Addendum to the

Coquitlam-Buntzen Water Use Plan: Report of the Consultative Committee

July 2003

Prepared on behalf of:

The Consultative Committee for the Coquitlam-Buntzen Water Use Plan

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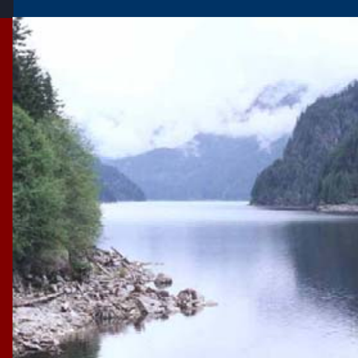
Coquitlam-Buntzen Water Use Plan

A Project of BC Hydro



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ADDENDUM - EXECUTIVE SUMMARY

Overview

This **Addendum** is to be read in conjunction with the ***Coquitlam-Buntzen Water Use Plan: Report of the Consultative Committee, June 2002*** [1](commonly referred to as the Consultative Committee Report or CCR). It documents new information collected since the Consultative Committee (CC) held their last meeting on March 11th, 2002 and summarizes the proceedings of two additional Fish Technical Committee (FTC) Meetings and one subsequent CC meeting held on March 31st, 2003, which was triggered because the original consensus agreement was found to be "ineffective".

In June 2002 the Consultative Committee for the Coquitlam Buntzen Water Use Plan completed their report. The report documented the deliberations and recommendations of the CC between November 1999 and March 2002. The final recommendation of the CC was a consensus agreement for an operating plan.[2] The core of the CC's Original Agreement was an adaptive management program that would implement and monitor two flow trials (plus current operations) within a fifteen-year period. The primary purpose, and the basis of the consensus agreement, was to reduce significant uncertainties regarding benefits to fish from increased instream flows. The results from the flow trials would inform a future CC undertaking a subsequent water use planning process at the end of the trial period.

At the time of the consensus agreement, the CC was aware of the possibility that the proposed flow trials might not be "effective", thereby jeopardizing the fundamental purpose of the recommendation: learning. Accordingly, the CC agreed to a process which included a trigger using the results from a *Statistical Power Analysis Study* to evaluate the "effectiveness" of the CC's agreement. The *Study* was completed at the end of 2002 and the authors concluded that the proposed experimental flow trials and monitoring program would not provide statistically reliable results. Subsequently, the Fish Technical Committee (FTC) met twice to (a) review the results of the *Statistical Power Analysis*, (b) review the newly collected field data and subsequent analyses associated with the Instream Flow Needs (IFN) Study, and (c) recommend potential changes to the CC's original agreement. The FTC agreed that the CC's Original Agreement would not be "effective"; they also refined one alternative and proposed three new treatment schedules for consideration by the CC. A final CC meeting was convened on March 31st, 2003 to review the new information collected and to consider the FTC's proposed options.

At the March 31st, 2003 CC meeting, a new consensus agreement was reached. This Addendum provides a summary of that new agreement including details about the operating plan, the recently completed studies, and the main issues raised at the final meeting.

It must be emphasized that this **Addendum** is a companion piece to the Consultative Committee Report (referred to as the **CCR**) and cannot be read without it, since the **CCR** provides necessary context and details for many of the recommendations, issues, performance measures, objectives, alternatives, trade-offs, and monitoring program components.

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[1] EcoPlan International, Inc. 2002. *Coquitlam Buntzen Water Use Plan: Report of the Consultative Committee.* Vancouver.

[2] See p. 68-70 of the CC Report for details of the operating plan.

Statistical Power Analysis Study

The March 31st, 2003 CC meeting was triggered by the low statistical power that resulted from a *Statistical Power Analysis Study* (included in ***Appendix AA***) that was conducted to determine the level of "effectiveness" of the recommended adaptive management program. The primary result of the *Study* was a statistical power estimate (the probability) that the proposed monitoring program and adaptive management flow trials would be able to measure the difference in fish benefits between baseline conditions, referred to as 2FVC, and the two flow treatments, referred to as 4FVN and STP5,[3] within the 15-year review period. The *Statistical Power Analysis* indicated that the proposed adaptive management program would have a:

- ~40% chance of detecting a change between baseline conditions and the 4FVN flow treatment.
- ~20% chance of detecting a difference between 4FVN and STP5 treatment flow treatment.

These values were considered statistically unreliable. Upon review of the *Statistical Power Analysis* results, the FTC deemed the CC's proposed adaptive management program as "ineffective" because of the low power results. This conclusion triggered the additional March 2003 CC meeting and led to more work by the FTC to develop potential recommendations for how to proceed.

Fish Technical Committee

In the lead up to the final March 2003 CC meeting, the FTC met twice and reviewed the *Statistical Power Analysis Study* and the results from the *Instream Flow Needs* analysis (associated with the IFN Study, see ***Appendix BB*** for a copy of the report). The bulk of the FTC's work centered on developing options that would provide meaningful information (i.e. more statistically reliable) for future decision making at the end of the review period. The work for the *IFN Study* was a key aspect of this as it revised instream flow targets for flow alternative STP5 and amended fish habitat performance measures with actual field data.

The field surveys in the *IFN Study* provided a detailed analysis of the river including habitat, hydrology, and biological assessments at various flow regimes. The results of the study provided the basis for the weighted useable area calculations used for the fish habitat performance measures. Field work carried out in the study included: transect data collection, channel surveys, linear habitat mapping, and snorkel surveys.

As part of the CC Original Consensus Agreement (2002), the FTC was tasked with incorporating the results of the *IFN Study* into the Coquitlam WUP monitoring plan and adjust the STP5 flow regime.[4] Therefore, the ***Revised STP5*** flow regime became known as ***STP6*** and it had **revised** instream flow targets according to the new *IFN Study* field data (whereas STP5 relied heavily on simulated data).

[3] See Chapter 5 of the CC Report (CCR) for details of the alternatives.
[4] See Chapter 7 and Table 24, Page 68 of the CC Report for details.

The FTC's work led to one revised flow alternative (***Revised*** STP5 became ***STP6***) and three new treatment schedules.

Alternatives

As mentioned, the FTC proposed one new revised flow alternative and three new treatment schedules[5] for the CC to consider at the final March 31st, 2003 meeting.

Flow Alternatives

Four flow alternatives were focused on during the discussions at the final CC meeting: 3 which were unchanged from the last CC meeting—***2FVC*** *(current operations);* ***4FVN*** *(4 Fish Valves Optimized); and* ***STP5*** *(Share the Pain #5)*[6]—and one revised flow alternative developed by the FTC and referred to as **STP6**.

The FTC developed **STP6** (revised STP5) in the spirit of the original agreement. Therefore, like other "sharing the pain" alternatives, it first attempted to satisfy domestic water and fish interests, with hydroelectric power consistently a third priority. To do this, it included upper and lower target flows for both domestic water and instream (fish) needs. The FTC used the revised habitat suitability curves from the *IFN Study* to amend the monthly instream flow targets according to key fish species and life stages in Reaches 2 and 3 of the Coquitlam River (driven by steelhead parr, steelhead spawning, chinook/coho spawning and incubation).

The **STP6** flow targets assigned for GVRD withdrawals were unchanged from STP5. During the final CC March 31st, 2003 meeting, there was an accepted change in terms of priorities for when upper flow targets begin to be curtailed: ***GVRD priority went from first to second; river (fish) priority was changed to always being first.***[7] A summary of the target flows and priorities for both GVRD and the river are provided in ***Section A5***.

Treatment Schedules

The FTC proposed 3 additional treatment schedules for consideration by the CC at their final meeting. These Treatment Schedules were developed with the following criteria:

- having a statistical power of at least 0.5;
- having only one additional flow trial in addition to the current baseline flow regime (**2FVC**); and,
- utilizing **STP6** as the additional flow trial[8] based on available data from the IFN field study results.

[5] Treatment schedules define the start date, the duration, for each flow alternative.
[6] See CCR Report for details of flow alternatives, Pages 41 to 43.
[7] Therefore, if there were insufficient inflows to meet both GVRD and river (fish) upper target flows then GVRD nominations would be curtailed first to their lower target range before river upper targets flows would be changed and this was now year round.
[8] The FTC selected STP6 as the preferred flow trial because it is anticipated to create the largest effect and therefore improve the statistical power of quantifying fish benefits over other flow trials. A higher statistical power would better differentiate influencing factors and help address key uncertainties.

Therefore, the ***only*** changing variable between the 3 Treatment Schedules was the duration of the flow trials and when they would begin. The CC quickly focused on Treatment Schedule #2 and #3.

- **Treatment Schedule #2** would monitor the current base flow (2FVC) for ***6*** years, changing to STP6 for ***9*** years.

- **Treatment Schedule #3** would monitor the current base flow (2FVC) for ***3*** years, changing to STP6 for ***9*** years.

A summary of all the proposed Treatment Schedules can be found in ***Section A5***.

Trade-Offs

As with previous CC meetings, the objectives which experienced the greatest change resulting from the proposed flow trials were the focus of the CC member deliberations. These objectives were domestic water, fish and hydroelectric. The trade-offs at the final meeting were reviewed separately for flow alternatives and treatment schedules before a combination was considered. This separation aided in highlighting the different impacts and trade-offs associated with each.

Flow Alternatives

The trade-off discussions by the CC revolved around the impacts of STP6 and how they compared to STP5 and to a lesser extent 4FVN.

The degree to which STP6 performed against the primary objective areas are summarized below:

Fish	STP6 performed better than, or almost the same as (given the uncertainty in the PMs), STP5 on all performance measures. It performed slightly worse than 2FVC for steelhead spawning habitat, but this was a result of STP6 providing slightly more water than the optimal value calculated in the PM.
Domestic Water	STP6 performed slightly worse than 4FVN for annual water allocation, but marginally better during the driest year results (except for meeting the maximum nominations). It also performed better than STP5 across the domestic water PMs (except for 1 day worse for maximum nominations not satisfied in the driest year).
Hydroelectric	STP6 performed worse than 4FVN (except in driest years) and better than STP5 across all the power PMs.

The following points were made during the trade-off discussions:

- BC Hydro maintained that gains to fish from moving to 4FVN are significant, but the tradeoffs with power objectives in particular beyond this are difficult to justify. However, they would consider STP6 in order to gain better data and in the spirit of consensus.
- After reviewing the performance measure information, some CC members highlighted concerns with STP6 and low summer flows in the river. The concern

centered on the impact of low flows under the 'sharing the pain' concept. These concerns were relevant during low flow years when dam releases to the river were a second priority to GVRD's water use requirements (BC Hydro as third priority would have already stopped generating at this point). Furthermore, it was highlighted that STP6 target dam releases through the summer months were less than low dam releases under STP5.

- In response to the concerns regarding low flows under the STP concept, GVRD representatives indicated that demand from the Coquitlam Reservoir in 2015 was expected to be only slightly higher than at present and by 2007 water filtration facilities for the Capilano and Seymour water sources will be complete providing additional flexibility. For these reasons, they did not anticipate impacting the upper target dam releases for fish except, perhaps, in extreme circumstances (and would like to see the STP concept retained). Based on this information, it was suggested that during the testing period, dam releases for the river always be first priority. The low releases would serve as a safeguard not only for GVRD, but also potentially for fish since they provide important information about flow thresholds.

Treatment Schedule

As mentioned, the CC focused on Treatment Schedule #2 and #3. The main differences in moving from Treatment Schedule #2 to #3 were highlighted as follows:

- the loss of .1 in statistical power;
- an increase in annual average cost to BC Hydro of $312,000;
- three less years of the test period; and
- more water in the river three years sooner.[9]

The following comments were made by CC members:

- **BC Hydro**: Schedule #2 preferred on the basis of cost, but BC Hydro placed a value on consensus and would consider Schedule #3.
- **GVRD**: Schedule #2 was preferred (although one member stated he was prepared to go with Schedule #3) because of the additional statistical power and, hence, better learning. In addition, the GVRD indicated that they are building water filtration facilities for the Capilano and Seymour water sources (with partial funding from Provincial and Federal grants) and these are to be completed in 2007. Therefore, it would be preferable to have the 2FVC fish release at Coquitlam continue through 2007 as the GVRD would have operation experience with the 2FVC fish release.
- **Other CC members:** Schedule #3 was preferred. These members agreed that the statistical power is less valuable for fish than having more water in the river sooner.

[9] Increased dam releases over and above the present 2FVC may be affected by the ongoing dam upgrade work which is scheduled for completion at the end of 2006.

Recommendations

At the March 31st, 2003 CC meeting a new consensus agreement was reached. The main components of the agreement were: **Flow Alternative STP6** and **Treatment Schedule #3**. Many CC members placed a high emphasis on reaching consensus. In the end, ***nobody blocked*** the agreement***, 7 members endorsed it*** and ***12 accepted it*** with ***reservations*** *(see **Section A6*** for specific comments by CC members). One CC member had strong concerns about the low summer time instream flows for fish in STP6 and the reliance on the *IFN Study* data[10], but ultimately accepted it with reservations.

Flow Alternative STP6

Given the concern expressed by a number of CC members that summertime instream target in STP6 flows are too low for fish, it was agreed that STP6 would be modified to include a change in priority for when target flows would drop to their lower target values. Instream target flows (for fish) would be given first priority year round rather than giving GVRD domestic water nominations priority during the summer months. This recommendation would reduce the probability that dam releases to the river would fall below the desired target flows during the trial period. At the same time keeping the "sharing the pain" concept addressed GVRD's desire for greater certainty in the alternative by identifying the operating constraints in the very unlikely event of extreme conditions. A summary of the target flows and priorities for both GVRD and the river are provided in the table below.

Table: Target Flows for Flow Alternative STP6

		Jan 1-15	Jan 16-31	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	River Flow Target (cms)	5.9	2.92	2.92	4.25	3.50	2.91	1.10	1.20	2.70	2.22	6.07	3.96	5.00
	River Lower Flow Target (cms)	3.60	2.92	2.92	1.77	1.10	1.10	1.10	1.10	1.10	1.10	3.59	1.49	2.51
Share the Pain #6 (STP6)	**River Priority**	**1**		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
	GVRD Flow Target (cms)	11.9		11.9	11.9	12	12	12	18	23	23	12	12	11.9
	GVRD Lower Flow Target (cms)	10.7		10.7	10.7	10.8	11	10.9	15.8	20.2	20.9	10.8	10.8	10.7
	GRVD Priority	**2**		**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**

Treatment Schedule #3

There was acceptance to recommend this treatment schedule to reach consensus. The details of it are outlined in the following diagram.

[10] It is noted that the *IFN Study* report was not finalized nor distributed prior to the March 2003 CC meeting. However, the analyses and field data was used by the FTC during the development of STP6 and the revising of performance measures.

Treatment Schedule 3 - 3 Yrs Base (2FVC); 9 Years **STP6**																		
Activity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Treatment #1 - 2FVC baseline smolt monitoring	1	2	3	4	5	6												
Dam Modifications				1	2	3												
Treatment #2 - *STP6*							1	2	3	4	5	6	7	8	9			

Summary

The following table summarizes the main components associated with the CC's New Consensus Agreement.

Table: Summary of CBWUP Operating Recommendations

Recommendations	Comments
Change one low level (LLO) outlet at Coquitlam Dam to permit STP6 river flows	♦ Flow regime STP6 will require an infrastructure change, allowing regulated and variable flows through one of the LLOs (expected to be complete by the beginning of 2007)
<u>Treatment Schedule #3</u> Implement and monitor 2 flow trials: ♦ Test flow #1: 2FVC ♦ Test flow #2: STP6	♦ One of the main purposes of this plan is to test fish benefits from increased flows to Coquitlam River ♦ Test flow #1 will be tested first and will continue until the end of 2006 ♦ Test flow #2 will be implemented beginning in 2007 and will continue until the end of 2015 (9 years) ♦ Develop a monitoring plan with clear design measures
Develop a communication protocol	♦ A process will be established to notify agencies in the event of exceptionally low water levels when GVRD may need to access Coquitlam water
Other Recommendations	♦ **Other recommendations agreed to by the Coquitlam-Buntzen WUP CC as laid out in the June 2002 CBWUP Report of the Consultative Committee remain unchanged. In particular, bookends of 4FVN and STP5 would still remain in place and learning from the proposed operating**

	plan would be applied within these bookends at a future WUP (refer to Section 6.2, Pg. 68 in the CCR).

Expected Impacts from the Consensus Agreement

The impacts from the consensus agreement—according to each principal objective area—are summarized in the table below. Note some of these impacts are uncertain and are designed to be addressed as a part of the monitoring program.

Table: Expected Impacts of the Recommended Agreement

Objective	Flow Trial #2- STP6
Domestic Water (values supplied by GVRD)	• Increases regional water supply capacity on average by 4.0 cms[11] (from 7.88cms to 11.88cms: a 51% increase) • Saves GVRD ratepayers approx. $3.7 million per year by delaying costs to raise Seymour dam • Increased long-term planning certainty
Fish	• Increases instream flows benefiting salmon and steelhead trout (more than a doubling of flows) ➢ +17% steelhead spawning habitat ➢ +33% salmon spawning habitat
Hydroelectric	• $1.04 million annualized average costs to BC Hydro[12] • Annual power production is reduced by 71 GWh on average (from 125 to 54 GWh)

[11] Cubic metres per second
[12] Costs to BC Hydro are based on projections of Annual Generation Revenue and GVRD payments (costs do not include water rental costs for generation). A discount rate of 8% was used. Costs are based on an amortization schedule for STP6 starting in Year 2007 and extending to the end of 2015.

Monitoring Program

The components of the monitoring plan are unchanged from those described in the CCR (refer to Section 7) with the exception that it was agreed to not include control streams in the monitoring program[13].

The monitoring schedule has been modified to be consistent with the new operating plan using Treatment Schedule #3. The schedule and estimated costs of the monitoring table are summarized in the table below.

Table: Cost Estimate and Schedule for the Proposed Monitoring Program ($ in thousands)

Site	Monitoring Aspect:	*Current Operations Review*				*STP6 Review*								
		2003*	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Reservoir	*Access to Tributaries*	10												
River	*Annual Snorkel Assessment (Ramping Rates)*	12	5	5	10	5	5	5	5	5	5	5	5	15
	Pink Salmon Access	4		4		4		4		4		*4*		*10*
	Habitat Suitability Criteria	30				15								
	Invert. Productivity Index	20	20	20	20	20	20	20	20	20	20	20	20	30
	Reservoir Release TemperatureRegime	10	5	5										
	Fish Productivity Index	100	100	100	100	100	100	100	100	100	100	100	100	125
	Flushing Flow Effectiveness	30				30				30				40
Totals:		***216***	***130***	***134***	***130***	***174***	***125***	***129***	***125***	***159***	***125***	***129***	***125***	***220***

Conclusion

In summary, the Coquitlam-Buntzen Water Use Plan Consultative Committee succeeded in achieving consensus on an operating strategy that will enable more informed decisions to be made on a preferred operating flow regime in the future. In particular, the consensus agreement was reached in order to address significant uncertainties related to anticipated fish benefits. The consensus agreement was reached by revisiting the initial CC's Consensus Adaptive Management Agreement (2002) and applying better information provided by the recently completed *Statistical Power Analysis Study* and the results from the analyses done for the *Instream Flow Needs Assessment.*

This document in combination with the original Consultative Committee Report (CCR) are to be forwarded to BC Hydro and the Provincial Comptroller of Water Rights. This consultation process provided a framework to share information and learn, promote understanding between parties and interests, explore alternative ways to operate the facilities, evaluate impacts in a

13 Based on discussions of the Statistical Power Analysis results and other factors specific to the Coquitlam River by the FTC at their Feb 3rd and Mar 10th, 2003 meetings, it was agreed to **not** consider the use of control streams within the monitoring program.

structured way and thus allow each participant to make clear choices based on explicit trade-offs between technical and value-based information. Through this interest-based process, a consensus decision was reached whereby fish, domestic water, industry, and recreation interests will all be improved over current operations.

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APPENDICES…

A1 INTRODUCTION

This **Addendum** is to be read in conjunction with the ***Report of the Consultative Committee: Coquitlam-Buntzen Water Use Plan, June 2002.***[14] It documents new information collected since the Consultative Committee (CC) held their last meeting on March 11th, 2002 and summarizes the proceedings of two Fish Technical Committee (FTC) Meetings and one subsequent CC meeting, which was triggered because the original consensus agreement was found to be "ineffective".

In June 2002 the Consultative Committee for the Coquitlam Buntzen Water Use Plan completed their report. The report documented the deliberations and recommendations of the CC between November 1999 and March 2002. The final recommendation of the CC was a consensus agreement for an operating plan.[15] The core of the agreement was an adaptive management program that would implement and monitor two flow trials (plus current operations) within a fifteen-year period. The primary purpose, and the basis of the consensus agreement, was to reduce significant uncertainties regarding benefits to fish from increased instream flows. The results from the flow trials would inform a future CC undertaking a subsequent water use planning process at the end of the trial period.

At the time of the consensus agreement, the CC was aware that there was the possibility that the proposed flow trials might not be "effective", thereby jeopardizing the fundamental purpose of the recommendation: learning. Therefore, the CC agreed to a process which included a trigger using the results from a *Statistical Power Analysis Study* to evaluate the "effectiveness" of the CC's agreement. The *Study* was completed at the end of 2002 and the authors concluded that the proposed experimental flow trials and monitoring program would not provide statistically reliable results. Subsequently, the Fish Technical Committee (FTC) met twice to (a) review the results of the *Study*, (b) review the newly collect field data and subsequent analyses carried out for the Instream Flow Needs (IFN) Study, and (c) recommend potential changes to the CC's original agreement. A final CC meeting was convened to review the new information collected and to consider the FTC's proposed options and this was held on March 31st, 2003.

The information contained within this **Addendum** provides details of the studies completed and the meetings held with the FTC and CC at their final meetings. It must be emphasized that this **Addendum** is a companion piece to the Consultative Committee Report[1] (referred to as the **CCR**) and cannot be read without it, since the **CCR** provides necessary context and details for many of the recommendations, issues, performance measures, objectives, alternatives, trade-offs, and monitoring program components.

This document has been organized according to the same section numbers found in the **CCR** for ease of use.

[14] EcoPlan International, Inc. 2002. *Coquitlam Buntzen Water Use Plan: Report of the Consultative Committee.* Vancouver.

[15] See p. 68-70 of the CC Report for details of the operating plan.

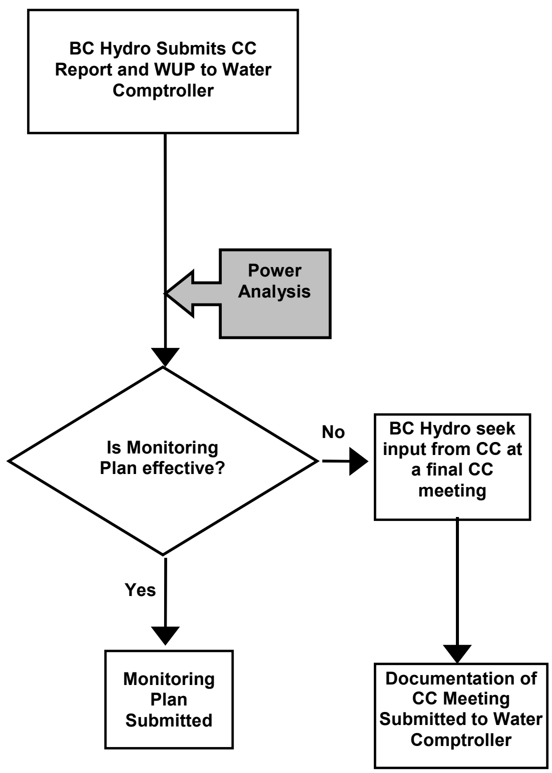
For more details about Water Use Planning and the facilities associated with the Coquitlam-Buntzen WUP refer to Section 1.0 of the CCR.

A2 THE CONSULTATION PROCESS…

For more details about the consultative process, the participants, and the committee structure for the Coquitlam-Buntzen WUP refer to Section 2 of the CCR.[16]

As agreed to at the 11 March 2002 Consultative Committee (CC) meeting, the CC agreed to use a *Statistical Power Analysis Study* as the measure by which the FTC would evaluate the "effectiveness" of the proposed monitoring program. It was further agreed that in the event the monitoring program was found to be "ineffective", that BC Hydro would seek input from the CC at one last meeting. The following flow chart was used to illustrate the process that was agreed to.

Figure : Process for CC Submissions to Water Comptroller



As agreed, BC Hydro undertook a *Statistical Power Analysis Study* and it was reviewed by the FTC during two meetings (held on Feb 14th & March 11th of 2003). The FTC determined that the monitoring program was ineffective and therefore BC Hydro arranged one last CC meeting which was held on March 31st, 2003. The final meeting included reviewing the completed studies and analyses (Step 5 of the *Provincial Guidelines for Water Use Planning*); reviewing the

[16] EcoPlan International, Inc. 2002. *Coquitlam Buntzen Water Use Plan: Report of the Consultative Committee.* Vancouver.

proposed flow alternatives developed by the FTC (Step 6); and assessing the trade-offs between competing interests for each operating alternative (Step 7).

In total, the Consultative Committee met 23 times, from November 1999 to March 2003 to move through the process steps. During this time there were a total of 67 sub-committee meetings to assist the CC in their deliberations.

The final CC meeting was facilitated by William Trousdale of EcoPlan International Inc., with assistance from Maria Harris.

A3 ISSUES, OBJECTIVES, AND PERFORMANCE MEASURES…

For details of the issues and how they were developed into objectives and performance measures, refer to Section 3 of the CCR.[17]

Issues

No new issues related to water management at BC Hydro facilities emerged during the final CC or FTC meetings. Updates were provided, however, on some issues which may be associated with the Coquitlam-Buntzen Water Use Plan, as follows:

- Seismic upgrading is ongoing at Coquitlam dam; it is expected that this work will be completed by the Fall of 2006. This work may have implications for being able to deliver variable flows from the low level outlets.
- Work has been ongoing by the Bridge-Coastal Restoration Program looking into the feasibility of fish passage up to the Coquitlam reservoir. The first two steps of a four stage feasibility assessment were completed and accepted by the BCRP Board in March 2003.
- A Hydrology Study of the Coquitlam Watershed for the Cities of Coquitlam and Port Coquitlam was recently completed.

Objectives

No new objectives were defined by the CC.[18]

Performance Measures

The performance measures (PMs) which were used in the final meeting could be classified into two categories: those which helped with selecting a new **flow alternative** (or flow trials), and those which helped with selecting a new **treatment schedule** for when the flow trials would begin and end. The following revisions and additions to the PMs are summarized below.

Changes to PMs Used for Selecting a Flow Alternative

These PMs are effectively unchanged from the original PMs documented in the CCR.

[17] EcoPlan International, Inc. 2002. *Coquitlam Buntzen Water Use Plan: Report of the Consultative Committee.* Vancouver.

[18] The CC's goal for better understanding and learning about fishery benefits was facilitated by the recently completed *Statistical Power Analysis Study*. And the information contained within the *Study* was used to help set a benchmark for what treatment schedules should be considered (refer to ***Section A5*** for more details).

The only changes which did occur happened with the **Fish PMs**. These changes were made during the Fish Technical Committee meetings and were mainly based on the improved field data collected for the *Instream Flow Needs Study* (final draft completed in July 2003 and described in more detail in ***Section A5***). These changes are summarized below:

- **Fish Habitat PMs** – the units for these PMs were changed from *square metres* of habitat to *percent of maximum* (POM) of the available habitat based on the empirically-derived habitat relationships.
- **Coho Habitat PM –** this PM replaced the Invertebrate Habitat PM (as coho became a driver for the development of alternatives).
- **Frequency of Event PMs** – the FOE PMs were initially developed because the *IFN Study* was incomplete (and the Fish Habitat PMs were based on simulated data) at the time of the final CC meeting in March 2002. With the completion of the field survey work (within the *IFN Study*) and subsequent refinement of fish habitat performance measures, the FOE PMs became obsolete.

Measures Used for Choosing a Treatment Schedule

A couple of additional measures were introduced prior to the final CC meeting in order to aid the CC when selecting a preferred treatment schedule *(Note. A treatment schedule details when and what flow trials are to occur)*. The treatment schedules considered by the CC are documented in ***Section A6***. The measures that were used are as follows:

- **Statistical Power –** this measure is a standard calculation which measures the statistical reliability for being able to differentiate a change between flow trials (so to be able to better quantify fish benefits). It is also based on the scope and degree of a proposed monitoring program. It is measured on a scale of 0 to 1.0, where 1.0 translates into a 100% probability of being able to correctly infer a change based on the measured results (and 0 referring to a 0% probability). Refer to the *Statistical Power Analysis Study* for a more complete description.
- **Net Present Value Costs –** this measure provides a monetary cost according to BC Hydro lost power revenue **and** GVRD payments in net present dollars over the review period being considered. It uses a discount rate of 8% and does not include water rental costs for water used for generation.
- **Annual Average Costs –** this measure amortizes the net present value costs to BC Hydro (above) over the number of years included in the review period. It uses an interest rate of 8%.

Number of Years – this measure provides the overall duration required to complete the treatment schedule.

A4 INFORMATION GAPS AND STUDIES…

For a complete summary of the studies undertaken in the Coquitlam-Buntzen WUP refer to Section 4 of the CCR.

At the conclusion of the Coquitlam-Buntzen WUP in March of 2002, there were two studies which still needed to be completed: (1) the *Instream Flow Needs Study*, and (2) *the Statistical Power Analysis Study*. The results from the studies were used by the FTC and the CC during their final meetings (March 31st, 2003). A copy of the reports are included in the Appendices. A brief description is provided below.

Instream Flow Needs (IFN) Study for the Lower* Coquitlam River

This study provided a detailed analysis of the river including habitat, hydrology, and biological assessments at various flow regimes. The results of the study provided the basis for the weighted useable area calculations used for the fish habitat performance measures. Field work carried out in the study included: transect data collection, channel surveys, linear habitat mapping, and snorkel surveys.

Conclusions: This study provided the empirical data needed to refine and revise the fish habitat suitability curves, which were needed to revise STP5 flow alternative and the fish habitat performance measures (described in ***Sections A5 and A6***). For more detail see the report in ***Appendix BB***.

Statistical Power of Monitoring Inferences Derived from Experimental Flow Comparisons Planned for the Coquitlam-Buntzen Water Use Plan (referred to as the *Statistical Power Analysis Study*)

This study evaluated the statistical reliability of the proposed consensus agreement made by the CC at their March 11th, 2002 meeting. Specifically it assessed the salmonid population monitoring program for inferring responses according to the proposed flow changes. The study also looked at ways in which the experimental design could be improved to provide more meaningful results.

Conclusions: As mentioned, this study was the trigger to see if there would be reliable information to base future decisions on. It concluded that there would not be; specifically it found that there would be:

- ~40% chance of detecting a change between baseline conditions and the 4FVN flow treatment; and
- ~20% chance of detecting a difference between 4FVN and STP5 flow treatments.

For more detail see a copy of the report in ***Appendix AA***.

* Lower Coquitlam River refers to that section of the river below BC Hydro's dam.

A5 OPERATING ALTERNATIVES…

For a complete summary of all the operating alternatives considered during the course of the Coquitlam-Buntzen WUP refer to Section 5 of the CCR. [19] ***This section only describes those alternatives which were introduced or used at the final March 31st, 2003 CC Meeting.***

For the purposes of clarity, this section has separated operating alternatives into their composite pieces according to:

Flow Alternative – which defines the breakdown of flows through the water control structures and/or identifies any reservoir constraints (Note. Flow alternatives are sometimes referred to as **treatments** or **flow trials** when there is more than one flow scenario)

Treatment Schedule – which defines the schedule of what flow alternative, when and for how long

The goal of making this distinction is to more easily highlight the different impacts and trade-offs outlined in ***Section A6***.

The treatment schedules and the one revised flow alternative described in this section were all developed by the FTC during their meetings (in 2003) and these were forwarded to the CC in a Pre-Reading Package for their consideration prior to the final March 31st, 2003 CC meeting.

Flow Alternatives (Flow Trials)

The general modeling constraints, assumptions, specifications, and key points applied to the flow alternatives were unchanged (see page 38 in the CCR).

Three of the original alternatives were referred to and used during the final CC meeting March 31st, 2003 and these were as follows:

2FVC – 2 Fish Valves Current Operations *(Treatment #1 in the Original CC Consensus Agreement).* This alternative was considered the base case and reflects current operating agreements with the GVRD.

4FVN – 4 Fish Valves Optimized (*Treatment #2 in the Original Agreement).* This alternative was equivalent to the average volume release of water from the dam into the Coquitlam River if four fish valves were always open (~10-12% of the mean annual discharge). The monthly flow release was optimized according to specific targets for identified fish species and stages. The GVRD proposed flow

[19] EcoPlan International, Inc. 2002. *Coquitlam Buntzen Water Use Plan: Report of the Consultative Committee.* Vancouver.

agreement was usually satisfied for this alternative (except sometimes in Aug to mid-Oct).

STP5 – Share the Pain #5 (*Flow Trial #3 in the Original Agreement*). The "Share the Pain" alternatives were designed to have target flow levels for both GVRD and fish requirements when sufficient water was available, and lower flow targets when natural inflows and storage was becoming limited. All of these alternatives also included water diversion for power generation; however, when water supplies started to become limited, it was the first water use to be curtailed. Also note that according to the CC's Original Consensus Agreement that STP5 was supposed to be revised once the results from the *IFN Study* were completed (described in more detail in the following section).

(For specific details of the above flow options refer to Section 5 of the CCR)

In addition to the 3 old alternatives (above), one revised and new alternative was developed prior to the final March 31st, 2003 CC meeting. This alternative was modified during the final meeting and those changes **are included** in the description below.

New* STP6** – Share the Pain #6. As part of the CC Original Consensus Agreement, the FTC was tasked with incorporating the results of the *IFN Study* into the Coquitlam WUP monitoring plan and adjust the STP5 flow regime.[20] Therefore, the ***Revised STP5 flow regime became known as ***STP6*** and it had **revised** instream flow targets according to the new IFN field data (whereas STP5 relied heavily on simulated data).

The FTC developed STP6 (revised STP5) in the spirit of the original agreement. Therefore, like other "sharing the pain" alternatives, it included upper and lower target flows for both domestic water and instream (fish) needs. The FTC used the revised habitat suitability curves from the *IFN Study* to amend the monthly instream flow targets according to key fish species and life stages in Reaches 2 and 3 of the Coquitlam River (driven by steelhead parr, steelhead spawning, chinook/coho spawning and incubation). The changes to the monthly flow targets are summarized in the following table (and compared with STP5 for reference). Refer to the *IFN Study* in ***Appendix BB*** for more details.

	STP5		New STP6	
	Dam Releases		Dam Releases	
	STP5 Target	STP5 Low	STP6 Target	STP6 Low
Jan 1-15	3.30	3.00	5.90	3.60
Jan 15-31			2.92	2.92
Feb	2.90	2.90	2.92	2.92
Mar	7.60	3.00	4.25	1.77
Apr	6.90	3.00	3.50	1.10
May	6.30	3.00	2.91	1.10
Jun	5.00	4.00	1.10	1.10
Jul	4.60	4.00	1.20	1.10
Aug	6.10	4.00	2.70	1.10
Sep	5.60	4.00	2.22	1.10
Oct	3.00	3.00	6.07	3.59
Nov	3.00	3.00	3.96	1.49
Dec	3.00	3.00	5.00	2.51

* *Note all monthly flow targets are in cubic meters per second*

[20] See Chapter 7 of the CC Report for details.

The flow targets assigned for GVRD withdrawals were unchanged from STP5. At the final CC March 31st, 2003 meeting, there was an accepted change in terms of priorities for when upper flow targets begin to be curtailed: ***GVRD priority went from first to second; river (fish) priority was changed to always being first.***[21] A summary of the target flows and priorities for both GVRD and the river are provided in the table below.

		Jan 1-15	Jan 16-31	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Share the Pain #6	River Flow Target (cms)	5.9	2.92	2.92	4.25	3.50	2.91	1.10	1.20	2.70	2.22	6.07	3.96	5.00
	River Lower Flow Target (cms)	3.60	2.92	2.92	1.77	1.10	1.10	1.10	1.10	1.10	1.10	3.59	1.49	2.51
	River Priority	**1**		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
	GVRD Flow Target (cms)	11.9		11.9	11.9	12	12	12	18	23	23	12	12	11.9
	GVRD Lower Flow Target (cms)	10.7		10.7	10.7	10.8	11	10.9	15.8	20.2	20.9	10.8	10.8	10.7
	GRVD Priority	**2**		**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**

For more details and discussion of STP6 (by CC members) refer to ***Section A6***.

