BC hydro

Stave River Project Water Use Plan

Monitoring Programs Annual Report: 2007

- **Pelagic Monitor (Nutrient Load/Total Carbon Levels)**
- **Littoral Productivity Assessment**
- **Fish Biomass Assessment**
- **Limited Block Load as Deterrent to Spawning**
- **Risk of Adult Stranding**
- **Risk of Fry Stranding**
- **Diel Pattern of Fry Out-migration**
- **Seasonal Timing and Assemblage of Resident Fish**
- **Turbidity Levels in Hayward Reservoir**

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BC Hydro Stave River Project Water Use Plan Monitoring Programs Annual Report: 2006

1 Introduction

This document represents a summary of the status and the results of the Stave River Water Use Plan (WUP) monitoring programs to 30 June 2007, as per the Stave River Order under the *Water Act*, dated 6 May 2004. There are nine monitoring programs:

- Pelagic Monitor (Nutrient Load/Total Carbon Levels)
- Littoral Productivity Assessment
- Fish Biomass Assessment
- Limited Block Load as Deterrent to Spawning
- Risk of Adult Stranding
- Risk of Fry Stranding
- Diel Pattern of Fry Out-migration
- Seasonal Timing and Assemblage of Resident Fish
- Turbidity Levels in Hayward Lake Reservoir

2 Background

The water use planning process for BC Hydro's Stave River project was initiated in September 1997 and completed in October 1999. The conditions proposed in the WUP for the operation of the project reflect the October 1999 recommendations of the Stave River WUP Consultative Committee.

In November 1999, the Stave River WUP was submitted to the Comptroller of Water Rights (Comptroller).

On 6 May 2004, BC Hydro was ordered to implement the conditions proposed in the Stave River WUP and prepare the monitoring programs terms of reference (TOR).

On 10 June 2005, the Stave River WUP monitoring programs TOR were submitted to the Comptroller for review and approval. On 30 June 2005, the TOR for all monitoring programs were accepted by the Comptroller.

On 11 January 2007, a revised Fish Biomass Assessment TOR was submitted based on minor budget and methodology revisions. On 7 February 2007, the TOR revisions were accepted by the Comptroller.

As outlined in the Stave River WUP, a review of this WUP is recommended within ten years of its implementation. A review may be triggered sooner if significant risks are identified that could result in a recommendation to change operations.

Some components of the Stave River WUP monitoring programs were initiated prior to acceptance by the Comptroller. Given this prior work pre-dates the TOR development and the Comptroller's acceptance, it is considered to be outside the

present WUP monitoring programs framework. Consequently, this work will not be subject to annual reporting, though the results will be fully integrated into the present programs, including implications on the interpretation of all new monitoring data.

3 Status

The following table outlines the status and schedule for the Stave River WUP monitoring programs.

Table 3-1: Status and Schedule of Stave River WUP Monitoring Programs Implementation

Monitoring Program	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	WLR YR1	WLR YR2	WLR YR3	WLR YR4	WLR YR5	WLR YR6	WLR YR7	WLR YR8	WLR YR9	WLR YR10
Pelagic Monitor (Nutrient Load/Total Carbon Levels)	✓	✓	U/W	■	■	■	■	■	■	■
Littoral Productivity Assessment	✓	✓	U/W	■	■	■	■	■	■	■
Fish Biomass Assessment	✓	✓	■	■	■	■	■	■	■	■
Limited Block Load as Deterrent to Spawning	×	✓	U/W	■	■	■	■	■	■	■
Risk of Adult Stranding		✓								
Risk of Fry Stranding		×	×	■	■					
Diel Pattern of Fry Out-migration				■	■					
Seasonal Timing and Assemblage of Resident Fish						■	■			
Turbidity Levels in Hayward Reservoir	✓	✓	U/W	■	■	■	■	■	■	■

Legend: ✓ = Project is complete for the year
■ = Project to be undertaken/initiated in identified year
U/W = Project is underway
× = Program started, but encountered operational or hydrological delays

4 Stave River WUP Monitoring Programs

This section outlines the status of the Stave River WUP monitoring programs as per the Order under the *Water Act,* dated 6 May 2004.

4.1 Pelagic Monitor (Nutrient Load/Total Carbon Levels)

4.1.1 Overview

The objective of this monitoring program is to determine the principle pathways and assess the extent to which reservoir management actions affect pelagic productivity in Stave Lake and/or Hayward Lake Reservoirs. During the Stave River water use planning process, the Consultative Committee assumed that the pelagic zone of the reservoirs were immune to operations, but noted that there was considerable risk in doing so and recommended that a monitoring program be carried out to assess the assumption's validity.

