Coquitlam-Buntzen Water Use Plan

Implementation Year 6

Reference: COQMON #2

Coquitlam River Rampdown Fisheries Impact Summary

Study Period: April 1, 2010 – March 31, 2011

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Executive Summary

This report summarizes rampdown events occurring on the Lower Coquitlam River for the water year April 1, 2010 to March 31, 2011. A total of 11 rampdown events were monitored during the annual survey period: 6 scheduled rampdowns; April 30, May 31, August 31, November 2, 2010, January 14 and April 1, 2011 and 5 unscheduled rampdowns May 19, June 29, October 2, November 13, 2010 and January 23, 2011

The 2010-2011 water year was the second complete year under the treatment 2 flow regime (only half the year in 2008-2009 was under treatment 2). Under treatment 2, rampdowns are to be more frequent, but of a much smaller scale in addition to being predictable due to regularly scheduled flow reductions. The increase in the maximum allowable reservoir stage elevation was also intended to reduce the need for large scale flow releases and subsequent full river rampdown fisheries impact surveys. In spite of planned flow reductions, there were 5 unscheduled spill events in the 2010-2011 water year (2008-2009 is the only year since surveys were initiated that an unscheduled spill did not occur).

Areas previously identified as susceptible to de-watering and fish stranding were visually inspected by survey crews during each rampdown event. Stranded fish were captured and relocated to the river mainstem by dip netting, seine netting or gee-type minnow traps. The five scheduled rampdowns stranded a total of 68 fish 47 of which were salvaged alive. All stranded fish observed during scheduled rampdowns were juvenile coho. The five unscheduled rampdown events produced a total of 766 stranded fish, 696 of which were salvaged live and relocated to the river mainstem. The total number of fish stranded for all rampdowns (834) was the largest observed since surveys were initiated in 2001.

Acknowledgements

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BC Hydro operations staff for access to the gate house and updates

Table of Contents

List of Tables

List of Figures

1.0 Introduction and Site Description

The Coquitlam River watershed located in the Greater Vancouver area in southwestern British Columbia is a typical southwest pacific coastal watershed. Natural river flows are dominated by snowmelt during the spring months, with lower flows through dry summer months prior to elevated precipitation driven flows October through March. The Coquitlam Lake Reservoir portion of the watershed is utilized by two facilities. One facility, with origins dating back to 1892, provides an intake for domestic water supply by the Greater Vancouver Regional District (GVRD) for the Greater Vancouver area. The other facility, BC Hydro's, Coquitlam-Buntzen generation project dates to 1903 and diverts water out of Coquitlam Lake Reservoir via a 3.9 km tunnel to Buntzen Lake Reservoir, where duel penstocks lead to powerhouses, for electricity generation, located in Indian Arm, Burrard Inlet.

The Lower Coquitlam River watershed covers an area of approximately 60 km^2 and has its source at the Coquitlam Dam located within the GVRD watershed boundary. The Lower Coquitlam River flows though the municipality of Port Coquitlam before becoming confluent with the Fraser River. At present the lower watershed is impacted by gravel extraction, urbanization and the variable controlled discharges from the dam.

Controlled flow releases from the Coquitlam River Dam have potential impacts on downstream aquatic communities. Fish can be affected by the ramping rate (rate at which flow is released or decreased from the dam outlets) at all life-history stages. Impacts can include stranding of redds, fry, juveniles or adults depending on the time of year. Rampdown monitoring serves to minimize the potential impacts by identifying areas known to be susceptible to stranding during rampdown events.

Investigations into the impact of rampdowns on fish in Lower Coquitlam River have been ongoing since 2001. Field methods have been developed and refined over the past six years and surveys have been opportunistic. Rampdown assessments undertaken since 2001 have focused on developing survey methods that will enable BC Hydro to evaluate the performance of the interim ramping rate (Table 2), and its influence on mitigating fish stranding on the Coquitlam River. With respect to this, the management questions outlined by the WUP Consultative Committee (CC) and addressed during monitoring in 2003-2005 (BC Hydro CQD WUP TOR 2006) are:

> *a) What is the most appropriate ramping rate protocol that should be developed for the Coquitlam Dam that best reduces fish stranding risk while being operationally feasible?*
>
> *b) What are the ongoing fish stranding risks and/or impacts of the revised ramping rate protocol?*

The result of management question (a) being addressed, was the implementation of the interim ramping rate protocol in 2005. The following hypothesis will be tested over the remainder of the review period to continue to evaluate the performance of the interim ramp rate protocol:

H1: *The LB1 WUP interim ramping rate protocol does not strand fish at index sites in the lower Coquitlam River.*

The ramping rate established under Treatment 1 had the goal of minimizing the impact of stranding during rampdowns, while maintaining operational feasibility (BC Hydro 2005). Following completion of the seismic upgrade on Coquitlam Dam in October 2008, a new flow release schedule (Treatment 2) was also initiated. Under this new flow regime a series of scheduled rampdowns will occur at pre-determined times throughout the year. These rampdowns amount to small scale reductions (between 3.00cms and 0.60cms) in the flow release from Coquitlam Dam (Table 1), but can represent a sizeable decrease in the total volume of flow entering Coquitlam River. For example, rampdowns scheduled for the dates January 15 and May 31 constitute a drop in the total flow release from 51% and 62% respectively (Table 1).

The introduction of the new flow regime is tied to Coquitlam River Fish Productivity as part of the Coquitlam River Water Use Plan. (LB1 WUP). It is central to a long-term adaptive management study being conducted in Coquitlam River to compare anadromous fish production under two experimental flow regimes. Fish population monitoring under the first flow regime (Treatment 1) occurred from 2000 until the completion of the Coquitlam Dam seismic upgrade in October 2008. Fish production under Treatment 2 will be monitored for up to 9 years; 2009 was the first year of monitoring during Treatment 2.

A new low level outlet (LLO) knife-gate installed at Coquitlam Dam in 2008 will control the flow adjustments at the same rate as the previous rampdown schedule (Table 2 for revised gate adjustment schedule). With the seismic upgrade to Coquitlam Dam complete, BC Hydro dam safety constraints no longer stipulate a maximum reservoir elevation of 149 metres, beyond which spill releases must be initiated to ensure dam integrity. The new maximum reservoir operating level is 155 metres. The increased reservoir capacity should reduce the need for unscheduled spills from Coquitlam Dam.

Since 2001, stranding risk has been assessed on the Coquitlam River at several locations from the face of the dam to the confluence with Maple Creek (Macnair et.al 2004-2009). The total survey area incorporates approximately 14 river kilometers. Maps of the area in Appendix 4 identify all stranding index sites. New areas of potential stranding risk under Treatment 2 have been identified by survey crews during rampdown surveys (Macnair 2009). These new sites were identified by their stranding risk characteristics: shallow sloped, numerous potholes and depressions, ephemeral channels, porous substrate, and observations of redds, adults or juveniles in habitat.

Figure 1 Coquitlam-Buntzen Reservoir, Diversion and Generating System

Due to the size of the study area and the infrequent occurrence of ramping events, some sections of the river have received little investigation. Areas that are not highlighted on the map (Appendix 5) are generally free of any characteristics that would indicate susceptibility to stranding. All areas not highlighted have been surveyed at least once over the past 8 years and have been determined by survey crews to have minimal or no stranding risk due to the complete absence of any observed stranding therefore, they are not included in any rampdown assessments.

Stranding is identified by three categories:

1. Adult stranding of spawning salmon, which is confined to the active spawning period (Oct.- Jan. depending on species), or other resident adult species.
2. Redd stranding during active spawning period (Oct.-Jan.).
3. Juvenile stranding (fry, parr and smolt), potential risk exists year round.

These categories are used to distinguish stranding by the life stage of salmonids using the Coquitlam River. A single adult female stranded or redd stranded may represent the possible loss of thousands of eggs and resultant loss of fry, whereas the loss of one fry

among potential millions (chum and pink for example) would not have the same impact on fish productivity.

Mortalities of adults and juveniles during rampdown events can result from fish being caught in pools or ephemeral channels which dewater during release reductions. This leaves fish isolated in pools that eventually completely drain. In addition, fry are vulnerable to increased predation risk and oxygen depletion when trapped in highly visible, shallow pools (Bradford, 1997). Elevated dam releases during the fall or spring may temporarily give access to spawning areas which dewater during subsequent flow reduction. This can impact redds by leaving them stranded, and rendering incubated eggs or alevins unviable.

Table 1 Coquitlam River flow release schedule under Treatment 1 and 2

	Reservoir diversion schedule (m^3/s)					
	Domestic water		Coquitlam Dam releases			
				Treatment 2		
Period	Target	Min	Treatment 1	Target	Min	Target species and life stage
Jan 1-15	11.9	10.7	1.0	5.9	3.6	Chinook spawning
Jan 15-31	11.9	10.7	1.0	2.9	2.9	Chinook incubation
Feb	11.9	10.7	1.0	2.9	1.8	Chinook incubation
Mar	11.9	10.7	0.8	4.3	1.1	Steelhead spawning
Apr	12.0	10.8	0.8	3.5	1.1	Steelhead spawning
May	12.0	11.0	1.1	2.9	1.1	Steelhead spawning
Jun	12.0	10.9	1.4	1.1	1.1	Steelhead parr
Jul	18.0	15.8	1.4	1.2	1.1	Steelhead parr
Aug	23.0	20.2	1.1	2.7	1.1	Steelhead parr
Sep	23.0	20.9	0.8	2.2	1.1	Steelhead parr
Oct	12.0	10.8	0.8	6.1	3.6	Chinook spawning
Nov	12.0	10.8	1.1	4.0	1.5	Chinook spawning
Dec	11.9	10.7	1.1	5.0	2.5	Chinook spawning

2.0 Methods

During spill reductions, locations susceptible to stranding risk are assessed during daylight hours by crews of between two and four people. Due to the short duration of most rampdown events and the large amount of habitat potentially affected, only locations that are most susceptible or have been previously identified as high risk are assessed. Areas susceptible to stranding are generally directly adjacent to the river mainstem and have a flat, un-sloped topography containing numerous potholes and depressions where isolated pools can form (Figure 18). Ephemeral side channels that fill during flow releases and drain completely following gate closures are also highly susceptible to stranding (Figure 19). Areas judged to have no stranding risk are usually steeply sloped river banks that drain rapidly and do not retain any standing water, or areas that have been surveyed repeatedly with no stranding having ever been observed.

Susceptible areas are visually surveyed several times over the course of the rampdown event to assess at what point stranding becomes evident. All isolated pools are assessed for fish and initial attempts at salvaging are conducted with dip nets. Areas that are difficult to net by hand or are known to strand large numbers of fish are fished overnight with baited minnow traps.

Rampdown site assessments are also linked to dam operations through the three LLO gates and their release stages (Table 2). Timing of site assessments can be correlated with the specific LLO gate flow release stage. For example, during the closure of the second LLO gate, survey crews know to respond to specific index sites which dewater during this stage of the rampdown. LLO gates are classed; LLO1 starting gate = first gate to close, LLO2 second gate = second gate to close, LLO3 = third and last gate to close (Table 2). LLO gate flow reductions can be influenced by rainfall and tributary inputs to varying degrees. For example, the stranding risk at rampdown sites located downstream of Or Creek, (Coquitlam Rivers main tributary Appendix B) is sometimes minimized due to high flows from this tributary which keeps the river stage from decreasing. Survey crews keep in constant contact with BC Hydro gate operators during rampdown events to ensure proper survey timing during dewatering. Prior to initiation of gate changes the rampdown survey crew rendezvous with BC Hydro operating staff to determine gate start and finish time. Contact is maintained throughout the gate changes via cel phone and through direct contact at the LLO gatehouse.

Table 2 Revised gate adjustment schedule for Coquitlam Dam Low level outlets gates during release reductions

Gate	Step	Gate Change		Action	
		From	*To*		
Starting Gate	1	60"	0"	Continous gate change until closed	
Second Gate	2	60"	46"	0.5hr change	
Second Gate	3	46"	36"	0.5hr change	
Second Gate	4	36"	24"	0.5hr change	
Second Gate	5	24"	16"	0.5hr change	
Second Gate	6	16"	9"	0.5hr change	
Second Gate	7	9"	3"	0.5hr change	
Second Gate	8	3"	0	0.25hr change	
LLO3 (Knife Gate Valve)	9	100%	85%	0.5hr change	
LLO3 (Knife Gate Valve)	10	85%	83%	0.5hr change	
LLO3 (Knife Gate Valve)	11	83%	81%	0.5hr change	
LLO3 (Knife Gate Valve)	12	81%	79%	0.5hr change	
LLO3 (Knife Gate Valve)	13	79%	76%	0.5hr change	
LLO3 (Knife Gate Valve)	14	76%	71%	0.5hr change	
LLO3 (Knife Gate Valve)	15	71%	66%	0.5hr change	
LLO3 (Knife Gate Valve)	16	66%	62%	0.5hr change	
LLO3 (Knife Gate Valve)	17	62%	60%	0.5hr change	
LLO3 (Knife Gate Valve)	18	60%	56%	0.5hr change	
LLO3 (Knife Gate Valve)	19	56%	53%	0.5hr change	
LLO3 (Knife Gate Valve)	20	53%	48%	0.5hr change	
LLO3 (Knife Gate Valve)	21	48%	45%	0.5hr change	
LLO3 (Knife Gate Valve)	22	45%	41%	0.5hr change	
LLO3 (Knife Gate Valve)	23	41%	34%	0.5hr change	
LLO3 (Knife Gate Valve)	24	34%	31%	0.25hr change	
LLO3 (Knife Gate Valve)	25	31%	28%	0.25hr change	For special
LLO3 (Knife Gate Valve)	26	28%	22%	0.5hr change	circumstances only
LLO3 (Knife Gate Valve)	27	22%	15%	0.5hr change	(where minimum flows
LLO3 (Knife Gate Valve)	28	15%	8%	0.5hr change	are provided outside of
LLO3 (Knife Gate Valve)	29	8%	0%	0.5hr change	the Knife Gate Valve)

Dewatered areas are classified according to index sites lettered A-E, including two to three specific rampdown sub-areas in each index site (Appendix 4). Rampdown survey areas within each index site are not always contiguous, and may represent a large area of discontinuous but comparable fluvial and river edge characteristics (see Appendix 4 & 5 for site maps and descriptions). All sites surveyed typically contain many small depressions and areas where fish and spawning habitat are susceptible to stranding. Isolated pools are examined and their location recorded so that they can be located during future rampdown assessments if they are determined to pose a stranding risk. All salvaged fish, both live and dead are enumerated, identified to species and live fish are returned to areas of the river mainstem not affected by the flow reduction.