Developing New Treatment Schedules

In addition to the treatment schedule (referred to as Treatment Schedule 1 below) which made up part of the CC's Original Consensus Agreement, the FTC proposed 3 additional treatment schedules for consideration by the CC at their final March 31st, 2003 meeting. These Treatment Schedules were developed with the following criteria:

- having a statistical power of at least 0.5;
- having only one additional flow trial in addition to the current baseline flow regime (2FVC); and,
- utilizing STP6 as the additional flow trial[22] based on available data from the IFN field study results.

Therefore, the ***only*** changing variable between the 3 Treatment Schedules was the durations of the flow trials and when they would begin. Below is a description of the treatment schedules presented to the CC for their consideration. Note that the reference year of 2001 was selected

[21] Therefore, if there was insufficient inflows to meet both GVRD and river (fish) upper target flows then GVRD would be curtailed first to their lower target range before river upper targets flows would be changed and this was now year round.

[22] The FTC selected STP6 as the preferred flow trial because it should create the largest effect and therefore have improved statistical power to better differentiate and address uncertainties with quantifying fish benefits.

because that is when meaningful collection data and monitoring began for fish on the lower Coquitlam River. All treatment schedules were assumed to begin starting in year 2004.

Treatment Schedule 1

- **Note: this is the original CC Consensus (Adaptive Management) Agreement that was considered "*ineffective*".**
- This option would provide 6 years of base flow data and 6 years data for each flow treatment (4FVN and STP5)
- The treatment schedule for this looks like the following:

Treatment Schedule 1 - Original CC Agreement: 3 Yrs 2FVC; 6 Yrs 4FVN; 6 Yrs STP5																		
Activity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Treatment #1 - 2FVC baseline smolt monitoring	1	2	3	4	5	6												
Dam Modifications				1	2	3												
Treatment #2 - 4FVN							1	2	3	4	5	6						
Treatment #3 - STP5													1	2	3	4	5	6

Treatment Schedule 2

- This option would provide 9 years of base flow data and 9 years data for STP6
- The treatment schedule for this looks like the following:

Treatment Schedule 2 - 6 Yrs Base (2FVC); 9 Years **STP6**																		
Activity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Treatment #1 - 2FVC baseline smolt monitoring	1	2	3	4	5	6	7	8	9									
Dam Modifications				1	2	3												
Treatment #2 - *STP6*										1	2	3	4	5	6	7	8	9

Treatment Schedule 3

- This option is exactly the same as Treatment Schedule 2 except that Treatment #1 (2FVC) would be reduced by 3 years
- Therefore it would have 6 years of base flow data and 9 years data for STP6
- The treatment schedule for this looks like the following:

Treatment Schedule 3 - **3** Yrs Base (2FVC); 9 Years **STP6**

Activity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Treatment #1 - 2FVC baseline smolt monitoring	1	2	3	4	5	6												
Dam Modifications				1	2	3												
Treatment #2 - *STP6*							1	2	3	4	5	6	7	8	9			

Treatment Schedule 4

- This option would provide 12 years of base flow data and 12 years data for STP6
- The total duration for this schedule exceeds the initial timeframe set out by the CC by 8 years
- The treatment schedule for this looks like the following:

Treatment Schedule 4 - 9 Yrs Base (2FVC); 12 Years **STP6**

Activity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Treatment #1 - 2FVC baseline smolt monitoring	1	2	3	4	5	6	7	8	9	10	11	12												
Dam Modifications				1	2	3																		
Treatment #2 - *STP6*													1	2	3	4	5	6	7	8	9	10	11	12

The technical tradeoffs between the proposed treatment schedules are provided in the following ***Section A6.***

A6 TRADE-OFF ANALYSIS AND RECOMMENDED OPERATING STRATEGY…

For a more complete summary of the technical and value trade-offs for the operating alternatives considered during the course of the WUP and for the recommendations made by the CC refer to Section 6 of the CCR.[23] This section only describes those trade-offs and decisions made at the final March 31st, 2003 CC Meeting; and does not include many of the recommendations reached by the CC (but they are documented in the CCR).

This section has been organized according to (i) selecting a preferred ***flow alternative*** and (ii) selecting a preferred ***treatment schedule*** to better highlight the different impacts and trade-offs. The last part discusses ***reaching consensus***.

Selecting a Flow Alternative

As mentioned in ***Section A5***, a total of 4 alternatives were included in the discussions at the final CC meeting: 2FVC (current operations), 4FVN, STP5 and STP6 *(revised STP5)*. The bulk of the trade-off discussions by the CC revolved around the impacts of STP6 and how they compared to STP5 and to a lesser extent 4FVN. The remainder of this section provides an overview of the technical and value trade-offs.

Technical Trade-Off Analysis – Selecting a Flow Alternative

The results of the impacts of STP6 on the primary performance measures (PMs) used by the CC in their evaluation of alternatives are provided in the Consequence Table below. In terms of the three identified primary objective areas, STP6 performed as follows:

Fish	STP6 performs better than, or almost the same as (given the uncertainty in the PMs), STP5 on all performance measures. It performed slightly less than 2FVC for steelhead spawning habitat, but this was a result of STP6 providing slightly more water than the optimal value calculated in the PM.
Domestic Water	STP6 performed slightly worse than 4FVN for annual water allocation, but marginally better during the driest year results (except for meeting the maximum nominations). It also performed better than STP5 consistently across the domestic water PMs (except for 1 day worse for maximum nominations not satisfied in the driest year).
Hydroelectric	STP6 performed worse than 4FVN (except in driest years) and better than STP5 across all the power PMs.

[23] EcoPlan International, Inc. 2002. *Coquitlam Buntzen Water Use Plan: Report of the Consultative Committee.* Vancouver.

Table: Consequence Table used at the Final March 31st, 2003 CC Meeting

Summary for Original PMs^: OBJECTIVES BY ALTERNATIVES MATRIX FOR COQUITLAM-BUNTZEN WATER USE PLAN

Note: This matrix includes CBWUP objectives experiencing the Greatest change. Not shown are flood, industry, recreation, and Wildlife/Environment PMs because they change little under the different flow regimes. Reservoir measure for fisheries is also not shown because it varies little with exception of extreme alternatives (eg. ESOR) and current operating agreement (2 Fish valves and current GVRD agreement).

			Alternatives			
Objective	**Performance Measure**	**Units** (Over 39 year model period)	**2 Fish Valves**	**4 Fish Valves 10-12%MAD Optimized**	**(STP 5) Sharing The Pain #5**	**(STP5 REVISED) Sharing The Pain #6**
			Current Agreement	**GVRD Proposed Agmnt. # 1**	**Fish & GVRD Proposed Agmnt # 1**	**Fish & GVRD Proposed Agmnt # 1**
Domestic Water	Annual average water allocation	cmsd (median)	7.88	14.31	13.84	14.05
	GVRD maximum nomination not satisfied per year	# of days (39 year median)	0	0	91	51
	GVRD minimum nomination not satisfied per year**	# of days (39 year median)	0	0	0	0
	GVRD Annualized Capital Costs for New Water Source	$ in million	$6.34	$2.60	$4.50	$2.60
Fish (River)^^	Steelhead Parr (rearing habitat)	Percent of Maximum Available Habitat	93%	90%	86%	91%
	Steelhead Spawning habitat	Percent of Maximum Available Habitat	58%	68%	76%	68%
	Salmon Spawning habitat	Percent of Maximum Available Habitat	55%	61%	70%	73%
	Coho Spawning Habitat	Percent of Maximum Available Habitat	72%	78%	82%	81%
Hydroelectric	Annual total power production	GWh - annual total (39 year average)	125	60	48	54
	Annual total power production and GVRD payments^^^	$ in millions - annual total 39 year average	$9.40	$8.03	$7.22	$7.69
Driest Year Results						
Domestic Water	Annual average water allocation	cmsd (median)	7.88	11.6	11.2	12.1
	GVRD *maximum* nomination not satisfied per year	# of days (driest year of 39)	0	57	317	318
	GVRD *minimum* nomination not satisfied per year**		0	55	80	44
Fish	Steelhead Parr (rearing habitat)	Percent of Maximum Available Habitat	87%	86%	80%	87%
Hydroelectric	Annual total power production	GWh - annual total (driest year of 39)	50.30	1.87	0.00	2.57

** Minimum nominations as agreed to at Working Group meeting on July 19, 2002 -- *Not* WSRP minimum nominations

^ Original PMs are those used before summer 2001 Working Group meetings.

^^ Steelhead parr is an indicatior for salmon rearing requirements. FTC did not feel that one measure for spawning could be developed.

^^^ This does not include capital costs to upgrade the LLO. These are expected to be approximately $310,000.

During the final CC meeting, Fish Technical Committee (FTC) representatives were asked to comment on STP6 and its target flows. Comments were as follows:

- All with the exception of the member representing North Fraser Salmon Assistance Project-CRWS supported the upper target dam releases of STP6 as the preferred flow treatment for fish based on existing information. He expressed concern with the analysis and preferred, on the basis of his professional experience, to support the original STP5 treatment.
- Concern was expressed about risks associated with low dam releases during the August bottleneck period.
- Many members of the FTC noted that they would suggest dropping the lower target dam release during the test period.

Value Trade-Off Analysis – Selecting a Flow Alternative

The majority of the discussions revolved around the selection of STP6 or not.

A number of CC members expressed concern that in view of revised and lower target dam releases for fish (from STP5), that STP6 should always satisfy target dam releases and remove the provision for "sharing the pain" (and therefore the lower or minimum target flows for the river). This was of particular concern during the summer months.

It was pointed out that:

- STP6 target dam releases through the summer months are less than low dam releases that were specified under the original STP5 treatment.
- GVRD demand from the Coquitlam Reservoir in 2015 is expected to be only slightly higher than at present and by 2007 water filtration facilities for the Capilano and Seymour water sources will be complete providing additional flexibility. For these reasons, GVRD commented that they do not anticipate impacting the upper target dam releases for fish except, perhaps, in extreme circumstances.
- In the unlikely event of a circumstance where there is insufficient water in the reservoir to meet both GVRD and fish releases during the trial period, the lower target releases serve as a safeguard not only for GVRD, but also potentially for fish since they provide important information about flow thresholds, based on the new field data collected during the IFN Study.

CC members were asked to comment on their level of support for STP6 as the preferred trial flow. Many expressed an opinion about whether they support the concept of "sharing the pain", that is retaining the lower river flow targets as part of the flow treatment during the test period. Comments are summarized in the table below.

Table: CC Member Comments about STP6

Affiliation	*Keep River Min Target Flow for Fish during Flow Trial Period?*	*Comments about STP6 Flow Treatment*
BC Hydro (2 members)	-	Agree that there are significant gains in fish Performance Measures up to the 4FVN flow treatment but not beyond. Yet there are significant costs to BC Hydro of dam releases over 4FVN. Therefore, face a significant struggle in increasing dam releases to anything greater than 4FVN. Prepared to consider doing so in the interests of data collection and of reaching consensus.
Buntzen Ridge Wilderness Recreation and Parks Assoc.	-	Agree with STP6 for fish. Change the name from "share the pain" to "share the gain"
Burke Mountain Naturalists (2 CC members with comments listed separately)	No	Agree with FTC. Concern that target dam releases may be too low for June and July.
		STP6 viewed as unacceptably low dam release for fish.
Coquitlam River Watershed Society	No	Supports STP6 because consensus is valued. Concerned about low flows, particularly during August and during extreme conditions.
Department of Fisheries and Oceans	Yes	Support STP6 for fish. Defer to site-specific empirical data.
Greater Vancouver Regional District (4 members)	Yes	Support for STP6 as a flow trial. Without analysis, GVRD is not prepared to accept STP6 target release without a provision for "sharing the pain" (i.e. "low" target fish releases). In principle, GVRD supports the concept of "sharing the pain" so that water is available to them in the very unlikely event that an extreme event should occur during the trial period. Two GVRD reps stated that targets should be based on the greatest amount of learning during the trial period. It was suggested by two of the GVRD representatives that negotiations would be needed in the event of an extreme event (eg. Climatic or contamination of another GVRD resource) so that fish flows are met where possible. ***Noted that it is highly unlikely during the proposed trial period that dam releases would ever fall below target flows even during low flow periods.
Habitat Conservation and Stewardship Program, Maple Ridge – Coquitlam	No	Not present for FTC discussion of STP6 scenario. Concerned about August bottleneck. Prefer to test target dam release for fish and remove lower release target.
Local Individual Residents (3 CC members with comments listed separately)	-	Surprised that preferred fish flow (STP6) is so close to 4FVN, but prepared to concede to opinion of FTC members. Agrees with the statistical power analysis in principle. Problem with the methods used to calculate the GVRD PM's.
	-	Change the word "bottleneck" to "lethal"
	No	Concerned about heavy reliance on IFN Study rather than professional judgment and experience. Raise Aug/Sep flows if possible.
Ministry of Water, Land, and Air Protection	No	Based on information we have, STP6 target release is the best possible outcome for fish. There is still uncertainty about this, but the data used to come up with STP6 is far better to the simulated data that was used to come up with STP5. Prefer to dispense with lower release target for the flow trial period.
North Fraser Salmon Assistance Project – Coquitlam River Watershed Society	No	On the basis of professional experience on the river, this member felt that the higher dam releases of STP5 would be better for fish than the target dam releases developed by the FTC for STP6.
Watershed Watch Salmon Society	No	Agree with STP6 target dam release but not with inclusion of lower release target. Agree that STP6 target is better than original STP5 target.

To take into consideration many CC members concern about the lower target flow in STP6, a suggestion was made to change the priority ranking of fish and domestic water so that fish are given first priority throughout the year rather than solely from October to June. This suggestion further reduces the probability of dam releases to the river falling below upper target levels during the flow trial period, especially important during the summer months including the

August 'bottleneck' period. At the same time this approach addressed GVRD's concern for more certainty in alternatives like the "sharing the pain" concept because they identify an operating condition in the very unlikely event of extreme conditions.

This change in priority ranking between fish and domestic water was accepted and is reflected in the description of STP6 provided in ***Section A5***. The level of support for this changed alternative is described in more detail under the sub-heading **Reaching Consensus** (see below).

Selecting a Treatment Schedule

As described in ***Section A5***, a total of 4 treatment schedules were included in the discussions at the final CC meeting. All the treatment schedules proposed by the FTC for consideration by the CC consisted of two flow trials (or treatments): the first being 2FVC (current operations) and the second as STP6. The trade-off discussions focused on costs and statistical power for when the flow trials should begin and for how long they should be carried out. The remainder of this section provides an overview of the technical and value trade-offs.

Technical Trade-Off Analysis – Selecting a Treatment Schedule

In order to evaluate the technical tradeoffs between the proposed treatment schedules, new performance measures were developed to help CC members. These new PMs are described in ***Section A3***. The results of the calculated PMs for each treatment schedule are summarized in the table below. These results indicate that the only treatment schedule that is dominated, or that performs worse across all performance measures, is Treatment Schedule #1 (which is the CC's Original Consensus Agreement).

Table: Summary of Technical Trade-offs Between Proposed Treatment Schedules

Objective (performance measure)	**Treatment schedule #1** Flow 1 = 2FVC: 3 yrs* Flow 2 = 4FVN: 6 yrs Flow 3 = STP5: 6 yrs	**Treatment schedule #2** Flow 1 = 2FVC: 6 yrs* Flow 2 = STP6: 9 yrs	**Treatment schedule #3** Flow 1 = 2FVC: 3 yrs* Flow 2 = STP6: 9 yrs	**Treatment schedule #4** Flow 1 = 2FVC: 9 yrs* Flow 2 = STP6: 12 yrs
Fish (statistical power; learning - fish flow requirements)	**.4** for moving from 2FVC to 4FVN **.2** for moving from 4FVN to STP5	**0.6**	**0.5**	**0.7**
Fish (Starting year for Flow2 - increased fish releases)	2007	2010	2007	2013
Power (Avg annual cost to BC Hydro)**	$1,106,000	$724,000	$1,036,000	$452,000
Domestic Water (Duration of experiment from Oct 2001 - GVRD constraint)***	18 yrs (2018)	18 yrs (2018)	15 yrs (2015)	24 yrs (2024)

* Proposed trial duration, starting 2004 (note: first year of meaningful collection of fish monitoring data was 2001. Therefore, the number of years with good fish data for the base flow (2FVC) will be 3 years longer than the proposed trial duration.)
** Discount rate of 8% was used. Costs to BCH are based on Annual Generation Revenue ***and*** GVRD Payments. Costs do not include water rental costs for water used for generation
*** Agreement reached in March 2002 was that trial flows for the CBWUP would be completed within 15 years from Oct. 22, 2001 to meet GVRD planning requirements. Note that the original agreement exceeded this constraint and would not be completed until 2018.

In addition, the following notes were provided to the CC regarding each treatment schedule:

- **Treatment Schedule #1 –** This is the original CC Adaptive Management Agreement and is considered *ineffective*.
- **Treatment Schedule #2 -** If Coquitlam Dam modifications are not complete by 2006 then Treatment Schedule 2 would probably not be impacted (Treatment Schedule 3 could be impacted by a delay in dam modifications).
- **Treatment Schedule #3** - Higher flows associated with STP6 would be provided sooner than in Treatment Schedule 2 or 4.
- **Treatment Schedule #4** - The total duration for this schedule exceeds the initial timeframe agreed to by the CC by 8 years. The 15-year timeframe was established to meet GVRD's long-term planning requirements.

Value Trade-Off Analysis – Selecting a Treatment Schedule

After reviewing the technical tradeoff information, the CC quickly reached several value-based decisions. First, the CC agreed to drop the original CC adaptive management program. Second, the CC agreed to accept the FTC recommendation of having one flow trial plus continued baseline flows (2FVC) rather than two plus baseline flows. Third, the CC agreed that Treatment Schedule #4 should be dropped from further consideration because the value placed on expected benefits to fish from bringing forward the start of higher dam releases of the second trial flow exceeds the value placed on statistical power and lower costs to BC Hydro from a 24-year trial duration. In addition, the 24 years for Treatment Schedule #4 greatly exceeded the GVRD time constraint and was viewed by some as too long a period over which to make operating decisions.

Therefore the value trade-offs were focused on selecting between Treatment Schedule #2 or #3. The main differences in moving from Treatment Schedule #2 to #3 were highlighted:

- the loss of .1 in statistical power;
- an increase in annual cost to BC Hydro of $312,000;
- three less years of the test period;
- more water in the river three years sooner.[24]

All CC members were given the opportunity to comment on the tradeoffs between Schedules #2 and #3. Preferences were as follows:

- **BC Hydro**: Schedule #2 preferred on the basis of cost, but BC Hydro values consensus and would consider Schedule #3.
- **GVRD**: Schedule #2 was preferred (although one member stated he was prepared to go with Schedule #3) because of the additional statistical power and, hence, better learning. In addition, the GVRD indicated that they are building water filtration facilities for the Capilano and Seymour water sources (with partial funding from Provincial and Federal grants). These water filtration facilities are scheduled for

[24] Increased dam releases over and above the present 2FVC may be affected by the schedule for the dam upgrading work. Construction is scheduled for completion by the fall of 2006, but a GVRD representative questioned whether BC Hydro will meet this construction schedule.

commissioning in 2007. It would be preferable to have the 2FVC fish release at Coquitlam continue through 2007 as the GVRD would have operation experience with the 2FVC fish release and would not see changes at Coquitlam (Treatment Schedule #2 would go to STP6 in 2007) at the same time as the filter plant changes are being made at Capilano and Seymour.

- **Other CC members:** Schedule #3 was preferred. These members agreed that the statistical power is less valuable for fish than it is to have water in the river sooner.

In the interest of reaching consensus there was a willingness to focus on Treatment Schedule #3 and this is described in more detail in the following section.

Reaching Consensus

CC members were asked to indicate their level of support and any final comments on the following proposed operating plan:

- Flow Treatment Schedule #3 with **STP6** (as amended with fish releases as the first priority throughout the year).
- Minimum river flow targets would be included as per STP6 as a safeguard for both fish and GVRD; and
- A process would be established to notify agencies in the event of exceptionally low water levels when GVRD would need to access Coquitlam water, which are not expected to occur during the trial period even during very dry periods.

As in the past, many members stressed their desire to find a common ground and a consensus alternative. ***The CC reached consensus on this operating plan with nobody blocking the plan, 7 members endorsing it and 12 accepting with reservations – see table (below).***

Table: Level of Support for Proposed Operating Plan (STP6 and Schedule #3)

Affiliation	*Accept w/ Reservations*	*Endorse*
BC Hydro (2 members)	X	
Buntzen Ridge Wilderness Recreation and Parks Assoc.	na*	na*
Burke Mountain Naturalists (2 members)	X	
Coquitlam River Watershed Society	X	
Department of Fisheries and Oceans		X
Greater Vancouver Regional District (4 members)		X

Habitat Conservation and Stewardship Program (HCSP), Maple Ridge – Coquitlam	X	
Local Individual Residents (3 members)	X	
Local Individual Residents (1 member)		X
Ministry of Water, Land, and Air Protection		X
North Fraser Salmon Assistance Project – Coquitlam River Watershed Society	X	
PoCo Hunting and Fishing Club **	X	
Port Moody Ecological Society	Na*	Na*
Watershed Watch Salmon Society	X	
Note: There is one CC member per organization unless otherwise indicated. * CC representative left prior to this discussion ** Decision by proxy (HCSP representative)		

Of the 12 people who accepted the operating plan, the member representing the North Fraser Salmon Assistance Program had strong reservations. But in the interest of consensus, was prepared to accept the proposed operating plan as a flow trial for the duration of this trial period. Based on extensive personal experience of the Coquitlam River, he was concerned that the proposed target flows in STP6 rely too heavily on IFN data and are too low for fish.

BC Hydro's corporate representatives accepted with reservations the operating plan with two caveats: financial impacts associated with the changed priorities for STP6, and scheduled completion dates for the dam upgrade work. Both of these caveats were subsequently removed.

Reservations expressed during the meeting by other CC members remain the same as those noted in the comments about the selection of STP6 (see above).

Post meeting submissions were received by 2 CC members explaining their reservations and these are included in the Meeting Minutes included in ***Appendix CC***. Their reservations were related to the operating plan not (a) taking into account temperatures, urbanization or sediment influx, (b) the low priority of conservation efforts by the GVRD[25], (c) concern about the loss of clean hydroelectric power, and (d) concern that river flows may be insufficient for other wildlife that use the river.

[25] See ***Appendix DD*** for GVRD's comments related to this point.

The following table summarizes the decisions agreed to by CC.

Table: Summary of CBWUP Operating Recommendations

Recommendations	Comments
Change one low level (LLO) outlet at Coquitlam Dam to permit STP6 river flows	♦ Flow regime STP6 will require an infrastructure change, allowing regulated and variable flows through one of the LLOs (expected to be complete by the beginning of 2007)
Treatment Schedule #3 Implement and monitor 2 flow trials: ♦ Test flow #1: 2FVC ♦ Test flow #2: STP6	♦ One of the main purposes of this plan is to test fish benefits from increased flows to Coquitlam River ♦ Test flow #1 will be tested first and will continue until the end of 2006 ♦ Test flow #2 will be implemented beginning in 2007 and will continue until the end of 2015 (9 years) ♦ Develop a monitoring plan with clear design measures
Develop a communication protocol	♦ A process will be established to notify agencies in the event of exceptionally low water levels when GVRD may need to access Coquitlam water
Other Recommendations	♦ **Other recommendations agreed to by the Coquitlam-Buntzen WUP CC as laid out in the June 2002 CBWUP Report of the Consultative Committee remain unchanged. In particular, bookends of 4FVN and STP5 would still remain in place and learning from the proposed operating plan would be applied within these bookends at a future WUP (refer to Section 6.2, Pg. 68 in the CCR).**

A7 MONITORING PROGRAM…

The components of the monitoring plan are unchanged from those described in the CCR (refer to Section 7) with the exception that it was agreed to not include control streams in the monitoring program[26].

The monitoring schedule has been modified to be consistent with the new operating plan using Treatment Schedule #3. The schedule and estimated costs of the monitoring table are summarized in the table below.

Table: Cost Estimate and Schedule for the Proposed Monitoring Program ($ in thousands)

Site	Monitoring Aspect:	*Current Operations Review*				*STP6 Review*								
		2003*	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Reservoir	*Access to Tributaries*	10												
River	*Annual Snorkel Assessment (Ramping Rates)*	12	5	5	10	5	5	5	5	5	5	5	5	15
	Pink Salmon Access	4		4		4		4		4		*4*		*10*
	Habitat Suitability Criteria	30				15								
	Invert. Productivity Index	20	20	20	20	20	20	20	20	20	20	20	20	30
	Reservoir Release TemperatureRegime	10	5	5										
	Fish Productivity Index	100	100	100	100	100	100	100	100	100	100	100	100	125
	Flushing Flow Effectiveness	30				30				30				40
Totals:		***216***	***130***	***134***	***130***	***174***	***125***	***129***	***125***	***159***	***125***	***129***	***125***	***220***

[26] Based on discussions of the Statistical Power Analysis results and other factors specific to the Coquitlam River by the FTC at their Feb 3rd and Mar 10th, 2003 meetings, it was agreed to **not** consider the use of control streams within the monitoring program.

A8 REVIEW PERIOD…

As part of the consensus operating plan agreement (with Treatment Schedule #3), the Consultative Committee recommended a 12 year review period for the Coquitlam-Buntzen Water Use Plan. This review period included the time required to make the necessary infrastructure changes to one of the low level outlets by the time required to implement STP6 (by 2007).

Three triggers to re-open the WUP were identified as follows:

1. If fish passage is found to be technically feasible[27].
2. If 200 cms flushing flows could be safely passed downstream.
3. If dam safety work changes the full storage capacity of the Coquitlam reservoir (and thereby affect the ability to meet water allocation targets).

[27] Taken from the June 11th 2001 CC Meeting Minutes as stated, "*The CC supports the idea of restoring sockeye to the Coquitlam River if it is found to be technically feasible. This WUP will incorporate operational issues regarding sockeye from the mouth of the Coquitlam River to the dam. If restoration of sockeye to the system is found to be technically feasible, then this should trigger re-opening of the WUP and consideration of operating issues related to sockeye upstream of the dam.*"

See also GVRD's additional comments related to feasibility in their submission to the Draft Addendum found in ***Appendix DD.***

A9 IMPLEMENTATION OF WATER USE PLAN PACKAGE…

Sequence of Events

In summary, the sequence of events for implementation of the agreed to operating plan is as shown in the flow diagram below.

Figure: Flow Diagram Showing Implementation Timing

Implement Buntzen Reservoir Management Plan[28]

Done

↓

Complete IFN Study

Done

↓

Approval of the Coquitlam-Buntzen WUP
Develop detailed monitoring program
Implement monitoring program
Continue Flow Trial #1 – 2FVC
Change one Low Level Outlet at dam to provide variable flows
Establish Monitoring Committee

3 Years

↓

Continue to Monitor
Start Flow Trial #2: STP6

9 Years

↓

Review Monitoring Results

Year 12 (2016)

[27] Implemented by BC Hydro in June 2001.

Appendix AA Statistical Power Analysis Study

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Statistical Power of Monitoring Inferences Derived from Experimental Flow Comparisons Planned for Coquitlam-Buntzen Water Use Plan

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SUMMARY

An experimental management program was recommended by the COQWUP CC to provide information on the response of anadromous salmonid populations of the Coquitlam River to changes in the operation of Coquitlam Dam. A 15 year long multi-treatment planned flow comparison was designed to compare productivity of fish populations of two operating regimes relative to the current baseline condition. The two instream flow release alternatives represent the final 2 of the 24 reviewed by the COQ WUP CC. A fish population monitoring program was proposed to estimate the benefits from each alternative, in terms of the incremental improvement of anadromous salmonid productivity over that which is provided from the current flow regime.

The objective of this analysis was to evaluate the statistical reliability of the proposed experimental treatment application and salmonid population monitoring program for inferring response of fish populations to flow changes. We developed a Monte Carlo framework to simulate the response of a salmon or steelhead population to habitat alteration and to quantify the reliability of alternative monitoring schemes for detecting changes in population abundance or productivity. We applied the framework to: 1) evaluate the statistical reliability of the proposed flow experiments for COQ WUP; and, 2) to explore experimental design options to improve reliability of the future anadromous salmonid monitoring program.

The main conclusion from our analysis was that the proposed experimental treatment application schedule and monitoring program are inadequate to provide statistically reliable inferences about changes in fish productivity resulting from the flow comparisons. There is less than a 40% inferring the correct response of coho salmon and steelhead trout populations to the flow changes from the baseline level. There is an even less chance of being able to statistically discriminate benefits between the 2 proposed instream flow alternatives (4FVN and STP#5).

Additional simulations were conducted to examine how changes in the experimental design and monitoring program would influence statistical reliability. Those simulations suggested that statistical power could be improved by developing an experimental program with: a) longer treatment duration; b) more precise measurement of smolt output; c) implementing treatments that will provide large effects on populations; and d) implementation of single and/or multiple control stock monitoring programs. To increase the expected statistical reliability of the proposed adaptive management program it is recommended that the follow actions be taken:

1) *Consider revision of the proposed experiment design*– This would include extension of the current baseline data collection period and implementation a single flow treatment to permit collection of ~3 generations pre- and post-treatment monitoring.

2) *If possible, improve the precision of smolt population monitoring*– Reasonably precise smolt estimation procedures have been developed for the Coquitlam River smolt enumeration during baseline studies, however, given the influence of smolt observation error on statistical reliability small improvements will likely increase power. *A* detailed examination of smolt outmigration data and trap efficiency should be conducted to establish feasibility for increasing the precision of smolt output estimates. Possibilities to increase smolt enumeration should be pursued.

3) *Investigate the feasibility of implementation multiple control stock network for COQ WUP and other WUP monitoring programs in the Lower Mainland* – Single stock monitoring is worthwhile because it helps to protect against transient effects that can confound experimental results, however, does not increase statistically power. Implementation of multiple control stocks, however, should lead to improvements in power. Since this may be cost prohibitive for implementation of a single WUP, it could be more cost effective to developed shared control streams with other Lower Mainland WUP programs. Possibilities for implementing shared control streams should be pursued.

INTRODUCTION

The Coquitlam-Buntzen Water Use Plan (COQ WUP) program considered more than 24 different operating alternatives for the Coquitlam-Buntzen hydroelectric system and each was evaluated for the potential economic, environmental, and social benefits (EPI 2002). Iterative modeling of the power system was combined with environmental performance measure analyses to refine operating alternatives through an extensive stakeholder consultation process. By the end of the process, the number of operating alternatives was reduced to 2, but a consensus on the final selection on flow regime could not be achieved. Lack of agreement on either flow alternative was primarily driven by doubt in the fish resource performance measures for the Coquitlam River. Uncertainty in fish resource assessments was mainly due to: 1) fundamental uncertainty about the functional relationships between flow->habitat->fish for the Coquitlam River, 2) poor contrast in available hydrometric data needed to calibrate hydraulic models which necessitated extrapolation of habitat predictions to flow levels above that observed but under consideration by the WUP Consultative Committee, 3) unknown influence of sediment quality issues from gravel mining operations and the practical extent to which impact that could be mitigated by deliberate flushing flows from Coquitlam Dam. Ultimately these uncertainties were significant enough to prevent final consensus on a single operating alternative, and an adaptive management program was devised to resolve uncertainty about the fish resource benefits from each of the final instream flow alternatives (EPI 2001).

The concept for the COQ WUP adaptive management program is an controlled comparison of the incremental fisheries benefits resulting from the final two alternative operating procedures. A 15 year long program was proposed which is to be phased three periods. In the first phase (Year 1 to Year 3) after approval of the COQ WUP by the Water Comptroller, the required modifications of Coquitlam Dam would be completed to permit delivery of flows in the ranges recommended by the COQ WUP. During this period, the instream flow assessment study would be completed and further baseline fish population data would be collected (3 years). In the second phase (Year 4 to Year 9), the first treatment (4FVN) would be completed and monitored. In the final phase of the experiment (Year 10 to Year 15), a second flow treatment (likely STP#5) would be applied. This second treatment would be contingent on the results of the completed instream flow study and from monitoring results from the first treatment. Initially, it was proposed that experimental assessments of flushing flow be conducted concurrent with the controlled flow releases. However, it was recognized that uncontrolled flushing events may confound the effects of the flow treatments and thus it was agreed that flushing flow assessments would be conducted opportunistically as natural events occur.

This analysis was conducted at the request of the COQ WUP Fisheries Technical Committee (the FTC) to evaluate the requirements of fish population monitoring programs to detect changes in the productivity of fish populations in the Coquitlam River during the proposed adaptive management program. The objectives of the analysis were to: 1) evaluate the statistical reliability of the proposed experiments for COQ WUP, and 2) to explore options to maximize the reliability of the future anadromous salmonid monitoring program. We developed a Monte Carlo framework to simulate the response of a salmon population to habitat alteration and to quantify the reliability of alternative monitoring schemes for detecting changes in population abundance or productivity. We used the framework to address four central questions associated with the design and implementation of monitoring for the COQ WUP. First, what is the relative efficiency of alternative population response estimators (smolts, spawners, or inferred smolt equilibrium abundance derived from stock and recruitment analyses) in terms of statistical power for inferring the response of populations to flow changes? Second, what are the benefits, in terms of statistical reliability of monitoring inferences, from increasing the precision of measurements of smolt or spawner population indicators? Third, what are the required levels of replication (pre- and post-treatment monitoring duration) to obtain acceptable statistical inferences? Finally, does the implementation of control stock monitoring (single or multiple streams) increase the reliability of monitoring results and inferential quality of experimental monitoring program results? By addressing those issues we hope to increase understanding about monitoring requirements and provide some recommendations for the development of an informative experimental management plan for the Coquitlam-Buntzen Water Use Plan.

METHODS

Approach to the Analysis

We used a two-stage anadromous salmonid life history model to simulate a time series of observed spawner and smolt data to evaluate the utility of alternate monitoring programs for the Coquitlam River. The freshwater stage of the model predicts smolt production as a function of spawner abundance using a Beverton-Holt stock-recruitment relationship. Returning spawners are predicted from smolt numbers by assuming a constant density independent marine survival rate. Different levels of process and observation error in both freshwater and marine components of the model were simulated. Part way through each simulation, a positive change stock productivity and carrying capacity of the smolt-spawner relation was imposed to mimic expected population responses to freshwater habitat manipulations. Bias and precision in effect size estimates using smolt, spawner and the equilibrium smolt abundance estimated from the smolt-spawner recruitment curve, before and after (a before-after or BA design) the imposed change, were computed and a t-test was performed to test for statistical differences. To simulate before-after-control-impact (BACI) designs, a time series for one or more control stocks was also simulated with different degrees of covariance in freshwater and marine process error. Differences between treatment and control were computed before and after the imposed habitat change and tested for statistical significance.

Model Structure

The following form of a Beverton-Holt stock recruitment (SR) relationship was used to predict smolts (*Sm*) as a function of spawner (*Sp*) abundance,

$$Sm_t = \frac{\alpha * Sp_{t-fwyrs}}{\beta + Sp_{t-fwyrs}} * e^{v_{i,sm,p}} , \quad (1)$$

where t is the year of entry into the ocean, *fwyrs* is the number of years between spawning and ocean entry, α and β are parameters of SR relationship, and $v_{i,sm,p}$ is a normally distributed error term for treatment (i=1) or control stocks (i=2) with mean 0 and SD = $\sigma_{sm,p}$. Note that with this form of the Beverton-Holt SR model α/β is the stock productivity (maximum number of smolts produced at low spawner abundance) and α – β/*MS* is the equilibrium number of smolts, where *MS* is an observed or assumed marine survival rate. To simulate the effects of habitat improvement, α and β were multiplied by factors (α_{mult} and β_{mult}, respectively) that shifted the smolt-to-spawner recruitment curve to achieve the desired change in carrying capacity (Cap_{effect}) and stock productivity ($Prod_{effect}$),

$$\beta_{mult} = \frac{Cap_{effect} * (\alpha - \frac{\beta}{MS})}{\Pr od_{effect} * \alpha - \frac{\beta}{MS}} \quad (2)$$

$$\alpha_{mult} = \Pr od_{effect} * \beta_{mult} \quad (3)$$

The number of spawners produced *maryrs* later is proportionally dependent on the number of smolts produced,

$$SP_{t+maryrs} = Sm_t * MS * e^{v_{i,sp,p}} , \quad (4)$$

where $v_{i,sp,p}$ is a normally distributed error term with mean 0 and SD = $\sigma_{sp,p}$. The model assumes lognormal process error in both freshwater and marine stages (Allen 1973; Ricker 1975; Peterman 1981; Bradford 1995).

