Coquitlam-Buntzen Water Use Plan

Coquitlam River Rampdown Fisheries Impact Summary

Implementation Year 8

Reference: COQMON #2

Coquitlam River Rampdown Fisheries Impact Summary

Study Period: April 1, 2012 – April 2, 2013

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Executive Summary

This report summarizes rampdown events occurring on the Lower Coquitlam River for the water year April 1, 2012 to April 2, 2013. A total of 9 rampdown events were monitored during the annual survey period: five scheduled rampdowns; April 30, May 28, and August 31 2012, and January 16 and April 2, 2013 and four unscheduled rampdowns; April 23, June 21, August 21 and November 11-12, 2012.

The 2012-2013 water year was the fourth complete year under the treatment 2 flow regime (only half the year in 2008-2009 was under treatment 2). Under treatment 2, rampdowns are more frequent, but of a much smaller scale in terms of total discharge reduction. Additionally, they are predictable due to their scheduled flow reduction dates. The increase in the maximum allowable reservoir stage elevation (from 149m to 155m) was also intended to reduce the need for large scale flow releases and subsequent full river rampdown fisheries impact surveys. In spite of a hoped for reduction in unscheduled spill events, four occurred in the 2012-2013 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 1504 fish, 995 of which were salvaged alive. The four unscheduled rampdown events produced a total of 602 stranded fish, 467 of which were salvaged live and relocated to the river mainstem. The total number of fish stranded for all rampdowns, 2106, was the largest observed since surveys were initiated in 2001. This is the third consecutive year that a high for fish stranding observations has been achieved. The majority of stranded fish (87.4%) observed during fish salvage operations were juvenile coho.

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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 Treatments 1 and 2 has the goal of minimizing the impact of stranding during rampdowns, while maintaining operational feasibility (BC Hydro 2005) (See Table 2). Following completion of the seismic upgrade on Coquitlam Dam in October 2008, a new flow release schedule (Treatment 2) was 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 $3.00m^3s$ and $0.60m^3s$) 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 into Coquitlam River of 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.

The low level outlet (LLO) knife-gate installed at Coquitlam Dam in 2008 will maintain the flow reduction at the same rate as the Treatment 1 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. It is hoped that the increased reservoir capacity will 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 2010). These new sites were identified by their stranding risk characteristics:

River margins with; shallow sloped banks and benches, numerous potholes and depressions, ephemeral channels, porous substrate, and observations of redds, adults or juveniles in habitat.