When evaluating whether fish are stranded or not, a distinction is made between fish stranded in an area that will eventually become effectively dry (resulting in mortalities), and fish that are in temporarily isolated areas. Isolated areas will remain continually wetted and capable of supporting fish until higher flows return whether by an increase in flow from the dam, seasonal rainfall or freshet conditions. These isolated areas may be supported by a number of sources, such as: interstitial flows, bank seepage, tributaries or ground water. Fish in these areas are not considered “stranded” and are therefore not included in stranding data

River stage elevation changes were monitored at several staff gauge sites during the course of rampdown events (Appendix 5). Stage reductions were determined by survey crews at hourly visual inspections of staff gauges located in reach 1, reach 2a and reach 2b (Appendix 1 & 2). These gauges are monitored from the onset of flow reductions to the end of daily salvage operations (which are called off at the onset darkness for safety and visibility reasons). River stage elevation is also monitored using hourly flow data from the Water Survey of Canada (WSC) gauge located in Port Coquitlam (08MH002).

The area of each rampdown site was calculated by estimating the extent of inundation during a full 3 LLO gate release. This is done on a yearly basis by survey crews in all areas, regardless of whether stranding has occurred at a site. The full extent of each site is included in the area calculation; therefore, areas within the ramp site that do not pose a stranding risk are represented in the area calculation. The total extent of each stranding site is represented as dewatered area in square metres (see Appendix 4 for ramp site descriptions). Survey crews perform area measurements a using hip chain and tape measure, measuring the length and width of each site to determine its areal extent. For scheduled rampdown events, the area of inundation is not quantified due to the fact that these are base flows and do not inundate areas of the river which are not normally wetted.

3.0 Results

3.1 Scheduled Rampdown Summaries

Coquitlam Rampdown April 30, 2010

On April 30, 2010 a scheduled (Treatment 2), flow reduction from Coquitlam Dam was undertaken. Low Level Outlet (LLO) releases from Coquitlam Dam were scheduled to be reduced from 3.5m^3s to 2.9 m^3s. The scheduled rampdown began at approximately 1030hr and was completed by 1230hr. Coquitlam River stage elevation dropped approximately one centimetre in the reaches downstream of Or Creek (R3,R2b, R2a and R1) (Figure 2) No stranding was observed and no stranding risk was evident as the detectable decrease in river stage elevation was too small in these areas. River stage elevation decreased by a total of 5 centimetres in Reach 4, but no stranding was observed in any risk areas.

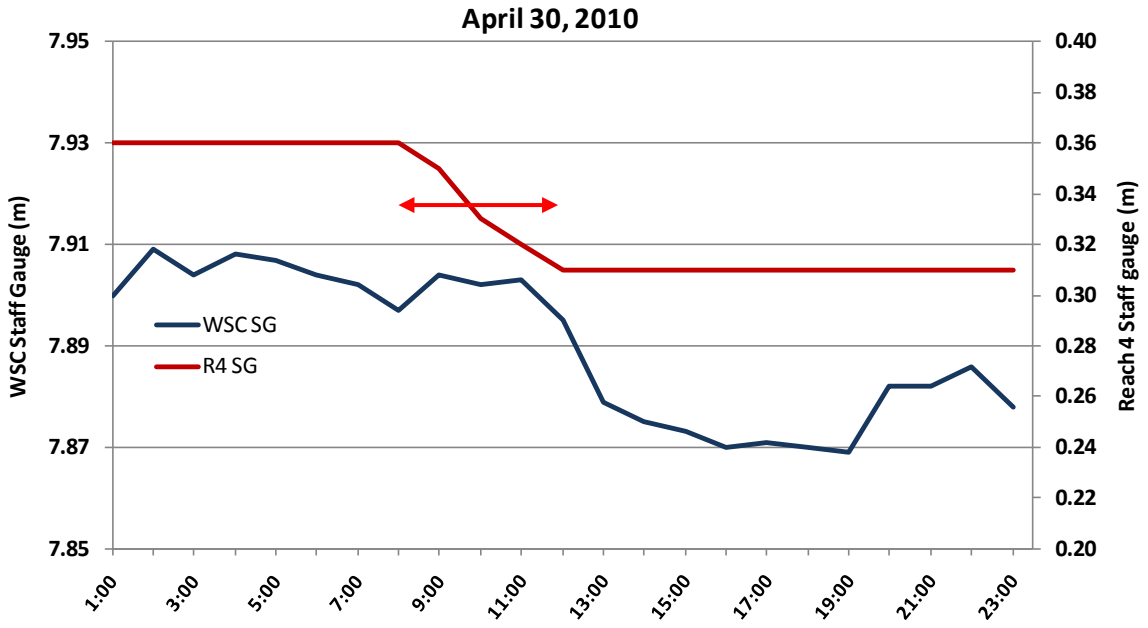

Figure 2 Coquitlam River stage elevation (m) change during rampdown event April 30, 2010, WSC data and Reach 4 data. Red arrow indicates rampdown period.

Coquitlam Rampdown May 31, 2010

On May 31, 2010 a scheduled (Treatment 2), flow reduction from Coquitlam Dam was undertaken. Low Level Outlet (LLO) releases from Coquitlam Dam were scheduled to be reduced from 2.9 m^3s to 1.1 m^3s. The scheduled rampdown began at approximately 1030hr and was completed by 1230hr. Due to rainfall and freshet conditions at the time of the rampdown, potential stranding areas downstream of Or Creek did not experience any river stage reduction. In fact, flow increased over the course of the day and river stage actually rose downstream of Or Creek (Figure 3).

The area above Or Creek (Reach 4, rampdown site E) was not influenced by the rainfall and freshet conditions and did experience a significant reduction in river stage during the gate closure. The Reach 4 staff gauge in Site E showed an average decrease of 4.0cm per hour over the course of the rampdown survey (total river stage reduction of 14cm). The majority of this decrease in river elevation occurred during the final gate adjustments when the river stage dropped 6.0cm in one hour (Figure 3, Appendix 1). This rapid decrease did directly lead to stranding and mortalities, as all were observed after the final gate change was made. At total of 55 coho fry were stranded in Site E, 19 of which were mortalities (Table 3). This was the first scheduled rampdown where stranded fish were observed.

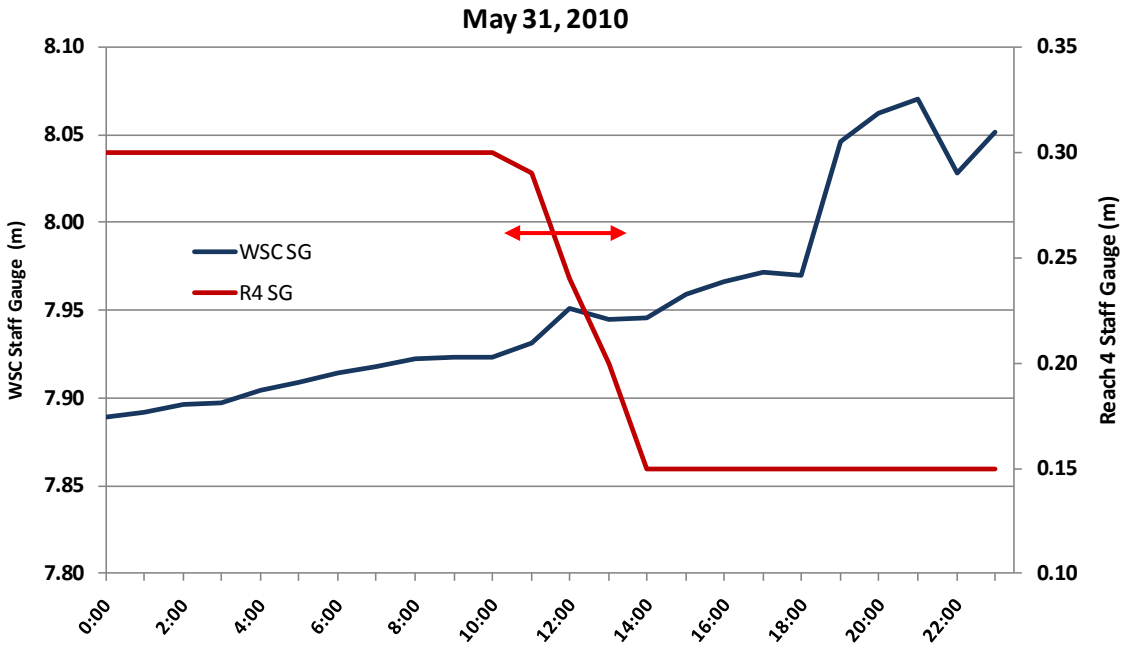

Figure 3 Coquitlam River stage elevation (m) change during rampdown event May 31, 2010, WSC data and Reach 4 data. Red arrow indicates rampdown period.

Table 3 Fish stranding by sub-section and species for May 31, 2010 rampdown

Fish Salvaged														
Index Site Code	A1	A2	A3	B1	B2	C 1	C2	D1	D2	D3	E1	E2	E3	Total
Coho Fry	0	0	0	0	0	0	0	0	0	0	9	27	0	**36**

Mortalities														
Index Site Code	A1	A2	A3	B1	B2	C 1	C2	D1	D2	D3	E1	E2	E3	Total
Coho Fry	0	0	0	0	0	0	0	0	0	0	19	0	0	**19**

Coquitlam Rampdown August 31, 2010

On August 31, 2010 a scheduled (Treatment 2), flow reduction from Coquitlam Dam was undertaken. The flow release was scheduled to be reduced from the August target of 2.7 m^3s to the September flow target of 2.2 m^3s. The scheduled rampdown began at approximately 1315hr and was completed by 1430hr. Heavy rain had been falling prior to the flow reduction and continued throughout the day. Due to the precipitation, Coquitlam River stage elevation increased below Or Creek despite the flow reduction (Figure 4). No stranding was observed in any areas below Or Creek and no stranding risk was evident due to the increase in river stage.

Above Or Creek, Coquitlam River experienced a total river stage reduction of 3 cm, a stage decrease rate of approximately 0.75 cm an hour (Appendix 1). Isolated pools did form in Reach 4 during the flow reduction but no stranding was observed throughout the survey.

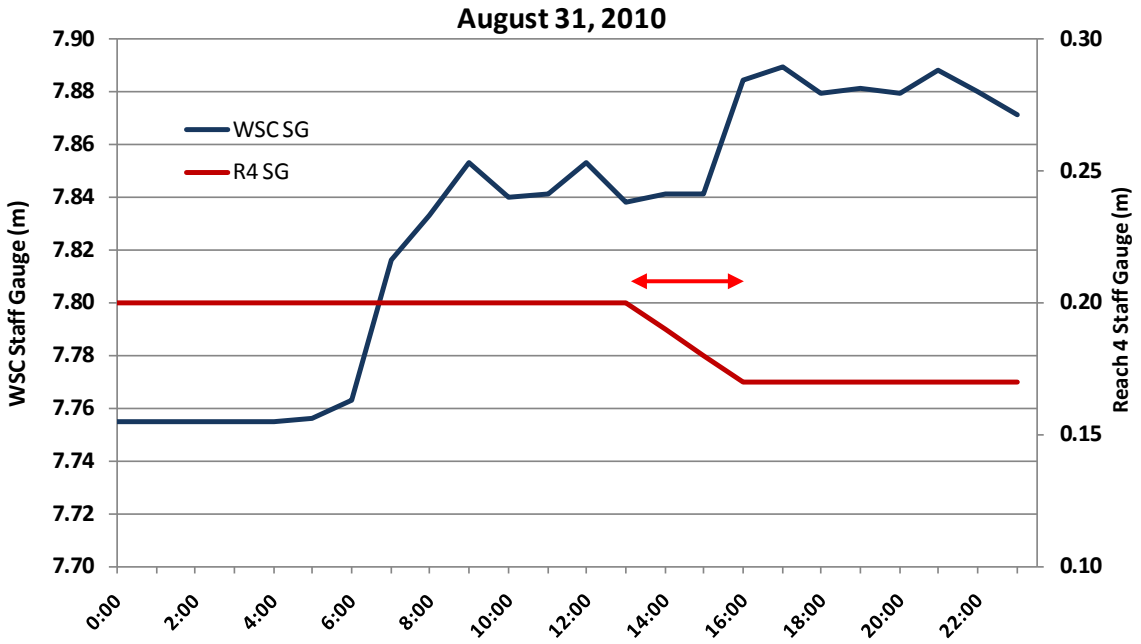

Figure 4 Coquitlam River stage elevation (m) change during rampdown event August 31, 2010, WSC data and Reach 4 data. Red arrow indicates rampdown period.