To generate observed 'observed' data, we assumed that spawner and smolt abundance was estimated with multiplicative errors (Walters and Ludwig 1981; Caputti 1988; Korman and Higgins 1997):

$$ObsSm_t = Sm_t * e^{v_{sm,o}} , \quad (5)$$

$$ObsSp_t = Sp_t * e^{v_{sp,o}} , \quad (6)$$

where and $v_{sm,o}$ and $v_{sp,o}$ are normally distributed error terms with mean 0 and SD = $\sigma_{sm,o}$, SD = $\sigma_{sp,o}$, respectively.

To simulate control stocks with different degrees of covariation with the treatment stock, the process error terms of Eqn.'s 1 and 2 for the control stocks ($\upsilon_{2,sm,p}$ and $\upsilon_{2,sp,p}$) were computed from,

$$\upsilon_{2,sm,p} = \sqrt{(1 - COV_{fw})} * \upsilon_{2,sm,p} + \sqrt{COV_{fw}} * \upsilon_{1,sm,p} , \quad (7)$$

$$\upsilon_{2,sp,p} = \sqrt{(1 - COV_{mar})} * \upsilon_{2,sp,p} + \sqrt{COV_{mar}} * \upsilon_{1,sp,p} , \quad (8)$$

where COV_{fw} and COV_{mar} are the squared correlation coefficients (r^2) between treatment and control stock based on residuals from the smolt-to-spawner recruitment curves and marine survival rates, respectively.

Model Parameterization

Fish Population Dynamics Parameters

As with most anadromous fish populations in B.C. the population dynamics of coho salmon and steelhead populations of the Coquitlam River are poorly documented. To parameterize the population dynamics component of the model we used spawner and smolt abundance data from 15 coho stocks from coastal streams along the western slope of North America from Oregon to Central British Columbia (Bradford et al. 2000). Much less information is available to describe the population dynamics of steelhead populations. We could only locate two long term data sets to estimate population dynamics of steelhead (Keough, Snow

Creek). Estimates of α, β, and $\sigma_{sm,p}$ were derived for each of the stocks by fitting the model using a maximum likelihood approach assuming lognormal error (Table 1). Marine survival rates were computed as the ratio of $spawners_{t+1}/smolts_t$ and therefore included the effects of fishing mortality. Estimates of $\sigma_{sp,p}$ for each stock were computed based on log-transformed survival rates. As most of the spawner and smolt abundance estimates were made from fences or weirs, we assumed that the variance in marine survival rates and residuals around smolt-to-spawner recruitment relationships represents process error alone.

Coho salmon and steelhead have similar assumed underlying forms of the spawner-smolt stock recruitment relationships, following that implied by the form of Beverton-Holt or "hockey stick" stock recruitment models (Bradford et al 2001). We used the meta-analyses data to derive standardized (i.e. smolts/female spawner per kilometer) estimates of required parameters. For steelhead trout, we computed population dynamic parameters using the available data and found that both river systems were contained within the 20% and 80% levels for stock productivity, survival rates, and survival rate variation. However, steelhead life history does not conform to that observed for coho salmon. Since steelhead typically spend 2-4 years longer in the ocean we predicted that coho salmon will exhibit a quicker response time, thus provide the most optimistic evaluation of statistical reliability of proposed experimental strategies.

The simulated stock was assumed to have an equilibrium smolt abundance during the pre-treatment period of 1000 smolts/km, and spend two years in freshwater (*fwyrs*=2) and 18 months at sea (*maryrs*=1). Simulations were performed using stock productivity values based on the median (80 smolts/spawner), 20th (40 smolts/spawner), and 80th (140 smolts/spawner) percentile from 13 of 15 productivity estimates (Table 1). Values for α and β used in the simulated were derived to attain these stock productivity's and the assumed 1000 smolts/km equilibrium smolt abundance during the pre-treatment period (40: α=2000, β=50; 80: α=1333, β=16.7; 140: α=1167, β=8.3). Simulations were based on median estimates for marine survival (*MS*=0.05) and process error in marine ($\sigma_{sp,p}$=0.9) and freshwater ($\sigma_{sm,p}$=0.3) phases.

Baseline assumptions for parameters of population dynamics and monitoring program design and the range of parameters explored to assess sensitivity of power estimates are provided in Table 2.

Effect Size

There is considerable uncertainty about the potential magnitude of the productivity response of coho and steelhead populations to the flow treatments. The implementation of the proposed either of the flow alternatives (4FVN, STP#5 refer to EPI 2002 for description of the instream flow treatment regimes) is anticipated to approximately double the flow in the river over the baseline reference conditions (2FV+PA). Members of the FTC suggested that the anticipated changes in weighted useable habitat ranges between approximately 0 and 50% where maximum differences were as high a 100% (Figure 1). Some FTC members expressed the view that population increases from implementation of the 4FV or STP#5 alternatives could provide as high as a 100% increase in abundance over that now existing in the river, however, others expected much more modest improvements (i.e. 10% - 50%). Both alternatives greatly increased minimum flow during critical flow periods (August). Differences in the productive capacity of habitats between the 4FVN and STP#5 alternatives were expected to be much less, likely in the order of 0% - 25%. For the evaluations conducted post-treatment effects reflecting baseline (50% increase) and optimistic (100%

increase) in freshwater carrying capacity and stock productivity were explored (*Cap_{effect}* and *$Prod_{effect}$* from Eqn.'s 2 and 3 of 1.5 and 2, respectively).

Monitoring Program Parameters

We considered four critical decisions regarding the design of the monitoring program for the adaptive management program are: 1) what is the most appropriate population indicator for indexing the productivity of the fish populations?; 2) how long should treatments be applied and fish population indicators monitored?; 3) how precisely to population indicators need to be measured; and, 4) should control stock monitoring be implemented to improve statistical reliability?.

Three fish productivity response indicators were considered in our analysis: 1) smolt output; 2) spawning population; and 3) the theoretical equilibrium smolt capacity of the river derived through stock and recruitment analysis (smolt equilibrium). Smolt abundance is a popular metric because it is a spatially integrated measure of freshwater productivity, and for all but low spawning population abundance, independent of confounding factors that affect fish survival in the ocean. Spawning population is believed to be a poor indicator of fish response because of high inherent variation (Pella and Myren 1974; Korman and Higgins 1997) and exposure to transient factors that confound fish population responses (i.e. Walters et al 1989; ocean conditions, fishing). Stock recruitment analyses allow the smolt metric to be explicitly corrected for the influence of spawning stock across all abundance levels and explicit accounting of density dependent effects. In our analyses, we compared the performance of indicator to allow decisions about what to monitor during the adaptive management program to index fish population productivity.

The duration of flow treatment application is a primary component of the design of the adaptive management program not only for the statistical reliability but also for the overall cost of the program. The COQ WUP CC recommended a schedule for the adaptive management program, including the timing of the experimental flow releases and monitoring program. This plan specified that baseline data which would serve as reference for flow changes would be based on: 1) those data already collected during the outmigration studies conducted 1996-2001 and 2) supplemented with 3 additional years of data while dam modifications required to provide the treatments were being completed. Each of the flow treatments were proposed to last 6 years in duration. This six year period would allow two generations of coho salmon (i.e. 3 year life history) and 1 generation of steelhead to be produced (i.e. 6 year life history), and match the treatment duration recommended by the COQ WUP CC. For exploratory purposes our analysis evaluated total program duration of 6, 12, 18, 24, 30 and 36 years. Total program duration was composed of a balanced number of years prior to and after the implementation of the treatment. For example, a 12 year experiment would have 6 pre- and 6 post-treatment years of monitoring.

Observation error is an important parameter of monitoring program design. There are few empirical studies of the precision of alternative methods for assessing smolt and spawner abundance, and none for the Coquitlam River itself. Estimates of the potential range of precision of mark recapture approaches for estimating the smolt enumeration were derived through professional judgement and simulation exercises based on information on trapping efficiency data collected from the Coquitlam River between 1996-2001 (Higgins, unpublished data). Estimates of the potential range precision of measuring spawning populations derived from that used in published studies (i.e. Walters and Ludwig 1981; Korman and Higgins 1997, Korman et al. 2002). We simulated 3 levels of observation error reflecting high (i.e., fence where $\sigma_{sm,o}$=0, $\sigma_{sp,o}$=0), moderate (i.e., robust mark-recapture where $\sigma_{sm,o}$=0.3, $\sigma_{sp,o}$=0.3), and poor (i.e., weak mark-recapture program where $\sigma_{sm,o}$=0.6, $\sigma_{sp,o}$=0.6) monitoring precision for spawners and smolts.

A critical issue identified by the COQ WUP CC for consideration in this analysis was the statistical benefits of control stock monitoring. The capability of control stock monitor to isolate and remove non-treatment components of effect size estimates will be related to: 1) the number of control streams monitored; and 2) the intrinsic level of covariation in survival rates of fish among control and treated populations. We simulated monitoring programs that used 0,1,3, and 5 control stocks. Estimates of covariance in freshwater (COV_{fw}) and marine (COV_{mar}) survival rates were derived from a meta-analysis of coho survival data where the average and maximum squared Pearson correlation coefficients in freshwater and marine survival rates for stocks within ~30 km was 20%, respectively (Bradford 1999). We used COV_{fw} and COV_{mar} that spanned and exceeded this range to cover maximum expected levels of covariation (0, 0.2, 0.4, 0.6).

Analysis of Simulated Data

Following each individual simulation the estimated effect of a true change in the productivity of the populations was computed using three population response estimators based on measured differences in the three measurement indicators described above. Mean spawner and subsequent smolt abundance observed in the simulations during the pre- and post-treatment periods were computed from log-transformed data. Smolt-to-spawner Beverton-Holt relationships were fit to the pre- and post-treatment data using a maximum likelihood approach assuming lognormal error. Initial estimates for α and β recruitment parameters used in the non-linear iterative search procedure were randomly drawn from a uniform distribution with a range of 10% to 250% of the true values used in the simulation. If the non-linear search procedure failed to produce reasonable estimates of equilibrium smolt abundance (negative values or values greater than 10 times the true carrying capacity) the trial was rejected and an estimation failure was recorded. Equilibrium smolt abundance for pre- and post-treatment periods were computed from $\alpha - \beta/MS$ with the assumed marine survival rate held constant across both periods. Apriori, we expected that differences between mean smolt output and spawner abundance during the initial part of the post-treatment period could be lower than the new equilibrium implied by habitat restoration because of the population response lag created by the combined productivity of the stock and life history of anadromous species. In theory, the stock recruitment derived equilibrium smolt indicator accounts for lagged response by removing effects of spawner abundance and should therefore produce less negative bias than the simpler abundance-based measures.

To compare the reliability of alternative population response estimators and experimental designs for monitoring we computed statistical power of inferences about population response to habitat alteration. Statistical power was estimated for both BA and BACI comparisons as the percentage of 1500 trials with a significant increase in the metric during the post-treatment period based on a one-tailed *t* test using a maximum acceptable type I error level of 20%. This type I error rate was chosen so that, when using a minimum acceptable power level of 80%, the probability of making a type II error would equal that of a type I error (Peterman 1990). For the BACI comparisons, we computed the difference between the control and treatment stocks for the pre-and post-treatment periods. When more than one control stock was simulated, we computed a mean abundance across controls for both periods and used these mean values to then compute the differences between control and treatment during pre- and post-treatment periods.

RESULTS

Power of the COQ WUP Experiment to Detect Change

A primary conclusion from our analyses is that it is unlikely that the proposed duration and sequence of experimental treatments and salmon population monitoring program identified in the COQ WUP Consultative Report (EPI 2002) will provide a statistically reliable basis to differentiate the coho salmon or steelhead trout response to implementation of the 4FVN and STP#5 alternatives from that observed at the baseline instream flow regime (2FV+PA).

We estimate that for comparison of the baseline reference to the either treatment under assumed baseline population and monitoring parameters for the Coquitlam River experiment (80 smolts/spawner, coho, $\sigma_{sm,o}$=0.3, $\sigma_{sp,o}$=0.6, +50% effect size $\sigma_{sp,p}$=0.9, $\sigma_{sm,p}$=0.3, 6 years pre and 6 year post, Type 1 error rate α=0.2) would yield an expected ~40% chance of correctly inferring whether productivity had been improved (Figure 3). Power for the steelhead life history (i.e. 4.2) was about 5-10% less. If flushing flows are ineffective, it is possible that the stock productivity would be impaired and respond closer to that expected from the low productivity stock, and there would be less than a 25 % chance of drawing the correct inference form the monitoring data. Only under very optimistic conditions for stock productivity (140 smolts/spawner) and effect size (100%), could inferences be characterized as reliable, as the chances of drawing the correct inference approaches or exceeds 80%. This means that is a very limited capability to detect a population response between the baseline (2FV+PA) and the proposed treatments (4FVN, STP#5), and even lower chance of differentiating response between the proposed treatments.

Options for Improvement

Our results suggest that monitoring programs that rely on smolt abundance or smolt equilibrium indicators consistently provided the most reliable inferences about population response to the planned flow changes (Figure 3). Smolt based measures provided the marginally more powerful experimental monitoring comparisons than smolt equilibrium measures (typically a 5%-10% increase in power), except during short duration experimental monitoring programs conducted on low productivity stocks. Higher power of smolt comparisons was a function of 1) relatively unbiased estimates of population response, and 2) much greater precision of effect size estimates. Lower power during short experiments was caused by negatively biased estimates of post treatment abundance because the effect of spawning population abundance was not being accounted for. Across all of the conditions we simulated, monitoring programs that use spawner based population indicators not likely to produce inferences of acceptable statistical power for practical habitat management experiments (i.e. <30 years in duration).

As expected from statistical theory, for a given level of process and observation error, the power of monitoring inferences increased asymptotically with the duration of monitoring, productivity of the stock, and magnitude of the population response (Figure 3). In addition, there is an important interaction between productivity of the stock the magnitude of the population response, and the duration of monitoring. Under a proposed experimental scenario (+50% effect size, 2 generations of pre- and post-treatment monitoring) the power for experiments based on the smolt population response indicator conducted on highly productive stocks was 2.5-fold higher compared to the power from an experiment conducted on a low-productivity stock (~50% vs ~20%; Figure 2). Since productivity can not be controlled by the planners of experiments, power of inferences can be influenced by either increasing the effect size or by increasing the duration of the experiment. For example, under proposed baseline assumptions for the Coquitlam experiment, 5 generations of pre and post treatment smolt population monitoring (i.e. 30 years total duration for coho salmon) were required to produce and 80% change of correctly inferring population response from the monitoring program. However, if the magnitude of the effect size can be doubled (100%), the duration can be reduced to 12 or 18 years total duration (Figure 2). Together, low productivity, small true effect size, and short experiments have a pathological effect on experimental monitoring comparisons. Under these conditions, there is likely less than a 50% chance of drawing the appropriate conclusions from monitoring data, even for experimental monitoring programs that extend to greater than 30 years in total duration (Figure 2).

Our results suggest that the power of inferences about population response based on smolt and spawner data during pre- and post-treatment periods can also be improved by reducing observation error, however the extent of this improvement depends on the population response indicator and background process variation. To demonstrate the benefits of reducing observation error of either smolts or spawner monitoring techniques we computed the power of a typical 12 year long experiment where after 6 years of baseline monitoring a 50% increase in productivity under various levels of smolt and spawner observation error and two levels of variation in survival of smolts to the spawner life stage ($\sigma_{sp,p}$ = 0.4, $\sigma_{sm,p}$= 0.9). We first held observation error for smolts constant at a moderate level ($\sigma_{sm,o}$ = 0.3) while varying the precision of spawner data ($\sigma_{sp,o}$= 0.0 - 0.7). We then repeated this process holding spawner measurement precision constant and varying smolt measurement precision over the same ranges (i.e. $\sigma_{sp,o}$ = 0.3, $\sigma_{sm,o}$= 0.0 - 0.7). Irrespective of the level of observation precision of smolts or spawner surveys increased process error decreased the statistical power of inferences about population response to habitat change based on the smolt, spawner or smolt equilibrium response indicators. Marginal improvements in power in spawner based experimental comparisons can be obtained through the reduction of spawner observation error, however this is only under conditions with low process and observation error ($\sigma_{sp,p}$ = 0.4, $\sigma_{sm,o}$ < 0.3; Figure 3). Although smolt equilibrium based metrics, in part, rely on spawner time series data for the formulation of pre- and post-treatment stock and recruitment relationships, reducing observation error for spawner surveys did not have an observable impact on the power of monitoring results. Reductions in observation error in smolt surveys did result in a considerable improvement in the power of experimental monitoring comparisons for both smolt and smolt equilibrium response indicators. The largest improvements in power were most apparent for the smolt equilibrium indicator. For example, for a high process error and moderate productivity cases reducing smolt measurement error from $\sigma_{sm,o}$= 0.6 (e.g. low precision mark recapture) to $\sigma_{sm,o}$ = 0.0 (e.g. enumeration fence) would result in an increase in expected power from 0.30 to 0.52 and 0.20 to 0.64 for smolt and smolt equilibrium monitoring comparisons, respectively (Figure 3).

Performance of Before-After-Control-Impact Designs

Implementation of control stock monitoring will increase the power of monitoring programs, but the relative improvement is affected by the populations response indicator selected, the number of controls, and the magnitude of covariation among treatment and control stocks. Under the baseline conditions for the COQ WUP experiment a single control stock (assuming COV_{fw} and COV_{mar} =0.4) does not result in an appreciable increase in statistical power

(Figure 4). However, control stock monitoring has an unquantifiable value in protecting the quality of inferences by accounting for transient factors that affect all stocks.

The power of BACI experiments based on smolt or spawner based response indicators improved with the increased levels of covariation between treatment and control stocks and to a much lesser extent with the number of control stocks used in the comparison (Figure 4). Our simulations also show when using a stock and recruitment approach for monitoring. The improvement in power of experimental monitoring comparisons was strongly influenced by the magnitude of observation and process variance (Figure 5). For example, for comparisons based on the smolt based population response indicator under low and high process error assumptions, lower power was achieved when the precision was low. For experiments where only low precision estimates of smolt abundance can be obtained, there is appears to be little benefit, in terms of increased power of comparisons, from control stock monitoring. The variability in the differences between control and treatment stocks is influenced by the inter-annual variance for both so when multiple controls are used the variance is reduced, as this provides a better estimate of the coherent non-treatment factors on survival. When only one treatment stock was simulated, the variance in the difference between control and treatment is still relatively large. Consequently, there is not much of an improvement in power from increasing the number of control stocks. If we had increased the number of treatment stocks the effects of using multiple-stock comparisons would have been more apparent.

CONCLUSIONS AND RECOMENDATIONS

Our analysis indicated that he proposed schedule experimental treatment applications for the flow comparison and salmonid population monitoring is not sufficient to provide statistically reliable inferences about the response of coho salmon or steelhead trout to the flow changes. Additional analyses suggested that statistical power of experimental monitoring inferences could be improved by consideration of :a) longer duration treatments; b) more precise measurement of smolt output; c) implementing treatments that will provide large effect on populations; and d) implementation of single and/or multiple control stock monitoring programs. Our recommendations to increase the expected statistical reliability of the proposed adaptive management program are, in terms of the value for increasing statistical reliability are:

1) *Consider revision of the proposed experiment design*– This would include extension of the current baseline data collection period and implementation a single flow treatment to permit collection of ~3 generations pre- and post-treatment monitoring.

2) *If possible, improve the precision of smolt population monitoring*– Reasonably precise smolt estimation procedures have been developed for the Coquitlam River smolt enumeration during baseline studies, however, given the influence of smolt observation error on statistical reliability small improvements will likely increase power. *A* detailed examination of smolt outmigration data and trap efficiency should be conducted to establish feasibility for increasing the precision of smolt output estimates. Possibilities to increase smolt enumeration should be pursued.

3) *Investigate the feasibility of implementation multiple control stock network for COQ WUP and other WUP monitoring programs in the Lower Mainland* – Single stock monitoring is

worthwhile because it helps to protect against transient effects that can confound experimental results, however, does not increase statistically power. Implementation of multiple control stocks, however, should lead to improvements in power. Since this may be cost prohibitive for implementation of a single WUP, it could be more cost effective to developed shared control streams with other Lower Mainland WUP programs. Possibilities for implementing shared control streams should be pursued.

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Table 1. Meta-analysis of population dynamic parameters for 13 coho stocks based on data from Bradford et al. (2000). Smolt-to-spawner parameter estimates (columns 4-8) were computed based on stream length-standardized smolt and spawner data. Standard deviation (SD) of residuals around the smolt-to-spawner relationship and marine survival were computed from log-transformed data. Note marine survival estimates include the effects from fishing mortality.

Stock Name	Length (km)	Years of Data	α	β	SD of Smolt-to-Spawner Function (ln)	Stock Prod. (smolts/ spawner)	Smolt Carrying Capacity (smolts / km)	Marine Survival Rate	SD of Marine Survival Rate (ln)
Big Beef	18.0	18	1,905	25.2	0.31	75	1,352	0.04	0.75
Black Creek	33.0	12	3,264	54.2	0.45	60	2,076	0.03	1.09
Carnation	3.1	26	1,401	12.2	0.29	115	1,134	0.03	0.94
Dechutes	54.0	17	5,355	217.0	0.34	25	600	0.05	0.93
Deer Cr	2.3	13	1,416	14.9	0.24	95	1,090	0.03	0.52
Flynn Cr	1.4	13	465	3.4	0.61	139	392	0.05	1.02
Hooknose	5.8	13	865	1.8	0.27	471	824	0.06	0.72
Hunts	5.4	11	1,172	28.4	0.66	41	549	0.08	0.87
Minter	16.6	11	1,889	5.8	0.24	325	1,762	0.04	0.65
Needle Branch	9.7	12	36	0.5	0.36	67	24	0.09	1.08
Nile	6.0	9	1,032	21.1	0.17	49	571	0.06	0.49
Skykomish	92.4	11	3,438	31.7	0.14	109	2,744	0.04	0.66
Snow	7.0	15	1,767	45.7	0.36	39	766	0.04	1.94
		Percentile							
			20^{th}		0.24	44	558	0.03	0.66
			Median		0.32	81	795	0.05	0.90
			80^{th}		0.36	139	1,134	0.06	1.02

Table 2 Summary of baseline population dynamics parameter and monitoring program assumptions for simulations to evaluate the statistical reliability of alternative anadromous salmonid population monitoring programs in the Coquitlam River. Where applicable, bolded parameter values represent baseline levels assumed.

	Baseline	**Range Explored in Sensitivity Analysis**
Population Dynamics Parameters		
Maximum Population Response	+50%	+50% (Realistic), +100% (Optimistic)
Stock Productivity (smolts/spawner)	80	40 (Low), 80 (Median), 140 (High)
Life History (ocean. freshwater yrs)	2.1	2.1 (Coho); 4.2 (steelhead)
Baseline Smolt Abundance (smolts/km)	1000	-
Process Error Freshwater Marine	 0.3 0.9	 0.3 0.4 (low), 0.9 (high)
Inter-stock Covariation (r^2) Freshwater Marine	 0.4 0.4	 0.0 – 0.6 0.0 – 0.6
Monitoring Program Parameters		
Experimental Monitoring Duration (years)	12	6, 12, 18, 24, 30, 36 or (1 to 6 generations pre- and post-treatment monitoring)
S.D. Observation error Smolts Spawners	 0.3 0.6	 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7
Number of Control Streams	0 or 1	0, 1, 3, 5

Figure 1 Comparison of relative gains in rearing and spawning habitat for coho salmon and steelhead trout expected from the initiation of 4FVN and STP#5 operating scenarios relative to the current 2FV +CA alternative. Weighted useable area represents an average river wide estimate for key periods for each species and life stage. The X axis represents flow duration over observed inflow years (1963-1997) where 0% is the minimum observed, 50% is the median; and 100% is the maximum habitat provided during rearing and spawning periods. For a more complete description of physical habitat simulation assumptions and procedures refer to EPI (2001). Data provided by Alf Leake, B.C. Hydro Generation Environment.

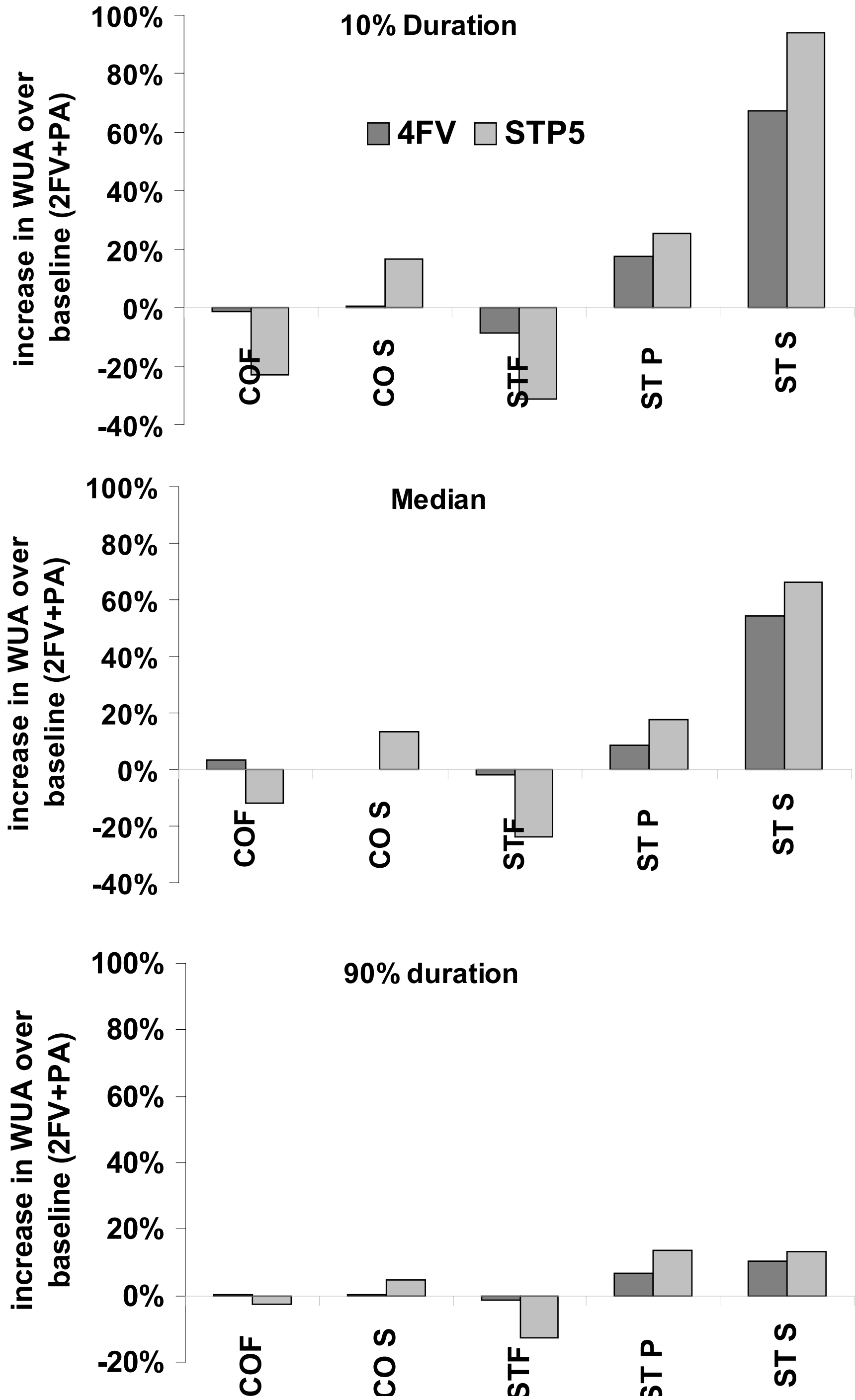


Figure 2. Influence of monitoring duration, stock productivity, and true effect size on the percentage of significant trials from a one-tailed t-test (type I error<0.2) based on uncontrolled BA experimental comparisons of smolt, spawner and smolt equilibrium monitoring indicators. Results are based on 1500 trials simulating a 12 year long experiment with a 50% and 100% effect size after year 6 under different moderate levels of observation error ($\sigma_{sm,o}$ and $\sigma_{sp,o}$ =0.3) and baseline process variance ($\sigma_{sp,p}$=0.9).

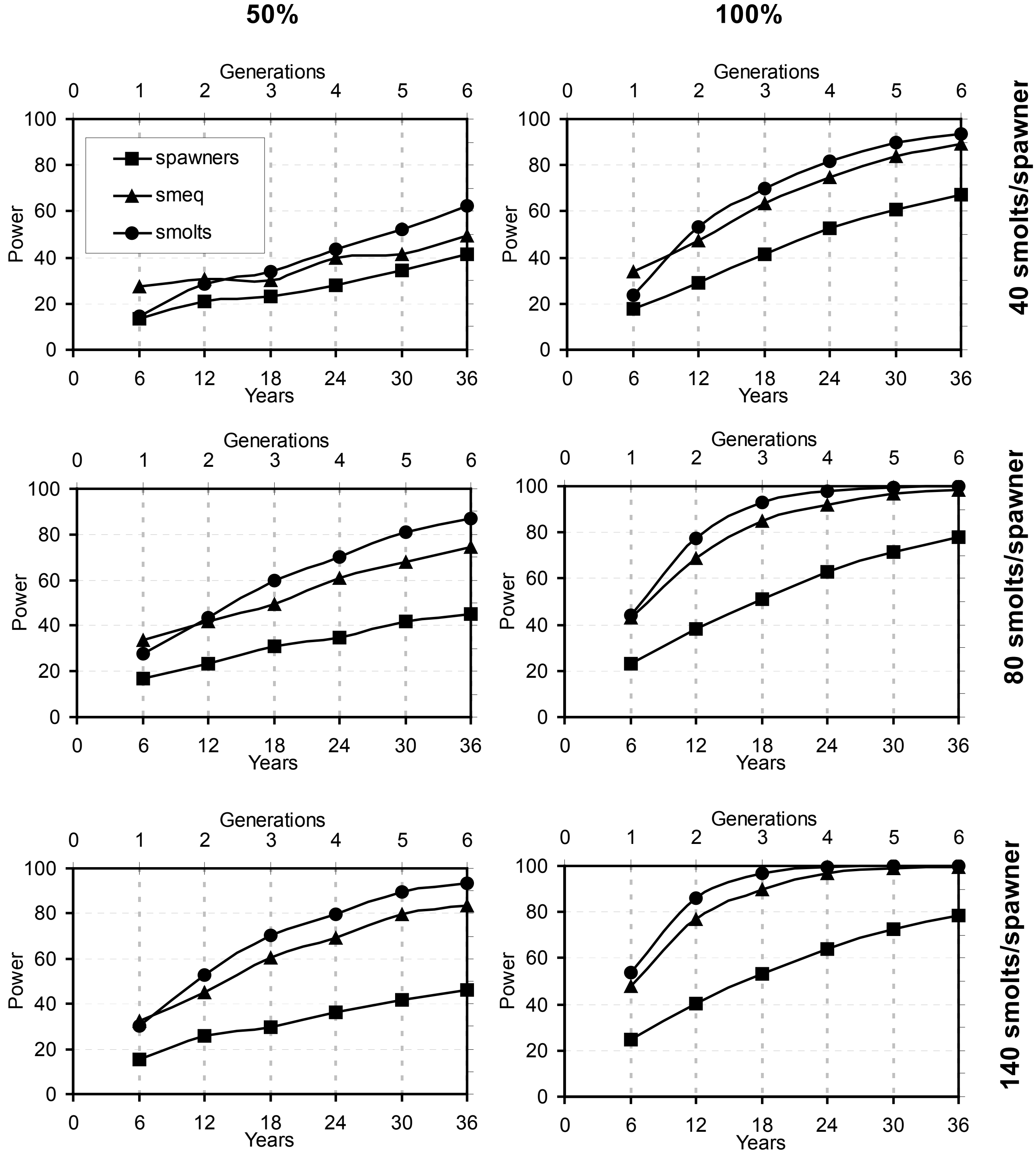


Figure 3. Effect of observation and process error on the statistical power of BA inferences derived from smolt, spawner, and derived smolt equilibrium population indicators. Results are based on 1500 trials simulating 12 year long experiment with a 50% effect size on a coho salmon population (life histyory 3.2) after year 6 under different various levels of observation error for spawners and smolts, median stock productivity (80 smolts/spawner) and two magnitudes of variation in the survival rate for smolts to spawners ($\sigma_{sp,p}$=0.4, $\sigma_{sp,p}$=0.9). Simulations were conducted by first varying smolt observation error under fixed moderate spawner observation error ($\sigma_{sp,o}$=0.3), then varying spawner precision under the same level of fixed smolt measurement precision ($\sigma_{sm,o}$=0.3).

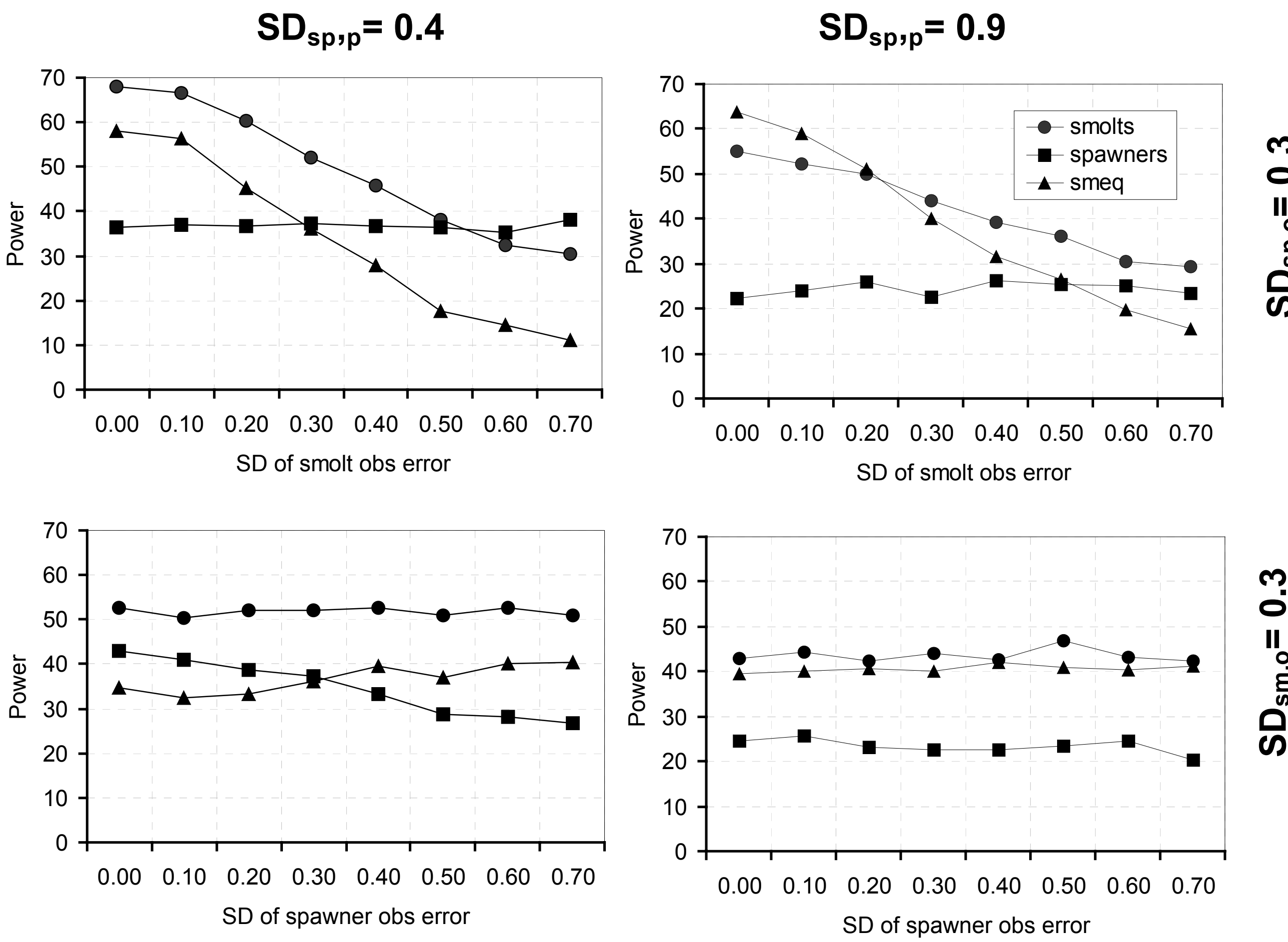


Figure 4. The percentage of significant trials from a one-tailed t-test (type I error<0.2) based on a BA and BACI comparison of smolt, spawner and smolt equilibrium monitoring indicators under different assumptions about the extent of covariance among treatment and control stocks (r^2=0, 0.2, 0.4, 0.6), and different numbers of control stocks (1, 3, 5) used in the comparison. The statistical power of the before-after comparison (BA) for the treatment stock is also shown for reference. Results are based on 1500 12 yr. trials simulating a 50% effect size after yr. 6 under different moderate levels of observation ($\sigma_{sm,o}$ and $\sigma_{sp,o}$ =0.3) and process $\sigma_{sp,p}$=0.9).

