydro project team for their patience and their fine job organizing and leading the process. The project team kept the Consultative Committee interested and informed on very technical matters. A special note to Lee Failing, Kim Meidal and the two Pauls (Paul Higgins and Paul Vassilev) in providing a remarkable level of information especially as the alternatives became increasingly complex.

- Stl'atl'imx Nation (observers): We are encouraged that the preferred alternative took into account vegetation and wildlife and not only fish. We are happy to see the extent in this area. We are impressed with the result of the Consultative Committee.

- Local resident: It's been a great opportunity to work with other Consultative Committee members and be part of a great process. Thanks to everyone. A lot of respect was shown to the public. It was a treat to be involved in a think-tank environment. I am also very glad that Stl'atl'imx came on board.

- Local resident: I didn't think for a minute the process would result in a win-win-win outcome.

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APPENDIX A: CONSULTATIVE COMMITTEE CONTACT LISTS

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Consultative Committee Members		Note
John Brett Phone: 250 256-4429	Yalakom Ecological Society Box 1175 Lillooet, B.C. V0K 1V0	
Al Caverly Phone: 250 371-6321 Fax: 250 828-4000 Email: alan.caverly@gems2.gov.bc.ca	Ministry of Water, Land and Air Protection (WLAP) Southern Interior Region 1259 Dalhousie Drive Kamloops, B.C. V2C 5Z	
Karl Delling Phone: 250 238-2544 Phone2/Fax: 250 238-2294 Email: karlh@goldtrail.com	Lillooet District Community Resources Board Box 5 Gold Bridge, B.C. V0K 1P0	
Steve Hall Phone: 250 238-2425 Fax: 250 238-2425 Email: Steven_Hall@telus.net	Gold Bridge Resident Fisheries Consultant Crane Creek Gold Bridge, B.C. V0K 1P0	
Don Ingram Phone: 250 256-7969	Lillooet Resident PO Box 1219 Lillooet, B.C. V0K 1V0	Joined in November 2000
Wing Joe Phone: 604 528-3428 Fax: 604 528-7705 Email: wing.joe@bchydro.com	BC Hydro Corporate Representative 6911 Southpoint Drive, E15 Burnaby, B.C. V3N 4X8	
Darryl Kroeker Phone: 250 374-8307 Fax: 250 374-6287 Email: d_kroeker@ducks.ca	Ducks Unlimited 954 Laval Cres. Kamloops, B.C. V2C 5P5	
Fraser Lang Radio # N493349	Yalakom Community Council Box 1241 Lillooet, B.C. V0K 1V0	

Consultative Committee Members		Note
Steve Macfarlane Phone: 604 666-5529 Fax: 604 666-0292 Email: macfarlanes@pac.dfo-mpo.gc.ca	Fisheries and Oceans Canada (PRO) Pacific Region 555 W. Hastings St. Vancouver, B.C. V6B 5G3	
Austin Mayo Phone: 250 383-7012 Cell: 250 812-7111 Email: ausmo@shaw.ca ausmo@hotmail.com	#118-200 Dallas Road Victoria, B.C. V8V 1A4	Last attended October 2001. Moved
*Ian McGregor Phone: 250 371-6252 Fax: 250 828-4000 Email: Ian.mcgregor@gems8.gov.bc.ca	Ministry of Water, Land and Air Protection (WLAP) Southern Interior Region 1259 Dalhousie Drive Kamloops, B.C. V2C 5Z5	
Terry Molstad Phone: 604 528-2892 Fax: 604 528-1857 Email: terry.molstad@bchydro.com	BC Hydro Corporate Representative 6911 Southpoint Drive, E08 Burnaby, B.C. V3N 4X8	Did not attend Final CC Meeting
Denise Mullen-Dalmer Phone: 250 952-0264 Fax: 250 952-0258 Email: denise.mullendalmer @gems1.gov.bc.ca	Electricity Development Branch Min of Employment & Investment Box 9327 Stn Prov Govt 4th Floor, 1810 Blanshard St. Victoria, B.C. V8W 9N3	
*Heather Stalberg Phone: 604 666-5529 Fax: 604 666-0292 Email: StalbergH@pac.dfo-mpo.gc.ca	Fisheries and Oceans Canada (DFO) Pacific Region 555 W. Hastings St. Vancouver, B.C. V6B 5G3	

* Alternative representatives

Official Observers

Kevin Conlin
Phone: 250 387-9582
Fax: 250 387-9750
Email: kevin.conlin@gems1.gov.bc.ca

BC Fisheries
PO Box 9359, Stn Prov Govt
Victoria, B.C. V8W 9M2

Kent Dehnel
Phone: 416 537-3657
Email: kentdehnel@bcenertech.com

West Kootenay Power
807 Dupont Street
Toronto, Ontario M6G 1Z7

Rob Dunsmore
Phone: 250 304-9806
Fax: 250 359-0710
Email: rdunsmore@wkpower.com

West Kootenay Power

Bijou Kartha
Phone: 250 952-6801
Fax: 250 387-1898
Email: bijou.kartha@gems7.gov.bc.ca

MWALP, Water Management
PO Box 9340 Stn Prov Govt
Victoria, B.C. V8W 9M1

Rick Kooistra
Phone: 250 256-5204
Fax: 250 256-5250

Ainsworth Lumber Company Ltd.
530 Main St., Box 880
Lillooet, B.C. V0K 1V0

Phil Hallinan
Phone: 250 314-9660
Fax: 250 314-9660
Email: hallinan@sageserve.com

Fraser Basin Council
200A 1383 McGill Road
Kamloops, B.C. V2C 6K7

Rodney Louie
Phone: 250 256-0425
Fax: 250 256-0426
Email: snhc@webside.ca

Stl'atl'imx Nation
PO Box 2218
Lillooet, B.C. V0K 1V0

John Mackie
Phone: 604 775-8890
Fax: 604 775-8828
Email: mackiej@pac.dfo-mpo.gc.ca

Navigable Waters Protection
Canadian Coast Guard - Pacific
555 W. Hastings St.
Vancouver, B.C. V6B 5G3

Geoff Pfiefer
Phone: 250 256-7584

Yalakom Resident
Box 1158
Lillooet, B.C. V0K 1V0

Desmond Peters, Jr.
Phone: 250 256-0425
Fax: 250 256-0426
Email: snhc@webside.ca

Stl'atl'imx Nation
PO Box 2218
Lillooet, B.C. V0K 1V0

Chief Perry Redan,
Phone: 250 256-0425
Fax: 250 256-0426

Email:

Stl'atl'imx Chiefs Council, WUP representative Stl'atl'imx Nation
Box 2218
Lillooet, B.C., V0K 1V0
SNHC@webside.ca

Fred Shields
Phone: 250 259-8378

Seton-Portage Resident
Box 2051
Seton-Portage, B.C. V0N 3B0

Fisheries Technical Subcommittee

Barry Chilibeck (until mid 2001), DFO
Heather Stalberg, DFO
Paul Higgins, BC Hydro
Daryl Kroeker, Ducks Unlimited
Fraser Lang, Yalakom Community Council
John Brett, Yalakom Ecological Society
Steve Macfarlane, DFO
Mike Bradford, DFO
Steve Hall, Goldbridge resident
Alan Caverly, WLAP
Bryan Hebden, BC Hydro

Wildlife Technical Subcommittee

Paul Higgins, BC Hydro
Daryl Kroeker, Ducks Unlimited
Fraser Lang, Yalakom Community Council
Steve Hall, Goldbridge resident
Alan Caverly/Doug Jury, WLAP
John Brett, Yalakom Ecological Society
Ed Hill, BC Hydro

BC Hydro Support Staff

Sue Foster — Project Manager
Phone: 604 528-2737
Email: sue.foster@bchydro.com

Daryl Fields — Resource Valuation
Phone: 604 623-4446
Email: daryl.fields@bchydro.com

Dave Bruce — Environment (recreation)
Phone: 604 528-1805
Fax: 604 528-8390
Email: david.bruce@bchydro.com

Bryan Hebden — Environment
Phone: 250 371-6927
Email: bryan.hebden@bchydro.com

Paul Higgins — Environment
Phone: 604 528-7728
Email: paul.higgins@bchydro.com

Ed Hill — Environment
Phone: 604 528-3253
Email: ed.hill@bchydro.com

Kim Meidal — Power Studies
Phone: 604 528-2421
Email: kim.meidal@bchydro.com

Barry Wilkinson — Community Relations
Phone: 604 528-2353 or 1-800-663-1377
Email: barry.wilkinson@bchydro.com

Patricia Fryer — Community Relations
Phone: 604 528-2357 or 1-800-663-1377
Email: pat.fryer@bchydro.com

Paul Vassilev — Power Studies
Phone: 604 528-2443
Email: paul.vassilev@bchydro.com

Jack Edwards — Aboriginal Relations
Phone: 604 623-3795
Email: jack.edwards@bchydro.com

Resource Valuation Consultants

Lee Failing — Compass Resource Management (Facilitator)

Phone: 604 641-2875
Email: lfailing@compassrm.com

Robin Gregory — Value Scope Research
Phone: 604 980-0346
Email: rgregory@interchange.ubc.ca

Graham Horn — Plant Management
Phone: 604 641-2877
Email: ghorn@planit.bc.ca

APPENDIX B: BRIDGE RIVER WATER USE PLAN PERFORMANCE MEASURES CONCEPTS

B1 Technical Weighting of Fisheries Performance Measures

B2 Minimum Significant Increment of Change for Environmental Performance Measures

B3 Technical Weighting of Wildlife Performance Measures

APPENDIX B1: TECHNICAL WEIGHTING OF FISHERIES PERFORMANCE MEASURES

1.0 METHOD

Based on the set of alternatives run as of March 2001, the worst and best performance measure values across the set of alternatives were reported. On the basis of this range in consequences, each member of the Fisheries Technical Committee (FTC) was asked to weight the importance of a swing in the performance measure value from its worst to its best, based on the relative contribution to the Bridge River Water Use Plan objective (which is to maximize the abundance and diversity of fish). FTC members also reported the rationale for their judgements. Resultant weights were then compared, rationale for differing opinions was debated and in some cases, weights were revised. In the end, the FTC agreed that simple averaging of the weights would provide sound guidance to the Consultative Committee about the relative importance of each performance measure. It was recognized that the exercise depended on existing environmental studies and professional judgement.

2.0 RESULTS

2.1 Downton Reservoir

The impacts of Entrainment were unanimously viewed by Fisheries Technical Committee members as having the greatest potential to affect the abundance and diversity of fish in Downton Reservoir. Although based on limited environmental study, it was assigned an average weight of 56%. Littoral productivity followed at 26%, with the lower weight largely attributable to the small range across worst to best values, and Backwatering was last at 18% (Figure B1-1).

2.2 Carpenter Reservoir

Most respondents weighted Littoral Productivity highest, followed by Entrainment and Backwatering, with average weights of 50% for Littoral, 35% for Entrainment, and 15% for Backwatering (Figure B1-2). Respondents who assigned lower weights to Entrainment felt that entrainment primarily affects kokanee, since they are of less management concern (because they are introduced, and potentially subject to collapse). Those who weighted Entrainment higher were more concerned about the stranding and entrainment of bullet trout and rainbow trout, and/or placed higher priority on kokanee. Several respondents believed that entrainment, at frequencies expected under the alternatives considered, is not believed to significantly affect abundance. However, there is significant uncertainty in this area of discussion and no time series population data to back up this belief.

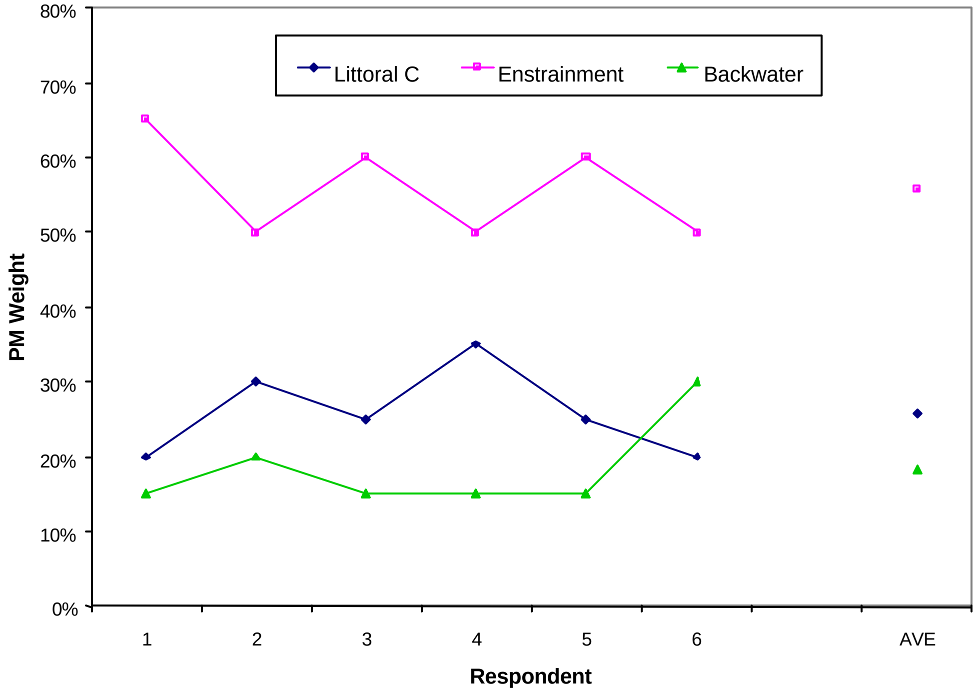

Figure B1-1: Downton Fisheries Performance Measure Weighting

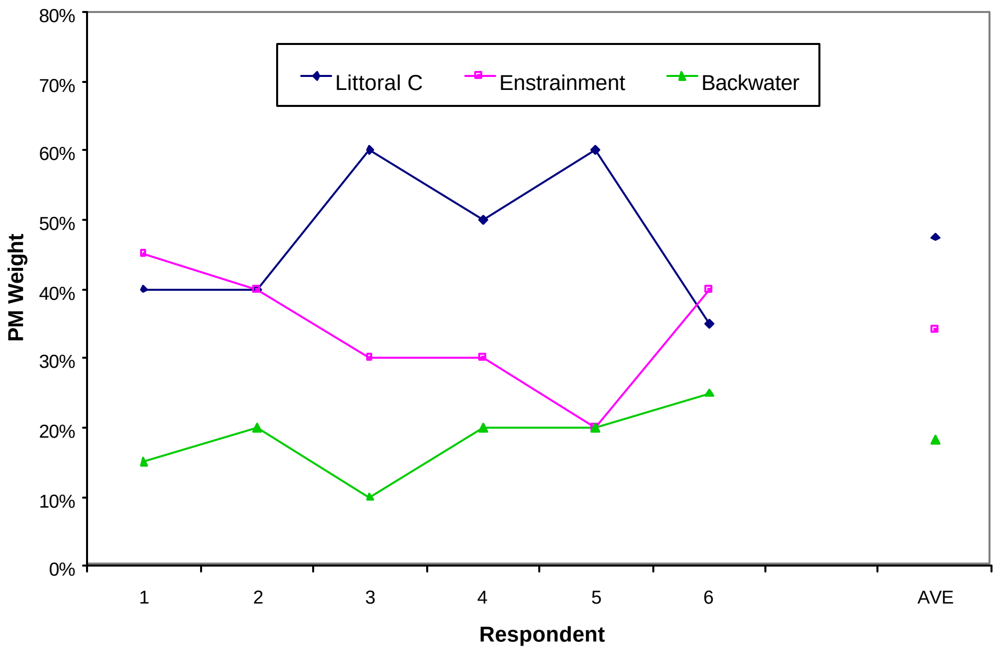

Figure B1-2: Carpenter Fisheries Performance Measure Weighting

2.3 Seton Lake Reservoir

All respondents weighted Entrainment significantly higher than Pelagic Carbon (Figure B1-3). Rationale included: a) there is high certainty about benefits resulting from reductions in entrainment, while benefits from improvements in productivity are unknown and b) changes in Pelagic Carbon may be much less important than in terms of improving reservoir productivity than increases in turnover rate from increased inflows (which are not affected by the alternatives). On average, assigned weights were 70% for Entrainment and 30% for Pelagic.

2.4 Middle Bridge River

On average, assigned weights were 65% for Spills, 20% for Juvenile Habitat, and 15% for Adult Habitat (Figure B1-4). Respondents who assigned a low weight to Spills assumed that spill timing continued at the normal timing and ramp downs are consistent with current practice. The higher weight assigned to Juvenile Habitat by one respondent was the result of consideration of impacts on eggs. (Note however that the Juvenile Habitat performance measure does not capture egg dewatering effects.)

2.5 Seton River

Figure B1-5 shows the weights assigned by the respondents to each of the three Seton River performance measures. No clear trend or area of agreement is apparent, and the average weight for each performance measure is 33%. However, debate after the initial weighting revealed that there is significant overlap between the Spill and Magnitude performance measures, and that different respondents were using different assumptions about the impacts represented by each performance measure. When the Spill and Magnitude performance measures are combined, it is clear that there are two competing hypotheses or lines of thinking about fisheries impacts in Seton River (Figure B1-6).

The first hypothesis is that the negative impacts on abundance of extreme high and low flows are well known while the understanding of how shape contributes to abundance is very uncertain. Respondents 1, 3, 4, 5 and 6 weighted Spills and Magnitude heavily as a result (roughly 70% for combined Spills and Magnitude, versus 30% for Shape). The second hypothesis is that the main ecosystem driver is the hydrologic regime, the shape of which is critical, and that, while poorly understood, natural restoration processes will occur in ways we cannot predict, affecting the greatest number of species. This view is held by Respondent 2 and results in a much higher weight assigned to the Shape performance measure (60%).

The Fisheries Technical Committee recommended that all three Seton River Fisheries performance measures be maintained and given equal weighting. This adequately reflects the degree of uncertainty and recognizes some overlap among the indicators.

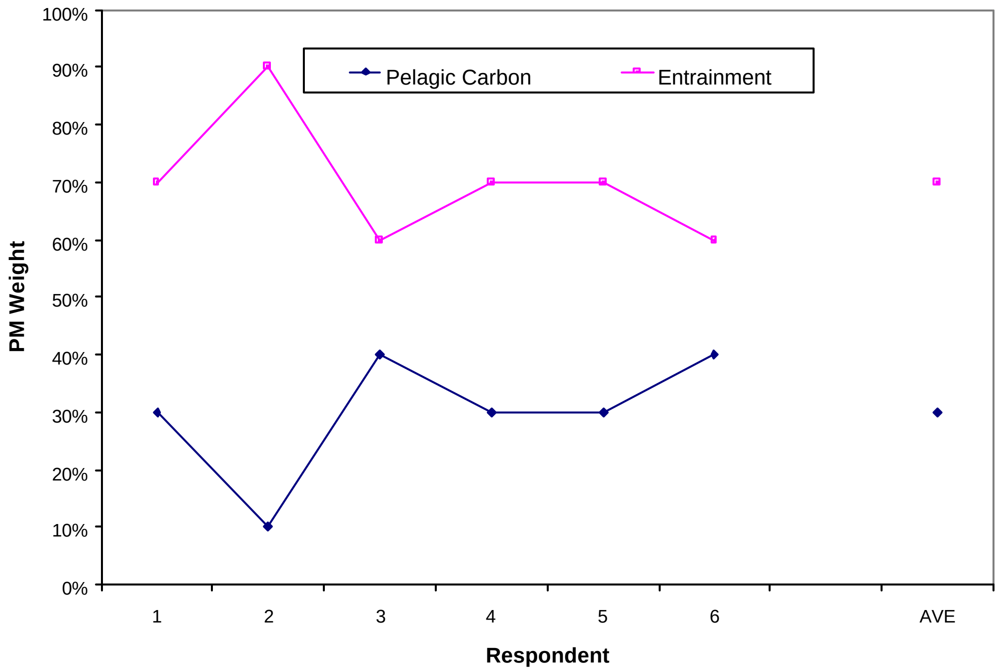

Figure B1-3: Seton Lake Fisheries Performance Measure Weighting

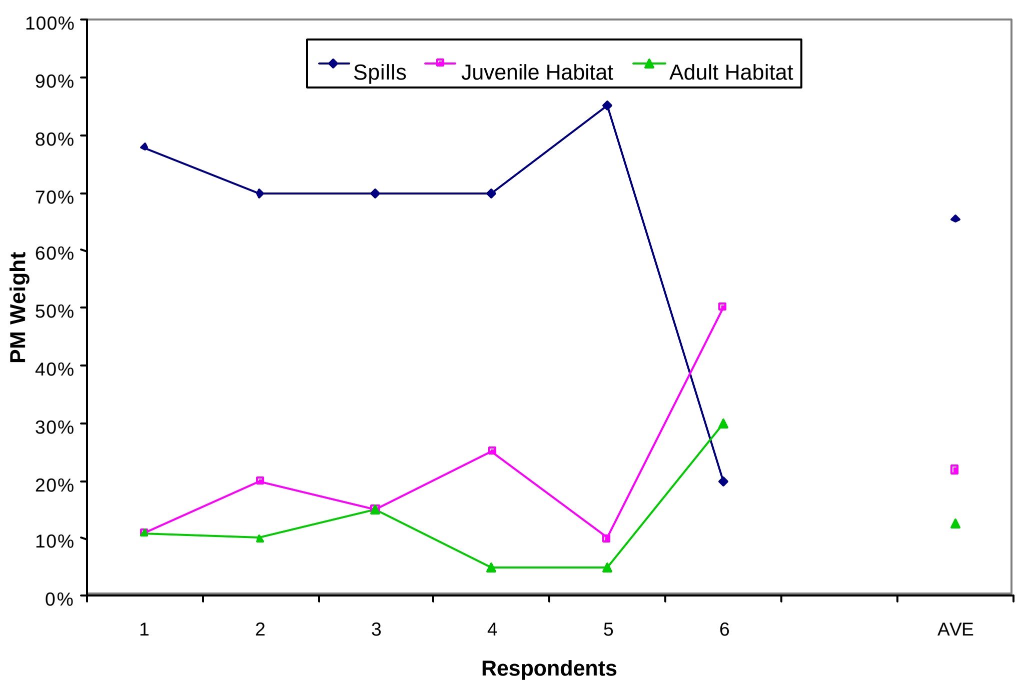

Figure B1-4: Middle Bridge River Fisheries Performance Measure Weighting

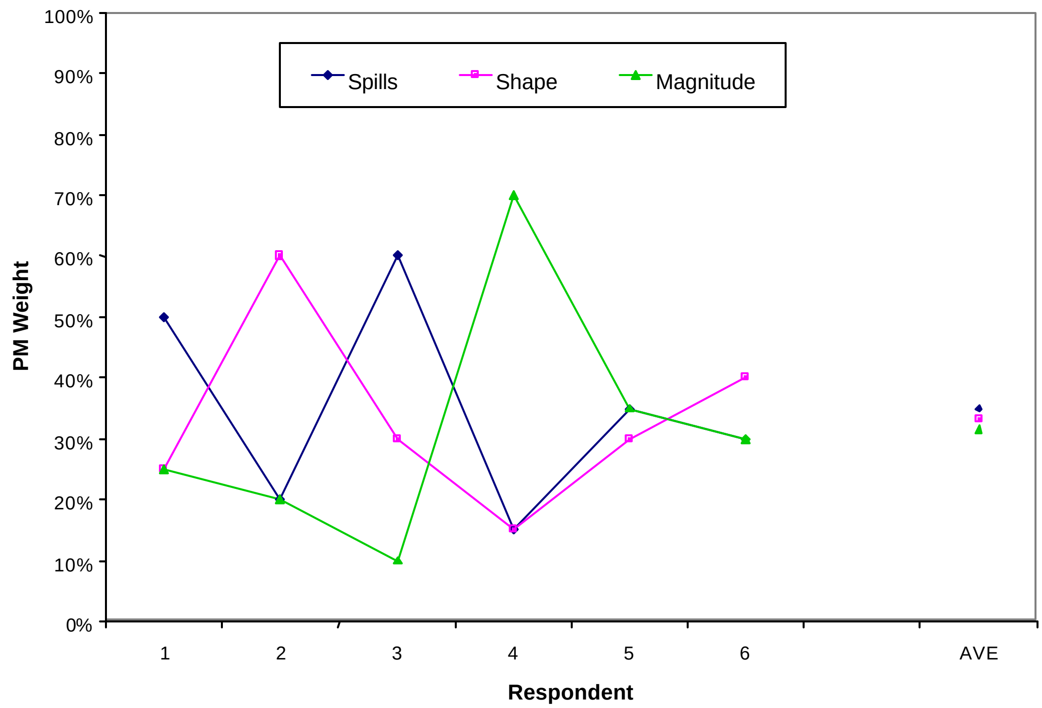

Figure B1-5: Seton River Fisheries Performance Measure Weighting

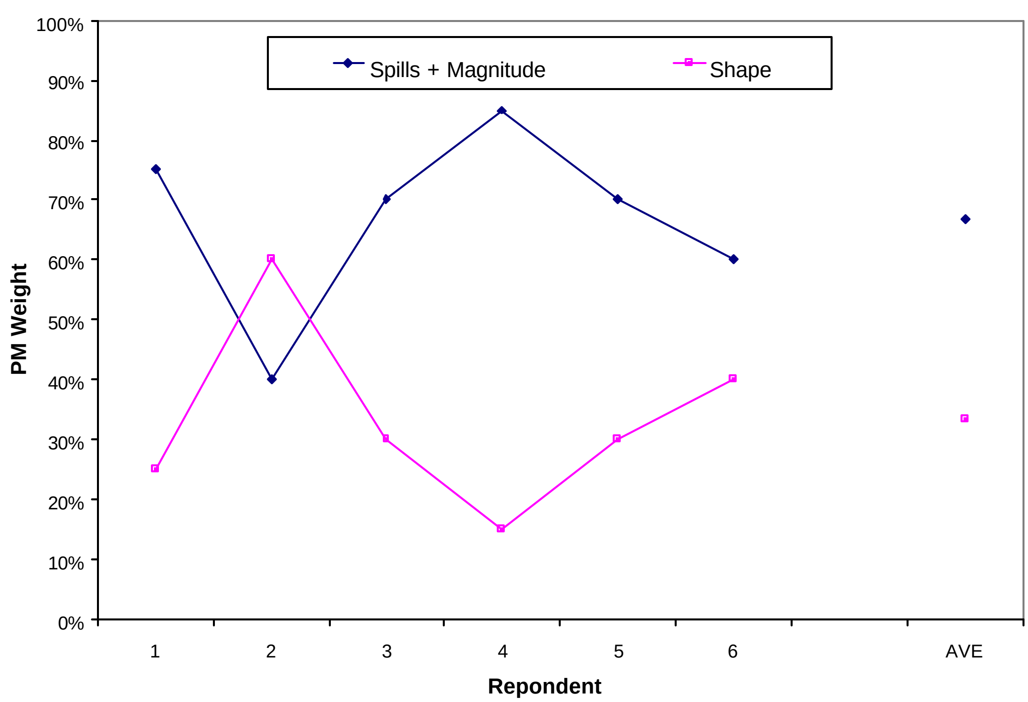

Figure B1-6: Seton River Fisheries Performance Measure Weighting with Spill and Magnitude Performance Measures Combined

APPENDIX B2: MINIMUM SIGNIFICANT INCREMENT OF CHANGE FOR ENVIRONMENTAL PERFORMANCE MEASURES

Water use planning decisions are made through trade-off analyses of individual performance measures for power generation, fisheries, wildlife, recreation, and flooding concerns. Since there are incomplete data and scientific understanding how operational changes influence aquatic and riparian resources there is uncertainty in environmental performance measures. Quantitative characterization of the magnitude of uncertainty in environmental performance measures is therefore not possible because error in predicting impacts on fish and wildlife compounds through sequential application of three types of models. BC Hydro system power operating models are used to predicting how a set of hydro system operation thresholds/decision rules influence reservoir elevation and river discharges. Physical models of the reservoirs and river area are applied to predict how operational changes impact abiotic conditions in aquatic and riparian habitats. Environmental models are used to generate performance measures that predict changes in habitat quantity/quality or mortality risk factors based on changes in abiotic conditions. Although we can not provide quantitative evaluation of uncertainty it is prudent to provide, at a minimum, a qualitative assessment of uncertainty.

Below is a table to assist Bridge River Water Use Plan Consultative Committee members to consider this uncertainty on a qualitative basis assist in understanding the significance differences in individual performance measures between operating scenarios. The table has four categories representing:

1. *Minimum Significant Increment of Change (MSIC)* – A judgement of the relative % change in a performance measure that should be considered significant when comparing alternative scenarios.

2. *Level of Modelling Uncertainty* – A judgement of the reliability of the performance measure to accurately reflect both direction and magnitude of environment impacts.

3. *Chance Modelling Errors Will Change Scenario Ranking* – A judgement of the reliability of the performance measure to systematically judge relative differences among alternative operating scenarios. In cases where modelling uncertainty results in systematic error that affects all alternatives equally, it is possible that the level of modelling uncertainty may be relatively high, but the chance that errors affect ranking may be low.

4. *Critical Modelling Assumptions and Issues* – A listing of key assumptions of the performance measure likely to contribute to uncertainty in the reported value of the performance measure.

The MSIC (1) is estimated based on qualitative assessment of (2), (3) and (4) by the Fisheries Technical Committee. Note that the MSIC addresses uncertainty related to data and modelling. That is, how accurate is the performance measure (e.g., Littoral Carbon performance measure) in reporting the specified impact (e.g., availability of food and habitat in the reservoir)? It does not address the uncertainty associated with the question: How important is this impact (e.g., availability of food and habitat in the reservoir) in influencing the fundamental objective of maximizing the abundance and diversity of fish and wildlife?

MSIC Summary Table

Minimum Significant Increment of Change (MSIC) - A judgement of the relative % change in a performance measure that should be considered significant when comparing alternative scenarios. For example, suppose Alternative A has a performance measure value of 9 and Alternative B has a performance measure value of 10. Assume also that the performance measure has an MSIC of 25%. One should view Alternative A and Alternative B as performing equally on this performance measure because the incremental difference between their performance measure values is less than the MSIC. The difference is more likely due to variability/uncertainty in data and modelling than to any true difference in performance.

Performance Measure	MSIC
FLOODING	5%
CAR/DOW Littoral Productivity	25%
CAR/DOW Entrainment	10%
CAR/DOW Tributary Spawning Success	10%
SONL Pelagic Productivity	30%
SONL Entrainment	10%
MBR Juvenile Habitat	25%
MBR Adult Habitat	25%
MBR/SONR Fish Spill Impact	25%
SONR Hydrograph Shape	20%
SONR Flow Exceedence	10%
CAR/DOW Wildlife Habitat	10%
SONR/LBR/MBR Wildlife Habitat	10%
SONR/LBR/MBR Wildlife Spills	10%

Table B2–1: Bridge Water Use Plan - Minimum Significant Increment of Change for Environmental Performance Measures - PERFORMANCE MEASURES

Performance Measure	Minimum Significant Increment of Change	Level of Modelling Uncertainty	Chance that Errors Affect Ranking	Critical Model Assumptions or Issues
FLOODING	5%	Low	Low	Based on empirical observation during past flooding events consequently there is relatively little uncertainty.
FISH RESERVOIRS Littoral Productivity CAR/DOW	25%	High	Moderate	Abiotic habitat factors are the primary factor controlling biological productivity in the littoral zone of the reservoir. Changes in light penetration and reservoir topographic are the primary habitat factors controlling productivity in the littoral zone and nutrients/temperature not significantly affected by operational changes. Other assumptions, such as substrate and inundated vegetation effects on littoral development will introduce a consistent bias affecting all alternatives equally, and preserve ranking. Littoral food chain is strictly autochthonous (field data suggest some interplay between detritus and autochthonous energy sources). These structural uncertainties could affect ranking of alternatives.
FISH RESERVOIRS Entrainment CAR/DOW	10%	Moderate	Low	Risk of entrainment is assumed to be proportional to the relative proportion of stored water that is withdrawn each week. This assumption is required because the abundance, distribution, and behaviour of fish in the water column in relation to water intakes are poorly documented and understood. It may either over or underestimate entrainment risk, but since it does so systematically across all alternatives, it is unlikely to affect ranking.
FISH RESERVOIRS Tributary Spawning Success CAR/DOW	10%	Low	Very Low	Impacts to tributary spawning success are directly proportional to area of tributary spawning habitat backwatered during reservoir filling. There is 100% mortality of eggs deposited in backwatered areas. This assumption is conservative and may overestimate mortality, but it affects all alternatives equally, and is unlikely to affect ranking.

Performance Measure	Minimum Significant Increment of Change	Level of Modelling Uncertainty	Chance that Errors Affect Ranking	Critical Model Assumptions or Issues
FISH RESERVOIRS Pelagic Productivity SONL	30%	Moderate	Moderate	Abiotic habitat factors are the primary factor controlling biological productivity in the pelagic zone of the reservoir. Changes in light penetration are the primary habitat factor controlling productivity in the pelagic environment; and nutrients/temperature are not significantly affected by operational changes. Suspended sediment inflow concentrations and temperature of reservoir tributaries do not vary from year-to-year. Average biomass turnover (P/B ratio) is reflected by average of literature values. Phytoplankton and zooplankton entrainment losses are not ecologically significant.
FISH RESERVOIRS Entrainment SONL	10%	Moderate	Low	Assumes that estimated differential mortality between the two passage routes (dam and power canal) is known. Assumes that there is an asymptotic relationship between amount of flow released from dam and the proportion of smolts that pass through the dam.
FISH RIVERS MBR Juvenile Habitat	25%	High	Moderate-High	Performance measure derived from relatively accurate aerial photography of wetted area of habitat at various flows and by professional judgements of quality by the FTC. Judgements were based on hydraulic characteristics and were highly variable among FTC members. Key assumptions are: - Hydraulic characteristics of the habitat are the critical factor determining quality of habitat in MBR. - Averaged qualitative judgements made by FTC of hydraulic characteristics of the habitat accurately reflect how changes in flow influence habitat quality.
FISH RIVERS MBR Adult Habitat	25%	High	Moderate-High	
FISH RIVERS MBR/SONR Fish Spill Impact	25%	Low	High	Negative and positive impacts of spills on fish and fish habitat are a function of timing, duration, and magnitude of spill events, however, performance measure identifies expected negative impacts only. Frequency is not explicitly considered in the performance measure. It is assumed that total number of spill days is an adequate indicator (number of events is not explicitly considered). Severity of negative impact of spill regime on all fish populations and fish habitat can be reliably indexed by summing qualitatively derived season-specific flow magnitude dependent impact parameters over a given year.

Performance Measure	**Minimum Significant Increment of Change**	**Level of Modelling Uncertainty**	**Chance that Errors Affect Ranking**	**Critical Model Assumptions or Issues**
FISH RIVERS SONR hydrograph shape	20%	Low	Moderate	That the method of calculation of the index (summing the squared deviation from weekly natural flow, followed by scaling) accurately reflects the degree of deviation from the natural hydrograph.
FISH RIVERS SONR Flow Exceedence	10%	Low	Low	Uncertainty in what is most biologically appropriate for the upper and lower bounds.
WILDLIFE RESERVOIRS Wildlife Habitat	10%	Low	Low	Inundation frequency and duration are the primary factors controlling riparian vegetation colonization and growth patterns. Modelling gross vegetation classes (e.g., sedge-grass-herb) will not alter ranking of alternatives. Inability to model community succession will not alter ranking of alternatives.
WILDLIFE RIVERS Wildlife Habitat	10%	Moderate	Low	Inundation frequency and duration are the primary factors controlling riparian vegetation colonization and growth patterns. Modelling gross vegetation classes (e.g., sedge-grass-herb) will not alter ranking of alternatives. Inability to model community succession will not alter ranking of alternatives.
WILDLIFE RIVERS Wildlife Spill Impact	10%	Low	Low	Impact of spills on wildlife using instream habitat is greatest at bankfull flow (i.e., Harelquin feeding, brooding). Impact to wildlife using floodplain habitats is initiated at and increases at river flows above bankfull flows (i.e., waterfowl nesting, small mammals). Impact severity is proportional to sum of days with river flow exceeding average bankfull conditions.

Table B2–2: Bridge Water Use Plan - MSIC FOR OTHER REPORTED DATA (NON-PERFORMANCE MEASURES) - RESERVOIRS

Performance Measure	Minimum Significant Increment of Change	Level of Modelling Uncertainty	Chance that Errors Affect Ranking	Critical Model Assumptions or Issues
Pelagic Productivity	CAR:15% DOW:15% SONL:30%	Moderate	Low	Abiotic habitat factors are the primary factor controlling biological productivity in the pelagic zone of the reservoir. Changes in light penetration are the primary habitat factor controlling productivity in the pelagic environment; and nutrients/temperature are not significantly affected by operational changes. Suspended sediment inflow concentrations and temperature of reservoir tributaries do not vary from year-to-year. Average biomass turnover (P/B ratio) is reflected by average of literature values. Phytoplankton and zooplankton entrainment losses are not ecologically significant.
River Productivity	25%	High	Very Low	Secondary productivity of lotic reservoir habitat are primarily regulated by river flow velocity (based on field data). Alternative hypotheses is that particle size, a correlate to velocity determines habitat and productivity. Sediment re-suspension predictions are uncertain, but effects on certainty occur outside of growing season and are more likely to influence predictions of [SS] transport to Seton Lake than pelagic productivity.
Drift	n/a	Low	Very Low	Not influenced by operations in the model.
Total Carbon	25%	Moderate	High	Total carbon is assumed to be a reliable measure of total secondary productivity and thus a measure of the food available for fish populations.
Stranding	10 %	Moderate	Low	Risk of mortality and losses in fish population productivity due to reservoir stranding are proportional to time and relative area that pools are isolated from main pool of the reservoir. This assumption is required because the incremental impacts to fish survival and implications for productivity of fish populations are poorly documented understood.

Performance Measure	Minimum Significant Increment of Change	Level of Modelling Uncertainty	Chance that Errors Affect Ranking	Critical Model Assumptions or Issues
Carpenter→ Seton Suspended Sediment Transfer	5%	Moderate	Low	Inter-basin suspended sediment transfer is estimated as a function deposition and re-suspension of sediment in the Carpenter Reservoir. Uncertainty in estimates of a) sediment loading from inflows, b) water velocity as a function of topography and water elevation, and c) estimated particle sinking rates are relatively small. Uncertainty in estimates of re-suspension of sediments as a function of velocity is relatively larger. Overall, prediction of inter-basin scour are expected to report the correct direction of response.

Table B2-3: Bridge Water Use Plan - MSIC FOR OTHER REPORTED DATA (NON-PERFORMANCE MEASURES) - RIVERS

Performance Measure	Significant Increment of Change	Level of Modelling Uncertainty	Chance that Errors Change Rank	Critical Model Assumptions or Issues
LBR/SONR Juvenile Habitat	n/a	High	High	Previous physical habitat simulation models were applied to assess fish habitat in LBR and SONR. Subsequent field studies have suggested poor explanatory power of physical habitat models for predicting juvenile standing crop. In recognition of this, and other concerns about the overall capability of physical habitat simulation for assessing spawning habitat, the FTC therefore have proposed to adopt alternative approaches for both LBR and SONR. For LBR an adaptive management program has been proposed to empirically determine how flow regimes impact fish habitat. For SONR, a revised fish habitat performance measure was developed to more broadly characterize the acceptability of habitat based on hydrograph shape and desirable flow extremes.
LBR/SONR Effective Spawning Habitat	n/a	High	High	
SONR/CAY Flow Mix Guideline	10%	Moderate	Moderate	Uncertainty in the accuracy of predictions of Seton/Cayoosh flow mix result from discrepancies or discretionary choices about how to model Cayoosh diversion operations.

APPENDIX B3: TECHNICAL WEIGHTING OF WILDLIFE PERFORMANCE MEASURES

Wildlife Habitat Index

The Wildlife Habitat index was computed as the sum of the products of the total area and the relative importance of each nine habitat types identified by the WTC as important for the protection and conservation of wildlife in the Bridge-Seton watershed:

$$W_i = \sum_{1}^{h} (A_{hi} * WHI_{hi})$$

where W_i = the wildlife value index for operating scenario I; A_h = area of a given habitat strata h for scenario i; and WHI_{hi} = the wildlife habitat index for habitat strata h for operating scenario i. WHI is calculated as:

$$WHI_{hi} = \Sigma (H_h * M_h)$$

Where H_h= standardized Habitat Availability/Capability index for habitat strata h and M_h= standardized management importance index for habitat strata h. At the outset of the assessment it was recognized that very sparse information regarding the species present and how they depend on riparian and wetland habitats to support life functions was available. A workshop was conducted with the wildlife biologists familiar with the Bridge-Seton and adjacent watersheds to identify the key wildlife species that reside in the Bridge-Seton watershed, their key habitat dependencies as they relate to supporting important life functions, and develop a method for quantifying relative management importance of different habitat types based on the species that were believed to be dependent on them. The Wildlife Management Concern Index for each habitat type was calculated as sum of management importance scores (m_h ; 1= low, 2=moderate, 3=high) across taxa:

$$M_h = \sum_{1}^{t} (m_h)$$

The results of this exercise are presented in Table B3-1 below.

The Habitat Availability/Capability Index was computed by weighting each of the 10 habitat types individually for their rarity, contribution to ecosystem diversity, and habitat productivity, based on the subjective scale (i.e., 1 - low, 2 - moderate, 3 – high).

$H_h = H_R * H_D * H_C$

Habitat rarity, H_R, accounts for regional habitat scarcity with habitat types that are regionally scarce are weighted higher than habitat types that are regionally abundant. Habitat diversity, H_D accounts for the fact that some habitat types support a greater overall diversity of plants and animals than others. These organisms may or may not be "target sensitive species of concern", but provide food and habitat support target and other wildlife species. Therefore, it represents a general measure of whole-ecosystem diversity. Habitat types that support a higher number of plant and faunal species (as determined from field data and literature) are weighted higher than those that support relatively few species. There are two considerations related to diversity, one in the habitat index and one in the wildlife index. In the habitat index, (ecosystem) diversity refers not specifically to the species of concern, but rather to the overall plant and faunal diversity in that habitat type, as judged from field studies and literature review. This measure of diversity has to do with the "supporting species" in the system – not those that are species of concern, but those that provide food, habitat, and secondary support for species of concern. This measure of diversity is quite different from "target wildlife" diversity, which involves the extent of use of a given habitat by wildlife species of concern. Both measures are appropriate here, and were viewed as not to constitute a "double count" of diversity. They can be combined to create a “wildlife habitat weighted score” that should reflect both the ecosystem ecology and the values placed on certain species. Habitat productivity, H_C accounts for expected differences in the primary productivity of each habitat type, which is important because productivity is a rate variable. Habitats with higher productivity, as determined from the literature and professional judgement, are accordingly higher weighting values.

Table B3-1: Qualitative assessment of the relative level of management concern, M_h, and importance of different habitats types for supporting wildlife species in the Bridge-Seton watershed. (1 - low, 2 - moderate, 3 – high).

Group	Wetlands	Aquatic Veg	Barren Soil	Grass/Herb	Shrub/Woodlands	Cottonwood Forest	Coniferous Forest	Shallow Lentic	Low-mod Gradient Rivers	High gradient Rivers
Herpetofaunae	3	3	2	3	2	3	2	2	3	1
Waterfowl	3	3	2	3		3		3	3	2
Waders	3	3	2	1		1		3	3	
Piscivorous Birds	1	1	1	1	1	3	3	3	2	
Non-piscivorous Raptors	3	1	1	3	2	3	3	1	1	
Shorebirds	3	1	3	2				3	3	
Woodpeckers					1	3	3			
Passerines	3	3	1	2	3	3	2	1		2
Bats										
Beaver					3	3		1	2	
Other Furbearers	2	2	1	2	3	3	3		3	
Bear	3	1	1	2	2	3	1		3	
Ungulates	3	3	1	3	3	3	2			
Livestock	3	1	1	3	3					
Total Score	**27**	**19**	**14**	**22**	**21**	**28**	**17**	**15**	**20**	**5**
Standardized	**0.96**	**0.68**	**0.50**	**0.79**	**0.75**	**1.00**	**0.85**	**0.75**	**1.00**	**1.00**

Table B3-2: Example calculation of the Wildlife Habitat Index (WHI_h) for each major habitat type considered in the BRS WYP assessment.

Habitats	Rarity	Diversity	Prod	Habitat Availability/ Capability Index	Wildlife Mgmt Concern Index	Standardized Habitat Index	Standardized Wildlife Index	Wildlife* Habitat Index
All Wetlands	3	3	3	9	27	1.00	0.96	0.96
Hydroriparian Wetlands	3	2	3	8	19	0.89	0.68	0.60
Barren Wetland Soils	1	1	1	3	14	0.33	0.50	0.17
Grass-Herb Wetlands	2	3	2	7	22	0.78	0.79	0.61
Decididuous Shrub/Woodlands	2	3	2	7	21	0.78	0.75	0.58
Cottonwood Forest	3	3	2	8	28	0.89	1.00	0.89
Coniferous Forest	1	2	1	4	17	0.44	0.61	0.27
Shallow Lentic	1	1	2	4	15	0.44	0.54	0.24
Low-moderate Gradient Rivers	2	2	3	7	20	0.78	0.71	0.56
High Gradient Rivers	2	2	2	5	5	0.56	0.18	0.10

APPENDIX C: FINDINGS FROM STUDIES AND ROUND 1 AND 2 ALTERNATIVES

C1 Process for Prioritizing Studies Under Step 5 of Bridge River Water Use Plan

C2 Bridge River Water Use Plan - Summary of Study Findings

APPENDIX C1: PROCESS FOR PRIORITIZING STUDIES UNDER STEP 5 OF BRIDGE RIVER WATER USE PLAN

Study Proposals

Studies undertaken in Step 5 of the *Water Use Plan Guidelines* may include field data collection, analysis and/or model building. The costs and benefits of each study proposed will be described using the "Study Proposal Template." These will be summarized in a summary matrix (Table C1-1).

Evaluation Criteria (See Figure C1-1 for Flowchart Summary)

1. Will the study provide information related to the calculation of a performance measure?

   If not, the study is not eligible for Step 5 studies.

2. Is the data gap or uncertainty that this study addresses significant enough to affect the ranking of alternatives?

   A "no" answer should normally disqualify a study from further consideration. For some studies, the answer will be clearly "yes." For others, it may be unclear. Judgement will have to be used.

   In some cases, there may be data gaps that we could fill that would *improve* a performance measure, but that are unlikely to affect the ranking of alternatives. Examples of cases where an uncertainty exists, but is not likely to affect ranking of alternatives include:

   - We may not know a parameter value exactly, but we can with reasonable confidence establish a range of plausible values for it. If, within that range, the performance measure value does not change significantly, then it is not essential to address the uncertainty.

   - If all alternatives are equally affected by an uncertainty (all biased up or all biased down), the absolute value of the performance measure may be wrong, but the relative ranking of the alternatives is not affected.

3. Can the study provide meaningful, reliable data within the time frame available in the Water Use Plan project schedule?

   If not, the study is not eligible for Step 5 studies.

   In many cases, especially for studies involving fisheries and wildlife, year-to-year variability is significant and it not possible to draw scientifically defensible conclusions from a single field season. If a study cannot provide data that provides useful information after a single field season, it is not a candidate for Step 5 studies. It may however be a candidate for longer term monitoring programs that are conducted as part of Water Use Plan implementation. If it turns out that participants feel that a particular uncertainty significantly affects the ability to make responsible decisions at Step 7, then a monitoring program may be designed to address the uncertainty and ensure that better information is available for the next Water Use Plan review. Participants may link their recommendations about the timing of the next Water Use Plan review to the expected timing of results from long term monitoring programs.

4. Do the benefits outweigh the costs?

   If 1 through 3 are yes, then it is necessary to look at the cost of a proposed study. There may be a range of study designs that will provide a range of data quality, and these should be evaluated. If the costs for studies in support of a performance measure are very high, then it may be important to consider alternative performance measures. In some cases, a simpler measure may provide better value.

Study Prioritization

After evaluating each study against the above criteria, it will be assigned one of five priorities:

Priority 1	The information provided by this study is essential for Water Use Plan. Responsible decisions cannot be made without it.
Priority 2	This study will provide information that is likely to affect the ranking of alternatives. The benefits clearly outweigh the costs.
Priority 3	This study has benefits, but is of lower priority. Some reasons for lower priority include: - costs may outweigh benefits; - the benefits may not be significant enough to affect ranking of alternatives; - the performance measure this study addresses has less likelihood of being the "limiting factor" (relative to other performance measures).
Priority 4	This study is not necessary or desirable for Water Use Plan.
Priority X	This study may be important, but cannot be completed within the Water Use Plan timeline.

Study Approval

The Consultative Committee will prioritize studies as above, and will make recommendations to BC Hydro about which studies should be approved. However, BC Hydro retains the final decision making responsibility for study approval, and will make this decision based on the recommendations of the Consultative Committee, the costs and benefits outlined as above (and in the study proposal template), and the availability of resources.

Guidelines for Prioritizing Step 5 Studies

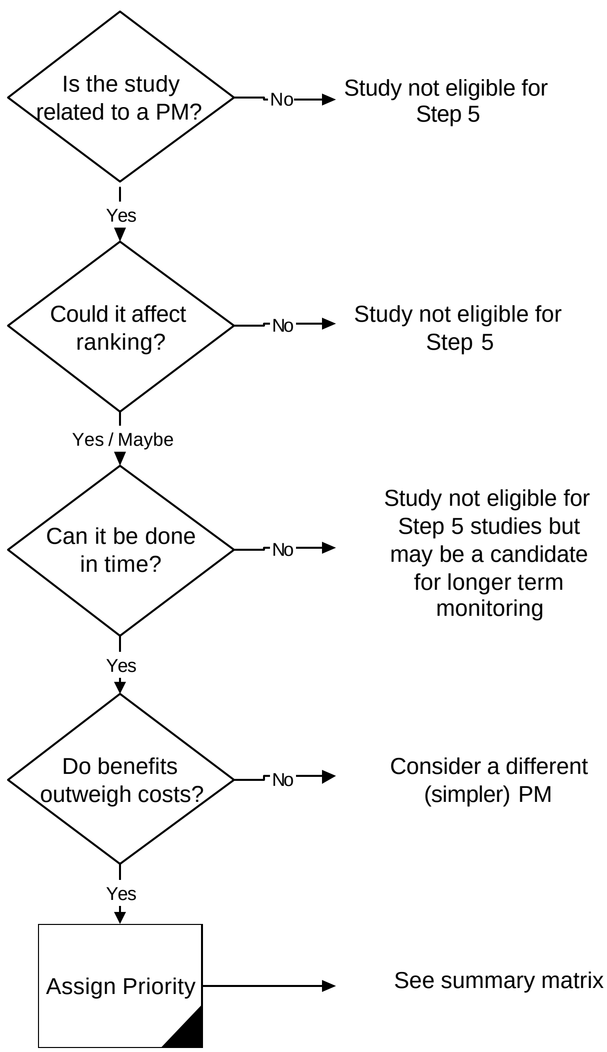

Figure C1-1: Guidelines for Prioritizing Step 5 Studies

Table C1-1: Summary Matrix for Priority Setting

Based on the information contained in the Study Proposal Template, the following summary table will be completed and used to assign a priority to each study.

Study	Cost	Completion Date	Uncertainty or Data Gap Affected	Affects Ranking?	Benefits	Risks	Priority Assigned

APPENDIX C2: BRIDGE RIVER WATER USE PLAN - SUMMARY OF STUDY FINDINGS[1]

Table C2-1: Summary for Priority Studies

FISH

Study	Major Findings	Implications for Alternatives/ Performance Measures
Pelagic Productivity Assessment Field studies were conducted to characterize the pelagic ecosystem. A model to simulate how changes in physical habitat conditions influence the biological productivity of pelagic zones of the Bridge River reservoirs was developed. The model is used to estimate seasonal changes in primary productivity rates and biomass of zooplankton resulting from different operating regimes.	- Field observations suggest strong vertical and horizontal gradients of temperature and suspended sediments (light penetration) in the reservoirs. Changes in these gradients were closely linked to wind patterns, and together these factors regulate the volume and rate of production in the pelagic zone. - Regional data (18 large sockeye lakes in B.C.) were compiled and compared to the field data. There is a strong linkage between habitat (light penetration) and primary productivity (photosynthetic rate) and, zooplankton biomass was directly correlated to photosynthetic rate. This formed the basis of the biological model. - CAR and SONL had slightly higher primary productivity compared to other lakes in Fraser Basin. Zooplankton biomass was high in CAR and extremely low in SONL relative to other lakes in B.C. This suggests that kokanee populations[2] may have dropped relative to (in CAR only) post-stocking levels. It also suggests that pelagic food availability may be limiting fish populations in SONL, but it's unlikely to be limiting in CAR (for pelagic-dependent species).	- *Pelagic C = secondary production in pelagic zone (measured as mass C).* - Pelagic C is one of several components of the Total Reservoir Productivity Performance Measure - see below. - Sufficient regional and site specific data were collected to develop a defensible model for predicting changes in pelagic productivity under different operating scenarios. - It may be possible to increase pelagic productivity through alternatives that reduce suspended sediment. Pelagic productivity improvements are likely more important to SONL fishery than CAR.