A direct test of the assumption proved to be difficult and costly. As a result, the Consultative Committee recommended that the monitoring program be carried out through a weight of evidence approach where a series of impact hypotheses are tested to identify the most likely pathway(s) of principle influence by deduction.

Monitoring Indicators:
a) Water Quality – Physical Variables.
b) Water Quality – Chemical.
c) Plankton.

d) Carbon Estimate of Primary Production.

This monitoring program involves collection of data up to eight times per year at two or more locations, and in some cases at several depths.

4.1.2 Status

This monitoring program will be implemented in two phases. The first phase was completed in April 2004, prior to Comptroller acceptance of the TOR, and therefore is not subject to the same reporting requirements as the present monitoring program.

Year two of the second phase of this monitoring program was initiated in April 2006 and was carried out over seven months. The field component ended in November 2006 and the Stave Reservoir Pelagic Monitor and Littoral Productivity Assessment report was completed in June 2007. Results were presented to the Stave Monitoring Advisory Committee in June 2007. Year three of the second phase of this monitoring program is currently underway.

4.1.3 Interpretation of Data

Several conclusions were drawn from the phase one work:

- Nutrient levels (total phophorus, phosphate, and nitrate) are extremely low and characteristic of an ultra-oligotrophic state.
- Light penetration is high, as reflected in the high light extinction coefficients, which is indicative of low productivity in the reservoir.
- Bacteria and pico-cyanobacteria densities were very low (7000-9000 cells/L compared to 35,000 to 65,000 cells/L for coastal BC Lakes.
- Phytoplankton communities were sparse, consisting mainly of small opportunistic species well adapted to low nutrient environments.
- Zooplankton populations were equally sparse with a seasonal average density of 0.5 individuals/L and a biomass of 4 µg/L. All were small in size and generally immature nauplii. There was little grazable food for fish.
- Pelagic primary production was estimated at 9.8 $mgC/m^2/d$ for Stave Lake Reservoir and 10.6 $mgC/m^2/d$ for Hayward Lake Reservoir, both of which are considered to be very low compared to other coastal BC Lakes.
- Primary production was dominated by pico- and nano- sized cells.

Upcoming phase two year three reporting will attempt to establish trends in data collected since the initiation of phase one in 2001 in particular looking at the relationships between environmental variables and reservoir operations.

Littoral Productivity Assessment

4.1.4 Overview

The objective of this monitoring program is to test the validity of the Effective Littoral Zone (ELZ) performance measure used in the Stave River water use planning process and, in turn, use the results to determine the nature and extent of reservoir operations impacts on littoral productivity. Like the pelagic monitoring program, this monitoring program uses a set of impact hypotheses to evaluate the range of possible impact pathways in a weight of evidence approach. The program also takes advantage of the relatively stable operation on Hayward Lake Reservoir as a comparative control for evaluating the effects of water level fluctuations on Stave Lake Reservoir.

Monitoring Indicators:

a) Periphyton.
b) Littoral primary production.
c) Carbon Estimate of Primary Production.

The water quality data and primary production estimates of the Pelagic Monitor are used in this monitoring program.

This monitoring program involves collection of data up to eight times per year at two or more locations, in most cases at several depths (2 m intervals).

4.1.5 Status

This monitoring program will be implemented in two phases. The first phase was completed in April 2004, prior to Comptroller acceptance of the TOR, and therefore is not subject to the same reporting requirements as the present monitoring program.

Year two of the second phase of this monitoring program was initiated in April 2006 and was carried out over seven months. The field component ended in November 2006 and the Stave Reservoir Pelagic Monitor and Littoral Productivity Assessment report was completed in June 2007. Results were presented to the Stave Monitoring Advisory Committee in June 2007.Year three of the second phase of this monitoring program is currently underway.

4.1.6 Interpretation of Data

Several conclusions were drawn from the phase one work:

- Pattern of littoral productivity as a function of shoreline elevation, along with the differences between Stave Lake and Hayward Lake reservoirs, were consistent with the ELZ performance measure predictions, though no attempt was made to directly test the validity of the measure. This aspect of the work remains incomplete.

- Littoral productivity in Stave Lake Reservoir averaged 5.3 $mgC/m^2/yr$ for the three year duration of the monitor, littoral productivity in Hayward Lake Reservoir averaged 12.3 $mgC/m^2/yr$.