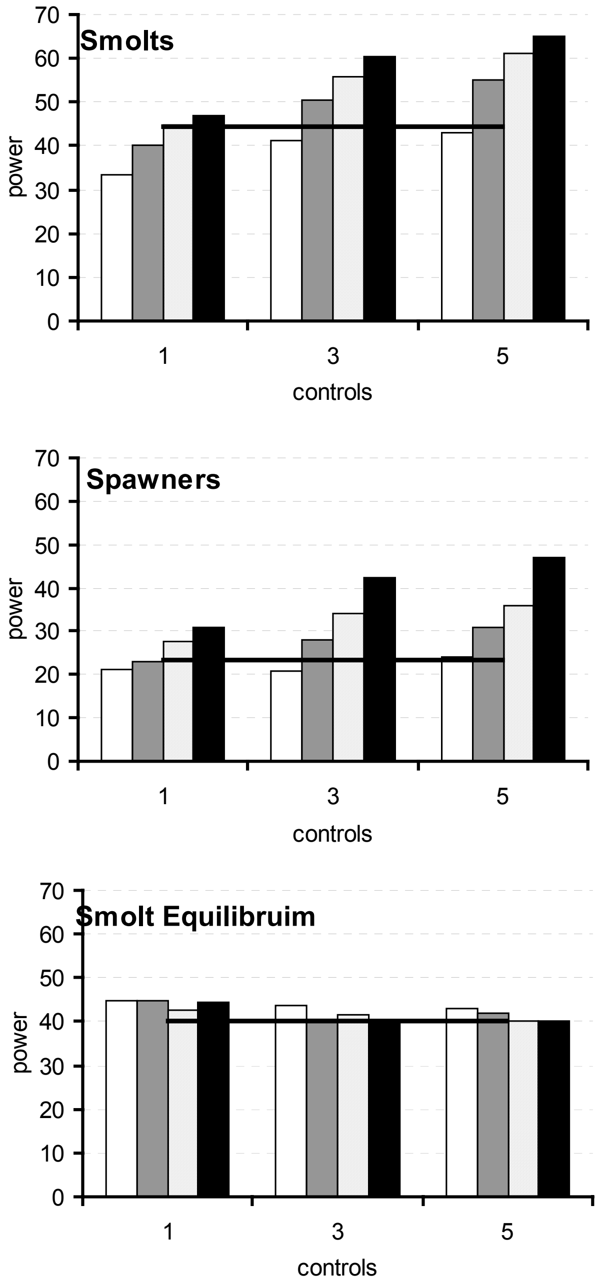
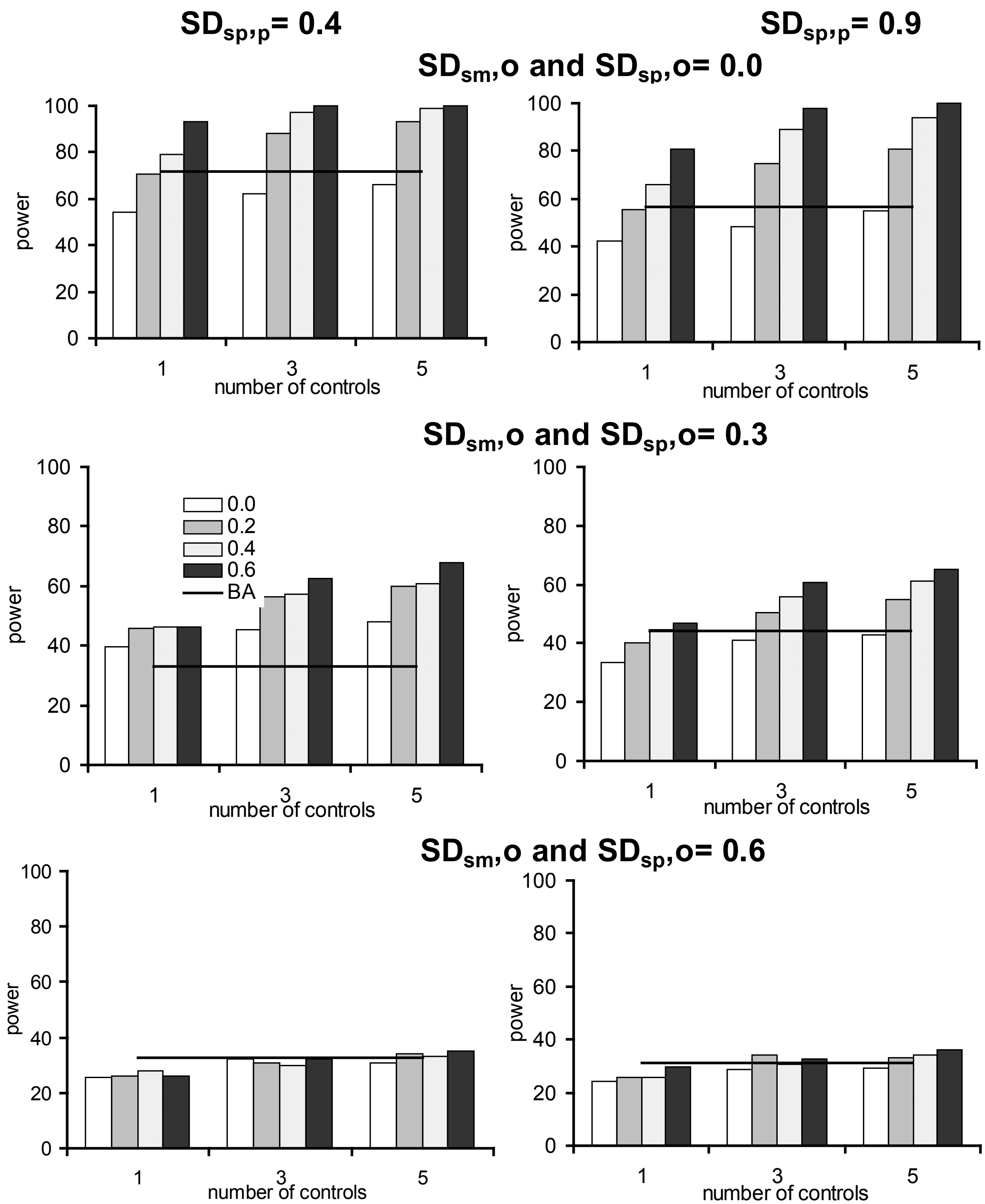
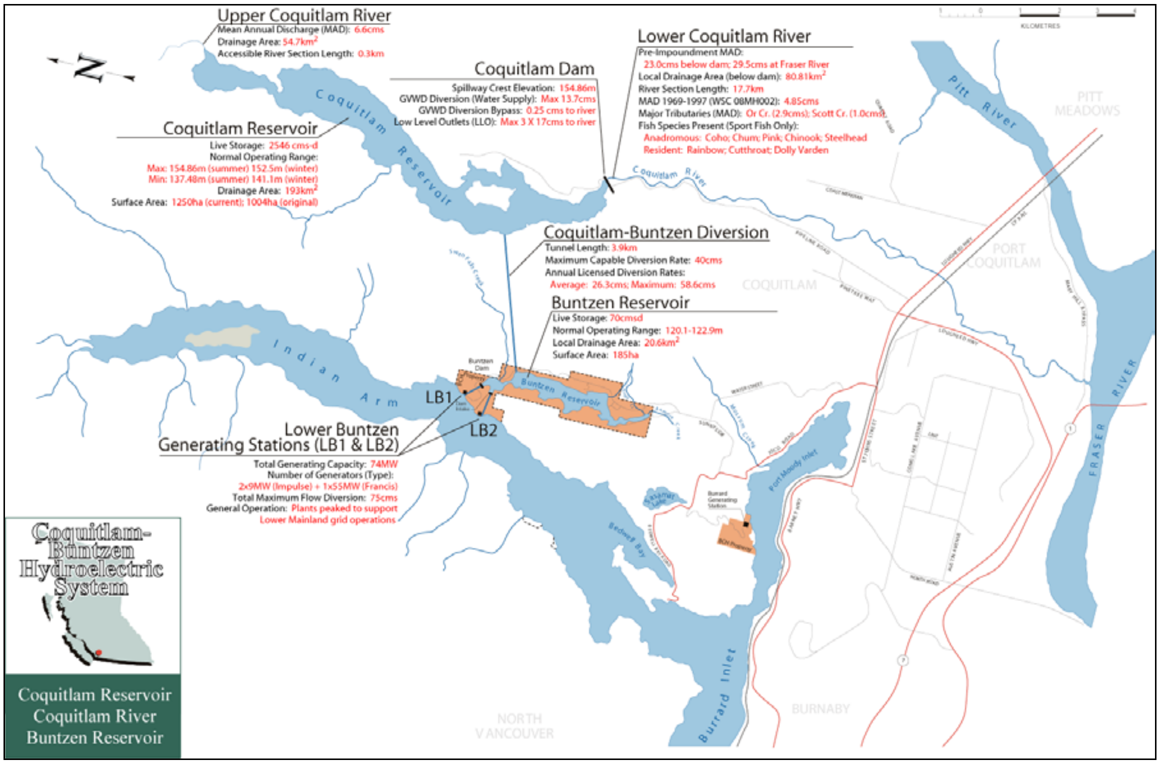


Figure 5. The percentage of significant trials from a one-tailed t-test (type I error<0.2) based on a BACI comparison of smolt abundance under different assumptions about the extent of covariance among treatment and control stocks (r^2=0, 0.2, 0.4, 0.6), and different numbers of control stocks (1, 3, 5) used in the comparison. The statistical power of the before-after comparison (BA) for the treatment stock is also shown for reference. Results are based on 1500 12 year long experiments simulating a 50% effect size after year 6 under different combinations of observation ($\sigma_{sm,o}$, $\sigma_{sp,o}$) and process ($\sigma_{sp,p}$) errors.



Appendix BB INSTREAM FLOW NEEDS STUDY



LOWER COQUITLAM RIVER
2003 INSTREAM FLOW NEEDS ASSESSMENT

Interim Report on Transect Data Collection

Prepared for:
COQ WUP Fisheries Technical Committee

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EXECUTIVE SUMMARY

The results of instream flow data collected requested in the Instream Flow Needs Assessment terms of reference (FTC, 2000) are summarized. The study was requested by the consultative committee for the LB1 Water Use Plan project, which is tasked with recommending a water use strategy for the Coquitlam-Buntzen hydroelectric system. Habitat mapping requirements outlined in the terms of reference were not met due to the inability to release experimental flows over the data collection period. After two previous habitat-flow analyses were conducted using HEC-RAS modeling and meta-analysis (Hatfield and Bruce, 2001), results of this study for the reaches of interest were analysed to ensure results represented empirical data. Empirical measurements were integrated with provincially sanctioned habitat use curves for priority fish species life histories defined by the fisheries technical committee: spawning chinook, steelhead and coho, and rearing steelhead parr. Habitat-flow relationships were developed for each species life history, fitting empirical results to a maxima function ($y = Ax^c \bullet e^{nx^b}$) with parameters *n*, *A*, *b*, and *c* optimized for each species. Suitability of fit was compared with other equations to ensure the best function was used. Target flows (in percent of mean annual discharge) to achieve maximum habitat potential were found to be 43% for spawning steelhead and coho, 67% for spawning chinook, and 16% for rearing steelhead parr. The local inflow analysis (Summit, 1999) defined the flows into the reaches of interest that would be augmented by dam releases to achieve fish benefits estimated in this analysis. Results of this study were provided to the consultative committee and incorporated into their recommendation for operations submitted to the Comptroller of Water Rights in British Columbia.

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1 Background

In 1999, the COQ WUP FTC (fisheries technical committee) recommended the completion of an instream flow needs (IFN) assessment for the Coquitlam River. Evaluations of several flow targets, ranging from 5 to 50% of mean annual discharge (MAD) would be reviewed for all reaches in the river. Table 2 outlines the flow targets and natural annual discharges for each reach.
Figure 1 shows the relative locations of each of the transect/study sites on the Coquitlam River for these reaches.

Table 1: Coquitlam River and GVRD target releases defined in the COQ WUP

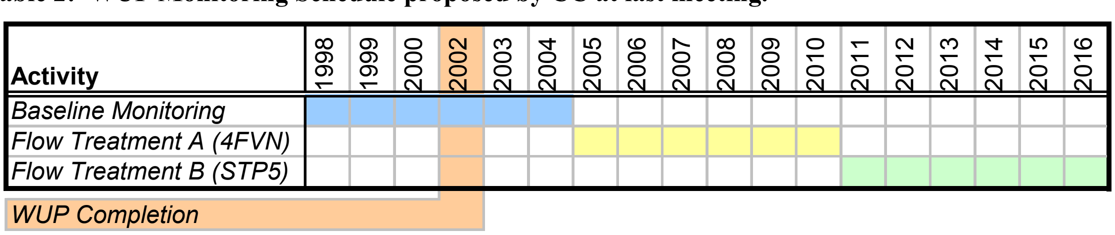
	Reservoir Diversion Schedules (cms)					**Species Driver and Priority for Coquitlam River Releases**
	Domestic Water		**Coquitlam River Releases**			
	Target	**Min**	**4 Fish Valves "New"**	**"Share the Pain 5"***		
				Target	**Min**	
Jan	11.9	10.7	1.1	3.3	3.0	Chinook Spawning
Feb	11.9	10.7	2.3	2.9	2.9	Chinook Incubation
Mar	11.9	10.7	4.3	7.6	3.0	Steelhead Spawning
Apr	12.0	10.8	3.5	6.9	3.0	Steelhead Spawning
May	12.0	11.0	3.0	6.3	3.0	Steelhead Spawning
Jun	12.0	10.9	4.9	5.0	4.0	Steelhead Parr
*Jul***	18.0	15.8	1.7	4.6	4.0	Steelhead Parr
*Aug***	23.0	20.2	3.3	6.1	4.0	Steelhead Parr
*Sep***	23.0	20.9	1.0	5.6	4.0	Steelhead Parr
Oct	12.0	10.8	1.1	3.0	3.0	Chinook Spawning
Nov	12.0	10.8	1.1	3.0	3.0	Chinook Spawning
Dec	11.9	10.7	1.1	3.0	3.0	Chinook Spawning

* To be revised upon completion of IFN
** STP5 River priority is 2 behind domestic water in ** months.

1.1 The COQ WUP Process

The study proved difficult in terms of meeting appropriate flow targets, and the COQ WUP consultative committee (CC) was under time pressure to incorporate modeled habitat information into its decision making, instead of the empirical data expected from the IFN study. As a result, the CC drafted a recommendation in March, 2002 to increase flow allocations to the GVRD for consumptive use and to the Coquitlam River for fisheries benefits. Two fish flow release trials were to be evaluated over a 15 year period (see Table 2) to determine the productive benefits of each release, and provide information for future water use decisions. It was agreed at that time to undertake a “power analysis” of the monitoring program, to ensure that the biological benefits expected under each regime would be distinguishable and scientifically defensible.

Table 2: WUP Monitoring Schedule proposed by CC at last meeting.



1.2 Power Analysis Results

The power analysis (Higgins et. al., 2002) was completed in December 2002 and was reviewed by the FTC in February 2003. At the meeting, the FTC accepted the main conclusion of the analysis: *The draft monitoring program and experimental design would not likely provide statistically reliable results*.

There were two main options from which several combinations could be developed:
(a) Extend the monitoring program to capture at least 6 more years of baseline data and at least 9 years of *each* treatment; or
(b) Extend the monitoring program to capture at least 6 more years of baseline data and at least 9 years of *one* treatment.

The FTC suggested that for either option to be acceptable, it would be advisable to revisit the IFN data collection and determine if there is enough data to refine the current flow targets and offer new solutions to the CC in terms of flow targets. The FTC agreed to summarize the data collected to date and review the new flow targets suggested by the empirical data. This document summarizes the data analysis conducted for the available data-set, and suggests new flow targets in keeping with the objectives of the original target setting exercises. In most cases, flow targets were set to optimize fisheries benefits, while meeting flow limitations of varying degrees.

1.3 Interim IFN Study Scope

The Interim IFN summarizes the following aspects of work conducted for the instream flow needs study:
- Hydrologic Review: a summary of monthly inflows to the Lower Coquitlam River completed by Summit Environmental (2000)
- Staff Gauge Installation: stage-discharge relationships have been developed over the course of the WUP for each reach
- Transect Analysis: instream flow habitat analyses were conducted for three flow targets in two target reaches (reaches 2 and 3)

This document summarizes the results of transect data collection for reaches 2 and 3, which represent the bulk of rearing and spawning habitats available in the river below the Coquitlam Dam. A summary of these data is provided in Table 3. Linear Habitat Analysis for these reaches is not yet complete, due to inability to target consistent flows for the duration of each data collection period.

Table 3: Summary of transects selected from IFN Data relevant to spawning and rearing habitat use.

			Low				Intermediate 1			Intermediate 2			Additional Surveys		
Section	NMAD (cms)	HabNo	Flow (cms)	% NMAD	Date		Flow (cms)	%NMAD	Date	Flow (cms)	% NMAD	Date	Flow (cms)	% NMAD	Date
R2a	27.38	T15	2.19	8.0	28-Feb-01	BCH	5.73	20.9	09-Jun-00	17.07	62.3	20-Dec-01	7.87	28.8	16-May-00
		T18	1.79	6.5	03-Sep-00	BCH	6.66	24.3	16-May-00	14.79	54.0	20-Dec-01			
		T19	1.54	5.6	19-Sep-00	PT	6.16	22.5	15-May-00	14.15	51.7	02-Dec-00	8.18	29.9	13-Jun-00
		T20	2.60	9.5	03-Sep-00	BCH	6.48	23.7	16-May-00	17.45	63.7	20-Dec-01			
R2b	26.81	T21	2.54	9.5	03-Sep-00	BCH	7.01	26.2	17-May-00	17.13	63.9	21-Dec-01			
		T22	2.45	9.1	03-Sep-00	BCH	5.96	22.2	17-May-00	17.29	64.5	21-Dec-01			
		T23					5.10	19.0	09-Jun-00	10.31	38.5	17-May-00	16.24	60.6	21-Dec-01
		T25	1.50	5.6	19-Sep-00	PT	5.67	21.2	09-Jun-00	15.72	58.6	05-Jan-01	7.26	27.1	17-May-00
		T27	1.94	7.2	03-Sep-00	PT	5.71	21.3	15-May-00	15.45	57.6	05-Jan-01			
R3	25.82	T31	0.97	3.8	26-Jan-01	BCH	6.31	24.4	20-May-00	15.75	61.0	22-Dec-01			
		T32	2.84	11.0	Oct-99	ABM	6.14	23.8	10-Jun-00	7.82	30.3	20-May-00	17.28	66.9	22-Dec-01
		T33	2.28	8.8	Oct-99	ABM	5.08	19.7	30-May-00	15.14	58.6	22-Dec-01			
		T34	2.52	9.8	Oct-99	ABM	4.80	18.6	20-May-00						

Spawning Transects
Rearing Transects

Figure 1A: Coquitlam River IFN Transect Locations and Reach Breaks – Upper Coquitlam River

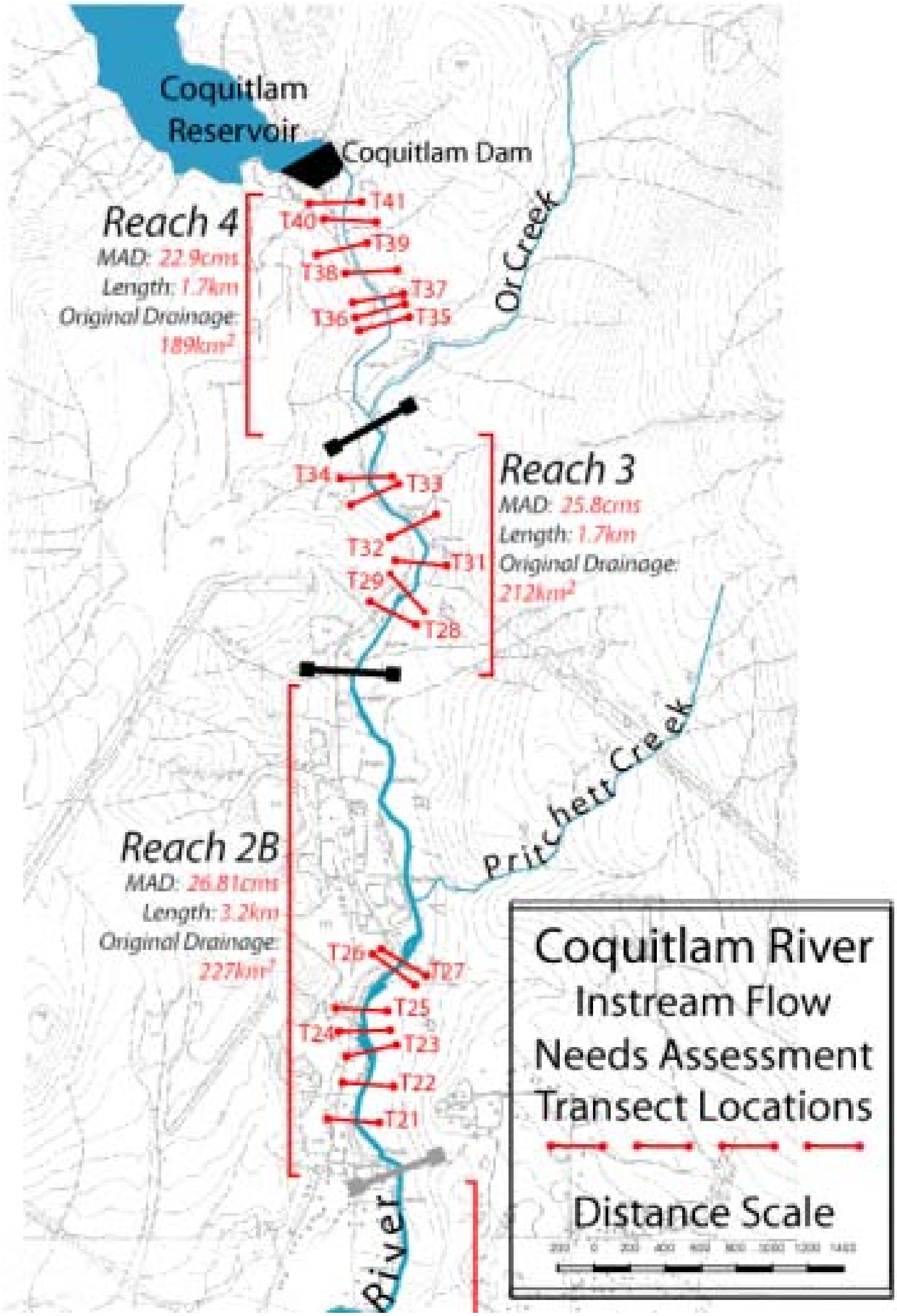
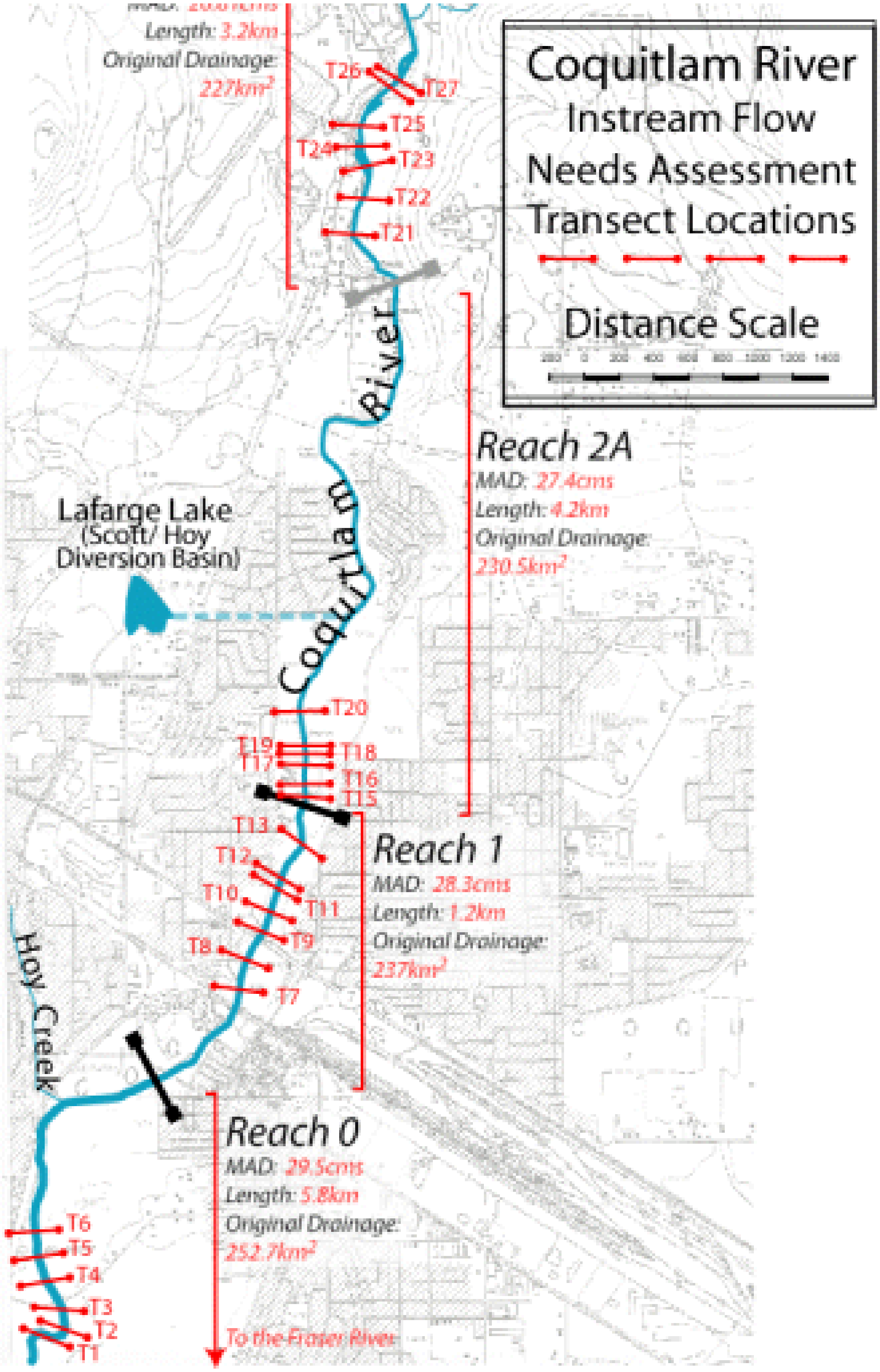


Figure 2B: Coquitlam River IFN Transect Locations and Reach Breaks – Lower Coquitlam River



2 Methods

Prior to start of the data collection program, COQ FTC members developed reach breaks to best describe the changes in general habitat characteristics over the 17km section of the Lower Coquitlam River. Table 4 describes the reach break scheme, which drew on previous studies by Riley, et. al. (1998) and De Leeuw (1982).

Figure 1 illustrates the locations of the reach breaks. Transect information was collected at six sites within 1km sample sections, each section representing the six reaches described in Table 4. Two snorkel sites straddled transect "clusters" for each section, and 12 sites in all were snorkeled. The snorkel data and transect information were to be combined to provide weighted usable area information.

Table 4: Summary of reach break information developed by COQ FTC (2000)

Reach	Length*	Descriptor	Break Location		Drainage Area (km^2)
			Northing	Easting	
0	5.8	Fraser River Confluence to Kingway (Port Coquitlam)	5452300	514300	252.7
1	1.2	Kingsway to Patricia Footbridge	5456300	515200	237.0
2a	4.2	Patricia to Galette Road	5458000	516300	230.5
2b	3.2	Galette Road to Monte Creek confluence	5462500	517000	227.3
3	1.7	Monte Creek to Or Creek confluence	5463800	516800	212.3
4	1.7	Or Creek to Dam	5466700	516400	188.8

**Does not include sidechannels

2.1 Hydrologic Overview

2.1.1 Pre-Regulation Flow Regime

After the development of the Coquitlam River IFN Terms of Reference (2000), Summit Environmental finalized the Coquitlam River Local Inflow Analysis (2000). The objective of this study was to develop an inflow file to be used in performance measure (PM) development over the WUP process. Summit was able to provide a monthly range of inflow values on a reach by reach basis, through a combination of watershed area and historic inflow analysis. A daily record could not be simulated with any degree of confidence due to several factors:

- flashiness of the system could not be simulated properly;
- Westwood Plateau water diversion in Reach 2 could not be quantified; and
- Coquitlam Dam operations prior to 1986 were not adequately accounted for.

Results were provided on a monthly basis, in consideration of stream flow information from HYDAT (Environment Canada, 1999), for local stream gauges in Lower Coquitlam River (08MH002), Upper Coquitlam River (08MH141) and adjacent watersheds Kanaka Creek (08MH076) and Or Creek (08MH004). For the purposes of calculating Coquitlam WUP performance measures, monthly flows were monthly over the range of percentiles as defined by the Coquitlam Reservoir inflow percentiles. It was assumed therefore that a monthly reservoir inflow rank (over the 39year record) triggered an equivalent rank of local inflows downstream of the dam.

Water Survey of Canada information from the Coquitlam River at Port Coquitlam gauge (08MH002) provided the bulk of inflow information used to calibrate this model. The daily record provided was used for the 'frequency of events' PMs only.

Detailed methodology for this summary is contained in the hydrology report (Summit, 2000).

The target section for this analysis was limited to reaches 2 and 3, and therefore, target inflows were based on the length-weighted average of the inflows into this section. Reach lengths were defined by the FTC and are summarized in Table 4.

2.1.2 Assessment of Hydraulic Processes

The COQ WUP CC initiated a study by northwest hydraulic consultants to:

(a) ascertain the substrate condition of the Coquitlam River and

(b) define a flow prescription to improve those characteristics for the benefit of fish.

nhc (2001) measured the size distribution of the surface layer of the Coquitlam River at several sites along the Coquitlam River. The metric "fraction finer than 9.5mm" was used to describe the substrate condition, as recommended by Ron Ptolemy (pers comm 2001) where:

- Clean substrate: 10% or less of the material has a grain size smaller than 9.5mm;
- Poor substrate: 10-40% of the material has a grain size smaller than 9.5mm; and
- Very Poor substrate: 40% or greater of the material has a grain size smaller than 9.5mm

Each sample fraction finer was determined by measuring the grain size distribution of the subsurface layer. The weight of material sampled from the sites was based on the largest clast criterion described by Church *et al* (1987), set to 1% for most sites. Samples were sieved in the field to 10mmand then a sub sample of the smaller material was lab-analyzed. Results were adjusted to reflect the total portion each size class represented of the sample.

Flushing flow prescriptions were developed by calculating the flow threshold at which coarse bed materials are mobilized, and targeting such flows for a duration that would result in entrainment of enough fines to benefit substrate condition for fish use. Equations and assumptions used to calculate this flow for the target reaches (reach 2 and 3) are summarized in the report (nhc, 2001). Several options were developed that would achieve various levels of substrate improvement, which were ranked by the COQ WUP FTC using professional opinion and local knowledge of the Coquitlam River.

2.1.3 Staff Gauge Installations

Staff gauges (WSC-class metric porcelain coated plates) were installed within the boundaries of each reach. Locations are shown in

Figure 1. With the exception of reach 4, whose gauge was most recently dismantled by high flows, stage-discharge relationships were developed for each gauge. Each site was selected to provide the most accurate flow results across the range of flows evaluated.

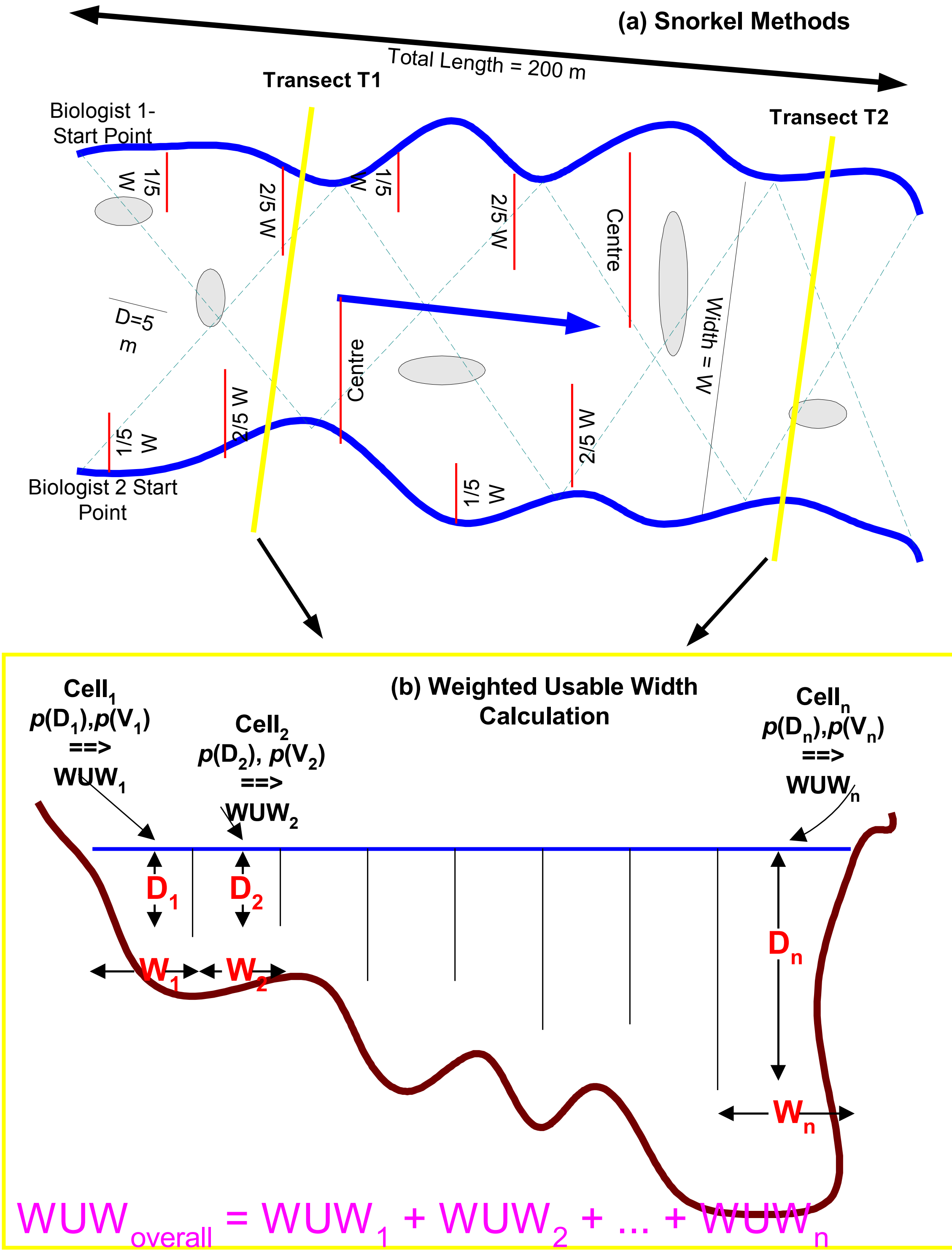
2.2 Habitat Suitability Criteria

2.2.1 Data Collection

Two sites were snorkeled per reach, to develop Coquitlam River suitability of use curves for fish species and life history stages. This was carried out by snorkeling through the site and dropping numbered, colored lead weights in locations that fish were occupying. The swimmers noted the species and life history stage of the fish associated with each numbered weight. Another crew member subsequently measured depth, velocity, substrate and cover at each location where a weight was dropped and recorded the corresponding weight number. After field observations were collected, all tag numbers and their respective observations were collated into a single spreadsheet. Figure 3 illustrates the applied methods.