[1] These findings were issued as pre-reading for the Bridge River Water Use Plan Consultative Committee meeting of March 6-7, 2001 and have been updated only to add outstanding studies, namely Metals and Contaminants.

[2] Kokanee are native to Seton Lake Reservoir, stocked in Carpenter (2 to 3 times) in the 1980s but established a spawning population well into the 1980s. Remnants remain.

FISH

Study	Major Findings	Implications for Alternatives/ Performance Measures
Littoral Productivity Assessment Studies were conducted to characterize the littoral ecosystem in CAR and DOW. Field surveys examined the effects of light penetration, inundation, flow velocity and vegetation on secondary production in the littoral zone. A controlled experiment was conducted to investigate the influence of inundation and vegetation on standing crop of benthic invertebrates. The information was used to develop a model of how seasonal changes in inundation and habitat conditions influence biological productivity in the littoral zone.	- Spatial distribution of benthic invertebrates was very patchy and strongly influenced by the presence of vegetation, woody debris and water velocity. - DOW is much less productive than CAR, both on a per unit area basis (possibly due to colder, more turbid conditions), and also because the total available area for littoral production is smaller (due to the steep sided nature of the reservoir). - There are complex seasonal patterns in the abundance of benthic invertebrates related to inundation history. - Field data collected from the study allow parameterization of model to estimate changes in biomass of benthic invertebrates in the littoral zone under alternative operating strategies.	- *Littoral C = secondary production in littoral zone (measured as mass C).* - Littoral C is one of several components of the Total Reservoir Productivity Performance Measure - see below. - It may be possible to increase littoral C production by 1) increasing flowing length of UBR and MBR; 2) reducing suspended sediment, and thus increasing light penetration; 3) providing seed/bug sources. - Study results suggest that there is less potential for developing littoral area in DOW vs. CAR, due to steep sides and colder, more turbid conditions.
Tributary Drift Monitoring Field studies were conducted to estimate species composition and rate of delivery of invertebrate biomass to the reservoir. The objective was to determine whether input from tributaries generates a biologically meaningful component of reservoir fish food resources.	- Relatively consistent drift rates across all streams sampled and seasons. DOW tributaries have slightly higher drift rates than CAR tributaries. - Total contribution of drift to the reservoir carbon budget is small, but may be locally important.	- *Tributary Drift C = mass of fish food invertebrates contributed by tributaries to the reservoir (measured as mass of secondary C).* - Tributary Drift C is one of several components of the Total Reservoir Productivity Performance Measure - see below. - Since drift rate is not influenced by hydro system operation it is assumed to be constant. - Contribution of drift to available fish food resources is included in reservoir C budget so that total secondary production can be estimated.

FISH

Study	Major Findings	Implications for Alternatives/ Performance Measures
Reservoir Productivity/ Fish Food Assessment A performance measure combining pelagic, littoral, and tributary drift assessments was developed to allow assessment of the influence of alternative reservoir operations on available fish food resources.	- Conducted a review of available literature to estimate C production from mean annual biomass predictions (called turnover rate) for aquatic taxa in rivers, lakes and reservoir. - This allowed scaling of the mean standing crop of pelagic and littoral organisms during the growing season to overall production estimates.	- *Total Reservoir Productivity Performance Measure = Pelagic C + Littoral C + Tributary Drift C.* - This performance measure is the sum of secondary carbon mass in the pelagic zone, littoral zone and drift. It represents all of the food available to fish in the reservoir. - There remains significant uncertainty in the extent to which fish actually rely on the different food sources (pelagic vs. littoral vs. drift).
Entrainment - CAR/DOW A performance measure for entrainment was developed by reviewing existing information in CAR and DOW and conducting hydraulic modelling upstream of power intake. A conceptual model to link daily reservoir turnover to relative entrainment risk was developed.	- Hydraulic modelling of the reservoir in front of power intakes indicated that there is a very small "risky volume" (volume in which fish are exposed to significantly elevated velocity). - There are significant biological uncertainties about 1) fish behaviour in relation to intake operation, and 2) how distribution and patterns of habitat use influence entrainment. - Entrainment risk was assumed to be a function of reservoir discharge rate and reservoir volume. - The entrainment performance measure was tested against field data from LAJ, and predictions of entrainment risk closely matched the field data.	- *Carpenter and Downton Entrainment Performance Measure = weekly volume withdrawn divided by total reservoir volume, summed over weeks of the year.* - Alternatives that minimize the discharge rate from a reservoir, and maximize the volume of water in the reservoir reduce entrainment risk. - Performance measure is unitless index of relative risk, not absolute value of the impact on fish populations. As required, short-listed alternatives under consideration will be evaluated qualitatively to refine population impact assessments to assist decision making.

FISH

Study	Major Findings	Implications for Alternatives/ Performance Measures
Entrainment - SONL A performance measure for entrainment was developed by reviewing existing information for SONL. A conceptual model to link the proportion of outmigrating smolts that pass through the Seton powerhouse (rather than Seton Dam) to relative entrainment risk was developed.	- FTC reviewed previous studies and agreed on assumptions for 1) the relationship between proportion of flow diverted to SONR and the % outmigrating smolts entrained, 2) mortality rates for fish passing through the dam or the powerhouse. - Information exists on sockeye salmon entrainment, but there is poor data on other anadromous species (coho, pink, chinook) and resident species. - There is uncertainty about how distribution and behaviour of resident species influence risk of entrainment rates. - There is uncertainty about behaviour of outmigrant salmon species in relation to flow routing.	- *SONL Entrainment Performance Measure = weekly flow diverted to Seton Dam, divided by weekly flow diverted to turbine.* - Entrainment risk drops as more water is released from the dam relative to the turbine. - The performance measure reports a unitless index of relative risk, and represents the risk faced by outmigrating smolts. Risks to resident fish are assumed to be smaller, and will be relatively insensitive to operational alternatives given lack of ability to significantly alter SONL levels and discharge. - As required, short-listed alternatives under consideration will be evaluated qualitatively to refine population impact assessments to assist decision making.
Reservoir Fish Stranding: CAR/DOW A performance measure to index the risk of stranding for fish during drawdown periods in CAR and DOW was developed. GIS (DOW) and field survey data (CAR) were used to estimate the area of isolated pools at given reservoir elevations.	- No information is available to quantify population impact or magnitude of mortality resulting from stranding of reservoir fish. - In absence of the biological information about the rate of stranding and impacts on fish, FTC agreed to assume that impacts are proportional to instantaneous area of isolated pools. - There is an inverse relationship between reservoir elevation and area of isolated water bodies (i.e., stranding risk rises as elevation drops).	- *Stranding Risk Performance Measure = sum of the total area of isolated pools each week in the reservoir, summed over the year.* - The performance measure reports a unitless index of relative risk of stranding, not the total mortality resulting from stranding. As required, short-listed alternatives under consideration will be evaluated qualitatively to refine population impact assessments to assist decision making.

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Study	Major Findings	Implications for Alternatives/ Performance Measures
Tributary Spawning Success: CAR/DOW Biological observations of tributary spawning and habitat survey data for tributaries to CAR and DOW were compiled and used to develop a model to estimate the area of tributaries backwatered under different reservoir elevations.	- Access to tributary spawning habitat was judged by the FTC to not be a problem in either CAR or DOW reservoirs. - The major risk factor affecting spawning success in tributaries is potential mortality due to backwatering of incubating eggs. Low velocity and oxygen circulation after backwatering subsequent intra gravel are the major factors driving mortality. - An extensive literature search and review provided no definitive data indicating at what depth/velocity egg mortality occurs. - It is assumed that eggs are at risk of mortality if any backwatering occurs during the period of spawning or incubation. - Spring spawning rainbow trout are assumed to be most at risk. Spawning is common within the drawdown zone of DOW.	- *Tributary Spawning Success Performance Measure = hectares backwatered during the spawning and incubation period for rainbow trout.* - Performance measure may be refined if input is received from Stl'atl'imx Nation. - Alternatives that result in rising water levels in the spring would result in increased risk to tributary spawning success.
Shore Spawning Success: SONL Available information on shoal/shore spawning of kokanee in SONL were compiled and a performance measure was developed to index effects of alternative operations on shore spawning success.	- Shoal/shore spawning on Seton Lake occurred historically, however, there are incomplete field data to determine the extent to which this occurs. Archives in the Lillooet museum and First Nations confirm that kokanee were abundant. - One hypothesis about the influence of CAR diversion inputs on shore spawning success is that increased suspended sediments from CAR during incubation will influence the survival of eggs deposited by shore spawning kokanee. The performance measure is based on this hypothesis.	- *Shore spawning success Performance Measure = kg suspended sediments loading to SONL per year during the spawning and egg incubation period.* - Fundamental assumption is that spawning success is reduced with increased flow of suspended sediments into SONL. - The nature of this relationship is very uncertain, so judgement of impacts is not straightforward.

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Study	Major Findings	Implications for Alternatives/ Performance Measures
Metals and Contaminants: CAR, DOW, SONL A phased overview assessment and field sampling program was initiated to assess 1) current metals concentration in water, sediment and fish, 2) whether changes in operations will influence metal concentration in fish.	- Sediment sampling indicated some elevated levels of mercury/arsenic, but consultant concluded they are unlikely to cause any ecological harm - There are occasional exceedences of Water Quality Guidelines. Given the high levels of natural mineralization in the area, this is expected. The preliminary conclusion is that there is no major cause for concern with respect to drinking water quality. - There are no identifiable operating changes that could increase the risks associated with sediment contamination because upstream sediments are same or lower concentration than those downstream. - Mercury levels in bull trout in CAR are elevated, and operating alternatives that increase vegetation in CAR should trigger monitoring.	- *Metals Sediment Index Performance Measure = kg ss per year entering SONL from CAR.*. - The performance measure provides an indication of the movement of sediment from CAR to SONL. - Given the findings that concentrations of incoming sediment are likely similar or lower than existing sediments, the weight given to this performance measure may be lowered. However, note that this performance measure is used as a proxy for pelagic productivity, shore spawning and water clarity in SONL.
Effective Spawning Habitat: LBR/SONR A physical habitat model was developed to provide an index of the amount of effective spawning habitat in LBR and SONR.	- Assessments were conducted for three key species: chinook, coho, and steelhead, with the understanding that the requirements of other species would be covered within these. - Each of these species has different preferences for depth, velocity and substrate. Based on these preferences, and modelling of the river conditions under different operating alternatives, the area, in square metres, that is suitable for spawning can be calculated. - There is uncertainty about the reliability of the approach; but assumed to be reliable enough to rank alternative dam operating scenarios. - Habitat suitability curves were examined by the FTC and Water Use Plan Fisheries Advisory Team.	- *Effective Spawning Habitat Performance Measure = minimum area of river channel (square metres) that has suitable hydraulic and substrate conditions at the time of spawning and that remains wetted throughout the incubation period.* - This area that is usable for spawning changes throughout the year. The performance measure is reported as the 90th percentile, i.e., 90% of the time, the area usable will be at least this. - The area is different for each species. The performance measure reports the average across species tracked.

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Study	Major Findings	Implications for Alternatives/ Performance Measures
River Juvenile Fish Habitat Index: LBR/SONR A physical habitat model was developed to provide an index of the amount of usable habitat for juvenile fish in LBR and SONR. A field study to quantify the amount of side channel habitat was also conducted on SONR.	- Assessments were conducted for three key species: chinook, coho, and steelhead. - Each of these species has different preferences for depth and velocity. Based on these preferences, and modelling of the river conditions under different operating alternatives, the area, in square metres, that is suitable for juveniles can be calculated. - There is uncertainty about the reliability of the approach; but assumed to be reliable enough to rank alternative dam operating scenarios. - Habitat suitability curves were examined by the FTC and Water Use Plan Fish Advisory Team. - The Seton Side Channel study confirmed that there is side channel refuge for juveniles under high flow conditions. Side channel area in SONR is included in the calculation of the Juvenile Habitat Performance Measure.	- *Juvenile Habitat Performance Measure = minimum area of hydraulically suitable river channel (square metres) available to juveniles of each species throughout the year.* - This area that is usable for juvenile rearing changes throughout the year. The performance measure is reported as the 90th percentile, i.e., 90% of the time (the area usable will be at least this). - The area is different for each species. The performance measure reports the average across species tracked. - The availability of side channel refuge in SONR side channels may partially mitigate the negative impact of high flows.
Middle Bridge River Life History Study A field study was conducted to fill data gaps about the relative abundance, distribution, and life history of resident fish species in MBR with a focus on bull trout, a blue-listed species..	- Results from the field study suggested that: 1) bull trout and rainbow trout do not spawn in the MBR, but use the river extensively for feeding, 2) juvenile bull or rainbow trout are not found in the MBR, 3) several age classes of whitefish are common in MBR and spawning is probable, 4) very few kokanee were observed anywhere in the immediate vicinity of CAR or MBR; kokanee spawning was in late August, 5) bull trout drop downstream gradually as CAR elevations fall and 6) few rainbow trout were observed in the study.	- Results are applicable to interpretation of the habitat modelling performance measures: 1) riverine habitat seems to be most important for adult bull trout and rainbow trout in the MBR/CAR complex; 2) timing of the application of the habitat modelling for adult rainbow and bull trout should be year round not just restricted to the regional spawn timing. - Because bull and rainbow trout are not using MBR for spawning, the study supports the conclusion that the tributary spawning success performance measure need only check backwatering effects for spring spawners. - Study suggests that MBR need not be managed for kokanee.

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Study	Major Findings	Implications for Alternatives/ Performance Measures
Middle Bridge River Flow/Habitat Study A field study was conducted to quantify the functional relationship between river flow and the amount of usable habitat for juvenile and adult fish in Middle Bridge River. Flows on MBR were manipulated, and the observations by the FTC were used to judge the relative quality of habitat for three species (rainbow trout, bull trout, and kokanee).	- The study provided relationships between wetted channel area and river flow. It demonstrates that habitat is relatively insensitive to flow changes. - For BT and RBT juveniles, habitat is maximized at 20-25 m^3/s discharge from La Joie Dam, largely as a result of improvements in mainstem conditions at lower flows. Habitat is minimized at 100-120 m^3/s. For flows greater than 100-120 m^3/s, increased side channel area increases available habitat for juveniles. - For BT and RBT adults, habitat is maximized at 10-15 m^3/s. Usable habitat then declines exponentially with increasing flow. - For kokanee adults, usable habitat increases with increasing flow, but these results were very uncertain.	- *Juvenile Habitat Performance Measure = area of hydraulically suitable river channel (square metres) available to juveniles of each species throughout the yea.* - *Adult Habitat Performance Measure = area of hydraulically suitable river channel (square metres) available to adults of each species throughout the year.* - Performance measure is reported as the 90th percentile, i.e., 90% of the time, the area usable will be at least this. - Negative impacts of higher flows may be lower than previously thought due to buffering effect of side channel habitat in Reach 1 (below the Hurley).
Fish Spill Impacts Index A FTC workshop was conducted to develop a system for weighting spills of different magnitude, duration and timing, based on their expected impacts on fish and the aquatic ecosystem.	- Smaller spills, or spills occurring during the normal freshet period were given lower weight, reflecting the belief that they are less damaging than larger spills at other periods of the year. - Significant uncertainties remain about the actual impacts of spills on fish and aquatic ecosystems.	- *Spill Impact Performance Measure = weighted number of spill-weeks.* - The index is useful for ranking alternative operating scenarios, but cannot be used to draw strong inferences about impacts to fish populations. As required, short-listed alternatives under consideration will be evaluated qualitatively to refine population impact assessments to assist decision making.

WILDLIFE

Study	Major Findings	Implications for Alternatives/ Performance Measures
Riparian Habitat LBR, SONR, MBR Studies were conducted to characterize riparian vegetation communities in LBR, SONR, and MBR and to parameterize a vegetation growth model in relation to physical site characteristics and inundation frequency.	- Used the field data to develop models to predict how riparian plant communities will change under different operating scenarios. - Experts were consulted to develop a weighting scheme to index relative desirability of different riparian conditions for wildlife populations. - Spill magnitude and frequency are used to predict habitat types under each operating alternative.	- *Wildlife Habitat Performance Measure = sum of weighted habitat (hectares), summed over all habitat types in rivers.* - Weights reflect the relative value of the habitat type to wildlife.
Riparian/Wetland Habitat: CAR/DOW Studies were conducted to characterize riparian/wetland vegetation communities in DOW and CAR and to parameterize a vegetation growth model in relation to physical site characteristics and inundation frequency.	- Used the field data to develop models to predict how riparian/wetland plant communities will change under different operating scenarios. - Experts were consulted to develop a weighting scheme to index relative desirability of different riparian conditions for wildlife populations. - Inundation frequency and duration is used to predict the type and area of habitat under each operating alternative.	- *Wildlife Habitat Performance Measure = sum of weighted habitat (hectares), summed over all habitat types in reservoirs.* - Because riparian habitat develops over a timescale of years, the performance measure reports expected habitat conditions in 2040. - Weights reflect the relative value of the habitat type to wildlife. - Alternatives with inundation regimes that maximize the area and quality of riparian/wetland vegetation are preferred from a wildlife perspective. - Occasional inundation of the riparian zone (1 in 10 years) may be desirable to hold the riparian area in an early successional stage. - In some cases, it may be possible to enhance riparian/wetland vegetation with habitat manipulation.

WILDLIFE

Study	Major Findings	Implications for Alternatives/ Performance Measures
Wildlife Spill Index: LBR, SONR, MBR A WTC workshop was conducted to develop a conceptual model for the impacts of spills on wildlife and riparian habitat, and to agree on parameters for that model.	- Agreed on two spill threshold levels that have significant effects on wildlife: 1) the Vegetation Restructuring Flood Event, which affects the riparian habitat condition and 2) the Floodplain Inundation Flood Event, which affects floodplain/instream users (including harlequin ducks). Threshold levels for each river section were established by review of hydraulic simulation results and professional judgement. - Significant uncertainties remain about the actual impacts of spills on wildlife and riparian ecosystems.	- *Wildlife Spill Performance Measure = frequency of floodplain inundation event.* - This performance measure reports the direct effects of large spills/floods on wildlife using the instream or floodplain habitats. - Spill magnitude and frequency are used to predict riparian habitat type - see Wildlife Habitat Index Habitat above. - As required, short-listed alternatives under consideration will be evaluated qualitatively to refine population impacts assessments to assist decision making.
Harlequin Duck Studies Field surveys were conducted to fill data gaps about 1) whether harlequin ducks nested in floodplain habitats of LBR, MBR, and SONR; 2) nest site selection in relation to water levels; and 3) patterns of instream habitat use.	- Harlequin ducks use SONR for nesting and brooding, currently use LBR only for brooding; and are not present in MBR. - Nests are found in concealed locations (mainly islands) at variable heights relative to water level, usually 0.3 to 2 m above water level. - Insufficient data/understanding exist to predict exactly the impacts of high flows on nesting and brooding success, but enough to expect that flows greater than the bankfull flow may impact nests and loafing sites and reduce riverine habitat quality for harlequin ducks.	- Harlequin ducks were used in as a key species to formulate the wildlife spill measure for instream habitat users. - The instream habitat users performance measure is computed during the nesting and brooding period (15 Apr–15 July). - Alternatives that reduce the frequency of a floodplain inundating event within the relevant time period are assumed to be preferable for harlequin ducks.

RECREATION

Study	Major Findings	Implications for Alternatives/ Performance Measures
Floating Debris: SONL An independent specialist in woody debris management was engaged to assess the extent to which floating debris is an issue in SONL and to identify options for mitigation.	- The primary conclusions of the assessment were: 1) SONL has very low debris accumulation relative to other reservoirs and about the same amount as Anderson Lake; 2) BC Hydro operations have two offsetting effects - a) they reduce seasonal variations which reduces debris problems and b) they introduce a daily variation which may aggravate debris problems; 3) operational changes are unlikely to significantly alter current debris conditions.	- Because the consultant could identify no operating alternatives that might mitigate current debris conditions, no performance measure is needed. - Suggested alternatives: - verify whether debris is entering SONL via CAR, and if so, modify debris control at the intakes. - offer advertised period of high water early in the season to allow property owners access to clear debris.
Water Clarity: SONL To develop a performance measure for water clarity, a model was developed to predict the mean change in the depth of light penetration in SONL.	- Used physical models for pelagic productivity assessments to estimate total sediment loading to SONL from Anderson Lake and CAR.	- *Performance measure = mean depth (metres) of light penetration in SONL.* - Alternatives that minimize sediment loading to SONL are assumed to improve this performance measure.
Beach Area Index: SONL A performance measure was developed as an index of the influences of SONL operations on usable beach area. A field survey of Seton Beach was conducted to collect information needed to estimate change in beach area with change in SONL water level.	- Data on all beaches not available; Seton Beach area was selected as a proxy for all beaches on Seton Lake. - Topographic survey data were used to calculate how the area of Seton Beach changes with changing reservoir elevation - Under the current operation beach area ranges from 0 to 3.8 ha., and maximum beach width is 0.8 m.	- *Performance measure = mean area of Seton Beach (ha) during period when swimming beach is used (1 June through 15 September).* - Only alternatives that affect the maximum elevation of SONL will affect this performance measure.

RECREATION

Study	Major Findings	Implications for Alternatives/ Performance Measures
Temperature: SONL Recreation subgroup agreed that temperature impacts are primarily localized at Seton Beach, as a result of the Cayoosh Diversion. In lieu of a performance measure, a study was conducted to estimate effects of the Cayoosh discharge pipe on beach water temperature and to identify options to mitigate temperature impacts.	- Temperature of Cayoosh diversion water is roughly 2-9 C lower than ambient SONL temperature. - Approximate temperature reduction at sites 25 m either side of diversion relative to Seton epilimnion: July: -2 C to -9 C August: 0 C to -3.5 C September: -1 C to -5 C - Approximate average temperature reduction at sites about 150 m (i.e., 140 m south side, 170 m north side) either side of diversion relative to Seton epilimnion: generally less than 0.5°C. - Based on measurements at 4 sites at Seton Beach and 2 mid-lake sites, the difference in average temperature at Seton Beach and other mid-lake locations is <1°C.	No performance measure required. Operational options to address this would involve curtailing discharge from the Walden North power plant during the recreation period. This would result in direct generation losses at Walden North. Two mitigation options considered: 1) construct a 10 m rock berm to direct discharge to deeper water; 2) extend discharge pipe by 10 m to allow direct discharge to deeper water. Cost of (1) is roughly $100k; Cost of (2) is roughly $500k million, and there are feasibility concerns due to possibility of pressurizing the pipe.

FLOODING

Study	Major Findings	Implications for Alternatives/ Performance Measures
Property Damage Flood Frequency: **LBR, SONR, MBR**	- Field studies and hydraulic modelling were conducted to estimate the threshold discharge at which property damage occurs in each river system (i.e., Property Damage Flood Event).	- *Flood Performance Measure = frequency of exceeding the property damage threshold.* - Threshold flow rates selected for each river, above which property/road damage occurs.

APPENDIX D: DESCRIPTION OF ALTERNATIVES

D1 Description of Operational Alternatives and Model Runs

D2 Key Lessons from Round 1 and 2 Alternatives

D3 Carpenter Reservoir Drawdown Zone Re-Vegetation Program

APPENDIX D1: DESCRIPTION OF OPERATIONAL ALTERNATIVES AND MODEL RUNS

Round 1 Alternatives: References and Examples

A. Licence: operation under licence as a reference.

B. Interim: approximates today's operating constraints including water budget of 3 m^3/s in Lower Bridge River.

C. Modified Interim: today's operating constraints with licence constraints removed (specifically the diversion maximum at Seton for Seton Generating Stations unit and combined diversion rates at Bridge River Generating Station No. 1 and No. 2 and diversion limit at La Joie). Note: All subsequent alternatives set Alternate C as its base; that is all subsequent alternatives eliminated licence constraints.

D. Modified Interim with firm Seton River hydrograph at 11/36.

E. Modified Interim and Lower the Top on Carpenter and Downton reservoirs (to explore potential gains in riparian area).

F. Modified Interim and Raise the Bottom of Carpenter and Downton reservoirs (to explore the potential gain in reservoir productivity).

Round 2 Alternatives: Exploring the System

G. Limit significantly Carpenter and Downton reservoirs.

H. Series to explore entrainment at Seton:

- H1: Lower Bridge River - 10 m^3/s with power canal out of service for smolt migration at Seton River.
- H2: Lower Bridge River -10 m^3/s with power canal out of service for smolt migration and lower tops in Carpenter and Downton reservoirs.
- H3: Lower Bridge River -10 m^3/s with power canal in service except for 3-week maintenance outage; no constraints on Carpenter and Downton reservoirs top.

I. I1: Seton Generating Station Upgrade: Seton turbine discharge capacity increased to use all spill water.

J. Series to explore maximum productivity in Carpenter Reservoir:

- J1: Hold Carpenter Reservoir at 644 m for growing season.
- J2: Hold Carpenter Reservoir at 644 m for growing season plus provide minimum 25 m^3/s Seton River during outmigration.

J3: Hold Carpenter Reservoir at 644 m with no constraint on Seton River hydrograph.

Round 3 Alternatives: Systemic Comparison - K and L Series

To explore impacts of Carpenter Reservoir constraints, Seton Lake Reservoir hydrographs and Lower Bridge River flows.

K. Series with Carpenter Reservoir unconstrained.

K1/2: Lower Bridge River at 3 m^3/s with and without Seton River hydrograph constraint.

K3/4: Lower Bridge River at 10 m^3/s with and without Seton River hydrograph constraint.

L. Series with Carpenter Reservoir constrained (maximum 647 m).

L1/2: Lower Bridge River at 3 m^3/s with and without Seton River hydrograph constraint.

L3/4: Lower Bridge River at 10 m^3/s with and without Seton River hydrograph constraint.

I. I3: Seton Upgrade with Lower Bridge River at 3 m^3/s with soft Seton River constraint of 11/36 (including 25 m^3/s for outmigration).

For all alternatives:

- Downton Reservoir unconstrained.
- Middle Bridge River has minimum flow of 600 cfs.
- Spill boundaries on Lower Bridge River (i.e., < 20 m^3/s for 50% of time and <50 m^3/s for 10% of time).
- Spill priority at Seton River (i.e., spill at Seton River before Lower Bridge River).
- Cayoosh diversion open year round.
- Seton Generating Station, La Joie and Bridge River Generating Stations No. 1 and No. 2 licence constraints eliminated.

Round 4 Alternatives: Short-Listed Alternatives

M&N: Series to explore effects of different fill profiles and buffer incursion (duration/frequency) at Carpenter Reservoir for littoral/riparian balance.

For all alternatives:

- Downton Reservoir minimum at 718 m except for two alternatives (M2 and N1).
- "Soft" minimum of 600 cfs at Middle Bridge River.
- Lower Bridge River water budget at 3 m^3/s.
- Spill boundaries on Lower Bridge River (as for Round 3 alternatives).
- Seton River set at soft 11/36 (including minimum 25 m^3/s for outmigration) to mimic hydrograph boundaries specified by Fish Technical Committee.
- Spill priority at Seton River (i.e., spill at Seton River before Lower Bridge River).
- Cayoosh Creek diversion open year round except for one alternative (M6).

Not all alternatives were modelled for all years of inflow record. Alternatives M2, M5 and N2 (which were based on all years of inflow record) were presented to the Consultative Committee, in addition to bringing forward L2 and I3 from Round 3.

Round 5 Alternatives: Final Alternatives

Round 5 alternatives sought a balance between improvements on Carpenter Reservoir wildlife and Downton and Carpenter reservoirs fish while preserving downstream constraints on Lower Bridge River flows and Seton River hydrograph, using alternatives N2 and L2 as boundaries. In addition, the Seton Generating Station alternative was further explored.

I4: Seton Generating Station upgrade (through building a new plant) to utilize all water that would otherwise be spilled (I3) while meeting Seton River hydrograph similar to Alternative N2.

Other alternatives (O series and additional N) varied with respect to Downton Reservoir minimums (unconstrained through to minimum of 718 m) and Carpenter Reservoir filling profiles, maximums and buffer incursion duration and frequency. All alternatives maintained other boundaries set for Round 4 alternatives with the exception of a higher minimum flow of 650 cfs at Middle Bridge River.

Alternatives I4, O4, N2-2, and O3-2 were presented to the Consultative Committee.

APPENDIX D2: KEY LESSONS FROM ROUND 1 AND 2 ALTERNATIVES

Table D2-1: Key Lessons from Round 1 and Round 2 Alternatives

DOW Findings	Suggests
• Current status of grizzly habitat at inlet is good; grizzly habitat around DOW is viewed as important. • Due to topo features and substrate (e.g., pumice beaches), there is limited opportunity to improve either riparian or littoral habitat unless we are willing to drop reservoir elevation to near 730 m. At around 730 m, could see increased sedge-grass-herb habitat. • Previous studies suggest that DOW supports a productive fishery under some conditions and can support a reasonable number of rainbow trout in what appears to be a harsh environment. • FTC weights entrainment as the most important fish performance measure in DOW. • Stabilizing DOW eliminates significant flexibility in the system, resulting in power costs and large spills in LBR and SONR. • The cost impact of setting a minimum elevation of 720 m seems to be relatively small (see comparison of Alternative C with Alternative F); however, there could be trade-offs with minimum flows on MBR.	• Lower priority on seeking littoral/riparian improvements on DOW, but important to protect existing grizzly habitat. • Stabilization has unacceptable impacts elsewhere in the system.
MBR Findings	**Suggests**
• Eliminating diversion licence restriction at La Joie enhances power values and increases flexibility to manage MBR flows. • MBR juvenile/adult habitat is relatively insensitive to flow (due to availability of side channel habitat at high flows and influence of Hurley in Reach 1). Reach 2 is short, so area of impact is very small (but there are bull trout and mountain whitefish using it). Aquatic insects are affected by flow reductions. • This insensitivity suggests that summer flows could be lower than winter minimum flows (key factor driving winter concerns is egg dewatering). • The higher the minimum flow on MBR, the greater the risk of entrainment in DOW and/or the greater the chance of conflicts with DOW minimum elevations. • Wildlife values in this area are low due to nature of habitat and proximity to town. However, this is the only remnant of the original Bridge River floodplain and no assessment of wildlife has ever been done.	• Eliminate diversion licence limit at La Joie. • Do not assess wildlife impacts. • Focus on minimum flows to prevent winter egg dewatering. • Set up priority system for MBR flows vs. DOW minimum elevations.

CAR Findings	**Suggests**
• Radio tagged Bull trout were not stranded in pools or entrained in the course of a normal year reaching El. 618 m. • Optima for littoral productivity occur at El. 637 m or 644 m . El. 644 m appears a reasonable compromise between littoral and pelagic productivity. • To achieve maximum Littoral carbon, need to be very stable around 644 m (frequent fluctuation of 2-4 m will prevent littoral growth). However, stability results in increased LBR spills (see Alternative G). • Alternatively, instead of stabilizing at El. 644 m, it may be feasible to rise slowly (maximizing duration at elevation El. 637 m, where there is a significant bench) that could enhance Littoral carbon. • Wildlife habitat not much affected by incursions, provided they do not exceed 18 weeks duration. • An operating alternative that inundates Minto (El. 637 m) for less than 18 weeks could increase sedge-grass-herb habitat down to Minto. Spill impacts at LBR would be significant. • Stabilizing CAR eliminates significant flexibility in the system, resulting in power costs and negative environmental impacts due to spills at LBR and SONR. • Cost of setting a minimum elevation of +620 m in the absence of other constraints, may be relatively small (see comparison of Alternative F with Alternative C Round 1.)	• Need to game with environmental model to find an operating strategy in CAR that maximizes fish productivity. (*Done in Round 3-4; eventually resulted in M-series alternatives.)* • Need to find balance between fish productivity and riparian benefits. • Stabilization has unacceptable negative impacts elsewhere in the system.
• There are some trade-offs between littoral productivity and wildlife vegetation. • There is relatively high confidence in the modelling predictions about riparian vegetation (for grasses and willows more so than cottonwood) and relatively high confidence that these will translate into ecosystem benefits. • Lower confidence about the predictive ability of the models for Littoral Carbon and about the probability that fish will benefit from improved habitat. • Fish performance measures do not capture the benefits to fish of increased length of natural river (MBR) that result from alternatives that lower the top of CAR. • Fish performance measures do not capture the carbon input to the reservoir from growth and inundation of riparian vegetation.	• If, in developing an operating strategy to maximize environmental benefits in CAR, we need to make trade-offs between littoral productivity and riparian vegetation, we should favour riparian benefits. • Use Wildlife Habitat performance measure in CAR as a proxy for fish benefits deriving from increased length of MBR.
SONL Findings	**Suggests**
• Current operating range is very small (20-40 cm elevation change). • No opportunity to address debris, erosion through operations.	• No change from current operation.

LBR Findings	**Suggests**
• Cannot predict how fish will respond to flow. • There is an opportunity for Adaptive Management (AM) on LBR because it is relatively independent of operations in the rest of system. • Alternatives that reduce storage capacity in CAR/DOW increase spills in LBR unless there is opportunity to violate reservoir constraints in wet years. • Frequent large spills are believed to have significant impact on the fish and wildlife, and would affect the ability to conduct meaningful AM trials. • LBR has high wildlife values relative to SONR.	• Conduct AM flow trials. • Spill first at SONR. • Agree on maximum acceptable frequency / magnitude of spills in order to keep "constrained reservoir" alternatives within acceptable bounds. • Focus riverine wildlife habitat evaluation on LBR.
BR1&2 GS Findings	**Suggests**
• Eliminating licence restrictions at BR1&2 increases power values and system flexibility with some environmental benefits.	• Eliminate licence restrictions BR1&2 generating stations (separation of powerhouse licences, diversion volume).
SONR Findings	**Suggests**
• Eliminating the diversion limit increases power generation while enhancing spill management at Seton Dam. • Provided flow magnitudes remain within 5-60 m^3/s, we are largely indifferent to flow magnitude, and care primarily about the shape of the hydrograph on SONR. • May be possible to upgrade SON GS. "I2" could be designed to use more of upgrade capacity. • Benefits of I2 may be smaller than expected: • Removal of licence constraints means existing capacity is better utilized. • To utilize even more capacity at plant would mean greater risk of entrainment.	• Eliminate Seton diversion licence restriction. • Modify SONR fish performance measures to Hydrograph shape, Magnitude, and Spills. • Test alternative hydrographs for meeting SONR entrainment, wildlife and power objectives. • Develop a new alternative to better utilize an upgraded SON GS facility.
SON Entrainment Findings	**Suggests**
• Two independent studies confirm that there is an asymptotic relationship between flow down SONR and entrainment. As a result, if flows in SONR are > 25 m^3/s during peak smolt outmigration, sockeye mortality at the turbines is estimated to be very low. However, residual mortality at the dam remains significant. Smolts outmigrating at other times of the year, and resident fish are still subject to some risk of mortality at the turbine outside the peak smolt outmigration period. • Cost of maintaining 25 m^3/s may be relatively small (see J3 and B). • Option to provide the 25 m^3/s flow year round was considered, but rejected by FTC due to severe negative effects of high flow on overwintering juveniles.	• No need to further consider shutting down SON GS during outmigration. • All alternatives should include the constraint to maintain higher flows (> 25 m^3/s) during outmigration period. • A sequencing protocol is needed at the dam to minimize mortality at the dam.

APPENDIX D3: CARPENTER RESERVOIR DRAWDOWN ZONE RE-VEGETATION PROGRAM

Rationale

The Bridge River Water Use Plan Consultative Committee has recommended that a 5 year program be initiated to enhance vegetation in Carpenter Reservoir to a maximum cost of $80,000 per year. As an integral component to the N2-2P operating alternative selected by the Consultative Committee the planting program was proposed as a means to 1) mitigate the effects of dust storms resulting from reservoir drawdowns particularly in the western end of the reservoir near the town of Goldbridge; 2) increase the aesthetic quality and hence expected recreational opportunities in the western end of the reservoir; 3) enhance the quality of riparian habitats to increase their potential to support wildlife populations; and 4) provide localized improvements in the quality and productivity of aquatic habitats in the reservoirs. The benefits were measured by the area of green-up and the wildlife habitat index for CAR.

Objectives and Scope

The Carpenter Reservoir Drawdown Zone Re-vegetation Program is to undertake a 5-year planting program to vegetate an approximately 500 ha area of the Carpenter Reservoir drawdown zone between Gun Creek Fan and Tyax Junction. The scope of the program as it was identified by the Bridge River Water Use Plan Consultative Committee is:

1. To design and implement a five-year reservoir planting program for the western end of Carpenter Lake, focusing on the area between Tyax Junction and the Gun Creek Fan.

2. The program will focus on the planting fall rye in barren areas, but also consider the selective planting of other species as is deemed desirable to meet the riparian zone management goals for Carpenter Reservoir.

3. To conduct annual evaluations during the each of the proposed five years of planting and after a period of five years without planting to assess the degree to which natural recolonization of the area from Tyax junction to Gun Creek fan has been established.

Approach

It is proposed that the Carpenter Reservoir Drawdown Zone Re-Vegetation Program have three phases: 1) Plan ; 2) Implementation; 3) Evaluation. Each of these phases are described below.

Phase 1 Plan

The objective of this phase of the program is to develop a detailed plan for implementation of the supplemental riparian planting activities. The following activities are proposed: 1) detail review of outcome of pilot planting studies and other reservoir re-vegetation related programs in British Columbia. reservoir drawdown zones; 2) site inspection to identify planting sites and to assess site-specific logistical options; 3) develop a detail plan outlining the project co-ordination requirements, schedule, planting locations, planting methods, plan for follow-up monitoring, site access and operational logistics, required permits, estimated costs, and expected outcomes. The development of this plan will require liaison with significant stakeholders to ensure the plan meets goals and objectives for the Consultative Committee. This task would be initiated and completed during the first fiscal year of the implementation of the Water Use Plan after its approval.

Phase 2 Implementation

Following the development of the period, a five year implementation plan would be initiated. This phase of the work would involve: 1) development of terms of reference for planting contracts; 2) contract award; 3) contract supervision and management. A coordinator will be identified and will be responsible for the technical and administrative oversight of the planting program.

Phase 3 Evaluation

Under the supervision of the re-vegetation program coordinator field surveys are proposed for a subset of the planting locations and adjacent control areas to assess the effectiveness of the planting activities. The evaluation approached is described as part of the monitoring program (see Appendix H3, Study No. BRS – 2).

Schedule

The proposed schedule for the re-vegetation program is provided in the table below. In Year 1 after the acceptance of the Bridge River Water Use Plan, a plan will be developed for the re-vegetation activities. In Year 2 through Year 6 intensive planting activities will be implemented. Evaluation of the success of planting activities will occur 1) on an annual basis during Year 2 through Year 6 to monitor the annual success of the program, and 2) immediately prior to the review of the Water Use Plan in Year 9 or Year 10 to allow determination of the extent to which the program successfully initiated the natural re-colonization of the area between Tyax Junction and the Gun Creek Fan.

Task	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
1 Project Coordination	X	X	X	X	X	X	X	X	X	X
2 Plan Development	XXXX									
3 Implementation		XXXX	XXXX	XXXX	XXXX	XXXX				
4 Evaluation		X	X	X	X	X			XX	
5 Reporting										
a Draft Report										X
b Final Report										X

Budget

The total estimated cost of the Carpenter Reservoir Re-Vegetation Program is $370,000. This amount excludes monitoring and evaluation costs (see Appendix H3). The estimated annual cost is itemized by task in the table presented below:

	Project Coordination	Plan Development	Plant Implementation	Total Cost ($)
Year 1	2,000	8,000	0	10,000
Year 2	2,000	0	70,000	72,000
Year 3	2,000	0	70,000	72,000
Year 4	2,000	0	70,000	72,000
Year 5	2,000	0	70,000	72,000
Year 6	2,000	0	70,000	72,000
Year 7	0	0	0	0
Year 8	0	0	0	0
Year 9	0	0	0	0
Year 10	0	0	0	0
Total	12,000	8,000	350,000	370,000

APPENDIX E: DETAILED CONSEQUENCE TABLES

E1 Detailed Consequence Tables

E2 Seton Generation Upgrade Opportunity

E3 Alternative N2-2P Hydrographs

APPENDIX E1: DETAILED CONSEQUENCE TABLES

Exhibit E1-1: Index Subcomponents for Table 6-1 (Round 4 Consequence Table)

ACTUAL IMPACTS (Median Values, Except as Noted)				Alternative					
Objective	**Performance Measure**	**What's Good?**	**MSIC**	**M2**	**M5**	**L2**	**N2**	**I3**	**B**
Flood	Flood Days * (no. days per year)	Less	5%	**1**	**1**	**0**	**0**	**0**	**2**
Fish	Fish-Rivers: LBR Summary (OK or NO)	OK	n/a	**OK**	**OK**	**OK**	**OK**	**OK**	**NO**
	Fish-Rivers: SONR Summary (constructed scale)	More	n/a	**2**	**2**	**2**	**2**	**1**	**0**
	Shape (0-1)	More		0.8	0.7	0.9	0.8	0.8	0.6
	Flow Magnitude (wks / yr)	Less		4.0	3.0	1.0	1.0	0.0	6.0
	Spills (weighted spill days)	Less		21.0	19.0	20.0	17.0	10.0	28.0
	Fish-Reservoirs: DOW INDEX (0-100)	More	15%	**42**	**70**	**48**	**69**	**65**	**69**
	Fish-Reservoirs: Littoral C (t / season): 25%	More	25%	1.9	2.3	2.1	2.3	4.2	3.7
	Fish-Reservoirs: Enstrain (unitless): 55%	Less	10%	15.6	4.4	11.2	5.3	9.3	7.4
	Fish-Reservoirs: Backwater (km): 20%	Less	10%	4.1	3.3	4.8	3.1	3.8	3.4
	Fish-Reservoirs: CAR INDEX (0-100)	More	15%	**69**	**71**	**41**	**41**	**29**	**29**
	Fish-Reservoirs: Littoral C (t / season): 50%	More	25%	6.1	6.5	4.3	4.6	5.0	4.6
	Fish-Reservoirs: Enstrain (unitless): 35%	Less	10%	6.0	5.8	8.7	8.3	11.2	10.2
	Fish-Reservoirs: Backwater (km): 15%	Less	10%	5.3	6.8	6.7	10.3	13.1	13.8
Water Quality	Suspended Sediment Load (t / year)	Less	30%	**94**	**89**	**77**	**84**	**108**	**78**
Wildlife	DOW Reservoir WL Habitat Index ** (weighted hectares)	More	10%	**223**	**231**	**322**	**313**	**295**	**300**
	CAR Reservoir WL Habitat Index ** (weighted hectares)	More	10%	**759**	**522**	**758**	**520**	**602**	**600**
	River Wildlife Habitat Index (weighted hectares)	More	10%	**48**	**48**	**48**	**48**	**48**	**33**
Power	Annual Revenue ($M / yr)	More	2%	**144**	**145**	**146**	**148**	**144**	**145**

* Median Values reported here refer to the Worse Impact, 9 years out of 10. Actual median flood days equal zero under all alternatives. Worse impact reported is the worst out of 40 years, not 90th percentile.
** Median Values reported here refer to Maximum values in order to better represent the cumulative effect of wildlife development.

Exhibit E1-2: Median and 90% Values for Table 6-1 (Round 4 Consequence Table)

ACTUAL IMPACTS				Alternative											
Objective	**Performance Measure**	**What's Good?**	**MSIC**	**M2**		**M5**		**L2**		**N2**		**I3**		**B**	
				Median (over 40 years)	Worst (9 years out of 10)	Median (over 40 years)	Worst (9 years out of 10)	Median (over 40 years)	Worst (9 years out of 10)	Median (over 40 years)	Worst (9 years out of 10)	Median (over 40 years)	Worst (9 years out of 10)	Median (over 40 years)	Worst (9 years out of 10)
Flood	Flood Days * (no. days per year)	Less	5%	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**
Fish	Fish-Rivers: LBR Summary (OK or NO)	OK	n/a	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**NO**	**NO**
	Fish-Rivers: SONR Summary (constructed scale)	More	n/a	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**0**	**0**
	Shape (0-1)	More		0.8	0.7	0.7	0.7	0.9	0.8	0.8	0.7	0.8	0.8	0.6	0.4
	Flow Magnitude (wks / yr)	Less		4.0	11.0	3.0	8.0	1.0	8.0	1.0	5.0	0.0	0.0	6.0	10.0
	Spills (weighted spill days)	Less		21.0	30.0	19.0	32.0	20.0	30.0	17.0	27.0	10.0	10.0	28.0	36.0
	Fish-Reservoirs: DOW INDEX (0-100)	More	15%	**42**	**12**	**70**	**64**	**48**	**42**	**69**	**62**	**65**	**51**	**69**	**54**
	Fish-Reservoirs: Littoral C (t / season): 25%	More	25%	1.9	0.9	2.3	2	2.1	2	2.3	2	4.2	1	3.7	1
	Fish-Reservoirs: Enstrain (unitless): 55%	Less	10%	15.6	26.0	4.4	5	11.2	13	5.3	6	9.3	10	7.4	9
	Fish-Reservoirs: Backwater (km): 20%	Less	10%	4.1	5.1	3.3	4	4.8	5	3.1	4	3.8	4	3.4	4
	Fish-Reservoirs: CAR INDEX (0-100)	More	15%	**69**	**55**	**71**	**58**	**41**	**30**	**41**	**25**	**29**	**15**	**29**	**16**
	Fish-Reservoirs: Littoral C (t / season): 50%	More	25%	6.1	5.0	6.5	5.4	4.3	3.5	4.6	3.5	5.0	4.2	4.6	3.8
	Fish-Reservoirs: Enstrain (unitless): 35%	Less	10%	6.0	6.7	5.8	6.4	8.7	9.2	8.3	9.4	11.2	12.3	10.2	11.4
	Fish-Reservoirs: Backwater (km): 15%	Less	10%	5.3	6.2	6.8	8.2	6.7	8.2	10.3	11.5	13.1	14.8	13.8	14.8
Water Quality	Suspended Sediment Load (t / year)	Less	30%	**94**	**184**	**89**	**141**	**77**	**150**	**84**	**127**	**108**	**173**	**78**	**127**
Wildlife	DOW Reservoir WL Habitat Index ** (weighted hectares)	More	10%	**223**	**181**	**231**	**220**	**322**	**306**	**313**	**289**	**295**	**280**	**300**	**290**
	CAR Reservoir WL Habitat Index ** (weighted hectares)	More	10%	**759**	**724**	**522**	**496**	**758**	**744**	**520**	**501**	**602**	**591**	**600**	**586**
	River Wildlife Habitat Index (weighted hectares)	More	10%	**48**	**19**	**48**	**19**	**48**	**19**	**48**	**19**	**48**	**19**	**33**	**16**
Power	Annual Revenue ($M / yr)	More	2%	**144**	**127**	**145**	**126**	**146**	**123**	**148**	**127**	**144**	**118**	**145**	**124**

* Median values reported here refer to the Worst Impact, 9 years out of 10. Actual median flood days equal zero under all alternatives. Worst impact reported is the worst out of 40 years, not 90%ile
** Median values reported here refer to Maximum values in order to better represent the cumulative effect of wildlife development.

Exhibit E1-3: Index Subcomponents for Table 6-2 (Round 5 Consequence Table for Final Water Use Plan Alternatives)

ACTUAL IMPACTS (Median Values, except as noted)										
				Alternative						
Objective	Performance Measure	What's Good?	MSIC	B	N2-2	O3-2	O4	I4	N2-2P
				Median	Median	Median	Median	Median	Median
Flood	Flood Days * (no. of days per year)	Less	5%	**4**	**0**	**1**	**1**	**0**	**0**
Fish	Fish-Rivers: LBR Summary (OK or NO)	OK	n/a	**NO**	**OK**	**OK**	**OK**	**OK**	**OK**
	Fish-Rivers: SONR Summary (constructed scale)	More	n/a	**0**	**2**	**1**	**1**	**1**	**2**
	Shape (0-1)	More		0.6	0.8	0.9	0.9	0.8	0.8
	Flow Magnitude (wks / yr)	Less		6.0	1.0	2.0	3.0	1.0	1.0
	Spills (weighted spill days)	Less		30.0	17.0	18.0	17.0	11.0	17.0
	Fish-Reservoirs: DOW INDEX (0-100)	More	15%	**67**	**67**	**68**	**66**	**69**	**67**
	Fish-Reservoirs: Littoral C (t / season): 25%	More	25%	15.8	6.8	4.9	26.6	9.7	6.8
	Fish-Reservoirs: Enstrain (unitless): 55%	Less	10%	7.2	5.0	4.1	9.9	4.6	5.0
	Fish-Reservoirs: Backwater (km): 20%	Less	10%	3.5	3.1	3.0	4.1	3.3	3.1
	Fish-Reservoirs: CAR INDEX (0-100)	More	15%	**39**	**51**	**54**	**53**	**76**	**51**
	Fish-Reservoirs: Littoral C (t / season): 50%	More	25%	19.4	21.4	19.4	18.3	25.6	21.4
	Fish-Reservoirs: Enstrain (unitless): 35%	Less	10%	10.2	9.2	8.4	8.3	6.1	9.2
	Fish-Reservoirs: Backwater (km): 15%	Less	10%	13.2	9.2	6.9	6.9	5.0	9.2
Water Quality	Suspended Sediment Load * (t / year)	Less	30%	**131**	**125**	**160**	**173**	**174**	**125**
Wildlife	CAR Reservoir WL Habitat Index ** (weighted hectares)	More	10%	**1121**	**1108**	**1201**	**1307**	**1352**	**1208**
	Wildlife Habitat Area (ha) - sedge-grass-herb	More		307	276	240	239	263	285
	Wildlife Habitat Area (ha) - deciduous shrub	More		147	109	130	199	218	117
	Wildlife Habitat Area (ha) - cottonwood	More		173	212	327	388	395	228
	Wildlife Habitat Area (ha) - fall rye	More		0	0	0	0	0	54
Aesthetics	Green-up (eastern-most point)	More	n/a	**Gun Creek**	**Gun Creek**	**Gun Creek**	**Gun Creek**	**Gun Creek**	**Minto 40-80 cm; Tyax 30 cm**
Power	Total Annual Revenue ($M / yr)	More	2%	145	147	146	146	146	147
	Annual Planting Costs ($M/year) ^	Less	n/a						0.042
	Annual Levelized Capital Costs ($M/year)	Less	n/a					6.15	
	Net Annual Revenue ($M / yr)	More	2%	**145**	**147**	**146**	**146**	**140**	**147**

* Median value reported is the Worst Impact, 9 years out of 10. Median flood days equal zero under all alternatives.
** Median value reported is the Maximum value in order to better represent the cumulative effect of wildlife development.
^ Value reported is the levelized annual cost of the 5-year planting program.