Coquitlam Rampdown November 2, 2010

On November 2, 2010 a scheduled (Treatment 2), flow reduction from Coquitlam Dam was undertaken. Low Level Outlet (LLO) release from Coquitlam Dam was scheduled to be reduced from 6.1 m^3s to 4.0 m^3s. The scheduled rampdown began at approximately 0920hr and was completed by 1145hr. River stage elevation downstream of Or Creek dropped approximately two centimetres following completion of the flow reduction (Figure 5, Appendix 1) No stranding was observed and no stranding risk was evident as the detectable decrease in river stage elevation was too small downstream of Or Creek. Upstream of Or Creek river stage elevation dropped a total of 9.0 cm over the course of the rampdown with an average decrease of 3.0 cm/hr (Appendix 1).

Stranding was observed in site E3 following completion of the rampdown. A total of 13 coho fry were observed to be stranded, of the 13 fry observed, there were 2 mortalities (Table 4). This was the second scheduled rampdown where stranded fish were observed.

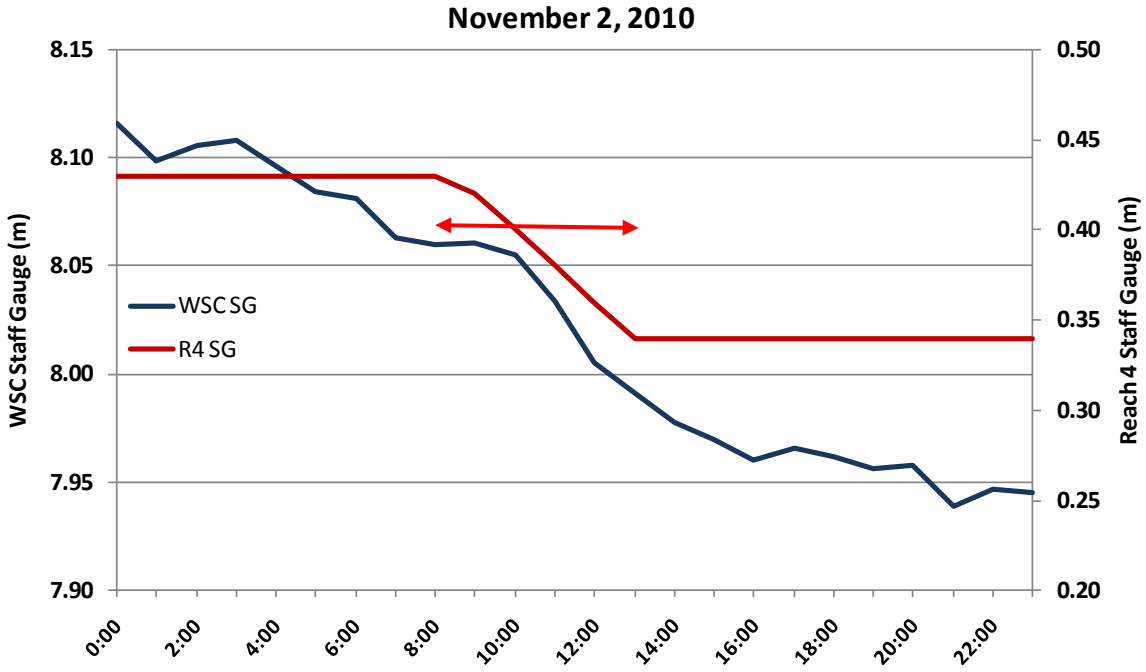

Figure 5 Coquitlam River stage elevation (m) change during rampdown event November 2, 2010, WSC data and Reach 4 data. Red arrow indicates rampdown period.

Table 4 Fish stranding by sub-section and species for November 2, 2010 rampdown

Fish Stranded														
Index Site Code	**A1**	**A2**	**A3**	**B1**	**B2**	**C 1**	**C2**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**Total**
Coho Fry	0	0	0	0	0	0	0	0	0	0	0	0	11	**11**
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**11**	**11**

Fish mortalities														
Index Site Code	**A1**	**A2**	**A3**	**B1**	**B2**	**C 1**	**C2**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**Total**
Coho Fry	0	0	0	0	0	0	0	0	0	0	0	0	2	**2**
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**

Coquitlam Rampdown January 14, 2011

On January 14, 2011 in response to the current flow regime (Treatment 2), the Low Level Outlet (LLO) release from Coquitlam Dam was scheduled to be reduced from 5.9 m^3s to 2.9 m^3s. The scheduled rampdown began at approximately 0930hr and was completed by 1330hr. In response to heavy rain, river stage elevation downstream of Or Creek did not decrease during the rampdown, but instead rose and maintained a very high volume throughout the day (Between 60 m^3s and 30 m^3s during rampdown

survey period, Water Survey of Canada data). Fish stranding surveys were not undertaken downstream of Or Creek for this reason.

Upstream of Or Creek (Reach 4), river stage dropped a total of fifteen centimetres following completion of the flow reduction and had an average decrease of 2.1 cm/hr (Figure 6, Appendix 1). No stranding was observed despite evident stranding risk in most rampdown sites.

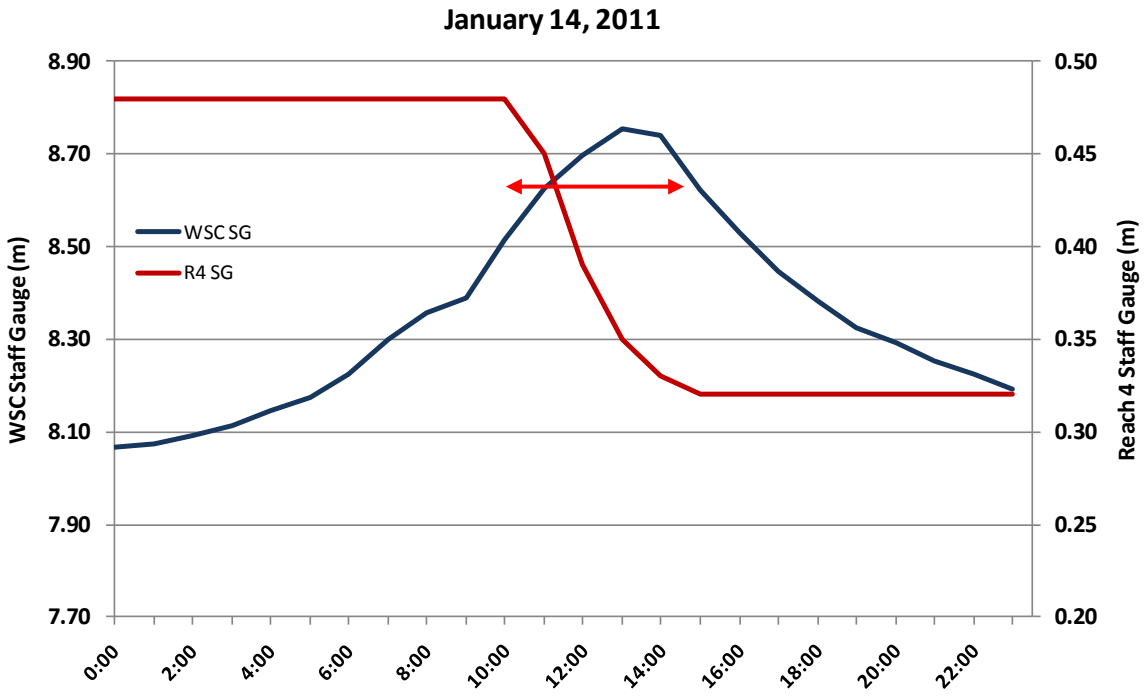

Figure 6 Coquitlam River stage elevation (m) change during rampdown event January 14, 2011, WSC data and Reach 4 data. Red arrow indicates rampdown period.

Coquitlam Rampdown April 1, 2011

On April 1, 2011 in response to the Treatment 2 flow regime the Low Level Outlet (LLO) release from Coquitlam Dam was scheduled to be reduced from 4.3 m^3s to 3.5 m^3s. The scheduled rampdown began at approximately 0800hr and was completed by 1030hr.

River stage elevation dropped between 2 and 5centimetres (depending on reach location) following completion of the flow reduction (Figure 7, Appendix 1). No stranding was observed and virtually no stranding risk was evident as the detectable decrease in river stage elevation was too small. River stage downstream of Or Creek continued to decrease following the flow reduction, this was due to heavy rainfall prior to April 1 that had increased the flow in Coquitlam River. Coquitlam River stage had

been decreasing since March 31, therefore, observed stage reduction downstream of Or Creek was influenced by natural flow reduction.

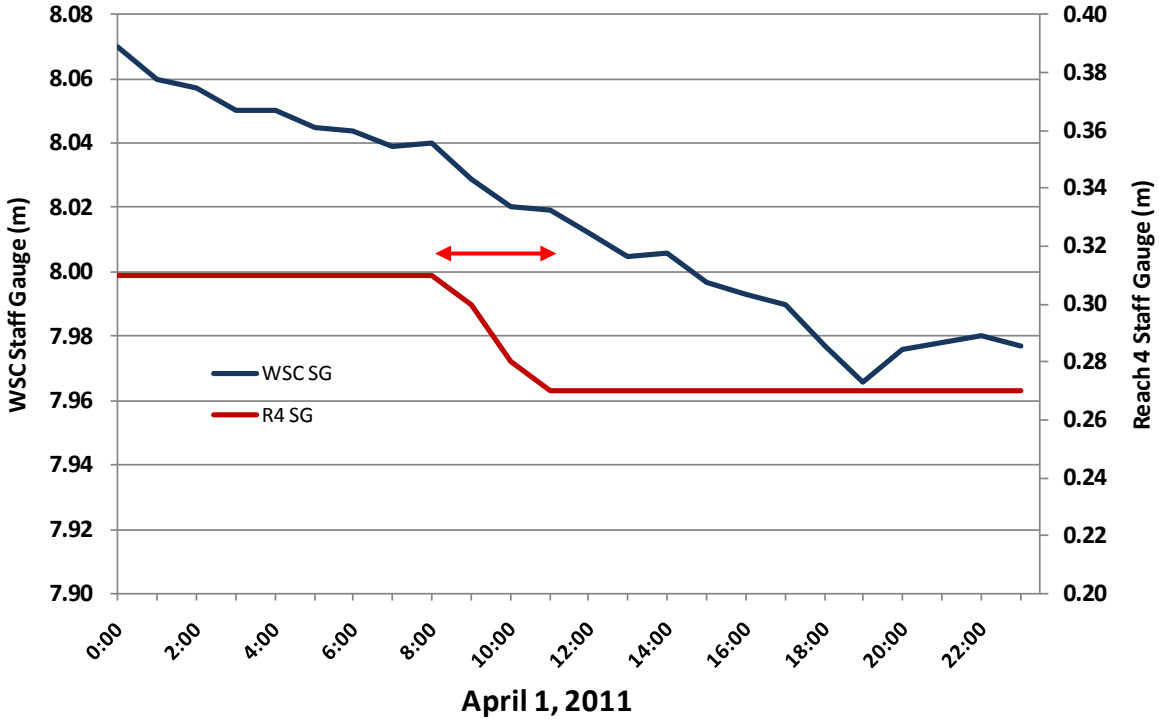

Figure 7 Coquitlam River stage elevation (m) change during rampdown event April 1, 2011, WSC data and Reach 4 data. Red arrow indicates rampdown period.

3.2 Unscheduled Rampdowns

Five unscheduled rampdowns occurred on Coquitlam River during the 2010-2011 monitoring program. Three of the five events were large rampdowns from a full three LLO gate spill, the other was related to sockeye passage, and involved only a minor flow increase (from 2.9 m^3s to 6.0 m^3s spilling from the LLO gates on Coquitlam Dam.

Coquitlam Rampdown May 19, 2010

In order to facilitate kokanee smolt outmigration from Coquitlam Reservoir, an experimental flow increase from Low Level Outlet gate 1, (LLO1), at Coquitlam Dam was scheduled to run from May 13 to May 19, 2010. The release increased flow in the LLO from approximately 2.9 m^3s to 6.0 m^3s. The rational for the flow increase was based on the hypotheses that Kokanee smolt outmigration may be encouraged with a stronger "attraction flow" through the LLO gates. The timing of the flow increase occurred at a very sensitive time on Coquitlam River, as coho smolt migration and coho fry emergence was at its peak. The rampdown was scheduled for Wednesday, May 19, 2010, commencing at 1200hr, and was complete at 1530hr.