- Littoral production was estimated to account for 5% of the total Stave Lake Reservoir primary production and 50% of the total Hayward Lake Reservoir production. The difference appears to reflect the more riverine state of Hayward Lake Reservoir, though there were a number of confounding factors that introduced some uncertainty in this conclusion.

- Hayward Lake Reservoir tends to be about 1°C warmer than Stave Lake Reservoir and does not thermally stratify during the summer months.

- Hayward Lake Reservoir tends to have slightly higher nutrient levels than Stave Lake Reservoir.

- There were no apparent differences in light penetration between the two reservoirs, though this may be the result of the low sampling frequency (turbidity events tend to be short in duration and occur sporadically).

Upcoming phase two year three reporting will attempt to establish trends in data collected since the initiation of phase one in 2001 in particular looking at the relationships between environmental variables and reservoir operations.

4.2 Fish Biomass Assessment

4.2.1 Overview

The objective of this monitoring program is to determine whether an increase in fish biomass occurs in Stave Lake Reservoir following implementation of the WUP, as was predicted from performance measure modelling. Considerable uncertainty was expressed by the Consultative Committee regarding this outcome: Some Committee members believed that the potential was great and that further gains in fish biomass were possible with greater constraint on reservoir operations. Other Committee members believed that the likelihood of an observable effect is low and that further attempts to constrain the reservoir would likely lead to a negligible response in fish biomass at great financial cost. To resolve the uncertainty, the Consultative Committee recommended that a monitoring program be carried out with the recommended WUP constraints operations, which are expected to partially reduce reservoir fluctuation in Stave Lake Reservoir.

Monitoring Indicator: a) Total relative fish biomass.

This monitoring program involves hydro-acoustic surveys and fish surveys.

4.2.2 Status

The second year of data collection was initiated in September 2006, carried out over several weeks and successfully completed in October 2006. The Stave Reservoir Fish Biomass Assessment report was completed in February 2007. Results of the monitoring program were presented to the Stave Monitoring Advisory Committee in June 2007. Year three of this monitoring program is scheduled for initiation in October 2007.

4.2.3 Interpretation of Data

Total fish biomass in Stave Lake Reservoir was estimated at 10.1 kg/ha in year one and 17.2 kg/ha in year two accounting for a 70% change. The increase appears to be partially related to the location of additional transects during the 2006 study. The time trend is too short to allow trend analysis.

The major species contribution of the biomass were as follows:

	Year 1	**Year 2**
Cutthroat trout	0.4 kg/ha	0.6 kg/ha
Dolly Varden	6.9 kg/ha	12 kg/ha
Kokanee	1.3 kg/ha	1.8 kg/ha
Rainbow trout	0.03 kg/ha	0.05 kg/ha
Peamouth chub	0.04 kg/ha	0.05 kg/ha

Monitoring program results were consistent with the reconnaissance data of prior fish surveys in Stave Lake Reservoir, and are in line with that of other oligotrophic lakes and reservoirs.

4.3 Limited Block Load as Deterrent to Spawning

4.3.1 Overview

The objective of this monitoring program is to verify the assumption made by the Stave River WUP Consultative Committee that a fall limited block loading operation (allowance for annual peaking operations from 15 October to 30 November when discharge at Ruskin Dam exceeds 100 m^3/s) deters salmonid spawners from spawning high on the stream banks, which typically dewater during the incubation period causing significant egg mortality. The proposed operation is expected to increased operational flexibility at the Ruskin generating facility while significantly reduced egg mortality, and hence increase smolt output. The Stave River WUP Consultative Committee recommended that a monitoring program be carried out to ensure that the hypothesised benefits were being realized.

There are three aspects to this monitoring program:

1. Verify that the operation deters spawning in high stranding risk areas
2. Verify that the operation does not impact spawning in low stranding risk areas
3. Verify that the recent high chum salmon escapement numbers in the river are not impacted by the operation.

Monitoring Indicators:
a) Redd Density.
b) Redd Size.
c) Egg Pockets.

Each variable is measured and compared from areas above and below the water level at a Ruskin Dam discharge of 100 m^3/s.

This monitoring program involves data collection in three parts. The first part consists of weekly redd counts and a daily monitor of redd construction. The second part consists of a hydraulic modelling exercise. The third part consists of collating the annual escapement data.