Exhibit E1-4: Median and 90% Values for Table 6-2 (Round 5 Consequence Table for Final Water Use Plan Alternatives)

ACTUAL IMPACTS															
				Alternative											
Objective	Performance Measure	What's Good?	MSIC	B		N2-2		O3-2		O4		I4		N2-2P	
				Median	Worst	Median	Worst	Median	Worst	Median	Worst	Median	Worst	Median	Worst
Flood	Flood Days * (no. of days per year)	Less	5%	**4**	**4**	**0**	**0**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**
Fish	Fish-Rivers: LBR Summary (OK or NO)	OK	n/a	**NO**	**NO**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**
	Fish-Rivers: SONR Summary (constructed scale)	More	n/a	**0**	**0**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**
	Shape (0-1)	More		0.6	0.5	0.8	0.7	0.9	0.8	0.9	0.8	0.8	0.8	0.8	0.7
	Flow Magnitude (wks / yr)	Less		6.0	10.0	1.0	5.0	2.0	10.0	3.0	8.0	1.0	4.0	1.0	5.0
	Spills (weighted spill days)	Less		30.0	39.0	17.0	28.0	18.0	31.0	17.0	28.0	11.0	17.0	17.0	28.0
	Fish-Reservoirs: DOW INDEX (0-100)	More	15%	**67**	**54**	**67**	**51**	**68**	**57**	**66**	**51**	**69**	**64**	**67**	**51**
	Fish-Reservoirs: Littoral C (t / season): 25%	More	25%	15.8	5	6.8	4	4.9	3	26.6	16	9.7	7	6.8	4
	Fish-Reservoirs: Enstrain (unitless): 55%	Less	10%	7.2	9	5.0	10	4.1	8	9.9	13	4.6	6	5.0	10
	Fish-Reservoirs: Backwater (km): 20%	Less	10%	3.5	4	3.1	4	3.0	4	4.1	5	3.3	4	3.1	4
	Fish-Reservoirs: CAR INDEX (0-100)	More	15%	**39**	**28**	**51**	**39**	**54**	**44**	**53**	**44**	**76**	**63**	**51**	**39**
	Fish-Reservoirs: Littoral C (t / season): 50%	More	25%	19.4	15.9	21.4	16.9	19.4	16.0	18.3	15.9	25.6	20.6	21.4	16.9
	Fish-Reservoirs: Enstrain (unitless): 35%	Less	10%	10.2	11.3	9.2	9.8	8.4	9.0	8.3	8.8	6.1	6.9	9.2	9.8
	Fish-Reservoirs: Backwater (km): 15%	Less	10%	13.2	14.6	9.2	11.2	6.9	8.4	6.9	9.0	5.0	6.0	9.2	11.2
Water Quality	Suspended Sediment Load * (t / year)	Less	30%	**131**	**131**	**125**	**125**	**160**	**160**	**173**	**173**	**174**	**174**	**125**	**125**
Wildlife	CAR Reservoir WL Habitat Index ** (weighted hectares)	More	10%	**1121**	**1103**	**1108**	**1080**	**1201**	**1151**	**1307**	**1296**	**1352**	**1324**	**1208**	**1179**
	Wildlife Habitat Area (ha) - sedge-grass-herb	More		307	290	276	258	240	214	239	219	263	255	285	266
	Wildlife Habitat Area (ha) - deciduous shrub	More		147	124	109	91	130	112	199	168	218	180	117	98
	Wildlife Habitat Area (ha) - cottonwood	More		173	172	212	188	327	290	388	375	395	389	228	202
	Wildlife Habitat Area (ha) - fall rye	More		0	0	0	0	0	0	0	0	0	0	54	42
Aesthetics	Green-up (eastern-most point)	More	n/a	**Gun Creek**		**Gun Creek**		**Gun Creek**		**Gun Creek**		**Gun Creek**		**Minto 40-80 cm; Tyax 30 cm**	
Power	Total Annual Revenue ($M / yr)	More	2%	145	124	147	121	146	127	146	128	146	127	147	121
	Annual Planting Costs ($M/year) ^	Less	n/a											0.042	0.042
	Annual Levelized Capital Costs ($M/year)	Less	n/a									6.15	6.15		
	Net Annual Revenue ($M / yr)	More	2%	**145**	**124**	**147**	**121**	**146**	**127**	**146**	**128**	**140**	**120**	**147**	**121**

* Median value reported is the Worst Impact, 9 years out of 10. Median flood days equal zero under all alternatives. Worst Value reported is worst out of 40 years, not 90%ile statistic.
** Median value reported is the Maximum value in order to better represent the cumulative effect of wildlife development.
^ Value reported is the levelized annual cost of the 5-year planting program.

Exhibit E1-5: Detail for Table 6-7 (Round 5 Consequence Table for Seton GS Upgrade Options)

ACTUAL IMPACTS (Median Values, except as noted)									
Objective	Performance Measure	What's Good?	MSIC	Alternative B		I3		I4	
				Median	Worst	Median	Worst	Median	Worst
Flood	Flood Days * (no. of days per year)	Less	5%	**4**	**4**	**0**	**0**	**0**	**0**
Fish	Fish-Rivers: LBR Summary (OK or NO)	OK	n/a	**NO**	**NO**	**OK**	**OK**	**OK**	**OK**
	Fish-Rivers: SONR Summary (constructed scale)	More	n/a	**0**	**0**	**1**	**1**	**1**	**1**
	Shape (0-1)	More		0.6	0.5	0.8	0.8	0.8	0.8
	Flow Magnitude (wks / yr)	Less		6.0	10.0	0.0	0.0	1.0	4.0
	Spills (weighted spill days)	Less		30.0	39.0	10.0	10.0	11.0	17.0
	Fish-Reservoirs: DOW INDEX (0-100)	More	15%	**67**	**54**	**63**	**51**	**69**	**64**
	Fish-Reservoirs: Littoral C (t / season): 25%	More	25%	15.8	5	17.6	6	9.7	7
	Fish-Reservoirs: Enstrain (unitless): 55%	Less	10%	7.2	9	9.3	10	4.6	6
	Fish-Reservoirs: Backwater (km): 20%	Less	10%	3.5	4	3.8	4	3.3	4
	Fish-Reservoirs: CAR INDEX (0-100)	More	15%	**39**	**28**	**38**	**26**	**76**	**63**
	Fish-Reservoirs: Littoral C (t / season): 50%	More	25%	19.4	15.9	21.0	17.6	25.6	20.6
	Fish-Reservoirs: Enstrain (unitless): 35%	Less	10%	10.2	11.3	11.2	12.3	6.1	6.9
	Fish-Reservoirs: Backwater (km): 15%	Less	10%	13.2	14.6	13.1	14.8	5.0	6.0
Water Quality	Suspended Sediment Load * (t / year)	Less	30%	**131**	**131**	**173**	**173**	**174**	**174**
Wildlife	CAR Reservoir WL Habitat Index ** (weighted hectares)	More	10%	**1121**	**1103**	**1110**	**1093**	**1352**	**1324**
	Wildlife Habitat Area (ha) - sedge-grass-herb	More		307	290	392	354	263	255
	Wildlife Habitat Area (ha) - deciduous shrub	More		147	124	101	87	218	180
	Wildlife Habitat Area (ha) - cottonwood	More		173	172	169	163	395	389
	Wildlife Habitat Area (ha) - fall rye	More		0	0			0	0
Aesthetics	Green-up (eastern-most point)	More	n/a	**Gun Creek**		**Gun Creek**		**Gun Creek**	
Power	Total Annual Revenue ($M / yr)	More	2%	145	124	150	124	146	127
	Annual Planting Costs ($M/year) ^	Less	n/a						
	Annual Levelized Capital Costs ($M/year)	Less	n/a			6.15	6.15	6.15	6.15
	Net Annual Revenue ($M / yr)	More	2%	**145**	**124**	**144**	**118**	**140**	**120**

* Median value reported is the Worst Impact, 9 years out of 10. Median flood days equal zero under all alternatives.
** Median value reported is the Maximum value in order to better represent the cumulative effect of wildlife development.
^ Value reported is the levelized annual cost of the 5-year planting program.

APPENDIX E2: SETON GENERATION UPGRADE OPPORTUNITY

BRIEFING NOTE

Issue

As part of developing the Bridge River Water Use Plan, Alternative I3 was defined to utilize excess flows at Seton Dam to generate additional power and avoid negative impacts on aquatic resources of spilling in the Seton River.

Background

The normal maximum discharge capacity of Seton Generating Station is only about 70% of the hydraulic capacity of the Bridge River #1 and #2 plants located upstream.

The hydraulic constraints at Seton Generating Station affect operations at the upstream Bridge River #1 and #2 plants based on the need to avoid environmentally damaging spills in the Lower Seton River.

In order to mitigate spills at Seton Dam into the lower Seton River, the Seton Generating Station is normally operated at or near its maximum possible discharge.

The Water Use Plan Consultative Committee Table raised the question of whether there could be upgrade alternatives that could increase power production and reduce environmentally damaging spills.

Upgrade Studies

In 1996, BC Hydro carried out a detailed study under the Resource Smart program that looked at a range of operating changes and upgrades to the existing generating station. These are documented in the "Seton Generating Station Additional Energy Feasibility Study, Report No. MEP68 January 1997."

The Bridge River Water Use Plan power model study for Alternative I3 considered an "assumed" additional generating facility that would utilize all excess water that would otherwise be spilled at the Seton Dam (i.e., Excess = Total flows available – existing turbine flows – flows for Seton River fisheries). “Existing turbine flow” take into account use of more water at the existing plant as the diversion licence restriction is eliminated (from Round 1 alternatives).

Capital cost estimates for constructing a new generation facility were adapted from a more detailed feasibility study carried out for a 13 MW redevelopment project that used quotes from three turbine-generator suppliers and recent construction costs of IPP projects in British Columbia.

Option A: Upgrade Existing Generation Facilities

This study considered four "groups" of upgrades:

1. Equipment upgrades to existing generation from 44 MW to 50 MW.

2. Replace existing turbine and upgrade equipment to increase capacity. Alternatives considered a range of upgrades from 45 MW to 60 MW.

3. Existing turbine plus an additional unit and necessary equipment for capacity increase. Three sizes of units were considered: 5 MW, 10 MW, and 15 MW.

4. Upgrade turbine to 45 MW plus additional unit (5 MW, 10 MW, or 15 MW).

The only alternative identified in this study with a positive net benefit was to upgrade to 50 MW by replacing the existing turbine ($5.8 million). The benefit/cost ratio was only 1.25 and this is relatively low to justify investment. This option would reduce annual spill in the lower Seton River by about 12%.

After the study was completed it was recognized that any lengthy outage (6 months or longer) for replacing turbines or carrying out construction would require the power canal to be dewatered. This would result in either significant spills at Seton Dam or substantial power losses at Bridge River #1 and #2 with spills in the Lower Bridge River during construction. These impacts were expected to be unacceptable from a revenue loss and environmental viewpoint, so the upgrade options were shelved pending discussions as part of the development of Water Use Plans.

Some of the other significant findings:

- Operating the existing generation at 45-50 MW provides only marginal energy increases because of the poor efficiency of the turbine at higher discharges

- The existing canal hydraulic capacity of 147 m^3/s at normal maximum reservoir level limits the potential capacity upgrade of the Seton GS to about 55 MW.

- Increasing the plant capacity above 50 MW triggers the need to construct new substation and transmission facilities at a cost of $7.5 - $9.0 million.

Option B: New Generation Facility

The construction costs for a new 12 MW generating facility are estimated at $50 million to include:

- Modified dam structures to provide new intake at forebay.

- Penstock from Seton Dam to powerhouse located at the confluence of the Seton River and Fraser River (approximately 3900 m).

- 12 MW Powerhouse.

- Environmental mitigation measures.

Construction duration is approximately 2 years on the basis that the entire project is contracted on turnkey basis to a single contractor (similar to IPPs).

Environmental aspects have not been studied and could have a significant impact on construction and operations, therefore affecting net benefits.

Additional $7.5 million to $9 million may be required if this generating capacity triggers requirement for transmission upgrade (this has not been reviewed since 1996).

Summary

Given the above information, the most appropriate approach to an upgrade alternative is Option B: New generation facility.

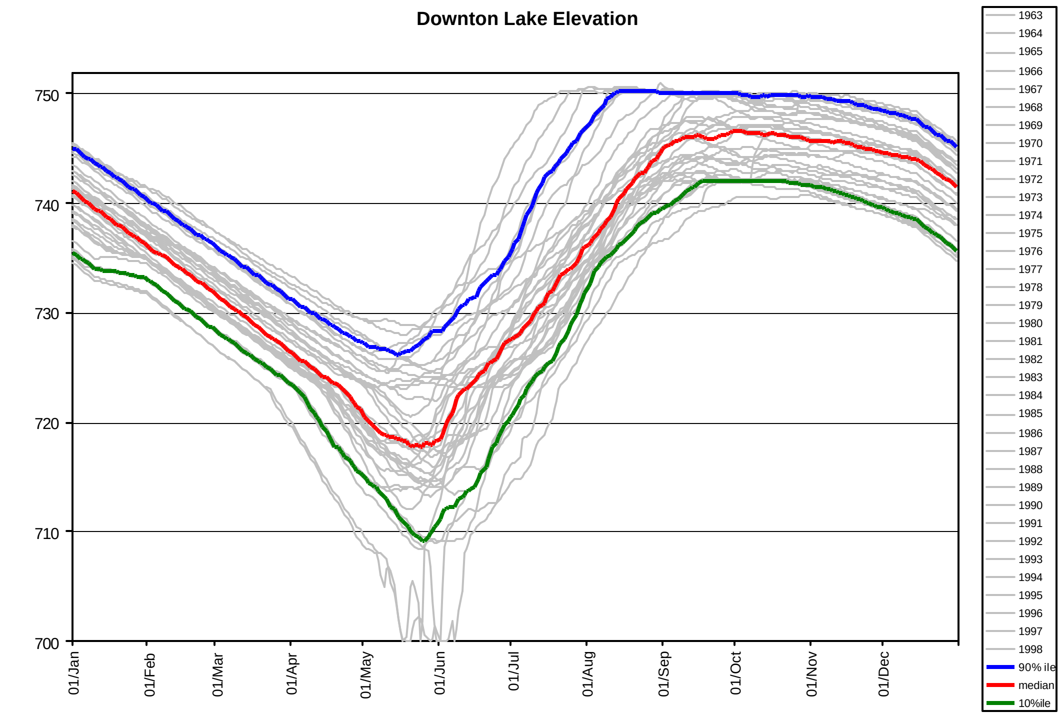
The annualized costs of constructing and operating a new 12 MW generating facility are estimated at $6.15 million ($6.0 million levelized cost of capital and $150k for operations and maintenance).

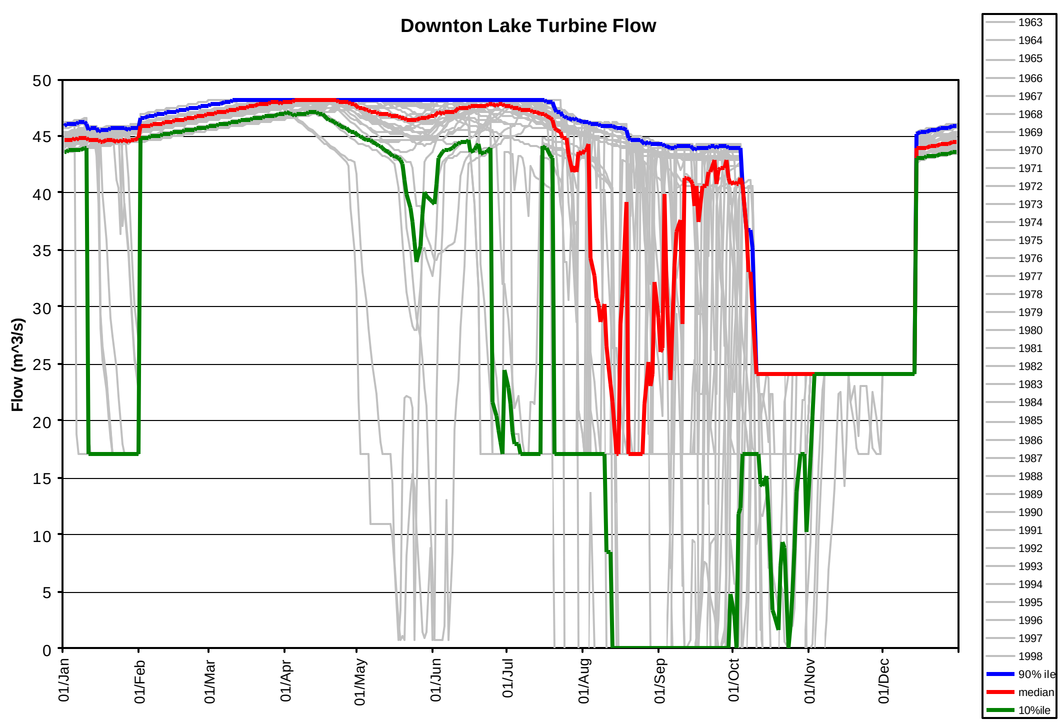
The annual revenue for Alternative I3 should be reduced by the annualized costs which makes the net power benefits $144 million for this alternative.

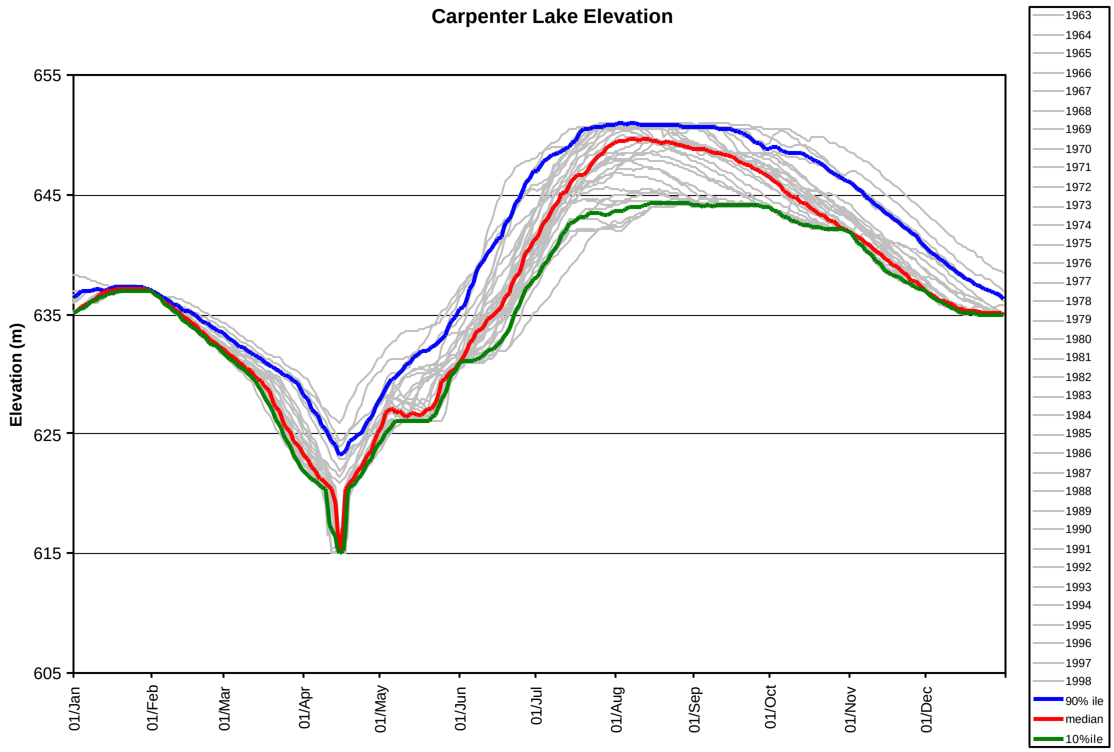
Construction would take a minimum of 2 years from approval to proceed.

Environmental aspects of a new generating facility have not been studied and could have a significant impact on construction costs and generation output.

APPENDIX E3: ALTERNATIVE N2-2P HYDROGRAPHS






Carpenter Lake Elevation
Elevation (m)
655
645
635
625
615
605
01/Jan
01/Feb
01/Mar
01/Apr
01/May
01/Jun
01/Jul
01/Aug
01/Sep
01/Oct
01/Nov
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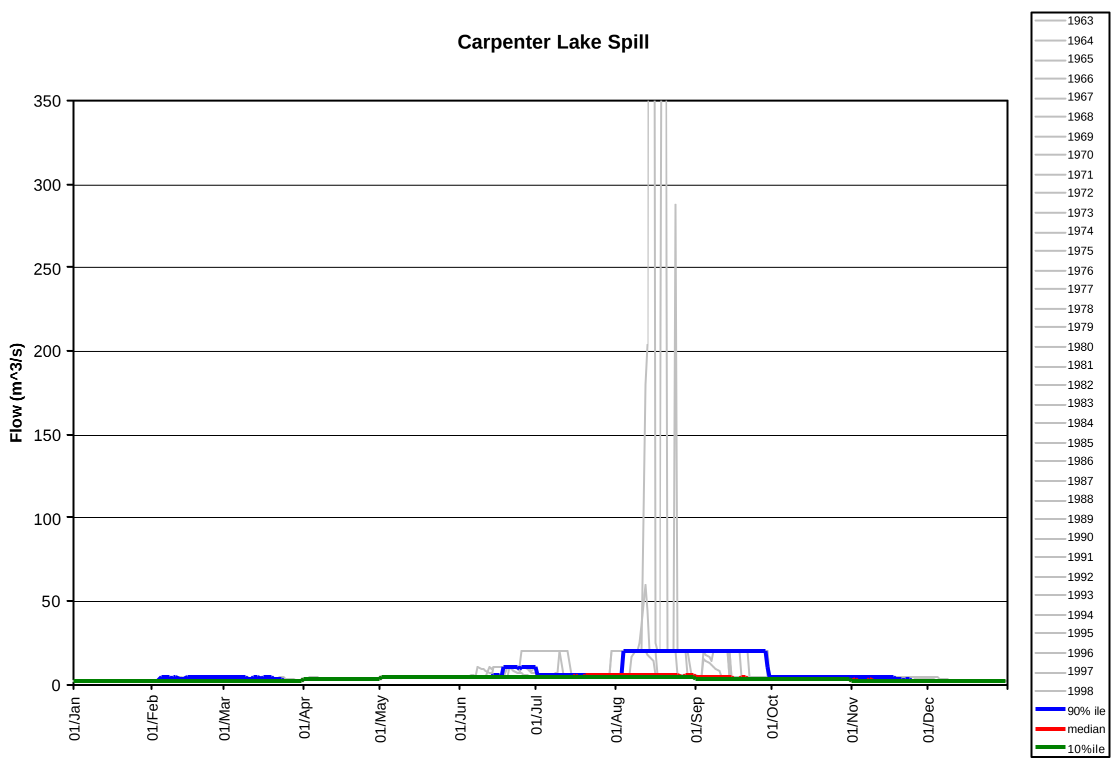
Carpenter Lake Spill
Flow (m^3/s)
350
300
250
200
150
100
50
0
01/Jan
01/Feb
01/Mar
01/Apr
01/May
01/Jun
01/Jul
01/Aug
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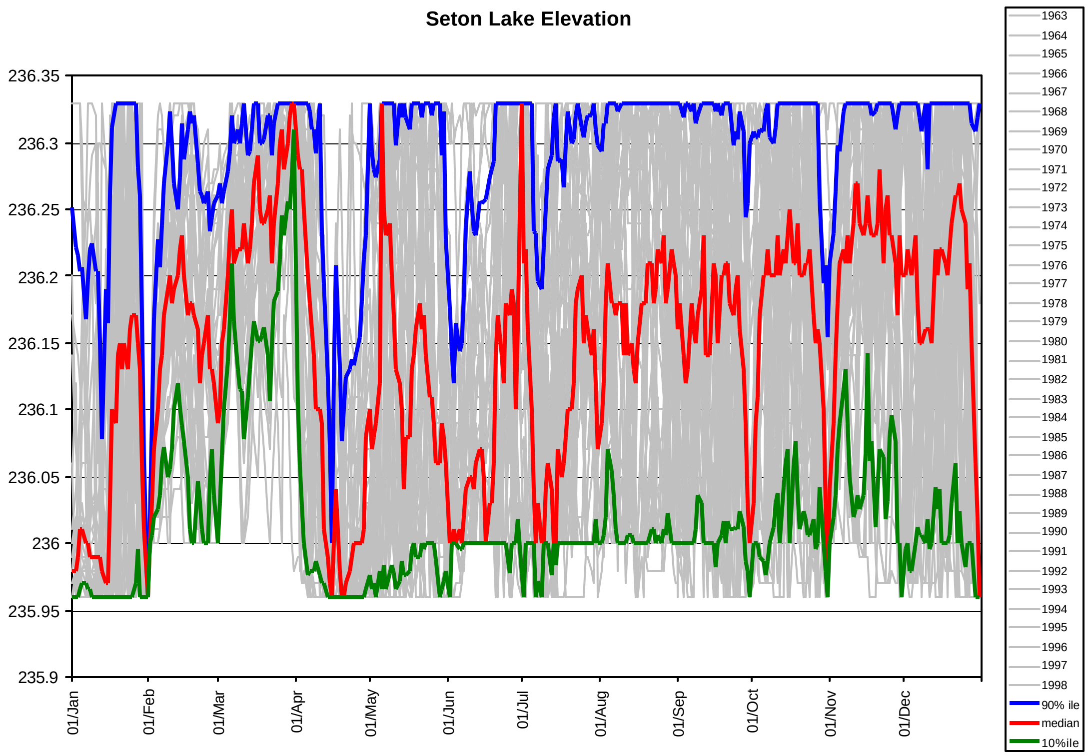
Seton Lake Elevation
236.35
236.3
236.25
236.2
236.15
236.1
236.05
236
235.95
235.9
01/Jan
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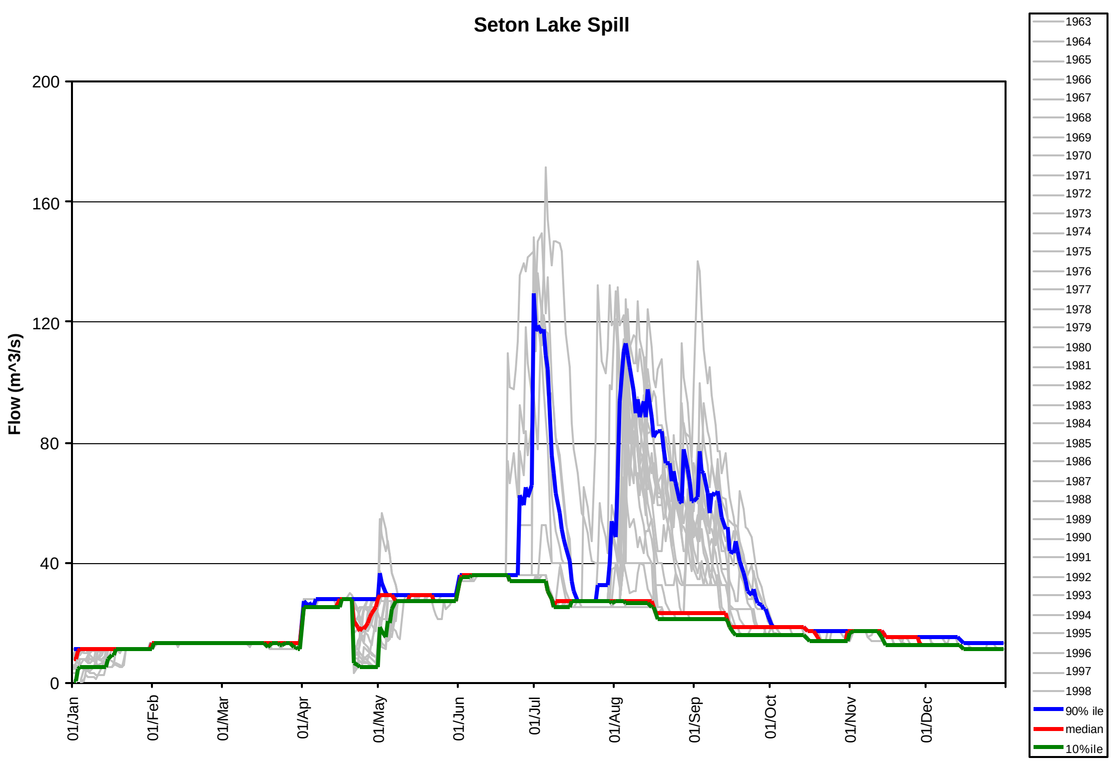
Seton Lake Spill
Flow (m^3/s)
200
160
120
80
40
0
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01/Feb
01/Mar
01/Apr
01/May
01/Jun
01/Jul
01/Aug
01/Sep
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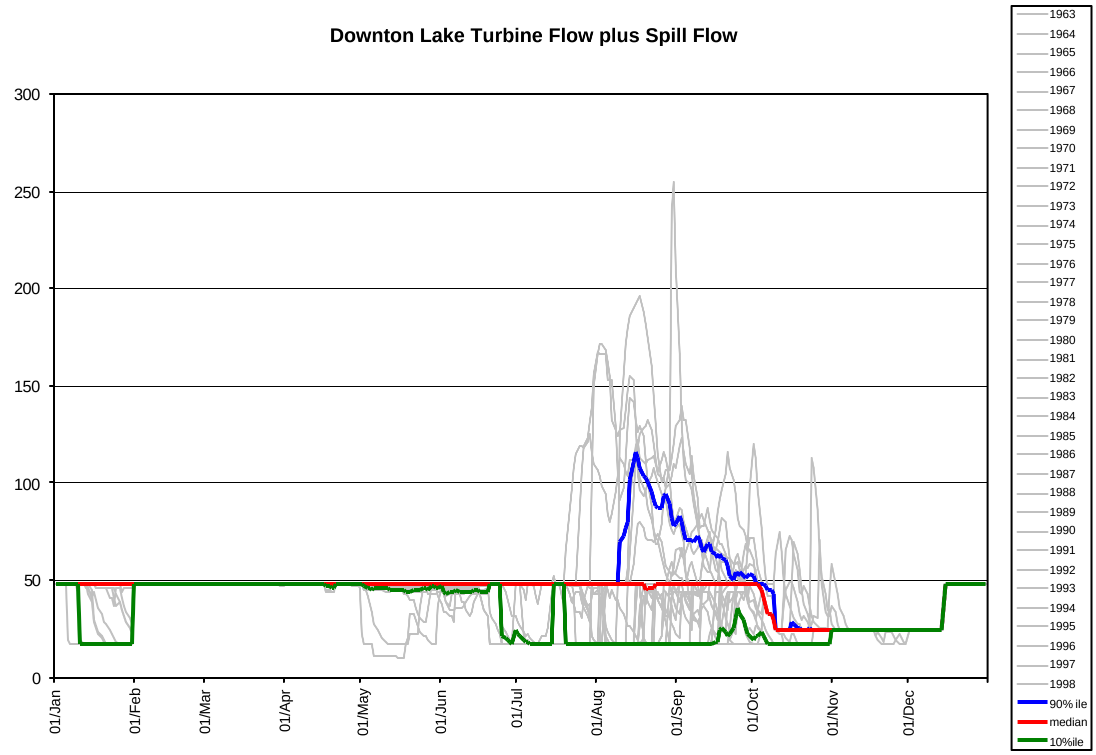
Downton Lake Turbine Flow plus Spill Flow
300
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200
150
100
50
0
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01/Feb
01/Mar
01/Apr
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01/Jun
01/Jul
01/Aug
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APPENDIX F: PREFERENCE ASSESSMENT METHODS

APPENDIX F: PREFERENCE ASSESSMENT METHODS

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APPENDIX F: PREFERENCE ASSESSMENT METHODS

1.0 INTRODUCTION

The key task of the Consultative Committee was to recommend a preferred operating plan for the Bridge River hydroelectric facilities to the Water Comptroller of BC. Given the complexity of this task, a structured decision-making approach was used to help the Consultative Committee explore preferences and reach a decision.

A structured approach to preference assessment can take various forms, ranging from very simple to very complex. For this project, a multi-method approach[1] was selected as offering the best combination of transparency, insight and ease of use. This Appendix describes the mechanics of the multi-method approach to preference assessment.

1.1 Purpose of Structured Decision Processes

Structured approaches are useful in decisions involving multiple decision makers, multiple objectives, a range of alternatives, high stakes, and uncertainty. All of these factors were present in the Bridge River Water Use Plan.

Any structured decision approach should help decision makers:

- develop objectives and performance measures
- develop alternatives
- gain a better understanding of impacts
- refine and improve alternatives
- make a decision
- monitor a decision over time

1.2 Background on possible methods

In the broadest sense, decision methods can range from an intuitive ranking of alternatives through to a technically complex weighting and mathematical treatment. The range of difference methods is shown in Exhibit F-1.

[1] This approach was pioneered by Dr. Ben Hobbs and was applied in B.F. Hobbs and GT.F Horn, "Building Public Confidence in Energy Planning: a Multi-method Approach to Demand-side Planning at BC Gas" (published in Energy Policy, 1997, Vol. 25, No. 3, pp. 357-375)."

Exhibit F-1: Possible Preference Assessment Approaches

Simple and Transparent	←		→		**Technically rigorous, but confusing**
Direct ranking of alternatives (with Objectives)	Simple Ranking of Objectives	Swing weighting	Paired Comparison	Equivalent Bundles	Complex non-linear trade-offs using both single and multi-attribute utility functions

Under *direct ranking of alternatives* (with a set of objectives) decision makers simply use the objectives as supporting information to help inform their decision. They would not attempt to rank or weight the objectives in any way.

Under *simple ranking of objectives*, decision makers rank objectives in terms of importance, much as they might do when making a house purchase.

Swing weighting requires that decision makers first rank each objective, and then assign points to indicate the relative importance of each objective. These weights are then used in a simple equation to compute an overall "score: for each alternative. The term "swing" weighting is used because decision makers are asked to say which objective they would most want to "swing-up" from its worst to its best value. This is important because in some cases an objective may be important, but the change (across the particular alternatives) may be relatively insignificant. For example, in buying a car, price is likely important, but it may be that a buyer is looking at three cars that are all about the same price. In this decision (i.e., between these three cars) the price would no longer be important (because the price is about the same for all three) and the decision would then come down to other factors such as colour, performance and comfort.

Paired Comparison requires decision makers to compare successive pairs of objectives, indicate which of the objectives is more important, and then assign a ratio that indicates how much more important it is. As with the swing-weighting, this produces weights that are then used in a simple equation to compute an overall "score" for each alternative. For this method to work, the objectives must be kept to a manageable number, otherwise it will require a large number of pairings. For example, if there is 10 objectives, the decision maker will need to evaluate 45 pairs of objectives.

Under the *equivalent bundle* approach, decision makers are given one bundle of attributes and part of another bundle. They then need to fill in a blank such that the two bundles are equal. For example, they might be told that in one bundle is a car that costs $20,000 and has 150 hp. In another bundle is a car with 200 hp. The decision maker then needs to say what they would be prepared to pay for a car with that horsepower, all else being equal. In practice, this approach has proven confusing and unpopular with stakeholders.

Lastly, decision makers could be asked to articulate *complex non-linear trade-offs*. This involves describing non-linear issues (e.g., thresholds) within objectives, specifying any interrelationships between objectives and translating all of this in a single complex formula that is in turn used to rank alternatives. In practice, this approach has proven to be too quantitatively overwhelming for decision makers. This in turn erodes their trust in the process and undermines the value of the exercise.

1.3 Background on the Multi-Method Approach

Each of the above preference assessment methods has certain advantages and disadvantages. The simple approaches are appealing in their simplicity, but they are not very rigorous. The more complex approaches are rigorous, but they can become unwieldy and very confusing for the decision maker (and analyst).

Therefore, instead of using one single approach, the group used a combination of the approaches and compared the results.

The essence of the multi-method approach is that it uses several simple approaches to arrive at the same answer, rather than a single complex approach. The three methods employed are indicated by the bold outlining in Exhibit F-1.

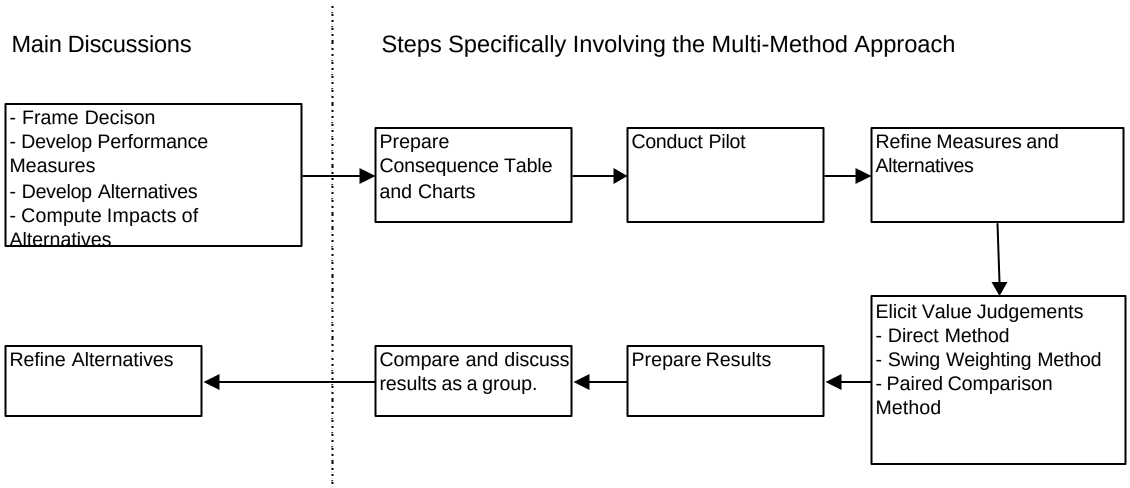
The benefits of the multi-method approach are:

- transparency for the decision maker.
- the results of the different approaches can be compared, thus allowing for cross-checking and error-checking.
- decision maker retains control over the final recommendations (i.e., the results are not drawn from a blackbox and proclaimed as being the "answer").
- results provide a framework for discussion and learning.

2.0 METHODOLOGY

The basic steps for the multi-method approach to preference assessment are set out in Exhibit F-2. Some steps are common to all structured decision approaches (e.g., setting objectives, developing alternatives and modelling impacts). Most processes also develop some form of consequence table and some processes will administer questionnaires and discuss results. However, only the multi-method approach includes a step for comparing results across preference assessment methods.

Exhibit F-2: Flow Chart of the Multi-Method Approach



3.0 STEP BY STEP APPLICATION

3.1 Develop Measures and Objectives and Calculate Impacts

The majority of the initial meetings of the Consultative Committee were devoted to defining the decision and developing objectives, performance measures and alternatives. In parallel, power modelling and ecological modelling work was undertaken to represent the impacts of the different alternatives.

3.2 Prepare Consequence Table and Charts

Information on the estimated impacts of the alternatives was structured as a consequence table, a simple example of which is shown in Exhibit F-3. This shows the objectives and performance measures down the side and the alternatives across the top.

Exhibit F-3: Consequence Table

Objective	Performance Measure	Alternative M2	M5	L2	N2	I3	B
Flood	Flood Days	1	1	0	0	0	2
Fish	Fish-Rivers: LBR Summary (OK or NO)	OK	OK	OK	OK	OK	NO
	Fish-Rivers: SONR Summary (constructed scale)	2	2	2	2	1	0
	Fish-Reservoirs: DOW INDEX (0-100)	42	70	48	69	65	69
	Fish-Reservoirs: CAR INDEX (0-100)	69	71	41	41	29	29
Water Quality	Suspended Sediment Load	94	89	77	84	108	78
Wildlife	DOW Reservoir WL Habitat Index	223	231	322	313	295	300
	CAR Reservoir WL Habitat Index	759	522	758	520	602	600
	River WL Habitat Index	48	48	48	48	48	33
Power	Annual Revenue ($M / yr)	144	145	146	148	144	145

Exhibit F-3 served as the primary summary table and interface for decision makers. In order to use the impacts to "score" the alternatives, these impacts were converted to a common 0 to 100 scale. This is a straightforward mathematical scaling exercise. A simple analogy would be the conversion of two test scores to a common percent score where the tests are out of different total points. For example, one test may have been 18 out of 20 and the other test 40 out of 50. In order to compare these, they must be converted to a common scale. The first would be 90% and the second would be other would be 80%. These numbers are now directly comparable.

For a description of each alternative, refer to Section 6 of the main report.

3.3 Pilot

Several months prior to the final analysis, a pilot analysis was conducted with the consultative group. This involved walking the Consultative Committee through a complete trade-off analysis (including questionnaires and processing of weights as described below) with preliminary alternatives and preliminary data. No decisions were to be made based on the inputs.

The purpose of the pilot was to introduce the group to the decision framework and get feedback on which of the measures were meaningful. For example, Consultative Committee members, in trying answer the questions in a meaningful way, pointed out that "flooding days" alone was difficult to evaluate against other impacts because it provided no sense of whether the flooding was actually damaging.

Most importantly, the pilot allowed the Consultative Committee members to provide early feedback on the format of the materials (tables, questionnaires, and charts) and to become familiar with the process before having to do it for real.

3.4 Elicit Value Judgements

Three approaches for eliciting preferences or value judgements were employed, with each approach requiring its own questionnaire.

The *Direct Ranking Approach* is the simplest of the three and only requires the decision maker to rank the alternatives. This is done by entering rankings beside each alternative. Consultative Committee members were also asked to indicate the relative ranking of each alternative by assigning points to each alternative, starting with 100 for the highest ranked alternative. For example, if a Consultative Committee member gave 100 points to the highest ranked alternative and 50 points to the second alternative, that would indicate that they felt the first was twice as important as the second.

Exhibit F-4: Direct Ranking Questionnaire

DIRECT RANKING EXERCISE

INSTRUCTIONS

STEP 1

<u>Rank the Alternatives</u> with 1 being your most preferred alternative. Ties are OK.

STEP 2

A. Assign 100 points to the #1 ranked alternative.

B. Then, assign points to the other Alternatives to reflect their importance relative to the #1 ranked alternative.

EXERCISE

Alternative Name	Rank	Points (from 0 - 100)
M2		
M5		
L2		
N2		
I3		
B		

The *Swing Weighting* Approach is more complex and required the decision maker to rank each objective and then indicate the relative importance of each objective. Similar to the direct ranking method, this is done by first entering a "1" for the most important objective and then "2" for the second most important objective and so on. The most important objective is the objective the Consultative Committee member would most want to "swing-up" from its worst to its best value (see above discussion of swing weighting). Ties are OK. Once the objectives are all ranked, the member then allocates 100 points to the objective they chose as the most important and some lesser amount of points to each successive objective.

The rankings and scores are applied within each block of questions.

Exhibit F-5: Swing-Weighting Questionnaire (Part 1)

SWING WEIGHTING EXERCISE

INSTRUCTIONS

For each Section…

For each Section…

A. Rank the measures in terms of their relative importance, with a rank = 1 being your most important measure. Ties are okay.

B. Assign 100 points to the #1 ranked measure.

C. Assign points to the other measures to reflect their importance relative to the #1 ranked measure.

Remember to assign points based on how important it is to swing the measure from its worst to its best. If the range from worst to best is very small or very large, that should affect the importance you give it.

NOTE

Start the ranking process and the point allocation anew for each section. (i.e. you should treat each section independently for this exercise). The totals for each section are not relevant, nor are comparisons across sections.

SECTION 1: FISH

Objective	Performance Measure	Location	Worst Case	Best Case	Rank	Points (from 0 to 100)
Fish	Fish-Rivers: LBR Summary (OK or NO)	LBR	NO	OK		
	Fish-Rivers: SONR Summary (constructed scale)	SONR	0	2		
	Fish-Reservoirs: DOW INDEX (0-100)	DOW	8	77		
	Fish-Reservoirs: CAR INDEX (0-100)	CAR	13	97		

In some cases, such as the "overall" section of Exhibit F-6, where there is more than one performance measure per objective, the decision maker was asked to rank a whole set of performance measures as a unit. For example, in comparing Fisheries versus Wildlife impacts, they were asked to consider whether they would rather swing all the fish measures from their worst to their best, or swing all the wildlife measures from their worst to their best.

Exhibit F-6: Swing-Weighting Questionnaire (Part 2)

SECTION 2: WILDLIFE

Objective	Performance Measure	Location	Worst Case	Best Case	Rank	Points (from 0 to 100)
Wildlife	DOW Reservoir WL Habitat Index	DOW	223	322		
	CAR Reservoir WL Habitat Index	CAR	520	759		
	River WL Habitat Index	LBR	33	48		

SECTION 3: OVERALL

NOTE: For this section, where there are multiple performance measures under a single objective, consider improving all of these measures from their worst to best when ranking them as a single unit relative to the other measures.

Objective	Performance Measure	Location	Worst Case	Best Case	Rank	Points (from 0 to 100)
Flood	Flood Days	All Rivers	2	0		
Fish	Fish-Rivers: LBR Summary (OK or NO)	LBR	NO	OK		
	Fish-Rivers: SONR Summary (constructed scale)	SONR	0	2		
	Fish-Reservoirs: DOW INDEX (0-100)	DOW	8	77		
	Fish-Reservoirs: CAR INDEX (0-100)	CAR	13	97		
Water Quality	Suspended Sediment Load	SONL	108	77		
Wildlife	DOW Reservoir WL Habitat Index	DOW	223	322		
	CAR Reservoir WL Habitat Index	CAR	520	759		
	River WL Habitat Index	LBR	33	48		
Power	Annual Revenue ($M / yr)	Total	144	148		

The *Paired Comparison* approach is the most complex of the three approaches.

For this exercise, Consultative Committee members needed to consider a total of nineteen pairs of objectives. For each pair, the decision maker needed to decide which objective or performance was the more important one in each pair and then indicate whether it was only slightly more important or significantly more important (see scale in Exhibit F-7).

Exhibit F-7: Paired Comparison Approach (Part 1)

PAIRED COMPARISON EXERCISE

INSTRUCTIONS

For each pair of performance measures:

1. Indicate which measures you would prefer to improve from the worst-case impact to the best-case impact, by circling either A or B as they are listed within each pair of measures; and;

2. Using the scale below, indicate the relative importance of the improvement in the chosen measures(s) relative to the other measure(s). Enter this choice under the column titled 'Relative Importance'. Note: Your choices may indicate equal preference (e.g., A is 1x as preferable as B).

Scale

1x 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9,	**2x** 2.1,...	**3x** 3.1,...	**4x** 4.1,...	**5x** 5.1,...	**6x** 6.1,...	**7x** 7.1,...	**8x** 8.1,...	**9x** 9.1,...

(equal……extreme)

Examples

PAIR	PREFERENCE CHOICE CIRCLE **A** OR **B** ACCORDING TO WHICH IMPROVEMENT YOU PREFER	RELATIVE IMPORTANCE Enter degree of relative importance (Refer to Scale)
Example of High Level Question	A Improve POWER Annual Revenue from $144 to $148 million/year **OR** B Improve FLOOD Days (All Rivers) from 2 to 0 days/year	***4x*** (hypothetical)
Example of Detailed Question	A Improve Fish-Reservoirs DOW Index from 8 to 77 **OR** B Improve Fish-Reservoirs CAR Index from 13 to 97	***6x*** (hypothetical)

NOTE: The response to Example 1, for example, indicates that you feel it is 4 times as important to improve Power from worst to best relative to an improvement in system-wide flooding.

The Consultative Committee members began by comparing the relative importance of Fish performance measures together as a group, and Wildlife performance measures as a group. This required them to consider six pairings and three pairings respectively, as shown in Exhibit F-8.

Exhibit F-8: Paired Comparison Approach (Part 2)

RESPONSE SHEET - LOWER LEVEL (DETAILED) QUESTIONS

PAIR	PREFERENCE CHOICE CIRCLE **A** OR **B** ACCORDING TO WHICH IMPROVEMENT YOU PREFER	RELATIVE IMPORTANCE Enter degree of relative importance (Refer to Scale)
FISH		
1	A Improve Fish-Rivers SONR Summary (constructed scale) from 0 to 2	
	B Improve Fish-Reservoirs CAR Index from 13 to 97	
2	A Improve Fish-Reservoirs DOW Index from 8 to 77	
	B Improve Fish-Rivers SONR Summary (constructed scale) from 0 to 2	
3	A Improve Fish-Reservoirs CAR Index from 13 to 97	
	B Improve Fish-Rivers LBR Summary from 'NO' to 'OK'	
4	A Improve Fish-Rivers LBR Summary from 'NO' to 'OK'	
	B Improve Fish-Reservoirs DOW Index from 8 to 77	
5	A Improve Fish-Rivers SONR Summary (constructed scale) from 0 to 2	
	B Improve Fish-Rivers LBR Summary from 'NO' to 'OK'	
6	A Improve Fish-Reservoirs DOW Index from 8 to 77	
	B Improve Fish-Reservoirs CAR Index from 13 to 97	

RESPONSE SHEET - LOWER LEVEL (DETAILED) QUESTIONS continued

PAIR	PREFERENCE CHOICE CIRCLE **A** OR **B** ACCORDING TO WHICH IMPROVEMENT YOU PREFER	RELATIVE IMPORTANCE Enter degree of relative importance (Refer to Scale)
WILDLIFE		
1	A Improve River WL Habitat Index from 33 to 48	
	B Improve DOW Reservoir WL Habitat Index from 223 to 322	
2	A Improve CAR Reservoir WL Habitat Index from 520 to 759	
	B Improve River WL Habitat Index from 33 to 48	
3	A Improve DOW Reservoir WL Habitat Index from 223 to 322	
	B Improve CAR Reservoir WL Habitat Index from 520 to 759	

In order to establish the relative importance amongst the objectives (e.g., Fisheries versus Wildlife impacts), Consultative Committee members were asked to compare the objectives against each other. This required a total of 10 questions as shown in Exhibit F-9 and Exhibit F-10.

Exhibit F-9: Paired Comparison Approach (Part 3)

RESPONSE SHEET - HIGHER LEVEL QUESTIONS

PAIR	PREFERENCE CHOICE CIRCLE **A** OR **B** ACCORDING TO WHICH IMPROVEMENT YOU PREFER	RELATIVE IMPORTANCE Enter degree of relative importance (Refer to Scale)
1	A Improve WILDLIFE DOW Reservoir Habitat Index from 223 to 322 *AND* Improve WILDLIFE CAR Reservoir Habitat Index from 520 to 759 *AND* Improve WILDLIFE River Habitat Index from 33 to 48	
	B Improve FLOOD Days (All Rivers) from 2 to 0 days/year	
2	A Improve WATER QUALITY Suspended Sediment Load (SONL) from 108 to 77	
	B Improve FLOOD Days (All Rivers) from 2 to 0 days/year	
3	A Improve FLOOD Days (All Rivers) from 2 to 0 days/year	
	B Improve FISH Rivers LBR Summary from 'NO' to 'OK' *AND* Improve FISH Rivers SONR Summary (constructed scale) from 0 to 2 *AND* Improve FISH Reservoirs DOW Index from 8 to 77 *AND* Improve FISH Reservoirs CAR Index from 13 to 97	
4	A Improve POWER Annual Revenue from $144 to $148 million/year	
	B Improve FLOOD Days (All Rivers) from 2 to 0 days/year	
5	A Improve POWER Annual Revenue from $144 to $148 million/year	
	B Improve WILDLIFE DOW Reservoir Habitat Index from 223 to 322 *AND* Improve WILDLIFE CAR Reservoir Habitat Index from 520 to 759 *AND* Improve WILDLIFE River Habitat Index from 33 to 48	

Exhibit F-10: Paired Comparison Approach (Part 4)

RESPONSE SHEET - HIGHER LEVEL QUESTIONS continued

PAIR	PREFERENCE CHOICE CIRCLE **A** OR **B** ACCORDING TO WHICH IMPROVEMENT YOU PREFER		RELATIVE IMPORTANCE Enter degree of relative importance (Refer to Scale)
6	A Improve WATER QUALITY Suspended Sediment Load (SONL) from 108 to 77		
	B Improve WILDLIFE DOW Reservoir Habitat Index from 223 to 322	*AND*	
	Improve WILDLIFE CAR Reservoir Habitat Index from 520 to 759	*AND*	
	Improve WILDLIFE River Habitat Index from 33 to 48		
7	A Improve WATER QUALITY Suspended Sediment Load (SONL) from 108 to 77		
	B Improve POWER Annual Revenue from $144 to $148 million/year		
8	B Improve FISH Rivers LBR Summary from 'NO' to 'OK'	*AND*	
	Improve FISH Rivers SONR Summary (constructed scale) from 0 to 2	*AND*	
	Improve FISH Reservoirs DOW Index from 8 to 77	*AND*	
	Improve FISH Reservoirs CAR Index from 13 to 97		
	B Improve WILDLIFE DOW Reservoir Habitat Index from 223 to 322	*AND*	
	Improve WILDLIFE CAR Reservoir Habitat Index from 520 to 759	*AND*	
	Improve WILDLIFE River Habitat Index from 33 to 48		
9	A Improve POWER Annual Revenue from $144 to $148 million/year		
	B Improve FISH Rivers LBR Summary from '' to 'OK'	*AND*	
	Improve FISH Rivers SONR Summary (constructed scale) from 0 to 2	*AND*	
	Improve FISH Reservoirs DOW Index from 8 to 77	*AND*	
	Improve FISH Reservoirs CAR Index from 13 to 97		
10	A Improve WATER QUALITY Suspended Sediment Load (SONL) from 108 to 77		
	B Improve FISH Rivers LBR Summary from 'NO' to 'OK'	*AND*	
	Improve FISH Rivers SONR Summary (constructed scale) from 0 to 2	*AND*	
	Improve FISH Reservoirs DOW Index from 8 to 77	*AND*	
	Improve FISH Reservoirs CAR Index from 13 to 97		

3.5 Prepare Results

Consultative Committee members entered their replies on a paper copy of the questionnaire shown. The replies were then entered into the model, which in turn computed scores, compared rankings and generated outputs for each person as well as for the group as a whole.

The direct rankings of the alternatives were entered as simply that - rankings.

For the swing weighting questionnaire, the scores were used to compute weights for each performance measure and each objective. And where applicable, weights for the objectives were multiplied by the weights for the underlying performance measure in order to compute the final weight for the performance measure. These weights were then entered into the following equation that computed an overall score by multiplying each weight times each scaled impact.

Score for a given alternative = $W_1(x_{1a})+W_2(x_{2a})+\ldots$

Where:
W = Weight of the first performance measure
X = the scaled impact on a given performance measure

For the paired comparison questionnaire, the indicators of relative importance provided by the Consultative Committee member were reconciled to calculate a set of weights that represented the judgements of the Consultative Committee member. Each of these weights were then entered into a similar equation as shown above

Exhibit F-11 shows the resulting weights by the swing weighting approach.[1] This weighting approach was generally the more favoured of the two weighting approaches. The performance measures are shown across the bottom with the weights on the vertical axis. The markers represent the weights for this particular Consultative Committee member and the vertical line represents the range of weights for all decision makers.