A total of 293 stranded fish were observed over the rampdown monitoring period. Of this total, 281 were salvaged alive and 12 were mortalities, all stranded fish were coho fry (Table 5). The number of stranded fish was high, though all fry were recovered from only two sites (Table 5). At this point in the year coho fry are very vulnerable to stranding as they congregate in high densities in the shallow margins and pools along edge habitat in Coquitlam River. All fish were salvaged from small pools (approximately 8-10 square metres in area) using a seine net.

The flow in Coquitlam River was dropping prior to the start of the rampdown in response to natural fluctuation in river stage brought on by freshet conditions (Figure 8). Therefore the river stage elevation decrease should be seen as a combination of natural and rampdown induced flow reduction.

Table 5 Total of salvaged fish and mortalities for rampdown event May 19, 2010

Fish Salvaged	Index Site Code													
	A1	A2	A3	B1	B2	C 1	C2	D1	D2	D3	E1	E2	E3	Total
Coho Fry	0	0	0	0	**255**	0	0	**26**	0	0	0	0	0	**281**

Mortalities	Index Site Code													
	A1	A2	A3	B1	B2	C 1	C2	D1	D2	D3	E1	E2	E3	Total
Coho Fry	0	0	0	0	0	0	0	**12**	0	0	0	0	0	**12**

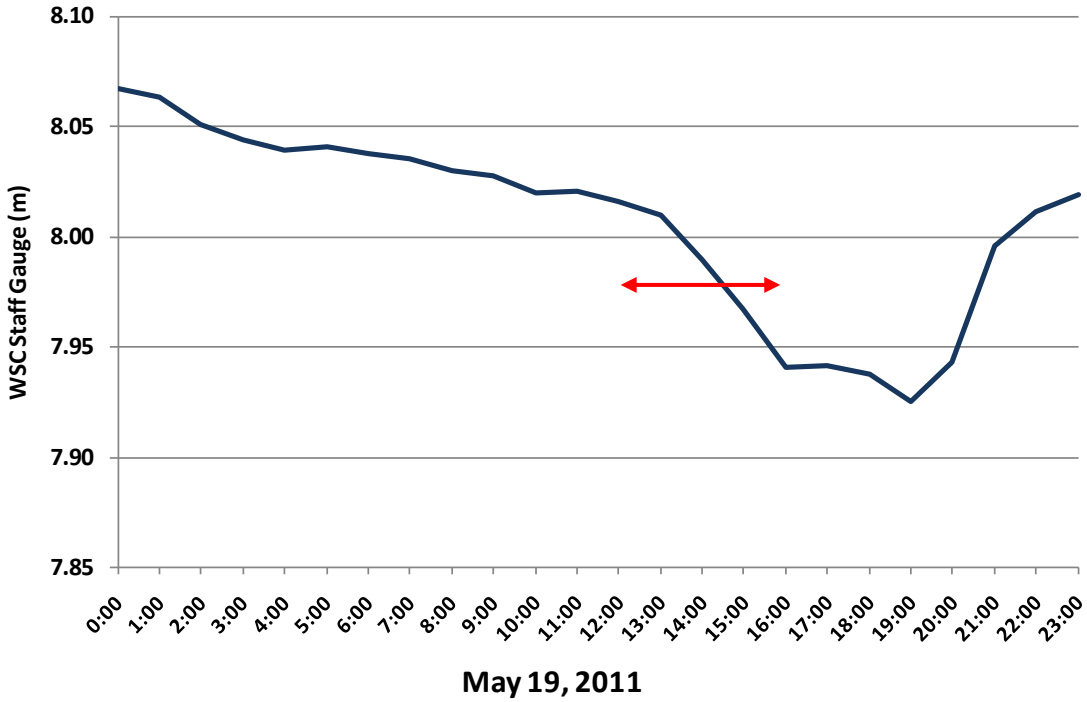

Figure 8 Coquitlam River stage elevation (m) change during rampdown event May 19, 2010, WSC data. Red arrow indicates rampdown period.

Coquitlam Rampdown Summary June 29-July 1, 2010

Spilling from all three LLO at Coquitlam Dam had been ongoing since June 21, 2010, when a rampdown of all three gates was scheduled for June 29, 2010. The spill had been initiated to ensure that Coquitlam Reservoir elevation did not approach the dam safety threshold of 155m. Due to ongoing maintenance at LBL 1 and 2 (Turbine replacement), BC Hydro is unable to pass water into this system, leading to reservoir elevation concerns at Coquitlam (Figure 1).

Commencing at 1100hr on June 29, 2010, the first gate was ramped down at the prescribed ramping rate, with full closure at 1230hr. The second gate began closing at approximately 1230 and was complete by 1600hr. The third gate and final gate was closed partially, going from 100% open to 66% between 1600hr and 1845hr. The remainder of the third gate was ramped down on the following day June 30, 2010, beginning at 1100hr and finishing at 1645hr (from 66% open to 10%).

This rampdown was the first time that a full three gate LLO spill release had occurred at this time of year since rampdown surveys began in 2001. Full three gate flow releases are rare in Coquitlam River in the late spring and summer as reservoir elevation is not normally a concern in the drier months.

A total of 411 stranded fish were observed over the two day rampdown monitoring period, this represents the largest number of stranded fish observed during all rampdown surveys dating back to 2001. Of this total, 401 were coho fry, 3 Chinook fry, 5 cotids, 1 lamprey and 1 longnose dace (Table 6). Stranded fish were all found in sites considered to be high risk for stranding. Of all fish stranded, 184 were stranded on June 29 during the first, second and third partial gate closure, and 227 were stranded on June 30. Fish were observed to be stranded in all 5 index sites and 7 of 13 sub-sites (Table 6)

Table 6 Total of salvaged fish and mortalities for rampdown event June 29- July 1, 2010

June 29-30														
Fish Salvaged	**Index Site Code**													
Species	**A1**	**A2**	**A3**	**B1**	**B2**	**C 1**	**C2**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**Total**
Coho Fry	98				116		31		3	43	25		33	**349**
Chinook Fry										2	1			**3**
Cotid					1					3			1	**5**
Dace													1	**1**
Lamprey							1							**1**
Total	**98**				**117**		**32**		**3**	**48**	**26**		**35**	**359**

Mortalities	**Index Site Code**													
Species	**A1**	**A2**	**A3**	**B1**	**B2**	**C 1**	**C2**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**Total**
Coho Fry	6				19		21			1	4		1	**52**

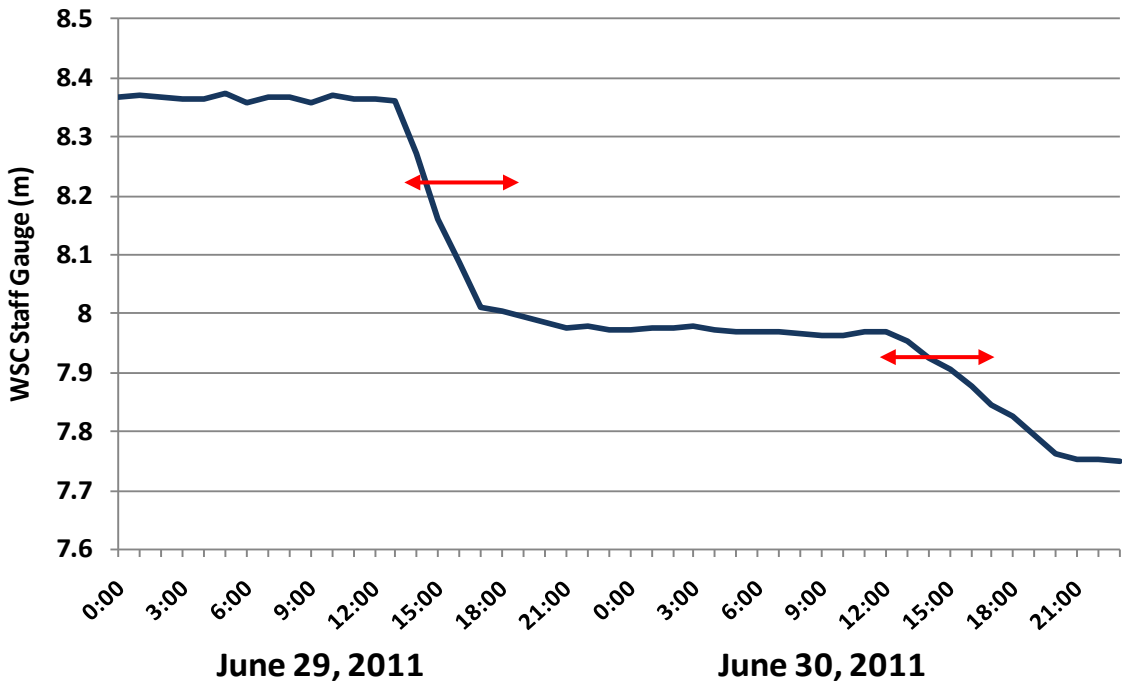

Figure 9 Coquitlam River stage elevation (m) change during rampdown event June 29 -30, 2010, WSC data. Red arrow indicates rampdown period.

Coquitlam Rampdown October 2-3, 2010

On October 2, 2010 a flow reduction from Coquitlam Dam was scheduled. A flow release (initiated to reduce reservoir elevation for dam safety) from all three LLO gates had been ongoing since September 25 and was scheduled to be reduced to the October flow target of 6.1cms. Commencing at 0930hr on October 2, two gates were ramped down at the prescribed ramping rate (Table 2). The flow reduction was complete at approximately 1600hr on the same day. The third and final gate was ramped down on the following day, October 3, 2010.

A total of 50 stranded fish were observed over the two day rampdown monitoring period. Of this total, 44 were salvaged and returned to the river mainstem and 6 were mortalities. No adult salmon or redds were observed stranded during the rampdown survey. Stranded fish were all found in sites considered to be high risk for stranding. The first day of the rampdown saw 39 fish stranded, while 11 were found on the second day (Table 7). Two mortalities were found on the first day and 4 on the second. Stranding was observed in all reaches of Coquitlam River.

Table 7 Total of salvaged fish and mortalities by site for rampdown event October 2, 3, 2010.

October 2-3, 2010														
Fish Salvaged	**Index Site Code**													
Species	**A1**	**A2**	**A3**	**B1**	**B2**	**C 1**	**C2**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**Total**
Coho Fry	1	3			3			1					14	**22**
Rt Fry					14									**14**
Rt Parr													8	**8**
Cotid													1	**1**
Dace						2								**2**
Crayfish						2								**2**
Total	**1**	**3**			**17**	**4**		**1**					**23**	**49**

Mortalities	**Index Site Code**													
Species	**A1**	**A2**	**A3**	**B1**	**B2**	**C 1**	**C2**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**Total**
Coho Fry					1	2	1							**4**
Rt Fry					1	1								**2**
					2	**3**	**1**							**6**

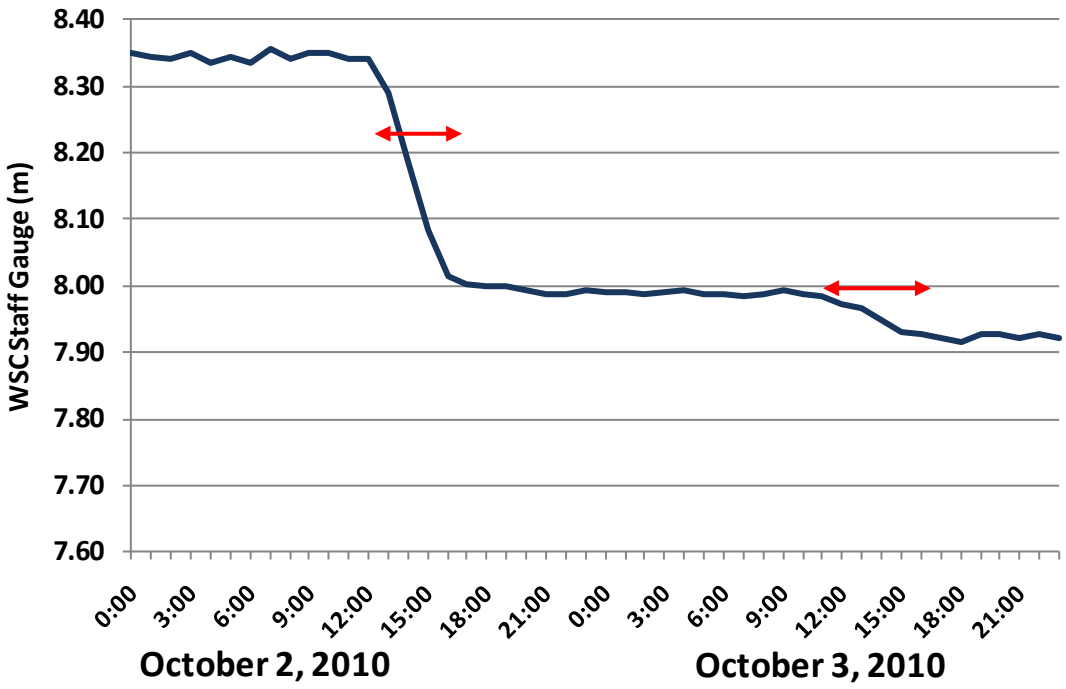

Figure 10 Coquitlam River stage elevation (m) change during rampdown event October 2, 3, 2010, WSC data. Red arrow indicates rampdown period.