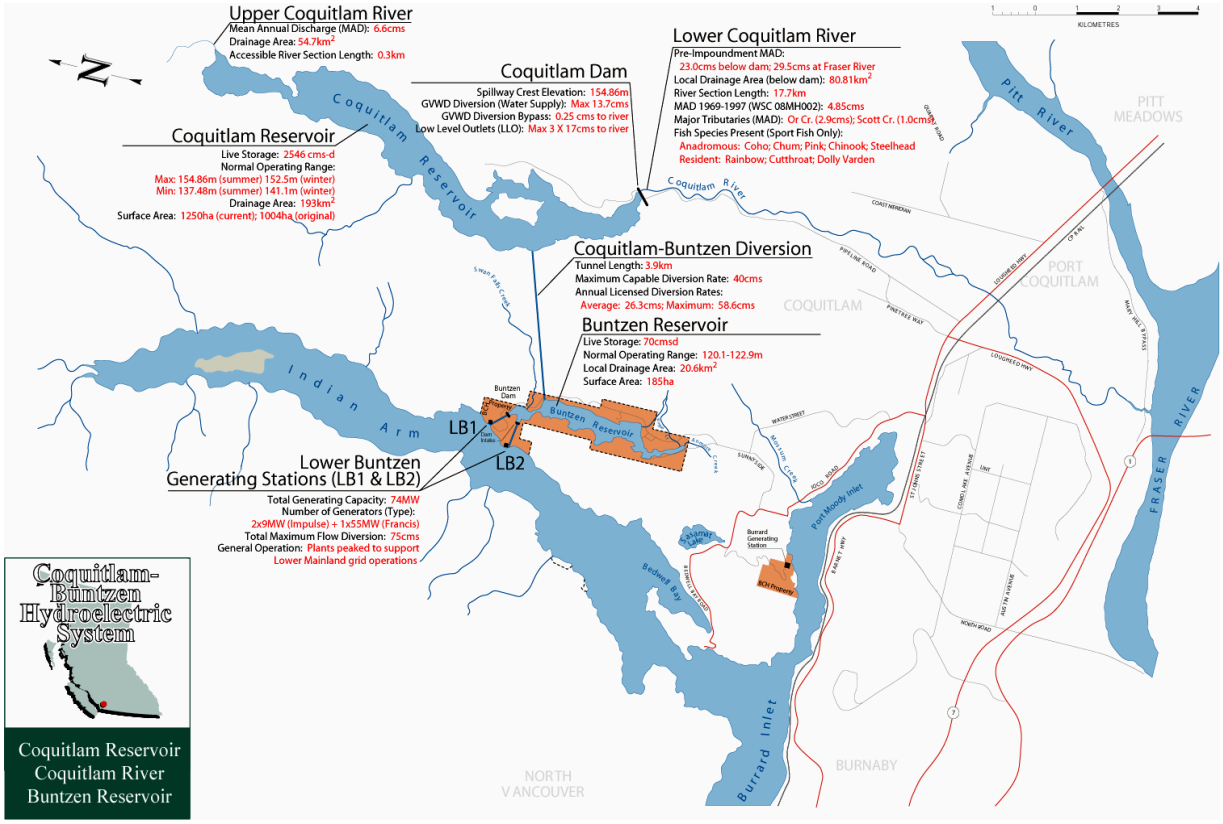

Figure 1 Coquitlam-Buntzen Reservoir, Diversion and Generating System

Due to the size of the study area, some sections of the river have received little investigation. Areas that are not highlighted on the maps in 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 10 years and have been determined by survey crews to have minimal or no stranding risk due to the complete absence of any observed stranding and the stream morphology characteristics of the area therefore, 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 (Sept.-May).
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 the resulting 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. Redd and adult stranding, however, is much less frequent than stranding of juvenile fish.

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 alevin unviable.

Table 1 Coquitlam River flow release schedule under Treatment 1 and 2. *Estimated flow is based on monthly flow transects performed to confirm flow target compliance. Scheduled gate changes occur at the end of each month with the exception of the January 15 date.

Reservoir Diversion Schedule (m^3/sec)						
	Domestic Water		Coquitlam Dam Releases			
				Treatment 2		
Period	Target	Min	Treatment 1	Target	Estimated*	Min
Jan 1-15	11.9	10.7	1.0	5.9	5.9	3.6
Jan 15-31	11.9	10.7	1.0	2.9	2.8	2.9
February	11.9	10.7	1.0	2.9	2.8	1.8
March	11.9	10.7	0.8	4.3	4.1	1.1
April	12.0	10.8	0.8	3.5	3.3	1.1
May	12.0	11	1.0	2.9	2.7	1.1
June	12.0	10.9	1.4	1.1	1.2	1.1
July	18.0	15.8	1.4	1.2	1.3	1.1
August	23.0	20.2	1.1	2.7	2.6	1.1
September	23.0	20.9	0.8	2.2	2.1	1.1
October	12.0	10.8	0.8	6.1	6.1	3.6
November	12.0	10.8	1.1	4.0	4.0	1.5
December	11.9	10.7	1.1	5.0	5.0	2.5

2.0 Methods

During spill reductions, locations susceptible to stranding risk are assessed during daylight hours by crews of between two and four people. Crew size varies depending on the stranding risk associated with a particular rampdown. 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. Therefore, fish stranding numbers presented in this report represent only what is observed in the index sites, not the entire Coquitlam River area. 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 8). Ephemeral side channels that fill during flow releases and drain completely following gate closures are also highly susceptible to stranding (Figure 9). 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 or seine nets. Fish that are observed to be in danger of stranding, but are not yet stranded can be “pushed” or “chased” out of risk areas by survey crews. Another technique employed is the use of shovels to dig out escape channels that open access to the river mainstem, allowing fish a safe passage out of stranding areas. Areas that are difficult to net by hand or are known to strand large numbers of fish are fished overnight with baited minnow traps if warranted.

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 moderates or even eliminates the stage reduction below the confluence. 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 rampdown start and finish time. Contact is maintained throughout the gate changes via cell 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. Release varies depending on reservoir elevation, discharge data shown is assuming a reservoir elevation of 150.0m above sea level.