Key messages to be drawn from the chart for this particular Consultative Committee member is that he feels that, across the magnitude of change estimated for this set of alternatives (i.e., the swing), Flooding, Water Quality, and Power are relatively important, whereas Lower Bridge Wildlife is not. The other measures are moderately important to this Consultative Committee member. In its deliberations, the Consultative Committee used this chart format to probe differences in weights across all Committee members and the differences in values that they represent. Some of the reasons for significant differences in values include:

- Water Quality: A consultant's report indicated that the potential for increases in contamination in Seton Lake as a result of operating changes is likely negligible. However, the second impact from water quality is a potential to negatively affect fisheries. The significance of this effect is a large uncertainty, and results in the wide range of weights assigned.
- Flooding: Most participants weighted this low because the differences across alternatives was small and the potential for damage to people and property was also small. However, one participant admitted to difficulty separating out the more catastrophic impacts of a dam failure and the relatively minor damage to roads and buildings that this performance measure was really indicating.
- Power: The large range in weights for this performance measure is not surprising and reflects the diversity in participants – from local residents who view these impacts as small relative to the total annual revenues

[1] The weights for the paired comparison could be shown in the same way; swing weighting results only are shown here for simplicity.

from the facility, to provincial representatives who are responsible for fiscal management.

Exhibit F-11: Individual Weights

CC Member	Respondent X

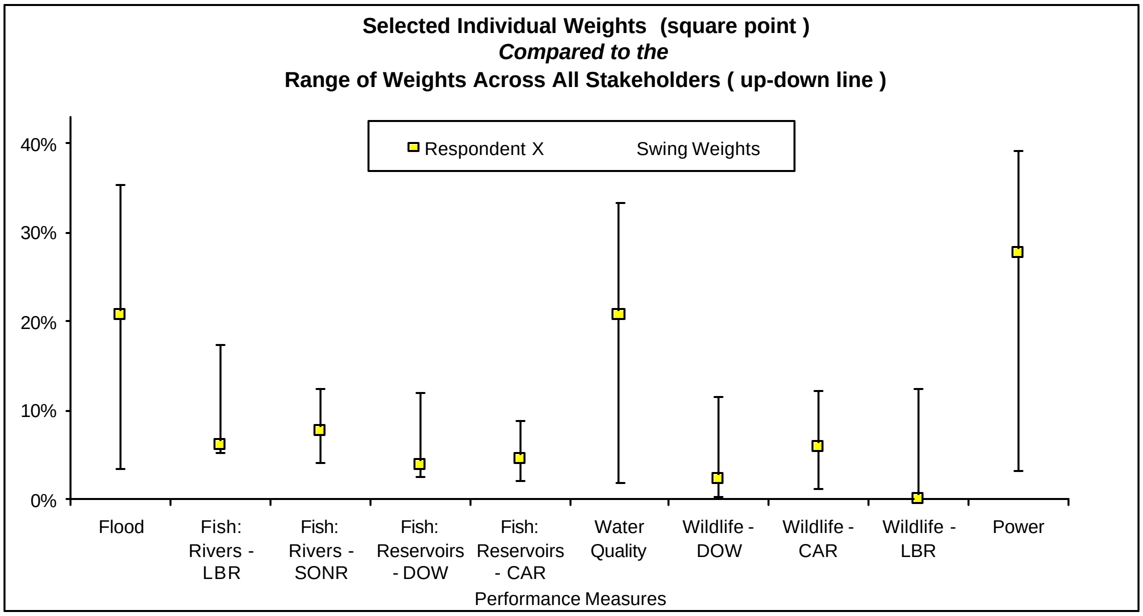


Exhibit F-12 compares the ranking of the alternatives by the Direct method versus the Swing method for an individual Committee member. The 45 degree line helps to identify areas of agreement and disagreement. Any alternatives that lie along the 45 degree line in the chart are ranked the same by either method. In the case shown here, "M2," "I3" and "B" lie along the line and are ranked fourth and fifth and sixth respectively by either the direct or the swing method.

The rankings of the other three alternatives differ slightly under the two methods. L2 is ranked first by the Swing method, but third by the Direct method. Meanwhile N2 is ranked first by the Direct method, but second by the Swing method. Lastly, M5 is ranked second by the Direct method and third by the Swing method.

These relatively minor differences need not be explicitly reconciled. A major difference that would require reconciling would be if an alternative were ranked first by one method and fifth or sixth by another.

In cases where this did occur, the explanation was either:

1. *A misinterpretation of the impact of an alternative.* In one example, a Consultative Committee member had ranked an alternative poorly by the Direct method, but well by swing weights. On exploring the reason, it turned out that the Consultative Committee member had overlooked the riparian benefits of the alternative. When this was discovered the Consultative Committee member changed the Direct ranking to align with the weights.

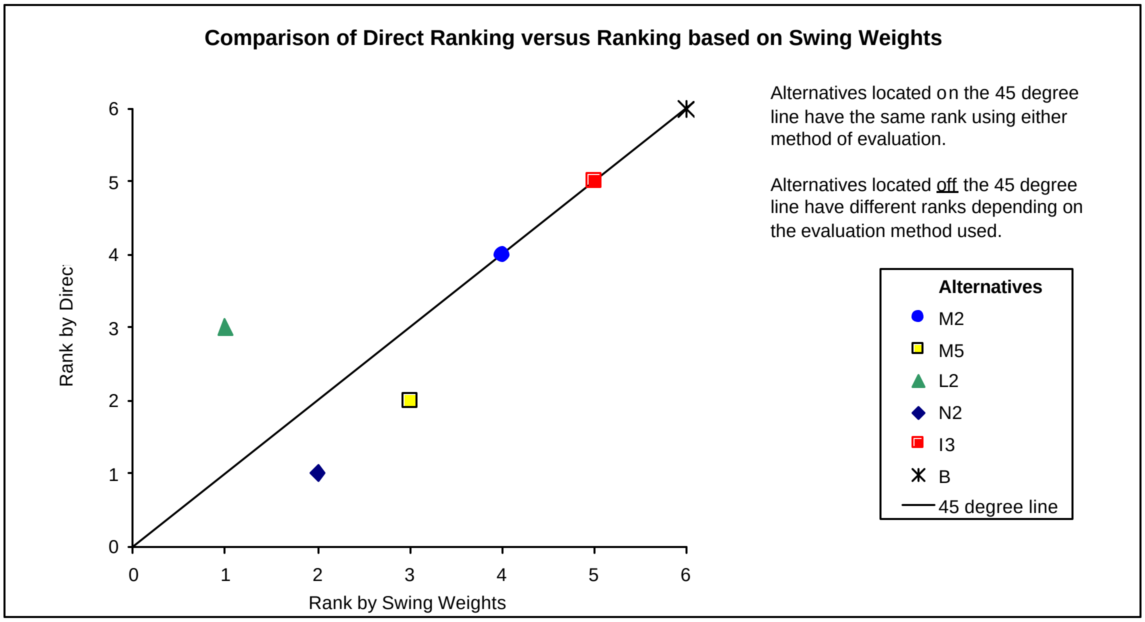
2. *A misrepresentation of a desired weight.* There were some cases of this in the pilot analysis where Consultative Committee members ended up with heavier or lighter weights than they had intended. But by the final analysis the Consultative Committee members were more comfortable with the process and their weights were more reflective of their value judgements.

3. *A failure of the performance measures to adequately capture an issue of concern to that particular stakeholder.* For example, in the final analysis there was one case where a stakeholder felt a capital cost had been unfairly charged to an alternative. The result was that the Consultative Committee member didn't like the alternative based on the weights (because it was costly), but he did like it by the Direct method because he felt the costs shouldn't have been attributed to the alternative in the first place.

4. *An error in the data collection.* There were some errors in the responses for the pilot analysis. These were largely due to inadequate instructions or unclear design of the questionnaire. However, these were addressed after the pilot and no errors came to light in the processing of the results for the final analysis.

Exhibit F-12: Individual Comparison of Rankings

CC Member	Respondent X



The table at the top of Exhibit F-13 shows the actual weight values for both weighting methods for a single Consultative Committee member. The chart at the bottom compares the two weighting methods. As with the chart that compared the ranking for the alternatives, any objectives that lie on the line (in this case Fish) have the exactly the same weighting by either method. Those that stray above the line are weighted more heavily be the swing method. Those that stray below the line are weighted more heavily by the Paired comparison method. In this case the weighting differences are reasonably close and don't require significant reconciliation.

Exhibit F-13: Individual Comparison of Weights

CC Member	Respondent X

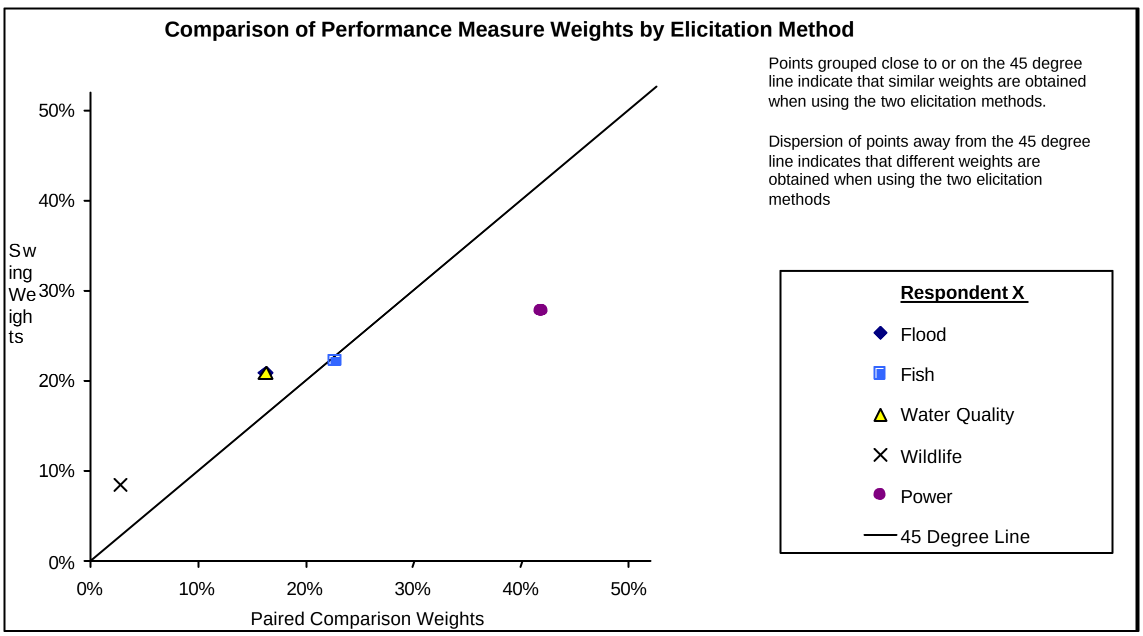
Weight Summary

Swing Weights

High Level	Flood	Fish				Water Quality	Wildlife			Power	Sum Check
Component Level		LBR	SONR	DOW	CAR		DOW	CAR	LBR		
High Level Weight	21%	22%				21%	8%			28%	100%
Component Level Weight		28%	34%	17%	21%		29%	71%	0%		
Final Weight	21%	6%	8%	4%	5%	21%	2%	6%	0%	28%	100%

Paired Comparisons

High Level	Flood	Fish				Water Quality	Wildlife			Power	Sum Check
Component Level		LBR	SONR	DOW	CAR		DOW	CAR	LBR		
High Level Weight	16%	23%				16%	3%			42%	100%
Component Level Weight		33%	54%	6%	8%		36%	57%	8%		
Final Weight	16%	8%	12%	1%	2%	16%	1%	2%	0%	42%	100%



3.6 Discuss Results as a Group

As part of the outputs, each Consultative Committee member was provided with an overall summary as shown in Exhibit F-14. The table shows the Consultative Committee members across the top (numbered for anonymity) and alternatives down the side. For each alternative, a ranking is shown for each of the Swing, Paired Comparison and Direct methods.

Exhibit F-14: Group Results

Rank of Alternatives by Stakeholder and by Method

		CC Members											
Alternatives	Weighting Method	1	2	3	4	5	6	7	8	9	10	11	12
M2	Swing	4	4	3	3	2	2	4	3	2	4	3	4
M2	Paired Comparison	4	4	4	2	2	2	4	4	2	4	4	5
M2	Direct	4	4	1	3	3	3	4	2	1	4	2	2
M5	Swing	3	3	4	4	4	4	3	4	4	3	4	3
M5	Paired Comparison	3	3	3	3	4	4	3	3	4	3	3	3
M5	Direct	2	2	6	2	2	2	3	5	4	2	4	3
L2	Swing	1	1	1	1	1	1	2	1	1	2	1	1
L2	Paired Comparison	1	2	1	1	1	1	2	1	1	2	1	2
L2	Direct	3	3	3	4	4	4	2	4	3	3	3	4
N2	Swing	2	2	2	2	3	3	1	2	3	1	2	2
N2	Paired Comparison	2	1	2	4	3	3	1	2	3	1	2	1
N2	Direct	1	1	2	1	1	5	1	3	5	1	1	1
I3	Swing	5	5	5	5	5	5	5	5	5	5	5	5
I3	Paired Comparison	5	5	5	5	5	5	5	5	5	5	5	4
I3	Direct	5	5	4	5	5	1	6	1	2	5	5	5
B	Swing	6	6	6	6	6	6	6	6	6	6	6	6
B	Paired Comparison	6	6	6	6	6	6	6	6	6	6	6	6
B	Direct	6	6	5	6	6	6	5	6	6	6	6	6

Indicates an alternative with a rank = 1
Indicates an alternative with a rank = 2
Indicates an alternative with a rank = 6

Key observations are:

- Alternative "B" (i.e., the status quo) was not preferred by any participants by any of the methods.

- Alternative I3 was ranked second to last by most Consultative Committee members except for three people who ranked it high by the direct method. For one person this was because from that person's percpective, the inclusion of capital costs resulted in an understatement of the power values, and so discounted that performance measure. The other two liked it on a Direct basis because they felt that upgrading Seton generating capacity made sense in concept and believed that the alternative had simply not been designed to take full advantage of the additional generating capacity for maximizing environmental benefits.

- Alternatives M2 and M5 received mid-range scores by most participants.

- Alternative N2 fared very well by the direct method, and was ranked second for most Consultative Committee members by the weighting methods.

- Alternative L2 fared very well for most Consultative Committee members by both weighting methods. However, most Consultative Committee members were not particularly in favour of Alternative L2 by the Direct Method. This was discussed as a group and was explained by two factors. First, the Alternative L2 Seton hydrograph (as it was shown on the wall charts during the session) appeared to be slightly worse than the hydrographs for other alternatives even though they were given equivalent scores by the Fish Technical Committee. This caused some people to give it a lower direct ranking. Second, Consultative Committee members who favoured wildlife habitat benefits had tended to lean immediately toward the "M" alternatives as their first choice, and those who favoured Fish chose "N" as their first or second choice. In other words, the fact that Alternative L2 was a "middle of the road" alternative caused it to be overlooked and generally pushed down in the Direct ranking. However, as the weighting exercise exposed, virtually all members valued both objectives. This was not a case where participants were polarized in two distinct camps (fish vs. wildlife), but rather one in which each participant sought a balance between two fundamentally important objectives. Thus all participants recognized the value of the compromise offered by Alternative L2, or a refinement of it.

In sum, when participants stated their preferences directly, there was no clear common ground. However, by both of the indirect (weighting) methods, Alternatives N2 and L2 emerged as alternatives that rank first or second for nearly all Consultative Committee members. It was concluded that further work should be undertaken to see if it was possible to mitigate the negative aspects of either Alternative L2 or N2 and enhance the positive aspects to create a single preferred alternative.

3.7 Refine Alternatives

The refining process involved experimenting with Alternative N2 to see if planting could mitigate the negative Wildlife Habitat impacts on Carpenter, and adjusting Alternative L2 to try to improve Fish benefits.

The Consultative Committee then met again and, in the end, reached consensus on recommending Alternative "N2-2P," which represents a compromise between the N2 and L2 alternatives. See Sections 6.4 through 6.6 of the main report for more details on refining the alternatives and reaching agreement.

APPENDIX G: PROPOSED LOWER BRIDGE RIVER ADAPTIVE MANAGEMENT PROGRAM

G1 Lower Bridge River Adaptive Management Program: Underlying Input Detail and Overview of Calculations

G2 Lower Bridge River Adaptive Management Program: Design Options Considered

APPENDIX G1: LOWER BRIDGE RIVER ADAPTIVE MANAGEMENT PROGRAM: UNDERLYING INPUT DETAIL AND OVERVIEW OF CALCULATIONS

This appendix contains some of the underlying inputs and a brief description of the methods by which costs and benefits were calculated.

Experiments, by definition, have uncertain outcomes. This uncertainty can make it challenging to assess the value in doing the experiment, particularly in cases where there are long time horizons and the decision maker (i.e., the Consultative Committee member) needs to rely on outside experts to inform the decision.

To assist the Consultative Committee in assessing the value of the experiment, a framework was set up that would allow the costs and benefits of experimental and non-experimental alternatives to be compared. The framework consisted of an input table, a decision tree, a simple Monte Carlo simulation and an output table.

The key steps in supporting this decision were:

1. ***Collect and Process Inputs from Experts***

   Each expert was asked to specify biomass production (with bands of uncertainty) at each different flow level under two competing hypotheses.[1] The first hypothesis was that high flows were good for fish, and second hypothesis was that low flows were good for fish. The results are shown in Figure G1-1 and Figure G1-2.

   The bands around the 50th percentile line in Figure G1-1 and Figure G1-2 represent the 90% confidence interval. While both experts are highly uncertain about the "best guess," they are 90% confident that the true value falls within the bounds shown.

[1] Judgements were elicited from Dr. M. Bradford, senior fisheries scientist with Fisheries and Oceans Canada and P. Higgins, senior fisheries biologist for BC Hydro. Both experts initially made their judgements independently. They then reviewed each others' approach and were given the opportunity to modify their judgements..

Under Hypothesis 1 (High Good), Expert 1 estimates biomass could rise continuously from about 640 kg at 0 m3/s (measured baseline conditions at zero discharge). He believes there is less than a 5% probability that the biomass value at 10 m3/s will exceed about 1700 kg or that it will be less than about 900 kg. This upper bound is the result of the existence of limiting factors other than flow, such as the cold, turbid water and canyon-like characteristics of the river. The lower (5th percentile) bound represents the extreme case where the introduction of any flow at all in Lower Bridge River results in a net loss of biomass. Under Hypothesis 2 (Low Good), Expert 1 estimates that biomass would likely peak at 1 m^3/s, before dropping steadily at higher flows. A peak at 1 m^3/s is consistent with some of the physical habitat modelling results. Expert 2's judgements follow a similar pattern, the only notable exception being a higher peak on the Low Good estimate at 1 m^3/s.

The experts were then asked to attach a probability to each hypothesis (P[n]), and indicate the likelihood that the experiment would be correct (P[x/n]).[1] See Table G1-1 and Table G1-2.

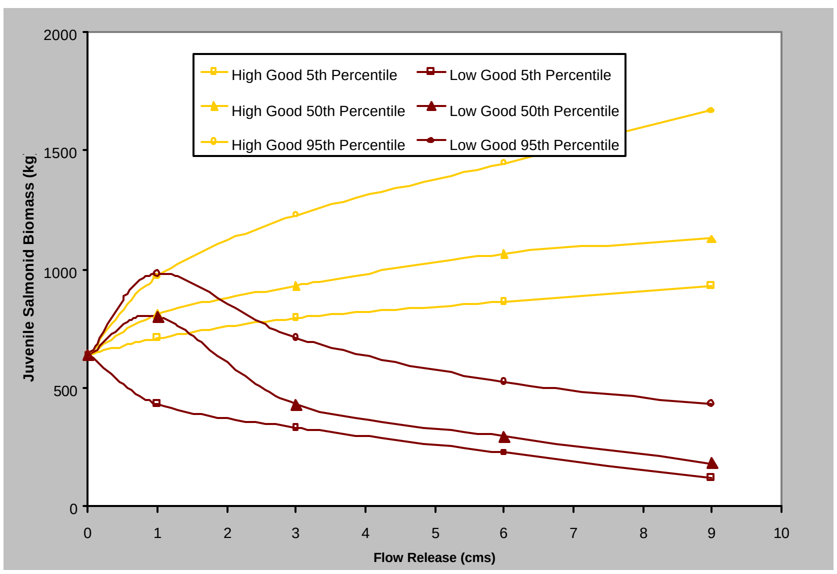


Figure G1-1: Judgements of Expert 1 on Relationship between Flow and Biomass

[1] In assigning probabilities, experts considered the estimated natural variability, the estimated detectable effect size, and the program of secondary indicators that will be used to help discern likely changes in salmonid biomass under each flow treatment.

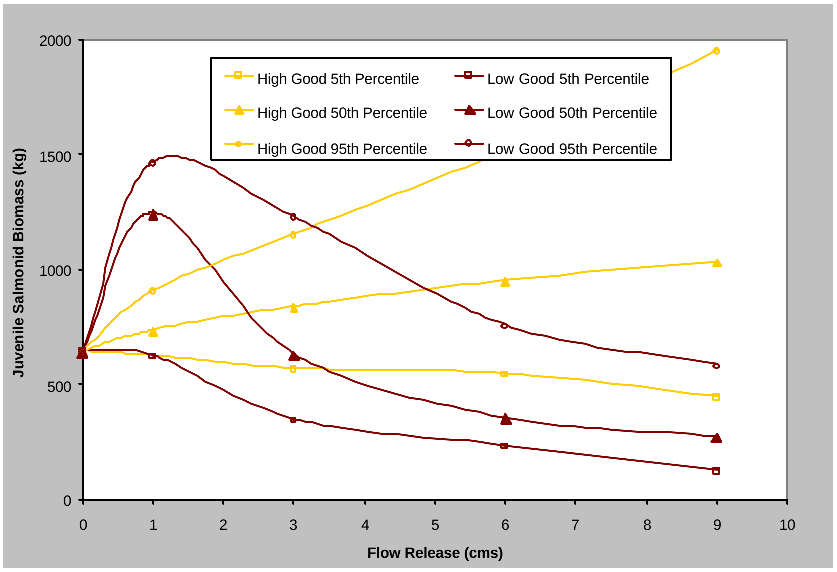


Figure G1-2: Judgements of Expert 2 on Relationship between Flow and Biomass

Table G1-1: Probabilities Assigned by Experts to Competing Hypotheses

Expert	Probability Assigned to "High Flows Good"	Probability Assigned to "Low Flows Good"
1	40%	60%
2	30%	70%

Table G1-2: Probabilities Assigned by Experts to Likelihood the Experiment is Correct

Expert	Probability that Experiment Correctly Predicts High Flows Good	Probability that Experiment Correctly Predicts Low Flows Good
1	60%	80%
2	60%	75%

Using the inputs described above, two additional probabilities were calculated: the probability of a given experimental outcome (P[x]), and the probability of a given hypothesis being true given a certain experimental outcome (P[n/x]).

2. Calculate the Full Range of Benefits for each Alternative and Each Expert

Using the above probabilities and biomass estimates, the high, low and expected benefits of each alternative for each expert were calculated. This involved setting up a simple decision tree that could be solved for a given decision maker and a given set of inputs from that decision maker. The non-experimental alternatives (i.e., 1 m3/s, 3 m3/s, 6 m3/s or 9 m3/s) as well as the experimental alternative were represented in the tree.

3. Calculate the Full Range of Costs for Each Alternative and Each Expert

The water and monitoring costs provided by BC Hydro were combined and represented as a string of annual costs for each alternative. This string was then levelized[1] and entered into the same tree format as described above in order to compute the range of annual costs associated with each option.

4. Calculate a Single Expected Benefit and Confidence Band for Each Alternative

To this point, the six separate judgements from each expert have been treated individually in the analysis. In order to calculate a single expected benefit for each alternative, a Monte Carlo[2] simulation was used to combine logical combinations of inputs (i.e., probabilities and biomass levels) as specified by the different experts. The simulation calculated the benefits for each combination of inputs until all combinations had been run a sufficient number of times to reveal a single overall pattern of expected biomass benefits. As expected, this resulted in the same extreme range of benefits as described above (reflecting the extreme judgements for each expert), but a narrower confidence band (reflecting the fact that a number of the judgements from the two experts were overlapping).

For example, in the case of the 1 m3/s option (shown in Figure G1-3 for illustration purposes) biomass could still range from as low as about 400 kg of biomass to as high as 1500 kg of biomass. But 90% of the values (for both experts and both hypotheses combined) fell between about 600 kg and 1200 kg of biomass.

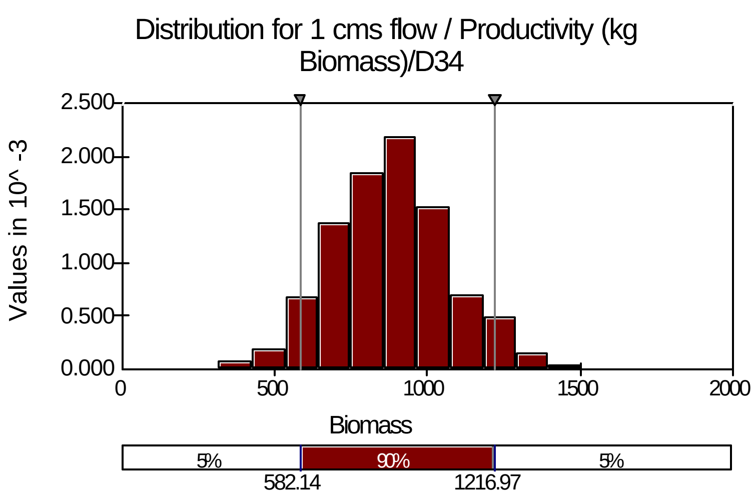


Figure G1-3: Sample of Results from the Monte Carlo Simulation

1 A "levelized" cost is a constant annual cost which, if discounted, would produce the same NPV as the underlying lumpy cash flow stream upon which it is based. In this respect, it is similar to using an average annual cost except that it includes the time value of money.

2 A Monte Carlo simulation is a method that produces the probability distribution (and/or expected value and confidence interval) of an outcome based on the known or estimated probability distributions of a number of uncertain inputs, by conducting repeated calculations that sample randomly from the specified input distributions.

5. Summarize Results

The expected values and confidence bands for all alternatives were presented in a simple two-way chart that showed both the extreme range of costs and benefits and the 90% confidence band. See Figure G1-4 and main body of the report for further discussion of the results.

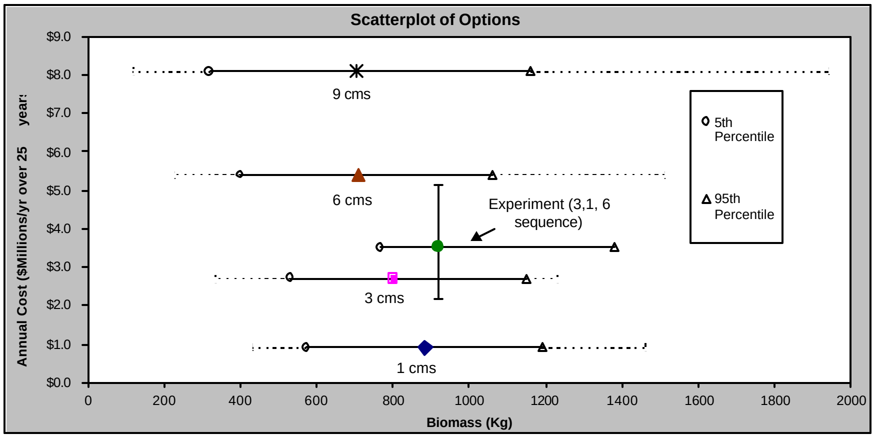
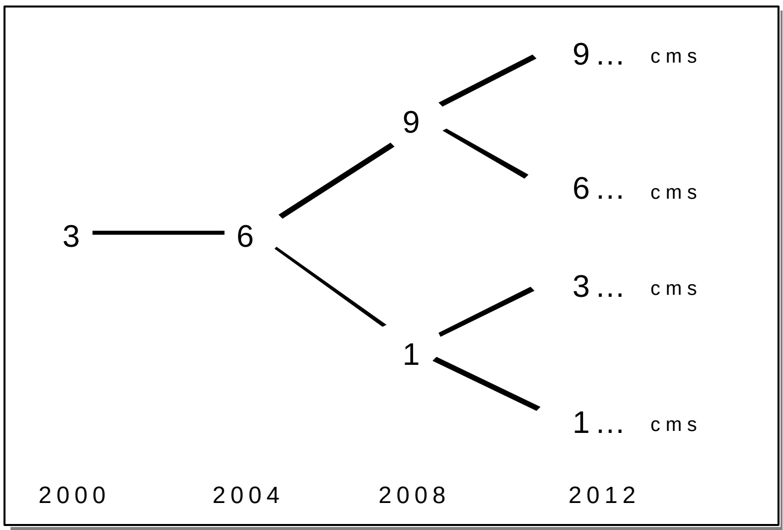


Figure G1-4: Final Chart of Results

APPENDIX G2: LOWER BRIDGE RIVER ADAPTIVE MANAGEMENT PROGRAM: DESIGN OPTIONS CONSIDERED

Prior to selecting the fixed 3-1-6 sequence, the Consultative Committee considered two other alternatives:

1. 3-6-1/9 "Titration" Design



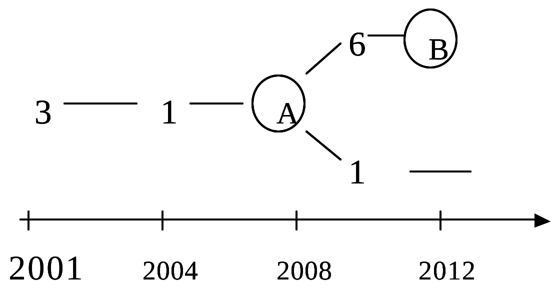
Description:

This approach offers the flexibility to choose the subsequent treatment on the basis of the results of the previous treatment. For example, if an increase in biomass was observed after 6 m3/s, then 9 m3/s would be tested, rather than 1 m3/s. This design was originally thought to have the benefit of finding an optimal flow rate sooner, and shorten the experimental trial period.

Reasons for Rejection:

The potential exists for a non-linear response of biomass to flow which could result in a significant error under the titration design. For example, if a biomass increase was observed at 6 m3/s, the titration design would dictate moving up to 9 m3/s without testing 1 m3/s. However, the Fisheries Technical Committee concluded that there is a reasonable probability that the shape of the functional response is such that biomass at 6 m3/s could be higher than biomass at 3 biomass, but higher still at 1 m3/s. This possibility would not be tested under the titration design. Given the possibility of a win-win at 1 m3/s (high biomass at low cost), the Consultative Committee rejected a design that could erroneously fail to even test it. Similarly, the potential exists, if a biomass reduction is observed at 6 m^3/s to drop to 1 m^3/s and miss a potential threshold effect occurring between 6 and 9 m^3/s.

2. *Decision Rule For Concluding the Experiment after 1 m3/s Trial*



A1 – If biomass at 1 cms is > [*threshold kg*], halt trials, adopt 1 cms

A2 – If, after the 3 and 1 cms treatments, the <u>expected</u> increase in biomass at 6 cms is > [*threshold kg*], test 6 cms

B – WUP review process

<u>Description</u>:

If a large increase in biomass were observed at 1 m^3/s, then the probability of realizing an even higher increase in biomass at higher flows would likely be reduced. Therefore, the Consultative Committee considered the option of implementing a simple decision rule that could be executed upon completion of the 1 m^3/s trial by a small management committee. Two alternative suggestions for the form such a decision rule could take were discussed (A1 and A2 above).

<u>Reasons for Rejection</u>:

- Multiple criteria for the decision rule were introduced, increasing the complexity of designing the rule, and putting to question the validity of implementing it without a full multi-party consultation representing all values.

- The Consultative Committee recognized that the scope of the flow trials had already been significantly reduced (from the original Water Use Plan proposal with a maximum test flow of 10 m^3/s to the current maximum of 6 m^3/s). It was agreed that the potential for large errors (either incurring large costs with no significant biological benefit, or incurring large biological risks) was small.

APPENDIX H: BRIDGE RIVER WATER USE PLAN MONITORING PROGRAM

H1 Bridge River Water Use Plan Preliminary Monitoring Proposals Reviewed by the Consultative Committee

H2 Consultative Committee Evaluation Comments on Preliminary Monitoring Proposals and Refinement

H3 Proposed Environmental Monitoring Program Recommended by the Bridge River Water Use Plan Consultative Committee

H4 Relationship of Monitoring Programs, Operating Strategies and Environmental Objectives

APPENDIX H1: BRIDGE RIVER WATER USE PLAN PRELIMINARY MONITORING PROPOSALS REVIEWED BY THE CONSULTATIVE COMMITTEE

Area	Operational Controls	Environmental Objectives	#	Study	General Description	Value to WUP	Duration	Comments (Strengths/weaknesses based on FTC discussion)	Upfront Cost k$	Annual Cost k$	Number of Years	Total Cost k$	Importance	Learning	Ranking
LBR	To conduct flow trials at TZG to determine the response of aquatic productivity to alternative flow releases as required to determine long term flow release policy	Determine how alternative flow release strategies from TZG influence aquatic productivity in LBR and use those data to choose long term flow regime.	**1**	**Lower Bridge River Aquatic Monitoring** ***(associated with LBR Adaptive Management)***	Implement annual program to monitor aquatic productivity response during flow trials	Provide data for the making decsions about the long term flow regime for LBR	annual program until next WUP review	Good baseline data exist for aquatic monitoring. Program focused on measuring short term physical habitat and productivity response at primary, secondary and juvenile fish standing crop levels.	**0**	**150**	**10**	**1500**	**1.00**	**1.00**	**1.00**
CAR	Maintain operational flexibility in CAR below maximum elevation criteria	Improve riparian vegetation in CAR to improve wildlife habitat, increase aesthetic values, and if applicable, to reservoir fish productivity.	**2**	**Carpenter Reservoir Riparian Vegetation Monitoring**	Document composition/cover of riparian vegetation before/after implementation of WUP	Enhancement of riparian vegeation surrounding Carpenter Reservoir is a key objective, follow up is required	1 year now, 1 year prior to WUP review	Could be affected by unusual operating conditions in year of or immediately preceding assessment. Inexpensive to complete.	**0**	**15**	**2**	**30**	**1.20**	**3.00**	**1.40**
LBR	To conduct flow trials at TZG to determine the response of aquatic productivity to alternative flow releases as required to determine long term flow release policy	Determine how alternative flow release strategies from TZG influence aquatic productivity in LBR and use those data to choose long term flow regime.	**3**	**Lower Bridge Adult Salmon Enumeration and Spawning Habitat Distribution Assessment** ***(associated with LBR Adaptive Management)***	Implement annual programs to count chinook,coho,and steelhead during flow trials and quantify changes in distribution of spawning activity	Provide information about fish rearing habitat seeding for aquatic productivity comparisons. Protects the inferences from the flow trial monitoring program confounding effects of variable escapements.	annual program until next WUP review	Juvenile standing crop was selected as a key measurement variable in the flow trials. Reliability of the use of the index greatly benefits from colelction of escapement data to assess whether spawning grounds were fully "seeded"	**0**	**100**	**10**	**1000**	**1.40**	**2.00**	**1.60**
MBR/CAR	Maintain operational flexibility in CAR below maximum elevation criteria	Improvement the abundance or diversity of CAR/MBR fish populations.	**4**	**Carpenter Reservoir/ Middle Bridge River Habitat and Fish Population Monitoring**	Physical habitat monitoring ([SS],temperature, light penetration), tributary access assessments and spawner counts, and seasonal reservoir fish monitoring to document trends in abundance and biological characteristics of CAR/MBR fish populations in relation to achieved reservoir operations and fish performance measures	Document of trends in abundance and biological characteristics of fish to assess achievement of objective. Assess suitability of MBR minimum flows (can infer egg dewatering effects). Additional benefit is the collection of information on fish life history, physical data on habitat conditions. Correlative analysis will help to identify operational thresholds that benefit or cause risk to fish.	annual program until next WUP review	Will be able to quantitatively discern trends in abundance and condition in relation to reservoir operation. Expect to improve understanding about whether populations are likely limited by food, reproduction or mortality factors. Quality of inferences about operational thresholds (direct links between operational parameters and fish abundance) improved over current levels but are still uncertain.	**0**	**50**	**10**	**500**	**1.60**	**1.20**	**1.60**
DOW	Maintain operational flexibility in DOW above a minimum reservoir elevation criteria.	Improve quantity or quality of riparian habitats in Dowtown Reservoir (protect Grizzly Flats)	**5**	**Downton Riparian Vegetation Monitoring**	Document composition/cover of riparian vegetation before/after implementation of WUP	Determination whether objective of protecting Grizzly Flats achieved	1 year now, 1 year prior to WUP review	In absence of study, qualitative observations might yield some information, but may not be dependable.	**0**	**15**	**2**	**30**	**1.60**	**2.40**	**1.60**

Area	Operational Controls	Environmental Objectives	#	Study	General Description	Value to WUP	Duration	Comments (Strengths/weaknesses based on FTC discussion)	Upfront Cost k$	Annual Cost k$	Number of Years	Total Cost k$	Importance	Learning	Ranking
SONL	Maintain current operational constraints in SONL	Obtain a better understanding of the impact of the Bridge River Diversion on the aquatic productivity in SONL	**6**	**Seton Lake Aquatic Productivity Monitoring**	Conduct seasonal surveys of pelagic productivity and fish abundance to obtain better information on the effects of diverson	Will provide increased understanding of the biological impacts of diversion and wheather it is possible to alter the seasonal operation of the bridge Diversion to mitigate known impacts	3 years	Effects of diversion on aquatic productivity and resident/anadromous fish population productivity are a key uncertainty that were not addressed in the WUP. Study required to resolve uncertainty about potential benefits of altering seasonal patter of diversion.	**0**	**100**	**3**	**300**	**1.60**	**2.40**	**2.00**
DOW	Maintain operational flexibility in DOW above a minimum reservoir elevation criteria.	Improve the abundance or diversity of fish populations in DOW and learn more about life history and abundance of Dow fish populations	**7**	**Downton Fish and Habitat Monitoring**	Physical habitat monitoring ([SS],temperature, light penetration), tributary access assessments and spawner counts, and seasonal reservoir fish monitoring to document trends in abundance and biological characteristics of DOW fish populations in relation to achieved reservoir operations and fish performance measures.	Document of trends in abundance and biological characteristics of fish to assess achievement of objective. Additional benefit is the collection of information on fish life history, physical data on habitat conditions that will be useful for WUP review. Correlative analysis will help to identify operational thresholds that benefit or cause risk to fish.	annual program until next WUP review	Will be able to quantitatively discern trends in abundance and condition in relation to reservoir operation. Expect to improve understanding about whether populations are likely limited by food, reproduction or mortality factors. Quality of inferences about operational thresholds (direct links between operational parameters and fish abundance) improved over current levels but are still uncertain.	**0**	**50**	**10**	**500**	**2.40**	**1.60**	**2.00**
SONL	Maintain current operational constraints in SONL	Obtain a better understanding of the basic life history and abundance of resident fish populations utilizing Seton Lake.	**8**	**Seton Lake Resident Fish Population Monitoring**	Seasonal surveys to document life history, relative abundance and distribution, and biological characteristics of fish populations	There are significant data gaps associated with the resident fish populations of Seton Lake that could not be filled during this WUP. The purpose of these studies will be to fill data gap associated with basic information habitat use, life history, and stock status of resident species.	annual program until next WUP review	Better information on life history, abundance, and distribution of the Seton resident fish populations will improve understanding on the potential and scope for modifying Carpenter Lake operation to improve productivity.	**0**	**30**	**10**	**300**	**2.20**	**2.80**	**2.20**
SONR	To implement a seasonally adjusted minimum flow release guideline (11/36) and to releases flows in pattern that more closely resembles a natural hydrograph in SONR	Obtain improved understanding of the operational impacts (degradation of salmon and steelhead spawning habitats) associated with the implementation of the Seton hydrograph	**9**	**Seton Gravel Scour Assessment and Gravel Replacement**	Conduct field program to assess gravel scour associated with the delivered hydrograph in key salmon and steelhead spawing areas in the river. Where required develop and implement a program to replace spawning gravels.	There is uncertainty about the amount of gravel scour that will occur under the flow regimes proposed by the SONR hydrograph. The purpose of this study will be to determine whether the delivered hydrograph results in unacceptable losses of spawning gravel for salmon and steelhead.	1 year now, 1 year prior to WUP review	The effects of operation on gravel scouring in Seton River are not well documented. It is uncertain whether ther implemented hydrograph will have negative impacts on spawning habitat. There is some uncertainty whether gravel replacement is WUP or BCRP.	**15**	**25**	**2**	**65**	**1.75**	**2.25**	**2.25**

Area	Operational Controls	Environmental Objectives	#	Study	General Description	Value to WUP	Duration	Comments (Strengths/weaknesses based on FTC discussion)	Upfront Cost k$	Annual Cost k$	Number of Years	Total Cost k$	Importance	Learning	Ranking
SONR	To implement a seasonally adjusted minimum flow release guideline (11/36) and to releases flows in pattern that more closely resembles a natural hydrograph in SONR	Obtain improved understanding about operational impacts (redd dewatering) associated with the implementation of the Seton hydrograph	**10**	**Seton River Redd Dewater Assessment**	Conduct field programs during spawning and incubation of salmon and steelhead to determine risk that implemented hydrograph causes redd dewtering.	There is uncertainty about the amount of egg deewatering that will occur under the flow regimes proposed by the SONR hydrograph. Monitoring is required to determine if significant stranding or dewatering impacts occur, and this will assist in developing refinements to the flow regime.	annual program until next WUP review	Population monitoring is not feasible; therefore egg dewatering is seen as the best indicator of whether the hydrograph is delivering the expected fish benefits.	**15**	**25**	**10**	**265**	**2.60**	**3.00**	**2.40**
SONR	To implement a seasonally adjusted minimum flow release guideline (11/36) and to releases flows in pattern that more closely resembles a natural hydrograph in SONR	Obtain improved understanding of the operational impacts (hydraulic impacts on rearing habitats) associated with the implementation of the Seton hydrograph	**11**	**Seton Hydraulic Habitat Assessment**	Conduct a study to assess how the implemented hydrograph performed with respect to hydraulic parameters	There is uncertainty about influence of the SONR on the hydraulic condition of juvenile fish rearing habitats in SONR. The purpose of this study document the hydraulic conditions actually provided by the hydrograph.	1 year prior to WUP review	SONR hydrographs were evaluated not on habitat based measures but rather qualitative scoring. The monitoring activity confirms how hydraulic conditions were affected by hydrograph; but does not provide understanding about the relationship between hydraulic conditions and fish abundance/condition.	**0**	**25**	**1**	**25**	**2.40**	**3.60**	**2.60**
CAR	Maintain operational flexibility in CAR below maximum elevation criteria	Validate and refine reservoir productivity model used to assess alternative operating scenarios for WUP review	**12**	**Carpenter Reservoir Productivity Model Validation and Refinement**	Conduct field sampling to better parameterize reservoir productivity model and to validate model assumptions	The productivity model used was developed from a limited data base and not tested. To improve the model, further field sampling and validation is beneficial for future application of the model for WUP review.	Five years implemented to capture widest range of inflow year type	There is a risk that new information and methods will dictate new modeling approach by the time this WUP is reviewed.	**0**	**100**	**3**	**300**	**2.40**	**2.20**	**2.80**
SONL	Maintain current operational constraints in SONL	Obtain an mproved understanding about operational impacts of entrainment on resident fish populations	**13**	**Seton Lake Resident Species Entrainment Studies**	Conduct radio telemetry study to assess seasonal patterns of resident fish movement in relation to power canal and dam operation	There are significant gaps in understanding about the potential for entrainment of resident species at SONGS. This purpose of this study is obtain better understanding of the magnitude of this problem.	two years	Some uncertainty about extent to which this will help to quantify entrainment and to identify operating alternatives to address it.	**15**	**75**	**2**	**165**	**3.00**	**3.40**	**2.80**
DOW	Maintain operational flexibility in DOW above a minimum reservoir elevation criteria.	Obtain a better understanding of the influences of minimum reservoir elevation on the entrainment of fish from Downton Reservoir	**14**	**Lajoie Entrainment Monitoring**	Application of pilot technology *(availability of the unit unknown*) being developed by BCH to monitor trends in entrainment in relation to reservoir operation in association with tailrace netting	Selection of minimum reservoir elevation constraint was largely based on entrainment issues and was highly uncertain. Assessing the relationship between entrainment and reservoir elevation will confirm the operational constraint or provide data needed to refine it.	annual program until next WUP review	Does not provide info about whether or not entrainment is affecting abundance or condition of populations in DOW. Immediate availability of technology unknown. More cost effective than full scale hydroacoustics.	**25**	**15**	**10**	**175**	**3.00**	**3.00**	**3.20**

Area	Operational Controls	Environmental Objectives	#	Study	General Description	Value to WUP	Duration	Comments (Strengths/weaknesses based on FTC discussion)	Upfront Cost k$	Annual Cost k$	Number of Years	Total Cost k$	Importance	Learning	Ranking
SONR	To implement a seasonally adjusted minimum flow release guideline (11/36) and to releases flows in pattern that more closely resembles a natural hydrograph in SONR	Iimprovement in abundance or diversity of fish populations in SONR	**15**	**Seton River Fish Stranding Assessment**	Conduct an analysis of historical ramping and salvage data to determine efficacy of current guidelines results determine need to further studies	Evaluate efficacy of operational control adopted in the WUP and determine whether discharge dependent ramping rates can be safely applied ('i.e. faster rates of flow change at high discharge)	annual program until next WUP review	Conisderable experience with ramping at Seton has been acquired and basic guidelines (and at some dam discharge levels possibly restrictive) have been established. However, it is uncertain whether faster ramping rates could be safely implemented at high discharge rates to provide more flexibility in managing water.	**25**	**20**	**3**	**85**	**3.40**	**3.80**	**3.20**
LBR	To conduct flow trials at TZG to determine the response of aquatic productivity to alternative flow releases as required to determine long term flow release policy	Avoid long term impacts to the productivity or species composition of riparian communities of LBR	**16**	**Lower Bridge River Riparian Vegetation Monitoring *(associated with LBR Adaptive Management)***	Implement annual program to monitor riparian vegetation response during flow trials	Concerns have been raised that planned flow trials will impact on riparian vegetation, monitoring is required to assess how the flow trials influenced riparian communities.	1 year now, 1 year prior to WUP review	Vegetation response will depend on the sequencing of flow trials so value of surveys at each flow level limited. Before/after monitoring serves to assess environmental objective.	**0**	**15**	**2**	**30**	**3.00**	**3.50**	**3.25**
LBR	To conduct flow trials at TZG to determine the response of aquatic productivity to alternative flow releases as required to determine long term flow release policy	Determine how alternative flow release strategies from TZG influence aquatic productivity in LBR and use those data to choose long term flow regime.	**17**	**Stockpile Gravel for Replacement After Spill *(associated with LBR Adaptive Management)***	Conduct a study to predict the gravel that may be lost as a result of spills and develop on-site stockpile of gravel for placement during spill	Provide contingency plan to return degraded salmon spawning habitats to original conditions if and when spills occur during the flow trials and result in gravel losses. Protects the investment in the trials.	1 year	There is uncertainty about the likelihood and magnitude of spill so the required quanity of gravel to stockpile is uncertain.	**0**	**75**	**1**	**75**	**2.40**	**4.20**	**3.40**
CAR	Maintain operational flexibility in CAR below maximum elevation criteria	Obtain a better understanding of the impacts of reservoir operation on fish populations in Carpenter Reservoir	**18**	**Carpenter/Middle Bridge Bull Trout Telemetry**	Conduct detailed fixed station radio telemetry study to assess seasonal patterns of movement and the subsequent risk of entrainment and stranding of bull trout.	Documentation of seasonal movement pattern of bull trout in Carpenter Reservoir in relation to water withdrawl and spatial locations in the reservoir may improve understanding of possible risks of entrainment and stranding	Three years	Expected to learn more about seasonal movement patterns. Bull trout are relatively abundant in CAR system, but blue-listed provincially. Unclear whether the study can provide reliable information about entrainment. Also, the study will not provide info about whether entrainment is limiting populations.	**15**	**75**	**3**	**240**	**3.20**	**3.80**	**3.40**
LBR	To conduct flow trials at TZG to determine the response of aquatic productivity to alternative flow releases as required to determine long term flow release policy	Develop and implement a system for monitoring compliance of LBR hydrograph to flow ramping guidelines	**19**	**Lower Bridge River Reach 4 Stage Monitoring**	To install and calibrate an automated stage monitoring station downstream of Terzaghi Dam to monitor compliance of ramping guidelines	Monitor compliance to an operational control (ramping)	annual program until next WUP review	A necessary compliance issue. A continuous recording station is located 4 km downstream of stream so will not cover sensitive section of the river.	**30**	**5**	**10**	**80**	**3.67**	**4.00**	**3.50**

Area	Operational Controls	Environmental Objectives	#	Study	General Description	Value to WUP	Duration	Comments (Strengths/weaknesses based on FTC discussion)	Upfront Cost k$	Annual Cost k$	Number of Years	Total Cost k$	Importance	Learning	Ranking
MBR	To implement DOW reservoir elevation dependent minimum flow schedule at LAJ	Improve quality of fish habitat conditions in MBR during shutdowns and low flow periods for fish with the objective of maintaining or improving abundance and diversity of CAR/MBR fish populations.	**20**	**Middle Bridge River Fish Habitat and Egg Dewatering Monitoring**	Conduct field surveys during flow reductions to assess whitefish egg dewatering	An critical uncertainty identified during the WUP process was the influence of flow reductions on survival of fish eggs. This information is necessary to confirm or refine the reservoir elevation dependent minimum flow release protocol for LAJ.	Five years	Does not provide info about whether egg dewatering is affecting abundance of populations in MBR.	**0**	**25**	**5**	**125**	**3.60**	**4.40**	**3.80**
SONL	Maintain current operational constraints in SONL	Obtain an improved understanding of the potential for adult salmon entrainment into the SON power canal	**21**	**Seton Adult Salmon Entrainment Evaluation**	Install side scan sonar to monitor movements of adult salmon into and out of the power canal	There are significant gaps in understanding about the potential for entrainment of upstream migrating salmon at SONGS. This purpose of this study is obtain better understanding of the magnitude of this problem.	five years	The practical feasbility or power canal operating issues of this program have not been explored yet.	**150**	**20**	**2**	**190**	**3.80**	**2.80**	**3.80**
LBR	To conduct flow trials at TZG to determine the response of aquatic productivity to alternative flow releases as required to determine long term flow release policy	Determine the efficacy of the LBR hydrographs for providing protection against juvenile fish stranding and redd dewatering	**22**	**Lower Bridge River Fish Stranding and Dewatering Assessment**	Conduct field surveys during flow reductions to assess whether the chosen hydrograph causes juvenile fish stranding or redd dewatering	There is uncertainty about the amount of stranding and egg dewatering that will occur under the flow regimes proposed in the flow trials. Monitoring is required to determine if significant stranding or dewatering impacts occur.	annual program until next WUP review	The hydrograph for the flow trials was developed to accommodate biological cues under the assumption that these will not cause operational impacts. Monitoring of egg dewatering and stranding provides information on the operational impacts of the hydrograph under the annual water budgets under comparison.	**0**	**50**	**10**	**500**	**4.00**	**3.40**	**4.00**

Ranking Scales

Scores were assigned by each member of the Fisheries Technical Committee. The average of all members is presented in the above tables and was used by the Consultative Committee as a starting point for discussion.

Importance Scale - 1 to 5, 1 = highest importance:

Reflects both of a) the importance of the resource and b) the extent to which the information is expected to influence a future decision.

Learning Scale - 1 to 5, 1 = highest potential for learning.

1 - will lead to fine quantitative discrimination among hypotheses.

3 - will lead to ability to discriminate quantitatively and/or to draw defensible inferences with strong weight of evidence among some hypotheses.

5 - likely to allow only qualitative comparison and/or weak inferences about competing hypotheses.

Rank Scale - 1 to 5, 1 = highest priority.

Should reflect integration of Importance, Learning scores as well as overall value (benefit to cost).