November 12, 13 2010

On October 2, 2010 following gate closure from a 3 gate LLO spill, hydro operations staff detected a problem with one of the LLO gates (Gate 3). This gate had failed to open during the spill and therefore future work was planned to fix the gate. The gate repair was completed in early November and a test of its operational capability was scheduled for November 12, 2010.

The test required the gate to be fully opened and then immediately closed, rampdown crews were on hand for the test on November 12, however, a delay in the operational test meant that the gate would be tested following sunset when survey crews are unable to perform fish stranding surveys due to a lack of light. The operational test went as planned and crews performed a fish stranding survey the following day, November 13, 2010. No fish were observed to be stranded, likely due to the very short duration of the flow that pulsed through Coquitlam River during the operational test (The entire operation took less than 4 hours).

Coquitlam Rampdown January 23-25, 2011

Spilling from all three LLO at Coquitlam Dam had been ongoing since January 19, 2011, when a rampdown of all three gates was scheduled for January 23-25, 2011. Commencing at 0900hr on January 23, the first gate was ramped down at the prescribed ramping rate (Table 2). The flow reduction was complete at approximately 1600hr on the same day. The second gate and part of the third were closed on January 24 and the remainder of the third gate was ramped down on the following day, January 25, 2011 (Figure 11).

A total of 7 stranded fish were observed over the three day rampdown monitoring period. This total included 3 were coho parr, 3 were steelhead parr and 1 stickleback (Table 8). Stranded fish were all found in sites considered to be high risk for stranding. Of all fish salvaged, one was salvaged on January 23 during the first partial gate closure, three were salvaged on day 2 during the second and third partial gate closure, and the remainder were salvaged on January 25 during final gate closure. All locations where fish were salvaged are shown in Figures 1-3. Rainfall was very heavy on Day 2 (January 24), and as a result the river stage elevation rose during the latter part of the survey due to heavy inputs from tributary and surficial runoff (Figure 11, Appendix 2).

Table 8 Total of salvaged fish and mortalities by site for rampdown event January 23-25, 2011.

Fish Salvaged														
Index Site Code	**A1**	**A2**	**A3**	**B1**	**B2**	**C 1**	**C2**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**Total**
Coho parr		1					1					2		**4**
Steelhead Parr							2							**2**
TSS												1		**1**
Total														**7**

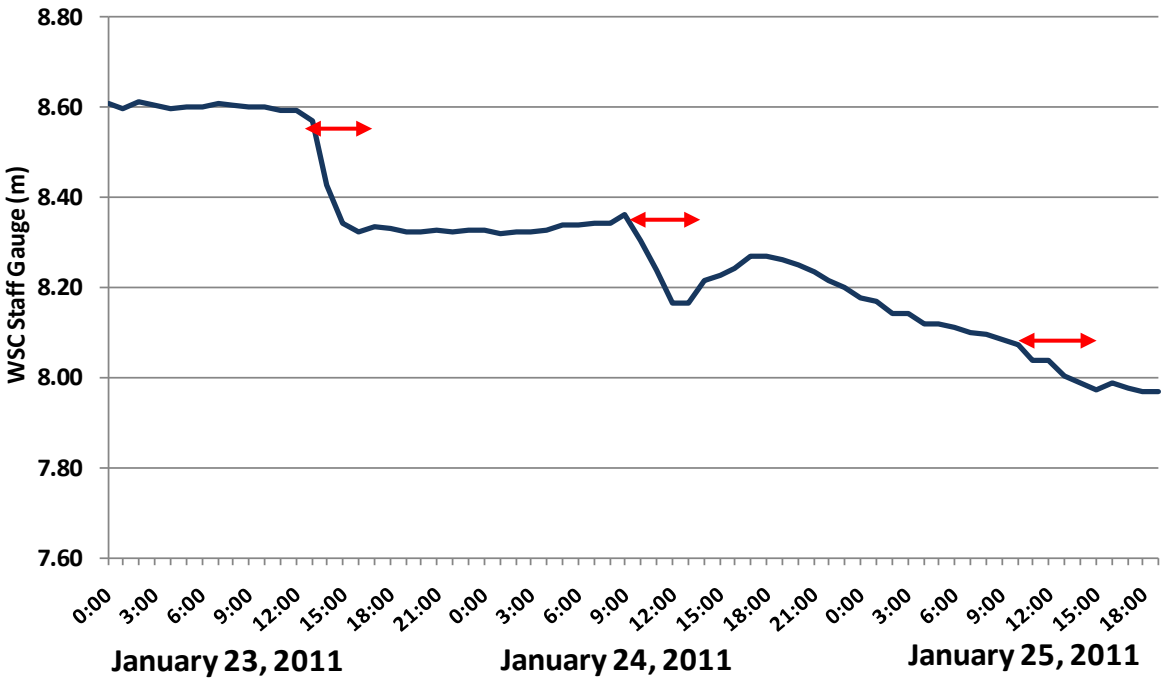

Figure 11 Coquitlam River stage elevation (m) change during rampdown event Jan. 23-25, 2011, WSC data. Red arrow indicates rampdown period.

4.0 Results and Discussion

In this, the second full year of rampdown monitoring under Treatment 2 (2010-2011), stranded fish were observed for the first time during scheduled rampdown surveys. Fish were found stranded during the May 31, 2010 and November 2, 2010 rampdown fish salvage surveys. Prior to these events, no stranding had been noted during the previous 11 scheduled rampdown events dating back to November 2008.

All fish stranded during these two rampdowns were found in Site E (corresponding to Reach 4), which is the uppermost section of Lower Coquitlam River (Appendix 5). This area is above the influence of Or Creek, and has only minimal natural inflow. In addition, its entire length is channelized and confined by berms and roadways. These conditions cause the river stage elevation to drop more rapidly and to a greater degree than areas downstream of Or Creek, making it more susceptible to stranding during scheduled rampdowns. Scheduled rampdowns typically see only a small decrease (or a river stage increase) in river stage elevation in the areas below Or Creek (Figure 12, Appendix 1).

Figure 12 shows the difference in river elevation change between Reach 4 and areas downstream during scheduled rampdowns. Of the six scheduled rampdowns, only three had an elevation decrease downstream of Reach 4, with a maximum elevation

decrease of 6 centimetres during the November 2, 2010 rampdown. All scheduled rampdowns in Reach 4 showed a river elevation decrease.

The two scheduled rampdowns that stranded fish had a total elevation decrease of at least 9 centimetres (May 31 and November 2, 2010). These two rampdowns stranded a total of 68 fish, 47 of which were salvaged alive. All fish observed stranded were coho fry (Appendix 3).

The May 31 scheduled rampdown from 2.9 m^3s to 1.1 m^3s represents a significant decrease in flow for the upper reach of Coquitlam River. While areas downstream may not be significantly impacted at this time due to expected freshest conditions, the flow reduction in Site E is equivalent to 62% of the total flow volume in this section of Coquitlam River. Future rampdown surveys at this time should focus efforts in Site E due to this increased hazard.

January 14, 2011 had the largest river stage decrease (16 centimeters), but did not strand any fish. This likely has to do with the time of year at which the rampdown occurred. The strongest determiner of stranding risk is the time of year at which a rampdown occurs (Table 11). Rampdowns that occur in the winter months (December 22 – March 21) are the least likely to strand fish. This is due to the general absence of juvenile fish in the system at this time (compared to spring and summer when literally millions of fry may be present) and the cold water conditions which minimizes fish movement and foraging.

The total decrease in river volume in Reach 4 is high during the January 15, May 31 and November 1 scheduled rampdowns, with a loss of 50%, 63% and 33% of total flow volume respectively (Table 1). These scheduled rampdowns are much more susceptible to stranding compared to the March 31, April 30 and August 31 scheduled rampdowns which have flow volume decreases of 19%, 17% and 19% respectively. This is also reflected in the river elevation decrease during these three rampdowns, which shows a maximum of 5 centimeters (Figure 12).

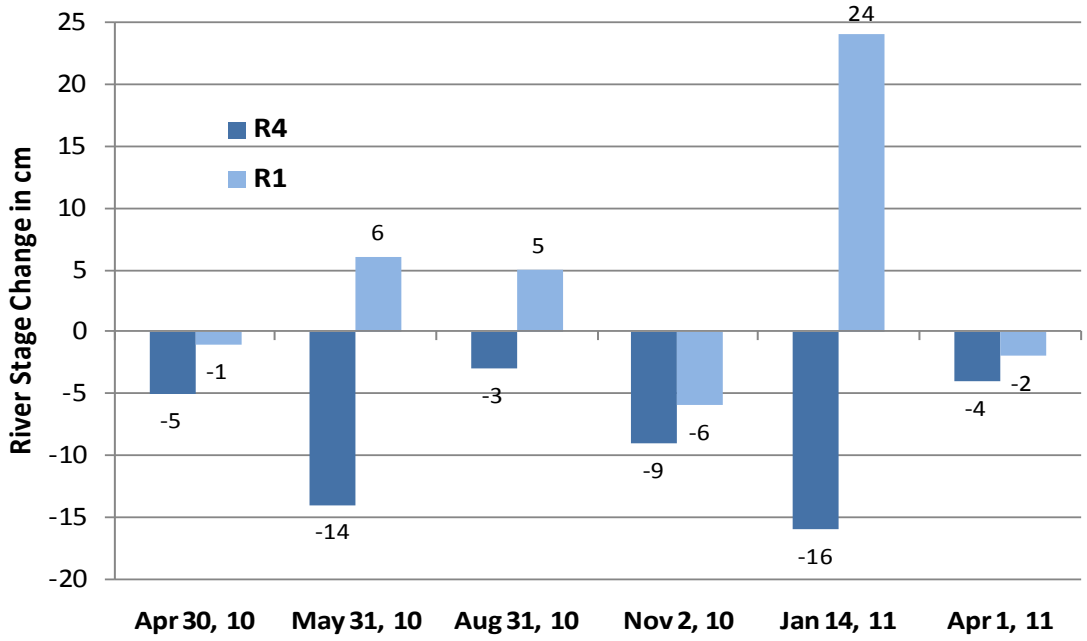

Figure 12 Showing river stage change during scheduled rampdowns. Comparison of Reach 4 with Reach 1 river stage change.

The second year of Treatment 2 showed an increase in the total number of rampdowns, (rising to eleven in 2010-2011) this is the highest number since surveys were initiated in 2001, (Table 12) . It was anticipated that a return to a reservoir maximum operating level of 155m from 149m (in place during treatment 1 2001-2009) would reduce the number of unscheduled spill events. However, the opposite has been evident in the past two years of monitoring. Of the five unscheduled rampdowns, three were from a full three LLO gate release, the other two were small scale and had only minor flow reductions (See sec. 3.2) With the high number of rampdowns the total number of fish stranded at 834 was the highest yet observed (Figure 13, Table 9).

Figure 13 shows the steady increase each year in the amount of fish stranded on Coquitlam River under Treatment 1. This increase was influenced by a number of factors, including: the number of rampdown events, timing of rampdown events, survey crews finding more stranding areas and increased efficiency in fish salvage. In the first two years under Treatment 2 this trend was reversed, but has swung far in the other direction this monitoring year (Figure 13).

The dramatic spike in observations of stranded fish was the result of two rampdowns which occurred at a particularly vulnerable time in Coquitlam River. The May 19 and June 29, 2011 unscheduled rampdowns occurred in spring and summer, which are much higher risk than fall and winter rampdowns (Table 11). These two rampdowns accounted for nearly 85% of all stranded fish. In addition virtually all of the fish stranded during these two rampdowns (97%) were coho fry. This highlights the fact that coho fry are most vulnerable to stranding in spring and summer when they are emerging and dispersing throughout Coquitlam River.

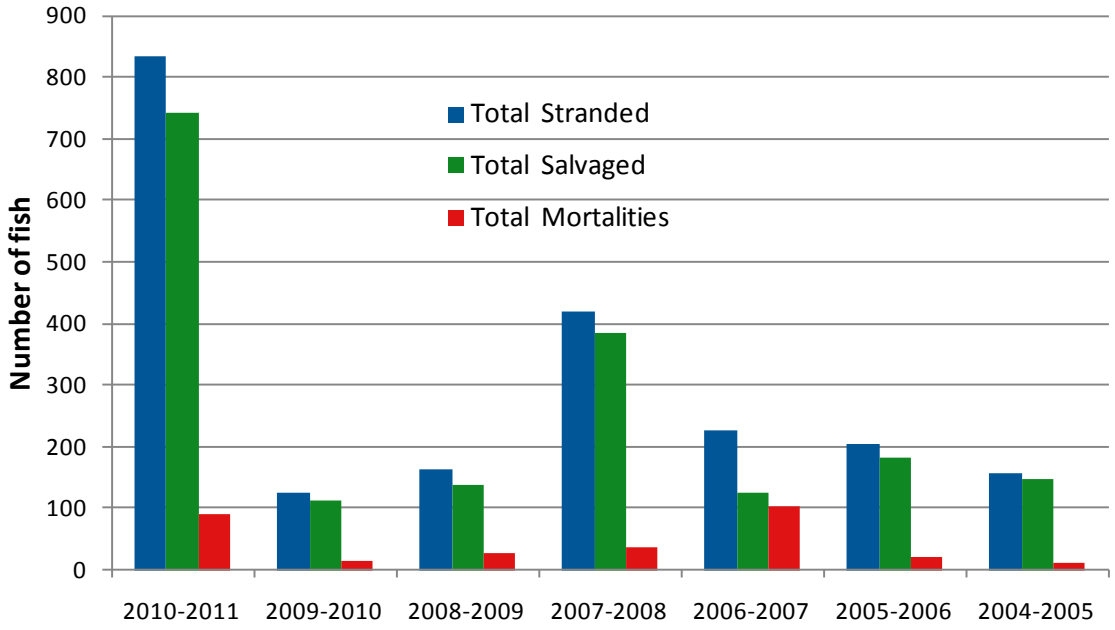

Figure 13 Fish salvaged and mortalities for all rampdowns 2004-2011.