Gate	Step	Gate Change		
		From	To	Q m^3sec
LLOG1	1	100%	55%	
LLOG1	2	55%	28%	
LLOG1	3	28%	11%	
LLOG1	4	10%	0%	
LLOG2	5	100%	77%	
LLOG2	6	77%	60%	
LLOG2	7	60%	40%	
LLOG2	8	40%	27%	
LLOG2	9	27%	15%	
LLOG2	10	15%	5%	
LLOG2	11	5%	0%	
LLOG3 (Knife Gate Valve)	12	100%	85%	9.5
LLOG3 (Knife Gate Valve)	13	85%	83%	8.8
LLOG3 (Knife Gate Valve)	14	83%	81%	8.5
LLOG3 (Knife Gate Valve)	15	81%	79%	8.3
LLOG3 (Knife Gate Valve)	16	79%	76%	8.1
LLOG3 (Knife Gate Valve)	17	76%	71%	7.9
LLOG3 (Knife Gate Valve)	18	71%	66%	7.7
LLOG3 (Knife Gate Valve)	19	66%	62%	7.3
LLOG3 (Knife Gate Valve)	20	62%	60%	7.0
LLOG3 (Knife Gate Valve)	21	60%	56%	6.6
LLOG3 (Knife Gate Valve)	22	56%	53%	6.2
LLOG3 (Knife Gate Valve)	23	53%	48%	5.9
LLOG3 (Knife Gate Valve)	24	48%	45%	5.5
LLOG3 (Knife Gate Valve)	25	45%	41%	5.1
LLOG3 (Knife Gate Valve)	26	41%	34%	4.8
LLOG3 (Knife Gate Valve)	27	34%	31%	4.1
LLOG3 (Knife Gate Valve)	28	31%	28%	3.5
LLOG3 (Knife Gate Valve)	29	28%	26%	3.2
LLOG3 (Knife Gate Valve)	30	26%	24%	2.8
LLOG3 (Knife Gate Valve)	31	24%	22%	2.6
LLOG3 (Knife Gate Valve)	32	22%	20%	2.4
LLOG3 (Knife Gate Valve)	33	20%	18%	2.2
LLOG3 (Knife Gate Valve)	34	18%	16%	2.0
LLOG3 (Knife Gate Valve)	35	16%	14%	1.8
LLOG3 (Knife Gate Valve)	36	14%	12%	1.6
LLOG3 (Knife Gate Valve)	37	12%	10%	1.4
LLOG3 (Knife Gate Valve)	38	10%	8%	1.2
LLOG3 (Knife Gate Valve)	39	8%	6%	1.0
LLOG3 (Knife Gate Valve)	40	6%	4%	0.6
LLOG3 (Knife Gate Valve)	41	4%	2%	0.5
LLOG3 (Knife Gate Valve)	42	2%	0%	0.3

Dewatered areas are classified according to index sites lettered A-E, including two to three specific rampdown sub-areas in each index site (Appendix 3 & 5). 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 using a GPS 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 which help to ensure a supply of oxygen and a degree of temperature regulation. Fish in these areas are not considered "stranded" and are therefore not included in stranding data

River stage elevation changes are monitored at several staff gauge sites during the course of rampdown events (Appendix 5). Stage reductions are determined by survey crews at approximately hourly visual inspections of staff gauges located in reach 1, reach 4 and reach 2b (Appendix 1 & 2). In February 2013 a staff gauge and transect site was installed in Or Creek. This will allow the survey crew to monitor the discharge in Or Creek during fish salvage operations. Or Creek is the main tributary to Lower Coquitlam River and its flow can greatly influence fish stranding in downstream of it, affecting reaches 3, 2b, 2a and 1. These gauges are monitored from the onset of flow reductions to the end of daily salvage operations. Target flow release from Coquitlam Dam is monitored during each rampdown at a transect established in Reach 4 (Appendix 5, Figure A). 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, 2012

On April 30, 2012 the Low Level Outlet release from Coquitlam Dam was scheduled to be reduced from 3.5cms to 2.9cms. The scheduled rampdown began at approximately 0930hr and was completed by 1100hr. Due to heavy rain at the time of the rampdown, river stage reduction was only evident in Reach 4. River stage elevation dropped approximately 4 centimetres in Reach 4, in contrast, downstream of Reach 4 river stage increased by as much as 25 centimetres (Figure 2, Appendix 1). No fish stranding was observed at all sites surveyed.

Coquitlam Rampdown May 28, 2012

On May 28, 2012 the scheduled flow reduction from Coquitlam Dam was initiated at approximately 1030hr and was completed by 1230hr. The scheduled reduction decreased the flow release from 2.9 m^3sec to 1.1 m^3sec. Reach 4 experienced a significant reduction in river stage during the gate closure. The staff gauge installed in Reach 4 showed a decrease of 16.0 centimetres in total over a two hour period. The majority of this decrease in river elevation occurred during the final gate adjustments when the river stage dropped 8.0cm in less than one hour (Appendix 1).

This rapid drop in river stage elevation and the level to which the river dropped was noted by fish salvage crews in Reach 4, who were operating approximately 400m downstream of Coquitlam Dam. Based on the reading at the staff gauge installed in Reach 4, fish salvage crews determined that the flow release had dropped below the target of 1.1m^3sec. BC Hydro staff at the LLO gate were immediately informed of the flow release discrepancy and its impact on downstream fish habitat. Hydro staff immediately raised the LLO gate to provide more flow as soon as they were alerted to the situation (this was at approximately 1300hr). Unfortunately a problem with the operation of the LLO gate rendered it unable to release sufficient flow into Coquitlam River. The Reach 4 staff gauge rose from .06m to .08m (Table 1) following the failed gate operation, at this point the discharge was still estimated to be under 1.1m^3sec according to the stage discharge curve. BC Hydro staff were eventually able to use an alternate flow release mechanism to deliver sufficient flow into Coquitlam River, and by 1700hr the discharge was at the 1.1 m^3sec target.