Depth and velocity are also measured randomly throughout the snorkel section to reflect the overall habitat availability of the site. A minimum of 100 random readings are required to provide a robust data set.

Figure 3: Illustrated methods for collecting (a) habitat suitability information; and (b) weighted usable width information



2.2.2 Data Analysis

The following steps were taken to evaluate the observation data collected in the field:

(1) Data were sorted into species/age categories;

(2) Species/age data sets were analyzed to test the distribution of observed values for each criteria. Software interfaces developed by BC Hydro (J. Bruce) utilize normal and log-normal distribution functions to distribute the data accordingly. For high confidence, sample sizes of at least 30 were targeted. If sample sizes were less than 20, surrogate data (such as provincial or regional preference curves) were used.
(3) Random measurements taken to evaluate "available" habitat were sorted and analyzed to test the distribution using the tools outlined in (3) above. "Corrected" use for observation *i* within distributions of each data set of *k* observations is derived below:

Equation 1

$$P_{i(corrected)} = \frac{P_{i(fish)} / P_{i(available)}}{\sum_{i=1}^{k} P_{i(fish)} / P_{i(available)}}$$

where:

P_i = probability index for fish, available and corrected forms
Corrected use calculations ensure that the suitability data take into consideration all available habitat.;

(4) Items (3) and (4) were repeated for each species/age class for depth and velocity. The data were then summarized for each site, and again on a reach by reach basis, and overall.

2.3 Transect – Weighted Usable Width

The COQ IFN TOR defined data collection requirements for the purposes of the WUP. The scope of the IFN was to include all of the Coquitlam River, and therefore, flow targets were pursued across the range of operational influence:

- Low Flow: 5-10% of mean annual discharge (MAD)
- Intermediate 1: 20% MAD
- Intermediate 2: 45-50% MAD
- High Flow: 100% MAD – limited by safety
- Flushing Flow: 200% MAD – water surface elevation only

Due to the flashy nature of the flows, the first three flow targets were achieved for only the core reaches, reach 2 and 3. The other flow targets were considered impractical by the COQ WUP FTC and were dropped from the study, to be modeled by hydrologists for the purposes of flood assessment.

2.3.1 Data Collection

Transect data was collected at a number of sites representative of the river characteristics (ie: pool:riffle:run ratio). Site selection was based on the habitat inventory data collected previously by Riley et al (1998), and from an on-site evaluations by COQ WUP FTC members. Each transect was surveyed from bankfull to bankfull (where feasible) at regular increments of 0.5 m, and at significant features along the cross section. They were marked with identification tags to allow further sampling if required. In addition to the survey information, depth and velocities were collected at 20-30 equidistant locations along the transect. For each data point, substrate and cover were assessed.

Within each sample section, at least six transects were surveyed; their locations reflective of the reach habitat unit ratios, and 39 were selected in all (see Table 5,
Figure 1).

Table 5: Transect information for the Coquitlam River IFN study

Transect Number	Reach	Reference	Habitat Type	D90 (m)	Transect Width (m Pin to Pin)	Natural MAD (cms)
T01	R0	220 m d/s Pit River Bridge	Run	0.02	30.5	29.5
T02	R0	Just below staff gauge	Glide	0.03	38.0	29.5
T03	R0	Under Pit River Bridge (Red Bridge)	Glide	0.04	33.6	29.5
T04	R0		Run	0.10	34.3	29.5
T05	R0		Riffle	0.04	31.1	29.5
T06	R0		Glide	0.04	27.4	29.5
T07	R1	250 m below Lougheed Bridge	Run	0.20	32.4	28.3
T08	R1	65 m below Lougheed Bridge	Riffle	0.20	42.7	28.3
T09	R1	60 m above Lougheed Bridge	Glide	0.30	35.5	28.3
T10	R1	181 m above Lougheed Bridge	Riffle	0.15	34.3	28.3
T11	R1		Run		27.7	28.3
T12	R1	67 m u/s T11	Riffle		38.1	28.3
T13	R1		Run		49.5	28.3
T15	R2a	33 m above foot bridge	Run	0.40	35.1	27.4
T16	R2a	104 m above foot bridge	Riffle	0.80	32.1	27.4
T17	R2a		Run	0.60	28.4	27.4
T18	R2a	30 m d/s from T19	Riffle	0.80	24.5	27.4
T19	R2a	310 u/s from foot bridge	Riffle	1.20	26.8	27.4
T20	R2a	Confluence of Grist Ck.	Run	0.90	25.8	27.4
T21	R2b	1491 Pipeline Rd	Riffle	0.30	46.8	26.8
T22	R2b	1527 Pipeline Rd (Mrs. Nedra Spani)	Riffle	1.40	39.8	26.8
T23	R2b	1639 Pipeline Rd	Glide	0.25	54.9	26.8
T24	R2b	Below concrete blocks	Run		25.7	26.8
T25	R2b	80 m below treed island	Riffle	0.70	29.7	26.8
T26	R2b	85 m d/s T27	Glide	0.40	36.6	26.8
T27	R2b	7 m above new staff gauge	Riffle	1.20	37.9	26.8
T28	R3	1925 Pipeline Rd (Bonnie 945-9651)	Glide	0.30	21.5	25.8
T29	R3		Riffle	1.20	33.0	25.8
T31	R3		Glide	1.00	49.1	25.8
T32	R3		Run	0.90	31.2	25.8
T33	R3		Riffle	0.65	24.2	25.8
T34	R3		Run	0.70	39.6	25.8
T35	R4		Riffle	1.70	33.7	22.9
T36	R4		Glide	1.40	30.1	22.9
T37	R4		Riffle	0.80	37.4	22.9
T38	R4		Riffle	0.60	33.8	22.9
T39	R4	100 m u/s from T38	Glide	0.80	49.7	22.9
T40	R4	Tony Mikes transect 124	Riffle	0.30	82.6	22.9
T41	R4		Glide	0.40	59.8	22.9

Spawning transect
Rearing Transect
Flow Transect

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For each transect and flow target, depth, velocity and substrate were collected for several cells across the transect (as illustrated in Figure 3(b)).

2.3.2 Data Analysis

Table 5 also illustrates those transects which were selected to represent spawning use, rearing use and stream flow measurements. Ron Ptolemy (pers. comm., 2002) provided a basis for defining spawning and rearing mesohabitats as described below:

- Rearing: "shallow" riffles with small (<30cm) D90. Width:Depth ratio > 75;
- Rapids: "deep" riffles with large (>50cm) D90. Width:Depth ratio 30-75; and
- Spawning: "deep" runs and glides with moderate (30-50cm) D90. Width:Depth ratio around 30.

Average depths and wetted widths were defined for all transects at 20% MAD.

Transect Data Analysis

The transect analysis utilizes suitability data to produce weighted usable areas for each transect site, as described below. Figure 4 illustrates the steps below:

(1) Transect data - distance, depth, velocity and substrate categories - are inputted into MELP-developed (Ptolemy, Bech, and Night, 1993) spreadsheets which utilize the functional relationships between habitat attribute and fish use derived in § 5.1.1;

(2) A composite weighting factor of suitability, C_i is derived for each cell i of similar or varying widths, as below:

Equation 2

$$C_i = P(v)_i \bullet P(d)_i$$

Where *P(v)* and *P(d)* are probabilities of use functions derived from the relationships for velocity and depth respectively in § 5.1.1;

(3) Percent usable width (PUW) of habitat unit j across the transect is then computed by summing the composite factors for each cell and determining the percentage of use across the wetted channel:

Equation 3

$$PUW(\%)_j = \frac{\sum_i^n C_i \bullet Width_i}{TotalWidth} \bullet 100\%$$

(4) Percent of maximum (POM) habitat is calculated by dividing the PUW values across all flows and applicable transects by the maximum PUW for each species/life history stage. Recall that applicable transects must match the habitat requirements of the life history stage (spawning or rearing) being analyzed.

Equation 4

$$POM(\%)_{sp,j} = \left(PUW(\%)_j \middle/ Max(PUW_{j=1\rightarrow n}) \right)$$

Habitat Use Curve Analysis

To develop habitat use curves, data was assumed to fit to typical habitat flow relationships, as described in the following equation:

Equation 5

$$y = Ax^c \bullet e^{nx^b}$$

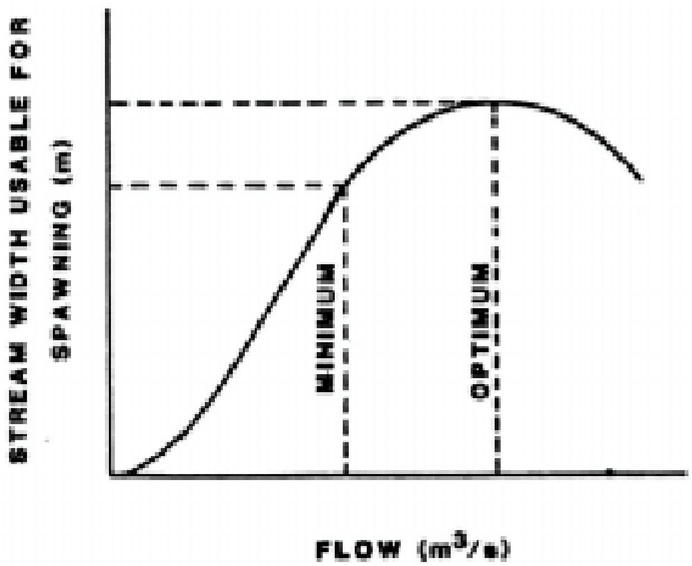
where:

y = amount of habitat units;
x = amount of flow units;

A = parameter for magnitude; and
n = parameter for the rate of incline/decline of the relationship
c = parameter for the lag response of habitat to flow
b = parameter for the magnitude of the post-peak habitat response to flow

The equation describes habitat flow relationships as single mode maxima functions with its intercept at the origin. Bjornn and Reisser (1991) describe this relationship as typical for spawning and rearing habitats in fish streams (see Figure 4). The appendix describes the history of habitat-flow relationships used for the Coquitlam WUP and the sensitivities around using alternative habitat use curve analyses.

Figure 4: Typical habitat use relationship described by Equation 5 (Bjornn and Reisser, 1991)



Curves were fitted to the data by minimizing the squared-difference of modeled data and actual data. The minimum was obtained by optimizing for the four parameters in Equation 5 (*A, b, c, and n*). Results are summarized in the next section. The Microsoft Excel™ Solver application optimized each relationship.

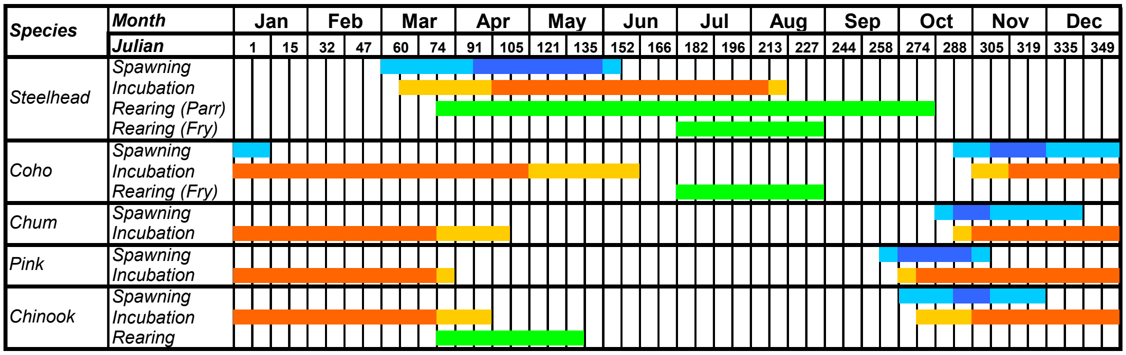
2.3.3 Species drivers and periodicity

The species drivers for the analysis as determined by the FTC were as follows:

- Rearing: Steelhead and coho salmon juveniles;
- Spawning: Steelhead, chinook and coho salmon; and
- Incubation: Chinook and coho salmon,

as governed by the periodicities summarized in Table 6.

Table 6: Fish periodicity chart developed for the Coquitlam River based on professional opinion and empirical references (COQ FTC, 2001).



Due to the lack of incubation information for the Coquitlam River, available wetted area versus flow relationships for the representative section were used to approximate flow-incubation relationships. The relationship was based IFN transect data modeled in HEC-RAS (COQ FTC, 2001).

Incubation curves were scaled to percent of maximum (POM) as above, where the maximum incubation flow was assumed to be the point of maximum spawning for the species of interest. All other incubation values were then taken as the POM of that peak habitat value. Flows above the peak habitat value were considered as equal to maximum.

3 Results

As described above, results are summarized for the reaches of primary concern for the Coquitlam River, reaches 2 and 3. The total river length of the 3 reaches is 9.1km, making up 92% of the maintsem wetted habitat, and 85% of the total available (tributary, sidechannel and mainstem) habitats in the river (Riley, et.al., 1998). Note that these figures do not include reach "0" areas.

3.1 Hydrologic Overview

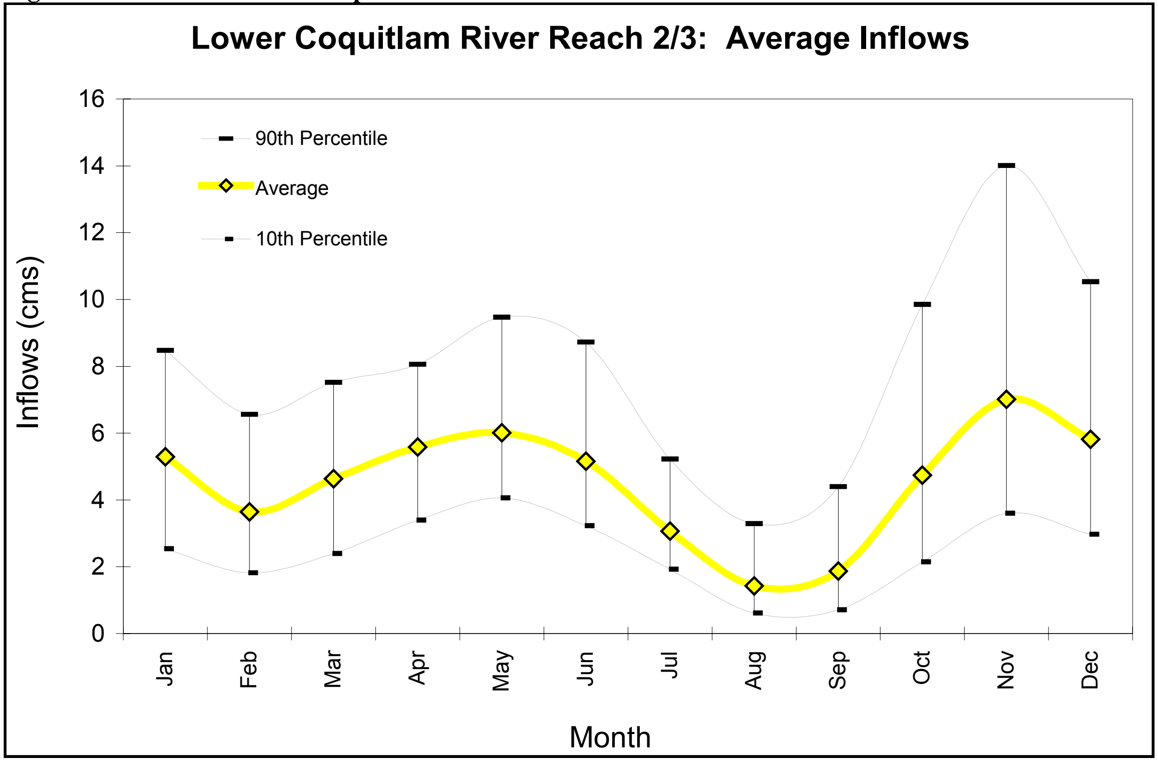
3.1.1 Pre-Regulation Flow Regime

Results of the study (Summit, 2000) are summarized below, reach-by-reach monthly means. The analysis broke flows into 90th, 75th, 50th (Median), 25th and 10th percentiles on a monthly basis as well, summarized in the appendices.

Table 7: Reach by reach inflows expected during an average year.

Month	Average Natural Inflows Expected at Each Reach Break						
	R4	R3	R2B	R2A	R1	R0	R2/3
Jan	0.2	3.8	4.8	5.0	5.1	7.9	5.3
Feb	0.2	2.5	3.3	3.4	3.5	6.1	3.6
Mar	0.1	3.4	4.2	4.3	4.4	6.4	4.6
Apr	0.1	4.1	5.0	5.2	5.3	7.0	5.6
May	0.1	4.5	5.4	5.6	5.7	6.8	6.0
Jun	0.1	3.9	4.6	4.8	4.9	5.5	5.2
Jul	0.0	2.3	2.7	2.8	2.9	3.4	3.1
Aug	0.0	1.1	1.3	1.3	1.4	1.6	1.4
Sep	0.0	1.4	1.7	1.7	1.8	2.5	1.9
Oct	0.1	3.5	4.3	4.4	4.5	6.4	4.7
Nov	0.2	5.1	6.3	6.5	6.7	9.6	7.0
Dec	0.2	4.1	5.3	5.4	5.6	8.8	5.8

Figure 5: Reach 2/3 inflows expected within 90% confidence intervals.



3.1.2 Assessment of Hydraulic Processes

nhc (2001) described the substrate condition in terms of percent of sample fraction finer than each particle size assessed. Results of the reach site comparisons are summarized in Figure 6 and Figure 7. In brief, the reach results are as follows:

- Reach 0: "Very poor" condition, >50% of bed material with particle size less than 9.5mm
- Reach 1: "Very poor" condition, 40-50% less than 9.5mm
- Reach 2: "Poor to Very poor" condition, 30-40% less than 9.5mm
- Reach 3: "Poor" condition, around 30% less than 9.5mm; and
- Reach 4: "Good to Poor" condition, 10-30% less than 9.5mm.

The results of this analysis drove the calculations to determine a flushing flow prescription for the river that would bring substrate conditions for the target reaches (reach 2 and 3) to an acceptable level. Table 8 summarizes the findings of this analysis, and provides rankings for flushing flow options as described by the FTC. In summary, the FTC recommended a flushing flow release of 30-50m^3s^{-1} on an opportunistic basis that would coincide with peak flow events out of Or Creek. The release would likely occur in the November-January period, and would last 3-5days depending on the event duration. The benefits of this release would include the transport of fines from the upper 20-30cm substrate layer of the channel bottom in Reaches 2 and 3. The FTC felt strongly that effective monitoring would be required to determine the fisheries productivity benefits associated with these releases.

Table 8: Flushing flow recommendations and FTC evaluations (nhc, 2001; COQ FTC 2002)

Flow	*Description of Release from Dam* [1]			*Substrate Information Associated with each Flow*			*Benefits*	
	Magnitude (m^3/s)	Duration [2] (days)	Frequency (years)	Physical Objective of the Release	Effectiveness for Substrate Maintenance	Implications for Downstream Reaches	Habitat Improvement (m^3/s)	Relative Ranking of Flow Alternatives by the FTC
1	50	5 to 10	every year or second year	entrain material finer than 8 mm (granules) from the bed surface and upper surface layer and transport them to Reach 1. Coarse bed material would remain immobile	Expected to clean surface and upper 5 to 10 cm of substrate. May be uneven cleaning along Reaches 3 and 2, with deposition along the lower part of Reach 2	It is anticipated that up to 5,000 m^3 of sand and granules would be transported to Reaches 1 and 0 and deposited there.	Too much uncertainty to meaningfully quantify, but better than no cleaning flow	**4** Productive capacity of substrate enhanced only marginally
2a	50	5 to 10	every year or second year	release 50 m^3/s from Coquitlam Dam during maximum flows on Or Creek to provide peak flow greater than 100 m^3/s. This would just mobilize the upper substrate layer, entrain sand and granules and transport them to Reaches 1and 0. Releases from dam would continue after peak flow from Or Creek for transport of sediment	Expected to clean surface layer of fine sediment and remove sand and granules up to depth of 20 to 30 cm. Cleaning expected to be patchy or uneven because of deposition of sediment from Or Creek.	It is anticipated that up to 5,000 m^3 of sand and granules would be transported to Reaches 1 and 0 and deposited there.	Too much uncertainty to meaningfully quantify; however, this flow is expected to be better than Flow 1	**3** Productive capacity expected to increase; Or Creek sediment contributions may limit effectiveness of overall flushing
2b	110	at least 1	every second year	Just mobilize the upper substrate layer, entrain sand and granules and transport them to Reaches 1 and 0	Expected to clean surface layer of fine sediment and remove sand and granules to a depth of about 20 to 30 cm.	It is anticipated that from 5,000 to 10,000 m^3 of sand and granules would be transported to Reaches 1 and 0. Minor bank erosion along Reaches 2 and 1.	Too much uncertainty to meaningfully quantify; however, this flow is expected to be better than Flow 2a since flows from Or Creek will be sediment laden	**2** Productive capacity expected to increase
3	200	0.33 to 1	every two to five years	mobilize the upper layer of the substrate, cause general bed transport and entrain fine sediment stored in the lower substrate layers and transport it to Reaches 1 and 0.	Expected to clean surface layer of fine sediment and remove sand and granules to depth of about 30 to 50 cm. Gravel and cobbles will also be mobile and re-arrangement of bars and bed expected.	It is anticipated that 10,000 m^3 or more of sand and granules would be transported to Reaches 1 and 0 with some grave. Cobbles would be deposited on the large bar above the Lougheed Highway. Bank erosion expected along Reaches 3, 2 and 1. Erosion of alders along the lower banks of Reaches 3, 2 and 1.	Significant Habitat Gains: **Approx. 50% Increase to Rearing Habitat** **Approx. 100% Increase to Spawning Habitat** (for other fish benefits refer to the May 14 Briefing Paper)	**1** Productive capacity of substrate expected to be maximized (see flushing flow brief)
FTC Recommendation	30 - 50 from LLOs	3 to 5 or more depending on Or Creek	opportunisticall y every year	release 30-50 m^3/s from Coquitlam Dam during maximum flows on Or Creek to provide peak flows targetted at approximately 70-100 m^3/s. This would just mobilize the upper substrate layer, entrain sand and granules and transport them to Reaches 1and 0. Monitoring is essential to determine the effectiveness on the substrate and improvement to fish habitat.	Expected to clean surface layer of fine sediment and remove sand and granules up to depth of 20 to 30 cm. Cleaning expected to be patchy or uneven because of deposition of sediment from Or Creek.	It is anticipated that up to 5,000 m^3 of sand and granules would be transported to Reaches 1 and 0 and deposited there.	Too much uncertainty to meaningfully quantify; however, this flow is expected to be better than Flow 1	**Relative ranking close to Flow 2a**

Figure 6: Large Particle size distribution for the lower reaches of Coquitlam River (nhc, 2001)

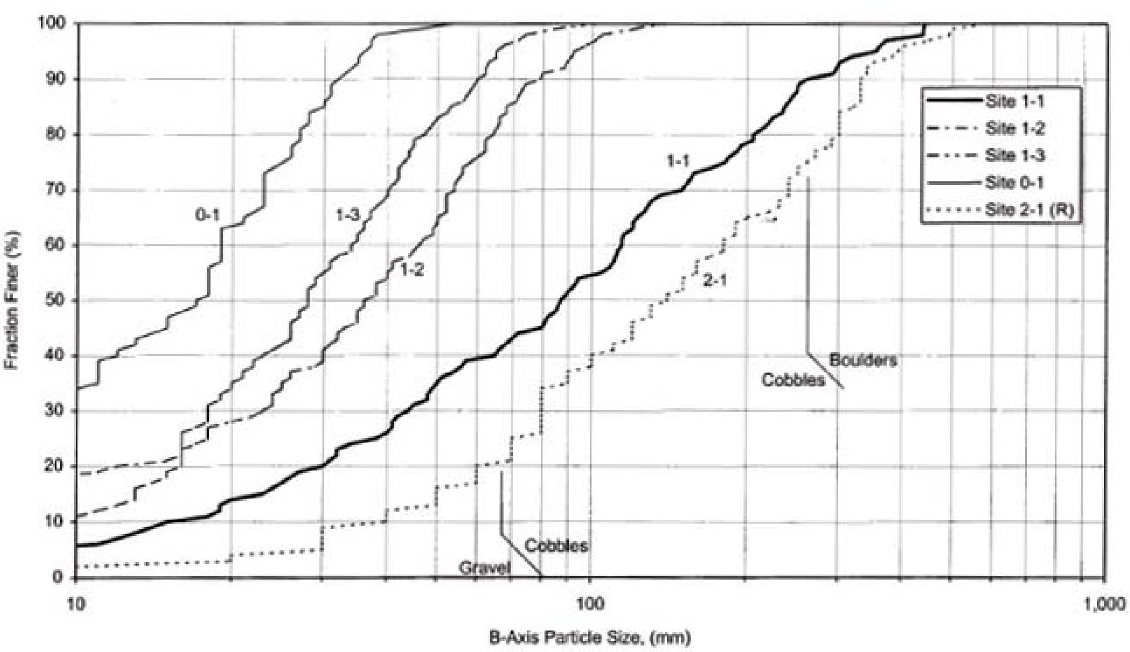
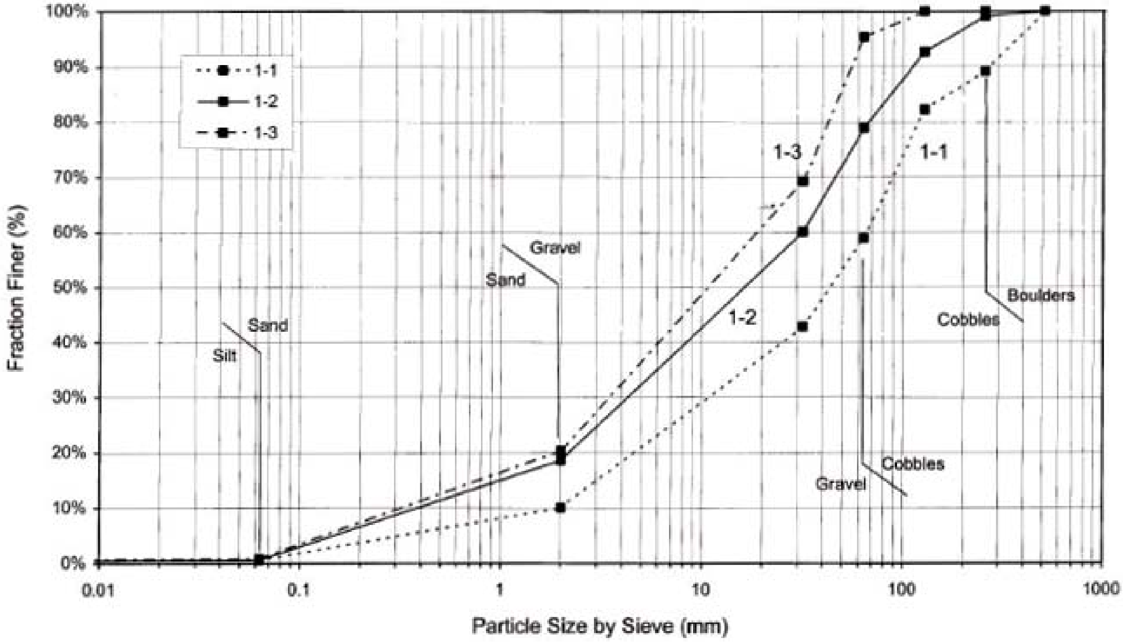


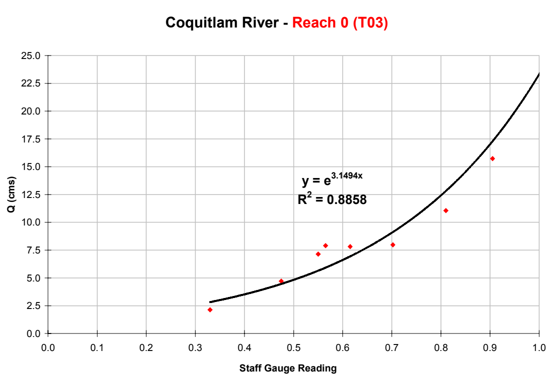
Figure 7: Small particle size distribution for reach 1 and 2 only (nhc, 2001)

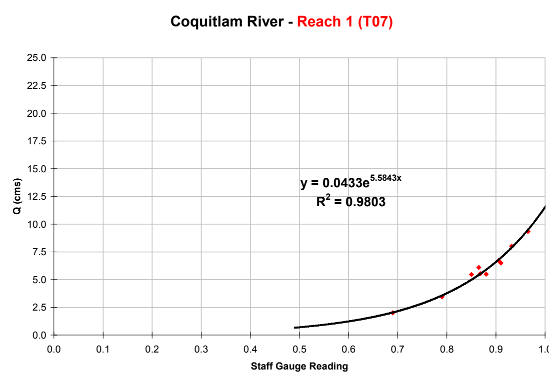


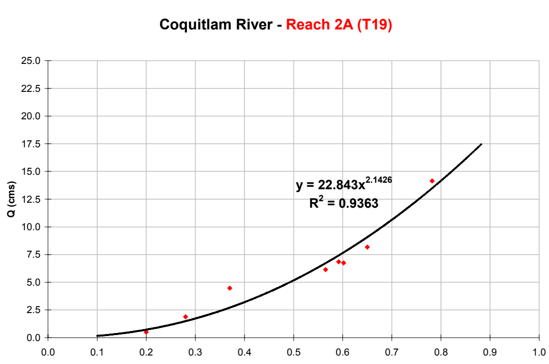
3.1.3 Staff Gauge Installations

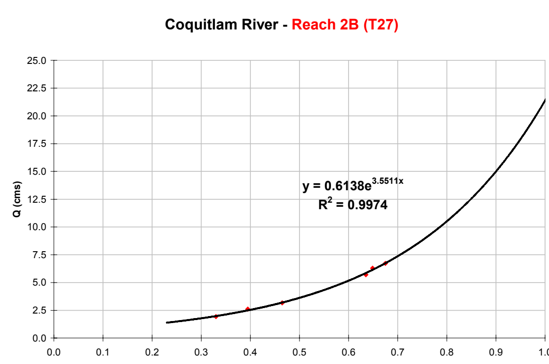
Staff gauges were installed at each reach and sub-reach to be used as reference during the instream flow data collection. The following relationships were derived for each reach through opportunistic sampling. The data were fit to power functions using the Excel™ trendline feature.

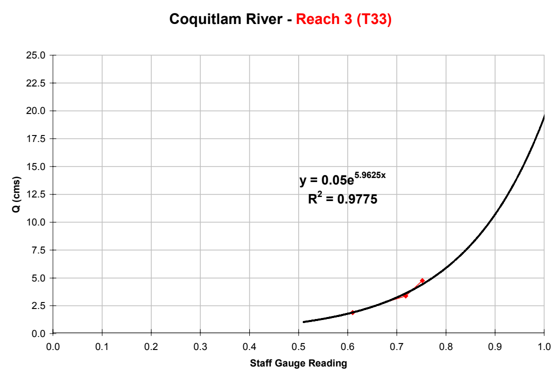
Table 9: Stage-Discharge relationships for each staff gauge. Note that gauges are not referenced to geodetic datum.











Coquitlam River – Reach 4 (T33)
Damaged Gauge

For future reference, stage-discharge relationships were developed for each reach, summarized in Table 9 below. Further monitoring is required to formalize each relationship, including the installation of a replacement gauge in Reach 4. The site was knocked out in December 2002 by floating debris and was not salvageable.

3.2 Habitat Suitability Curves

Habitat suitability was defined for rearing salmonids only in the river, in an attempt to determine their reach-specific habitat requirements. Curves were developed for coho juveniles, steelhead fry and steelhead parr for most of the reaches. The data collected was deemed by FTC members to be biased due to the limited range of flows observed, and the limited available habitats accessible to fish at those flows. Therefore, the Instream Flow Needs assessment would be based on provincially sanctioned suitability criteria, which are based on several coastal streams, and are general enough to be applied across a broad range of flows (MWLAP, pers. comm., 2001).

The following figures illustrate the habitat requirements of each of the species addressed in the IFN study.

Figure 8: Steelhead juvenile parr and fry rearing curves.

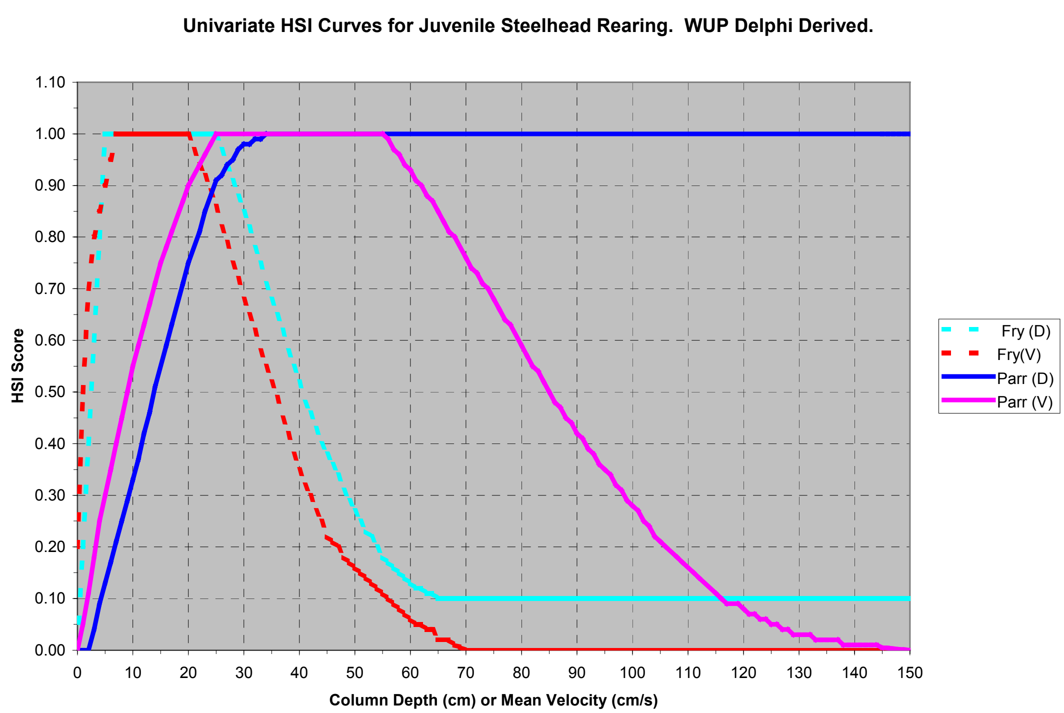


Figure 9: Coho (CO) and Chinook (CK) juveniles rearing curves.