Coho fry appear most likely to be stranded due to their year round residence, abundance at emergence and habit of congregating in shallow river margins, ephemeral channels and shallow pools (Dunn, 2002, Macnair 2008). All of these factors make them heavily susceptible to stranding. This contrasts with chum and pink fry which are the most numerous species when emergence is underway (March-May), but almost immediately migrate out of the river and are absent from the water column from June to February. Coho salmon juveniles were the most likely fish to be stranded over all years, representing 73.2% of all stranded fish. Overall, salmonids made up 93% of all stranded fish for the 2004-2011 period (Figure 14).

Table 9 Species and age class stranding composition by Site 2010-2011

		Index Site Code														
Species Stranded		**A1**	**A2**	**A3**	**B1**	**B2**	**C1**	**C2**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**Total**	**%Comp**
Coho Salmon (age 0)	*O. kisutch*	105	3		394			52	39	3	44	57	27	61	785	94.1%
Coho Salmon (age 1+)	*O. kisutch*		1					1					2		4	0.5%
Steelhead (age 0)	*O. mykiss*					15	3	1							19	2.3%
Steelhead (age 1+)	*O. mykiss*							2						8	10	1.2%
Chinook Salmon (age 0)	*O. tshawytscha*										2	1			3	0.4%
Threespine Stickleback	*Gasterosteus aculeatus*												1		1	0.1%
Lamprey	*Lampetra sp.*							1							1	0.1%
Longnose Dace	*Rhinichthys cataractae*						2							1	3	0.4%
Crayfish	*Pacifastacus leniusculus*						2								2	0.2%
Sculpin	*Cottus sp.*					1					3			2	6	0.7%
Total stranded by site		**105**	**4**	**0**	**394**	**16**	**7**	**57**	**39**	**3**	**49**	**58**	**30**	**72**	**834**	**100%**
Percentage stranded by site		**13.1%**			**49.2%**		**7.7%**		**11.0%**			**19.2%**				

Stranding by site was concentrated in the lower reaches of Coquitlam River with the majority (70%) in Reach 1 and 2a (Table 9). This agrees with the distribution over the past 8 years, which also shows a distribution heavily weighted to the downstream reaches (Figure 15). Reach 2b and 3 have the smallest amount of high risk stranding by area (Appendix 4), in addition to being the least accessible areas of river with the steepest banks. These factors all contribute to Reach 3 and 2b having the lowest stranding risk and the least amount of stranding.

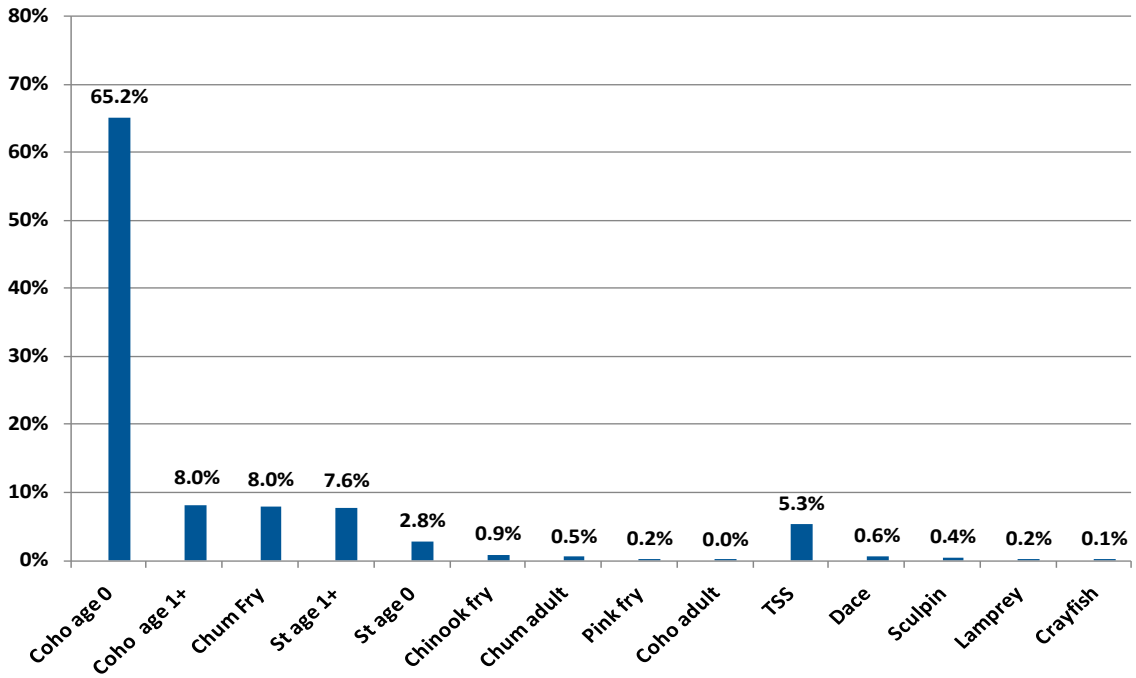

Figure 14 Stranding distribution of by species and age class, 2004-2011, all rampdowns.

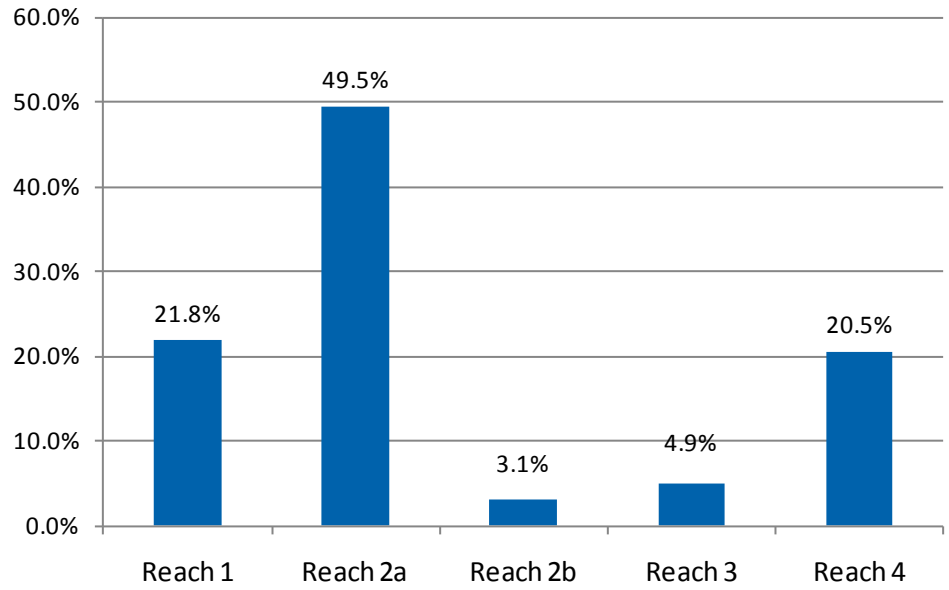

Figure 15 Stranding distribution by Reach, 2004-2011, all rampdowns.

Table 10 Yearly site by site comparison of stranded fish during all rampdown events, 2004-2011.

	Site A		Site B		Site C		Site D		Site E		Total	Total	Total	Ramp	%
Year	Salv	Mort	Salv	Mort	Salv	Mort	Salv	Mort	Salv	Mort	Stranded	Salvaged	Morts	Events	Morts
2010-2011	103	6	389	21	39	25	78	13	134	26	834	743	91	11	10.9%
2009-2010	21	0	40	2	0	0	5	0	45	13	126	111	15	10	11.9%
2008-2009	31	5	33	9	49	12	12	0	13	0	164	138	26	5	15.9%
2007-2008	67	6	32	11	199	17	20	1	65	1	419	383	36	3	8.6%
2006-2007	39	14	3	4	47	80	36	4	0	0	227	125	102	2	44.9%
2005-2006	95	0	0	0	1	9	0	7	85	6	203	181	22	2	10.8%
2004-2005	75	2	10	0	13	9	0	0	48	0	157	146	11	3	7.0%
Total	**431**	**33**	**507**	**47**	**348**	**152**	**151**	**25**	**390**	**46**	**2130**	**1827**	**303**	**36**	14.2%

Table 11 gives a breakdown of seasonal stranding totals for the 2004-2011 period (the table gives totals for salmonids only). The results demonstrate that fish stranding is highest in the spring and summer when fry and smolts are at the height of migration and emergence. With an even number of rampdowns (11) for the spring-summer and fall-winter periods over the past 8 years, the spring-summer period had 78% of all stranded fish (1522 of 1954, Table 11) This illustrates the strong influence that seasonal rampdown timing has on stranding fish.

This seasonal influence is further demonstrates by comparing the January 23-25, 2011 and June 29-30, 2010 rampdowns. Both were full 3 gate LLO releases for several days, yet a far greater number of fish were observed during the June rampdown (411 vs. 7, Table 6 & 8). Note also, major stranding can occur with only a small gate release or stage reduction, this is demonstrated by the May 19, 2010 and May 31, 2010 rampdown results

.

Table 11 Showing the relationship between seasonal timing and stranding risk all rampdowns, 2004-2011 and 2010-2011. Totals represent stranded salmonids only.

2004-2011		Life Stage When Stranded				
Season	# Rampdowns	Adult	Fry	Smolt/Parr	Total	Average
Spring (Mar 23-June 22)	6	0	743	62	805	134
Summer (June 23-Sept 22)	5	0	653	64	717	143
Fall (Sept 23 - Dec 22)	6	11	163	137	311	52
Winter (Dec 23 - Mar 22)	5	0	40	81	121	24

2011		Life Stage When Stranded				
Season	# Rampdowns	Adult	Fry	Smolt/Parr	Total	Average
Spring (Mar 23-June 22)	2	0	348	0	348	174
Summer (June 23-Sept 22)	1	0	404	0	404	404
Fall (Sept 23 - Dec 22)	2	0	55	8	63	32
Winter (Dec 23 - Mar 22)	1	0	4	2	6	6

Table 12 Number of rampdown per year 2001-2011

Monitoring Year	Unscheduled Events	Scheduled Events
2001-2002	1	n/a
2002-2003	1	n/a
2003-2004	3	n/a
2004-2005	3	n/a
2005-2006	6	n/a
2006-2007	4	n/a
2007-2008	5	n/a
2008-2009	1	3
2009-2010	5	5
2010-2011	5	6
Total	**34**	**14**

Stranding influence on fish production in Coquitlam River is likely to be minimal based on the results of the past 8 years. For pink and chum fry the influence is negligible. Decker et. al. 2009 reports the estimated average annual outmigrating population for chum and pink fry for the 2003-2009 period is 2,616,800 and 340,000 respectively. Contrast this with a total of 66 chum mortalities and zero pink mortalities observed during rampdowns for the same period. Coho and steelhead smolt population estimates for the same period average 14,972 and 6,867 per year respectively (Decker et. al. 2009). The estimated average number of coho and steelhead smolt mortalities per year due to rampdowns is 3 and 7 respectively, or less than 0.1% of the estimated population.

Coho fry populations are typically the hardest hit with respect to stranding, estimates of total fry productivity (based on fall standing stock estimates 2006-2009) range from 19,000 to 56,000 with a mean of approximately 37,000 (Decker 2011). Using available data it is possible to give a rough idea of the impact of stranding on the coho fry population in Coquitlam River. For example: If the total number of coho fry stranded in the 2010-2011 monitoring year, (785) was compared to the mean stranding stock (37,000), this would represent approximately 2.1% of the population. This level of loss could have the potential to have an impact on the coho fry population. Conversely: If the total number of coho fry stranded in the 2009-2010 monitoring year, (104) was compared to the 2009 stranding stock estimate (56,441), this would represent approximately 0.02% of the population, a very minimal amount.

Two steelhead redds were observed stranded following flow reduction on May 31, this is a first for steelhead redds on Coquitlam River. Elevated dam releases during the spring spawning period gave continuous access to steelhead spawning areas which then dewatered during flow reduction in June (Appendix 4). This can impact redds by leaving them stranded, and rendering incubated eggs or alevins unviable.

5.0 Conclusions and Recommendations

Due to the fact that the scheduled releases under Treatment 2 do not inundate large areas of habitat, that flow releases are maintained at a relatively constant rate throughout the year, and flow reductions are generally small in proportion to the amount of flow in the entire river, the risk of stranding appears to be minimal during most scheduled rampdowns downstream of Or Creek. The fact that in the first three years under Treatment 2 no stranded fish have been observed during scheduled rampdowns downstream of Or Creek supports this conclusion at the present time.