A flow transect performed on May 28, following the failed LLO gate flow increase (staff gauge at 0.08m), estimated the discharge from the LLO to be 0.98m^3sec, this is 13% below the flow target of 1.1m^3sec for the month of June. A second flow transect done following the release of water from the alternate source (staff gauge at 0.11m),

estimated the discharge at 1.12m^3sec, within compliance. At its lowest staff gauge reading of 0.06m, which lasted from approximately 1230-1330hr, the stage discharge curve developed for this section of Coquitlam River gives a discharge estimate of between 0.65-0.75 m^3sec

This rapid decrease in river stage lead directly to a large amount of coho fry stranding and mortalities. In total 1456 coho fry were observed to be stranded in all sites surveyed, 584 of which were mortalities (Table 3). This total represents the largest number of stranded fish and the most mortalities ever witnessed during a rampdown on Coquitlam River. The true number is likely to be larger as many isolated areas could not be salvaged or surveyed completely. Over 75% of all stranding was observed in Reach 4 (Table 3).

Stranding in sites downstream of Reach 4 was also evident, over 250 coho fry were observed in Reach 3 and over 125 in Reach 2 (Table 3). River stage dropped approximately 6.0cm in Reach 1 and 5.0cm in Reach 2 over the course of the rampdown.

Coquitlam Rampdown August 31, 2012

On August 31, 2012 the Low Level Outlet release from Coquitlam Dam was scheduled to be reduced from 2.7cms to 2.2cms. The scheduled rampdown began at approximately 1000hr and was completed by 1200hr. River stage reduction throughout Coquitlam River was minimal; 3 centimetres in Reach 4 and approximately 3 centimetres in Reaches 1 through 3. A complete survey of stranding sites in Reach 4 yielded no stranded fry or isolated pools. A total of 5 stranded coho were observed at one site in Reach 2b (Table 3).

Coquitlam Rampdown January 16, 2013

On January 16, 2013 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 1230hr. Upstream of Or Creek in Reach 4, river stage dropped a total of 17.0 centimetres following completion of the flow reduction and had a maximum hourly decrease of 6.0 cm/hr (Appendix 1) Stranding was observed in three locations in Reach 4, one location in Reach 3 and 1 location in Reach 1 (Table 3) In Reach 4, five coho fry and 1 steelhead trout fry were salvaged alive and returned to the river, In Reach 3 one steelhead fry and two tailed frog tadpoles (a blue-listed species) were salvaged alive, and in Reach 1 one steelhead trout fry was salvaged.

Coquitlam Rampdown April 2, 2013

On April 2, 2013 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 0830hr and was completed by 0900hr.

Upstream of Or Creek (Reach 4), river stage dropped a total of two centimetres following completion of the flow reduction and had a maximum hourly decrease of 2.0 cm/hr (Appendix 1). Stranding was observed in two locations in Reach 4, and two locations in Reach 3. In Reach 4, 75 chum fry and 3 coho smolts were salvaged, in Reach 3, 34 chum fry and 2 coho smolts were salvaged alive, there were 3 chum fry mortalities in Reach 3 (Table 3).

The amount of fish stranded for this flow reduction was unusually high, during the previous 4 rampdowns on this date a total of only 1 pink fry has been observed stranded (in 2010). Field staff concluded that the majority of the stranding was only indirectly related to the April 2 flow reduction; in fact, our observations indicate that all of the stranding in Reach 4 was directly related to the 4 week spill in the fall of 2012 (Oct. 16-Nov 14).

On March 9 during an adult steelhead survey field staff noticed a few chum fry stranded in a small puddle of water in Reach 4 in the area just downstream of the Grant's Tomb pool (Figure 11). The presence of fry in this puddle was noted as unusual, as it was situated well above the river level (approximately 10-15 cm), and fry could not have accessed it in February as the flow release is lower than in March (2.9 m^3s as compared to 4.3 m^3s in March). Over two weeks later during another steelhead survey on March 28, field staff noticed even more fry in this small puddle, perhaps a dozen or so, and then on April 2 during the rampdown, there were approximately 75 fry in the puddle. The likely explanation for this is that during the spill in the fall the area where the fry were stranded would have been fully wetted and would have provided adult spawning habitat. In fact, this small, now dry, gravel channel shows the remnants of several redds, all of which are now fully desiccated (Figure 11). The exception is this one small depression where we found the chum fry, therefore, it must have remained wetted all winter, and the conditions in the gravel were sufficient for the eggs laid therein to incubate successfully. Unfortunately, when they emerged from the gravel, they were trapped in an isolated puddle. This would explain how they got there, and the fact that their numbers increased each time we surveyed the puddle.