Area	Operational Controls	Environmental Objectives	#	Study	General Description	Value to WUP	Duration	Comments (Strengths/weaknesses based on FTC discussion)	Upfront Cost k$	Annual Cost k$	Number of Years	Total Cost k$	Importance	Learning	Ranking
SONL/ SONR	To implement a seasonally adjusted minimum flow release guideline (11/36) and to releases flows in pattern that more closely resembles a natural hydrograph in SONR	Provide operational method to set SONR flor regime	**1**	**Protage Creek Flow Monitoring**	Install and operate telemetric water survey gauge on Portagae Creek	Assistance in the day to day management of SONR flow regime	annual program until next WUP review	There is uncertainty as to the exact method for managing the Seton hydrograph under variable inflow years so this is proposed as one method for indexing flows.	**50**	**5**	**10**	**100**			
SON/ AND/ CAR/ DOW	Alteration of system operation	Protection of human health	**2**	**Bridge Seton Metals Contamination Monitoring**	Two components. 1) filing data gaps associated with background level of contaminations	Improve baseline information on background level of containment and ensure that change in oprations does not elevate current level of risk to those consuming fish from the area	1 year now then biannual	Program is addressed at human health issues. FTC felt uncomfortable commenting on the human health issue	**50**	**60**	**10**	**650**	**3.00**	**3.50**	**3.25**
SON/ AND/ CAR/ DOW	n/a	To provide better information to help manage inflows to the system	**3**	**Snowpack Monitoring**	Continue to monitor snowpack annual through September to increase ability to attentuate spills on all rivers, plus discern between various inflow years for hydrograph management	There is date gap as to how to manage high snowpack for spill mitigation and determination of inseason management for Seton hydrograph	annual program until next WUP review		**100**	**25**	**10**	**350**			
SON/ AND/ CAR/ DOW	n/a	To provide increased confidence in the power operation modelling tools	**4**	**AMPL model validation**	on an annual basis input observed inflows through the model to determine how the modelled management of water compares to the actual management of water	Development of improved confidence in power modelling tools	annual program until next WUP review		**0**	**50**	**10**	**500**			

APPENDIX H2: CONSULTATIVE COMMITTEE EVALUATION COMMENTS ON PRELIMINARY MONITORING PROPOSALS AND REFINEMENT

Name of Study	Comments from Bridge River Consultative Committee - 3-4 December 2001	Final Technical Committee Refinement
1. Lower Bridge Aquatic Monitoring	INCLUDE	Included
2. Carpenter Reservoir Riparian Vegetation	ENHANCE ▪ Greater importance now with planting as part of the option. ▪ Augment to monitor natural colonization. ▪ Increase number of years of data collection or intensity. ▪ Need to ensure learning rating is commensurate with importance score.	Enhanced (Added monitoring of planting program; increased quantitative accuracy)
3. Lower Bridge Adult Salmon and Steelhead Enumeration	INCLUDE ▪ Needed to support inferences on main performance measures for Lower Bridge River.	Included
4. Carpenter Reservoir/ Middle Bridge Habitat and Fish Population	INCLUDE	Included
5. Downton Riparian Vegetation	INCLUDE ▪ Protection of Grizzly Flats consistently been a key management issue for the Water Use Plan.	Included
Seton Lake Aquatic Productivity	INCLUDE ▪ Value of study dependent on doing No. 7 and No. 12. ▪ Knowledge of fish productivity factors in Seton Lake limited; specifically, impact of turbidity on productivity not understood. ▪ Possible operational change could be change in volume and/or timing of releases from Carpenter Reservoir; trade-off between Seton Lake turbidity and Carpenter Reservoir wildlife.	Included

Name of Study	Comments from Bridge River Consultative Committee - 3-4 December 2001	Final Technical Committee Refinement
6. Downton Fish and Habitat	INCLUDE ▪ Increase importance score to reflect relevance to decisions. ▪ Potential operating change is to go lower on Downton Reservoir to enhance Carpenter Reservoir wildlife and Middle Bridge River flows. ▪ Dam refurbishment drawdowns will provide strong signals (important to incorporate any environmental management work accompanying such drawdowns into monitoring studies).	Included
7. Seton Lake Resident Fish Population	INCLUDE ▪ Uncertainty on effects to resident species. ▪ First Nations concern about Gwenis (no work been done over the years; what affects productivity? Look at combination of records of flow changes and correlate to observed changes in Gwenis and other species. Document link to Stl'atl'imx Nation traditional ecological knowledge project. (Gwenis/kokanee as indicator.)	Included
8. Seton Gravel Scour	RE-EVALUATE ▪ Cost breakdown: evaluation: $15k; gravel replacement $25k (two times). ▪ A gravel replacement program has been approved under Bridge/Coastal Restoration program, although some question whether this proposal covers all replacement. ▪ Concern that study is within the scope of Water Use Plans. ▪ Items 8, 9, 10 and 14 should lead to development of model for calculating performance measures for Seton River (which was not possible for this Water Use Plan due to lack of information). ▪ Revisit learning potential. ▪ Clarify whether includes Seton River to Cayoosh only or to Fraser.	Combined with #9 & 10 at lower overall cost gravel replacement program excluded
9. Seton River Redd Dewater Assessment	RE-EVALUATE COSTS ▪ Egg dewatering is best indicator of whether the Seton River hydrograph is providing benefits ▪ Costs look high; need to reassess ▪ Items 8, 9, 10 and 14 should lead to development of model for calculating performance measures for Seton River (which was not possible for this Water Use Plan due to lack of information). ▪ Revisit learning potential. ▪ Clarify whether includes Seton River to Cayoosh only or to Fraser.	Combined with #8 & #10 at lower overall cost

Name of Study	Comments from Bridge River Consultative Committee - 3-4 December 2001	Final Technical Committee Refinement
10. Seton Hydraulic Habitat	INCLUDE ▪ Items 8, 9, 10 and 14 should lead to development of model for calculating performance measures for Seton River (which was not possible for this Water Use Plan due to lack of information). ▪ Revisit learning potential. ▪ Clarify whether includes Seton River to Cayoosh only or to Fraser.	Combined with #8 & #9 at lower overall cost
11. Carpenter Reservoir Productivity Model	INCLUDE ▪ Study helps define how much sediment is transported to Seton Lake. ▪ Traceable back to some questions posed during Water Use Plan. ▪ However, some members questioned the importance of sediment transport as a management driver (e.g., would better information have driven the Consultative Committee to a different operating regime?).	Included
12. Seton Lake Resident Species Entrainment	RE-EVLUATE/EXCLUDE ▪ Significant debate within Fisheries Technical Committee. ▪ Study would help confirm link between entrainment of salmon (proxy to date) and resident species. ▪ Gaps in entrainment risk knowledge are significant. ▪ However, concerns re: learning potential and availability of operating alternatives given likely answers. ▪ Explore other ways to address the information gap. ▪ Needs to be more specific; if cannot be, then consider excluding.	Excluded (Scoped down to review of trashrack data to be undertaken outside of Water Use Plan)
13. Lajoie Entrainment	EXCLUDE FROM WATER USE PLAN MONITORING: INCORPORATE INTO DAM SAFETY (EMS) PROGRAM ▪ Under N2-2P, won't learn anything significant because alternative will rarely go below 710 m. ▪ Reduce to 1 year study to be part of maintenance deep drawdown and/or dam safety refurbishment.	Excluded (Fish monitoring study will identify fish abundance impacts)

Name of Study	Comments from Bridge River Consultative Committee - 3-4 December 2001	Final Technical Committee Refinement
14. Seton River Fish Stranding	EXCLUDE ▪ Study was intended to explore changes to ramping guidelines (faster rates at higher flows compared to guidelines). ▪ Possibly Fish Advisory Team issue for system-wide learning. ▪ Low ratings for importance and learning. ▪ Items 8, 9, 10 and 14 should lead to development of model for calculating performance measures for Seton River (which was not possible for this Water Use Plan due to lack of information). ▪ Revisit learning potential. ▪ Clarify whether includes Seton River to Cayoosh only or to Fraser.	Excluded
15. Lower Bridge River Riparian Vegetation	ENHANCE ▪ Now more important given discussion of Lower Bridge River flow trials on wildlife access, instream habitat and riparian vegetation. ▪ Need to improve learning rating to be commensurate with increased importance (e.g., increase intensity of monitoring). ▪ Critical information for long-term flow decision in Lower Bridge River. ▪ Map/photograph vegetation/colonization of saplings at every flow change. ▪ Include Reach 4.	Enhanced (Transect survey increased to annual)
16. Stockpile Gravel	RE-EVALUATE COSTS; INCORPORATE INTO #1 ▪ Addresses concern that a large spill on Lower Bridge River would confound low trial information ▪ Learning rating is low because does not increase knowledge – rather protects the learning on studies No. 1 and No. 3. As an insurance policy on other studies, should be embedded in study No. 1. ▪ Large variation in opinion on how badly a large spill would confound adaptive management experiment. ▪ One member noted that there is a large stockpile of gravel available at Seton River, which could reduce costs. ▪ Include assessment (have spill, observe damage, replace); survey existing conditions.	Excluded (Not Water Use Plan monitoring issue)

Name of Study	Comments from Bridge River Consultative Committee - 3-4 December 2001	Final Technical Committee Refinement
17. Carpenter/ Middle Bridge Bull Trout Telemetry	RE-EVALUATE ▪ Diversity of opinion in Fisheries Technical Committee on importance. ▪ Bull trout appear to be abundant in Carpenter Reservoir although it was noted that bull trout are blue-listed. ▪ Interest in better understanding of entrainment. ▪ However, study would not enable us to ascertain if a change in entrainment has population impacts. ▪ Recognized that a really good entrainment study is very costly and results may still be highly uncertain. ▪ Some objectives covered by study No. 4. ▪ Learning too low. ▪ Poor cost-benefit? ▪ Performance measure didn't have high weight.	Excluded (Carpenter Reservoir fish monitoring study will identify change in fish populations which could trigger species specific. Study design not robust without increased cost)
18. Lower Bridge Redd 4 Stage Monitoring	EXCLUDE ▪ Low learning and importance. ▪ To provide comfort level that ramping rates are being adhered to, so no need to salvage. ▪ Possibly more appropriate as implementation/compliance monitoring issue.	Excluded
19. Middle Bridge Fish Habitat and Egg Dewatering	EXCLUDE ▪ Study No. 4 anticipated to address population issues generally.	Excluded
20. Seton Adult Salmon Entrainment	RE-EVALUATE/EXCLUDE ▪ Same comments and debate as for study No. 12. ▪ Review for more cost-effective approach or drop (e.g., Biosonics' trash rack data). ▪ Need to link to operations.	Excluded
21. Lower Bridge Fish Stranding and Dewatering	EXCLUDE ▪ If maintain current shape of Lower Bridge River hydrograph and ramping guidelines, this is not necessary.	Excluded

* No. refers to Study number in Appendix H1.

Additional (Non-Fish) Program

Name of Study	Comments from Bridge River Consultative Committee - 3-4 December 2001	Technical Committee Refinement
1. Portage Creek Flow Monitoring	RE-EVALUATE ▪ Implementation issue.	Excluded
2. Bridge/Seton Metals Contamination Monitoring	RE-EVALUATE ▪ Assess if footprint or WUP issue. ▪ Recognition of value in monitoring fish issue. ▪ Get better cost estimate.	Included
3. Snowpack Monitoring	RE-EVALUATE ▪ See notes for Study #1. ▪ BC Hydro has additional information.	Excluded
4. AMPL model validation	EXCLUDE ▪ Independent review planned as part of full WUP program. ▪ Implementation will not replicate model results.	Excluded

APPENDIX H3: PROPOSED ENVIRONMENTAL MONITORING PROGRAM RECOMMENDED BY THE BRIDGE RIVER WATER USE PLAN CONSULTATIVE COMMITTEE

Monitoring Program Proposal No.	Proposed Monitoring Programs
BRS-1	Lower Bridge River Aquatic Monitoring
BRS-2	Carpenter Reservoir Riparian Vegetation Monitoring
BRS-3	Lower Bridge River Adult Salmon and Steelhead Enumeration
BRS-4	Carpenter Reservoir and Middle Bridge River Fish Habitat and Population Monitoring
BRS-5	Downton Reservoir Riparian Vegetation Monitoring
BRS-6	Seton Lake Aquatic Productivity Monitoring
BRS-7	Downton Reservoir Fish Habitat and Population Monitoring
BRS-8	Seton Lake Reservoir Resident Fish Habitat and Population Monitoring
BRS-9	Seton River Habitat and Fish Monitoring
BRS-10	Carpenter Reservoir Productivity Model Validation and Refinement
BRS-11	Lower Bridge River Riparian Vegetation Monitoring
BRS-12	Bridge-Seton Metals and Contaminant Monitoring Program

SUMMARY OF PROPOSED MONITORING PROGRAMS COSTS

Table H3-1 documents costs of each monitoring program by year.

Table H3-1: Monitoring Program Summary of Costs

Study/Year	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Total (undiscounted)
BRS - 1	164,142	164,142	164,142	164,142	164,142	164,142	164,142	164,142	164,142	164,142	164,142	1,805,562
BRS - 2	52,924	10,000	10,000	10,000	10,000	10,000	0	0	0	76,473	0	179,397
BRS - 3	99,225	87,725	99,225	87,725	99,225	87,725	99,225	87,725	99,225	87,725	109,225	1,043,975
BRS - 4	69,759	69,759	69,759	69,759	69,759	69,759	69,759	69,759	69,759	69,759	0	697,590
BRS - 5	37,885	0	0	0	0	0	0	0	0	37,885	0	75,770
BRS - 6	100,050	100,050	100,050	0	0	0	0	0	0	0	0	300,150
BRS - 7	44,601	44,601	44,601	44,601	44,601	44,601	44,601	44,601	44,601	44,601	0	446,006
BRS - 8	49,986	49,986	49,986	49,986	49,986	49,986	49,986	49,986	49,986	49,986	0	499,860
BRS - 9	69,520	44,528	44,528	44,528	44,528	44,528	44,528	44,528	44,528	57,028	0	482,772
BRS - 10	100,129	100,129	100,129	0	0	0	0	0	0	0	0	300,387
BRS - 11	24,785	0	20,445	0	0	0	20,445	0	0	0	78,935	144,610
BRS - 12	0	39,030	0	39,030	0	39,030	0	39,030	4,050	0	0	160,170
TOTAL	813,006	709,950	702,865	509,771	482,241	509,771	492,686	499,771	476,291	587598	352,302	6,136,248

Bridge River Water Use Plan
Monitoring Program No. BRS-1

Lower Bridge River Adaptive Management Program:
Aquatic Ecosystem Productivity Monitoring

RATIONALE

Background

The lack of continuous flow releases from the Terzaghi Dam into the Lower Bridge River has been a long standing concern of the public, First Nations, and regulatory agencies and the resolution of instream flow management is a important component of the Bridge River Water Use Plan. In 1998, an agreement between BC Hydro and regulatory agencies (associated with litigation regarding 1991-92 dam operations) specified that an instream flow test release and monitoring program be developed and implemented in an attempt to resolve uncertainty about response of the aquatic ecosystem to reservoir releases. The agreement specified that an experimental flow release program was to continue until a Water Use Plan was developed for the Bridge-Seton watershed. Continuous instream flow releases for the purpose of testing the response of the aquatic ecosystem to flow changes were initiated with a water budget of 3 m^3/s on 1 August 2000. Instream flow assessment studies (1993-1995) and baseline ecological monitoring (1996-present) have improved scientific understanding about baseline conditions in the Lower Bridge aquatic ecosystem, however, they have not provided sufficient scientific understanding needed to provide reliable predictions about the impacts of instream flow releases on the productivity of the aquatic or riparian components of the ecosystem. Accordingly, the Bridge River Water Use Plan Consultative Committee recommended that as part of the Bridge River Water Use Plan the current flow testing program now underway at Terzaghi Dam be continued and expanded to test two additional flow levels to document the response of the ecosystem to instream flow changes in Lower Bridge River. The Consultative Committee recommended that, in the face of significant technical uncertainty and high value of the water resources for both power and fish, this approach was the only scientifically defensible means available to determine the relative ecological benefits of alternative flow releases that were proposed during the Bridge River Water Use Plan development.

A 12-year test flow release program was recommended to empirically measure the environmental benefits that could arise from three alternative instream flow release regimes considered by the Consultative Commitee (referred to as: 1 m^3/s/year, 3 m^3/s/year, 6 m^3/s/year treatments). The flow regimes do not differ in the relative shape of the delivered hydrograph, but rather the total magnitude of the flow regime in terms of annual water budget. Together with monitoring data collected since 1996 which represent baseline conditions, the test flow monitoring will be used to evaluate functional relationship between flow release from the dam and key physical and ecological indicator variables. This approach will provide the scientifically defensible data (as opposed to predictions from uncertain assessment models) to quantify response of the ecosystem and fish population response to instream flows. The Consultative Committee recommended that to properly support the adaptive management program three general monitoring activities be undertaken including: 1) Aquatic Ecosystem Productivity Monitoring; 2) Adult Salmonid Spawning Habitat Monitoring and Population Enumeration; 3) Riparian Vegetation Monitoring.

This proposal addresses required studies for the Aquatic Ecosystem Productivity Monitoring. Proposals for the other two monitoring activities are presented in Monitoring Program proposals No. 3 and No. 11.

Management Questions

The fundamental goal of the adaptive management program is to reduce uncertainty about the expected long term ecological benefits from releasing instream flow from Terzaghi Dam. As past studies have been unable to provide scientifically defensible prediction of the ecological benefits of flow releases. This lack of certainty was deemed to be a major impediment for decision making because incorrect decisions about long term flow regime will have significant consequences for energy production and could have significant consequences to the highly valued ecological resources in Lower Bridge River. The three specific learning objectives identified by the Consultative Commitee for the adaptive management program as related to understanding the influence of flow regime on aquatic ecosystem productivity are:

1. <u>How does instream flow regime alter the physical conditions in aquatic and riparian habitats of the Lower Bridge River ecosystem?</u> - Changes in the physical conditions regulate the quantity and quality of habitats for aquatic and riparian organisms. Documenting the functional relationships between river flow and physical conditions in the habitat is fundamental for identifying and developing hypotheses about how physical habitat factors regulate, limit or control trophic productivity and influence habitat conditions in the ecosystem.

2. <u>How do differences in physical conditions in aquatic habitat resulting from instream flow regime influence community composition and productivity of primary and secondary producers in Lower Bridge River?</u> - Changes in the flow regime are expected to alter the composition and productivity of periphyton and invertebrate communities. Understanding how these physical changes influences on aquatic community structure and productivity are important as they act as indicators to evaluate "ecosystem health" and the trophic status of the aquatic ecosystem in relation to provision of food resources for fish populations.

3. <u>How do changes in physical conditions and trophic productivity resulting from flow changes together influence the abundance and diversity of fish populations in Lower Bridge River?</u> - Changes in flow regime can have significant effects on the physical habitat and trophic productivity of the aquatic ecosystem and these two factors are critical determinants of the productive capacity of the aquatic ecosystem for fish. Understanding how instream flow regime influences

abundance, growth, physiological condition, behaviour, and survival of stream fish populations helps to explain observations of changes in abundance and diversity of stream fish related to flow alteration.

Detailed Hypotheses about the Impacts of Carpenter Reservoir Releases on the Lower Bridge River Ecosystem

The objective of the test flow program is to reduce uncertainty about the functional relationship between flow release from Terzaghi Dam and the relative aquatic ecosystem productivity of the Lower Bridge River ecosystem. Juvenile salmonid biomass was selected as a primary measure to assess the productivity of the aquatic ecosystem because it serves as a measure that integrates the effects of flow on the trophic productivity and habitat conditions in the Lower Bridge River ecosystem and reflects a highly valued ecological component. Two competing hypotheses about the effects of flow on the fish populations in Lower Bridge River have been developed. The two primary hypotheses associated with the aquatic monitoring program are:

- H_1: "High flow is better"
- H_2: "Low flow is better"

Both hypotheses are cast in terms of the effects of flow on the overall quality and quantity of fish habitat and each acknowledges significant gain in wetted habitat area will be obtained from rewatering of the 4 km long reach immediately below Terzaghi Dam that was usually dry until August 2000. However, the hypotheses differ on how increased flow will impact habitat quality in the rest of the river, and ultimately how fish populations will respond to altered habitat conditions. The null hypothesis (H_1) reflects the view that higher flow will provide a greater quantity of wetted channel area, and will not reduce the quality of juvenile rearing habitats. Higher flows are believed to have additional benefits for cueing migrations of anadromous fish, provide increased opportunities for spawning, and provide some habitat maintenance functions such as scouring fine sediments from riffles. The alternative hypothesis (H_2) reflects findings of physical habitat simulation and process research studies examining how large reservoir releases affect water quality (reduced summer and increased fall and winter water temperatures) and fish growth and behaviour in the river. It represents a view that low flow releases (i.e., $<3\ m^3$/s/year water budget) from the dam will optimize fish production because gain in wetted habitat area is made through the rewatering of the reach immediately below the dam without appreciable reduction in habitat quality in the other reaches of the river.

Key Water Use Decision Affected

The key water use plan decision affected by this result of the monitoring program is the magnitude of the long term flow release regime from Carpenter Reservoir into the Lower Bridge River. This decision has implications that are significant for ecological as well as power generating values in the Bridge-Seton system. The Lower Bridge River is viewed as an important fish (salmon and steelhead) producing stream, and the opportunities to enhance productivity in this river are highly valued. On the other hand, the cost of releasing water at Lower Bridge River is relatively high ($0.9 million per cubic metre per second/year) and the financial costs of incorrectly assuming a strongly positive fish response to higher flows could be high. The results from the program are to provide scientifically defensible information need to reliably choose between the completing hypotheses described above and aid in the selection of long term flow regime for the river. Refer to Section 6.0 of the Bridge River Water Use Plan Consultative Report for further discussion.

Monitoring Program Proposal

Approach

The approach to the implementation of the Lower Bridge River Aquatic Monitoring program will be to follow the standardized protocols for ecological sampling and data collection established and refined during its implementation of monitoring in Lower Bridge River from 1996 through to 2001. The relationship between the key learning objectives, the required monitoring actions, key physical and biological indicators and sampling requirements in terms of frequency and location are presented in Table H3-1 below.

Objective Number	Learning Objective	Sampling requirements				
		Impact Indicator		**Measurement Variable**	**Location**	**Frequency**
1	Document how reservoir releases alter the physical conditions in aquatic and riparian ecosystems of the Lower Bridge River.	1a	Discharge	Rate	km 20.0, km 25.8, km36.8, km 40.9	continuous
		1b	Stage	Height Variation		
		1c	Water quality	Temperature	km 20.0, km 23.6, km 26.4, km 30.4, km 33.3, km 36.4, km 39.8	~monthly (May-Dec)
		1d		Nutrients		
		1e		Electrochemistry		
		1f	Habitat Inventory	Wetted Area	km 20 -km 40.9	At multiple (5+) baseflow levels + dam release (0,2,3,4,5,6 cms)
		1g		Mesohabitat composition	km 20 -km 40.9	
2	Assess how changes in physical attributes of the aquatic and riparian ecosystems influence trophic productivity of the aquatic community in Lower Bridge River	2a	Epilithon	Species diversity	km 20.0, km 23.6, km 26.4, km 30.4, km 33.3, km 36.4, km 39.8	8 week colonization series Spring (May-June) Summer (July-Aug) Fall (Sep-Oct)
		2b		Cell density		
		2c		Chlorophyl a content		
		2e	Benthic Invertebrates	Species diversity		
		2f		Density		
		2g		Drift rate	km 23.6, km 30.4	~monthly (May-Dec)
3	Assess how alternative instream flow regimes influence the productivity and diversity of fish populations in Lower Bridge River	3a	Fish community composition	Species diversity	54 mainstem sites between km 20.0 and km 40.9	Fall standing crop assessment
		3b	Fish community productivity	Abundance, biomass/sq.m.		
		3c	Fish growth rate	Wet Weight, Fork Length	km 20.0, km 23.6, km 26.4, km 30.4, km 33.3, km 36.4, km 39.8	~monthly (May-Dec)
		3d	Fish habitat use	Microhabitat selection		pre-release and post release
		3e		Diel activity patterns		~monthly (May-Dec)
		3f	Fish condition	RNA/DNA		Spring, Summer, Fall, Winter
				Lipids		
				Protein		

Figure H3-1: Relationship between learning objectives associated with the Lower Bridge River Adaptive Management Program, key impact indicators, and sampling requirements for the Lower Bridge River Aquatic Ecosystem Monitoring Program

Method

Task 1 Project Coordination

Project coordination involves the general administrative and technical oversight of the program. This will include, but not be limited to: 1) budget management; 2) staff selection; 3) logistic coordination, 4) technical oversight in field and analysis components; and 5) liaison with regulatory and first nations groups.

Task 2 Field Sampling

The proposed aquatic ecology monitoring program follows the methods and protocol established during the implementation of Lower Bridge River Aquatic Ecology Monitoring implemented during the baseflow evaluation period (1996-2000) and the initiation of the 3 m^3/s/year flow treatment during 2000-1. Below is a brief description of each component of the field monitoring program.

Discharge, Stage, Temperature and Light

Continuous measurements of physical habitat parameters will be implemented. Discharge will be monitored by continuous recording pressure sensors at the Camoo Creek Bridge (~20 km) lower spawning platforms (~25 km) and at the point 50 m downstream of where groundwater enters the channel (36.8 km). Temperature and light will be monitored by Hobo Stowaway® recorders at eight locations (mainstem monitoring sites + Yalakom River) and all data recorders will be downloaded at 3 to 4 month intervals.

Nutrients and Water Quality

At seven monitoring locations, the six tributaries to the river (Mission, Yankee, Hell, Russell, Michelmoon, Yalakom, Antoine) and in Carpenter Lake Reservoir near to the dam water samples and in situ measurement of pH, conductivity, total dissolved solids will be collected at approximate monthly intervals. Water samples will be analyzed to estimate total dissolve phosphorous, total phosphorous, soluble reactive phosphorous, nitrate, nitrite, ammonium and total alkalinity.

Primary Productivity

To provide an index of primary productivity, the accrual of periphyton will be measured at seven monitoring locations three artificial samplers will be installed in the river to estimate periphyton accrual. One foot square Styrofoam samplers will be sampled on 7 day intervals for each 6-8 week long series conducted during Spring (~1 May - ~25 June); Summer (~1 July - ~31 August); and Fall (~1 September - ~1 November). Chlorophyll concentration will be used to index primary productivity. At the end of each series samples will be taken and preserved for quantitative analyses of periphyton community species composition and cell counts per unit area.

Secondary Productivity

To provide an index of secondary productivity benthic invertebrate density will be estimated at each monitoring site by the placement of three gravel filled colonization baskets at each monitoring site. Food availability for fish will be measured by measuring drift concentration will be monitored on approximate monthly intervals. We propose to collect 4-hour long samples initiated 6 times per 24-hour period to obtain resolution required for diel foraging observations (described below).

Fish Species Composition, Growth and Abundance

Fish growth rate is a key requirement of the monitoring programs, as it provides a measure to integrate many factors that control relative quality of conditions that the fish is living. Juvenile fish will be collected at monthly intervals from each of the seven sampling locations using minnow traps, pole seines and electrofishing to track season patterns of size in different parts of the river. Approximately 50-100 fish of each species age class present at each site will be collected, measured for length and weight and immediately returned to the point of collection. All sampling will occur outside of the general boundaries (i.e., 100 m section of river) of each of the monitoring sites.

Fish Habitat Use and Feeding Behaviour Observations

Previous studies of fish habitat use in Bridge River have demonstrated significant differences in the habitat use patterns of fish under low stable flow conditions present in Reach 3 and the more variable flow conditions in Reach 2. Observations of fish behaviour collected in between 1993 and 2000 (BC Hydro unpublished data) have demonstrated the fish using the upper river feed diurnally where, fish in the lower river emerge only at dusk to feed, irrespective of season. Based on these observations, it has been hypothesized that spatial variation in habitat use patterns for a given fish species and age class are habitat dependent, and that changes in flow particularly in Reach 3 will effect habitat use patterns and possibly fish productivity. Because fish density and growth rate is lower in the high flow reach (Reach 2) changes in diel habitat use patterns represent a key ecological uncertainty regarding the effects of reservoir releases on fish productivity. To resolve this uncertainty it is recommended that continued observations of habitat use patterns be collected to assess the whether increased flow alter the habitat use patterns.

Fall Standing Stock Assessment

Fall standing stock has been conducted in Bridge River in 1993, 1994, 1996, 1997, 1998, 1999, 2000, and 2001. These data represent the most complete systematically collected database to quantify the abundance of stream salmonids before the test flow release and have apriori identified as the key measurement variable for judging ecosystem response to the proposed flow treatments. To assess relative changes in fish productivity we propose to repeat the 54 site standing stock program following the protocol first established in 1993 and then followed by BC Hydro in 1996-present to allow a before-after comparison of the relative abundance/biomass of fish in the study area. Four pass closed section sampling is employed to derive depletion type population estimates by species and age class. All fish captured are weighed and measured and then returned to the stream at the point of capture after completing the site.

Habitat Inventory

Following the methods described in Riley et al (1997, 1998) and Higgins (2001) field surveys will be conducted to capture habitat inventory data at each flow level within each water budget treatment. The objective of the field surveys will be to quantify the area of wetted channel, to determine the relative proportion of riffles, runs, and pools, and to estimate basic hydraulic conditions of habitat in Reach 2, 3 and 4 under the test flow conditions. Similar baseline habitat inventory surveys were under baseline (0 flow) during 1996 and 1997, and conducted for the 3 m^3/s flow regime in 2000. These data are needed to draw inferences about the seasonal changes in the wetted area of the aquatic habitats under the proposed 3 m^3/s/year, 1 m^3/s/year, and 6 m^3/s/year flow treatments.

Task 3 Reporting

A detailed technical report will prepared prior to the review of the Bridge River Water Use Plan that outlines the findings from the program as they relate to the primary components described above.

Interpretation of Monitoring Program Results

The overall strategy of the Aquatic Ecosystem Monitoring Program is collect the data needed to make a scientifically defensible linkage between key physical habitat changes, changes in aquatic productivity (i.e., primary and secondary productivity), and to link both of those to impacts to response of fish populations. The approach for interpreting monitoring program to use juvenile salmonid biomass as the leading indicator of the influence of flow on aquatic productivity to accept or refute the null hypotheses associated with the influence of dam releases on aquatic productivity. Because past sampling has involved use of index locations that are sampled each year it is proposed that a repeated measure design using a 3 factorial mixed-model Analysis of Variance. The form of the proposed statistical model is:

$$F_{ij} = \mu + \beta T + S_j + Y_i(T) + e_{ij},$$

where, F_{ij} = standing crop biomass in year i at site j; μ is the mean density; β is the treatment coefficient, T is the fixed treatment effect (dam release), and Y_i and S_j are random year and site effects, respectively. Statistical power analysis was conducted to examine the power of statistical model under different sampling designs (Higgins et al, 1999). These analysis suggested that the experiment, under the observed levels of natural variation and measurement precision will provide a 50% (worst case) to 75% (best case) probability of correctly detecting statistical differences in standing crop biomass between the proposed flow treatments under the proposed experimental design of the adaptive management program (4 treatments each conducted for 4 years). Additional inferential power will be achieved by analysis of the information provided by the secondary indicators. Baseline monitoring data will be used to identify key linkages between physical habitat variables, productivity of lower trophic levels (periphyton, benthic food organisms), and fish productivity. Analysis of these relationships should provide deeper understanding of the relative importance of these linkages and where statistical inferences are weak can be used to provide a scientifically defensible support for the interpretation of the results.

Schedule

The program will be implemented each year during the experimental flow release program. The seasonal timing of the proposed components of the work are presented in the Table below:

Task	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1 Project Coordination	X	X	X	X	X	X	X	X	X	X	X	X
2 Ecology Sampling		XX		XX		XX		XX				
3 Standing Stock Assessment						XXXX						
4 Lab Analysis												
Water Quality Analysis		X		X		X		X				
Invertebrate Enumeration				XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	
Periphyton Analysis		X		X		X		X				
5 Data Analysis /Reporting										XXXX	XXXXX	XXXX

Budget

The total estimated annual budget for cost of the Lower Bridge River Aquatic Ecosystem Productivity Monitoring Program is $164,142. The estimated budget breakdown by task and year is provided in the Table below:

	Project Coordination	Ecology Sampling	Standing Stock	Lab Analysis	Data Analysis	Total Cost
Year 1	1,400	69,992	43,750	46,000	3,000	164,142
Year 2	1,400	69,992	43,750	46,000	3,000	164,142
Year 3	1,400	69,992	43,750	46,000	3,000	164,142
Year 4	1,400	69,992	43,750	46,000	3,000	164,142
Year 5	1,400	69,992	43,750	46,000	3,000	164,142
Year 6	1,400	69,992	43,750	46,000	3,000	164,142
Year 7	1,400	69,992	43,750	46,000	3,000	164,142
Year 8	1,400	69,992	43,750	46,000	3,000	164,142
Year 9	1,400	69,992	43,750	46,000	3,000	164,142
Year 10	1,400	69,992	43,750	46,000	3,000	164,142
Year 11	1,400	69,992	43,750	46,000	3,000	164,142
Total	15,400	769,912	481,250	506,000	33,000	1,805,562

Bridge River Water Use Plan
Monitoring Program No. BRS-2

Carpenter Reservoir Riparian Vegetation Monitoring Program

RATIONALE

Background

Field studies conducted in Year 2000 in the Carpenter Reservoir highlighted the influence of maximum reservoir elevation on riparian vegetation communities. Study results demonstrated that the implementation of the Carpenter Reservoir spill buffer in 1993 resulted in an overall reduction in the maximum annual operating level for the reservoir from 651.08 to 648.8 and this altered increased the spatial extent and species composition in riparian habitats of the reservoir. Changes in riparian conditions were inferred to be a function of local topography and inundation frequency. Overall, the changes that resulted from lower maximum operating levels are believed to have: 1) increased quality and quantity of wildlife habitat; 2) resulted in localized improvements in aesthetics and recreation potential for the reservoir; and 3) resulted in localized increases in trophic productivity of littoral habitats used by fish.

The Consultative Committee recognized the value of maintaining high quality riparian habitats in the area surrounding Carpenter Reservoir. Riparian habitats provide the physical structural and biological character for wildlife habitat, while contribute to environmental aesthetics (i.e., "green-up," reduction of dust storms) and localized enhancement of the littoral productivity in the reservoir. As a result of these benefits, the protection and enhancement of quality and quantity of high quality riparian areas surrounding Carpenter Reservoir emerged as a key environmental objective during the Bridge River Water Use Plan, and regulation of the reservoir filling and the maximum annual operating elevation to improve riparian conditions were a fundamental considerations in the final choice of the selected Water Use Plan operating alternative.

In addition, the final set of recommendations include a drawdown planting strategy (see Appendix D-3) which also requires monitoring and evaluation.

Management Questions

In the decision to recommend the N2-2P alternative, the Consultative Commitee faced two key management uncertainties. First, there was a desire to validate predictive methods used for Water Use Plan development to ensure effectiveness of the operational changes in meeting that goal. Second, the final decision to recommended Alternative N2-2P over the Alternative O3-2 was based on the assumption that reservoir re-vegetation activities could be successfully be implemented to provide riparian benefits to offset differences between the scenarios. The primary management questions addressed by the Carpenter Reservoir Riparian Vegetation Monitoring program are:

1. Will implementation of the chosen operating alternative have negative, neutral or positive impacts on the quality and quantity (species composition, biological productivity, spatial area) of riparian area surrounding Carpenter Reservoir?

2. Does the implementation of a short term (5 years) intensive reservoir re-vegetation program result in a benefits that were equal to or greater than that which were expected from implementation of the O3-2 operating alternative?

Detailed Hypotheses about the Impacts of Carpenter Reservoir Operation on Riparian Vegetation

Three primary hypotheses (and subhypotheses) associated with the two management questions are presented below. The first hypothesis is associated with providing the assurance that the implemented reservoir operating strategy has met its fundamental management objective: to protect and if possible enhance the riparian area surrounding Carpenter Reservoir. If it was found through monitoring that the implementation of Alternative N2-2P had a negative impact on riparian communities, it would likely alter future decisions regarding reservoir operating strategy because of the high value placed on high quality riparian conditions. This management hypothesis and the subhypotheses can be tested directly with the proposed monitoring program are:

H_1: Implementation of the chosen alternative will not result in a reduction of riparian habitats in the area surrounding Carpenter Reservoir.

H_{1A}: There is no significant change in the spatial extent of the vegetated area in the drawdown zone of Carpenter Reservoir.

H_{1B}: The is no significant change in the species composition of the plant community in the vegetated area of the drawdown zone of Carpenter Lake.

H_{1C}: The is no significant change in the relative productivity of the plant community in the vegetated area of the drawdown zone of Carpenter Lake.

A second hypothesis that influenced the development of the operating strategy was associated with the assumption that short term (<56 days) incursions into the reservoir buffer would not significantly influence the quality or spatial extent of drawdown zone vegetation. This assumption was important for making the decision to adopt Alternative N2-2P as it allowed for greater flexibility in reservoir operation with negligible impacts on spatial extent of riparian vegetation in the drawdown zone. Without this flexibility the frequency and magnitude of spills increases in Lower Bridge River and Seton River. However, this hypothesis is difficult to directly test because of uncertainty in the inflow patterns into the reservoir and the long time period required to fully capture operating impacts on vegetation community productivity and dynamics. Nevertheless, since this assumption was key in selecting Alternative N2-2P, empirical data collected in this program over the review period will be evaluated to determine whether it supports the hypothesis:

H_2: Incursions of less than 56 days into the reservoir buffer (i.e., above El. 648.9 m) do not significantly impact riparian community.

The third hypothesis was associated with the expected success of the reservoir re-vegetation program. Recognizing there was a trade-off made to protect upstream fish populations and there was consensus to undertake a reservoir planting program. The Consultative Committee expressed concern that a planting program should not be an annual program in perpetuity, but was justified to "jump start" the vegetation colonization process in the area between the Gun Creek fan and the Tyax Junction. Experience gained in other reservoir re-vegetation programs (Arrow Reservoir) indicated that a period of 3 to 5 years was required to establish conditions for natural re-colonization. This hypothesis will be tested directly through the reservoir planting evaluation component of the proposed program.

H_3: Implementation of extensive riparian planting for 5 years will provide the bases for continued natural re-colonization of the drawdown zone between Gun Creek fan and Tyax junction.

H_{3A}: Natural re-colonization is significantly greater at treated versus control locations.

H_{3B}: There is no significant difference in the species composition of naturally re-colonizing species in planted versus control areas.

Key Water Use Decision Affected

During the development of the Bridge River Water Use Plan, the Consultative Committee evaluated a range of alternative Carpenter Reservoir operating strategies with different reservoir fill patterns and maximum annual operating level constraints. These alternatives ranged from providing a limited reservoir operating range to imposing no constraints on reservoir filling or maximum elevation other than those imposed by the physical capacities. It was demonstrated that implementation of reservoir operating strategies that reduce maximum operating elevation (hence improve riparian conditions) results in unacceptably high frequency, magnitude, and duration of spills in the Lower Bridge and Seton Rivers. These spills were deemed to be undesirable to resident and anadromous fish species in the rivers. This trade-off led the Consultative Committee to the development of alternatives that use the full storage capacity of the system, explicitly placing priority on downstream fish populations over riparian conditions in the reservoir. Power modelling studies also revealed upstream issues associated with the control of storage in the system, as the management of storage in Downton Reservoir had apparent impacts on management of storage in Carpenter Reservoir which impacted riparian conditions there. In the final two alternatives considered by the Consultative Committee (N2-2P, O3-2) there was a need to make a explicit trade-off between protection of upstream resident fish populations (i.e., entrainment impacts in Downton Reservoir, low flows in the Middle Bridge River), and the development of riparian communities in the area surrounding Carpenter Reservoir. To resolve this trade-off, the Consultative Committee agreed upon a strategy (Alt N2-2P) which 1) approximately retains the existing spill buffer and a flexible operating constraint on annual maximum operating level which allows infrequent incursions of less than 8 weeks above El. 648.9 m; and 2) a 5 year program for planting fall rye over about 500 ha area (Gun Creek Fan to Tyax

Junction) with some planting of perennials in appropriate locations, for a total cost of $80,000 per year.

The decision by the Consultative Committee to recommend Alternative N2-2P over Alternative 03 was based on the explicit assumption that there would be no reduction in quality and quantity of riparian conditions from current conditions. Based on the technical information available from similar programs (i.e., Upper Arrow Lake Reservoir at Revelstoke) it was believed that the planting program would provide significant benefits; however, monitoring is required to confirm that similar success can be obtained in Carpenter Reservoir.

Monitoring Program Proposal

Approach

The proposed monitoring program has three primary components. The first component is the quantification of the spatial extent, species composition, and relative productivity of the riparian area surrounding Carpenter Reservoir to allow quantification of changes that occur as a result of changes in the operating strategy of the reservoir. The second component is the detailed evaluation of the intensive planting program to increase the spatial extent of vegetated area within the Carpenter drawdown zone. The final component is the analysis of the field data to draw inferences on the overall effect of the both operational changes and planting on riparian conditions. The program is to be conducted over an approximately 10-year long period, and the implementation of each component occurs periodically through the review period (refer to the Schedule section below).

Methods

The proposed monitoring program has the following primary tasks:

Task 1 Project Coordination

Project coordination involves the general administrative and technical oversight of the program. This will include, but not be limited to: 1) budget management; 2) staff selection; 3) logistic coordination, 4) technical oversight in field and analysis components; and 5) liaison with regulatory and First Nation groups.

Task 2 Riparian Vegetation Mapping and Analysis

Aerial Photography

To assess the impacts of the Alternative N2-2P reservoir operating alternative on the spatial extent of riparian vegetation adjacent to and within Carpenter Reservoir drawdown zone it is proposed that aerial photography be conducted prior to the implementation and immediately prior to proposed the review of the Bridge River Water Use Plan in approximately 10 years. Low level spatial geo-referenced colour air photos will be used to develop GIS based maps of the riparian vegetation and to compute changes in the spatial extent and location of vegetation occurring after 10 years. The observed patterns will be interpreted based on inundation frequencies imposed by the implemented reservoir operations and by site specific habitat conditions within the drawdown zone.

Vegetation Transect Surveys

Transect surveys are proposed to 1) to ground truth assessments of general changes in species composition occurring over the entire spatial area of the reservoir; 2) provide detailed geo-referenced topographic data of the transect, and 3) to provide a detailed assessment of the changes in species composition and relative productivity of riparian habitats resulting from the implementation of the Carpenter Reservoir operating strategy. During the baseline data collection in 2000, approximately 30 transect surveys were conducted in Carpenter Reservoir to establish baseline conditions for species composition and elevation patterns of establishment associated with reservoir inundation history. The following activities are proposed for this task: 1) permanent benchmarking of the baseline transects to allow repeated surveys through time, 2) supplemental sampling at the baseline transects prior to the implementation of the operating regime to quantify relative riparian productivity (biomass sampling); 3) repeating baseline vegetation surveys (including the biomass sampling) after approximately 10 years; 4) based on the data collected undertake a quantitative assessment of the changes in species composition with particular attention to spatial changes in riparian vegetation along elevation gradients in relation to inundation history within the drawdown zone.

<u>Task 3 Reservoir Drawdown Zone Planting Evaluation</u>

Field surveys are proposed for a subset of the planting locations and adjacent control areas prior to during and following the implementation of drawdown zone planting. The surveys will be first conducted prior to the initiation of any planting activities to allow 1) permanent benchmarks to be developed for monitoring sites; 2) to collect topographic descriptions of the treatment and control locations, and 3) quantify site specific baseline conditions for extent of vegetated area, species composition and relative productivity. They will be continued annually during the implementation of planting activities to allow documentation of the time course of changes in spatial extent of naturally occurring and planted vegetation, species composition, and relative productivity (biomass/cover). A final survey would be conducted four years after the completion of the planting program to assess changes in spatial extent, species composition, and relative productivity of the planted areas after several years with no planting activity. The objective of these final surveys is to evaluate the overall success of the planting program for improving the spatial extent of riparian vegetation in the drawdown zone.

<u>Task 3 Reporting</u>

A detailed technical report will prepared prior to the review of the Bridge River Water Use Plan that outlines the findings from the program as they relate to the primary components described above.

Interpretation of Monitoring Program Results

The data and information collected in the proposed monitoring programs would ultimately be used to assess the degree to which management objectives and technical expectations were met by the implementation of the operational change and planting program together. This information is critical for making future decisions which involve establishment of the appropriate balance between protection and enhancement of riparian areas surrounding Carpenter Reservoir and protection of downstream (i.e., spills in Lower Bridge and Seton Rivers) and upstream fish populations (i.e., entrainment and stranding of fish in Downton Reservoir). The monitoring program will allow verification that the approach to management of the trade-off surrounding Carpenter Reservoir riparian vegetation was or was not sound. This assessment will be critical for making future decisions about the appropriate balance between protection and enhancement of riparian areas surrounding Carpenter Reservoir and protection of downstream (i.e., spills in Lower Bridge and Seton Rivers) and upstream fish populations (i.e., entrainment and stranding of fish in Downton Reservoir).

Upon completion of the program a syntheses report will be prepared for use in the next review of the Bridge River Water Use Plan. This syntheses will include, but may not be limited to:

1. Quantitative assessment of the changes in spatial extent, species composition, and relative productivity of riparian vegetation surrounding Carpenter Reservoir associated with the implementation of Alternative N2-2P.

2. Quantitative assessment of the supplemental benefits of the implementation of extensive planting for improving the spatial extent and relative productivity of vegetated areas within the drawdown zone in Carpenter Reservoir.

3. Evaluation of the extent to which management objectives for protection and enhancement of the riparian areas surrounding Carpenter Reservoir were achieved by the implementation of the reservoir operating changes and intensive planting program.

Schedule

The schedule for the annual activities is necessarily phased to accommodate the requirements of the program. The first year of the program will be utilized to collect further baseline data on the system and the development of a detailed plan for the 5-year long planting program. In Years 2 through 6 the planting program will be implemented with annual site specific evaluation monitoring. It is proposed that no work be conducted in Years 7 though 9. In the final year immediately prior to the review of the Bridge River Water Use Plan, aerial photography and baseline vegetation transect surveys will repeated to allow a final assessment of observed changes in the riparian area surrounding Carpenter Reservoir. The schedule for the proposed program is provided in the Table below:

Task	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
1 Project Coordination	x	x	x	x	x	x	x	x	x	x
2 Vegetation Mapping										
a Aerial Photography/Analysis	x									x
b Transect Suveys	x									
3 Planting Strategy Evaluation		x	x	x	x	x				x
4 Reporting										
a Draft Report										x
b Final Report										x

Budget

The total estimated cost of the Carpenter Reservoir Riparian Vegetation Monitoring Program (including evaluation of the planting program) for the 10-year period is $179,397. As a result of the phased nature of the program the annual budget requirement varies from $0 to $76,473. The estimated budget breakdown by task and year is provided in the Table below:

	Project Coordination	Vegetation Mapping	Vegetation Transects	Plant Evaluation	Total Cost
Year 1	2,625	36,750	13,549	0	52,924
Year 2	0	0	0	10,000	10,000
Year 3	0	0	0	10,000	10,000
Year 4	0	0	0	10,000	10,000
Year 5	0	0	0	10,000	10,000
Year 6	0	0	0	10,000	10,000
Year 7	0	0	0	0	0
Year 8	0	0	0	0	0
Year 9	0	0	0	0	0
Year 10	2,625	36,750	27,098	10,000	76,473
Total	5,250	73,500	40,647	60,000	179,397

Bridge River Water Use Plan
Monitoring Program No. BRS-3

Lower Bridge River Adaptive Management Program:
Adult Salmon and Steelhead Enumeration

RATIONALE

Background

The Consultative Committee has recommended that adaptive management flow trials be conducted to provide information needed to define an appropriate instream flow releases to protect and enhance the aquatic and riparian ecosystem in Lower Bridge River, downstream of Terzaghi Dam. A 12-year test flow release program has been proposed to test three alternative instream flow release regimes (referred to as: 1 m^3/s/year, 3 m^3/s/year, 6 m^3/s/year treatments) that do not differ in the relative shape of the delivered hydrograph, but rather the total magnitude of the flow regime in terms of annual water budget. Detailed monitoring of physical habitat, aquatic productivity, and fish population response has been recommended by the Consultative Committee to obtain the required information to evaluate the physical and biological response to instream flow. The Fisheries Technical Committee developed a monitoring program to assess physical and biological response in the aquatic ecosystem and standing crop of juvenile fish. The rationale for this program and its methods are described in a separate monitoring proposal (Lower Bridge River Aquatic Ecosystem Monitoring Study No. 1). As a result of uncertainty about the availability and relative importance of spawning habitat for anadromous species, the Consultative Committee also recommended implementation of monitoring programs to evaluate effects of the flow regime on spawning habitat, spawning distribution, and to enumerate spawning escapements. The monitoring will fill data gaps in the relative use and availability of spawning habitats under the alternative test flow regimes. In addition, the collection of time series of escapement estimates ensure that variation in the abundance of the juvenile salmonid standing crop during the flow trials can be interpreted as a flow effect rather than an artifact of abnormally low spawning population abundance.

Management Questions

This monitoring program addresses two management questions. The first is associated with the interpretation of the results of the Aquatic Ecosystem Monitoring Program. The fundamental management question is related to how informative the use of juvenile salmonid standing crop biomass is as the primary indicator of impact of flow. The proposed monitoring program will collect the data needed to support judgements whether the sufficient numbers of adult salmon of each species were present in the system to produce progeny that would fully seed the available rearing habitat. The second is associated with filling data gaps identified during the development of the Water Use Plan. In addition to the value of this program to support interpretation of the findings of the aquatic monitoring program, the Bridge River water use planning process identified that there is significant uncertainty about the quality and quantity of spawning habitat in the Lower Bridge River. The implementation of the monitoring program would provide an opportunity to address this data gap.

Key Water Use Decision Affected

The key water use plan decision influenced by the results of this monitoring program is the development of the long term flow regime for the Lower Bridge River. This program will provide the information to better understand how instream flow influences spawning habitats in the Lower Bridge and supply the data needed to support interpretation of the response of the aquatic ecosystem through measurement of juvenile fish populations. The program is therefore of fundamental importance.

Monitoring Program Proposal

Approach

The approach to this project will be to conduct survey development, annual implementation of detailed systematic surveys of the escapement of chinook, coho, and steelhead. Supplemental less intensive surveys will be conducted to estimate spawning population abundance of sockeye and during odd years pink salmon. The surveys will allow collection of extensive data on the annual and inter-annual distribution of spawning in the system in relation to habitat characteristics and flow. Annual reports will be produced and a syntheses report will be produced at the end of the flow trials.

Methods

The proposed monitoring program has the following primary tasks:

Task 1 Project Coordination

Project coordination involves the general administrative and technical oversight of the program. This will include, but not be limited to: 1) budget management; 2) staff selection; 3) logistic coordination; 4) technical oversight in field and analysis components; and 5) liaison with regulatory and First Nation groups.

Task 2 Annual Surveys

Each year surveys of the Lower Bridge River will be conducted to estimate the abundance and biological characteristics of the populations of salmon and steelhead. Surveys will be conducted from Terzaghi Dam to the confluence with the Fraser River. Methods and the timing of the surveys will follow known spawning and migration periods and follow/refine methods that have been developed and implemented in the river. It is proposed that a spatially geo-referenced map be developed and fixed reach boundaries be established for use over all species. Standardized basemapping will allow linkage between spawner survey program observations and habitat inventory activities to investigation of spawning distribution in relation to habitat and flow conditions under the different treatment regimes in the flow trials. Two levels of survey intensity are proposed for developing spawning population abundance estimates. Because chinook, coho and steelhead are the only species of anadromous salmonids rearing in the Lower Bridge River, it is proposed that greater effort be directed at those species to achieve more accurate and precise estimates. As pink salmon and sockeye salmon fry do not rear in the system, it is proposed that lower level of resources be assigned to estimating escapement of those species.

<u>Task 3 Reporting</u>

Annual reports of the methods, results and final escapement estimates for the five species will be produced on annual basis. A review report will be completed in 11 years upon completion of the flow trials to provide a comprehensive syntheses of the results of the entire program.

Interpretation of Monitoring Program Results

The results from this program will provide quantitative estimates of escapement and level of precision of the estimates. Since the true capacity of the rearing environment is not known, these data will then be used to support professional judgements about the level of seeding that has been achieved in each years. In addition to experience from other river systems, this professional judgement will rely on using site specific auxiliary data collected in the Bridge River about juvenile salmonid abundance, growth rate and condition to support conclusions about this issue.