4.3.2 Status

Year 1 of this monitoring program began on 19 October 2005 and ended prematurely on 27 October 2005 due to insufficient inflows. Completion of the monitoring program was postponed until October 2006 when sufficient inflows were available to continue monitoring activities. Based on review of 2005/06 field data the continuation of monitoring in October 2007 is recommended to further address management questions regarding the effectiveness of the fall block load operation. Preliminary results of the work completed to date were presented to the Stave Monitoring Advisory Committee in June 2007.

A terms of reference incorporating methodology and analytical revisions will be produced prior to commencement of October 2007 field activities.

4.3.3 Interpretation of Data

Redd density was found to be consistently lower in high elevation sites compared to low elevation sites. Redds located above the 100 m^3/s elevation tended to be smaller than those at low elevations, but redds in both locations appeared to exhibit all states of development and contained some number of viable eggs. These preliminary results suggest that the limited load operation may have an influence on spawning behaviour; however, there is insufficient data to determine whether the influence is large enough to impact spawning success.

Tidal influences exerted a far greater confounding effect than originally anticipated, creating some uncertainty in the results. The monitoring program methodology will be modified to better account for this impact.

4.4 Risk of Adult Stranding

4.4.1 Overview

The objective of this monitoring program is to verify the assumption made by the Stave River WUP Consultative Committee that a fall limited block loading operation that provides a 100 m^3/s base flow does not cause significant stranding of unspawned (gravid) adult female chum salmon, thus offsetting the expected benefits of improved incubation success (see the Limited Block Load as Deterrent to Spawning monitoring program).

Monitoring Indicator: a) Stranded female carcasses that contain unspawned eggs compared to those found instream.

This monitoring program will involve weekly chum carcass counts done over the course of the spawning period.

4.4.2 Status

Monitoring was initiated in October 2006, carried out over several weeks and successfully completed in November 2006. The Risk of Adult Stranding Monitor report was completed in March 2007. Results of the monitoring program were presented to the Stave Monitoring Advisory Committee in June 2007.

4.4.3 Interpretation of Data

A total of 1340 adult chum salmon were observed above the 100 m^3/s base flow. The sex ratio of spawners was skewed towards females, averaging 1.37 females to every male. Of the female carcasses encountered, the majority were categorized as spawned out (87 % -100%), with fewer (0 % - 8.6%) identified as partially spawned out, and a smaller number (0 % - 7.1 %) classified as unspawned.

It was suggested that a performance measure be used to identify biologically significant levels of adult standing where the maximum yearly stranding rate of unspawned females is set at 0.39% of the total yearly female escapement [1]during normal fall block load operations. Should increases in stranding be observed above the performance measure in any survey year, evaluation of pre-spawn stranding rates of chum salmon on an unregulated watershed should be undertaken to assess if this value falls within typical natural variation, as published data on this subject area is limited.

4.5 Risk of Fry Stranding

4.5.1 Overview

The purpose of the monitoring program is to track the occurrence of chum fry stranding following implementation of a spring limited block loading operation (allowance for peaking operations from 15 February to 15 May when discharge at Ruskin Dam exceeds 100 m^3/s). While some stranding is expected, it is not to exceed 1.5% of the total chum fry population, a threshold established in prior fry stranding studies.

Monitoring Indicator: a) The proportion of stranded chum fry relative to the estimated total chum fry population.

This monitoring program will involve an annual stranding survey.

4.5.2 Status

This two year monitoring program was scheduled for implementation in April 2006, however, based on insufficient inflows was postponed until April 2007. April 2007 initiation was further postponed until April 2008 based on potential impacts to fry downstream of Ruskin Dam due to a high total gas pressure incident. The first program report is expected in September 2008.

4.5.3 Interpretation of Data

At this time there is no data to interpret for this monitoring program.

[1] Based on 2006 DFO escapement estimates

4.6 Diel Pattern of Fry Out-migration

4.6.1 Overview

The objective of this monitoring program is to collect behavioural data on out-migrating chum fry in response to rapid flow changes, in order to better understand diel migratory patterns and hence devise better operational strategies to minimize fry stranding while maintaining operational flexibility.

Monitoring Indicators:

a) Colonization rate of habitat newly watered from upstream areas and/or through emergence from bottom substrate.

b) Fry response to rising and falling water levels as cues and triggers to out migration behaviours.

c) Diel propensity for a response to migratory cues and triggers.

This monitoring program will involve using stationary trapping techniques, direct diver observation and underwater video.

4.6.2 Status

This monitoring program is scheduled to begin in April 2008 and will be carried out over two years. The first program report is expected in August 2009.