Table 3 Fish stranding by species, age class and Reach during scheduled rampdowns 2012-2013

			Reach						Stage Reduction (cm)		
Date	**Species**	**Salv/Mort**	**1**	**2a**	**2b**	**3**	**4**	**Total**	**R4**	**R2b**	**R1**
30-Apr-12	n/a	n/a							16	0	0
28-May-12	Co 0	s	5	52		277	536	870	16	7	8
28-May-12	St 1+	s					1	1	16	7	8
28-May-12	Co 0	m		37			468	505	16	7	8
28-May-12	St 1+	m					1	1	16	7	8
31-Aug-12	n/a	n/a									
16-Jan-13	Co 0	s					5	5	17	9	9
16-Jan-13	St 1+	s	1			1	1	3	17	9	9
16-Jan-13	Tld Frog	s				2		2	17	9	9
2-Apr-13	Co 1+	s			2		3	5	2	2	
2-Apr-13	Cm 0	s			34		75	109	2	2	
2-Apr-13	Cm 0	m			3			3	2	2	
			6	**89**	**39**	**280**	**1090**	**1504**			

3.2 Unscheduled Rampdowns

Four unscheduled rampdowns occurred on Coquitlam River during the 2012-2013 monitoring program. One of the three events was a large rampdown from a two LLO gate spill (November 11,12, 2011), the other three were related to regular maintenance issues at the low level outlet gates.

Coquitlam Rampdown April 23, 2012

As part of regularly scheduled Coquitlam Dam maintenance, a trash rack cleaning was scheduled for April 23, 2012. This required the flow release from the dam to be reduced for 24 hours from 3.5cms to 1.1cms.

A total of 259 stranded fish were observed over the course of the rampdown fish salvage. Of this total, 242 were salvaged alive and 17 were mortalities, the majority of stranded fish were coho fry (Table 4). Most stranded fish were recovered from Reach 4 which was the main area impacted by the flow reduction, (Table 4). River stage reduction was highest in Reach 4 where the river dropped by 17.0 centimeters over a five hour period during the rampdown (Appendix 1). Downstream of Reach 4 river stage decreased by approximately 3-5 centimetres, which meant that the risk of fish stranding was minimal for the majority of Coquitlam River.

Coquitlam Rampdown June 21, August 21, 2012

On June 21 and August 21, 2012 a wet test was performed at Coquitlam Dam to test the operational integrity of Low Level Outlet Gate 1, (LLOG1), one of three LLO gates at Coquitlam Dam. On both occasions the work plan called for the gate to be fully opened in the afternoon the day prior to the closure, and then closed the following day according to the prescribed ramp rate.

Both rampdowns began at approximately 0530hr and were completed by 1430hr. All areas of the river experienced a significant reduction in river stage during the gate closures. The staff gauge installed in Reach 4 showed a total decrease in river stage of 66.0 centimetres during the June 21 rampdown and 58.0 centimetres during the August rampdown. During the June gate test, Coquitlam dam flow volume release was reduced to 1.1m^3sec, as compared to 2.7 m^3sec in August, hence the greater reduction in river stage during the June rampdown (Figure 2).

Coho fry dominated the stranding results due to their abundance in the river at the time of the rampdowns. A far greater number of stranded fish were observed during the rampdown of June 21 with 202 total, as compared to 40 observed during the August 21 salvage, (Table 4). The stranding distribution throughout the river was broad, as fish were salvaged in every Reach (Table 4).

The ratio of salvaged fish to mortalities was poor for both rampdowns, of all 242 fish stranded 101 were mortalities, which translates to a mortality rate of 42%. This is well above average compared to the mean mortality rate of 19% for all rampdowns (using 2004-2012 data, Table 6). This high mortality rate is likely related to the volume of the flow release (approximately 14 m^3sec) which raised Coquitlam River Stage approximately 35.0 centimetres below Or Creek, and 66.0 centimetres above (Appendix 1). Despite the fact that river stage reduction was greatest in Reach 4, it did not have the largest number of stranded fish, that distinction went to Reach 2a.

Coquitlam Rampdown November 11-12, 2012

On November 11 and 12, 2012 a rampdown from a spill that been ongoing since October 16, 2012 was initiated at Coquitlam Dam. Commencing at 0800hr on November 11, the first gate was ramped down at the prescribed ramping rate and was completed at approximately 1330hr. The final gate closure on November 12 also began at 0800hr and was completed at 1400hr.

The timing of the spill coincided with peak spawning for Chum and Chinook salmon in Coquitlam River. This, combined with the duration of the spill, (nearly 4 weeks) meant that there was a high risk of redd and adult stranding. Virtually all stranding was observed on the first day as the majority of the flow reduction occurred on November 11. Reach specific river stage dropped a maximum of between 23 and 32 centimetres

over the course of the rampdown on the first day (rainfall caused the river stage to increase later in the day) (Appendix 1). Adult Chum were found stranded in 3 separate areas in Reach 1 and 2a for a total of 37 fish, all were salvaged live and returned to the river. Reach 1 and 2a were also the areas where the majority of redd stranding occurred, as 275 of 300 redds were observed here (Table 4).

The concentration of redd and adult stranding in the Lower Reaches of Coquitlam River was expected. This section of Coquitlam River has the highest density of Chum spawning, as well as having a river morphology that is characterized be many low gradient gravel bars. These gravel bars contain excellent spawning material, therefore when they become wetted, spawning salmon make active use of them.

The remainder of the stranding was dominated by juvenile Steelhead and Coho; a total of 61 were observed stranded with 44 salvaged live and returned to the river (Table 4). In total 101 stranded fish were observed over the two day period, only 1 of which was observed on the second day.