Schedule

The annual schedule for the proposed program is provided in the Table below:

Task	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1 Project Coordination												
2 Steelhead	X	XX	X									
3 Chinook				X	X	X	X					
4 Coho								X	X	X		
5 Sockeye				X	X	X						
6 Pink						X	X	X				
7 Sockeye				X	X	X						
8 Reporting											XXXX	

Budget

The estimated average annual cost of the Lower Bridge River Adult Salmon and Steelhead Enumeration program for the 11-year period is $94,907. The estimated budget breakdown by task and year is provided in the Table below:

	Project Coordination	**Steelhead**	**Chinook**	**Coho**	**Sockeye**	**Pink**	**Total Cost**
Year 1	2,625	27,600	20,700	20,700	16,100	11,500	99,225
Year 2	2,625	27,600	20,700	20,700	16,100		87,725
Year 3	2,625	27,600	20,700	20,700	16,100	11,500	99,225
Year 4	2,625	27,600	20,700	20,700	16,100		87,725
Year 5	2,625	27,600	20,700	20,700	16,100	11,500	99,225
Year 6	2,625	27,600	20,700	20,700	16,100		87,725
Year 7	2,625	27,600	20,700	20,700	16,100	11,500	99,225
Year 8	2,625	27,600	20,700	20,700	16,100		87,725
Year 9	2,625	27,600	20,700	20,700	16,100	11,500	99,225
Year 10	2,625	27,600	20,700	20,700	16,100		87,725
Year 11	12,625	27,600	20,700	20,700	16,100	11,500	109,225
Total	38,875	303,600	227,700	227,700	177,100	69,000	1,043,975

Bridge River Water Use Plan
Monitoring Program No. BRS-4

Carpenter Reservoir and Middle Bridge River Fish Habitat and Population Monitoring

RATIONALE

Background

The Consultative Committee developed aquatic ecosystem objectives for Carpenter Reservoir that are measured in terms of abundance and diversity of fish populations present in the reservoir. However, it was not possible, with the existing information on the Carpenter Reservoir ecosystem to develop explicit fish population level performance measures that directly reflected these objectives. Specific gaps in data and understanding were identified in: 1) the relative abundance, distribution and life history requirements of species of fish in the Carpenter Reservoir and its tributaries; and 2) the relationship between operating parameters (i.e., maximum/minimum elevation, timing of reservoir filling) of the reservoir and the impact factors reflected by the performance measures for determining the productivity of fish populations. Given the scope of these data gaps and the schedule of the Bridge River Water Use Plan it was not possible to conduct required studies in time available (1 year).

To provide required information for the trade-off assessments, habitat-based performance measures related to specific key operating impacts were developed. These performance measures independently assessed operating impacts that are believed to cause mortality or sublethal impacts to fish (stranding, entrainment, tributary backwatering) and trophic production required to support existing fish populations (littoral productivity, pelagic productivity). The application of the performance measures did help make trade-off decisions however they required an extensive amount of qualitative judgement about which factors were most important in the regulation of fish population abundance and diversity. As these judgements could not be supported with technical data, there remains significant uncertainty about how well the assessments actually reflect population response to different reservoir operating strategies as the relative importance of each impact factor is not currently known. To resolve these data gaps and uncertainties the Consultative Committee has therefore recommended fish habitat and population monitoring to obtain better information on the abundance, life history, habitat use of fish populations, and to assess how reservoir operating parameters impact reservoir habitats and fish populations.

Management Questions

Key management uncertainties encountered in the development of the BRS Water Use Plan associated with fish populations in Carpenter Reservoir and Middle Bridge River were related to three issues. First, there is considerable uncertainty about the fundamental characteristics of the fish community in Carpenter Reservoir and its tributaries (species composition, abundance, distribution, and life history). This lack of information limited the Consultative Committee capability to develop appropriate performance measures to assess how well given alternatives met overall aquatic ecosystem objectives. Second, the relative influence of the operating parameters of the reservoir (minimum annual elevation, maximum annual elevation, annual drawdown, reservoir fill schedules) and, how this relates to the identified performance measures (i.e., stranding, entrainment, tributary backwatering, littoral productivity, pelagic productivity) was not known. This created significant uncertainty about how each of these independent impacts individually influences the long term productivity of Carpenter Reservoir fish populations. Third, there is considerable uncertainty about the impacts of the instream flow regime of the Middle Bridge River (which is largely controlled by La Joie Generating Station) on fish populations. Of particular importance for the selection of the current operating alternative (N2-2P) was uncertainty about the potential for dewatering of whitefish eggs during winter months and how this would impact the whitefish population found in Middle Bridge River and Carpenter Reservoir.

The primary management questions that the proposed monitoring program will address are:

1. What are the basic biological characteristics or parameters of fish populations in Carpenter Reservoir and Middle Bridge River?

2. Will the selected alternative result in positive, negative or neutral impact on abundance and diversity of fish populations.

3. Which are the key operating parameters that contribute to reduced or improved productivity of fish populations in Carpenter Reservoir and Middle Bridge River?

4. Is there a relationship between specific characteristics of the instream flow in Middle Bridge River that contribute to reduced or improved productivity of fish populations in Carpenter Reservoir and Middle Bridge River?

5. Can refinements be made to the operation of Carpenter Reservoir and management of instream flow releases from La Joie Generating Station into the Middle Bridge River to improve protection or enhance fish populations in both of these areas, or can existing constraints be relaxed?

Detailed Hypotheses about the Impacts of Carpenter Reservoir Operation on Fish

Two primary hypotheses (and subhypotheses) associated with these management questions are listed below. The first hypothesis is associated with direct operational impacts on fish:

H1: The abundance and diversity of Carpenter Reservoir fish populations is limited by habitat impacts directly related to the operation of the reservoir.

H_{1A}: Operation of the reservoir at low elevations reduces fish abundance due to stranding.

H_{1B}: Operation of the reservoir at low elevations reduces abundance of fish populations due to fish entrainment from the reservoir.

H_{1C}: Operation of the reservoir reduces abundance of fish populations due to tributary access and backwatering of eggs deposited in the drawdown zone.

H_{1D}: Operation of the reservoir at low elevations reduces littoral productivity and this results in reduced abundance and diversity of Carpenter Reservoir fish populations.

H_{1E}: Operation of the reservoir at low elevations reduces pelagic productivity and this results in reduced abundance and diversity of Carpenter Reservoir fish populations.

H2: The abundance and diversity of Carpenter Reservoir fish populations is limited by habitat impacts directly related to the operation of the La Joie Generating Station.

H_{2A}: Operation of the reservoir or La Joie Generating Station restricts the amount of available effective spawning habitat (through redd dewatering) in Middle Bridge River and this limits the productivity of Carpenter Reservoir fish populations.

These hypotheses have significant consequences for the predicted impacts of operations on fish, however, they could not be resolved with scientific data during the Water Use Plan and professional judgement and experience from other reservoirs was used to help support critical trade-off decisions.

Key Water Use Decisions Affected

Implementation of the proposed monitoring program will provide information that are required to validate assumptions two key decisions in the Bridge River Water Use Plan. Both decisions relate to balancing the need for managing reservoir storage in Carpenter and Downton Reservoirs and how the actions taken influence abundance and diversity of fish populations in Carpenter Reservoir and Middle Bridge River.

Carpenter Reservoir is a key component in the Bridge-Seton system as it provides the majority of storage capacity to store water used in the diversion between the Bridge and Seton watersheds. This storage is required to maximize power generation capabilities and to buffer the frequency, magnitude, and duration of spills into the Lower Bridge and Seton Rivers that have been documented to have significant negative environmental impacts. Reducing spills requires the flexibility to utilize the full capacity of the reservoir to capture inflows by minimizing restrictions on the minimum and maximum annual operating elevation. Despite concerns for the effects of very low (i.e., littoral productivity, fish stranding, entrainment), very high operating levels (i.e., tributary backwatering) on fish populations, the Consultative Committee explicitly placed a higher priority on reducing spills in the Lower Bridge and Seton Rivers to protect anadromous species than protecting reservoir fish populations. Thus, a decision was made to maintain operating flexibility in Carpenter Reservoir with no restriction on minimum elevation. This decision was based on the implicit and uncertain assumption that compensatory population processes will buffer the adverse impacts of reservoir operation.

Middle Bridge River is the largest tributary flowing into to Carpenter Reservoir and is an important habitat for rearing and spawning of populations of resident species found in the reservoir. During the development of the Bridge River Water Use Plan, significant efforts were made to establish a minimum flow regime guideline that would effectively support these critical life history functions. However, it was determined, particularly in winter months, it not always possible to provide the desired flow because of insufficient storage in Downton Reservoir. Despite concerns for the potential for adverse impacts on whitefish populations spawning in the Middle Bridge River (redd dewatering), the Consultative Committe decided to alter the operation of Downton to ensure that the minimum flow was met because this better managed spill in Lower Bridge and Seton Rivers. They elected to accept a marginally deeper drawdown of the Downton (with its associated risk of entrainment impacts) to allow reduced potential for whitefish redd dewatering. This decision was based on the implicit (yet uncertain) assumption that compensatory population processes will buffer the adverse impacts of redd dewatering and there would be no reduction in abundance of whitefish (or other resident) populations.

This monitoring program will provide the information that is required to support the current operation or in the future to refine it by adjusting minimum or maximum operating parameters for Carpenter Reservoir, minimum operating parameters for Downton Reservoir and management of instream flow releases from La Joie Generating Station.

Monitoring Program Proposal

Approach

The general approach to this monitoring program will be to collect a comprehensive long term data set on fish populations and habitat conditions in Carpenter Reservoir and Middle Bridge River to resolve current gaps in data and scientific understanding. Through the collection of coincident information on habitat conditions and fish population information (age structure and abundance) it is possible to identify changes in natural or normal population structure, and changes over time can be used to develop and test hypotheses about the relationship between habitat conditions and population response. This will be accomplished by:

1. Collecting time series information on the abundance and biological characteristics of resident fish populations and reservoir habitat conditions;

2. Correlation of abundance of younger ages (recruitment) of fish with reservoir operating parameters;

3. Implementing a "stock synthesis" approach to estimating recruitment anomalies associated with operating impacts, which combines age composition and relative trend data collected during monitoring to better define recruitment changes;

4. Examination of trends in growth or distribution changes with operations.

The advantage of this approach is that it provides an explicit method for linking habitat conditions created by operating parameters of the reservoir to response of fish populations. This linkage is important for water use planning decisions because it avoids many of the shortcomings and criticisms of habitat based approaches, and it provides assessments in the units for which the overall aquatic objectives are measured. It provides an explicit way to identify: 1) what the key factors impacting populations are, and 2) the relative contribution of these factors to reservoir fish population regulation.

Methods

The proposed monitoring program has six primary tasks:

Task 1 Project Coordination

Project coordination involves the general administrative and technical oversight of the program. This will include, but not be limited to: 1) budget management; 2) staff selection; 3) logistic coordination; 4) technical oversight in field and analysis components; and 5) liaison with regulatory and First Nation groups.

Task 2 Field Studies

General Fish Population Index Surveys

General fish population index surveys are proposed to provide information on seasonal and inter-annual variation in the relative abundance, distribution and growth rate of all species in the reservoir fish community. Index surveys will be implemented during spring (low pool) and fall (maximum pool) periods. Sampling index surveys will have two components and follow a stratified random design developed in pilot sampling conducted in 2001. Standardized beach seine surveys will be conducted to quantify relative abundance of fish species and age classes occupying shallow areas of the littoral zone (depth <1 m) areas in the littoral zone. Standardized boat electrofishing surveys will be conducted in deeper areas of the littoral zone (depth 1-3 m) to index fish population utilizing nearshore habitats in the reservoir. Both surveys will be stratified by habitat types and longitudinal zones of the reservoir.

All fish collection efforts will be accompanied by detailed sampling of the biological characteristics of the fish populations and standardized habitat descriptions. All fish captured in the field program should be measured for weight/length, evaluated for sex and sexual maturity [as possible], and appropriate aging structures should be collected. Where possible individual coded tags will be applied to captured fish to provide information on movement patterns, growth, and population estimates through mark recapture methods (as reviewed below). Analyses of the biological information will include examination of weight-length relationships, length frequency, age structure, and patterns of growth of fish populations in each of the geographic zones of the study area. Habitat data collected at each index sites should include factors that are considered significant to fish sampling. These include, but are not limited to: temperature, light intensity (ambient/in situ), depth, water flow velocity, bank type, meso-habitat type, proximity to cover, and any other factors deemed to be important to sampling gear efficiency or fish habitat use.

Rainbow Trout and Bull Trout Tagging

Collection of absolute abundance information is proposed for key two species in the reservoir: bull trout and rainbow trout. Bull trout is a species of regional concern and rainbow trout are currently found in relative low numbers and both species are expected to be highly sensitive to habitat impacts caused by reservoir operations. Individual coded tags (PITT tags) will be applied to bull trout and rainbow captured during monthly angling (May-October) and during index sampling surveys (June, October). These tags will provide the capability to apply standard mark recapture methods to: 1) estimate absolute abundance of each species on an annual basis; 2) to estimate growth rate of individual life stages and species of fish; 3) to test index sampling methods for bias (i.e., hyperstability); 4) calibrate habitat-population models developed for each species.

Tributary Spawner Surveys

Tributary spawner surveys are proposed to document the abundance and distribution of fish spawning in the tributaries of Carpenter Reservoir. The surveys will focus on rainbow trout and kokanee as these species are most likely to be impacted by backwatering impacts in the reservoir. It is proposed that weekly surveys be conducted through the rainbow trout spawning period (June to early-August) and kokanee spawning period (September to early-October). Surveys will use visual surveys where water clarity allows and standard fisheries sampling techniques such as beach seining will be applied where turbid conditions are encountered (Gun Creek, Tyaughton Creek. Middle Bridge River) to produce estimates of spawning abundance and spatial distribution of spawning sites. These data provide estimates of the relative abundance of the kokanee. They also provide an independent estimate of relative abundance of rainbow trout needed to compare spawner enumeration, index, and absolute abundance methods.

Habitat Monitoring

To investigate the impacts of reservoir operation on fish populations supplemental habitat information will be collected during the fish sampling surveys. These include, but may not be limited to: 1) installation and maintenance of thermographs in key reservoir tributaries; 2) systematic monitoring of suspended sediment concentration from key tributaries; 3) seasonal limnological surveys to document temperature/oxygen profiles and light penetration/water clarity.

Task 3 Laboratory Analysis

To assist in assessing the productivity of reservoir fish populations, developing understanding of life history of each species, and ultimately modelling fish habitat-population dynamics field sampling will include biological sampling of fish to collect growth structures (scales and/or fin rays) from fish. Laboratory analysis will be conducted to assess the age of specimens and allow development of relationships between size and age of fish. These data allow estimation of average growth rates of the different life stages and species of fish in the reservoir and gain better understanding of how different habitats or reservoir operating strategies influence fish growth rate.

Task 4 Data Analysis and Reporting

A detailed technical report of the findings of the program will be prepared for distribution annually. Data assembly and data analysis will be initiated upon completion of the field season and a draft report will be prepared for circulation to technical experts, regulatory agencies and interested stakeholders. Review comments will be incorporated as appropriate and a final report will be prepared. Upon completion of the proposed program a syntheses report will be prepared for use in the next review of the Bridge River Water Use Plan.

Interpretation of Monitoring Program Results

The proposed monitoring program will provide valuable information for three specific categories of uncertainty.

1. Quantitative documentation of the basic biological characteristics of the fish populations - The monitoring program will provide a comprehensive data set to establish abundance, diversity, distribution, growth rates, habitat use, and life history of fish populations in the Carpenter Reservoir and Middle Bridge River. These data will be compared against a suitable benchmark for reservoirs/and lakes in British Columbia. to provide insight on the potential for improvement.

2. Review of the trends in relative abundance of the general fish community - The data collected will allow quantitative inferences in the trends in abundance of the key fish species in the reservoir in relation to the general operation of the reservoir and help determine if the implemented alternative (N2-2P), in general, has had a positive, neutral, or negative impact on the abundance and diversity of reservoir fish populations. Auxiliary data on other external factors (habitat conditions) will be collected to support inferences about the relationship between operational changes and observed trends.

3. <u>Examination of the influence of reservoir operating parameters on key species in the community</u> - Analyses will be conducted on a life stage and species specific basis to determine if there is a statistical correlation between operating parameters of the reservoir (i.e., minimum elevation, maximum elevation, annual drawdown) and the abundance or growth. The strength of inferences will depend of the amount of "contrast " in operations provided and because we expect two significant drawdown events for dam repairs in the next decade, it is likely that strong correlative inferences will be achieved. Qualitative inferences can then be drawn on the relative importance of the previously identified performance measures for reservoir fish in limiting population abundance and community diversity. The importance of these effects will be interpreted in light of the observed trends in abundance.

Note that the proposed uses of the monitoring program information listed above are not mutually exclusive, as the information from one category is useful for another. From 1. to 3. there is increasing resolution about the how operating impacts influence fish populations in Carpenter Reservoir and Middle Bridge River, but each sequential stages requires more information to support strong technical inferences.

Schedule

It is proposed that this program be conducted for a duration of 10 years, with a formal review of the program after five years. The proposed annual schedule of implementation of program tasks is presented in the Table below:

Task	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1 Project Coordination	X	X	X	X	X	X	X	X	X	X	X	X
2 Field Studies												
a General Indexing			XXX			XXXX						
b Absolute Abundance		XX	XX	XX	XX	XX	XX					
c Tributary Spawner Surveys			XXXXXXXXXXXXXXXXXXXXXXXX									
d Habitat Monitoring	X	X	X	X	X	X	X					
3 Lab Analysis												
a Fish Aging								XXXXXXXXXXX				
4 Reporting												
a Data analysis									XXXXXXXXX			
b Draft Report										XXXXX		
c Final Report											XXXXXXX	

Budget

The total estimated cost of the Carpenter Reservoir/Middle Bridge River Fish Habitat and Population Monitoring is $69,759 per year. The estimated budget breakdown by task is provided in the Table below:

Task			Expenses	Labour	Total
1.	Project Coordination		0	3,150	3,150
2.	Field Studies				
	a. General Indexing		16,480	18,000	34,480
	b. Absolute Abundance		4,995	4,500	9,495
	c. Tributary Spawnter Surveys		4,392	5,400	9,792
	d. Misc Field Expenses		3,500	0	3,500
3.	Reporting		0	3,000	3,000
4.	Contingency	10%	6,342	0	6,342
Total			35,709	34,050	69,759

Bridge River Water Use Plan
Monitoring Program No. BRS-5

Downton Reservoir Riparian Vegetation Monitoring

RATIONALE

Background

The Consultative Committee had consensus that a primary environmental goal for the management of the Downton Reservoir was the protection of the high quality wildlife habitats present in the western end of the reservoir. As a result of its unique qualities on the delta of the Upper Bridge River and immediate adjacent drawdown zone in the reservoir (regional scarcity, remoteness, existing habitat conditions) this area has been identified as significant habitat for regionally threatened grizzly bears populations. This goal was also found to be consistent with other regional land use planning initiative conducted by the provincial government (LRMP - Lillooet Region).

In the development of operating alternatives, the Consultative Committee elected to take no direct action to protect or enhance this area to improve wildlife values, but rather, sought an alternative that would preserve this high quality feature without causing or inflicting any change to riparian habitat conditions in the area.

Management Questions

The fundamental management questions that therefore arose during the development of the selected operating strategy was related to the anticipated response of the riparian vegetation to alternative strategies of operating Downton Reservoir. These questions were:

1. Will implementation of Alternative N2-2P have negative, neutral or positive impacts on the quality and quantity (species composition, biological productivity, spatial area) of riparian area on the Upper Bridge River fan and in the immediately adjacent drawdown zone of Downton Reservoir?

2. If there has been a negative impact on riparian vegetation and the overall quality of the habitat for wildlife on the area, what activities could be undertaken to preserve this critical habitat area?

Detailed Hypotheses about the Impacts of Downton Reservoir Operation on Riparian Vegetation

The fundamental management question resulted in the development of a single primary hypothesis (and subhypotheses) associated with effects of the selected alternative on the critical habitat area. The hypothesis is associated with providing the assurance that the implemented reservoir operating strategy has met its fundamental management objective. This hypothesis was then decomposed into three testable subhypotheses associated with the spatial extent, community species composition and relative productivity of riparian vegetation community associated with the critical habitat area on the fan and the adjacent area in the drawdown zone. The hypotheses are:

H_1: Implementation of the chosen alternative will not result in a alteration of the critical wildlife areas located on the Upper Bridge River Fan and the adjacent areas in the drawdown zone of Downton Reservoir.

H_{1A}: There is no significant change in the spatial extent of the vegetated area on the fan or in the adjacent drawdown zone.

H_{1B}: There is no significant change in the species composition of the plant community in the vegetated area on the fan or in the adjacent drawdown zone.

H_{1C}: There is no significant change in the relative productivity of the plant community in the vegetated area on the fan or in the adjacent drawdown zone.

Key Water Use Decision Affected

The decision by the Consultative Committee to recommend Alternative N2-2P over Alternative 03-2 was based on the assumption that there would be no reduction in quality and quantity of riparian conditions from current conditions, thus preservation of the critical wildlife habitat area. Based on the technical information available it was believed that adopting Alternative N2-2P would not alter the critical area. If it was found through monitoring that the implementation of Alternative N2-2P had a negative impact on riparian communities of the critical wildlife areas on the Upper Bridge River Fan and in the adjacent drawdown zone of Downton Reservoir, it would likely alter future decisions regarding reservoir operating strategy because of the high value placed on protecting this area.

Monitoring Program Proposal

Approach

The proposed monitoring program has two primary components. The first component is the quantification of the spatial extent, species composition, and relative productivity of the riparian area surrounding Downton Reservoir to allow quantification of changes that occur as a result of changes in the operating strategy of the reservoir. The second is the analysis of the field data to draw inferences on the overall effect of the both operational changes and planting on riparian conditions. The program is to be conducted over an approximately 10-year long period, however, the implementation of each component is not simultaneous (refer to the Schedule section below).

Methods

The proposed monitoring program has the following primary tasks:

Task 1 Project Coordination

Project coordination involves the general administrative and technical oversight of the program. This will include, but not be limited to: 1) budget management; 2) staff selection; 3) logistic coordination; 4) technical oversight in field and analysis components; and 5) liaison with regulatory and first nations groups.

Task 2 Riparian Vegetation Mapping and Analysis

Aerial Photography

To assess the impacts of Alternative N2-2P reservoir operating alternative on the spatial extent of riparian vegetation adjacent to and within Downton Reservoir drawdown zone it is proposed that aerial photography prior to the implementation of Alternative N2-2P be conducted prior to the implementation of Alternative N2-2P and immediately prior to proposed the review of the Bridge River Water Use Plan in approximately 10 years. Low level spatial geo-referenced colour air photos will be used to develop GIS based maps of the riparian vegetation and to compute changes in the spatial extent and location of vegetation occurring after 10 years. The observed patterns will be interpreted based on inundation frequencies imposed by the implemented reservoir operations and by site specific habitat conditions within the drawdown zone.

Vegetation Transect Surveys

Transect surveys are proposed to 1) to ground truth assessments of general changes in species composition occurring over the entire spatial area of the reservoir; 2) provide detailed geo-referenced topographic data of the transect, and 3) to provide a detailed assessment of the changes in species composition and relative productivity of riparian habitats resulting from the implementation of the new Downton Reservoir operating strategy. During the baseline data collection in 2000, approximately 30 transect surveys were conducted in Downton Reservoir to establish baseline conditions for species composition and elevation patterns of establishment associated with reservoir inundation history. The following activities are proposed for this task: 1) permanent benchmarking of the baseline transects to allow repeated surveys through time; 2) supplemental sampling at the baseline transects prior to the implementation of the operating regime to quantify relative riparian productivity (biomass sampling); 3) repeating baseline vegetation surveys (including the biomass sampling) after approximately 10 years; 4) based on the data collected undertake a quantitative assessment of the changes in species composition with particular attention to spatial changes in riparian vegetation along elevation gradients in relation to inundation history within the drawdown zone.

Task 3 Reporting

A detailed technical report will prepared prior to the review of the Bridge River Water Use Plan that outlines the findings from the program as they relate to the primary components described above.

Interpretation of Monitoring Program Results

The data and information collect in the proposed monitoring programs would ultimately be used to assess the degree to which management objectives and technical expectations were met by the implementation of the operational change. Upon completion of the program a syntheses report will be prepared for use in the next review of the Bridge River Water Use Plan. The syntheses will include, but may not be limited to:

1. Quantitative assessment of the changes in spatial extent, species composition, and relative productivity of riparian vegetation surrounding Downton Reservoir associated with the implementation of Alternative N2-2P.

2. Evaluation of the extent to which management objectives for protection and enhancement of the riparian areas surrounding Downton Reservoir, with particular reference to the critical area located on the fan of the Upper Bridge River and in the adjacent drawdown zone of the reservoir, were achieved by the implementation of the reservoir operating changes.

Schedule

The schedule for the annual activities is necessarily phased to accommodate the requirements of the program. The first year of the program will be utilized to obtain further required baseline data on the system. In Years 2 through 9 no specific activities are proposed. In the final year of the program immediately prior to the review of the Bridge River Water Use Plan, aerial photography and baseline vegetation transect surveys will repeated to allow a final assessment of observed changes in the riparian area surrounding Downton Reservoir. The schedule for the proposed program is provided in the Table below:

Task	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
1 Project Coordination	X									X
2 Vegetation Mapping										
a Aerial Photography/Analysis	X									X
b Transect Suveys	X									
4 Reporting										
a Interim Report	X									X
b Final Report										X

Budget

The total estimated cost of the Downton Reservoir Riparian Vegetation Monitoring Program for the 10-year period is $75,770. As are resulted of the phased nature of the program the annual budget requirement varies from $0 to $37,885. The estimated budget breakdown by task and year is provided in the Table below:

	Project Coordination.	Veg. Mapping	Veg. Transects	Total Costs
Year 1	2,625	24,750	10,510	37,885
Year 2	0	0	0	0
Year 3	0	0	0	0
Year 4	0	0	0	0
Year 5	0	0	0	0
Year 6	0	0	0	0
Year 7	0	0	0	0
Year 8	0	0	0	0
Year 9	0	0	0	0
Year 10	2,625	24,750	10,510	37,785
Total	5,250	49,500	21,020	75,770

Bridge River Water Use Plan
Monitoring Program No. BRS-6

Seton Lake Reservoir Aquatic Productivity Monitoring

RATIONALE

Background

The Consultative Committee developed aquatic ecosystem objectives for Seton Lake Reservoir that were established in terms of abundance and diversity of fish populations present in the lake. The Seton-Anderson watershed provides habitat for a wide range of anadromous and resident species which are valued from a commercial, recreational, and cultural perspective. There are data available to describe the anadromous fish populations that use the Seton-Anderson watershed and to draw subjective conclusions on how these populations may have been impacted by the diversion of water from the Bridge River watershed (Carpenter Reservoir) to the Seton-Anderson watershed. However, there is relatively poor understanding of how this impact varies from year-to-year and whether it is possible to modify the operation of the diversion to reduce this impact. The effects of the Bridge River diversion were first investigated in the 1960's by the International Pacific Salmon Fisheries Commission (IPSFC). That assessment suggested the diversion has resulted in the introduction of relative cold and turbid water from the glacial Bridge River (Carpenter Reservoir) and this significantly reducing water temperature, light penetration and productivity of the lake. While there is high certainty about the existence of this "footprint" impact, the degree to which operations can be modified to mitigate this impact remains uncertain. Field studies were conducted in 2000 to fill data gaps on existing habitat conditions and aquatic productivity. These studies, in association with the IPSFC finding and the more contemporary qualitative observations made by technical and First Nations representatives have suggested that there is significant spatial and temporal (seasonal, annual) variation in the physical impacts and possible consequences on aquatic productivity of the diversion. Thus, it has been hypothesized that it may be possible to modify seasonal operations to mitigate impacts of the diversion on aquatic productivity.

The role of aquatic productivity in the regulation of the abundance of anadromous and resident fish populations is not well understood. For example, it is not clearly understood why juvenile sockeye or kokanee (Gwenis) selectively rearing in Seton Lake Reservoir over the adjacent Anderson Lake which is not impacted by the diversion. Results from field studies conducted in 2000 and 2001 were compared to a large number of comparable large lakes in the Fraser and Skeena basin not affected by inter-basin diversions. This comparison resulted in the finding that while Seton Lake Reservoir provides photosynthetic rates comparable the other lakes, it has provides a disproportionately low zooplankton standing crop biomass. Despite the relativly low productivity of this critical zooplankton food resource for anadromous and resident fish species resulting from the diversion, early studies conducted by IPSFC suggested that sockeye salmon smolts rearing in Seton Lake Reservoir attain larger sizes and are expected to have greater overall survival rate than those rearing in the unimpacted Anderson Lake. The effects of reduced aquatic productivity also appears at higher trophic levels. For example, a comparison of the size at age and condition of lacustrine rainbow from Seton Lake Reservoir to other large lakes suggest the Seton fish are smaller and in poorer condition. It appears there are complex ecological interactions driven by changes in aquatic productivity resulting from the diversion, however, the uncertainty about these interactions could not be resolved by existing information available to conduct the water use plan assessments. Recognizing significant technical uncertainty and given the high value place on the productivity of Seton Lake Reservoir for the production of anadromous and resident fish species the Consultative Committee recommended that follow-up monitoring be initiated to reduce uncertainty about the effects of the seasonal and inter-annual operation of the Bridge River diversion.

Management Questions

The key management questions surrounding the capability to mitigate the negative impacts of the diversion. Currently there is considerable uncertainty about how changes in operation of Carpenter Reservoir will impact aquatic productivity of Seton Lake Reservoir, additional information will help to determine whether the current regime has degraded productivity and provide better insight if modifications of the operation can be made to improve conditions for aquatic and fish productivity. The primary management questions addressed by the proposed monitoring program are:

1. Will the selected alternative (N2-2P) result in positive, negative or neutral impact on aquatic productivity of Seton Lake Reservoir?

2. What is the inter-annual variation in physical conditions in the reservoir caused by the diversion and is this related to aquatic productivity?

3. Is there a relationship between the quality, quantity, and timing of water diverted from Carpenter Reservoir on the productivity of Seton Lake Reservoir resident fish populations?

4. To what extent does aquatic productivity alone limit the abundance and diversity of fish populations in Seton Lake Reservoir?

5. Can refinements be made to the selected alternative to improve habitat conditions or enhance fish populations in Seton Lake Reservoir?

Detailed Hypotheses about the Impacts of Bridge Generating Station Operation on Aquatic Productivity of Seton Lake Reservoir

The primary hypotheses (and subhypotheses) associated with these management questions are:

H1: The abundance and diversity of Seton Lake Reservoir fish populations are directly limited by habitat impacts directly related to the operation of the Bridge Generating Station.

H_{1A}: Diversions from Carpenter Reservoir reduce the temperature, light penetration, and euphotic volume of the reservoir.

H_{1B}: Diversions from Carpenter Reservoir introduce significant quantities of suspended sediment which settle out on and reduce effectiveness of shoreline spawning habitat.

H_{1C}: Daily fluctuations in Seton Lake Reservoir levels reduce effectiveness of spawning.

H_2: Aquatic productivity of Seton LakeReservoir directly influences the capacity of the lake to produce anadromous fish populations.

H_3: Implementation of Alternative N2-P has reduced the aquatic productivity of Seton Lake Reservoir directly influences the capacity of the lake to produce resident fish populations.

These hypotheses have significant consequences for the predicted impacts of operations on fish, however, they could not resolved with scientific data during the Water Use Plan and professional judgement and experience from other reservoirs was used to help support critical trade-off decisions. In particular hypotheses H_{1A} and H_{1B} were implicitly considered in making decisions about the final chosen operating alternative for the Bridge River Water Use Plan.

Key Water Use Decision Affected

The key operating decision that may be affected by this monitoring program is whether the seasonal operation of the generating station/diversion between Carpenter Reservoir and Seton Lake Reservoir can be altered to mitigate impacts of the diversion on aquatic productivity. Other specific water use management decisions that could change as a result of this study also include: 1) amount and timing of discharges from La Joie Generating Station especially during freshet periods when there is high turbidity; and 2) desired operation of Carpenter Reservoir to mitigate the effects of its diversion on Seton Lake Reservoir.

This monitoring program will also address data gaps associated with the effect of the Bridge diversion on aquatic productivity in Seton Lake Reservoir. Given the uncertainty associated with the assessment models used by the Consultative Committee follow-up monitoring has been recommended to help provide assurance that unexpected negative impacts to aquatic productivity or fish populations did not result from implementation of the selected alternative.

Monitoring Program Proposal

Approach

The general approach to this monitoring program is to conduct a before-after-control-impact design comparison of the effects of the implementation of the selected alternative on aquatic productivity in Seton Lake Reservoir. To provide stronger inferences about the influences of diversion Anderson Lake is considered to be a control lake for Seton Lake Reservoir because of its proximity, geology, size and orientation, and parallel sampling at lower intensity will be conducted there. Based on this fundamental design, detailed baseline assessments of Seton and Anderson lakes were initiated during the Water Use Plan data collection phase and were continued by BC Hydro and Fisheries and Oceans Canada during 2001. These baseline studies served to categorize the baseline (i.e., before) current trophic status of the Seton and Anderson lakes, their productivity capacity, and provided some insight into the effects of diversion on the aquatic ecosystem. Follow-up monitoring of the changes that result from the implementation of the selected alternative is proposed to allow: 1) documentation of how the change in operations influenced aquatic productivity, and 2) collection of data base under a wider range of inflow and diversion operation conditions which will provide insight about the potential for making changes to existing seasonal diversion rates. It is proposed that aquatic monitoring continue for three years to enable replication of years in before and after states. It is expected that the five years of data in total will allow resolution of the key management question surrounding the potential to alter seasonal pattern of diversion to increase aquatic productivity.

A critical feature of approach to this study is the strong experimental design and the application of standardized limnological sampling and limnetic fish sampling to not only compare between years in Seton Lake Reservoir and Anderson Lake, but also to make direct comparisons between a large number of other large lakes in British Columbia sampled by WLAP Fisheries and Fisheries and Oceans Canada Science Branch.

Methods

There are three general tasks proposed for the Seton Lake Aquatic Productivity Study. Each task is described below.

<u>Task 1 Project Coordination</u>

Project coordination involves the general administrative and technical oversight of the program. This will include, but not be limited to: 1) budget management; 2) staff selection; 3) logistic coordination; 4) technical oversight in field and analysis components; and 5) liaison with regulatory and First Nation groups.

Task 2 Field Surveys

Seasonal Limnology Surveys

Seton and Anderson lakes will be sampled six times (once monthly during the period May-October) at sample locations for physical, chemical, and biological variables. Physical data collection will involve profiling light transmission, temperature, conductivity, Secchi depth at a 10-15 locations down the axis and across the axis of Seton Lake Reservoir and three locations down the axis of Anderson Lake. Physical data collection will also occur at the Bridge Generating Station and Portage Creek to characterize inflow water quality. This sampling approach will serve to provide detailed documentation temporal and spatial changes in the physical conditions in the lake associated with the diversion. Chemical and biological variables will be collected at two stations to help link the influence of habitat conditions on chemical and biological differences. Chemical variables include: total suspended solids, turbidity, alkalinity, pH, silicate, total dissolved solids, nitrogen (nitrate, ammonia, particulate), phosphorus (total, particulate, soluble reactive), and carbon (dissolved inorganic, particulate). Biological variables include: bacterioplankton numbers, phytoplankton biomass (chlorophyll) and species composition, photosynthetic rates, zooplankton biomass and species composition. Methods for field studies will closely follow those conducted during 2000 and 2001.

Fall Limnetic Fish Surveys

The fall limnetic fish survey will utilize hydroacoustics and mid-water trawls to determine numbers, species composition, size and diet of limnetic fish in Anderson and Seton lakes. Juvenile kokanee and sockeye will be separated by the use of Sr/Ca ratios in otolith primordia. Methods for these studies will follow those conducted during 2000 and 2001, as well as conform to standards used by WLAP for large lakes and Fisheries and Oceans Canada Freshwater Habitat Science Branch for sockeye salmon assessments and research.

Task 3 Data Analysis and Reporting

A detailed technical report will prepared prior to the review of the Bridge River Water Use Plan that outlines the methods implemented for the monitoring program, the results of field measurements, analysis of these field measurements to assess the influence the diversion operation on 1) physical conditions; 2) chemical conditions; 3) trophic conditions (aquatic productivity); 4) limnetic habitat carrying capacity; and 5) anadromous and resident fish populations. The report will also provide recommendations for improvement of assessment methods (performance measures) to be applied in the review of the Bridge River Water Use Plan in 10 years and the potential for modifying seasonal diversion from Carpenter Reservoir into Seton Lake Reservoir.

Interpretation of Monitoring Program Results

Upon completion of the program syntheses report will be prepared for use in the next review of the Bridge River Water Use Plan. The syntheses will include, but may not be limited to:

1. Assessment of the status of aquatic production in Seton Lake Reservoir relative to local controls (Anderson) and other comparable large lakes in British Columbia not impacted by diversion.

2. Quantitative comparison of aquatic productivity before and after the implementation of Alternative N2-2P.

3. Quantitative information on the temporal variation in the physical and biological impacts of the diversion on Seton Lake Reservoir to establish whether changes/refinements in the operation of the diversion would likely result in improved aquatic production.

4. Assessment of the dependence of anadromous and resident fish populations on aquatic productivity in Seton Lake Reservoir (i.e., does trophic productivity limit the fish populations or do other habitat factors play a larger role?).

Schedule

It is proposed that this program be conducted for three years. The proposed annual schedule of implementation of program tasks is presented in the Table below:

Task	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1 Project Coordination	X	X	X	X	X	X	X	X	X	X	X	X
2 Field Studies												
a Limnological Sampling		XX	XX	XX	XX	XX	XX					
b Limnetic Fish Surveys							XX					
4 Reporting												
a Data analysis					X	XX	XX	XXX	XXX	XXXX		
b Draft Report											XXXXX	
c Final Report											XXXXXXX	

Budget

The total estimated cost of the Seton Lake Reservoir Aquatic Productivity Monitoring is $300,150 The annual estimated budget is $100,050. The estimated budget breakdown by task is provided in the Table below:

Task				Expenses	Labour	Total
1.	Project Coordination			0	1,750	1,750
2.	Field Studies					
	a.	Limnological Sampling		53,640	16,000	69,640
	b.	Limnetic Fish Surveys		11,196	7,200	18,396
	c.	Misc Field Expenses		1,000	0	1,000
3.	Reporting			0	4,500	4,500
4.	Contingency		5%	4,764	0	4,764
Total				70,600	29,450	100,050

Bridge River Water Use Plan
Monitoring Program No. BRS-7

Downton Reservoir Fish Habitat and Population Monitoring

RATIONALE

Background

The Consultative Committee developed aquatic ecosystem objectives for Downton Reservoir that were established in terms of abundance and diversity of fish populations present in the reservoir. However, it was not possible, with the existing information on the Downton Reservoir ecosystem to develop explicit population level performance measures that directly reflected these objectives. Specific gaps in data and understanding were identified in: 1) the species composition, relative abundance, distribution and life history requirements of species of fish in the reservoir and adjacent tributaries; and 2) the relationship between operating parameters of the reservoir (i.e., maximum/minimum elevation, filling schedule) and the fish population response. Given the scope of these data gaps and the schedule of the Bridge River Water Use Plan it was not possible to required conduct studies in time available (1 year).

To provide required information for trade-off assessments, individual habitat-based performance measures related to specific key operating impacts for Downton Reservoir were developed. These performance measures independently assessed operating impacts that are believed to cause mortality or sublethal impacts to fish (stranding, entrainment, tributary backwatering) and trophic production required to support existing fish populations (littoral productivity, pelagic productivity). The application of the performance measures did help make trade-off decisions however they required an extensive amount of qualitative judgement about which factors were most important in the regulation of fish population abundance and diversity. As these judgements could not be supported with technical data, there remains significant uncertainty about how well the assessments actually reflect population response to different reservoir operating strategies as the relative importance of each impact factor is not currently known. To resolve these data gaps and uncertainties the Consultative Committee has therefore, recommended monitoring to obtain more comprehensive information on reservoir habitats and fish populations.

Management Questions

Key management questions that arose during the development of the Bridge River Water Use Plan associated with the influence of reservoir operation on fish populations in Downton Reservoir were associated with three issues. First, currently there is relatively poor information on the basic biological characteristics of fish populations using Downton Reservoir and its tributaries. Significant information gaps exist for the species present, the abundance and productivity, seasonal changes in distribution, and fundamental life history characteristics. These data gaps result in fundamental uncertainty that influences appropriate choice and implementation of performance measures. Second, the relative importance of different operating parameters of the reservoir (minimum/maximum operating elevation, annual drawdown, reservoir fill schedule) on the short and long term abundance of fish population. This created uncertainty about how to develop 1) develop appropriate performance measures to assess impacts on the fish populations, and 2) to weigh different performance measures in the assessment of alternative reservoir operating strategies.

Ultimately, these uncertainties influenced the choice of operating strategy in the following way. During winter, Downton Reservoir is typically drawn down to low levels and this is believed to cause stranding and entrainment impacts. As inflows are negligible during winter and available storage in the reservoir is at its annual lowest elevation, desired minimum instream flow releases from the reservoir to prevent dewatering of whitefish eggs in Middle Bridge River cannot be accommodated without "deep" drawdown of the reservoir. Deep drawdowns cause concern for Downton fish populations through increased stranding and entrainment impacts. Studies have demonstrated that low reservoir elevations are known to increase entrainment and stranding rates of rainbow trout from the reservoir, but the population level impacts are not clear. Understanding what the minimum critical elevation where unacceptable rates of stranding and/or entrainment impacts occur and whether there is a long term population level impact from periodic deep drawdown were identified as the critical management issues.

The primary management questions addressed by the proposed monitoring program are:

1. What are the basic biological characteristics of fish populations in Downton Reservoir and its tributaries?

2. Will the selected alternative (N2-2P) result in positive, negative or neutral impact on abundance and diversity of fish populations?

3. Which are the key habitat factors that contribute to reduced or improved productivity of Downton Reservoir fish populations?

4. Is there a relationship between the minimum reservoir elevation and the relative productivity of fish populations?

5. Do periodic deep drawdowns result in long term impacts on rainbow trout populations?

6. Can refinements be made to the selected alternative to, without significant impact to instream flow conditions in the Middle Bridge River, improve habitat conditions or enhance fish populations in Downton Reservoir?

Detailed Hypotheses about the Impacts of Downton Reservoir Operation on Fish Populations

The primary hypothesis (and subhypotheses) associated with these management questions are:

H1: The abundance and diversity of Downton Reservoir fish populations are limited by habitat impacts directly related to the operation of the reservoir.

H_{1A}: Operation of the reservoir at low elevations reduces fish abundance due to stranding.

H_{1B}: Operation of the reservoir at low elevations (i.e <718 masl) causes significant rates of fish entrainment from the reservoir.

H_{1C}: Operation of the reservoir restricts the amount of available effective spawning habitat in tributaries and this limits the productivity of fish populations.

H_{1D}: Operation of the reservoir at low elevations reduces aquatic productivity and this results in reduced abundance and diversity of fish populations in Downton.

Each of these hypotheses could have significant consequences for the predicted impacts of operations on fish, however, they could not resolved with scientific data during the Water Use Plan and professional judgement and experience from other reservoirs was used to help support critical trade-off decisions. In particular hypotheses H_{1A} and H_{1B} were critical in making decisions about the final chosen operating alternative for the Bridge River Water Use Plan.

Key Water Use Decision Affected

Downton Reservoir is a component in the Bridge River system as it provides the additional storage capacity above that provided by Carpenter Reservoir required to manage inflows to the upper Bridge River watershed. Power modelling conducted for the Water Use Plan development determined that managing spills to desirable levels requires the flexibility to utilize of the full capacity of Downton Reservoir to capture inflows by placing few restrictions on the minimum and maximum annual operating elevation. This modelling also highlighted a critical trade-off between the capability to provide minimum instream flow releases in the Middle Bridge River downstream of La Joie Generating station (650 cfs). Provision of the 650 cfs minimum flow is desired to reduce egg dewatering and fish stranding, particularly during winter and spring periods when the reservoir is typically at the minimum annual elevation. Maintaining this minimum flow requires drawdown of Downton Reservoir below levels at which previous studies have identified as a critical threshold for fish entrainment (718 m) and fish stranding in the reservoir. Acknowledging this trade-off the Consultative Committee explicitly placed a higher priority on provision of instream flow in Middle Bridge River allowing Downton Reservoir to be periodically lowered to a minimum elevation of 710 m. This decision was based on the assumptions that 1) egg dewatering and fish stranding have a significant impact on fish populations in Middle Bridge River; 2) the relative frequency of this magnitude of reservoir drawdown was limited to less than 10% of years (i.e., 1 in 10), and 3) that compensatory population processes will buffer any adverse impacts of reservoir operation on the fish populations.

The primary water use decision addressed in this monitoring program will be the selection of an acceptable minimum reservoir operating level for Downton Reservoir. It is also critically linked to the management of instream flow releases from the reservoir into the Middle Bridge River. Implementation of the proposed monitoring program in Downton Reservoir will provide information required to validate assumptions about fish populations respond to low reservoir elevations and whether these periodically low reservoir elevation periods have a long term impact on the abundance and diversity of reservoir fish populations. This information will is required to support the current operation or in the future to refine it by adjusting the acceptable minimum operating elevation for Downton Reservoir.

Monitoring Program Proposal

Approach

The general approach to this monitoring program will be to collect a comprehensive long term data set on fish populations and habitat conditions in Downton Reservoir to resolve current gaps in data about Downton Reservoir fish populations and scientific understanding about how drawdown influences fish population abundance and diversity. Collection of coincident information on reservoir operating parameters, habitat conditions and fish population information (age structure and abundance) will make it possible to identify changes in natural or normal population structure, and changes over time can be used to develop and test hypotheses about the relationship between habitat conditions and population response. This will be accomplished by:

1. Collecting time series information on the abundance and biological characteristics of resident fish populations and reservoir habitat conditions.

2. Correlation of abundance of younger ages of fish (recruitment) with reservoir operating parameters.

3. Implementing a "stock synthesis" approach to estimating recruitment anomalies associated with operating impacts, which combines age composition and relative trend data collected during monitoring to better define recruitment changes.

4. Examination of trends in growth or distribution changes with operations.

The advantage of this approach is that it provides an explicit method for linking habitat conditions created by implementation of reservoir operating parameters to response of fish populations. This linkage is important for water use planning decisions because it avoids many of the shortcomings and criticisms of habitat based approaches, and it provides assessments in the units for which the overall aquatic objectives are measured.

Methods

The proposed monitoring program has six primary tasks:

<u>Task 1 Project Coordination</u>

Project coordination involves the general administrative and technical oversight of the program. This will include, but not be limited to: 1) budget management; 2) staff selection; 3) logistic coordination; 4) technical oversight in field and analysis components, and 5) liaison with regulatory and First Nation groups.

<u>Task 2 Field Studies</u>

General Fish Population Index Surveys

General fish population index surveys are proposed to provide information on seasonal and inter-annual variation in the relative abundance, distribution and growth rate of all species in the reservoir fish community. Index surveys will b e implemented during spring (low pool) and fall (maximum pool) periods. Sampling index surveys will have two components and follow a stratified random design developed in pilot sampling conducted in 2001. Standardized beach seine surveys will be conducted to quantify relative abundance of fish species and age classes occupying shallow water (depth <1 m) areas in the littoral zone. Standardized boat electrofishing surveys will be conducted in deeper areas of the littoral zone (depth 1-3 m) to index fish population utilizing nearshore habitats in the reservoir. Both surveys will be stratified by habitat types and longitudinal zones of the reservoir.

All fish collection efforts will be accompanied by detailed sampling of the biological characteristics of the fish populations and standardized habitat descriptions. All fish captured in the field program should be measured for weight/length, evaluated for sex and sexual maturity [as possible], and appropriate aging structures should be collected. Where possible individual coded tags will be applied to captured fish to provide information on movement patterns. Analyses of the biological information will include examination of weight-length relationships, length frequency, age struc ture, and patterns of growth of fish populations in each of the geographic zones of the study area. Habitat data collected at each index site should include factors that are considered significant to fish sampling. These include, but are not limited to: temperature, light intensity (ambient/in situ), depth, water flow velocity, bank type, meso-habitat type, proximity to cover, and any other factors deemed to be important to sampling gear efficiency or fish habitat use.

Tributary Spawner Surveys

Tributary spawner surveys are proposed to document the abundance and distribution of fish spawning in the tributaries of Downton Reservoir. The surveys will focus on rainbow trout as these species are most likely to be impacted by backwatering impacts in the reservoir. It is proposed that weekly surveys be conducted through the rainbow trout spawning period (June to early-August). Surveys will produce estimates of spawning abundance and spatial distribution of spawning sites. They also provide an independent estimate of relative abundance of rainbow trout needed to compare spawner enumeration, index, and absolute abundance methods.

Habitat Monitoring

To investigate the impacts of reservoir operation on fish populations supplemental habitat information will be collected during the fish sampling surveys. These include, but may not be limited to: 1) installation and maintenance of thermographs in key reservoir tributaries; 2) systematic monitoring of suspended sediment concentration from key tributaries; 3) seasonal limnological surveys to document temperature/oxygen profiles and light penetration/water clarity.

Task 3 Laboratory Analysis

To assist in assessing the productivity of reservoir fish populations, developing understanding of life history of each species, and ultimately modelling fish habitat-population dynamics field sampling include biological sampling of fish to collect growth structures (scales and/or fin rays) from fish. Laboratory analysis will be conducted to assessment of the age of specimens and allow development of relationships between size and age of fish. These data allow estimation of average growth rates of the different life stages and species of fish in the reservoir and gain better understanding of how different habitats or reservoir operating strategies influence fish growth rate.

Task 4 Data Analysis and Reporting

On an annual basis a detailed technical report of the findings of the program will be prepared for distribution. Data assemble and data analysis will be initiated upon completion of the field season and a draft report will be prepared for circulation to technical experts, regulatory agencies and interested stakeholders. Review comments will be incorporated as appropriate and a final report will be prepared.

Interpretation of Monitoring Program Results

Upon completion of 10 years of the program a syntheses report will be prepared for use in the next review of the Bridge River Water Use Plan. The syntheses will include, but may not be limited to:

1. Quantitative documentation of the basic parameters of the fish populations - The monitoring program will provide a comprehensive data set to establish abundance, diversity, distribution, growth rates, habitat use, and life history of fish populations in the Downton Reservoir. These data will be compared against a suitable benchmark for reservoirs/lakes in British Columbia to provide insight into the likely potential for improvement.

2. Review of the trends in relative abundance of the general fish community - The data collected will allow quantitative inferences in the trends in abundance of the key fish species in the reservoir in relation to the general operation of the reservoir and help determine if the implemented alternative, in general, had a positive, neutral, or negative impact on the abundance and diversity of reservoir fish populations. External factors unrelated to operations could affect fish populations. Data on these factors will also be collected and used to support inferences about the relationship between operational changes and the observed trends.

3. Examination of the influence of reservoir operating parameters on key species in the community - Analyses will be conducted on a life stage and species specific basis to determine if there is a statistical correlation between operating parameters of the reservoir (i.e., minimum elevation, maximum elevation, annual drawdown) and the abundance or growth. Quantitative inferences can then be drawn on the relative importance of the reservoir drawdown for reservoir fish in limiting population abundance and community diversity. The importance of these effects will be interpreted in light of the observed trends.

Schedule

It is proposed that this program be conducted for a duration of 10 years, with a formal review of the program after five years. The proposed annual schedule of implementation of program tasks is presented in the Table below:

Task	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1 Project Coordination	X	X	X	X	X	X	X	X	X	X	X	X
2 Field Studies												
a General Indexing			XXX			XXXX						
b Tributary Spawner Surveys			XXXXXXXXXXXXXXXXXXXXXXXXX									
c Habitat Monitoring	X	X	X	X	X	X	X					
3 Lab Analysis												
a Fish Aging								XXXXXXXXXXX				
4 Reporting												
a Data analysis									XXXXXXXXX			
b Draft Report										XXXXX		
c Final Report											XXXXXXX	

Budget

The total estimated cost of the Downton Reservoir Fish Habitat and Population Monitoring is $44,601 per year. The estimated budget breakdown by task is provided in the Table below:

Task			Expenses	Labour	Total
1.	Project Coordination		0	2,800	2,800
2.	Field Studies				
	a. General Indexing		13,252	13,750	27,002
	b. Tributary Spawner Surveys		3,294	4,050	7,344
	c. Misc Field Expenses		1,000	0	1,000
3.	Reporting		0	2,400	2,400
4.	Contingency	10%	4,055	0	4,055
Total			21,601	23,000	44,601

Bridge River Water Use Plan
Monitoring Program No. BRS-8

Seton Lake Reservoir Resident Fish Habitat and Population Monitoring

RATIONALE

Background

The Consultative Committee developed aquatic ecosystem objectives for Seton Lake Reservoir that are measured in terms of abundance and diversity of fish populations present in the lake. The Seton-Anderson watershed provides habitat for a wide range of anadromous and resident species which are valued from a commercial, recreational, and cultural perspective. There are relatively good information on the anadromous species that use the Seton-Anderson watershed and how these populations may be impacted by the diversion of water from the Bridge River watershed to the Seton-Anderson watershed. However, there is relatively poor understanding of the basic biological characteristics of resident fish species inhabiting the lake. The Consultative Committee viewed resident species to play a significant role in the functioning and overall productivity of the ecosystem, and are of special importance because they have long been valued by First Nations as a source of food and for the significant cultural values that they embody. While there has been no systematic studies or monitoring of these populations, observations and oral testimony from First Nations people in the area have suggested that there has been a significant decline in the abundance of resident species associated with the operation of the Bridge River Generating Station.