4.6.3 Interpretation of Data

At this time there is no data to interpret for this monitoring program.

4.7 Seasonal Timing and Assemblage of Resident Fish

4.7.1 Overview

The objective of this monitoring program is to prepare an inventory of resident fish species downstream of Ruskin Dam, assess how the inventory may change though the year, and evaluate the likelihood of operational impacts. The fish community structure of non-anadromous salmonids and non-salmonids was poorly characterized in the existing inventory data. As a result, potential impacts to this community could not be directly addressed in the present WUP and therefore will be carried over to the next WUP review period.

Monitoring Indicators:

a) Seasonal timing of fish species and life-stage presence.

b) Relative abundance.

c) Habitat type association.

d) Likelihood of an operations related impact for each species and life-stage.

This monitoring program will involve reconnaissance-level fish surveys carried out every six to eight weeks, non-lethal fish capture methods and fish enumeration.

4.7.2 Status

This monitoring program is scheduled to begin in January 2010 and will be carried out in years six and seven following implementation of the WUP. The first program report is expected in August 2011.

4.7.3 Interpretation of Data

At this time there is no data to interpret for this monitoring program.

4.8 Turbidity Levels in Hayward Lake Reservoir

4.8.1 Overview

The objective of this monitoring program is to track turbidity levels in Hayward Lake Reservoir to ensure that they do not exceed Provincial Drinking Water Quality Standards following implementation of the WUP, which is expected to cause a slight increase in the amplitude of water level fluctuation. There are a number of local residents that draw their drink water directly from Hayward Lake Reservoir. Some expressed concern that the increased range of water level fluctuation could increase turbidity levels and impact water quality.

Monitoring Indicator: a) Water turbidity.

This monitoring program will involve turbidity observations and an annual shoreline survey.

4.8.2 Status

Year two of the monitor involved turbidity measurement at six sites on six occasions between May 2006 and April 2007. The second year Turbidity Levels in Hayward Reservoir report was completed in June 2006. The results were presented to the Stave River WUP Monitoring Advisory Committee in June 2006. Year three of this monitoring program is currently underway with a revised terms of reference currently under development incorporating minor methodology changes to address year two findings.

4.8.3 Interpretation of Data

Monitor results to date suggest that turbidity levels are generally low, though susceptible to increase above the Federal and Provincial drinking water quality standard during periods of heavy rain. For the monitoring period average turbidity at the six monitoring sites levels averaged 2.39 NTU for the 2006 through 2007 monitoring year and 0.43 NTU for the 2005 through 2006 monitoring year with resulting increases during year two relating to heavy rain events. Although year two average turbidity levels were above the 1.0 NTU Canadian and Provincial drinking water quality standard the District of Mission water filtration/disinfection process is in place to ensure water quality is of a suitable standard for consumption.

No actively eroding shoreline locations were observed during the single shoreline survey.

More data needs to be collected to discern patterns related to seasons, weather, and reservoir operations. Monitoring of reservoir tributaries will also be undertaken to allow consideration as a point source of reservoir turbidity.

5 Stave River WUP Monitoring Programs Costs

The following table summarizes the Stave River WUP monitoring programs costs approved by the Comptroller on 30 June 2005 and actual costs to 31 March 2006.

Table 5-1: Stave River WUP Monitoring Program Costs

Description		Costs Approved by Comptroller of Water Rights	Actual Costs to 30 June 2007
Monitoring Programs			
Pelagic Monitor (Nutrient Load/Total Carbon Levels)	Direct Management	$139,307	$3,556
	Implementation	269,800	$34,069
Littoral Productivity Assessment	Direct Management	140,339	$2,912
	Implementation	518,800	$85,490
Fish Biomass Assessment	Direct Management	137,787	$5,665
	Implementation	254,500	$72,617
Limited Block Load as Deterrent to Spawning	Direct Management	71,991	$3,927
	Implementation	87,600	$18,100
Risk of Adult Stranding	Direct Management	17,795	$2,371
	Implementation	20,200	$20,695
Risk of Fry Stranding	Direct Management	34,129	$2,251
	Implementation	59,400	$6,098
Diel Pattern of Fry Out-migration	Direct Management	36,254	$56
	Implementation	78,400	$0
Seasonal Timing and Assemblage of Resident Fish	Direct Management	19,299	$0
	Implementation	34,400	$0
Turbidity Levels in Hayward Reservoir	Direct Management	106,662	$3,094
	Implementation	75,800	$9,453