Table 4 Total of salvaged fish and mortalities by Reach for unscheduled rampdown events 2012-2013. Stranded redds are not included in fish stranding totals.

			Reach						Stage Reduction (cm)		
Date	**Species**	**Salv/Mort**	**1**	**2a**	**2b**	**3**	**4**	**Total**	**R4**	**R2b**	**R1**
23-Apr-12	Co 0	s	35				185	220	17	4	6
23-Apr-12	Ch 0	s					2	2	17	4	6
23-Apr-12	Cm 0	s					20	20	17	4	6
23-Apr-12	Co 0	m					12	12	17	4	6
23-Apr-12	Cm 0	m					5	5	17	4	6
21-Jun-12	Co 0	s	8	37	1	37	7	90	65	34	36
21-Jun-12	St 0	s			4	2	2	8	65	34	36
21-Jun-12	St 1+	s		10				10	65	34	36
21-Jun-12	TSS	s			1			1	65	34	36
21-Jun-12	Dace	s			2			2	65	34	36
21-Jun-12	Co 0	m	7	22	11	26	15	81	65	34	36
21-Jun-12	St 0	m	2				3	5	65	34	36
21-Jun-12	St 1+	m		5				5	65	34	36
21-Aug-12	Co 0	s	1	2	6		2	11	58	31	37
21-Aug-12	St 0	s		1	17			18	58	31	37
21-Aug-12	Crayfish	s			1			1	58	31	37
21-Aug-12	Co 0	m			1			1	58	31	37
21-Aug-12	St 0	m			9			9	58	31	37
10-Nov-12	Co 0	s		4	15		6	25	28	26	31
10-Nov-12	St 0	s		15	2			17	28	26	31
10-Nov-12	St 1+	s				2		2	28	26	31
10-Nov-12	Crayfish	s				1	2	3	28	26	31
10-Nov-12	Cm Adult	s	15	22				37	28	26	31
10-Nov-12	Co 0	m		4		2		6	28	26	31
10-Nov-12	St 0	m		9				9	28	26	31
10-Nov-12	St 1+	m		2				2	28	26	31
10-Nov-12	*Redds*	*m*	*250*	*25*	*12*	*8*	*5*	*300*	28	26	31
	Total Stranded		**68**	**133**	**70**	**70**	**261**	**602**			

4.0 Results and Discussion

4.1 Stranding Risk

In this, the fourth full year of rampdown monitoring under Treatment 2 (2012-2013), stranded fish were observed in greater numbers than any previous monitoring year. The total of 2106 stranded fish observed is nearly equivalent to the total of all previous rampdowns combined from 2004-March 2011 (2130 total stranded) and the number of mortalities (644) exceeds the total (303) during the same time period (Table 6). A similar result was also observed in the previous of monitoring (2011-2012, 1924 stranded, 467 mortalities, Table 6), however, year 4 managed to surpass even those numbers. Virtually all of this increase in stranding in the last 2 years is the result of fish salvages in the month of May or early June (including scheduled and unscheduled events), which were responsible for 94% of all stranding observed on Coquitlam River in the 2011-2012 monitoring year and 65.4% in 2012-2013.

The May 31 scheduled flow reduction 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 of Reach 4 may not be significantly impacted at this time of year from a scheduled flow reduction, primarily due to freshet conditions; the flow reduction in Reach 4 is equivalent to 62% of the total flow volume in this section of Coquitlam River. In 2012-2013, 64.2% of all stranding was observed in Reach 4.

Reach 4 is particularly susceptible to stranding during most rampdowns. This area is above the buffering influence of Or Creek, and has only minimal natural inflow. In addition, its entire length is composed of shallow pools, and small channels that attract juvenile fish. Reach 4 is also narrow and confined by berms and roadways along its length, which results in the river stage elevation decreasing more rapidly and to a greater degree than areas downstream of Or Creek, (See Figure 2). Scheduled rampdowns typically see only a small decrease (or a river stage increase depending on rainfall or freshet conditions) in river stage in the areas below Or Creek (Figure 2).

In year 4 the ratio of salvaged fish to mortalities was the second worst on record (Table 6), with a 30.6% mortality rate for all stranded fish observed. This is well above average compared to the mean mortality rate of 19.3% for all rampdowns (using 2004-2012 data). The high mortality rate in year 4 was primarily as a result of the May 31, 2012 rampdown where 506 mortalities were observed, or 78.5% of the 2012-13 total. All fish stranded during the May 31 rampdown were found in Reach 4. Figure 2 shows the difference in river elevation change between Reach 4 and areas downstream during flow reductions. The rapid stage decrease of 16.0cm in approximately 1.5 hours combined with the reduction in stage below the minimum lead directly to the record number of stranded fish and mortalities.