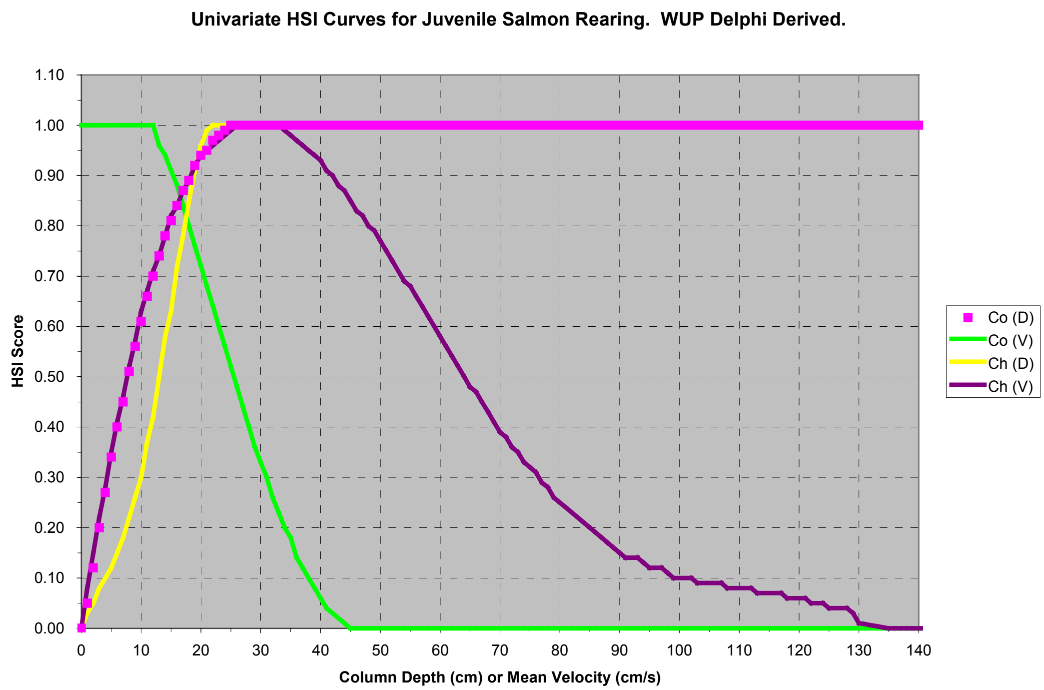


Figure 10: Steelhead spawning curves.

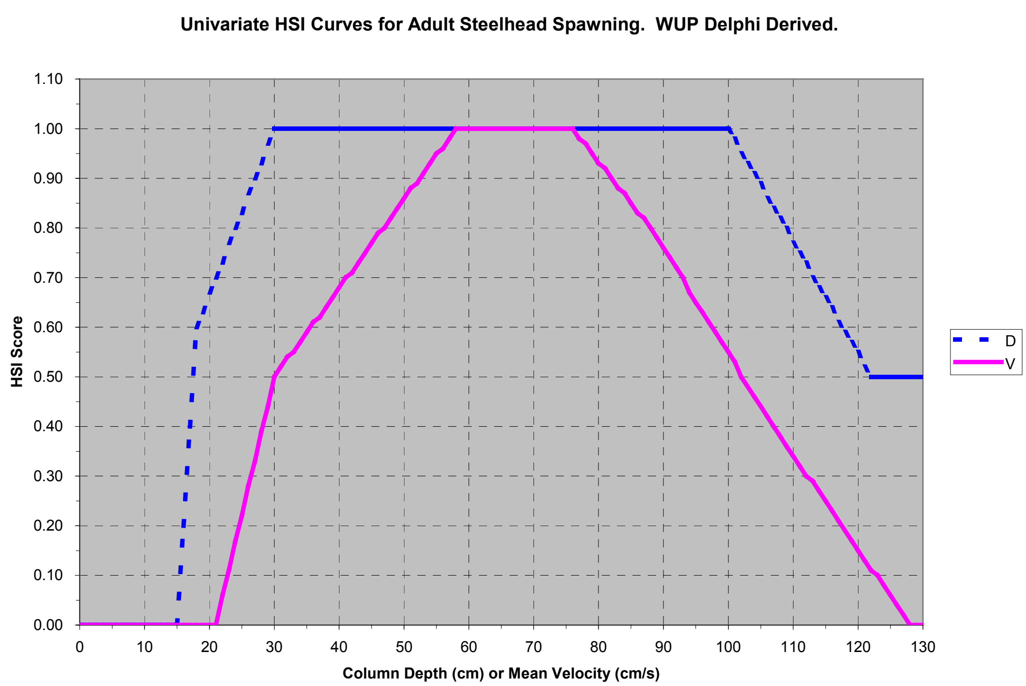


Figure 11: Chinook spawning curves.

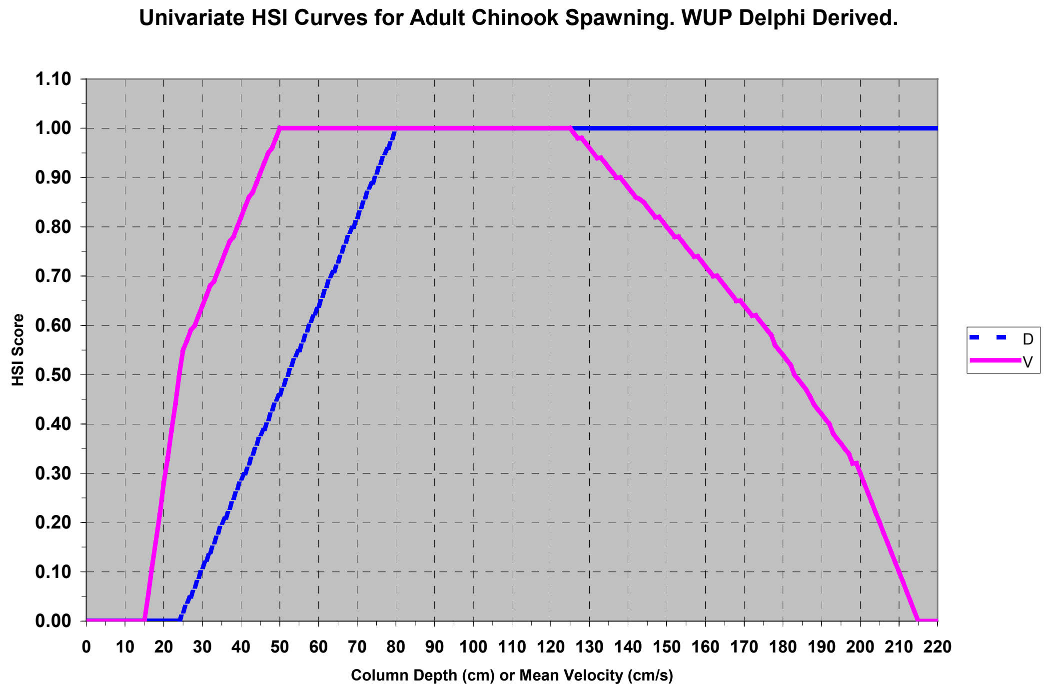
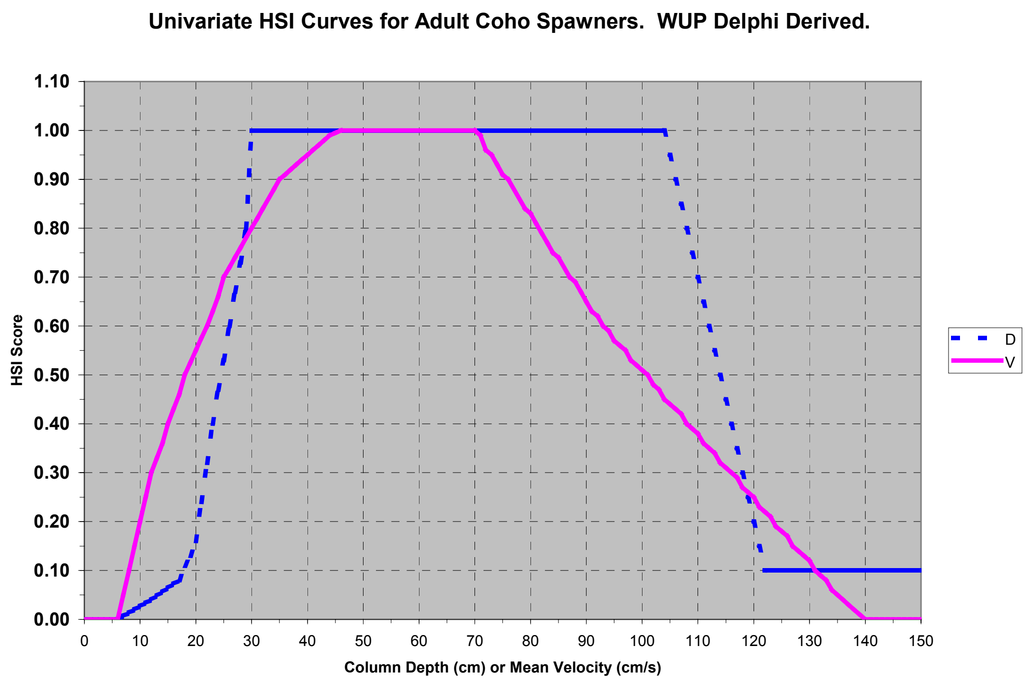


Figure 12: Coho spawning curves.



Time and resources permitting, habitat suitability will be collected at a range of flows for reference on the Coquitlam River. In situ habitat preferences were considered by the FTC to be inferior to meta-data, and therefore will likely only be applicable for developing rationale for current habitat use, and related productivity inferences.

3.3 Transect – Weighted Usable Width

Using the approach defined above, fish habitat relationships for the Coquitlam River represented by Reaches 2 and 3. Empirical data are summarized on the same plots as the modeled data and are tabulated in the Appendix attached. The model parameters defining the lines fitting the species empirical data are summarized in the table attached.

The correlation coefficient between the fitted line and the data is represented by the Pearson R-Square value in the bottom row of the table. The sum-of-squares difference (the criterion for minimizing fit-error), is described in the second to last row for the species of interest.

Table 10: Line fit parameters describing the relationships for percent of maximum habitat versus flow relationships by empirical transect data for various species of interest in the Coquitlam River.

Data Fitting Equation Parameters: $y_{PUW} = A\, x_{\%MAD}^{\,c} \exp(n\, x^b)$
(maxima function)

Parameter	*Spawners*				*Rearers*				Parameter Comments
	ST	CH	CO	CM	CO	CH	STF	STP	
A	8.76	2.03	2.33	531.16	100.04	61155.95	99.99	61155.00	height of the curve
n	-3.25	-1.44	-1.68	-9.46	-7.53	-12.95	-8.08	-12.41	rate of decline of the curve
c	1.39	0.96	0.71	3.78	0.98	2.07	1.06	1.89	rate of incline of the start of curve
b					0.34	0.27	0.39	0.23	height of the end of the curve
Sum of Squares Diff	0.07	0.19	0.11	0.15	0.15	0.19	0.06	0.16	Sum of Squares difference between function and actual data
Pearson R^2	0.93	0.71	0.82	0.69	0.67	0.65	0.85	0.64	Pearson r-square of correlation coefficient

A summary of habitat-flow results is shown in the following table for the species of interest on the river, taken from relationships documented in subsections 3.3.1 to 3.3.3.

Table 11: Habitat-flow results for indicator species based on percent of maximum targets (POM = 0.8 – 1.0).

Life History	Species	*Flow Targets Achieving Percent of Maximum Habitat*							
		POM = 1.0		POM = 0.95		POM = 0.9		POM = 0.8	
		m^3s^{-1}	% MAD	m^3s^{-1}	% MAD	m^3s^{-1}	% MAD	m^3s^{-1}	% MAD
Rearing	Coho	1.6	6%	1.1	4%	0.8	3%	0.6	2%
	Steelhead Parr	4.4	16%	2.7	10%	2.2	8%	1.6	6%
	Steelhead Fry	1.6	6%	1.1	4%	0.8	3%	0.6	2%
Spawning	Steelhead	11.7	43%	8.8	32%	7.7	28%	6.3	23%
	Coho	11.7	43%	7.7	28%	6.3	23%	4.7	17%
	Chinook	18.3	67%	12.9	47%	11.0	40%	8.5	31%
	Chum	10.9	40%	9.3	34%	8.5	31%	7.7	28%

3.3.1 Spawning:

Spawning flow requirements as defined by the empirical data relationships, are summarized for steelhead and chinook spawners in the following figures. Relationships are highlighted for peak, 95%, 90% and 80% of peak habitats.

Figure 13: Chinook salmon spawning habitat relationship for representative section of Coquitlam River.

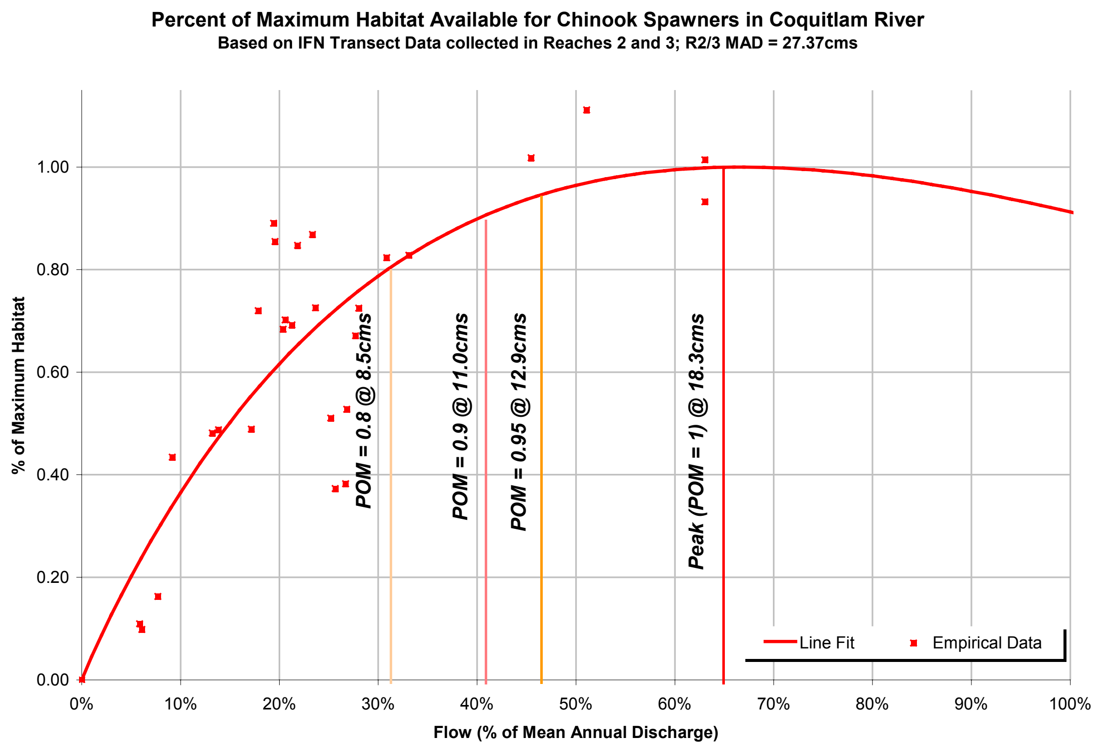


Figure 14: Steelhead spawning habitat relationship for representative section of Coquitlam River.

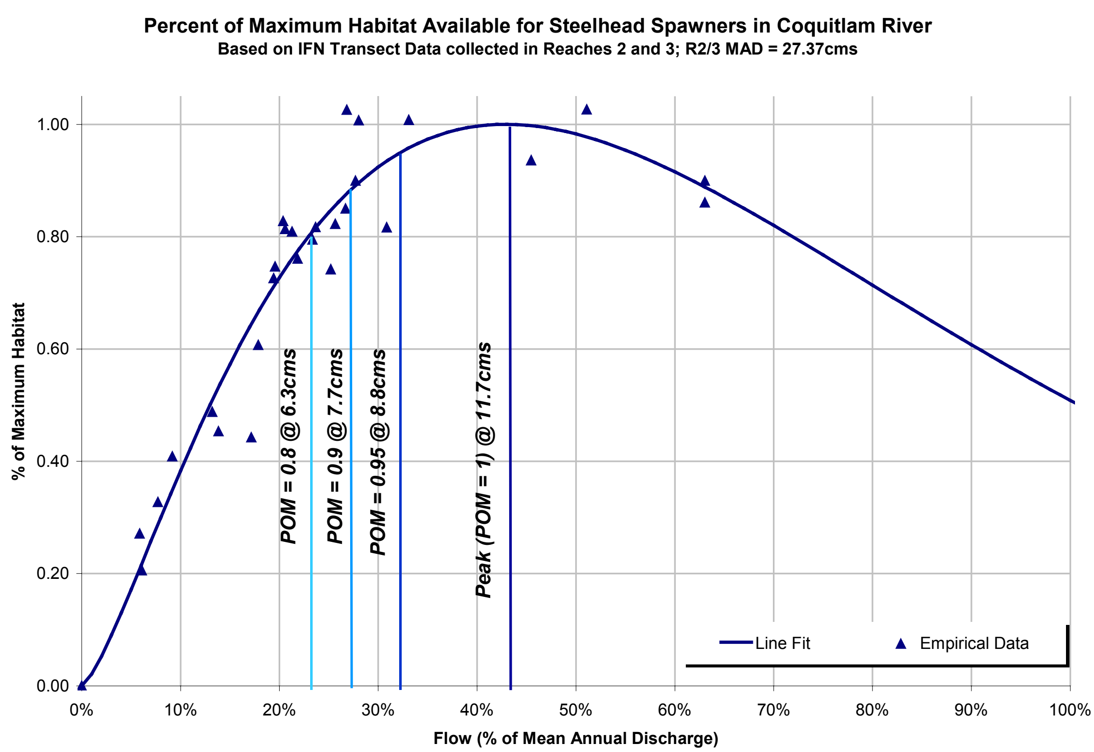
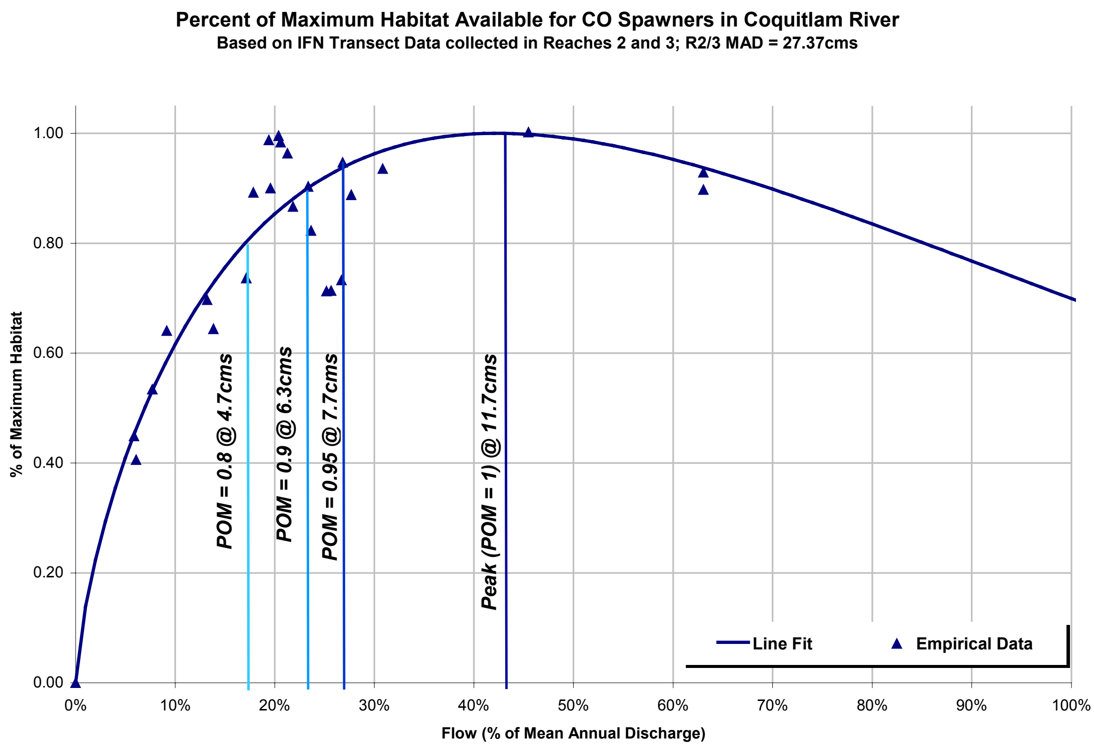


Figure 15: Coho salmon spawning habitat relationship for representative section of Coquitlam River.



3.3.2 Rearing:

Rearing flow requirements as defined by the empirical data relationships, are summarized for steelhead and chinook spawners in the following figures. Relationships are highlighted for peak, 95%, 90% and 80% of peak habitats.

Figure 16: Steelhead fry rearing habitat relationship for representative section of Coquitlam River

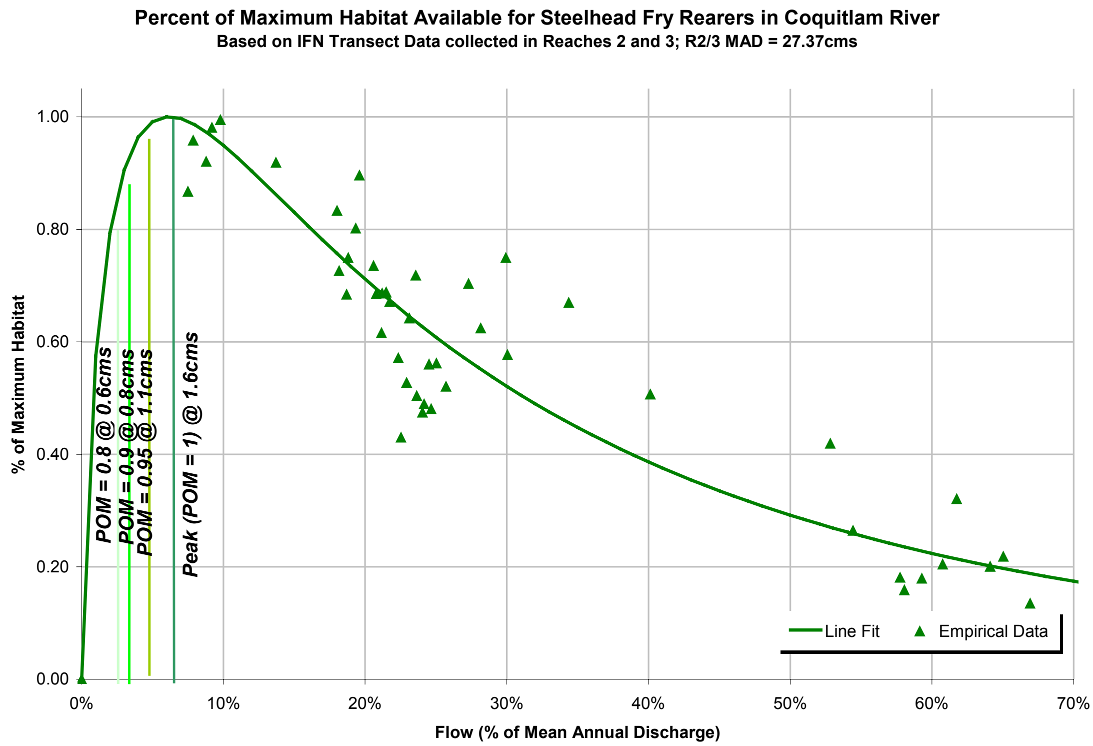


Figure 17: Steelhead parr rearing habitat relationship for representative section of Coquitlam River.

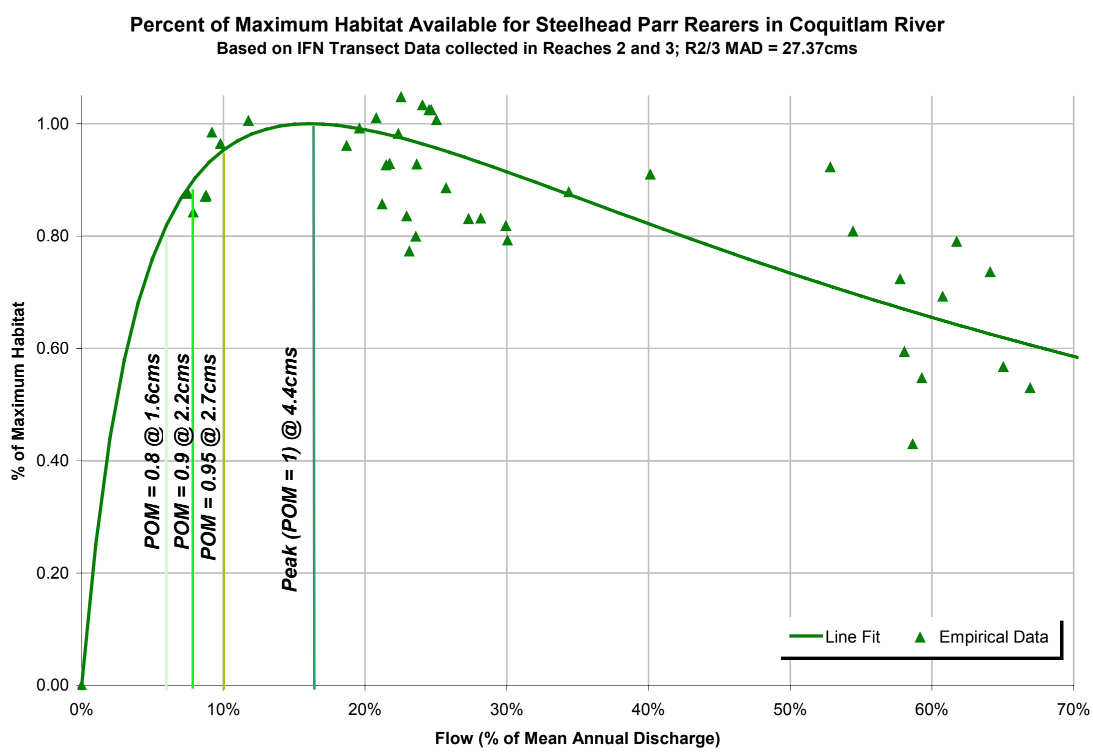
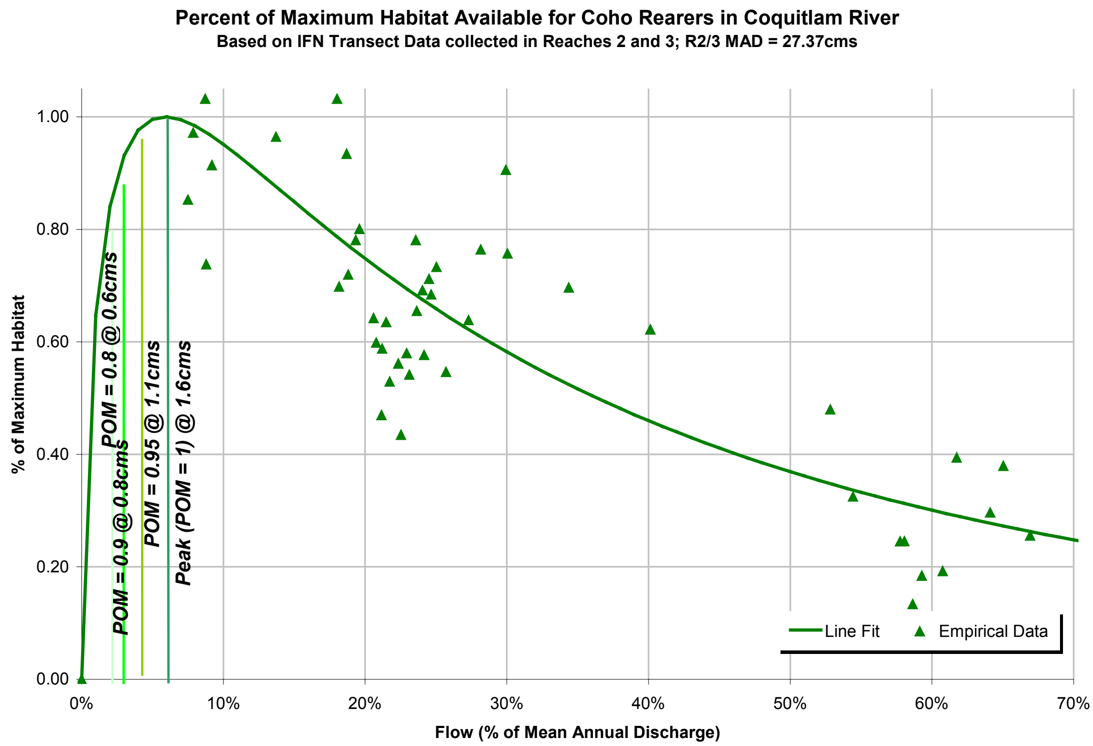


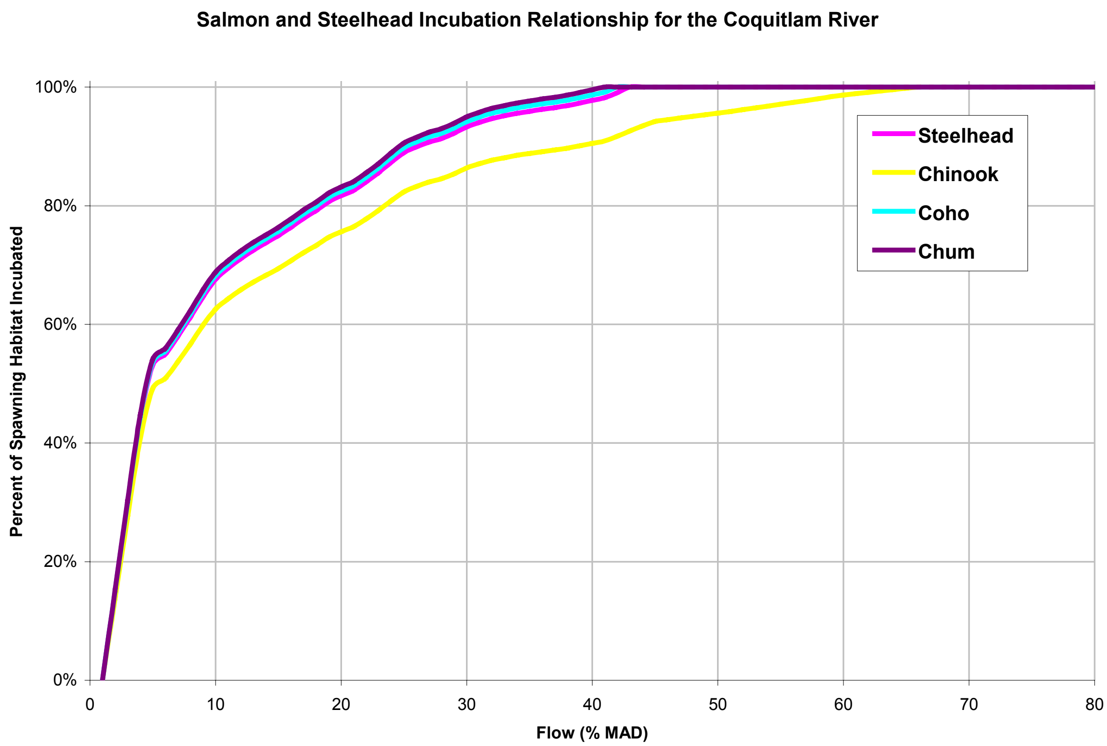
Figure 18: Coho juvenile rearing habitat relationship for representative section of Coquitlam River.



3.3.3 Incubation:

Incubation requires that eggs are kept wetted with enough oxygen and flow to promote development and limit fungal growth. Flow-incubation relationships for the three target salmon species are summarized in the following figure.

Figure 19: Incubation-flow relationships for (a) steelhead incubation; (b) Chinook incubation; (c) Coho incubation; and (d) Chum incubation.



4 Discussion: Defining a Fisheries Flow for the Coquitlam River

Based on the habitat requirements described in sections 3.3.1 and 3.3.2 and the monthly hydrology characteristics in section 3.1.1, a fisheries flow regime can be developed to optimize habitat availability based on the instream flow results obtained to date.

The fish periodicity represented in Table 6 drives the flow target timing, based on the species driver defined for each time period. The fisheries technical committee has defined the species drivers as described in the following table. Criteria for habitat targets are summarized in Table 13.

Table 12: Species life history drivers for flow targets in the Coquitlam River, as determined by the COQ WUP FTC (2001).

Period	Driver
Jan 1-15	Coho Spawning
Jan 15-31	Chinook/Coho Incubation
Feb	Chinook/Coho Incubation
Mar	Steelhead Spawning
Apr	Steelhead Spawning
May	Steelhead Spawning
Jun	Steelhead Parr
Jul	Steelhead Parr
Aug	Steelhead Parr
Sep	Steelhead Parr
Oct	Chinook Spawning
Nov	Chinook Spawning
Dec	Chinook Spawning

Table 13: Driver species habiat value targets and their rationale as determined by the COQ WUP FTC (2003).

Driver	*POM Habitat Value*		Rationale
	Target	Low	
Steelhead Spawning	0.95	0.80	Species of concern and sport fishery interest in the Coquitlam River.
Chinook Spawning	0.90	0.80	Extirpated but currently being re-introduced through hatchery initiatives.
Coho Spawning	1.00	0.95	Represents late-spawning salmon
Steelhead Parr	1.00	0.95	Target species during critical period
Chinook/Coho Incubation	1.00	1.00	Requires the provision of wetted area to spawned regions.

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A1 Local Inflow Analysis

The following tables describe the various ranges in flows expected based on inflow analysis completed by Summit (2000). Reach 2/3 inflows were used for the purposes of developing flow release prescriptions for the Coquitlam WUP.

Table A - 1: Median local inflows by month.

Month	Median Natural Inflows Expected at Each Reach Break						
	R4	R3	R2B	R2A	R1	R0	R2/3
Jan	0.2	4.0	5.1	5.3	5.4	8.3	4.9
Feb	0.2	2.6	3.4	3.5	3.6	6.1	3.3
Mar	0.1	3.5	4.3	4.4	4.5	6.4	4.2
Apr	0.1	4.4	5.4	5.6	5.7	7.4	5.3
May	0.1	4.6	5.5	5.7	5.8	6.8	5.4
Jun	0.1	4.1	4.8	5.0	5.1	5.6	4.7
Jul	0.0	2.2	2.6	2.7	2.7	3.0	2.5
Aug	0.0	0.9	1.1	1.1	1.2	1.3	1.1
Sep	0.0	1.3	1.6	1.7	1.7	2.3	1.6
Oct	0.1	3.5	4.3	4.4	4.5	6.3	4.2
Nov	0.2	4.9	6.1	6.3	6.5	9.2	5.9
Dec	0.2	4.8	6.1	6.3	6.4	9.7	5.9

Table A - 2: 10th percentile local inflows by month.

Month	10th Percentile Natural Inflows Expected at Each Reach Break						
	R4	R3	R2B	R2A	R1	R0	R2/3
Jan	0.1	1.8	2.3	2.4	2.4	3.7	2.2
Feb	0.1	1.3	1.7	1.7	1.7	3.2	1.6
Mar	0.1	1.7	2.2	2.2	2.3	3.3	2.1
Apr	0.1	2.5	3.0	3.2	3.2	4.1	3.0
May	0.0	3.1	3.6	3.8	3.8	4.4	3.6
Jun	0.0	2.4	2.9	3.0	3.1	3.3	2.8
Jul	0.0	1.5	1.7	1.8	1.8	1.9	1.7
Aug	0.0	0.5	0.5	0.6	0.6	0.6	0.5
Sep	0.0	0.5	0.6	0.7	0.7	0.8	0.6
Oct	0.0	1.6	1.9	2.0	2.0	2.5	1.9
Nov	0.1	2.6	3.2	3.4	3.4	5.0	3.1
Dec	0.1	2.1	2.7	2.8	2.8	4.4	2.6

Table A - 3: 25th percentile local inflows by month.

Month	25th Percentile Natural Inflows Expected at Each Reach Break						
	R4	R3	R2B	R2A	R1	R0	R2/3
Jan	0.1	2.8	3.5	3.7	3.8	5.8	3.4
Feb	0.1	1.6	2.1	2.2	2.3	4.0	2.1
Mar	0.1	2.6	3.2	3.4	3.4	5.0	3.1
Apr	0.1	3.2	3.8	4.0	4.1	5.3	3.7
May	0.1	3.8	4.5	4.7	4.8	5.5	4.4
Jun	0.0	3.3	3.8	4.0	4.1	4.4	3.8
Jul	0.0	1.8	2.1	2.1	2.2	2.4	2.0
Aug	0.0	0.6	0.8	0.8	0.8	0.9	0.7
Sep	0.0	0.8	1.0	1.0	1.0	1.2	0.9
Oct	0.1	2.2	2.8	2.9	2.9	4.0	2.7
Nov	0.2	3.1	3.9	4.0	4.1	6.3	3.8
Dec	0.1	3.0	3.8	4.0	4.1	6.2	3.7

Table A - 4: 75th percentile local inflows by month.