With limited opportunity for field studies during the Bridge River Water Use Plan development (one field season) it was not possible to conduct the required studies to understand the basic habitat requirements and life history of these fish populations. During the Bridge River Water Use Plan it was also decided that potential changes in the way that Seton Lake Reservoir is currently operated (operating range ~0.4 m) would not be considered because of physical constraints associated with discharge facilities and the power canal at Seton Dam. Thus, the primary operating change possible in Seton Lake Reservoir was considered to be the seasonal timing of diversion from Carpenter Reservoir into Seton Lake Reservoir. Trade-off decisions to define the preferred operating alternative were made using generalized ecosystem level indicators rather than explicit performance measures. The general ecosystem indicators were : 1) expected changes in pelagic productivity in Seton Lake Reservoir associated with the Bridge River diversion and believed to be linked to the food base for resident species of Seton Lake Reservoir; and 2) the estimated transfer of suspended sediment which was hypothesized to impact the success of shore spawning species (e.g., kokanee or Gwenis). The application of the general performance measures allowed trade-off decisions to be made however they required an extensive amount of qualitative judgement about which factors limited fish population abundance and diversity. As these judgements could not be supported with technical data or observation, there remains significant uncertainty and risk associated with how well the assessments actually reflect resident fish population response to different operating strategies at Bridge Generating Station. To resolve these data gaps, reduce uncertainties, and reduce risk of further demise of resident fish populations the Consultative Committee recommended monitoring to obtain more comprehensive information on Seton Lake Reservoir habitats and the biological characteristics of the fish populations using them.

Management Questions

There are two key management issues that arose during the development of the selected operating alternative in terms of impacts to Seton Lake Reservoir resident fish populations. First, was the fundamental lack of any data to provide understanding of the relative species composition, relative abundance, habitat requirements, and life history was too sparse to develop credible conceptual models of the possible impacts of operations on the resident fish species. While the resident populations are currently believed to be a very low abundance, particularly in relation to those existing before the development of the water diversion project, it is not possible to determine whether the operation of the facility or its construction were the cause of the apparent decline in population levels. The Consultative Committee recognized that there is potential for operating impacts to have reduced populations, but were forced to use ecosystem level generalities about potential impacts (i.e., lower pelagic productivity means lower fish productivity) which in the end could not be strongly supported or refuted on a technical nor oral testimony basis. The assessments were accordingly viewed as highly uncertain, but it was recognized that it could not be rectified during the current Water Use Plan assessment process and further monitoring was required to close data gaps. The second issue is directly related to providing some assurance that the selected alternative would not have a negative impact on the resident populations. Accordingly, the Consultative Committee recommended that both of these issues be addressed though follow-up monitoring studies.

The primary management questions addressed by the proposed monitoring program are:

1. What are the basic biological characteristics of resident fish populations in Seton Lake Reservoir and its tributaries?

2. Will the selected alternative (N2-P) result in positive, negative or neutral impact on abundance and diversity of fish populations in Seton Lake Reservoir?

3. Is there a relationship between the quality, quantity, and timing of water diverted from Carpenter Reservoir on the productivity of Seton Lake Reservoir resident fish populations?

4. Can refinements be made to the selected alternative to improve habitat conditions or enhance resident fish populations in Seton Lake Reservoir?

Detailed Hypotheses about the Impacts of Bridge Generating Station Operation on Resident Fish in Seton Lake

The primary hypothesis (and subhypotheses) associated with these management questions are:

H1: The abundance and diversity of Seton Lake Reservoir fish populations are directly limited by habitat impacts directly related to the operation of the Bridge Generating Station.

H_{1A}: Diversions from Carpenter Reservoir reduce the temperature, light penetration, and euphotic volume of the reservoir.

H_{1B}: Daily fluctuations in Seton Lake Reservoir levels result in reduce effectiveness of shoreline spawning habitat.

H_{1C}: Daily fluctuations in Seton Lake Reservoir levels result in reduce effectiveness of spawning.

All of these hypotheses have significant consequences for the predicted impacts of operations on fish, however, they could not resolved with scientific data during the Water Use Plan and professional judgement and experience from other reservoirs was used to help support critical trade-off decisions. In particular hypotheses H_{1A} and H_{1B} were implicitly considered in making decisions about the final chosen operating alternative for the Bridge River Water Use Plan.

Key Water Use Decision Affected

This monitoring program will address two key decisions for the Bridge River Water Use Plan. First it will provide basic information about the resident fish populations in Seton Lake Reservoir and its tributaries from which to support stronger decision making capability for protection and possible enhancement of these highly valued populations. More comprehensive information on the habitat use, life history, and biology of the populations will support more thorough assessment of impacts. Second, the monitoring program will provide information to judge the relative impact of the implementation of selected alternative on trends in abundance and biological characteristics of resident species. Given the uncertainty associated with the assessment process the Consultative Committee therefore recommended follow-up monitoring to help provide assurance that unexpected negative impacts to these populations did not result from the selected alternative.

Monitoring Program Proposal

Approach

The general approach to this Seton Lake Reservoir Resident Fish Habitat and Population Monitoring Program will be to collect a comprehensive long term data set on fish populations and habitat conditions in Seton Lake Reservoir and its tributaries to resolve current gaps in data about resident fish populations and scientific understanding about how water diversion from Carpenter Reservoir influences fish population abundance and diversity. Collection of coincident information on reservoir operating parameters, habitat conditions and fish population information (age structure and abundance) makes it is possible to identify changes in natural or normal population structure, and changes over time can be used to develop and test hypotheses about the relationship habitat conditions and population response. This will be accomplished by:

1. Collecting time series information on the abundance and biological characteristics of resident fish populations and reservoir habitat conditions;

2. Correlation of abundance of younger ages (recruitment) of fish with reservoir operating parameters;

3. Implementing a "stock synthesis" approach to estimating recruitment anomalies associated with operating impacts, which combines age composition and relative trend data collected during monitoring to better define recruitment changes;

4. Examination of trends in growth or distribution changes with operations.

The advantage of this approach is that it provides an explicit method for linking habitat conditions created by operating parameters of the reservoir to response of fish populations. This linkage is important for water use planning decisions because it avoids many of the shortcomings and criticisms of habitat based approaches, and it provides assessments in the units for which the overall aquatic objectives are measured. The proposed monitoring program is expected to allow determination whether the proposed operation of Seton Lake Reservoir and Bridge Generating Station influences both the habitat conditions and populations of resident fish.

Methods

The proposed monitoring program has four primary tasks:

<u>Task 1 Project Coordination</u>

Project coordination involves the general administrative and technical oversight of the program. This will include, but not be limited to: 1) budget management; 2) staff selection; 3) logistic coordination; 4) technical oversight in field and analysis components; and 5) liaison with regulatory and first nations groups.

<u>Task 2 Field Studies</u>

General Fish Population Index Surveys

General fish population index surveys are proposed to provide information on seasonal and inter-annual variation in the relative abundance, distribution and growth rate of all species in the fish community. Index surveys will be implemented during spring and fall periods. Sampling index surveys will have two components and follow a stratified random design. Standardized beach seine surveys will be conducted to quantify relative abundance of fish species and age classes occupying shallow water (depth <1 m) areas in the littoral zone. Standardized boat electrofishing surveys will be conducted in deeper areas of the littoral zone (depth 1-3 m) to index fish population utilizing nearshore habitats in the reservoir. Two sampling methodologies are required because it has been shown that boat electrofishing is not effective on very small fish and it is problematic to navigate in depths <1 m. Both sampling methods will be stratified by habitat types and longitudinal zones of the Seton Lake Reservoir.

All fish collection efforts will be accompanied by detailed sampling of the biological characteristics of the fish populations and standardized habitat descriptions. All fish captured in the field program should be measured for weight/length, evaluated for sex and sexual maturity (as possible), and appropriate aging structures should be collected. Where possible individual coded tags will be applied to captured fish to provide information on movement patterns. Analyses of the biological information will include examination of weight-length relationships, length frequency, age structure, and patterns of growth of fish populations in each of the geographic zones of the study area. Habitat data collected at each index sites should include factors that are considered significant to fish sampling. These include, but are not limited to: temperature, light intensity (ambient/in situ), depth, water flow velocity, bank type, meso-habitat type, proximity to cover, and any other factors deemed to be important to sampling gear efficiency or fish habitat use.

Tributary and Beach Spawner Surveys

Tributary and beach spawner surveys are proposed to document the abundance and distribution of fish spawning in the tributaries of Seton Lake as well as beaches in Seton Lake Reservoir. The surveys will focus on kokanee (Gwenis), rainbow trout, and bull trout as these species are most likely to be impacted by backwatering impacts in the reservoir. As there currently is no information on possible kokanee salmon spawning locations it is proposed in the first year of study extensive tributary and lake surveys will be conducted to identify potential spawning locations. To the extent possible in the first year, and for all subsequent years weekly surveys be conducted through the spring rainbow trout spawning period (June to early-August), and the fall-winter spawning periods of kokanee (Gwenis) and bull trout. Surveys will produce estimates of spawning abundance and spatial distribution of spawning sites. They also provide an independent estimate of relative abundance of rainbow trout needed to compare spawner enumeration, index, and absolute abundance methods.

Habitat Monitoring

To investigate the impacts of reservoir operation on fish populations supplemental habitat information will be collected during the fish sampling surveys. These include, but may not be limited to: 1) installation and maintenance of thermographs in key reservoir tributaries; 2) systematic monitoring of suspended sediment concentration from Bridge generating station and key tributaries; 3) seasonal limnological surveys to document temperature/oxygen profiles and light penetration/water clarity; 4) a bathymetric survey of Seton Lake Reservoir to identify possible shoal spawning locations for kokanee (Gwenis).

Task 3 Laboratory Analysis

To assist in assessing the productivity of Seton Lake Reservoir resident fish populations, developing understanding of life history of each species, and ultimately modelling fish habitat-population dynamics field sampling include biological sampling of fish to collect growth structures (scales and/or fin rays) from fish. Laboratory analysis will be conducted to assess the age of specimens and allow development of relationships between size and age of fish. These data allow estimation of average growth rates of the different life stages and species of fish in the reservoir and gain better understanding of how different habitats or reservoir operating strategies influence fish growth rate.

Task 4 Data Analysis and Reporting

On an annual basis a detailed technical report of the findings of the program will be prepared for distribution. Data assemble and data analysis will be initiated upon completion of the field season and a draft report will be prepared for circulation to technical experts, regulatory agencies and interested stakeholders. Review comments will be incorporated as appropriate and a final report will be prepared.

Interpretation of Monitoring Program Results

Upon completion of 10 years of the program a syntheses report will be prepared for use in the next review of the Bridge River Water Use Plan. The syntheses will include, but may not be limited to:

1. Quantitative documentation of the basic parameters of the fish populations - The monitoring program will provide a comprehensive data set to establish abundance, diversity, distribution, growth rates, habitat use, and life history of resident fish populations in the Seton Lake and its tributaries. These data will be compared against a suitable benchmark for reservoirs/lakes in British Columbia to provide insight into the likely potential for improvement.

2. Review of the trends in relative abundance of the general fish community - The data collected will allow quantitative inferences in the trends in abundance of the key fish species in the reservoir in relation to the general operation of the reservoir and help determine if the implemented alternative, in general, had a positive, neutral, or negative impact on the abundance and diversity of reservoir fish populations. External factors unrelated to operations could affect fish populations. Data on these factors will also be collected and used to support inferences about the relationship between operational changes and the observed trends.

3. Examination of the influence of reservoir operating parameters on key species in the community - Analyses will be conducted on a life stage and species specific basis to determine if there is a statistical correlation between operating

parameters of the reservoir (i.e., minimum elevation, maximum elevation, annual drawdown) and the abundance or growth. Quantitative inferences can then be drawn on the relative importance of the reservoir drawdown for reservoir fish in limiting population abundance and community diversity. The importance of these effects will be interpreted in light of he observed trends.

Schedule

It is proposed that this program be conducted for a duration of 10 years, with a formal review of the program after five years. The proposed annual schedule of implementation of program tasks is presented in the Table below:

Task	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1 Project Coordination	X	X	X	X	X	X	X	X	X	X	X	X
2 Field Studies												
a General Indexing			XXX			XXXX						
b Tributary Spawner Surveys			XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX\									
c Habitat Monitoring	X	X	X	X	X	X	X	X	X			
3 Lab Analysis												
a Fish Aging								XXXXXXXXXXX				
4 Reporting												
a Data analysis									XXXXXXXXX			
b Draft Report										XXXXX		
c Final Report											XXXXXXX	

Budget

The total estimated cost of the Seton Lake Reservoir Fish Habitat and Population Monitoring is $49,986 per year. The estimated budget breakdown by task is provided in the Table below:

Task		Expenses	Labour	Total
1. Project Coordination		0	2,800	2,800
2. Field Studies				
a. General Indexing		13,252	13,750	27,002
b. Tributary Spawner Surveys		5,490	6,750	12,240
c. Misc Field Expenses		1,000	0	1,000
3. Reporting		0	2,400	2,400
4. Contingency	10%	4,544	0	4,544
Total		24,286	25,700	49,986

Bridge River Water Use Plan
Monitoring Program No. BRS-9

Seton River Habitat and Fish Monitoring
(Hydraulic Habitat, Redd Dewatering, Gravel Mapping, and Population Monitoring)

RATIONALE

Background

A critical environmental concern expressed throughout the development of the Bridge River Water Use Plan was the development of an acceptable instream flow regime for Seton River. The Consultative Committee set environmental objectives for Seton River that are measured in terms of the abundance and diversity of fish populations using the river. Seton River is well known to provide spawning and rearing habitat to several anadromous (chinook, coho, pink salmon, steelhead) and resident species (bull trout, whitefish, rainbow trout). However, there are relative poor data to describe the biological characteristics of the population in terms of the abundance, productivity, and life history. The available information relating these biological data to habitat use and the expected way the flow regime will influence the fish populations is even poorer.

To evaluate alternative instream flow regimes for Seton River, performance measures were developed to reflect the quality and quantity of the spawning and rearing habitats for several selected key species and life stages, with assumptions that this ultimately is related to population abundance and diversity. Performance measures were developed in a phased manner. Initially, physical habitat simulation models developed in earlier efforts to resolve instream flow issues at Seton River were applied to investigate the effect of instream flow regime on the rearing and spawning phases of key anadromous species. Discussion of model output lead to uncertainty about the use of the physical habitat simulation approach for establishing the flow regime and the desire to manage the instream flow releases to provide more naturalized conditions in the river. There was consensus that the physical habitat modelling was flawed because: 1) it did not account for all physical or biological factors influencing the productivity of the fish populations, and 2) there was insufficient spatial resolution to confidently extrapolate habitat conditions to the entire river. This uncertainty resulted in the development of new fish performance measures that reflected the degree to which the hydrograph shape and magnitude conformed to that observed prior to operation of the Bridge River diversion. Application of these new performance measures was also found to be problematic because there is no objective way to weight the value of conformity of the different measures of the "natural hydrograph." With increasing acknowledgement of technical uncertainty, performance measure development progressed in a recursive fashion, where there was a trend from very detailed mechanistic analysis of habitat conditions, to criteria for naturalize conditions, and finally to the application of simple three stage (i.e., 0-bad, 1-OK, 2-better) qualitative scoring system.

Despite the central role that Seton Dam flow releases play in development of the Bridge River Water Use Plan, the fish habitat performance measures for Seton River fish populations remained uncertain. The simple measures did ultimately allow trade-off decisions to be made to select the final alternative (N2-2P). The Consultative Committee expressed concern about uncertainty how habitat changes would influence fish abundance and diversity. Given poor baseline data on habitat and populations in Seton River, the Consultative Committee recommended implementation of habitat and population monitoring studies to help validate or refute the selection of the hydrograph and to provide information needed to develop more certain and effective performance measures for future water use planning purposes.

Management Questions

The four primary management questions were identified in discussion of the effects of the flow regime on fish habitat in Seton River were:

1. What are the basic biological characteristics of the rearing and spawning populations in Seton River in terms of relative abundance, distribution, and life history?

2. How does the proposed Seton River hydrograph influence the hydraulic condition of juvenile fish rearing habitats in downstream of Seton Dam?

3. What is the potential risk for salmon steelhead redd dewatering due to changes in flow between spawning and incubation periods imposed by the Seton hydrograph?

4. How will the Seton River hydrograph influence the short term and long term availability of gravel suitable for use by anadromous and resident species for spawning and egg incubation?

Small changes in flow can have considerable impact on the hydraulics (depth, velocity) in the mainstem river channel. Similarly, the impacts of high flow levels on juvenile fish was assumed to be buffered by 1) overflow of the mainstem into sidechannels that provide favourable habitat for juvenile and subadult fish; 2) a possible "dynamic equilibrium" of suitable hydraulic conditions (i.e., for different flow levels there is a fixed volume of hydraulic habitat that conforms to tolerances or preferences of small fish). There was concern that seasonal changes in flow regime between the spawning period and the emergence of larvae could similarly impact the potential for redd dewatering. The potential for dewatering is largely unknown because of the dependence on where fish deposit eggs, the interaction between channel geometry and the observed flow regime. The selected hydrograph may also impact on the quantity of suitable gravel for spawning because 1) there little (if any) gravel recruitment to the river channel below the dam; and 2) the implemented hydrograph may result in river discharges that mobilize spawning gravel. In combination, redd dewatering and gravel mobilization erode the quantity and effectiveness of spawning habitats in the river.

To obtain improved understanding of the operational impacts of the implementation of the Seton River hydrograph on fish habitat, the Consultative Committee recommended the implementation of a study to assess how the implemented hydrograph performed with respect to critical habitat issues. The recommended focus of this monitoring was: 1) documenting the hydraulic conditions in the river that are provided by the hydrograph; 2) collect further information on juvenile fish habitat use in the Seton River as it pertains to flow; 3) monitor the salmon and steelhead spawning locations to assess the potential for redd dewatering impacts; and 4) monitoring changes in quantity and spatial location of gravel suitable for fish spawning. The purpose is to document how the implemented hydrograph influences habitat and to gain further information useful in the refinement of future performance measures for fish resources in Seton River.

Detailed Hypotheses about the Hydraulic Impacts of Seton Dam Operation on Fish Habitat

Three primary null hypotheses (and subhypotheses) associated with these management questions are:

H_1: The amount of hydraulic habitat that can be inhabited be juvenile fish is dependent on discharge rate from Seton Dam.

H_{1A}: Juvenile standing crop biomass per unit area is inversely related to flow velocity.

H_{1B}: Juvenile standing crop biomass per unit area is independent of flow depth.

$H_{1C:}$ Juvenile standing crop biomass per unit area is independent of both flow velocity and depth.

H_2: The selected Seton River hydrograph does not result in dewatering of salmon or steelhead redds.

H_3: The selected Seton River hydrograph does not result in mobilization of gravel nor net loss of gravel from the system.

Each of these hypotheses could have significant consequences for the predicted impacts of operations on fish, however, they could not resolved during the Water Use Plan. This is because the technical data to do so do not exist and there is some expected to be inter-annual variation in the hydrograph, which could not be predicted with the power modelling studies. Data from the program will be collected to explicitly test these null hypotheses.

Key Water Use Decision Affected

Seton Dam is a 'hydraulic bottleneck' in the Bridge-Seton system, and changes in the operation of the dam (i.e., instream flow release) have considerable upstream impact on the management of Carpenter and Downton Reservoir. This hydraulic characteristic has two practical consequences. First, there are periodic high flows in the river that are necessitated by water management concerns. For example, in high inflow years water is managed in the system to prevent excessive flow releases from Terzaghi Dam which result in power losses as well as environmental impacts. Because Seton power canal imposes a limitation on water that can be "generated" out of the system water management requires release of water discharge rates that are greater than that thought to be beneficial for fish. Second, variable inflows patterns to the system the Seton River on seasonal and inter-annual basis, have resulted in highly variable and unpredictable changes in flow in Seton River which are believed to reduce the productive capacity of the habitat. Implicit in the decision to select a given operation is a trade-off between providing instream flow regimes to protect/enhance fish resources in Seton River and expected riparian performance in Carpenter Reservoir. This trade-off was pervasive during the development of the Bridge River Water Use Plan. There was great uncertainty in making this trade-off so this monitoring program directly addresses this uncertainty. Follow-up monitoring was recommended by the Consultative Committee so that better estimates of the impacts of alternative flow regimes could be made and this would support more informed decisions about this trade-off in the future.

Monitoring Program Proposal

Approach

The general approach to this monitoring program will be to conduct field studies to provide three critical pieces of information improving the capability to make wise decisions regarding flow management at Seton River. First, field studies will provide direct observation of key uncertainties about the impacts of the hydrograph on the quality of juvenile habitats, redd dewater, and gravel scour in the river channel. Second these data collection of habitat and population data simultaneously will allow more reliable judgements about the short term impacts of habitat alteration on population abundance and diversity. Finally, the monitoring studies will provide the time series data on juvenile and adult populations that allow long term inferences about the effect of the flow regime on population abundance and diversity.

The approach to the work will be to collect coincident habitat and population information on Seton River fish populations, and use this information to better understand the effects of the flow regime on critical habitat characteristics and to relate how habitat conditions influence habitat use and relative productivity. Supplemental topographic information will first be collected to add to the current topographic database to allow development of a digital elevation model of the system. The spatial referencing approach is critical for linking and managing data associated with the hydraulic modelling, rearing habitat observations, spawner enumeration, redd dewatering observations, and gravel mapping components of the proposed program. Since Seton River is relatively short, and much of the topographic data and recent airphotos currently exist, this can be accomplished at low cost. Annual surveys will be conducted to 1) index population abundance and distribution in relation to habitat conditions 2) quantify redd dewatering; and 3) quantify/map changes in spawning gravel location. These surveys contribute to the overall data base, which is integrated, analyzed and stored in the GIS system (ARCVIEW). Annual data reports will be produced to summarize methods and results of each years' program and a final completion report will be completed to synthesize the results in terms of the hydrograph that was actually delivered during the monitoring period.

Methods

The proposed monitoring program has three primary tasks:

Task 1 Project Coordination

Project coordination involves the general administrative and technical oversight of the program. This will include, but not be limited to: 1) budget management; 2) staff selection; 3) logistic coordination; 4) technical oversight in field and analysis components; and 5) liaison with regulatory and First Nation groups.

Task 2 Field Studies

Supplemental Topographic Surveys, Basemap Development, and Hydraulic Modelling

A significant amount of topographic survey data is available for Seton River channel and floodplain, but this is insufficient to develop the base digital elevation model for spatial referencing of habitat information, redd locations, sediment mapping and hydraulic modelling. Topographic survey of the Seton River channel from Seton Dam to the Fraser River confluence will be conducted to develop fully geo-referenced GIS data bases appropriate for storing spatial (x,y,z) information on physical and biological data collected during the monitoring program. Building on past modelling efforts, a hydraulic model will then be developed (HEC RAS, Riv 2D) to allow linkage of habitat characteristics and local population abundance to river hydraulics. Together, the GIS basemap and hydraulic model provides data management and analysis required for the proposed project.

Rearing and Spawning Habitat Monitoring

Juvenile habitat use surveys will be conducted to collect quantitative information on habitat conditions and standing crop to better understand 1) extent of use of mainstem and sidechannels; and 2) factors that control habitat quality. Diurnal snorkel surveys will be used to describe habitat use in relation to hydraulic conditions and quantitative electrofishing will be used to evaluate patterns of growth (monthly) and fish habitat in terms of juvenile standing crop during fall. This information helps evaluate the outcome of the implementation of the Seton hydrograph, as well as provide information needed to develop future performance measures for rearing fish.

Spawner count and redd surveys will be conducted on a weekly basis during spawning migrations of key species (chinook, pink, coho). The focus of the monitoring is to provide better information on the abundance and distribution of the spawning fish in the system. Foot surveys will be conducted from Seton Dam to the confluence with the Fraser River to: 1) enumerate spawning fish; 2) document distribution; and 3) locate redds (GPS). At selected location of high redd density, continuous stage monitoring devices will be installed to follow the progression of the hydraulic conditions at the redd locations during the incubation period (i.e., when the hydrograph is descending to its minimum). With sufficient number of redds to follow, elevation referencing of the stage to the redds will allow statistical quantification of redd dewatering risks. Using annual redd locations from the entire Seton River, redd dewatering for the whole river can be estimated using the hydraulic model.

Annual gravel mapping surveys will be conducted to survey the extent of gravel movement resulting from the implementation of the Seton hydrograph. Annual topographic surveys will map the channel sediment composition during periods of low water. Assessment of changes in spatial location, composition, and total area of gravel suitable for salmon spawning will be attained through GIS. Annual surveys allow resolution of data needed to identify loss rate from the system, as well determine hydrograph specific characteristics that increase gravel loss rates. The data collected during this phase of the monitor will be used to determine whether there is a gravel transport issue and what the appropriate mitigative action is.

<u>Task 3 Reporting</u>

A detailed technical report of the findings of the program will be prepared for distribution. Data assemble and data analysis will be initiated upon completion of the field season and a draft report will be prepared for circulation to technical experts, regulatory agencies and interested stakeholders. Review comments will be incorporated as appropriate and a final report will be prepared.

Interpretation of Monitoring Program Results

Upon completion of the program a syntheses report will be prepared for use in the next review of the Bridge River Water Use Plan. The syntheses will include, but may not be limited to:

1. <u>More comprehensive description of the rearing and spawning habitat use and relative productive capacity of habitats in the Seton River</u> - Improved understanding of the patterns of habitat use and relative abundance of rearing and spawning fishes in the mainstem and sidechannel habitats in the Seton River will fundamentally provide a better basis for evaluating the current hydrograph and developing future performance measures.

2. <u>Assessment of Risk of Redd Dewatering</u> - A fundamental, yet uncertain, assumption of the Seton hydrograph is that it will not result in significant dewatering of salmon or steelhead redds. The proposed studies will provide a quantitative assessment of redd dewatering from field data as well as provide modelling platform for evaluating how alternative flow regimes result in risk of redd dewatering.

3. <u>Assessment of Influence of the Flow Regime on Gravel Mobilization</u> - Another fundamental uncertain assumption was that the implemented hydrograph would not cause significant mobilization and loss of gravel suitable for fish spawning from the system.

4. <u>Assessment in trends in abundance of juvenile and spawning fish in relation to the habitat conditions provided by the delivered instream flow regime</u> - Trend information can be interpreted to help understand whether the selected Seton hydrograph is has a positive, negative or undetectable impact on Seton fish populations.

Schedule

It is proposed that this program be conducted for a duration of 10 years, with a formal review of the program after five years. The proposed annual schedule of implementation of program tasks is presented in the Table below:

Task	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
1 Project Coordination	X	X	X	X	X	X	X	X	X	X
2 Field Studies										
a Topgraphic Survey/Calibration	XXX									
b Hydraulic Modelling										XXX
c Juvenile Habitat/Population Surveys	X	X	X	X	X	X	X	X	X	X
d Spawner Habitat/Population Surveys	X	X	X	X	X	X	X	X	X	X
e Gravel Mapping	X	X	X	X	X	X	X	X	X	X
3 Reporting										
a Annual Report	X	X	X	X	X	X	X	X	X	X
b Final Report										XXXX

Budget

The total estimated cost of the Seton River Habitat and Fish Monitoring is $482,772. The estimated standard annual cost of the program is $44,528/year. Note in the first and final year of the program additional budgets over the standard annual program are requested to follow the study plan. The budget breakdown by task and implementation years is provided in the Table below:

	Project Coord.	Topographic Survey and Mapping	Hydraulic Modelling	Juvenile Surveys	Spawner Surveys	Gravel Mapping	Annual Report	Final Report	Annual Total
Year 1	1,750	24,992	0	14,958	19,820	5,000	3,000	0	69,520
Year 2	1,750	0	0	14,958	19,820	5,000	3,000	0	44,528
Year 3	1,750	0	0	14,958	19,820	5,000	3,000	0	44,528
Year 4	1,750	0	0	14,958	19,820	5,000	3,000	0	44,528
Year 5	1,750	0	0	14,958	19,820	5,000	3,000	0	44,528
Year 6	1,750	0	0	14,958	19,820	5,000	3,000	0	44,528
Year 7	1,750	0	0	14,958	19,820	5,000	3,000	0	44,528
Year 8	1,750	0	0	14,958	19,820	5,000	3,000	0	44,528
Year 9	1,750	0	0	14,958	19,820	5,000	3,000	0	44,528
Year 10	1,750	0	7,500	14,958	19,820	5,000	3,000	5,000	57,028
Total	17,500	24,992	7,500	149,580	198,200	50,000	30,000	5,000	482,772

Bridge River Water Use Plan
Monitoring Program No. BRS-10

Carpenter Reservoir Productivity Model Validation and Refinement

RATIONALE

Background

Two fundamental environmental concerns in the development and selection of the final operating alternative were the effects of the operation of Carpenter Reservoir on aquatic production in the reservoir and the physical quality of the water diverted to Seton Lake Reservoir. It was hypothesized that there is a lack of suitable food resources in the cold and turbid reservoir to support healthy fish populations. In response to this concern, a detailed model was developed to predict how different reservoir operations influence physical conditions (i.e., flow velocity, suspended sediment concentration, and light penetration) for littoral and pelagic habitat conditions. Light penetration was identified as the key factor for the model because it was believed a critical variable in regulating primary and secondary productivity of glacially turbid lakes and reservoirs. It was also judged unfeasible to develop models that related the complex hydrodynamics of the reservoir to nutrient and temperature dynamics, because of cost and data availability. The light based model used predictions of light penetration with empirical correlation between light accumulation and standing crop of benthic or plankton organisms to predict the biomass dynamics of the food sources. Biomass dynamics was translated to production estimates through literature derived production/biomass ratios and used as independent performance measures for comparing alternative Carpenter Reservoir operating scenarios. The model also generated predictions of the seasonal changes in concentration of suspended sediment in water diverted into Seton Lake.

Management Questions

The Carpenter Lake Reservoir Productivity Model played a central role in the development of the operating strategy for Carpenter Reservoir and directly controlled predictions of pelagic productivity in Seton. The model was effective for performing trade-off analysis, however, three aspects of the model application remain uncertain. First, the model was developed and calibrated using sparse physical input data. Driving data for the model (i.e., flows and suspended sediment input from Downton Reservoir tributaries) and the model calibration data (suspended sediment data from the reservoir) were collected inconsistently over a small number of years and limited number of locations in the reservoir. Ideally a large number of locations should be monitored over many years to help fit the model under a full range of variation of inflow conditions. Second, benthic and zooplankton sampling is highly variable and a single season of sampling is unlikely to encompass the full range of variation in light and productivity correlation. More data collection is required to increase confidence in the empirical correlation approach, as well as test hypotheses about the relative contribution of nutrients and temperature to aquatic productivity. The final uncertainty relates to the differential importance of the littoral and pelagic components of the ecosystem to the fish food base. Clear understanding of the importance of littoral and pelagic food sources is needed as there are differential impacts of operation on pelagic and littoral habitats.

Detailed Hypotheses about the Impacts of Carpenter Reservoir Operation on Aquatic Productivity and Sediment Transport to Seton Lake

The fundamental assumption of the model was that light penetration was the fundamental driving force in determining productivity in the reservoir. Suspended sediment concentration, thus light penetration, is highly variable in the reservoir and was the assumed to be the physical factor which can most likely be influenced by reservoir operation. The primary hypotheses that relate to these management questions are:

H_1: Light is the primary factor regulating the productivity of littoral habitats in Carpenter Reservoir.

H_2: Light is the primary factor regulating the productivity of pelagic habitats in Carpenter Reservoir.

H_3: Light penetration in Carpenter Reservoir can be impacted by changes in reservoir operation.

H_4: Suspended sediment transport rates into Seton Lake Reservoir can be altered by changes in Carpenter Reservoir operation.

Key Water Use Decisions Affected

The refinement and validation of this model will influence the capability, reliability and confidence in predictions about 1) how reservoir operation strategy influence aquatic productivity in Carpenter Reservoir; and 2) what the impact of Carpenter Reservoir operation is on aquatic productivity in Seton Lake.

Monitoring Program Proposal

Approach

The approach adopted for refining and validating the Carpenter Reservoir Productivity model is to undertake further data collection to provide more representative and reliable input data for driving the physical submodel and to conduct further field monitoring. This sampling will be linked to biological sampling to allow refinement of the physical and biological predictions, as well to permit validation of model components.

Methods

There are three general tasks proposed for the Carpenter Reservoir Productivity Model Validation and Refinement program. Each task is described below.

Task 1 Project Coordination

Project coordination involves the general administrative and technical oversight of the program. This will include, but not be limited to: 1) budget management; 2) staff selection; 3) logistic coordination; 4) technical oversight in field and analysis components; and 5) liaison with regulatory and First Nation groups.

Task 2 Field Surveys

Limnological Surveys

Carpenter Reservoir will be sampled six times (once monthly during the period May to October) at sample locations for physical, chemical, and biological variables. Biweekly surveys will be conducted a fixed 6-8 stations down the longitudinal axis of the reservoir. At each station profiles will be conducted to document suspended sediment concentration and composition, temperature, conductivity and light penetration. Continuous recording thermographs will be placed in key tributaries, and a thermistor chain will be anchored in the reservoir. Measurements of turbidity from La Joie Generating Station tailrace, Middle Bridge River, Hurley River, Gun Creek, Tyaughton Creek, and several smaller tributaries will be collected to document seasonal changes in suspended sediment input during these biweekly surveys. Physical data collection will also occur at the Bridge Generating Station to estimate seasonal variation of diversion water quality. This sampling approach will serve to provide detailed documentation temporal and spatial changes in the physical conditions in the reservoir that are key elements of the model. Chemical and biological variables will be collected at two stations to help link the influence of habitat conditions on chemical and biological differences. Chemical variables include: total suspended solids, turbidity, alkalinity, pH, silicate, total dissolved solids, nitrogen (nitrate, ammonia, particulate), phosphorus (total, particulate, soluble reactive), and carbon (dissolved inorganic, particulate). Biological variables include: bacterioplankton numbers, phytoplankton biomass (chlorophyll) and species composition, photosynthetic rates, zooplankton biomass and species composition. Methods and sampling locations for field studies will closely follow those conducted during 2000 and 2001 to further extend the database.

Littoral sampling

Littoral sampling proposed for the monitoring program will be design to build upon sampling efforts in Year 2000 employing the rapid assessment methodology. This method allows for the collection and rapid processing. Stratified sampling in relation to the progression of the reservoir are used investigate the relationship between habitat variables (light penetration, cover, vegetation etc.) and standing crop biomass of benthic organisms. Data collection in 2000 was incomplete to fully understand and quantify the relationship between light penetration, flow velocity, cover, and vegetation. The field studies conducted over the 3 year period will collect empirical data to quantify these relationship.

Model Validation

There will be two primary model validation tasks. The first relates to using the updated and more comprehensive model input data (suspended sediment, flow) from tributaries, more extensive data from within Carpenter Reservoir, and associated output sediment concentration from the Bridge Generating Station tailrace to refine model structure/parameters to obtain calibrated estimates of seasonal changes in suspended sediment concentration in the reaches of the reservoir as well as sediment load that is discharged into Seton Lake Reservoir. The second relates to the assembly and analysis of the additional field data to 1) use the additional field data to test predictions of the model with the field data; 2) use the additional field data to re-evaluate functional relationships between light and other habitat variables to observed benthic or pelagic standing crop biomass. This analysis will be implemented to test the quality of the 'old' model and to use the new data to refine either the structure and/or parameter estimates.

Task 3 Reporting

Upon completion of the three-year study program a detailed technical report will be prepared.

Interpretation of Monitoring Program Results

The Carpenter Reservoir Productivity Model was a critical element in helping to make trade-off decisions in the Bridge River Water Use Plan. A fundamental uncertainty in the trade-off analysis was how accurate and precise the predictions of how Carpenter Reservoir operations can impact conditions in the reservoir and how that effects biological productivity. In addition, this understanding will reduce uncertainty about the quality of water that is introduced into Seton Lake Reservoir. The results from this study will allow a significant reduction in uncertainty in addressing fundamental trade-offs and improve the quality of decisions in the planned Bridge River Water Use Plan review.

Schedule

It is proposed that this program be conducted for a duration of three years. The proposed annual schedule of implementation of program tasks is presented in the Table below:

Task	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1 Project Coordination	X	X	X	X	X	X	X	X	X	X	X	X
2 Field Studies												
a Limnological Sampling		XX	XX	XX	XX	XX	XX					
b Littoral Surveys			XX	XX		XX						
c Physical Surveys			X	X	X	X	X	X	X			
d Model Validation Analyses												
3 Reporting										XXXXXXXXXXXXXX		

Budget

The total estimated cost of the Carpenter Reservoir Productivity Model Validation and Refinement is $300,387. The annual estimated budget is $100,129. The estimated budget breakdown by task for each year is provided in the Table below:

Task			Expenses	Labour	Total
1.	Project Coordination		0	1,750	1,750
2.	Field Studies				
	a. Limnological Sampling		29,820	8,000	37,820
	b. Littoral Surveys		21,524	9,100	30,624
	c. Physical Surveys		6,524	7,000	13,524
	d. Model Validation analyses		0	7,500	7,500
3.	Reporting		0	4,500	4,500
4.	Contingency	5%	4,411	0	4,411
Total			62,279	37,850	100,129

Bridge River Water Use Plan
Monitoring Proposal Study No. BRS-11

Lower Bridge River Adaptive Management Program:
Riparian Vegetation Monitoring

RATIONALE

Background

The Consultative Committee has recommended that adaptive management flow trials be conducted to determine the most appropriate instream flow releases to protect and enhance the aquatic and riparian ecosystem in Lower Bridge River, downstream of Terzaghi Dam. A 12-year program has been proposed to test three alternative instream flow release regimes (referred to as: 1 m^3/s/year, 3 m^3/s/year, 6 m^3/s/year) that do not differ in the relative shape of the delivered hydrograph, but rather the total magnitude of the flow regime in terms of annual water budget. Detailed monitoring of physical habitat, aquatic productivity, and fish population response has been proposed and is included in a separate proposals (Monitoring program BRS-1 and BRS–3).

Through discussion and development of the flow regimes to test and sequencing of the proposed flow regimes be tested, the Consultative Committee identified a concern that while the flow testing was focused on learning about the response of the aquatic ecosystem to instream flow management strategies the test program needed to explicitly evaluate the impacts of the flow regime on riparian habitat conditions. Since the temporal dynamics of the riparian plant community occur over much longer time scales than the aquatic community and the planned duration of each flow trial it was recognized that a full scale evaluation was not feasible. The Consultative Committee then recommended that a monitoring program be implemented to document the riparian community affected by the flow trials and how the changes in flow regime (or treatment) impacted the riparian community in terms of the spatial extent, relative recruitment rate of plant species, and the overall relative productivity of the riparian community.

Management Questions

The fundamental management questions addressed by the Lower Bridge River Riparian Vegetation Monitoring relate to: 1) the influence of instream flow regime on the spatial extent, species diversity, and relative productivity of the riparian community; 2) how the changes in riparian community and instream flow conditions influence the capability of the Lower Bridge River corridor to support wildlife populations. Higher flows will limit colonization of marginal areas because of exceedence of inundation thresholds and it is expected that lower flow levels will increase the spatial extent of riparian vegetation. However, it is also believed that very low flows may limit riparian vegetation because of insufficient groundwater or hyphoeric flow to support vegetation development or sustain high levels of productivity over the entire floodplain of the river.

Key uncertainties that have emerged are associated with the duration of the proposed flow trials. There is concern that the relatively short duration of the flow trials will not allow the full effects of flow regime to be expressed. The Consultative Committee recognized that it is was not practical to provide flow treatments at the required decadal scale to observe response of species such as cottonwood, so there was a need to develop some monitoring methods that could evaluate the short term response of plant species to flow changes. Examples of key short term response indicators were: sapling recruitment rate and growth rate. A second uncertainty was relating wildlife population response to the changes in riparian conditions. The Consultative Committee understood that the linkage between wildlife population productivity associated with riparian zones of rivers was not well documented nor understood. They also recognized that there are a large number of species that differentially depended on riparian habitats of the Lower Bridge River corridor at is was not feasible to consider all possible populations. Thus it was recommended that observations of wildlife habitat use be collected during the program and be used to support a subjective assessment of the influence of the alternative flow levels on key wildlife populations.

Detailed Hypotheses about the Impacts of Instream Flow on Riparian Vegetation in Lower Bridge River

The explicit hypotheses to be tested from the results of the monitoring program relate both to the entire community as well as focusing on differential success of annual and perennial species. These hypotheses include:

H_1: The spatial extent of riparian vegetation in the Lower Bridge River corridor is directly related to the magnitude of instream flow release from Terzaghi Dam.

H_2: The species composition of the riparian vegetation community in the Lower Bridge River corridor is directly related to the magnitude of instream flow release from Terzaghi Dam.

H_3: The relative productivity (standing crop biomass) of the riparian vegetation community in the Lower Bridge River corridor is directly related to the magnitude of instream flow release from Terzaghi Dam.

H_4: The relative rate of recruitment of annual plant species in the Lower Bridge River corridor is directly related to the magnitude of instream flow release from Terzaghi Dam.

H_5: The relative rate of growth of annual plant species in the Lower Bridge River corridor is directly related to the magnitude of instream flow release from Terzaghi Dam.

H_6: The relative rate of recruitment of perennial plant species in the Lower Bridge River corridor is directly related to the magnitude of instream flow release from Terzaghi Dam.

H_7: The relative rate of growth of perennial plant species in the Lower Bridge River corridor is directly related to the magnitude of instream flow release from Terzaghi Dam.

Key Water Use Decision Affected

The key water use planning decision affected by this monitoring program will be establishment of a long term instream flow regime for the Lower Bridge River that considers the overall aquatic and riparian objectives for the area. The objective the recommended program was to evaluate impacts of the flow trials on the riparian community and to use these data to help make predictions about the long term response of the plant community to each treatment level and to assess how these factors may impact on wildlife populations. Ultimately this information will contribute to the decision about the long term flow regime for the Lower Bridge River.

Monitoring Program Proposal

Approach

The proposed monitoring program will have three components: 1) aerial photograph analysis to estimate the change in riparian community that has resulted from the implementation of the 11-year flow testing program; 2) repeated transect surveys at fixed locations completed immediately prior to the initiation of each of the three proposed treatment levels at approximately four-year intervals, and 3) upon completion of the flow trials a dendrochronological survey will be completed to gather data needed to estimate changes in productivity of a key perennial species under each flow treatment level. The sampling design will be treated as a repeated measures design for sampling changes in riparian community associated with each of the planned flow levels. A baseline survey was conducted in 2000 which provided random site selection and baseline information for the "no flow release treatment" from Terzaghi Dam. Opportunistic observations of wildlife will be collected.

Methods

The proposed monitoring program has the following primary tasks:

<u>Task 1 Project Coordination</u>

Project coordination involves the general administrative and technical oversight of the program. This will include, but not be limited to: 1) budget management; 2) staff selection; 3) logistic coordination; 4) technical oversight in field and analysis components; and 5) liaison with regulatory and First Nation groups.

Task 2 Riparian Vegetation Mapping and Analysis

Aerial Photography

To assess the overall impacts of the adaptive management flow trials on riparian vegetation it is proposed that aerial photography prior to the implementation of the flow trials and immediately prior to proposed the review of the Bridge River Water Use Plan in approximately 11 years. Low level spatial geo-referenced colour air photos will be used to develop GIS based maps of the riparian vegetation and to compute changes in the spatial extent and location of vegetation occurring after 10 years. The observed patterns will be interpreted based on inundation frequencies imposed by the implemented reservoir operations and by site specific habitat conditions within the drawdown zone. This task is directly linked with proposed aerial photography for the Carpenter and Downton reservoirs vegetation monitoring programs, thus accomplished at very low cost.

Transect Surveys

Transect surveys are proposed to 1) to ground truth assessments of general changes in species composition occurring over the entire spatial area of the reservoir; 2) provide detailed geo-referenced topographic data of the transect; and 3) to provide a detailed assessment of the changes in species composition and relative productivity of riparian habitats resulting from the implementation each flow treatment level. During the baseline data collection in 2000, approximately 30 transect surveys were conducted in Lower Bridge River and in the adjacent Yalakom River to establish baseline conditions for species composition and elevation patterns of establishment associated with inundation history in the treated and a control area. The following activities are proposed for this task: 1) permanent benchmarking of the baseline transects to allow repeated surveys through time; 2) supplemental sampling at the baseline transects prior to the implementation of the operating regime to quantify relative riparian productivity (biomass sampling); 3) repeating baseline vegetation surveys (including the biomass sampling) after approximately 10 years; 4) based on the data collected undertake a quantitative assessment of the changes in species composition with particular attention to spatial changes in riparian vegetation along elevation gradients in relation to inundation history within the drawdown zone.

Dendrochronology

Field studies conduct during 2000 demonstrated the dendrochronology as a feasible method for evaluating the effects of river flow regime on relative productivity (measured as growth rate). Standard tree coring techniques are applied to measure growth increment of the trees based on annuli (i.e., tree ring) width. It is proposed that upon completion of the flow trials approximately 120 cores will be taken in Reach 2, 3 and 4 of Lower Bridge River as well as in the Yalakom River). These growth increments will be measured in the laboratory and then analyzed in relation to the flow regime.

Task 3 Reporting

A detailed technical report will prepared prior to the review of the Bridge River Water Use Plan that outlines the findings from the program as they relate to the primary components described above.

Interpretation of Monitoring Program Results

The data and information collect in the proposed monitoring programs would ultimately be used to assess the degree to which management objectives and technical expectations were met by the implementation of the operational change.

Upon completion of the program, a syntheses report will be prepared for use in the next review of the Bridge River Water Use Plan. The syntheses will include, but may not be limited to:

1. Quantitative assessment of the *long term changes* in spatial extent, species composition, and relative productivity of riparian vegetation in the Lower Bridge River corridor associated with the implementation of *all* of the flow trials.

2. Quantitative assessment of the *short term changes* in spatial extent, species composition, and relative productivity of riparian vegetation in the Lower Bridge River corridor associated with the *each one* of the implemented flow trials.

3. Quantitative assessment of the effect of instream flow regime on growth rate of key perennial species in the Lower Bridge River riparian corridor.

The results of the monitoring program can also be used to better support more inferences of the expected influence of instream flow regime on wildlife habitat conditions and permit more defensible conjecture about impacts of flow regime on abundance and diversity of wildlife populations.

Schedule

The schedule for the annual activities is necessarily phased to accommodate the requirements of the program. The work will primarily conducted in four years. The first year of the program will be utilized to obtain further required baseline data on the system. In Years 3, 7, and 11 specific activities are proposed to meet the goals of the program in relation to the timing of the flow trials. In the final year of the program immediately prior to the review of the Bridge River Water Use Plan, aerial photography and baseline vegetation transect surveys will repeated to allow a final assessment of observed changes in the riparian area in the Lower Bridge River corridor. The schedule for the proposed program is provided in the Table below:

Task	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11
1 Project Coordination	x	x	x	x	x	x	x	x	x	x	x
2 Vegetation Mapping											
a Aerial Photography/Analysis	x										x
b Transect Suveys	x		x				x				x
3 Dendrochronology											
4 Reporting											
a Draft Report	x		x				x				x
b Final Report	x		x				x				x

Budget

The total estimated cost of the Lower Bridge River Riparian Vegetation Monitoring Program for the 11-year period is $144,610. As a result of the phased nature of the program the annual budget requirement varies from $0 to a maximum of $78,935 in the final year of the program. The estimated budget breakdown by task and year is provided in the Table below:

	Project Coordination	Veg. Mapping	Veg. Transects	Dendro Chronology	Reporting	Total Cost
Year 1	2,625	12,000	7,660	0	2,500	24,785
Year 2	0	0	0	0	0	0
Year 3	2,625	0	15,320	0	2,500	20,445
Year 4	0	0	0	0	0	0
Year 5	0	0	0	0	0	0
Year 6	0	0	0	0	0	0
Year 7	2,625	0	15,320	0	2,500	20,445
Year 8	0	0	0	0	0	0
Year 9	0	0	0	0	0	0
Year 10	0	0	0	0	0	0
Year 11	2,625	12,000	15,320	38,990	10,000	78,935
Total	10,500	24,000	53,620	38,990	17,500	144,610

Bridge River Water Use Plan
Monitoring Proposal Study No. BRS-12

Bridge-Seton Metals and Contaminant Monitoring Program

RATIONALE

Background

It has been suggested that one possible impact of the construction and operation of dams and reservoirs in the Bridge-Seton watershed is the elevation of concentration of metals in the environment and the bioaccumulation of these metals in aquatic and terrestrial organisms. Limited tissue sampling in the Bridge-Seton reservoirs had demonstrated elevated concentrations of metals and contaminants in sediments and fish, and accordingly concern has been raised about the impacts of any operation change that is associated with the implementation of the Bridge River Water Use Plan.

Field studies were conducted during the development of the Bridge River Water Use Plan to: 1) gather additional data on metals and contaminants on water, sediment and fish tissue; 2) as possible, to provide information to develop an explicit performance measure for water use planning assessments that would predict the influence of proposed operational changes on metal and contaminant concentration in the physical environment and biota; and 3) to determine risks of adverse impacts to human health, specifically to local residents who rely on the fish resources for food. These studies provided better baseline data and some capability to provide qualitative predictions about changes in metals and contaminants resulting from operational changes, however, provided insufficient information to provide quantitative, reliable predictions. Given the possible impacts on the aquatic environment and human health, the Consultative Committee recommended that periodic monitoring of metal and contaminant concentration be conducted to document changes in water, sediment and fish tissue to: 1) ensure protection of health; and 2) to provide additional information required for future review of the Bridge River Water Use Plan.

Management Questions

The primary management questions addressed by the Bridge Seton Metal and Contaminant Monitoring program are:

1. Will the new operation defined by Alternative N2-2P result in a change to the concentration/distribution of metals and other contaminants in the water and sediments of reservoirs and rivers in Bridge-Seton System?

This question can be specifically related to: 1) the redistribution of metals and contaminants from Carpenter basin into the Seton basin; and 2) the impacts of the introduction of metals and contaminants from Carpenter Reservoir into the Lower Bridge River.

2. If redistribution of metals and contaminants occurs, will this result in an increased bioaccumulation of metals and contaminants in fish in the Bridge-Seton system?

Studies suggested that bull trout in Carpenter Reservoir currently have elevated levels which marginally exceed human health guidelines for consumption, however, lower concentrations were observed in rainbow trout and bull trout from Seton Lake Reservoir. This question relates to whether changes in operation ultimately will result in exacerbation of this issue in Carpenter Reservoir and increase concentration in fish tissues in Seton Lake Reservoir to the point where consumption of fish in Seton poses a human health risk.

Detailed Hypotheses about the Impacts of Reservoir Operation on Metals and Contaminant Concentration in Abiotic and Biotic Components of the Ecosystem

The fundamental question addressed by the monitoring program is whether the change in operation resulting from the implementation of the new operation will alter the concentration or distribution of metals and contaminants in the abiotic and biotic components of the ecosystem. The concerns have focused on three geographic areas within the Bridge River system and accordingly the monitoring hypotheses are:

H_1: Implementation of the chose alternative (N2-2P) will not increase metal concentration into abiotic or biotic components of the Carpenter Reservoir ecosystem.

H_{1a}: There is no significant increase in the concentration of metals and contaminants in water

H_{1b}: There is no significant increase in the concentration of metals and contaminants in sediment.

H_{1c}: There is no significant increase in the concentration of metals and contaminants in fish tissue.

H_2: Implementation of the chose alternative (N2-2P) will not increase metal concentration into abiotic or biotic components of the Lower Bridge River ecosystem.

H_{2a}: There is no significant increase in the concentration of metals and contaminants in water.

H_{2b}: There is no significant increase in the concentration of metals and contaminants in sediment.

H_{2c}: There is no significant increase in the concentration of metals and contaminants in fish tissue.

H_3: Implementation of the chose alternative (N2-2P) will not increase metal concentration into abiotic or biotic components of the Seton Lake Reservoir ecosystem.

H_{3a}: There is no significant increase in the concentration of metals and contaminants in water.

H_{3b}: There is no significant increase in the concentration of metals and contaminants in sediment.

H_{3c}: There is no significant increase in the concentration of metals and contaminants in fish tissue.