Adult Coho escapement in Coquitlam River is also concentrated in Reach 4. Typically between 65-75% of all Coho spawning occurs in this Reach (Decker et. al. 2012). This heavy spawning concentration, combined with the fact that May represents peak emergence for Coho fry, adds another level of risk for rampdowns at this time of year. The fall 2012 adult coho escapement was one of the largest on record (est 3850 adult coho compared to 2002-2011 average of 1908, Decker et. al. 2012) this fact would result in greater than average numbers of fry in the system, increasing the potential for stranding and mortalities.

The other events that contributed significantly to stranding and mortalities in year 4 were all unscheduled rampdowns that involved significant decreases in the flow released from Coquitlam Dam. Figure 2 shows the large drop in river stage during the June 21, August 21 and November 11-12, 2012 rampdown events. The June and August events both had the largest total river stage elevation decrease of all rampdowns in year 4 (Figure 2, Appendix 1).

On June 21 and August 21, 2012, the increased flow release was required as part of a "wet test", to ensure proper LLO gate function. This called for one LLO gate on Coquitlam Dam to be opened for approximately 20 hours. Though the June and August rampdown had an identical flow release for an identical time period, a greater amount of stranding was witnessed during the June event. Evidence would suggest that this is due to the greater number of coho fry in Coquitlam River in June, Table 3 shows a total of 171 coho fry observed stranded on June 21 compared to only 12 during the August event. In addition, though the flow releases were identical, the June rampdown returned to a flow of 1.1 m^3s and the August event to 2.7 m^3s. This resulted in a greater decrease in river stage in Reach 4 during the June rampdown (Figure2, appendix 1)

Though coho fry were the dominant stranded fish overall in Year 4, during the August 21 rampdown Steelhead fry were observed in the greatest number (Table 4). This could be directly related to the fact that Steelhead emergence was at its peak in the weeks preceding the rampdown, therefore Steelhead fry would be abundant in Coquitlam River during this time of year. Adult steelhead spawning also occurs in Reach 4 but in lower concentrations of between 10-25% of total steelhead spawning for the river. Peak fry emergence for Steelhead fry is in late June through July.

As the results of the spring and summer rampdowns demonstrate, perhaps the strongest determiner of stranding risk on Coquitlam River is the time of year at which a rampdown occurs. Rampdowns that occur in the fall and winter months (September21 – March 21) are the least likely to strand fish. Data on stranding by season given in Table 7 shows that fall and winter rampdowns strand an average of 25 and 14 fish per rampdown respectively, while the average for spring and summer is 229 and 106 fish per rampdown. This seasonal difference is likely due to the reduction of juvenile fish in the system during the fall and winter (compared to spring and summer when literally millions of fry may be present) and possibly colder water conditions in winter which can minimize fish movement (Bustard 2011).

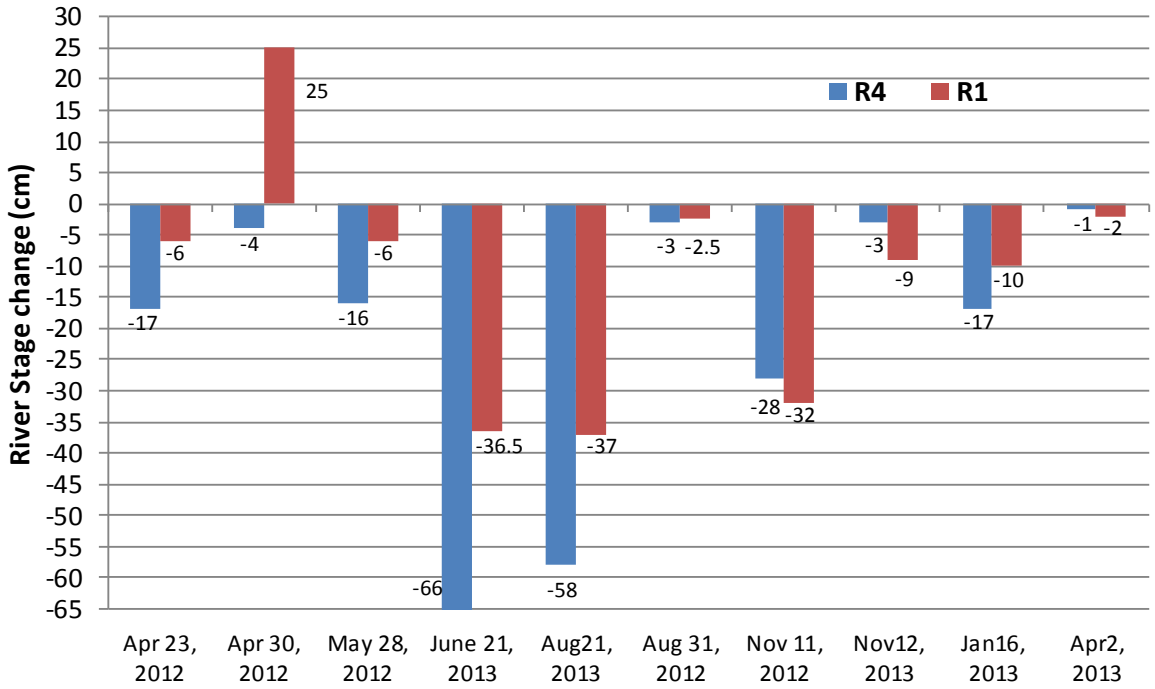

Figure 2 Comparison of Reach 4 with Reach 1 river stage change. Total river stage change during all rampdowns 2012-2013.