Month	75th Percentile Natural Inflows Expected at Each Reach Break						
	R4	R3	R2B	R2A	R1	R0	R2/3
Jan	0.3	4.8	6.1	6.3	6.5	10.4	5.9
Feb	0.2	3.6	4.6	4.8	4.9	8.2	4.4
Mar	0.2	4.5	5.5	5.7	5.8	8.2	5.4
Apr	0.2	5.1	6.2	6.5	6.6	8.8	6.1
May	0.1	5.6	6.7	6.9	7.1	8.5	6.5
Jun	0.1	5.2	6.2	6.4	6.5	7.3	6.0
Jul	0.1	3.3	4.0	4.1	4.2	5.0	3.9
Aug	0.0	1.4	1.7	1.8	1.8	2.3	1.7
Sep	0.1	2.0	2.5	2.6	2.6	3.7	2.4
Oct	0.2	5.0	6.2	6.4	6.6	9.3	6.0
Nov	0.3	7.8	9.5	9.9	10.1	13.6	9.3
Dec	0.3	5.9	7.5	7.7	7.9	12.3	7.2

Table A - 5: 90th percentile local inflows by month.

Month	90th Percentile Natural Inflows Expected at Each Reach Break						
	R4	R3	R2B	R2A	R1	R0	R2/3
Jan	0.3	6.0	7.7	7.9	8.1	13.0	7.4
Feb	0.3	4.6	5.9	6.2	6.3	10.7	5.7
Mar	0.3	5.4	6.8	7.0	7.2	10.9	6.6
Apr	0.2	5.9	7.2	7.5	7.7	10.3	7.1
May	0.2	7.1	8.5	8.8	9.0	11.0	8.3
Jun	0.1	6.6	7.8	8.1	8.3	9.3	7.6
Jul	0.1	3.9	4.7	4.8	5.0	6.2	4.6
Aug	0.1	2.4	2.9	3.1	3.1	3.9	2.9
Sep	0.1	3.2	4.0	4.1	4.2	5.8	3.9
Oct	0.2	7.2	8.9	9.2	9.4	12.8	8.6
Nov	0.3	10.2	12.6	13.0	13.3	18.2	12.3
Dec	0.4	7.5	9.5	9.9	10.1	16.0	9.2

A2 In-Situ Habitat Suitability Curves

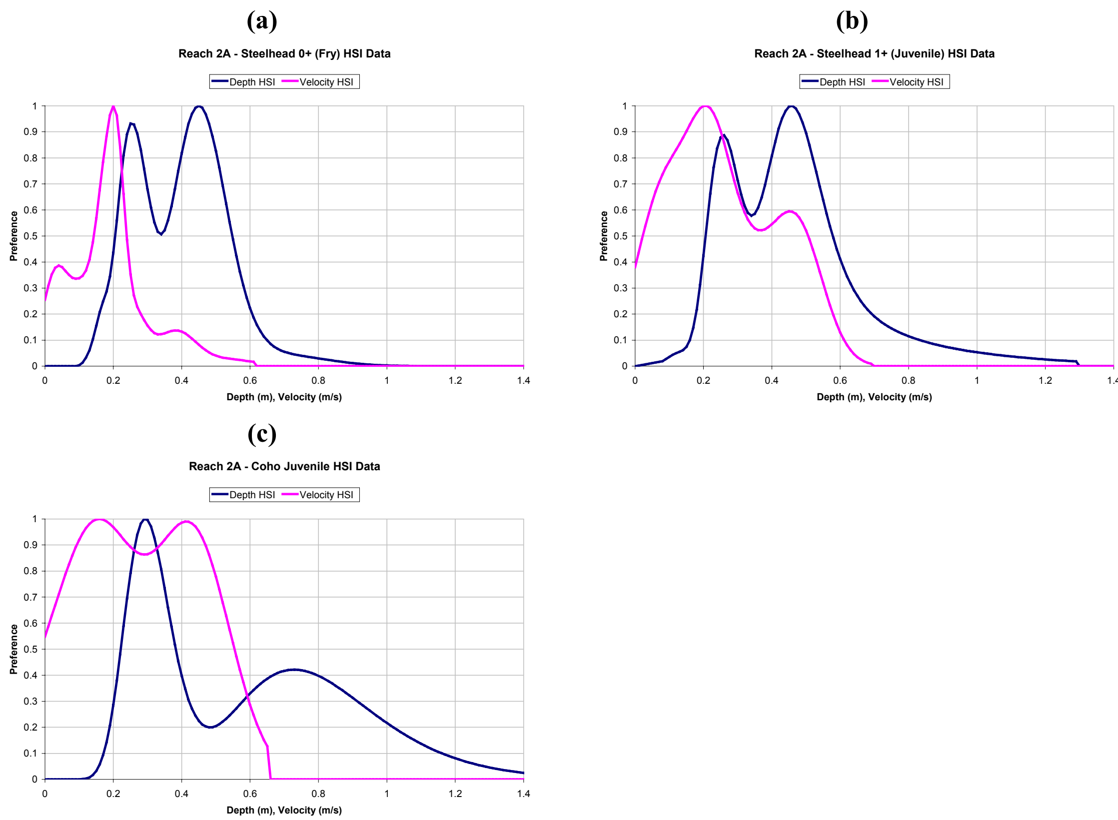
In 2000-2001, under the terms of the Coquitlam River Instream Flow Needs Assessment terms of reference (2000), BC Hydro collected local habitat use data for juvenile salmonids as follows:

- Coho fry (age 0+)
- Coho juveniles (age 1+ to 2+)
- Rainbow trout fry (age 0+)
- Rainbow trout juveniles/parr (age 1+ to 2+)

During the Coquitlam Water Use Plan process, it was determined that the site specific curves were too limited by available habitat, and therefore should not be applied to performance measures evaluating changing flow conditions. More generalized curves would be applied based on meta-data compiled by the provincial ministry and BC Hydro biologists (see section 3.2).

Note that the bi-modality observed in the following relationships is a function of data gaps and would normally be removed or smoothed to more adequately represent sites specific habitat use.

Figure A - 1: Steelhead fry (a), parr (b) and coho juvenile (c) habitat suitability (HSI) data summaries.



A3 Habitat Use Relationship Sensitivity Analysis

This section summarizes the comparison of two base curve relationships which drove the habitat-use curve development for the Coquitlam River system. In developing the set of parameters constraining each habitat-use relationship, the sum of squares difference between the modeled result and the field empirical results were minimized to the lowest possible value. Microsoft Excel's Solver was used to optimize a solution, but because of the dimensions of the solution parameter set (3-4 parameters, depending on the life history), seed solutions were incorporated after every solution to ensure a minimum had been achieved.

What follows is a comparison of results using this technique but for two different types of equations.

A3.1 Equation 1: Maxima Function

As described in section 2.3.2, the maxima function was employed to dictate the relationship of the habitat versus flow:

$$y = Ax^{c} \bullet e^{nx^{b}}$$

where:

- y = amount of habitat units;
- x = amount of flow units;
- A = parameter for magnitude;
- n = parameter for the rate of incline/decline of the relationship;
- c = parameter for the lag response of habitat to flow; and
- b = parameter for the magnitude of the post-peak habitat response to flow.

As described in section 3.3, the following relationship for the sum of squares was defined:

Data Fitting Equation Parameters: $y_{PUW} = A\, x_{\%MAD}^{\,c} \exp(n\, x^{b})$
(maxima function)

Parameter	*Spawners*				*Rearers*				Parameter Comments
	ST	CH	CO	CM	CO	CH	STF	STP	
A	8.76	2.03	2.33	531.16	100.04	61155.95	99.99	61155.00	height of the curve
n	-3.25	-1.44	-1.68	-9.46	-7.53	-12.95	-8.08	-12.41	rate of decline of the curve
c	1.39	0.96	0.71	3.78	0.98	2.07	1.06	1.89	rate of incline of the start of curve
b					0.34	0.27	0.39	0.23	height of the end of the curve
Sum of Squares Diff	0.07	0.19	0.11	0.15	0.15	0.19	0.06	0.16	Sum of Squares difference between function and actual data
Pearson R^2	0.93	0.71	0.82	0.69	0.67	0.65	0.85	0.64	Pearson r-square of correlation coefficient

A3.2 Equation 2: Log normal distribution

As described in Bruce and Hatfield (unpublished) a log normal distribution can describe habitat-flow relationships as follows:

$$y = \frac{1}{Sx\sqrt{2\pi}} e^{-(\ln x - M)^{2} / (2S^{2})}$$

where

- y = amount of habitat units;
- x = amount of flow units > 0
- S = height of the curve
- M = lag of curve (position of peak)

The following table summarizes the parameters and the sum of squares results for each of the indicator species:

Data Fitting Equation Parameters: $y = (1/Sx\sqrt{2\pi})e^{-(\ln x-M)^2/2S^2}$
(log normal distribution)

Parameter	Spawners				Rearers				Parameter Comments
	ST	CH	CO	CM	CO	CH	STF	STP	
S	0.97	1.05	1.13	1.07	2.78	1.70	3.16	1.47	height of the curve
M	0.02	0.34	0.12	0.65	2.37	0.70	2.85	0.32	rate of decline of the curve
Sum of Squares Diff	0.08	0.21	0.15	0.21	0.16	0.22	0.09	0.16	Sum of Squares difference between function and actual data
Pearson R^2	0.91	0.68	0.77	0.56	0.64	0.63	0.80	0.64	Pearson r-square of correlation coefficient

In all cases but one (steelhead parr) the line fit quality provided by the maxima function surpass the log normal distribution fit. In the case of steelhead parr, the two are very similar, and provide the same flow target thresholds for optimal habitats as described in Table 11. Therefore, the maxima equation was the most suitable of the choices available for fitting habitat-flow data to a curve.

Appendix CC FINAL MINUTES FROM CC MEETING

Final Meeting Minutes – March 31, 2003
Consultative Committee Meeting
For
Coquitlam-Buntzen Water Use Plan

On Monday, March 31th, 2003, the Consultative Committee of the Coquitlam-Buntzen Water Use Plan (CBWUP) met at the BC Hydro District Hall in Coquitlam. The meeting started at 5:10 p.m. and concluded at approximately 11:15 p.m. The following attended the meeting:

Consultative Committee Members

1. Paul Archibald, GVRD
2. Lawrence Bojczuk, Buntzen Ridge Wilderness Recreation and Parks Association (left at 10:10)
3. Derek Bonin, GVRD
4. Kirsten Doucette, Port Moody Ecological Society (left at 10:30)
5. David Dunkley, GVRD
6. Don Gillespie, Burke Mountain Naturalists
7. Dr. Don Gillespie, Resident
8. Elaine Golds, Burke Mountain Naturalists
9. Brent Hilpert, resident
10. Eunice Hodge, Coquitlam River Watershed Society
11. Janice Jarvis, Habitat Conservation & Stewardship Program, Maple Ridge-Coquitlam
12. Ian McArthur, resident
13. Tony Matahlija, North Fraser Salmon Assistance Project-CRWS
14. Bruce Misewich, BC Hydro
15. Ross Neuman, Ministry of Water, Air, Land Protection
16. Craig Orr, Watershed Watch Salmon Society
17. Joe Pauker, Resident
18. Rick Simpson, Port Moody Ecological Society and PoCo Hunting and Fishing Club (left at 9:15)
19. Dan Sneep, DFO
20. Walter Udell, BC Hydro
21. Stan Woods, GVRD

BC Hydro Resource Staff

22. Charlotte Bemister
23. Michael Harstone
24. Paul Higgins
25. Ed Hill
26. Janie Hutchings
27. Alf Leake
28. Vlad Plesa

Observers

29. Steve McAdam, Ministry of Water, Land, & Air Protection
30. Dana Soong, City of Coquitlam
31. Ted White, Land and Water BC

Consultants

32. William Trousdale, EcoPlan International (Facilitation)
33. Maria Harris (Minutes)

Note: First Nations were consulted about this meeting and chose to meet separately with BC Hydro.

1.0 Distributed Materials

Please contact EcoPlan International if you require any of the following documents.

1. Pre-reading package for the Consultative Committee (distributed prior to meeting) – agenda included. **Please note the following corrections:**

   a. Page 11: Fish Performance Measures: the 4th performance measure is "Coho spawning habitat" (NOT "Invertebrate habitat")
   b. Page 12: Fish Performance Measures on this page should be disregarded because they are based on simulated data rather than newer "real" data collected through the IFN study. In order to provide meaningful information, the fish performance measures on page 12 would need to be recalculated using different threshold flows.
2. Charts showing habitat/flow relationships for chinook, steelhead, and coho spawning and for steelhead and coho rearing.
3. Information and registration packages for:
   a. The World Summit on Salmon Conference, June 10-13, SFU
   b. The World Summit on Salmon Satellite Conference, June 14-16, West Coast Vancouver Island Aquatic Management Board

2.0 Introduction and Agenda Review

The facilitator reviewed the proposed meeting agenda, the objectives of which were to:

1. Review CC agreement and what has happened since
2. Review the statistical power analysis results
3. Review and Evaluate FTC proposed Treatment Schedules and discuss other options
4. Revise CC recommendations, documenting both the rationale for recommendations and areas of consensus and disagreement.
5. Establish next steps

Minutes of this meeting along with supporting documentation will be submitted to the Comptroller of Water Rights as an addendum to the Consultative Committee Report dated June 2002.

The meeting agenda was agreed to as proposed.

3.0 Current Events related to Coquitlam-Buntzen

The CC received the following update about work related to the Coquitlam-Buntzen system that is currently underway.

Dam Safety

Dam seismic work is ongoing. Construction completion is estimated for fall 2006 at the earliest. This may have implications for being able to deliver variable flows as required for 4FVN and STP5/STP6 alternatives.

Status of the Coquitlam- Buntzen Water Use Plan

The Water Use Plan (WUP) and the Consultative Committee Report (CCR) have not been submitted to the Provincial Comptroller of Water Rights at this time. Both the Consultative Committee Report (through an ***Addendum***) and the Water Use Plan will be revised to reflect the outcome from the final CC meeting.

Bridge Coastal Restoration Program (BCRP) Fish Passage Review

Work has been ongoing by the Bridge-Coastal Restoration Program looking into the feasibility of fish passage into the Coquitlam reservoir. The first two steps of a four-stage feasibility review assessment were completed and accepted by the BCRP board a few weeks ago. A report of the study will soon be available online at the BCRP website (part of the BC Hydro website). Fish passage still remains a trigger for the re-opening of the WUP, if it is found to be feasible.

PoCo Hydrological Study

The report from this water management study is complete. Recommendations of the report were read to the CC for their information. Complete report details are available from Al Jensen, City of Port Coquitlam.

4.0 Where We Left Off

The facilitator provided a review of the previous two CC meetings (Oct. 22, 2001 and Mar. 11, 2002) as a reminder of how the CC arrived at the need for another meeting. The facilitator's presentation, taken from the Pre-Reading Package for the Consultative Committee, is included for reference as Appendix A to these minutes.

In summary, the CC met again because the Adaptive Management Program (agreed to at the last CC meetings and as documented in the June 2002 CBWUP Consultative Committee Report) needs to be altered so test flows effectively determine fisheries benefits and create a better understanding of trade-offs between fisheries, domestic water and power generation. This determination was made after the FTC reviewed the recently completed Statistical Power Analysis[1].

Aside from the need to alter test flows for the Adaptive Management Program, or monitoring plan, all other CBWUP operating recommendations made in the Consultative Committee Report remain unchanged.[2] In response to questions raised by CC members, it was specifically noted that:

1. A new Adaptive Management Program is being recommended because a central goal of this WUP is to learn more about fish flow requirements downstream of the Coquitlam Dam; and
2. There is no change to the CC recommendation that flow regimes to the river following the flow testing program proposed for this WUP will not be less than 4FVN, will not exceed STP5, and that all water allocations within the 4FVN and STP5 will be on the table for review at that time.

5.0 Statistical Power Analysis Results

Paul Higgins, BC Hydro fisheries biologist and member of the WUP Fish Advisory Team, reviewed results of the Statistical Power Analysis. He addressed:

- **Objectives** of the Statistical Power Analysis which were to:
    - Evaluate the statistical reliability of the fish population monitoring proposed for the experimental flow release plan.
    - Explore options to maximize the reliability of future anadromous fish population monitoring for Coquitlam WUP.

[1] The Report was done by Paul Higgins (BC Hydro), Josh Korman (Ecometric Research) and Michael Bradford (Fisheries and Oceans Canada). The full name of the report is entitled, "Statistical Power of Monitoring Inferences Derived from Experimental Flow Comparisons Planned for Coquitlam-Buntzen Water Use Plan": November 26, 2002.

[2] Summary of CBWUP Operating Recommendations provided in the CBWUP: Report of the Consultative Committee, June 2002, p. xi.

    - Provide recommendations for experimental flow programs in terms of the application of experimental flow treatments and fish population monitoring.
- Factors influencing reliability of anadromous fish population monitoring (i.e. factors that can and cannot be controlled);
- Key **questions** addressed by the statistical power analysis, namely:
    - What is the best *population response indicator* (smolts, spawners, stock-recruitment metric) to monitor to maximize statistical reliability?
    - What are the benefits from increasing *measurement precision* of population indicators?
    - What are the required level of *replication* required to generate acceptable statistical inferences?

      Does the implementation of *control* stock monitoring improve the inferential quality of monitoring program results?
- Methodology
- ***Conclusion: The researchers concluded that the proposed experimental design (the Adaptive Management Program agreed to by the CC and reported in the CC Report of June 2002) will not provide statistically reliable results.***
- **Future options**, which are to:
    - Ignore ramifications of low power and implement experimental program as originally planned; or
    - Consider ramifications of power and redesign experiment treatment application and monitoring by:
        - Increasing ***duration*** of the flow treatment program ← **PREFERRED**
        - Increasing smolt ***measurement precision*** ← not much room for improvement
        - Generating larger ***effect size*** ← not sure if possible
        - Monitoring multiple ***control stocks*** ← difficult and costly

6.0 Conclusions from the FTC Meetings

The FTC met twice on February 3, 2003 and March 10, 2003. Michael Harstone, BC Hydro, facilitated these meetings and provided the CC with an overview of the FTC's conclusions, summarized as follows:

1. Based on the Statistical Power Analysis results, the FTC deemed the CC's Adaptive Management Agreement as "ineffective" because of the low power results.
2. The FTC looked at different ways of improving statistical power and concluded that the preferred option would be to change the treatment schedules (duration and number of trial flows).
3. The FTC proposed 3 new treatment schedules for consideration by the CC. These schedules were based on:
    - Aiming to have a statistical power of at least 0.5
    - Only having one flow trial plus continue baseline flows (2 fish valves)
    - Selecting the upper flow alternative (Revised STP5, or what was referred to as STP6) and **not** the lower flow volume alternative known as 4FVN. The revision to STP5 (STP6) was based on the new field data collected during the recently done Instream Flow Needs (IFN) field study results, described below.

Below are four treatment schedules (original plus 3 new) forwarded by the FTC for consideration by the Consultative Committee.

Treatment Schedules Forwarded by FTC

Schedule #1 is the original CC Adaptive Management Agreement and is considered ***ineffective***. Schedules #2-4 are the new treatments forwarded by the FTC. They all incorporate the same test flow (STP6) and vary only in terms of test flow duration. The arrow-boxes indicate the statistical power of the proposed treatment schedule.

Treatment Schedule 1 - Original CC Agreement: 3 Yrs 2FVC; 6 Yrs 4FVN; 6 Yrs STP5

Activity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Treatment #1 - 2FVC baseline smolt monitoring	1	2	3	4	5	6												
Dam Modifications				1	2	3												
Treatment #2 - 4FVN							1	2	3	4	5	6						
Treatment #3 - STP5													1	2	3	4	5	6

p=.4

p=.2

Treatment Schedule 2 - 6 Yrs Base (2FVC); 9 Years **STP6**

Activity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Treatment #1 - 2FVC baseline smolt monitoring	1	2	3	4	5	6	7	8	9									
Dam Modifications				1	2	3												
Treatment #2 - *STP6*										1	2	3	4	5	6	7	8	9

p=.6

Treatment Schedule 3 - **3** Yrs Base (2FVC); 9 Years **STP6**																		
Activity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Treatment #1 - 2FVC baseline smolt monitoring	1	2	3	4	5	6												
Dam Modifications				1	2	3												
Treatment #2 - *STP6*							1	2	3	4	5	6	7	8	9			

p=.5

Treatment Schedule 4 - 9 Yrs Base (2FVC); 12 Years **STP6**																								
Activity	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Treatment #1 - 2FVC baseline smolt monitoring	1	2	3	4	5	6	7	8	9	10	11	12												
Dam Modifications				1	2	3																		
Treatment #2 - *STP6*													1	2	3	4	5	6	7	8	9	10	11	12

p=.7

Decision: *CC members agreed to:*

1. *Discontinue the original CC Adaptive Management Program which was to test flows at 2FVC for 3 years, 4 FVN for 6 years and STP5 for 6 years*
2. *Accept the FTC recommendation of having one flow trial plus continued baseline flows (2 fish valves) rather than two plus baseline flow.*

Discussion of the FTC's conclusions at the CC meeting focused on two issues, namely:

- Duration of the treatment schedule; and
- Rationale for how STP6 was developed and which flow trial should be used.

These issues are addressed in Sections 7 and 8 below.

7.0 Treatment Schedule Duration

Overview of Key Technical Trade-offs Between FTC Treatment Schedules

As mentioned above, the original CC Adaptive Management Agreement (Treatment Schedule #1) was considered ineffective and therefore excluded from the CC's trade-off analysis. Technical trade-offs between the other three treatment schedules were discussed by the CC and are summarized below.

Summary of Trade-offs Between Short-listed Treatment Schedules

	Treament schedule #2 Flow 1 = base (2FVC): 6 yrs* Flow 2 = STP6: 9 yrs	**Treament schedule #3** Flow 1 = base (2FVC): 3 yrs* Flow 2 = STP6: 9 yrs	**Treament schedule #4** Flow 1 = base (2FVC): 9 yrs* Flow 2 = STP6: 12 yrs
Statistical power (learning - fish flow requirements)	0.6	0.5	0.7
Avg annual cost to BC Hydro**	$724,000	$1,036,000	$452,000
Duration of experiment from Oct 2001 (GVRD constraint)***	18 yrs (2018)	15 yrs (2015)	24 yrs (2024)
Starting year for Flow2 (increased fish releases)	2010	2007	2013

* Proposed trial duration, starting 2004 (note: first year of meaningful collection of fish monitoring data was 2001. Therefore, the number of years with good fish data for the base flow (2FV) will be 3 years longer than the proposed trial duration.)
** Discount rate of 8% was used.
Costs to BCH are based on Annual Generation Revenue ***and*** GVRD Payments
Costs do not include water rental costs for water used for generation
*** Agreement reached in March 2002 was that trial flows for the CBWUP would be completed within 15 years from Oct. 22, 2001 to meet GVRD planning requirements.

The primary impacts to these treatment schedules that were presented to the CC, as well as relevant comments, are summarized below.

Treatment Schedule 2

- This option would provide 9 years of base flow data and 9 years data for STP6
- The Statistical Power has been calculated for this as approximately **0.6** moving from 2FVC up to STP6
- Cost to BC Hydro under this option are:
    - Net Present Value Costs= **$6,197,000**[3]
    - Average Annual Costs = **$724,000**

Other Notes:

- If Coquitlam Dam modifications are not complete by 2006 then Treatment Schedule 2 would probably not be impacted (Treatment Schedule 3 could be impacted by a delay in dam modifications)
- The GVRD (with partial funding from Provincial and Federal grants) is building water filtration facilities for the Capilano and Seymour water sources. These water filtration facilities are scheduled for commissioning in 2007. It would be preferable to have the 2FV fish release at Coquitlam continue through 2007 as the GVRD would have operation experience with the 2FV fish release and would not see changes at Coquitlam (Treatment Schedule 2 would go to STP6 in 2007) at the same time as the filter plant changes are being made at Capilano and Seymour.

Treatment Schedule 3

- This option is exactly the same as Treatment Schedule #2 except that Treatment #1 (2FVC) would be reduced by 3 years -- it would have 6 years of base flow data and 9 years data for STP6

[3] A discount rate of 8% was used. Costs to BC Hydro are based on both Annual Generation Revenue and GVRD payments. Costs do not include water rental costs for generation.

- The Statistical Power has been calculated for this as approximately **0.5** moving from 2FVC up to STP6
- Cost to BC Hydro under this option are:
  - Net Present Value Costs= **$7,806,000**
  - Average Annual Costs = **$1,036,000**
- Higher flows associated with STP6 would be provided sooner than in Treatment Schedule 2 or 4.
- Treatment schedule 3 could be impacted by the dam modifications if construction is not complete by 2006 and the reservoir returned to its normal operating range

Treatment Schedule 4

- This option would provide 12 years of base flow data and 12 years data for STP6
- The total duration for this schedule exceeds the initial timeframe agreed to by the CC by 8 years. The 15-year timeframe was established to meet GVRD's long-term planning requirements.
- The Statistical Power has been calculated for this as approximately **0.7** moving from 2FVC up to STP6
- Cost to BC Hydro under this option are:
  - Net Present Value Costs= **$4,530,000**
  - Average Annual Costs = **$452,000**

Removal of Treatment Schedule #4 from Further Consideration

Decision: *CC members agreed to remove Treatment Schedule #4 from further consideration because:*

- *The value placed on expected benefits to fish from bringing forward the start of higher dam releases of the second trial flow exceeds the value placed on statistical power from a 24-year trial duration.*
- *24 years for Treatment Schedule #4 was viewed by some as too long a period over which to make an operating decision*

Value Trade-offs Between Treatment Schedules #2 and #3

The CC focused on Treatment Schedule #2 and #3. Since there were stated reservations regarding low flows of STP6, the main purpose in discussing treatment schedule preferences was to gain insight on the importance of duration, statistical power and cost. The issues surrounding STP6 were considered separately. The main differences, and therefore value tradeoffs, in moving from Treatment Schedule #2 to #3 are:

- The loss of .1 in statistical power;
- An increase in annual cost to BC Hydro of $312,000;
- Three fewer years of the test period;

- More water in the river three years sooner.[4]

All CC members were given the opportunity to comment on the tradeoffs between Schedules #2 and #3. Preferences were as follows:

- **BC Hydro**: Schedule #2 preferred on the basis of cost and the higher statistical power, but value consensus and would consider Schedule #3. BCH reps also cited that the business case to increase instream flows to STP6 had not been made and they believed 4FVN Alternative was optimum for fish benefits.
- **GVRD**: Schedule #2 was preferred (although one members stated he was prepared to go with schedule #3) because of the additional statistical power and, hence, better learning. In addition, the GVRD cited the advantages of operation experience under Schedule #2 in constructing their water filtration facilities for the Capilano and Seymour water sources.
- **Other CC members**: Schedule #3 preferred because they felt that statistical power is less valuable for fish than it is to have water in the river sooner.
- In the interest of reaching consensus, CC members agreed, in spite of reservations, to recommend the duration of trial flows as set out in Treatment Schedule #3 subject to discussions surrounding several CC member's concerns related to STP6.

Decision: *In the interest of reaching consensus, CC members agreed, in spite of reservations, to recommend the duration of trial flows as set out in Treatment Schedule #3.*

8. Trial Flow #2: Evaluation of STP6 (Revised STP5)

Description of Operating Parameters and Performance Measures for STP6

At the last CC meetings, the CC agreed to revising STP5 based on the better information that a completed IFN Study would provide with actual field measurements. The CC was provided with an overview of how STP5 was revised (now called STP6) and a comparison of the performance measures was made to earlier operating alternatives. The following key points of this presentation were referred to during the CC discussion:

- Whereas earlier operating alternatives were evaluated using simulated data, STP6 is based on new data collected on the Coquitlam River for the CBWUP Instream Flow Needs Study.
- STP6, like other "sharing the pain" alternatives, includes both upper and lower target flows.[5]

[4] Increased dam releases over and above the present 2FVC may likely only occur after construction work on the dam is complete. Construction is scheduled for completion by the fall of 2006, but a GVRD representative questioned whether BC Hydro will meet this construction schedule.

[5] "Share the Pain" alternatives were designed by the CC Working Group in the summer of 2002 to provide a target flow nomination to both the river and GVRD on a monthly basis to satisfy optimal conditions where reservoir operations and natural inflows allow such provision. Where reservoir operation deviates from the prescribed operation (i.e. reservoir elevation drops below target reservoir elevation), BC Hydro diversion from Coquitlam Reservoir is the first to be restricted. When the reservoir elevation drops below a target elevation, depending on the priority of the water use, nominations are gradually reduced to the lower targets for both/either GVRD and river flows as needed. (ref: June 2002 CC report, p.42)

- Priority of water use for STP6 is the same for previous STP alternatives, namely that GVRD and fish releases share priority #1 during all months except July, August, and September. For July to September, GVRD is given priority #1 and river releases #2.[6]
- In terms of the original performance measures set out by the CC, STP6 performs better than, or almost the same as, STP5 on almost all performance measures except steelhead spawning habitat. STP6 performs worse than 4FVN on Domestic Water objectives and Power objectives, and better or equal on Fish objectives.

The CC discussed the effect of dry years on performance measures for steelhead rearing (June to September). The percent of maximum steelhead rearing habitat for STP6 during the period June to September is as follows:

Median year: 91%
Driest year (June-September): 87%

Appendix B provides further detail of presentations made to the CC about:

- Rationale for creating a new operating alternative (STP6)
- STP6 operating parameters; and
- Fish, domestic water, and electricity performance measures for STP6 compared to other operating alternatives.

Detail about fish performance measures, provided to the CC by Alf Leake of BC Hydro, is summarized in Appendix C.

Main Discussion Points

CC members raised questions about whether:

- Dam releases can be increased after the flow trial period;
- Target dam releases specified by the FTC for STP6 are adequate for fish;
- "Lower" dam release targets should be removed from STP6.

What if experience indicates that STP6 flows are too low for fish?

Concern was expressed about whether choice of STP6 as the second flow treatment would constrain the upper bound of future fish releases if experience indicates that this is beneficial to fish. It was noted that there is scope within the CBWUP recommendations to increase fish flows after the flow trial period if necessary. CBWUP Recommendations in the June 2002 Consultative Committee Report state that it was "agreed that future flow regimes to the river will not be less than 4 FVN, will not exceed STP5, and that all water allocations within the 4FVN & STP#5 will be on the table for review at that time (after the flow testing program)". [7] This recommendation is unchanged by the proposed change to replace flow trials 4FVN & STP5 **with** a single flow trial of STP6.

Are STP6 target dam releases adequate for fish?

FTC members were asked to comment on whether they felt that STP6 target flows are adequate for fish. The following members of the FTC were present at this meeting: Steve McAdam (WLAP), Ross Neuman (WLAP), Dave Dunkley (GVRD), Dan Sneep (DFO), Janice Jarvis

[6] Where both parties share first priority, both nominations are restricted at the same time when reservoir elevation drops approximately 2 m below the target elevation. (ref: June 2002 CC report, p.43)
[7] CBWUP Report of the Consultative Committee, June 2002, p.xi

(HCSP), Craig Orr (WWSS), and Tony Matahlija (NFSAP-CRWS). Comments from the FTC were as follows:

- All with the exception of Tony Matahlija (North Fraser Salmon Assistance Project-CRWS) supported the upper target dam releases of STP6 as the preferred flow treatment for fish based on existing information. Tony expressed concern with the analysis and preferred, on the basis of his professional experience, to support the original STP5 treatment.
- Concern was expressed about risks associated with low dam releases during the August bottleneck.
- Many members of the FTC noted that they would suggest dropping the lower target dam release during the test period.

Should STP6 include a "low" dam release in addition to the "target" dam release?

A number of CC members expressed concern that in view of revised and lower target dam releases for fish, the second flow trial should always satisfy target dam releases for STP6 and remove the provision for "sharing the pain" (and therefore the lower target flow for the river). This is of particular concern during the summer months.

It was pointed out that:

- STP6 target dam releases through the summer months are less than low dam releases that were specified under the original STP5 treatment.
- GVRD demand from the Coquitlam Reservoir in 2015 is expected to be only slightly higher than at present and by 2007 water filtration facilities for the Capilano and Seymour water sources will be complete providing additional flexibility. For these reasons, GVRD commented that they do not anticipate impacting the upper target dam releases for fish except, perhaps, in extreme circumstances .
- In the unlikely event of a circumstance where there is insufficient water in the reservoir to meet both GVRD and fish releases during the trial period, the lower target releases serve as a safeguard not only for GVRD, but also potentially for fish since they provide important information about flow thresholds, based on the new field data collected during the IFN Study.

Value Trade-offs: Preferences and Uncertainties

CC members were asked to comment on their support for using STP6 as the trial flow. Many expressed an opinion about whether they support the concept of "sharing the pain", that is retaining the lower dam release targets as part of the flow treatment during the test period. Comments are summarized in the table below.

CC Member Comments about STP6

Affiliation	*Keep Lower Dam Release Target for Fish during Flow Trial Period?*	*Comments about STP6 Flow Treatment*
BC Hydro (2 members)	-	Agree that there are significant gains in fish Performance Measures up to the 4FVN flow treatment but not beyond. Yet there are significant costs to BC Hydro of dam releases over 4FVN. Therefore, face a significant struggle in increasing dam releases to anything greater than 4FVN. Prepared to consider doing so in the interests of data collection and of reaching consensus.

Buntzen Ridge Wilderness Recreation and Parks Assoc.	-	Agree with STP6 for fish. Change the name from "share the pain" to "share the gain"
Burke Mountain Naturalists (2 CC members with comments listed separately)	No	Agree with FTC. Concern that target dam releases may be too low for June and July.
		STP6 viewed as unacceptably low dam release for fish.
Coquitlam River Watershed Society	No	Supports STP6 because consensus is valued. Concerned about low flows, particularly during August and during extreme conditions.
Department of Fisheries and Oceans	Yes	Support STP6 for fish. Defer to site-specific empirical data.
Greater Vancouver Regional District (4 members)	Yes	Support for STP6 as a flow trial. Without analysis, GVRD is not prepared to accept STP6 target release without a provision for "sharing the pain" (i.e. "low" target fish releases). In principle, GVRD supports the concept of "sharing the pain" so that water is available to them in the very unlikely event that an extreme event should occur during the trial period. Two GVRD reps stated that targets should be based on the greatest amount of learning during the trial period. It was suggested by two of the GVRD representatives that negotiations would be needed in the event of an extreme event (eg. climatic or contamination of another GVRD resource) so that fish flows are met where possible. ***Noted that it is highly unlikely during the proposed trial period that dam releases would ever fall below target flows even during low flow periods.
Habitat Conservation and Stewardship Program, Maple Ridge – Coquitlam	No	Not present for FTC discussion of STP6 scenario. Concerned about August bottleneck. Prefer to test target dam release for fish and remove lower release target.
Local Individual Residents (3 CC members with comments listed separately)	-	Surprised that preferred fish flow (STP6) is so close to 4FVN, but prepared to concede to opinion of FTC members. Agrees with the statistical power analysis in principle. Problem with the methods used to calculate the GVRD PM's.
	-	Change the word "bottleneck" to "lethal"
	No	Concerned about heavy reliance on IFN Study rather than professional judgment and experience. Raise Aug/Sep flows if possible.
Ministry of Water, Land, and Air Protection	No	Based on information we have, STP6 target release is the best possible outcome for fish. There is still uncertainty about this, but the data used to come up with STP6 is far better to the simulated data that was used to come up with STP5. Prefer to dispense with lower release target for the flow trial period.
North Fraser Salmon Assistance Project – Coquitlam River Watershed Society	No	On the basis of professional experience on the river, this member felt that the higher dam releases of STP5 would be better for fish than the target dam releases developed by the FTC for STP6.
Watershed Watch Salmon Society	No	Agree with STP6 target dam release but not with inclusion of lower release target. Agree that STP6 target is better than original STP5 target.

Steve McAdam, an FTC member and observer at the CC meeting noted that in his opinion STP6 target flows are adequate for fish. He noted that this view is supported by Ron Ptolemy of the FTC.