Though no stranding has yet to be observed under the (August 31, January 15, March 31, April 30) scheduled rampdowns it is recommended that they continue to be monitored by survey crews during the upcoming monitoring year. The potential for stranding definitely exists, particularly in the section of Coquitlam River above Or Creek. As described, this section is minimally influenced by natural inflows and therefore has the potential to be impacted by the scheduled flow reductions. Furthermore, areas downstream of Or Creek cannot always be expected to receive buffering flows from rainfall and freshet conditions, in their absence, the risk of stranding during scheduled rampdowns is amplified.

The increase in the number of unscheduled rampdown events due to climatic conditions (Heavy rainfall resulting in LLO spilling) dam maintenance and experimental flows was again an issue during the 201-11 monitoring year. Following the increase in the minimum operating level from 149m to 155m it was hoped that the number of unscheduled ramp events would decrease (as it did in year 1).

Stranding sites examined under the previous flow regime have been reevaluated under the new Treatment 2 conditions. The results of the third year under Treatment 2 demonstrate that some formerly susceptible areas may now be considered low risk for stranding. Additionally, new areas may still appear and those new areas already identified have been categorized and included in all rampdown fish salvage surveys. The fluvial morphological structure of Coquitlam River will continue to transform as it adapts to the increased annual flow, therefore areas of stranding will shift.

The interim ramping rate established under Treatment 1 still appears to be effective under Treatment 2 during both scheduled and unscheduled rampdowns. Comparison of rampdown mortalities to fish productivity clearly shows the negligible impact that rampdowns appear to have on fish productivity in Coquitlam River. However, results from this year of greatly elevated coho fry stranding during scheduled and unscheduled rampdowns at critical time periods is cause for concern. Rampdowns that occur in spring and summer should require extra vigilance to ensure that high numbers of juvenile mortalities do not occur.

With respect to the management questions outlined in the introduction, results to date support the continued use of the interim ramping rate protocol. Although fish will continue to be stranded regardless, survey crews are well adapted to the conditions of the ramp rate and are able to salvage the majority of fish that become stranded. Minimizing impacts with careful adherence to rampdown schedules and consistent monitoring of potential stranding sites will continue to be the most appropriate means to reduce the fish stranding risk while being operationally feasible. Observations have shown no visible increase in stranding risk after two years under the Treatment 2 flow regime.

- It is recommended that future trash rack maintenance and experimental flow releases (to accommodate Kokanee out-migration) be scheduled outside of the fry and smolt migration period, as this would greatly reduce any risk of juvenile stranding. If this is not possible, ensure that rampdowns during this time period have a full stranding crew on site (minimum 4 people).

- Results to date for Treatment 2, indicate that some scheduled rampdowns may eventually be done without survey crews on site. The scheduled flow reductions on August 31, March 31 and April 30 have not stranded any fish to date, and the river stage elevation reduction does not appear to pose a risk of stranding. Recommend that if this trend continues in Year 3, that monitoring of these rampdowns be dropped.

- Develop reach specific flow transects to estimate the influence of tributary inflow on rampdown fisheries impact surveys.

6.0 Literature cited

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Appendix 1 Total daily and hourly river stage reductions by staff gauge scheduled Rampdowns

April 30, 2010

R2B (at Galette)		R1 Staff Gauge		WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0900	.74	1000	1.25	0800	7.90	
1000	.74	1100	1.25	1100	7.90	
1100	.73	1300	1.24	1300	7.90	
1300	.72	1500	1.24	1500	7.88	
1500	.72	1700	1.24	1700	7.88	
1630	.72			1900	7.89	
6.5hrs		7.0hrs		8.0hrs		Total time
-0.02m		-0.01m		-0.01m		Total Stage Reduction (m)
0.33		0.14		0.13		Stage Change (cm)/hr

May 31, 2010

R2B (at Galette)		R1 Staff Gauge		WSC Staff Gauge		Reach 4 Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0830	0.69	0815	1.20	0800	7.92	0800	.30	
0930	0.70	1100	1.22	1000	7.92	1030	.29	
1100	0.72	1300	1.23	1200	7.95	1115	.28	
1300	0.72	1500	1.24	1400	7.95	1200	.24	
1500	0.73	1615	1.25	1600	7.94	1300	.20	
1600	0.74			1800	7.97	1500	.15	
7.5hrs		8.0hrs		10hrs		7.0hrs		Total time
+0.05m		+0.05m		+0.06m		-0.15m		Total Stage Change (m)
+0.67cm		+0.63cm		+0.60cm		-2.1cm		Stage Change (cm)/hr

August 31, 2010

R2B (at Galette)		WSC Staff Gauge		Site E Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
1000	0.65	1200	7.85	1000	0.20	
1200	0.65	1400	7.84	1200	0.20	
1400	0.68	1600	7.88	1400	0.19	
1600	0.69	1800	7.88	1600	0.17	
6.0hrs		6.0hrs		4.0hrs		Total time
+0.04m		+0.03m		-0.03m		Total Stage Change (m)
+0.7cm		+0.5cm		-0.75cm		Stage Change (cm)/hr

November 2, 2010

Reach 4		Reach 2B		Reach 1		WSC			
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Site	Stranded
0900	0.43	0900	.79	0900	1.29	1000	8.06		
1000	0.40	1000	.78	1000	1.28	1100	8.04		
1100	0.36	1100	.78	1100	1.28	1200	8.01		
1200	0.34	1200	.78	1200	1.28	1300	7.99	E3	13
1300	0.34	1300	.77	1300	1.27	1400	7.98		
1400	0.34	1600	.76	1400	1.26	1500	7.97		
				1630	1.26	1700	7.97		
						1800	7.96		
						2000	7.95		
5.0hr		7.0hr		7.5hrs		10.0hrs		Total time	
-0.09		-0.03		-0.03		-0.11		Total Stage Change (m)	
3.0		0.4		0.6		1.0		Stage Change (cm)/hr	

January 14, 2011

Reach 4		Reach 1 WSC		
Time	Stage (m)	Time	Stage (m)	
0900	0.48	0800	8.36	
1000	0.48	1000	8.51	
1100	0.45	1200	8.70	
1200	0.45	1300	8.75	
1300	0.39	1400	8.75	
1400	0.35	1500	8.62	
1500	0.33	1700	8.45	
1400	0.32	1900	8.33	
7.0hr		6.0hr		Total time
-0.15		+0.39		Total Stage Change (m)
2.1		+6.5		Stage Change (cm)/hr

April 1, 2011

Reach 4		Reach 2B		Reach 1 WSC		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0800	0.31	0800	0.80	0800	8.04	
0900	0.30	1000	0.78	0900	8.03	
1000	0.28	1200	0.77	1000	8.02	
1100	0.27	1400	0.77	1200	8.01	
1200	0.27			1400	8.01	
				1600	7.99	
				2000	7.98	
3.0hr		4.0hr		6.0hr		Total time
0.04		0.03		0.03		Total Stage Change (m)
1.3		0.75		0.43		Stage Change (cm)/hr

Appendix 2 Total daily and hourly river stage reductions by staff gauge with number of fish stranded and site, unscheduled rampdowns.

May 19, 2010

R2B (at Galette)		R1 Staff Gauge		WSC Staff Gauge			
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Site	Stranded
0800	.81	0800	1.33	0800	8.06		
0930	.80	1100	1.30	1100	8.02		
1100	.79	1300	1.29	1300	7.99	B2	156
1300	.78	1500	1.27	1500	7.96	B2	99
1500	.76	1700	1.25	1700	7.94	D1	38
1700	.72	1800	1.24	1900	7.93		
1900	.72	1900	1.23				
6.0hrs		6.0hrs		6.0hrs		Total time	
-0.06m		-0.06m		-0.06m		Total Stage Change (m)	
1.0cm/hr		1.0cm/hr		1.0cm/hr		Stage Change (cm)/hr	

June 29, 2010

Reach 4		Reach 2B		Reach 1		WSC			
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Site	Stranded
	n/a	1200	1.15	1200	.60	1300	8.37		
		1300	1.13	1330	.58	1400	8.30		
		1530	0.95	1800	.28	1500	8.17	B2	135
		1700	0.83	2100	.23	1600	8.09		
		2000	0.79			1700	8.02	C2	7
						1900	8.01	B2	1
						2000	8.00		
						2100	7.97	A1	41
		8.0hr		8.0hrs		7.0hrs		Total time	
		-0.36		-0.37		-0.39		Total Stage Change (m)	
		4.5		4.6		5.6		Stage Change (cm)/hr	

June 30, 2010

Reach 4		Reach 2B		Reach 1		WSC			
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Site	Stranded
1300	0.98	1230	.77	1000	0.23	1200	7.97	A1	56
1630	0.60			1430	0.20	1300	7.95	D3, E3	13
				1930	0.18	1400	7.93	A1	5
						1500	7.91	D2, D3	22
						1600	7.88		
						1700	7.85	E3	35
						1800	7.83	D3, E1	49
						1900	7.80		
						2000	7.77	C2	46
n/a		n/a		7.5hrs		8.0hr		Total time	
				-0.05		-0.20		Total Stage Change (m)	
				0.6		2.5		Stage Change (cm)/hr	

Oct 2, 2010

Reach 4		Reach 2B		Reach 1		WSC			
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Site	Stranded
1000	1.05	1045	1.06	1000	1.51	1000	8.35		
1300	1.04	1145	1.06	1230	1.51	1200	8.33	B2	17
1430	0.63	1415	.93	1400	1.50	1300	8.28	A2	3
1600	0.55	1515	.87	1600	1.37	1400	8.18		
1700	0.51	1545	.81	1800	1.29	1500	8.07	A1	1
		1630	.80			1600	8.01	E3	18
		1800	.79			1700	7.99		
						1800	7.99		
						2000	7.99		
5.0hr		6.0hr		6.0hrs		5.0hrs		Total Time	
-0.54		-0.27		-0.22		-0.34		Total Stage Change (m)	
10.8		4.5		3.7		6.8		Stage Change (cm)/hr	

Oct 3, 2010

Reach 4		Reach 2B		Reach 1		WSC			
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Site	Stranded
1000	0.50	1000	0.77	1000	1.26	1000	7.98	D1	1
1200	0.48	1230	0.75	1100	1.25	1200	7.97	C2	1
1300	0.45	1330	0.74	1300	1.23	1400	7.94	B2,C1	9
1430	0.41	1430	0.72	1500	1.21	1600	7.92		
1600	0.41	1630	0.71	1700	1.19	1800	7.91		
						2000	7.92		
6.0hr		6.0hr		9hrs		8.0hr		Total Time	
-0.09		-0.06		-0.07		-0.07		Total Stage Change (m)	
1.5		1.0		0.8		0.9		Stage Change (cm)/hr	

January 23, 2011

Reach 4		Reach 2B		Reach 1 WSC			
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Site	Stranded
1100	.88	1030	1.30	1000	8.60		
1200	.84	1300	1.23	1200	8.60		
1400	.75	1430	1.09	1300	8.58		
				1400	8.43		
				1500	8.35	A1	1
				1600	8.33		
				1700	8.34		
	3hr		4hr		7hr	Total time	
	0.13		0.21		0.26	Total Stage Change (m)	
	0.04		0.05		0.04	Stage Change (m)/hr	

January 24, 2011

Reach 4		Reach 2B		Reach 1 WSC			
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Site	Stranded
0900	0.73	0800	1.10	0900	8.37		
1200	0.57	0930	0.95	1000	8.31		
1300	0.46	1145	0.90	1100	8.25	C2	1
1500	0.40	1300	0.89	1200	8.17		
1530	0.39	1430	0.97	1300	8.18	C2	2
1600	0.38	1600	0.99	1400	8.22		
				1500	8.24		
				1600	8.25		
				1700	8.28		
	7hr		8hr		8hr	Total time	
	0.35		0.11		0.09	Total Stage Change (m)	
	0.05		0.01		0.01	Stage Change (m)/hr	

January 25, 2011

Reach 4		Reach 2B		Reach 1 WSC			
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Site	Stranded
0800	0.38	0900	0.83	0800	8.10		
0930	0.34	1100	0.83	1000	8.08	E2	3
1030	0.29	1200	0.81	1200	8.05		
1100	0.28	1330	0.80	1300	8.01		
		1500	0.77	1400	8.00		
		1600	0.76	1500	7.98		
				1600	8.00		
				1700	7.99		
	3hr		7hr		9hr	Total time	
	0.10		0.07		0.11	Total Stage Change (m)	
	0.03		0.01		0.01	Stage Change (m)/hr	

Appendix 3 Total number of fish stranded by sub-section and species for each scheduled and unscheduled rampdowns.