Key Water Use Decision Affected

The decision to select Alternative N2-2P was in part due to the assumption that there would be no change in the concentration and distribution of metals and contaminants in the abiotic and biotic components of the Bridge River system. If this assumption is not valid, then further consideration of the impacts of changes in concentration and distribution need to be more fully studied and incorporated into the decisions about the preferred operating alternative for the system.

Monitoring Program Proposal

Approach

The general approach to Bridge-Seton Metals and Contaminant monitoring is to conduct 4 periodic monitoring programs (2-year intervals) immediately following the implementation of Alternative N2-2P to track changes in concentration of metals in water, sediment, and fish tissues. The proposed program will follow the scientifically defensible protocol established in the Water Use Plan data collection studies (2000). The sampling is proposed for 2003, 2005, 2007, 2009, and the results will be analyzed prior to and be used for the planned Bridge River Water Use Plan review period (refer to the Schedule section below).

Methods

The proposed monitoring program has the following primary tasks:

Task 1 Project Coordination

Project coordination involves the general administrative and technical oversight of the program. This will include, but not be limited to: 1) budget management; 2) staff selection; 3) logistic coordination; 4) technical oversight in field and analysis components; and 5) liaison with regulatory and First Nation groups.

Task 2 Water and Sediment Sampling

Water and sediment sampling will be implemented at stations established in the Year 2000 studies. Water will be sampled at 10-15 stations within the Bridge-Seton watershed, following the sampling protocol established in the Year 2000 study. Sediment will be sampled at 15-20 stations were employed to provide adequate coverage of depositional areas within Downton Reservoir, Carpenter Reservoir, Seton Lake Reservoir, Anderson Lake, and Lower Bridge River. Replicate sediment samples will be collected with proven sample collection and handling techniques at each location. Water and sediment samples are to be transported to Vancouver and analyzed by a certified laboratory. The chemical analysis will include assessment of a suite of metals and contaminants using the ICAP scan and compared to existing guidelines and standards for aquatic protection and human health (CCME 1999), historical data from the Bridge-Seton watershed, and other regional databases.

Task 3 Fish Tissue Sampling

Destructive and non-destructive techniques will be implemented to collect fish tissue for metal and contaminant analysis. Destructive sampling will be implemented on abundant species as permitted by Ministry of Water, Land and Air Protection (tentatively mountain whitefish). Destructive sampling will allow analysis of a full range of metal and contaminant parameters. Non-destructive sampling will be implemented on less abundant and sensitive species (bull trout, rainbow trout). It will be accomplished by tissue biopsy methods that were tested and proven successful in the Year 2000 study. The bioposy method allows sufficient tissue to be extracted without causing or increasing the chances of mortality of fish, however, because of limitations of current analytical methods, can only be used for monitoring mercury contamination. Approximately 35-50 specimens of each species from Seton Lake Reservoir, Carpenter Reservoir, Anderson Lake, and Bridge River will be obtained to derive standardized concentrations of metals and contaminants. Because concentration is age- or size-dependent, specimens will be captured and selectively retained to allow a representative sample across possible age/size classes. The data will allow development of a relationship between fish age (i.e., size) and mercury concentration, where the slope of the log-log regression is the standardized concentration of mercury per kilogram of fish tissue. Fish will be captured using a variety of sampling techniques including angling, gill netting and boat electrofishing.

Task 4 Reporting

Technical data reports will be prepared upon the completion of each sampling program. A detailed technical report will prepared prior to the review of the Bridge River Water Use Plan that outlines the findings from the program as they relate to the primary components described above.

Interpretation of Monitoring Program Results

The data and information collected in the proposed monitoring programs will be used to assess temporal and spatial changes in metal and contaminant concentration in the Bridge-Seton watershed. The monitoring data will also provide an opportunity to examine the relative metal and contaminant concentration in water, sediment and fish tissue with other well studies systems in British Columbia and elsewhere.

Schedule

The schedule for the annual activities is necessarily phased to accommodate the requirements of the program. No data collection is recommended until the second year of implementation of the Bridge River Water Use Plan operating alternative. In Years 2 through 8, every other year, the sampling program will be implemented. In the year immediately prior to the review of the Bridge River Water Use Plan, a final syntheses report will be prepared for use in the review of the Bridge River Water Use Plan. The schedule for the proposed program is provided in the Table below:

Task	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
1 Project Coordination		X		X		X		X		
2 Water/Sediment Sampling										
3 Fish tissue Sampling		X		X		X		X		
4 Reporting		X		X		X		X		
a Interim Report		X		X		X		X		
b Final Report									XX	

Budget

The total estimated cost of the Bridge-Seton Metals and Contaminant Monitoring Program for the 10-year period is $160,170. As a result of the phased nature of the program the annual budget requirement varies from $0 to $39,030. The estimated budget breakdown by task and year is provided in the Table below.

	Project Coordination	Water Sediment	Fish Issue	Total
Year 1	0	0	0	0
Year 2	4,050	9,950	25,030	39,030
Year 3	0	0	0	0
Year 4	4,050	9,950	25,030	39,030
Year 5	0	0	0	0
Year 6	4,050	9,950	25,030	39,030
Year 7	0	0	0	0
Year 8	4,050	9,950	25,030	39,030
Year 9	4,050	0	0	4,050
Year 10	0	0	0	0
Total	20,250	39,800	100,120	160,170

APPENDIX H4: RELATIONSHIP OF MONITORING PROGRAMS, OPERATING STRATEGIES AND ENVIRONMENTAL OBJECTIVES

Table H4-1: Inter-relationship between the general operating strategy, key environmental objectives, priority issues to be addressed by monitoring for the Downton Reservoir (DOW) and Middle Bridge River (MBR)

[Note for the type of monitoring: E= studies conducted to determine the effectiveness of the operation for meeting environmental goals, L = studies conducted to fill data gaps, minimize uncertainty, and improve understanding of the effects of operating parameters on ecological resources; Fish/Aquatic = directed at fish or aquatic ecosystem productivity issues, and Veg= directed at riparian vegetation issues. The monitoring study reference number is associated with the rank priority of studies presented in Table H4-1].

Area	General Operating Strategy under Alternative N2-P	Environmental Objective	Key Questions Addressed by Monitoring	Type	Monitoring Study Reference No.
Downton Reservoir (DOW)	Maintain operational flexibility in DOW above a minimum reservoir elevation criteria (710 masl).	Riparian: Maintain or improve the quality and quantity of riparian habitats. Fish/Aquatic: a) Maintain or improve the current abundance of fish populations; b) obtain better information on effects of reservoir operation on fish populations.	1. Document whether the N2-P operation maintains quantity or quality of riparian habitats in DOW (protect Grizzly Flats).	E - Veg	No. BRS- 5
			2. Confirm the assumption that seasonal variation in reservoir levels do not cause a negative trend in abundance or diversity of fish populations in DOW.	E - Fish	No. BRS- 7
			3. Fill data gaps and understanding about the life history and abundance of DOW fish populations and how they are related to operating parameters of the reservoir.	L - Fish	No. BRS- 7
Middle Bridge River (MBR)	To implement DOW reservoir elevation dependent minimum flow schedule in MBR.	Riparian: None specified. Fish/Aquatic: a) Maintain or improve the current abundance of fish populations; b) obtain information on the effects of low flow on fish habitat.	1. Confirm the assumption that implementation of the N2-2P alternative does not cause a negative trend in abundance or diversity of fish populations in MBR or CAR.	E - Fish	No. BRS- 4
			2. Document quality of fish habitat conditions in MBR during shutdowns and low flow periods for fish, particularly when flow releases are less than the recommended minimum.	E - Fish	No. BRS- 4

Table H4-2: Interrelationship between the general operating strategy, key environmental objectives, priority issues to be addressed by monitoring for the Carpenter Reservoir (CAR) and Lower Bridge River (LBR)

[Note for the type of monitoring: E = studies conducted to determine the effectiveness of the operation for meeting environmental goals, L = studies conducted to fill data gaps, minimize uncertainty, and improve understanding of the effects of operating parameters on ecological resources; Fish/Aquatic = directed at fish or aquatic ecosystem productivity issues, and Veg= directed at riparian vegetation issues. The monitoring study reference number is associated with the rank priority of studies presented in Table H4-2].

Area	General Operating Strategy under Alternative N2-P	Environmental Objective	Key Questions Addressed by Monitoring	Type	Monitoring Study Reference No.
Carpenter Reservoir (CAR)	Maintain operational flexibility in CAR below maximum elevation criteria.	Riparian: Improve the quality and quantity of riparian habitats through operation changes and planting. Fish/Aquatic: a) Maintain or improve the current abundance of fish populations; b) to improve understanding of the effects of reservoir operation on fish populations.	1. Confirm/refute the assumption that ranges in variation in seasonal reservoir levels results does not cause a reduction in abundance or diversity of riparian communities surrounding CAR.	E - Veg	No. BRS- 2
			2. Confirm/refute the assumption that wide ranges in seasonal reservoir levels results do not cause a negative trend in abundance or diversity of fish populations in MBR or CAR.	E - Fish	No. BRS- 4
			3. Fill gaps in data and understanding of fish habitat use and life history of fish populations in CAR.	L-Fish	No. BRS- 4
			4. Fill gaps in data and understanding of influence of CAR reservoir operation on diversion water quality and productivity of aquatic ecosystem in the reservoir.	L-Aquatic	No. BRS- 10
Lower Bridge River (LBR)	To conduct flow trials to determine the response of the aquatic ecosystem to alternative flow releases.	Riparian: Maintain or improve the quality of riparian habitats. Fish/Aquatic: To ascertain the effect of flow on the productive capacity of the aquatic ecosystem.	1. Assess the short term impacts of the flow trials on riparian communities of LBR.	E- Veg	No. BRS- 11
			2. Monitor key ecosystem indicators to determine how alternative flow release strategies influence aquatic productivity, fish habitat, and rearing fish populations in LBR.	L –Fish	No. BRS- 1
			3. Assess the impacts of changes in flow on adult salmonids spawning habitats and populations in LBR.	L- Fish	No. BRS- 3

Table H4-3: Interrelationship between the general operating strategy, key environmental objectives, priority issues to be addressed by monitoring for the Seton Lake (SONL) and Seton River (SONR)

[Note for the type of monitoring: E = studies conducted to determine the effectiveness of the operation for meeting environmental goals, L = studies conducted to fill data gaps, minimize uncertainty, and improve understanding of the effects of operating parameters on ecological resources; Fish/Aquatic = directed at fish or aquatic ecosystem productivity issues, and Veg= directed at riparian vegetation issues. The monitoring study reference number is associated with the rank priority of studies presented in Table H4-3].

Area	General Operating Strategy under Alternative N2-P	Environmental Objective	Key Questions Addressed by Monitoring	Type	Monitoring Study Reference No.
Seton Lake (SONL)	Maintain current operational constraints in SONL.	Riparian: None specified. Fish/Aquatic: a) Maintain or improve the current abundance of fish populations; b) Improve understanding of the effects of diversion on productivity.	1. Obtain an improved understanding about operational impacts of Carpenter Reservoir diversion on aquatic productivity in Seton Lake.	L - Fish	No. BRS- 6
			2. Obtain a better understanding of the basic life history and abundance of resident fish populations utilizing Seton Lake.	L - Fish	No. BRS- 8
Seton River (SONR)	To implement a seasonally adjusted minimum flow release guideline (11/36) and naturalized hydrograph.	Riparian: None specified. Fish/Aquatic: 1) Improve the fish habitat and fish population abundance.	1. Fill data gaps about abundance and distribution of fish and fish habitat in SONR.	E - Fish	No. BRS- 9
			2. Obtain improved understanding about operational impacts (redd dewatering, gravel mobilization, rearing habitat, spawning habitat) associated with the implementation of the SONR hydrograph.	L - Fish	No. BRS- 9

APPENDIX I: LETTER FROM STL'ATL'IMX NATION

Stl'atl'imx Nation
Hydro Committee
Box 2218
Lillooet, B.C., V0K 1V0
tel: (250) 256 - 0425   Fax: (250) 256 - 0426
email address: SNHC@webside.ca

January 18, 2002

Lee Failing, Facilitator
Bridge-Seton Water Use Planning

Re: Consultative Committee
Final Report - Alternatives

Dear Ms. Failing,

At the meeting held on December 23, 2001, the SCC committed to providing a written letter outlining our concerns and/or agreement with the Water Use Planning Process for the Bridge-Seton system. This arises from the last meeting of the CC on December 3 & 4, 2001.

One of the key issues is defining full and informed consent for consultation and agreement.

To obtain full and informed consent, there are certain steps that are required:

- informed and notified of any plans/proposal contemplated by Government agency(ies)
- reach agreement on participation in all aspects of proposed activities, depending on the nature of the proposed activity
- where consultation is part of a process, a parallel process with the SCC may be required, as the SCC is not defined as a stakeholder
- resources for meaningful participation is required, both for Chiefs and/or technical support
- technical support is required to review reports and studies that are proposed or require review
- legal review may be required, including a review of the proposed process/project
- all communities impacted will require involvement in final decision/ratification
- timing of proposed process/project must consider limitations of community/tribe to respond
- decision-making process should be separate from stakeholders, if consultation
- approach to process/project must consider holistic nature or approach and any linkages to other similar activities
- others as identified by participants at the start/during the process

This list by no means limited to the above nor to be viewed as final requirements by a government agency(ies) as a consultation process for the Nation, nor does it limit in any way obligations of the defined process as outlined or replace the requirements of a consultation process. It is prepared as an example only.

Comments on other issues raised in the December 3 & 4, 2001 meeting.

Seton GS upgrade

The SCC has concerns with the elevation of water storage in Seton Lake, and question the right of BCH to store water in Seton Lake, as there is presently no license for storage. This matter has been raised with the Water Comptroller.

License changes

The SCC have concerns with revised or renewed licenses for BCH operations in Bridge System if issues relating to license issues are not resolved.

Management committee

The SCC and involvement in the management committee that will oversee the monitoring programs. The SCC want to see this management committee become part of the cooperative approach that is presently being reviewed by SCC/BCH/DFO with the intent to formalize a working relationship on most of the fisheries projects/programs in the Bridge System.

Review period

Generally agree with a review of the WUP process in the time period agreed to at the December 3 & 4, 2001 meeting.

Monitoring

Capacity building and management are key issues of proposed Cooperative Fisheries Agreement and the monitoring program must consider this and the involvement of the SCC is critical.

Other issues

Metal contamination and on-going monitoring of heavy metals in Seton Lake is critical. Spill response and the development of emergency plans is important.

These are some of the key issues for your review and consideration as you prepare the final report. Please contact the SNH office at (250)256-0425 should you require clarification on any of these matters.

Respectfully,

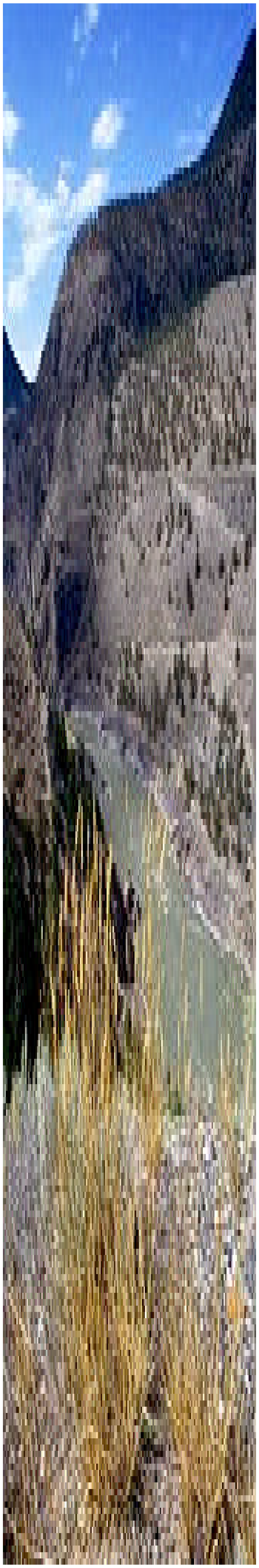
Chief Perry Redan,
Stl'atl'imx Chiefs Council, WUP representative.

APPENDIX J: STL'ATL'IMX TRADITIONAL ECOLOGICAL KNOWLEDGE

J1 Report on Exploring Traditional Stl'atl'imx Ecological Wisdom and its Application to Western Natural Resource Management Practices: Task One, Phase One

J2 Traditional Ecological Knowledge – Phase I Project and Workshop Outline

APPENDIX J1: REPORT ON EXPLORING TRADITIONAL STL'ATL'IMX ECOLOGICAL WISDOM AND ITS APPLICATION TO WESTERN NATURAL RESOURCE MANAGEMENT PRACTICES: TASK ONE, PHASE ONE



Report

on

EXPLORING TRADITIONAL STL’ATL’IMX ECOLOGICAL WISDOM AND ITS APPLICATION TO WESTERN NATURAL RESOURCE MANAGEMENT PRACTICES: TASK ONE, PHASE ONE

October 1, 2001

Submitted To:

Stl’atl’imx Nation Hydro Committee
PO Box 2218, 10 Scotchman Road,
Lillooet, BC
V0K 1K0

Submitted By:

Tanja Hoffmann, M.A.
Circa Heritage Consulting
918 Victoria Drive,
Vancouver, BC
V5L 4E9

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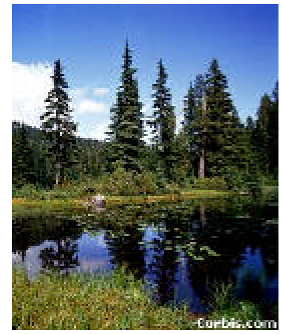
1.0

INTRODUCTION



1.0 INTRODUCTION

This report presents the preliminary results of the first task of phase one for the project titled "Exploring Traditional Stl'atl'imx Ecological Wisdom and its Application to Western Natural Resource Management Practices."

As outlined in the proposal for the above-captioned project, the tasks and deliverables for phase one are summarized in Table 1 below.

Table 1: Summary of Tasks and Deliverables for Phase One

Task	Method(s)	Deliverables
1. Complete Literature Review and Summary of Reports Identified in the TOR	➢ Conduct a review, data gap analysis, and critique of identified sources.	Provide a preliminary report / workshop material that identifies: ➢ information gaps, and discrepancies that may influence future water use planning processes, and, ➢ topics and priorities for exploration in the Technical Review Workshop.
2. Present the results of the Literature Review / Gap Analysis to the Stl'atl'imx and Bridge-Seton Consultative Committee	➢ Work with Stl'atl'imx Nation Hydro staff to prepare, organize and present a workshop.	➢ Deliver the workshop; ➢ Document the comments/feedback resulting from the workshop.
3. Produce a final report.	➢ Summarize the results of the literature review; ➢ Collate and summarize comments/recommendations stemming from the workshop; ➢ Provide draft report to Stl'atl'imx for review; ➢ Incorporate comments/ feedback in the report.	➢ Final report; ➢ Present results of final report to the Stl'atl'imx and the Bridge-Seton Consultative Committee.

1.1 Assumptions

A number of assumptions were used to guide the objectives and methodology of task one. These assumptions are outlined below.

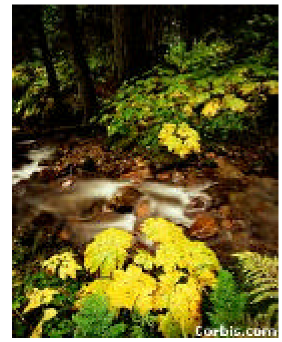
The following definition of "traditional ecological knowledge" (TEK) was used to guide the review of sources provided for this study: "a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings with one another and with their environment" (Berkes 2000 c.f. Failing 2000: 1). More specifically, Failing (2000: 7) noted that "for the purposes of water use planning (WUP), traditional knowledge refers to the knowledge and worldviews that aboriginal people bring to the process of planning for and reconsidering water flows and reservoir levels at hydroelectric facilities."

Informing this general and more project specific definition of TEK is Berkes (2000 c.f. Failing 2000: 6) comment that "whether a practice is traditional or contemporary is not the key issue. The important aspect is whether or not there exists local knowledge that helps monitor, interpret, and respond to dynamic changes in ecosystems and the resources and services that they generate." Thus, it is not the antiquity or the continuity of a practice that is necessarily the most important aspect of traditional knowledge, rather it is the ability of the community to respond to anticipated or unexpected environmental, social, or economic change.

For the purposes of this study, "traditional ecological knowledge" has been identified as a body of knowledge separate from other ways of

1.1

Assumptions



1.1

Assumptions Continued…

knowing. That is, by inserting the word "ecological" into the term, there is the assumption that "ecology" and knowledge thereof is distinguishable from "other kinds" (e.g. spiritual, social, political, economic etc.) of knowledge.

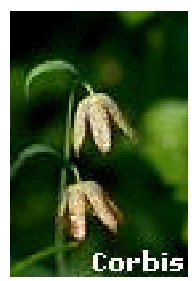
Since the primary objective of this project is to document TEK as it relates to water use planning (WUP) there exists the assumption that traditional knowledge regarding water and more specifically the watercourses included in the Bridge River WUP, can be separated from the wider realm of traditional knowledge. This assumption supposes that water-related knowledge can be viewed as a "component" of traditional knowledge.

A discussion of the implications of these assumptions is included in section 4.0 of this report.

1.2 Objectives

1.2

Objectives

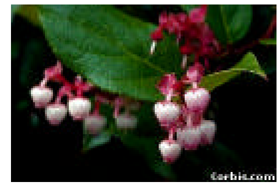


The objectives for Task One, Phase One are:

- to review and summarize knowledge pertaining to traditional ecological knowledge (TEK) documented in the following sources:
    - Arcas, 1999 "Stl'atl'imx Nation/BC Hydro Heritage Resources Study."
    - Deva Heritage Consulting, 1998 "Stl'atl'imx/Hydro Community Research Project: Final Report."
    - Summit Environmental Consultants (Summit), 1999[a], "Stl'atl'imx Nation Traditional Territory Environmental Studies: Fish, Wildlife, Traditional

1.2

Objectives Continued…



Food and Medicine, and Herbicide and Other Pesticide Use."

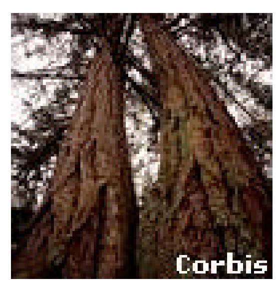
- ♦ Summit, 1999[b] "Stl'atl'imx Nation Oral Testimony Project: Sekwe'elw'as, Tl'it'kit, and Chalath Communities."
- ♦ VanDine, D.F. 1998 "Seton Lake Shoreline Impact Study Part II, St'at'imc Nation: Draft Report."
- ♦ VanDine, D.F. 1999 "Seton Lake Shoreline Impact Study St'at'imc Nation Part I: Seton Lake Water Levels, Final Report."

- ➢ to provide a critique the above-noted sources in terms of their application to the use of TEK in the water use planning (WUP) process;
- ➢ to provide a gap analysis that outlines where information gaps and discrepancies exist that may influence future water use planning processes;
- ➢ and finally, to recommend topics and priorities for exploration in the Technical Review Workshop.

2.0 METHODOLOGY

2.0

METHODOLOGY



The methodology consisted of a literature review intended to summarize and critically assess the knowledge documented in the sources listed above. The critique of these sources was not designed to assess the knowledge itself but rather to evaluate if the traditional knowledge, as it has been documented, could be used to inform the water use planning process. This included an analysis of the objectives, methodology, and results of each study.

3.0 PRELIMINARY RESULTS

The preliminary results of the literature review, critique and gap analysis are presented below.

3.1 Literature Review

A literature review of the report titled "Stl'atl'imx Nation/BC Hydro Heritage Resources Study (Arcas 1999)" revealed the following:

- The primary objective of the study was two-fold. First, the project sought to gather information that would inform a long-term cultural heritage management strategy for the Stl'atl'imx Nation. Second, the study attempted to identify impacts to archaeological sites in conflict with BC Hydro developments and activities.

- The methodological approach included a collation, summary and analysis of written and oral sources pertaining to the above-noted objectives. A ground-truthing component was also included as part of the project.

- The study results reveal that a number of significant archaeological sites are in conflict with BC Hydro developments. The field reconnaissance revealed a number of un-registered archaeological sites also in conflict with Hydro activities and facilities.

- Due to the archaeological focus of the Arcas study, no specific traditional ecological knowledge relating to the use and management as it pertains to the WUP was revealed. However, it should be noted that the study emphasized the connection Stl'atl'imx people maintain with their cultural heritage and the physical and spiritual context thereof (Arcas 1999: 49).

3.0

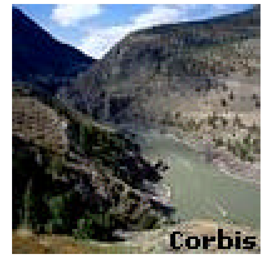
PRELIMINARY RESULTS

3.1

Literature Review

3.1

Literature Review Continued…



A review of Deva Heritage Consulting's (1998) report titled "Stl'atl'imx/Hydro Community Research Project: Final Report" revealed the following:

- The primary objective of the study was to collate, analyze and summarize oral testimony concerning impacts the establishment and operation of BC Hydro facilities had on Stl'atl'imx lands (with particular emphasis on reserve lands).

- The methodological approach to accomplish the above-noted objective included a review of existing documentation (both oral and written sources) and a series of interviews with Stl'atl'imx community members.

- The individuals interviewed for this study expressed major concerns relating to "the loss and changes in environment and habitat, and with that, the way of life and traditional activities that were lost" (Deva 1998: 2). Both general and specific concerns were communicated regarding impacts to the environment and wildlife habitat in the Bridge River valley and Seton Lake area, and about hunting, trapping, fishing, plant gathering, agriculture, trade, commerce, travel routes, heritage sites, medicine gathering places, sacred areas, and social and recreational values in other areas of Stl'atl'imx territory. Health issues relating to Hydro activities were also stressed by the knowledge-holders.

- While the majority of issues raised in the Deva (1998) study were in response to questions concerning Hydro impacts, there were several comments that could be directly or indirectly related to a water use planning. The first of these is the practice of controlled burning. Controlled burning of mountain sides was used by the Stl'atl'imx to improve plant production in areas of continual use

(Deva 1999: 25). While this practice may not relate directly to water use planning, it is an example of a type of "management prescription" that illustrates that the Stl'atl'imx were (and are) "managing" certain aspects of their environment for the benefit of their communities.

- One interviewee reports that the Elders created bodies of water and stocked them with fish for subsistence purposes. The interviewee noted that "There is a pond up here at Moon Creek where we use to fish for trout…I think there is hardly any now…It is just a home-made pond, the Elders made it and stocked it with fish, and they grew big" (10 c.f. Deva 1998: 34). This practice demonstrates that the Stl'atl'imx were not just adapting to changes in environment, but were altering the landscape to address subsistence or other purposes.

- While the reports of controlled burning and fish stocking are two clear methods via which the Stl'atl'imx adopted a proactive response to a changing environment, the Deva report also summarizes Stl'atl'imx observations of changes in species variety, demographics, and distribution. These observations are clearly based on an in-depth knowledge of these same characteristics in a pre-impact context. Thus, while only two examples of proactive management strategies are recorded, the depth and range of knowledge exhibited in comments relating to Hydro impacts indicates that more knowledge of these and other strategies exists in the Stl'atl'imx communities. This is particularly evident in discussions of various fish-related topics including fish spawning and species distribution.

3.1

Literature Review Continued…

The review of the report titled "Stl'atl'imx Nation Traditional Territory Environmental Studies: Fish, Wildlife, Traditional Food and Medicine, and Herbicide and Other Pesticide Use" (Summit 1999) revealed the following:

- The principal objective of the project was to provide BC Hydro and the Stl'atl'imx Nation Hydro Committee with a summary and review of existing information regarding fisheries, wildlife, traditional foods and medicines, and herbicide/pesticide use in Stl'atl'imx territory "in order to identify environmental changes in the Stl'atl'imx territory resulting from hydroelectric operations" (Summit 1999a: ii).

- The methodological approach included a literature review and analysis of existing documentary sources pertaining to the above-noted topics. Oral testimonies collected from Stl'atl'imx Nation community members during companion studies (Deva 1998, Summit 1999b) were integrated into the report.

- The report outlines the positive and negative effects BC Hydro operations and facilities had and have on the fisheries, wildlife, a and the traditional food and medicines in Stl'atl'imx territory. The report also summarizes potential and perceived health effects of Hydro operations on the Stl'atl'imx themselves.

- The results of the interviews emphasized the past and on-going connections the Stl'atl'imx maintain with their environment. The knowledge pertinent to the current study is summarized in the discussions of the above-noted companion reports (Deva 1998, Summit 1999b).

3.1

Literature Review Continued…

3.1

Literature Review Continued…

The review of Summit Environmental Consultants' (1999b) report titled "Stl'atl'imx Nation Oral Testimony Project: Sekwe'elw'as, Tl'it'kit, and Chalath Communities" revealed the following:

- The primary objective of the study was to interview Stl'atl'imx community members regarding resource use prior to and following BC Hydro presence in Stl'atl'imx territory.

- This objective was met through a series of tasks that included meeting with Stl'atl'imx Nation Hydro and community representatives, conducting interviews, preparing and reviewing transcripts, and producing a draft and final report.

- The oral testimony collected during this project once again reveals the depth of detailed knowledge Stl'atl'imx people hold regarding their territory. Several individuals gave detailed accounts of the Stl'atl'imx seasonal round, and others supplemented that information with descriptions of particular sites where a number of different subsistence practices occur (e.g. Seton Lake). Also included were observations regarding plant and animal species distribution, variety, and demographics both pre and post Hydro impact.

The draft report titled "Seton Lake Shoreline Assessment: Seton Lake Shoreline Impact Study, Part II, St'at'imc Nation" by VanDine Geological Engineering Ltd. (VGEL) was reviewed for this project. This report revealed the following:

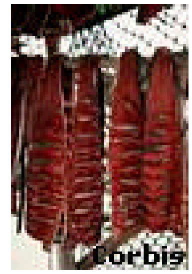
- The primary objectives of the project were to review and summarize geotechnical information as it relates to slope stability and erosional effects of BC Hydro operations along select portions of the Seton Lake shoreline, and to assess physical and social effects resulting from changes to the Seton Lake shoreline.

- For the draft report, VGEL used a variety of documentary and photographic sources to determine the historical shoreline conditions of Seton Lake. Oral testimony recorded as part of the Deva (1998) report was also used to assist in defining the pre-impact nature of the shoreline. Present shoreline conditions were established using the results of fieldwork and documentary analysis.

- The draft report concludes that while BC Hydro operations have resulted in the flooding of some lands, these lands would have been subject to periodic flooding if the lake had maintained its natural state. Furthermore, VGEL concludes that, despite oral testimony that recounts substantial beach front along the shores of Seton Lake, the pre-Hydro beach width would not have been that much wider than its present day condition. VGEL describes several possible factors that may have effected the Chalath community. These include the narrowing of beaches, the erosion of shoreline in front of the Seton Lake Band Cemetery, and concern regarding the demise of trees along the shore. Other factors included a general change in the character of the lake water and its associated shoreline.

A review of VGEL's (1999) report titled "Seton Lake Shoreline Impact Study, St'at'imc Nation, Part I: Seton lake Water Levels revealed the following:

- The objective of the study was to compile the Seton Lake water levels from the earliest records to present day, and to "calculate changes to the lake levels over time and identify any



discrepancies and source of error in the information used" (VGEL 1999: 1).

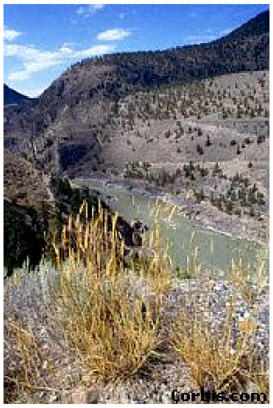
- VGEL collated and reviewed background data from a variety of published and unpublished sources. In addition, VGEL collected comments from non-Stl'atl'imx residents of the area regarding their recollections of water levels in Seton Lake.

- VGEL concludes that, based on an analyses of pre and post Hydro records, seasonal fluctuations of the water levels in Seton lake have been reduced, while the average monthly mean, maximum and minimum lake levels have increased. However, the absolute monthly maximum and minimum lake levels have decreased.

Neither VGEL reports were found to contain a great deal of information relevant to the present study. The few comments regarding the condition of Seton Lake pre and post BC Hydro, have already been summarized in the other reports reviewed for this project.

3.2 Critique and Gap Analysis

The objectives of these projects have significant implications for this study. An analysis of the primary objective of each study revealed that each project was designed to document the impacts BC Hydro operations had and continue to have on Stl'atl'imx lifeways. This primary objective greatly informed the methodological approaches used for each study. For example, interview questions were designed to solicit input on a variety of activities (hunting, plant gathering, trapping, fishing etc.) and how those activities were and are impacted by Hydro facilities and operations. Consequently, much of the



knowledge garnered from these studies exhibits the Stl'atl'imx ability to react and adapt to changes to their territory.

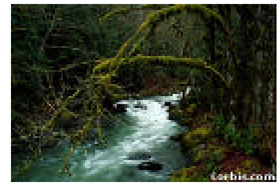
The questions used during the interviews were geared toward gauging Stl'atl'imx *reaction* to impact. This resulted in descriptive responses that list the variety, type, and location of various resources used by the Stl'atl'imx prior to and following BC Hydro operations. It is clear however, that the Stl'atl'imx possess knowledge that reaches far beyond a reactionary response to unanticipated change. That is, the results of these reports demonstrate that the Stl'atl'imx maintain an in-depth understanding of the physical, social, economic, and spiritual environment in which they live.

The most relevant question to this study is: what are the Stl'atl'imx traditional *proactive* ways of knowing? That is, how did (and do) the Stl'atl'imx practice traditional methods of altering the environment to enhance or stabilize resources? The answer to this question may be found in the two clear instances of proactive activities cited by the Stl'atl'imx knowledge holders. Both controlled burning, and stocking of fish in a human-made lake indicate the Stl'atl'imx practice proactive management techniques. Given the depth of knowledge the Stl'atl'imx maintain regarding their environment, it is suggested that these are only two examples of what is likely a vast array of knowledge regarding proactive practices.

It should be noted that anthropologists and western scientists have tended to focus on the reactive and adaptive aspects of indigenous populations when it comes to traditional knowledge and the natural environment. The danger in this type of focus is that it can promote a "Rousseauian" interpretation of traditional knowledge where concepts of the "ecologically noble savage" abound. While the adaptive responses of First Nations populations are well documented (including

3.2

Critique and Gap Analysis Continued…



in the studies reviewed for this report), *proactive* practices whereby certain aspects of the environment are "managed" deserve equal consideration. With regard to the application of traditional ecological knowledge to the water use planning process, it is the exploration of these proactive activities that may be most relevant.

Management in the Stl'atl'imx sense may not translate to "management" in the western scientific sense. Given the in-depth understanding of their physical, social, and spiritual environment, Stl'atl'imx management will likely be more holistic than a western scientific approach. Indeed, there are at least two examples of what could be considered Stl'atl'imx management practices cited in the Deva (1998: 25) and Summit (1999b: 22) reports respectively. In the first instance, a Stl'atl'imx Nation member makes reference to the fact that access to berry patches in and around villages and on lower mountain slopes was controlled by a community leader or "Clan Chief" (Teit 1931 c.f. Deva 1998: 25). One interpretation of this practice might be that the community recognized the important and finite fruit a single berry patch could offer and as a management strategy to ensure future harvest, access to the patches had to be controlled. The second reference is to the "first fish ceremony" where the "Grand Chief would catch the first fish and qwilem [cook it on an open fire] and have a feast. After this everyone could go fishing" (28 July 1998 c.f. Summit 1999b: 22). This practice could have been designed in part to allow a number of fish to pass upriver as a conservation strategy designed to ensure regeneration of future fisheries. Needless to say, in keeping with a more holistic approach, both of these practices likely had social, spiritual, economic, and political aspects.

3.2

Critique and Gap Analysis Continued…

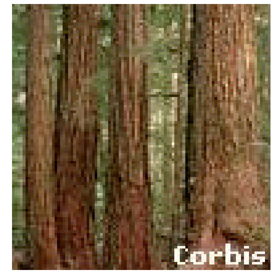
The assumptions inherent in attempting to gather and analyze traditional *ecological* knowledge have implications for this study. As noted previously, the attempt to separate traditional *ecological* knowledge from the wider scope of traditional knowledge can be difficult. In order to do so, the community must agree that ecological knowledge *can* be separated from traditional knowledge. Alternatively, the scientific community must recognize that ecological knowledge can not be compartmentalized and must be viewed in the context of the wider spiritual, cultural, social, economic, etc. knowledge base. This is one of the essential conflicts in attempting to conduct a study of this nature. It becomes even more difficult when there is the assumption that one type of knowledge will or can be applied to another way of knowing toward a desired result. In this particular case, there is the assumption that traditional ecological knowledge can be applied to western natural resource management practices.

Western natural resource management practices tend to be based primarily on scientific data derived from scientific analyses. The assumption is that science is value-free and its results are inherently objective. While it is true that scientific *methods* may be objective, the practice of science is not. Science is informed by a complex array of social, economic, and cultural factors that influence who practices science, what questions are given priority, and how the results of scientific research are disseminated. Interestingly, it has long been recognized that traditional knowledge is inherently socially bound – a characteristic that has often served in invalidate it. It can be argued that if viewed within their individual contexts, both ways of knowing are equally "true" and "objective." However, problems arise when one way of knowing is applied to the context of another way of knowing. Traditional knowledge does not share the same contextual boundaries as scientific knowledge, thus when it is applied to a scientific paradigm it is labeled as “anecdotal” and “subjective.” With regard to the current project, there is some danger that an attempt to contextualize traditional knowledge in a scientific framework will only serve to re-enforce inaccurate assumptions.

With regard to information gaps, the primary objective of the above-noted projects was to collect knowledge regarding BC Hydro’s impacts on Stl’atl’imx lifeways. Consequently, to date, there is a lack of documented knowledge concerning Stl’atl’imx proactive “management” strategies. This is not to imply that this knowledge does not exist or that it is not shared among Stl’atl’imx people on a daily basis, but rather that the questions designed to solicit the knowledge in an interview context have yet to be asked.

3.2

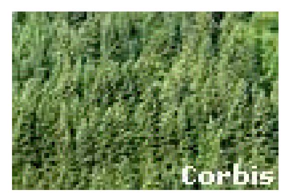
Critique and Gap Analysis Continued…



4.0 SUMMARY AND WORKSHOP TOPICS

4.0

SUMMARY AND WORKSHOP TOPICS



In summary, the objectives of the projects reviewed for this report were designed to solicit knowledge regarding the impacts of BC Hydro operations on Stl’atl’imx lifeways. The knowledge required for input into a water use plan is of a more proactive management-based nature and only a few occurrences of this type of knowledge were cited. The kind of information that could be used to create a platform for water use planning is clearly held and used by the Stl’atl’imx, but the reports reviewed for this project were not designed to document it.

Based on the literature review, critique, and gap analysis, potential workshop topics could include:

- How will the Stl’atl’imx position their knowledge in the water use plan? Are the Stl’atl’imx willing to compartmentalize information and have it “plugged-in” to the existing scientifically based plan? Are the western scientists willing to fit their knowledge into a traditional knowledge based water use plan?

4.0

Summary and Workshop Topics Continued…

- If one assumes that in their individual contexts, both scientific and traditional ways of knowing are equally valid, is it possible to create a water use plan that addresses both ways of knowing on an equal footing? What aspects of western knowledge could be used to develop a water use plan? What aspects of traditional knowledge could be used in a similar fashion?

- Is there specific, proactive management-based traditional knowledge that could be identified by workshop participants and then used to build a water use plan? If so, what (if any) are the conditions for the use of that knowledge? Must the knowledge be contextualized somehow or can it be pulled out and applied as a discrete “formula?”

5.0 CLOSURE

5.0

CLOSURE

I trust this report is sufficient for your current needs. Please do not hesitate to contact the undersigned should you have any questions or concerns regarding this document. I look forward to your response.

Sincerely,

Tanja Hoffmann, M.A.

Circa Heritage Consulting

APPENDIX J2: TRADITIONAL ECOLOGICAL KNOWLEDGE - PHASE I PROJECT AND WORKSHOP OUTLINE

PROJECT PURPOSE

To determine how Stl'atl'imx Nation traditional ecological knowledge can be integrated into the Bridge River Water Use Plan and associated monitoring programs.

PROJECT BACKGROUND

The current traditional ecological knowledge project is being conducted in two phases. Phase I consists of a literature review, including a gap analysis, critique, and summary of selected sources. Following the literature review, traditional knowledge holders and western scientists will be brought together in a workshop format to discuss the integration of traditional ecological knowledge and Western science to address a specific issue identified in the Water Use Plan process. The results of the literature review and workshop will be summarized in a final report, a draft of which will be presented to the Stl'atl'imx Nation Hydro, workshop participants, and Consultative Committee for review and comment. The final report will incorporate the comments garnered from the review.

The objectives and methodology for Phase II of the traditional ecological knowledge project will be identified, at least in part, during Phase I. Essentially, Phase II will be designed to begin recording traditional ecological knowledge in a manner more consistent with a baseline study.

RESULTS OF PHASE I LITERATURE REVIEW AND GAP ANALYSIS

In summary, the objectives of the projects critiqued in the literature review were designed to solicit knowledge regarding the impacts of BC Hydro operations on Stl'atl'imx Nation lifeways. The knowledge required for input into a water use plan is of a more proactive management-based nature and only a few occurrences of this type of knowledge were cited. The kind of information that could be used to create a platform for water use planning is clearly held and used by the Stl'atl'imx Nation, but the reports reviewed for this project were not designed to document it.

WORKSHOP RATIONALE

Given that Stl'atl'imx Nation traditional ecological knowledge baseline knowledge has not been recorded for Western resource management purposes, the study team proposes to conduct a pilot study that would focus on one aspect of the Water Use Plan that may benefit from the integration of traditional ecological knowledge. The Stl'atl'imx Nation knowledge holders and the Water Use Plan scientists have identified major data gaps regarding the resident fish species type, distribution and abundance in Seton Lake. In particular, there are gaps associated with understanding the causes of reduced productivity of resident fish species in the lake, and the extent to which these species could benefit from operating changes. The following workshop would be aimed at integrating traditional ecological knowledge and Western science perspectives to identify some of the data gaps and work toward a monitoring program(s) that may be used to fill them.

WORKSHOP OBJECTIVES

The workshop participants (comprised of traditional ecological knowledge experts and Western scientists) would work toward identifying:

- data gaps associated with resident fish stocks in Seton Lake Reservoir.
- the gaps that might be best filled with traditional ecological knowledge, those that could be addressed through Western science, and those that could be resolved using an integrated approach.
- methods appropriate for the monitoring programs identified for the Seton Lake fish study, including long-term strategies for monitoring, hypothesis development, selection of indicators, data interpretation, and implementation.
- the scope and basic methodology for a Phase II study aimed at collecting traditional ecological knowledge baseline knowledge for future resource management strategies.

PROJECT AGENDA

Prior to the workshop, the Stl'atl'imx Nation would host an internal traditional ecological knowledge expert meeting where the objectives, rationale, and scope of the workshop would be presented and discussed.

Following this initial meeting, the Stl'atl'imx Nation and Water Use Plan/BC Hydro project team would agree on a list of workshop participants. These participants would include Stl'atl'imx Nation traditional ecological knowledge experts and a cross-section of Western scientists (biologists, ecologists, hydrologists etc.) some with specific knowledge of the watershed and others with a more general knowledge base.

The 1.5 to 2 day workshop would be scheduled to take place in March 2002. A proposed workshop agenda is as follows:

Day 1

- Introduction.
- Presentation of Project Objectives.
- Overview of traditional ecological knowledge and Western science as world views.
- Presentation of case studies where traditional ecological knowledge and Western science have been integrated and used in resource management.

Day 2

- Identification of Seton Lake Reservoir fish data gaps (from both traditional ecological knowledge and Western science perspectives).
- Discussion of various approaches (traditional ecological knowledge, Western science, or both) that could be used to address each data gap.
- Discussion of short and long-term monitoring programs that could be implemented to address those gaps.
- Preliminary review of potential monitoring indicators.
- Discussion of Phase II objectives and methodological approach.
- Workshop wrap-up and feedback.

The outcomes of the workshop would be circulated in report format to the participants, the Stl'atl'imx Nation Hydro, BC Hydro, and the Water Use Plan Consultative Committee for review. Responses to the report would be summarized in a final report to be submitted to the water comptroller.

Draft Outline of Stl'atl'imx Knowledge/Western Science Water Use Planning Pilot Project Final Report (Phase I)

1.0 INTRODUCTION

1.1 Rationale and Objectives

1.2 Study Scope and Assumptions

1.3 Study Team

1.4 Report Format

2.0 CONTEXT

2.1 Concepts of "Traditional Ecological Knowledge"

2.2 Other projects that have integrated Traditional and Scientific Knowledge

3.0 METHODOLOGY

3.1 Literature Review

3.2 Community Workshop

3.3 Stl'atl'imx Knowledge/Western Science Workshop

4.0 RESULTS

4.1 Literature Review

4.2 Community Workshop

4.3 Stl'atl'imx Knowledge / Western Science Workshop

5.0 RECOMMENDATIONS

5.1 Future Information Sharing

5.2 Phase II Scope and Potential Methodology

6.0 SUMMARY AND CONCLUSIONS

7.0 CLOSURE

8.0 REFERENCES

GLOSSARY

Ancillary service:
: the services needed to maintain system reliability and meet WSCC/NERC operating criteria, including spinning, non-spinning, and replacement reserves, regulation, voltage control and black start capability.

Baseload:
: a manner of power plant operation such that a unit is run at a more or less constant output level, regardless of changes in loads. For most plants the most efficient power operations level is to hold steady at a maximum design output level (in contrast to "load-following" or "cyclical" operation).

Black Start Capability:
: the ability of a generator to start operations independent of any outside electrical power source. Most generation units require external auxiliary power to start.

Bundled service:
: the provision of all services associated with the production and delivery of electric energy to an individual customer - including generation, transmission, distribution, and ancillary services - under one rate charged to the customer.

Capacity factor:
: the ratio of energy actually produced by a generating unit to the maximum energy it could possibly produce (that is, its rated generating capacity) in the same time period. The annual capacity factor of an individual unit (or, collectively, a plant) is a function of both the amount of time that the unit is operating and the level at which the unit is operating. For instance, if a hypothetical unit were on and operating 100% of the time at 50% of its rated capacity, it would have a 50% capacity factor. Similarly, if a hypothetical unit were on and operating 50% of the time, but at 100% of its rated capacity, it would also have a 50% capacity factor. Combining these concepts, if a hypothetical unit were on and operating 50% of the hours of the year and at a 50% level for each of the hours it was on, it would have an annual capacity factor of 25%.

Cost-of-service regulation:
: the method of regulation used to set rates for utility services prior to restructuring. Rates under cost-of-service regulation were based principally on the costs of generating and delivery electricity, plus an allowable profit margin.

Dispatch:
: the operating control of an integrated electric system to: (1) assign generation of specific generating units and other power sources to maintain the most reliable and economical power supply as area loads rise or fall; (2) control operations and maintenance of high-voltage lines, substations and equipment, including administration of safety procedures; (3) operate the interconnection; and (4) schedule energy transactions with other interconnected electric utilities.

Electric capacity:

the maximum continuous load-carrying ability of electric equipment, including transmission lines, generators and substations.

Generating capacity:

the maximum amount of power a generating unit can produce for a sustained period of time.

Generating facility:

a power plant, normally consisting of several generating units, that produces electrical energy.

Generating unit:

generally refers to the combination of a steam or combustion turbine and electrical generator, which together produce electrical energy.

Generator:

entities that own, operate, and maintain generation assets to supply energy and ancillary services. (An electrical generator is also a piece of equipment that produces an electric current.)

Grid:

a system of interconnected power lines and generators that is managed so the generators are dispatched as needed to meet the requirements of customers connected to the grid at various points. The grid is interconnected to ensure reliability of the system when generating units fail.

Independent System Operator (ISO):

a state corporation created by AB 1890 to provide nondiscriminatory transmission access. The ISO is responsible for the operation, control and reliability of the statewide transmission system under restructuring. The ISO maintains instantaneous balance of the grid system by dispatching plants to ensure loads match the resources available to the system. It is regulated by the Federal Energy Regulatory Commission (FERC).

Islanding:

term used to describe a temporary separation or isolation of transmission grid areas because of system disturbances, such as outages or current fluctuations. Islanding can occur automatically or manually by the operator. Islanded areas must generate their own electricity as long as they remain cut off from the grid.

Kilowatt-hour (kWh):

a measure of electric energy, equivalent to the energy created by generating 1 kilowatt of power for one hour, or 10 kilowatts for 6 minutes, etc.

Load (electric):

The amount of electric power delivered or required at any specific point or points on a system in order to operate the energy consuming equipment of the consumers.

Load-following:

a manner of power plant operation that roughly follows the daily and seasonal electrical demand; i.e. at highest output levels during daytime peaks, and at lowest or zero output levels during nighttime hours (in contrast to "baseload" operation).

Must-run:

the designation given to a power plant or generating unit that must remain on-line during specific times in order to maintain the reliability of the grid in a given geographical area. Prior to restructuring, the CPUC determined must-run designations; in the restructured electric industry, the Independent System Operator (ISO) now has the authority to determine which generators are designated as must-run. A must-run unit is subject to a contract between the unit owner and the ISO that, in return for certain payments, entitles the ISO to call upon the owner to run the unit or to provide ancillary services when needed to maintain electrical system reliability.

Must-take:

refers to generation that, for a variety of reasons, must be purchased by the local utility. Reasons are generally contractual - such as the mandatory purchase by utilities of power produced by qualifying facilities (QFs) under PURPA - or because of the nature of the power plant, such as nuclear plants that run at full power 24 hours per day because of physical limits that prevent rapid increases or decreases of power levels.

Non-spinning reserve:

the portion of idle generating capacity (controlled by the ISO) capable of being loaded in 10 minutes and operated for at least two hours, or load that can be interrupted (de-energized) in 10 minutes.

North American Electric Reliability Council (NERC):

an organization made up of electric utilities and other electricity providers that promotes the reliability of the electricity supply for North America by coordinating operations of utilities and other suppliers, reviewing the past for lessons learned, monitoring the present for compliance with policies, standards, principles and guides, and assessing the future reliability of the bulk electric systems.

Operating reserve:

the combination of spinning and non-spinning reserve required to meet WSCC and NERC requirements for reliable operation of the grid.

Ramping:

changing the loading level of a generator in a constant manner over a fixed time (e.g. "ramping up" or "ramping down"), directed by computer or manual control.

Reliability:

electric system reliability is defined by several criteria: the availability of sufficient electric power generation to meet growing customer demand; the time required to restore power to customers following an outage; and the ability of the system to withstand sudden disturbances, such as electric short circuits or unanticipated loss of system facilities (which relates to the degree of built-in system redundancy to handle such unexpected problems).

Renewable energy or power:

any source of electric generation that uses naturally replenishable resources. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Some (such as geothermal and biomass) may be stock-limited in that stocks are depleted by use, but on a time scale of decades, or perhaps centuries, they can probably be replenished. Renewable energy resources include biomass, hydro, geothermal, solar, and wind. In the future they could also include ocean thermal, wave, and tidal action technologies.

Spinning Reserve:

the portion of unloaded but running generating capacity (controlled by the ISO) that can be loaded in 10 minutes and run for at least 2 hours.

Stranded costs:

investment costs that a utility cannot recover in an open, competitive market because of technological changes or other factors.

Synchronous condenser:

an electrical device that increases the power factor on the grid by reducing circulating currents. (Circulating currents are created by the expanding and collapsing of magnetic fields within electric motors and transformers, and do not produce real work. They are called circulating because they merely run back and forth between generators and loads, creating heat and limiting the amount of real power than is transmitted over a conductor.) A synchronous condenser generally consists of a generator that has been converted to a motor by disconnecting it from the turbine shaft. Operators reduce circulating currents by adjusting the field excitation to the condenser.

Transmission congestion:

an operating condition reached when too many generators attempt to use a portion of the grid and power flows cannot be physically accommodated by the system; also called a "transmission bottleneck."

Transmission system:
: a network of high voltage circuits that carry power from electricity generating plants to distribution substations, where voltage is reduced for delivery through the distribution system to homes, businesses and farms.

Unbundled services:
: separation of generation, transmission, distribution, and other services and programs, as opposed to bundled service, where all needed electric services are provided in one package at one rate.

VAR Support:
: a process where power plant dispatchers uses a spinning generator or synchronous condenser to maintain voltage on a system and, more importantly, to reduce circulating currents by adjusting the current going through the excitation field of the generator or condenser (see "synchronous condenser").

Western Systems Coordinating Council (WSCC):
: one of 10 regional reliability councils in the North American Electric Reliability Council (NERC), responsible for maintaining the reliability of the electric system in the Western half of North America (including parts of Mexico and Canada).