9.0 Revised CC Recommendations

To take into consideration many CC members concern about the lower target flow in STP6, a suggestion was made to change the priority ranking of fish and domestic water so that fish are given first priority throughout the year rather than from October to June. This suggestion further reduces the probability of dam releases to the river falling below upper target levels during the flow trial period, especially important during the summer months including the August 'bottleneck' period. At the same time this approach addressed GVRD's concern for more certainty in alternatives like the "sharing the pain" concept because they identify an operating condition in the very unlikely event of extreme conditions.

CC members were asked to indicate their level of support for the following operating plan:

- Flow Treatment Schedule #3 with **STP6 modified** to give fish releases first priority throughout the year.[8]
- Lower target flows would be retained as a safeguard for both fish and GVRD;
- A process would be established to notify agencies in the event of exceptionally low water levels when GVRD would need to access Coquitlam water, which are not expected to occur during the trial period even during very dry periods;
- Other recommendations agreed to by the CBWUP CC as laid out in the June 2002 CBWUP Report of the Consultative Committee remain unchanged. In particular, bookends of 4FV and STP5 flows remain in place and learning from the proposed Adaptive Management Program would be applied within these bookends.

19 CC members participated in this ranking exercise.[9]

As in the past, many members stressed their desire to find a common ground and a consensus alternative. ***The CC reached consensus on this flow treatment schedule with nobody blocking the plan, 7 members endorsing it and 12 accepting with reservations – see table (below).***

Of the 12 people who accepted the revised operating plan, the member representing the North Fraser Salmon Assistance Program had strong reservations but in the interest of consensus was prepared to accept the proposed treatment schedule as a flow trial for the duration of this trial period. Based on extensive personal experience of the Coquitlam River, he was concerned that the proposed target flows in STP6 rely too heavily on IFN data and are too low for fish.

BC Hydro's corporate representatives accepted with reservations the revised CC recommendations with two caveats:

1. That the financial impacts of prioritizing fish first throughout the year does not have significant cost implications, and

2. That the proposed treatment schedule for the proposed dam safety work was realistic (scheduled to be completed in 2006)

<u>Post Meeting Note 1</u>
BC Hydro's Corporate Representatives reviewed the financial implications of prioritizing STP6 flows for fish first throughout the year, followed by GVRD withdrawals, with energy needs last and as a result have removed the financial caveat placed on the STP6 flow trial recommendation.

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[8] The "Share the Pain" alternatives were designed by the CC Working Group to provide a target flow nomination to both the river and GVRD on a monthly basis to satisfy optimal conditions where reservoir operations allow such provision. Where reservoir operation deviate from the prescribed operation (i.e. reservoir elevation drops below target reservoir elevation), BC Hydro diversion from Coquitlam Reservoir is the first to be restricted. When the reservoir elevation drops further than a target elevation, depending on the priority of the water use, nominations are gradually reduced to the lower targets for both/either GVRD and river flows as needed.

[9] The member for PoCo Hunting and Fishing Club (one of the 19) participated by proxy. Members for the Buntzen Ridge Wilderness Recreation and Parks Association and for the Port Moody Ecological Society left the meeting before this ranking exercise.

Post Meeting Note 2
BC Hydro's Corporate Representatives provided more clarification with regards to the dam safety caveat as follows:

> **Increased dam releases over and above the present 2FVC can only occur after construction work on the dam is complete or advanced to a stage that the current reservoir operating constraints can be removed and the reservoir returned to full operating range.**

Reservations expressed during the meeting by other Committee members remain the same as those noted in the comments about STP6 (tabulated on page 11 of these minutes). In addition, members who wished to explain their reservations were invited to submit written comments for inclusion in the minutes. The following submissions were received:

Post Meeting Note 3
Submission by: Don Gillespie (Burke Mountain Naturalists), April 3, 2003

On March 31st we voted to accept the STP6 flow regime. At that time some of us voted "accept with reservations".

The reservations I have are that:
1) Although the flow quantity is considered sufficient to achieve 80 to 100 % of maximum usable area (habitat) it takes no account of either temperature or the likely influence of urbanization and sediment influx that are known to plague the Coquitlam river. The resulting target flow regime is only 14 % of the mean annual discharge.

2) The water use plan effectively directs most of the water to the GVRD resulting in power production losses compared to the present flow regime. The GVRD water requirements result from wasteful use and misuse of a precious resource that is not properly valued. The lost clean hydroelectric power production will be made up for by increased consumption of fossil fuels in thermal electric power plants.

Post Meeting Note 4
Submission by: Dr. Don Gillespie (Local Resident), April 11, 2003

1. The proposed flows might be sufficient for fish populations but probably not for other forms of wildlife that use the river corridor.
2. The proposed flows, 14% of m.a.d., will result in a lack of flushing and therefore the river, down stream of the gravel operations, will remain severely compromised.
3. Water conservation remains a low and unacceptable priority for G.V.W.D.

Level of Support for Proposed Treatment Schedule #3 (with STP6)

Affiliation	Accept w/ Reservations	Endorse
BC Hydro (2 members)	X	
Buntzen Ridge Wilderness Recreation and Parks Assoc.	na*	na*
Burke Mountain Naturalists (2 members)	X	
Coquitlam River Watershed Society	X	
Department of Fisheries and Oceans		X
Greater Vancouver Regional District (4 members)		X
Habitat Conservation and Stewardship Program (HCSP), Maple Ridge – Coquitlam	X	
Local Individual Residents (3 members)	X	
Local Individual Residents (1 member)		X
Ministry of Water, Land, and Air Protection		X
North Fraser Salmon Assistance Project – Coquitlam River Watershed Society	X	
PoCo Hunting and Fishing Club **	X	
Port Moody Ecological Society	Na*	Na*
Watershed Watch Salmon Society	X	
Note: There is one CC member per organization unless otherwise indicated. * CC representative left prior to this discussion ** Decision by proxy (HCSP representative)		

10.0 Next Steps

1. CC members were invited to email comments explaining their reservations to EcoPlan for inclusion with the minutes.
2. CC members would be given an opportunity to review the minutes of this meeting.
3. A summary addendum and the minutes from the March 31, 2003 CC meeting will be provided to the Comptroller as part of the June 2002 CBWUP: Report of the Consultative Committee.

The meeting ended at approximately 11:15 p.m.

Appendix A
Facilitator's Review of the October 22, 2001 and March 11, 2002 CC Meetings

CC Evaluation of Proposed Operating Alternatives – Oct 22, 2001

- Of the six alternatives presented at the final trade-off meeting, every one was "Blocked" by more than one member
- The CC focused on 2 alternatives—4FVN and STP5—to try and remove "Blocks"
- Many members stressed a desire to find common ground and a consensus alternative
- The majority of CC members cited two primary reasons for the "Blocks":
    1. the alternative did not satisfy fish objectives well enough (4FVN, STP4)
    2. the alternative had too much uncertainty surrounding actual benefits to fish (STP4, STP5)
- Certainty was also valued highly by GVRD and BC Hydro planning and operation purposes
- Members acknowledged that there was a high degree of uncertainty and this could be address through completion of the IFN study and long-term field-testing.

Consensus Agreement – Adaptive Management Program

- Consensus agreement was reached based on an adaptive management program, or monitoring plan, with two flow trials in a 15 year period:
    1) Test Flow #1: 4FVN
    2) Test Flow #2: STP5 or less (based on results of the IFN Study)
    3) Both flow trials to be completed within 15 years from Oct. 22, 2001

Goal of the Agreement

- The goal of the Adaptive Management Program is to ensure that there is sufficient information in place by the end of the 15 yr review period to determine the fisheries benefits of two test flows and to enable a better understanding of trade-offs between fisheries, domestic water and power generation.
- ***This would allow a future consultative committee to make more informed trade-offs when determining a river flow regime.***

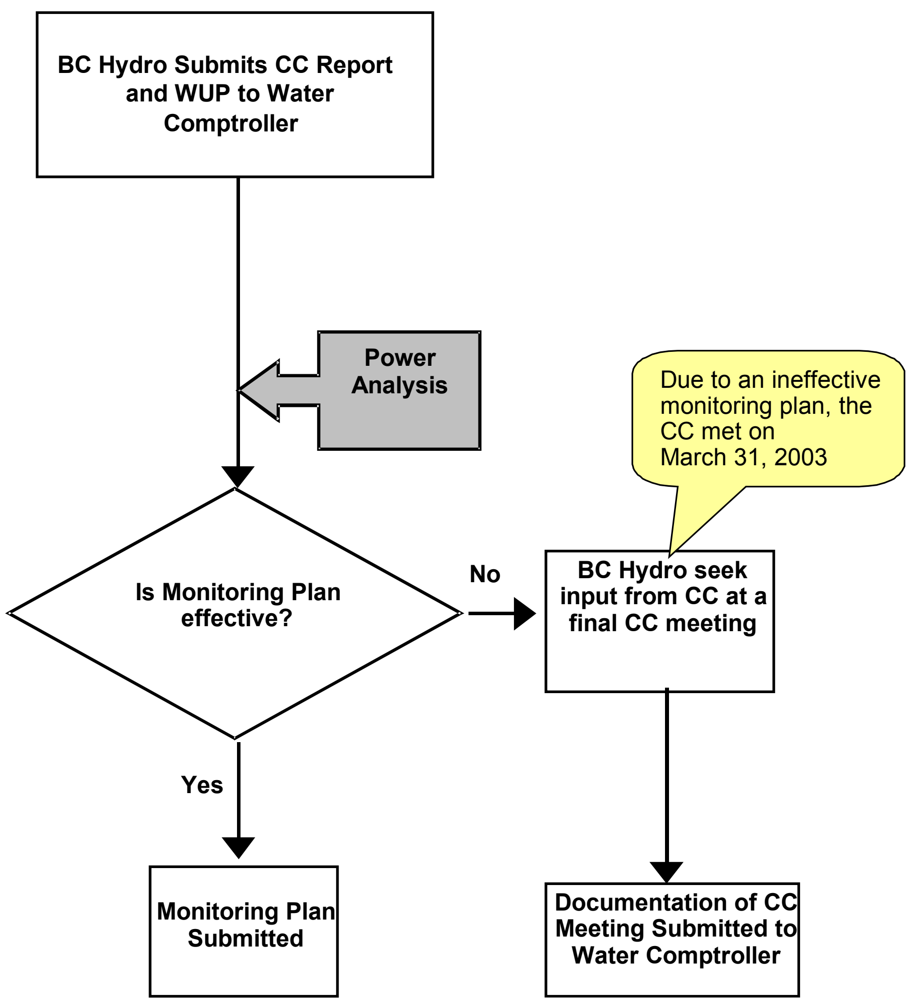
Triggering Event that would re-open the Coquitlam-Buntzen WUP and require a final meeting

- Because the purpose of the monitoring plan is to provide information to better understand trade-offs after 15 years, the CC required the monitoring plan be *effective* enough that quality information will result from the monitoring plan.
- *"Effective"* was defined as being cost effective and having sufficient statistical power to distinguish between the two flow trials.

- To measure effectiveness, a statistical power analysis was done.
- The FTC would review the power analysis as to its *"effectiveness"*.
- If an **"effective"** monitoring plan could not be crafted within the spirit of the original Adaptive Management Agreement, the CC would be reconvened for one final meeting.
- The proceedings from this meeting (now scheduled for March 31, 2003) would be forwarded to the Water Comptroller

This process is shown in the decision tree below.

Process for CC Submissions to Water Comptroller



Appendix B
STP6: Operating Parameters and Performance Measure Calculations

Why revise STP5?

- Based on the CC's Consensus Agreement, STP5 was to be revised with the completed *Instream Flow Needs (IFN) Study*
- The *IFN Study* measures how much fish habitat there is for any given flow down the river.
- The completed *IFN Study* was to replace the simulated data with field surveys
- All the field data for the most important reaches of the Coquitlam River have now been collected.
- Results from the IFN study were used to revise the habitat suitability curves (based on the identified drivers: Steelhead Parr, Steelhead Spawning, Chinook and Coho Spawning and Incubation); the old suitability curves formed the basis of the monthly flow targets for fish in the original STP5 alternative. New habitat suitability curves were presented to the CC and are included in Appendix C of the minutes.

Operating parameters of the FTC's Revised STP5 (New STP6) Alternative

- In some cases the revised monthly fish flow targets increased (as was the case in the wintertime to better meet Chinook spawning requirements), but in general fish flow targets decreased as a result of lower summer flows required for Steelhead Parr (rearing). The ***Revised STP5*** (now known as ***STP6***) upper and lower flow targets are summarized in the following table (the original STP5 alternative is included for comparison).
- The volume of water for STP6 (that will be discharged from the dam downstream to the Coquitlam River) is roughly halfway between the 4FVN and the old STP5.
- The monthly flow targets for domestic water are unchanged in STP6 and the priorities for the upper and lower flow targets between fish and domestic water are also unchanged.

	STP5		New STP6	
	Dam Releases		*Dam Releases*	
	STP5 Target	STP5 Low	STP6 Target	STP6 Low
Jan 1-15	3.30	3.00	5.90	3.60
Jan 15-31			2.92	2.92
Feb	2.90	2.90	2.92	2.92
Mar	7.60	3.00	4.25	1.77
Apr	6.90	3.00	3.50	1.10
May	6.30	3.00	2.91	1.10
Jun	5.00	4.00	1.10	1.10
Jul	4.60	4.00	1.20	1.10
Aug	6.10	4.00	2.70	1.10
Sep	5.60	4.00	2.22	1.10
Oct	3.00	3.00	6.07	3.59
Nov	3.00	3.00	3.96	1.49
Dec	3.00	3.00	5.00	2.51

* Note all the monthly flow targets above are in cubic metres per second

- In STP6 the upper flow targets were based on providing enough flow to meet benchmark areas (set by the FTC) based on a percentage of the maximum useable habitat. For Chinook/Coho drivers (Oct to Feb), upper flow targets were based on achieving 90% of the maximum useable area and the lower target was based on 80% of the maximum. For Steelhead Spawning (Mar to May) the upper target was based on 95% and the lower was based on 80% of the maximum possible values or at least a minimum flow of 1.1cms. For Steelhead Parr (June to Sep) the upper target flows were based on meeting 100% of the optimal useable habitat area and the lower flows were based on the greater of 95% of the maximum or a minimum flow of 1.1cms.

Model Output and PM Calculations

As indicated above, STP5 was revised (and is now called STP6) based on the results of the IFN study results, as agreed to at the final CC meeting in March 2002. Performance measures were calculated for the revised alternative and are shown below in the Objectives by Alternatives Matrix on the next page. Previously evaluated alternatives (2FV Current Agreement; 4FVN; STP5) and their calculated performance measures are shown as well.

Note that the fish performance measures are shown as “Percent of Maximum Available Habitat” rather than “Weighted Useable Area”.

Summary - As indicated in the Objectives by Alternatives Matrix, STP6 performs better than, or almost the same as, STP5 on almost all performance measures except steelhead spawning habitat. STP6 performs worse than 4FVN on Domestic Water objectives and Power objectives, and better or equal on Fish objectives.

Summary for Original PMs^: OBJECTIVES BY ALTERNATIVES MATRIX FOR COQUITLAM-BUNTZEN WATER USE PLAN

Note: This matrix includes CBWUP objectives experiencing the Greatest change. Not shown are flood, industry, recreation, and Wildlife/Environment PMs because they change little under the different flow regimes. Reservoir measure for fisheries is also not shown because it varies little with exception of extreme alternatives (eg. ESOR) and current operating agreement (2 Fish valves and current GVRD agreement).

			Alternatives			
Objective	**Performance Measure**	**Units** (Over 39 year model period)	**2 Fish Valves**	**4 Fish Valves 10-12%MAD Optimized**	**(STP 5) Sharing The Pain #5**	**(STP5 REVISED) Sharing The Pain #6**
			Current Agreement	**GVRD Proposed Agmnt. # 1**	**Fish & GVRD Proposed Agmnt # 1**	**Fish & GVRD Proposed Agmnt # 1**
Domestic Water	Annual average water allocation	cmsd (median)	7.88	14.31	13.84	14.05
	GVRD maximum nomination not satisfied per year	# of days (39 year median)	0	0	91	51
	GVRD minimum nomination not satisfied per year**	# of days (39 year median)	0	0	0	0
	GVRD Annualized Capital Costs for New Water Source	$ in million	$6.34	$2.60	$4.50	$2.60
Fish (River)^^	Steelhead Parr (rearing habitat)	Percent of Maximum Available Habitat	93%	90%	86%	91%
	Steelhead Spawning habitat	Percent of Maximum Available Habitat	58%	68%	76%	68%
	Salmon Spawning habitat	Percent of Maximum Available Habitat	55%	61%	70%	73%
	Coho Spawning Habitat	Percent of Maximum Available Habitat	72%	78%	82%	81%
Hydroelectric	Annual total power production	GWh - annual total (39 year average)	125	60	48	54
	Annual total power production and GVRD payments^^^	$ in millions - annual total 39 year average	$9.40	$8.03	$7.22	$7.69
Driest Year Results						
Domestic Water	Annual average water allocation	cmsd (median)	7.88	11.6	11.2	12.1
	GVRD *maximum* nomination not satisfied per year	# of days (driest year of 39)	0	57	317	318
	GVRD *minimum* nomination not satisfied per year**		0	55	80	44
Fish	Steelhead Parr (rearing habitat)	Percent of Maximum Available Habitat	87%	86%	80%	87%
Hydroelectric	Annual total power production	GWh - annual total (driest year of 39)	50.30	1.87	0.00	2.57

** Minimum nominations as agreed to at Working Group meeting on July 19, 2002 -- *Not* WSRP minimum nominations

^ Original PMs are those used before summer 2001 Working Group meetings.

^^ Steelhead parr is an indicatior for salmon rearing requirements. FTC did not feel that one measure for spawning could be developed.

^^^ This does not include capital costs to upgrade the LLO. These are expected to be approximately $310,000.

Appendix C
BC Hydro Presentation of Revised Fish Performance Measures

Water Use Planning

Coquitlam/Buntzen CC Meeting

March 31, 2003

Fish PM Information Summary

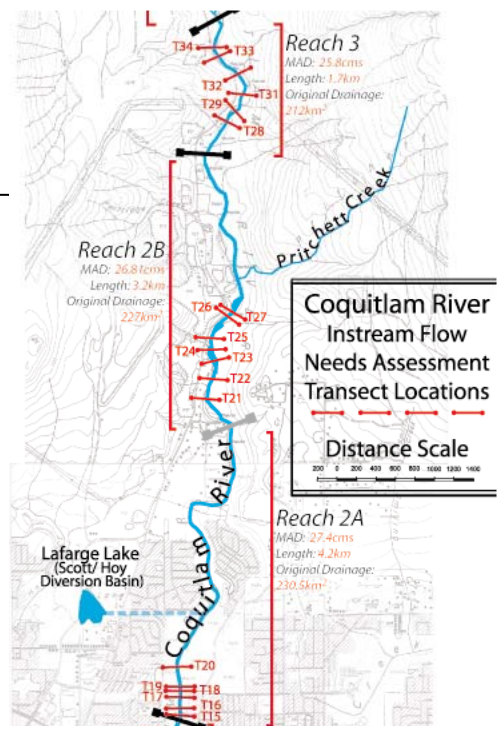
PM Descriptions

- What's Changed?
  - Empirically-derived habitat relationship with flow for R2-3
  - Habitat PMs - Percent of Maximum Available Habitat instead of Habitat Area
  - Coho Habitat PM instead of Invertebrate PM

Transect Results

Section	NMAD (cms)	HabNo
R2a	27.38	T15
		T18
		T19
		T20
R2b	26.81	T21
		T22
		T23
		T25
		T27
R3	25.82	T31
		T32
		T33
		T34

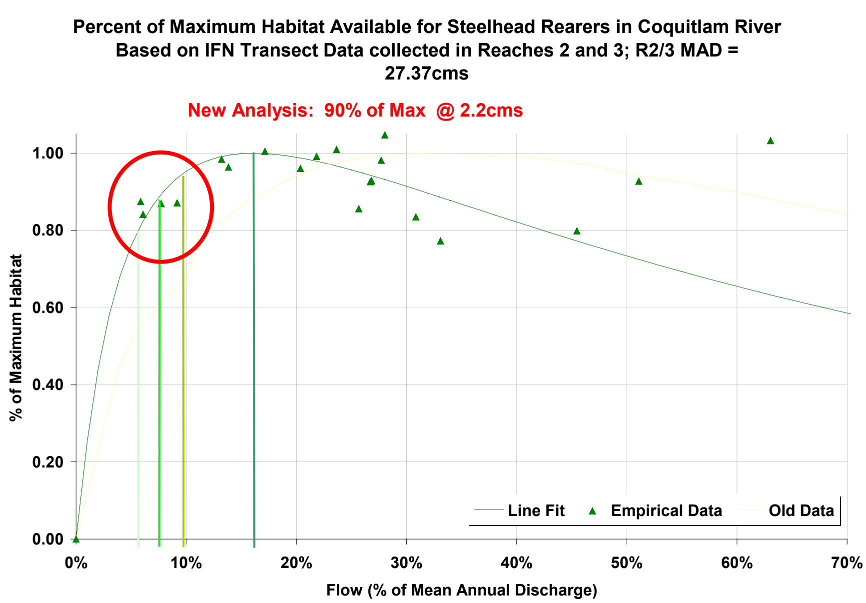
Spawning Transects
Rearing Transects



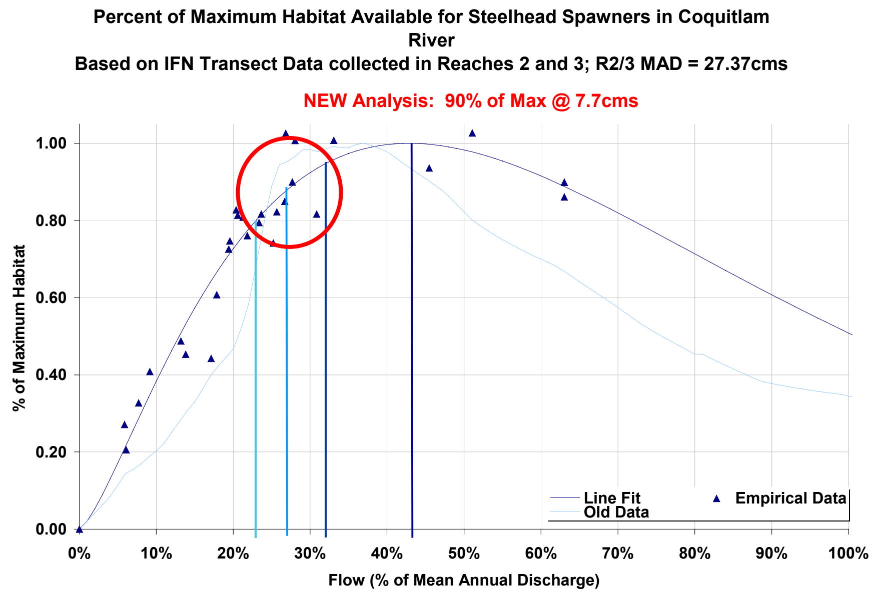
POM PM Descriptions

- Percent of Maximum (POM) Habitat
  - Develop habitat flow relationship from empirical data, using Percent Usable Width
  - Divide flow-habitat values by the maximum described in the relationship

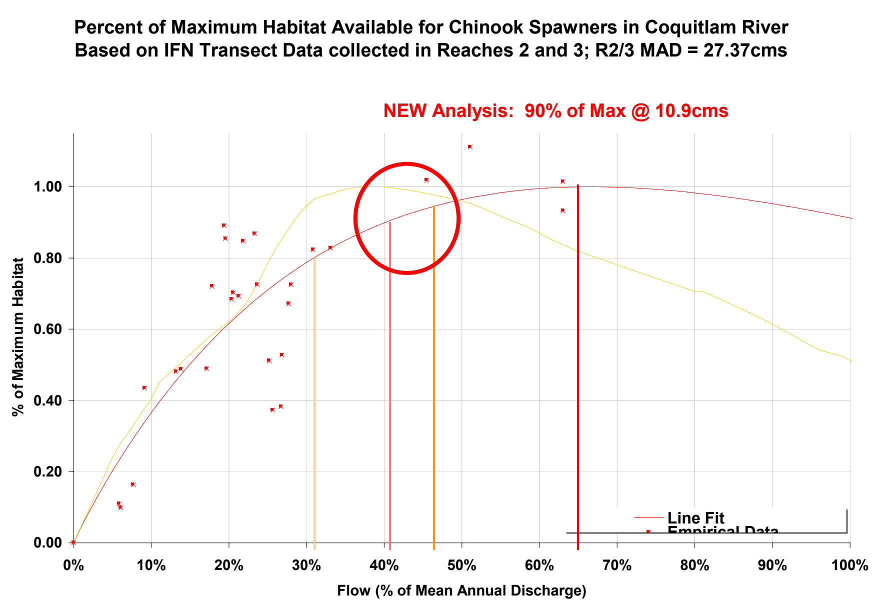
Transect Results (ST Parr)

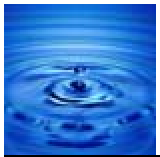


Transect Results (ST Spawning)

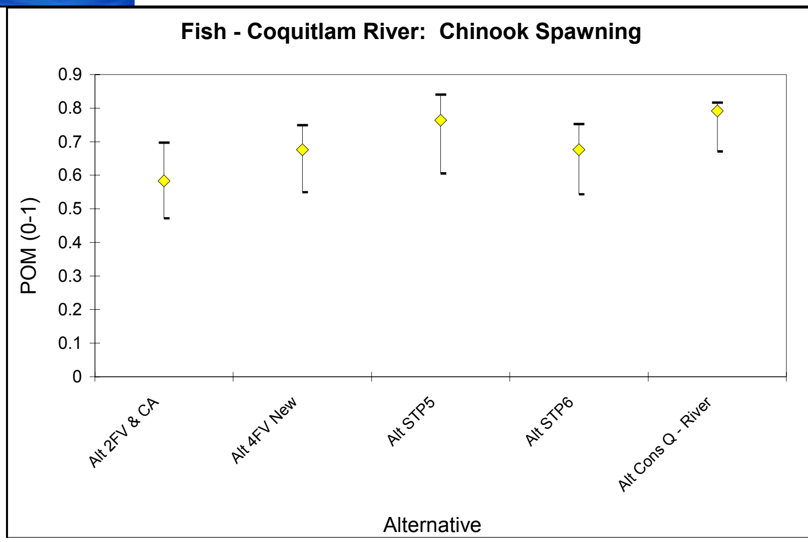


Transect Results (CH Spawning)

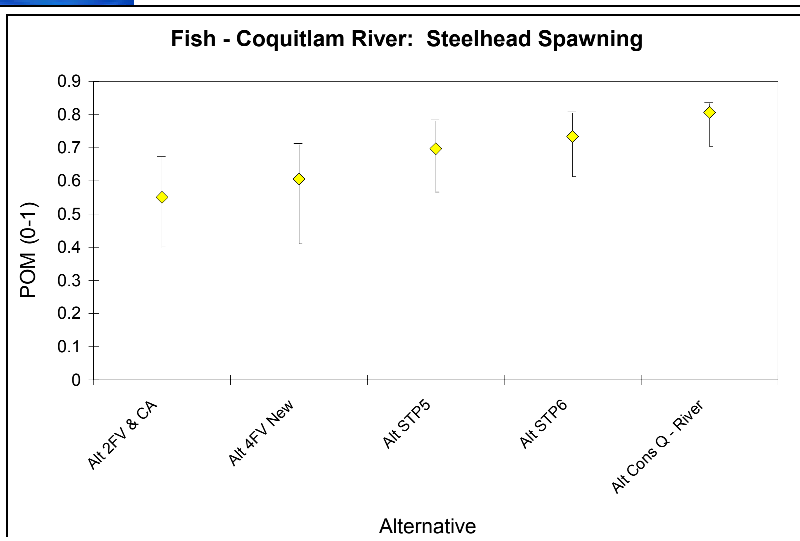




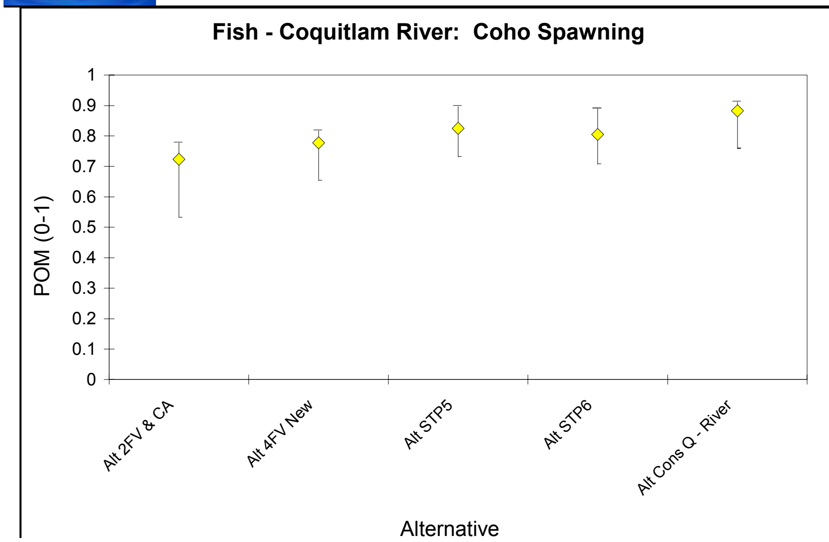
POM PM Results - CH Spawning



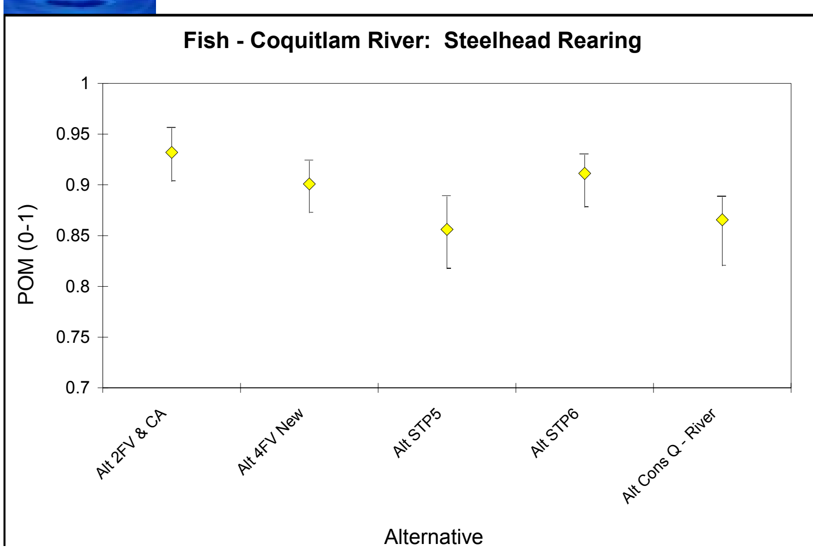
POM PM Results: ST Spawning



POM PM Results: CO Spawning



POM PM Results: ST Parr



Appendix DD CC Member Written Submissions

The following comments were received by CC members in response to the draft version of this document—*Addendum to the Report of the Consultative Committee*—which was distributed on May 1st, 2003.

Submission #1: Stan Woods (CC member – GVRD representative)

From: Stan Woods
Sent: 2003, June 27 5:52 PM
To: 'Fryer, Patricia'
Subject: Draft Addendum to the Coquitlam Buntzen CC Report

Here are my comments on the draft addendum document distributed in your memo dated 10 June, 2003. I note that Appendix 3 - the IFN Report was not provided and we should have an opportunity to comment on this before the CC's Submission is finalized.

It would also be helpful to see the separate submissions from other cc members, specifically the submission referred to in (b) on the bottom of page 19 with the statement "the low priority of conservation efforts by the GVRD". The GVRD does not agree with this statement and would like to understand what information was considered by the person who made this submission.

The text on page 22, A8 Review period relating to the first trigger to re-open the WUP should be modified to "If fish passage over the dam into the reservoir is found to be technically feasible" **and no impact to the quality of drinking water can be assured**.

The text in bold and underlined above is very important to the GVRD. The potential impacts on drinking water quality of improving fish passage over the dam needs to be carefully assessed as part of the feasibility assessment.

Hope these comments are helpful.

Stan Woods, P.Eng.
Senior Engineer
Regional Utility Planning
Policy & Planning Department
Greater Vancouver Regional District

Submission #2: Elaine Golds (CC member)

From: Elaine Golds
Sent: 2003, June 30 12:51 AM
To: Fryer, Patricia
Subject: Re: comments on Coquitlam Buntzen WUP Addendum

Hi

These are my comments on the addendum:

I am very concerned that the addendum makes no mention of the fact that CC members have not yet had an opportunity to review the IFN study which, in great part, formed the basis of our somewhat reluctant decision to support STP6 at our last CC meeting. I am further disturbed by the use of the adjective "completed" which is consistently used to describe this report. Anyone reading the addendum would mistakenly surmise that CC members had received the IFN report to review and were familiar with its contents well in advance of making a decision on flow agreements.

In fact, the last meeting of the CC was a good example of how not to conduct public consultation given that we were asked to make an immediate decision on the basis of data taken from a report which we had not seen. At that meeting, limited data from the IFN report was "floated" before our eyes for a few minutes but most people did not even receive a copy of the critical figure presented. The IFN report apparently shows that less water in the river (low summer flows) will be better for fish - a finding which seems illogical. At our last CC meeting, we were asked to take the results of the IFN study essentially on faith. This accounts, I feel, for the large number of CC members who could only accept STP6 "with reservation".

I was furthermore taken aback when I received the addendum package for comment with, still, no IFN study. I was looking forward to finally having an opportunity to learn why less water in the river is better for fish. The IFN study has still not appeared yet the June 30 deadline for getting comments back to you has arrived. I feel this is really unacceptable.

Therefore, I request that it be made very clear in the addendum that the CC were asked to make a decision without having had an opportunity to read the IFN study. On page iv, it is stated that the IFN study was a "key aspect" of the decision making process. This is true - therefore, it must also be made clear that members of the CC were not given an opportunity to read and reflect upon the IFN study prior to making a decision. We took a lot on "faith" at that last CC meeting...the addendum should accurately reflect that.

It seems a shame that, despite the 23 CC meetings over what is now almost a 4 year period, the final process to reach such a critical agreement was so rushed that a decision was forced from the CC before a key report was distributed for everyone's perusal.

So many meetings, so much good pizza, so why was I left with a bad taste in my mouth?
Regards.
Elaine

Submission #3: Ian McArthur (CC member)

From: Ian McArthur
Sent: 2003, June 30 7:02 AM
To: Fryer, Patricia
Subject: Re: comments on Coquitlam Buntzen WUP Addendum

Hi Patricia,

I would have to agree with Elaine very strongly on her comments below.

Ian McArthur

Submission #4: Joe Pauker (CC member)

From: J. Pauker
Sent: 2003, June 30 11:08 PM
To: pat.fryer@bchydro.com
Subject: Coquitlam-Buntzen Wup

June 30, 2003
Re: Draft meeting minutes March 31, 2003 and your letter of June 10, 2003.

1.) At the meeting of March 31 it was not immediately apparent at first glance that an innocuous looking label STP6 was so drastically different than STP5. The water flows from Mar. to Sept. were so much lower in both target and low flows, from as low as two times to a high of six times less. Most of the flows were in some months that had been declared lethal for salmon and steelhead survival. It seems studies have been massaged since March 11 to provide the results to supply as little for fish as possible. The lack of water volume and quality has already proven that salmon will not survive during some of the low periods.

2.) The" Share The Pain" method is invalid. Using the value of the costs to GVRD and BC HYDRO to provide a programme for fish rehabilitation is invalid. BC HYDRO and GVRD are not solely to blame for the existing degradation of the Coquitlam River. The Municipal, Provincial and Federal governments have been fully responsible for control of the Coquitlam River since Europeans have arrived in this area. The money eventually comes from the general population via the various taxes fees anyway.

3.) Any studies to date are suspect. The sewer and drainage systems are not adequate for the existing and growing population to provide a standard quality or volume for the river to complete reliable studies (i.e. such as blue water last week in the upper reaches of the Coquitlam River.)

4.) If our Federal Government carries on with the WTO proposed agreements on water, we will not have any say in the use of our own water. NAFTA was signed by the Federal Government without full public consultation of the ramifications of the agreement. The B.C. Government may still privatize BC Hydro.

Have a good day.

Sincerely Joe Pauker.