Scheduled Rampdowns 2010-2011

Fish Salvaged	Index Site Code													
	A1	A2	A3	B1	B2	C 1	C2	D1	D2	D3	E1	E2	E3	Total
Coho age 0	0	0	0	0	0	0	0	0	0	0	9	27	11	**47**
	0			**0**		**0**		**0**			**47**			

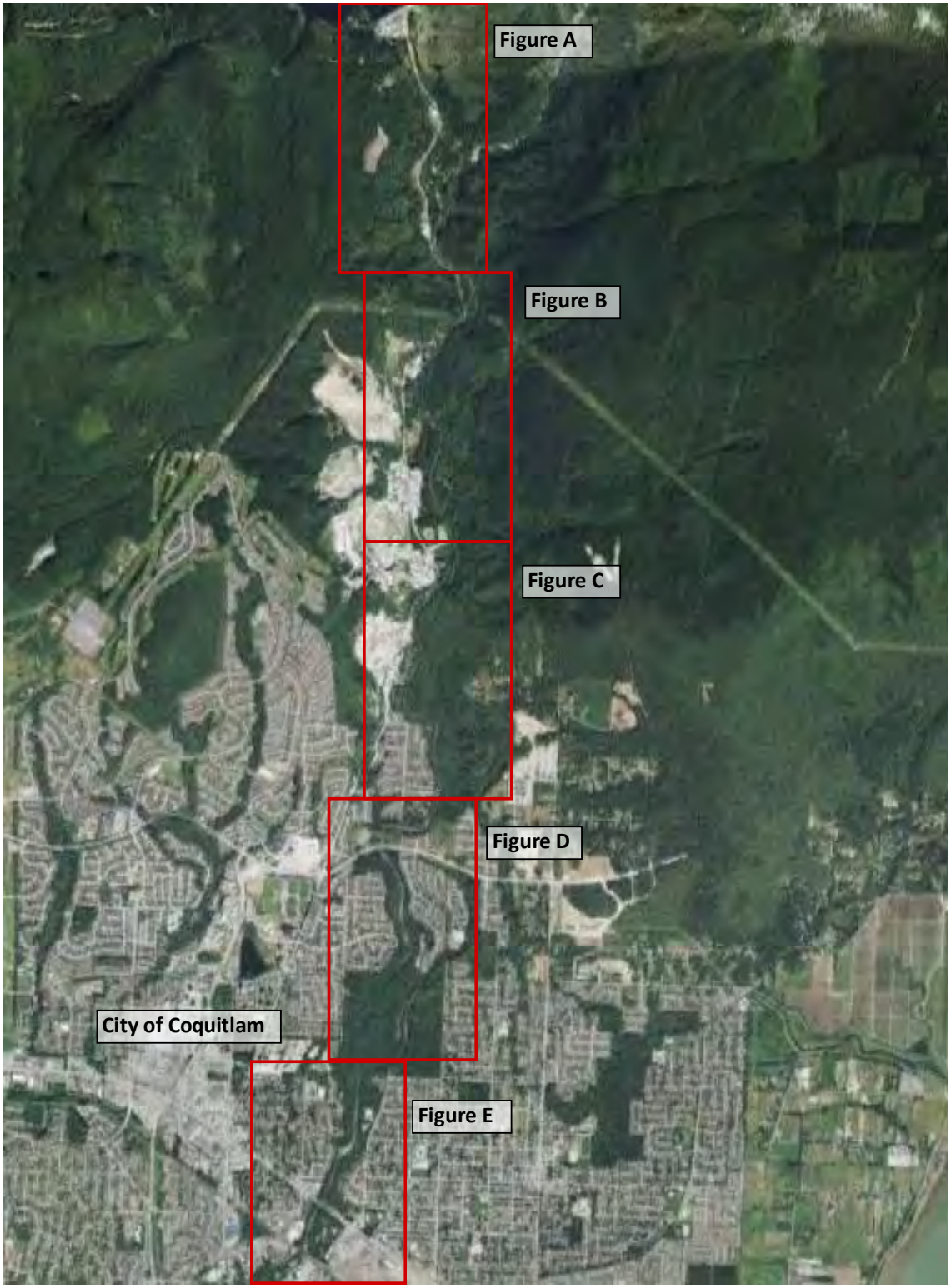
Mortalities	Index Site Code													
	A1	A2	A3	B1	B2	C 1	C2	D1	D2	D3	E1	E2	E3	Total
Coho age 0	0	0	0	0	0	0	0	0	0	0	19	0	2	**21**
	0			**0**		**0**		**0**			**21**			

Unscheduled Rampdowns 2010-2011

Fish Salvaged	A1	A2	A3	B1	B2	C 1	C2	D1	D2	D3	E1	E2	E3	
Coho age 0	99	3	0	0	374		31	27	3	43	25		47	**652**
Coho age 1+		1					1					2		**4**
Chinook Fry										2	1			**3**
Steelhead age 1+							2						8	**10**
TSS												1		**1**
Steelhead age 0					14									**14**
Cotid					1					3			2	**6**
Dace						2							1	**3**
Crayfish						2								**2**
Lamprey							1							**1**
Total	**99**	**4**	**0**	**0**	**389**	**4**	**35**	**27**	**3**	**48**	**26**	**3**	**58**	**696**
Total Site	**103**			**389**		**39**		**78**			**87**			

Mortalities	Index Site Code													
	A1	A2	A3	B1	B2	C 1	C2	D1	D2	D3	E1	E2	E3	Total
Coho age 0	6		0	0	20	0	21	12		1	4		1	**65**
Steelhead age 0					1	3	1							**5**
Total	**6**	**0**	**0**	**0**	**21**	**3**	**22**	**12**	**0**	**1**	**4**	**0**	**1**	**70**
Total Site	**6**			**21**		**25**		**13**			**5**			

Appendix 5 Coquitlam River Rampdown Site Maps



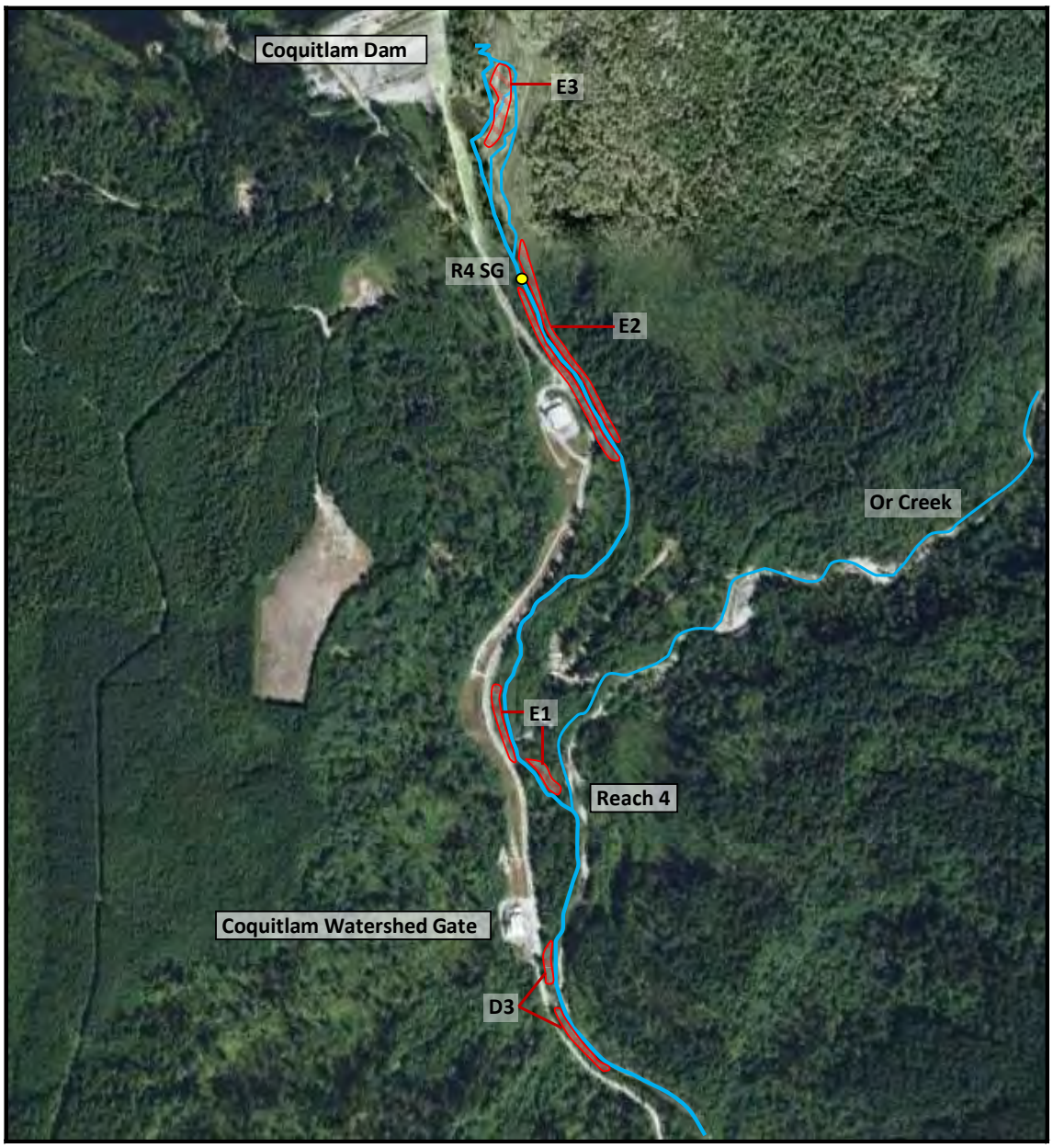


Figure A

Coquitlam River Stranding, Sites D & E, Reach 4 and 3.

Figure B

Coquitlam River Stranding, Site D, Reach 2a & 3.

Figure C

Coquitlam River Stranding, Site C, Reach 2a & 2b.

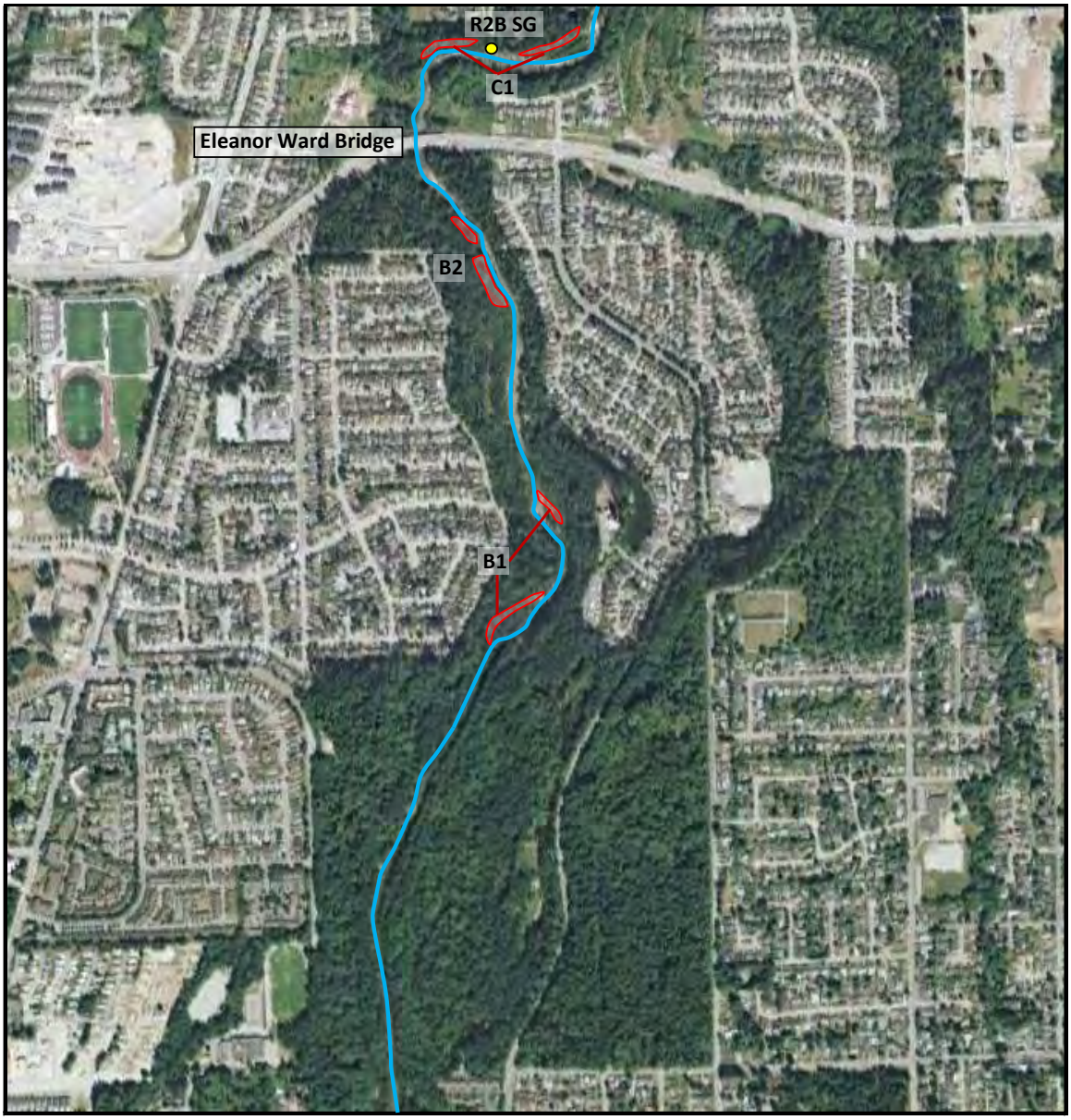


Figure D

0 250 500 750 1000

Coquitlam River Stranding, Site B & C, Reach 2a.

Figure E

Coquitlam River Stranding, Site A, Reach 1.