Final river stage elevation is also an important contributing factor as rampdowns occurring from October 1 -January 15 (under Treatment 2) have a higher final stage elevation than spring and summer rampdowns. For example, rampdowns in the spring and summer months return to an average flow of 2.3 m^3s respectively, while those in the fall and winter return to an flow of 4.7 m^3s.

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). This compared to the March 31, April 30 and August 31 scheduled rampdowns which have flow volume decreases of 19%, 17% and 19% respectively. However, during periods of low flow in Coquitlam River (mid-late summer) even small reductions in release can have impacts. For example the Sept 1, 2011 rampdown which had a minimal elevation decrease (0.05-0.03 metres depending on Reach), but stranded 98 fish (in 2012 only 5 stranded fish were observed during this scheduled rampdown)

Coho fry have the highest stranding risk 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 are the most likely fish to be stranded over all years, representing 81.1% of all stranded fish between 2004-2013. In Year 4 coho fry represented 86.6% of all stranding observations. Overall, salmonids made up 96% of all stranded fish for the 2004-2013 period (Figure 5).

Figure 3 shows the increase in the past three monitoring years in the amount of fish stranded on Coquitlam River under Treatment 2. This increase has been influenced by a number of factors already outlined, including: the number of rampdown events, seasonal timing of rampdown events, total flow volume decrease, minimum target flow release, as well as survey crews finding more stranding areas and increased efficiency in fish salvage. In the first year under Treatment 2 (2009-2010) fish stranding was reduced, but the results have swung far in the other direction the past three monitoring years (Figure 3).

In Year 4 stranding was again concentrated in the upper reaches of Coquitlam River with the majority (64.2%) in Reach 4 (Table 5). This trend is the opposite of years prior to Treatment 2, which involved solely unscheduled rampdowns (Figure 4), and reflects the prominence of stranding in Reach 4 during scheduled flow reductions. There has been minimal stranding to date in Reach 1 and 2a during scheduled rampdowns (observed on only 3 of 24 scheduled rampdowns to date.

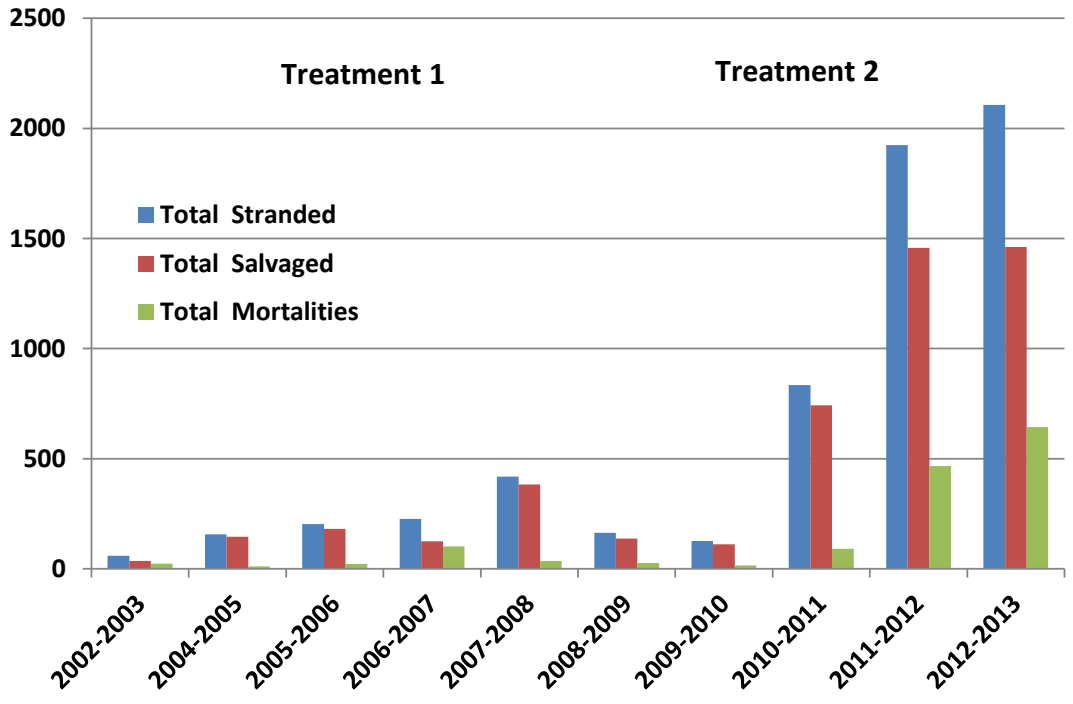

Figure 3 Fish salvaged and mortalities for all rampdowns 2004-2013.

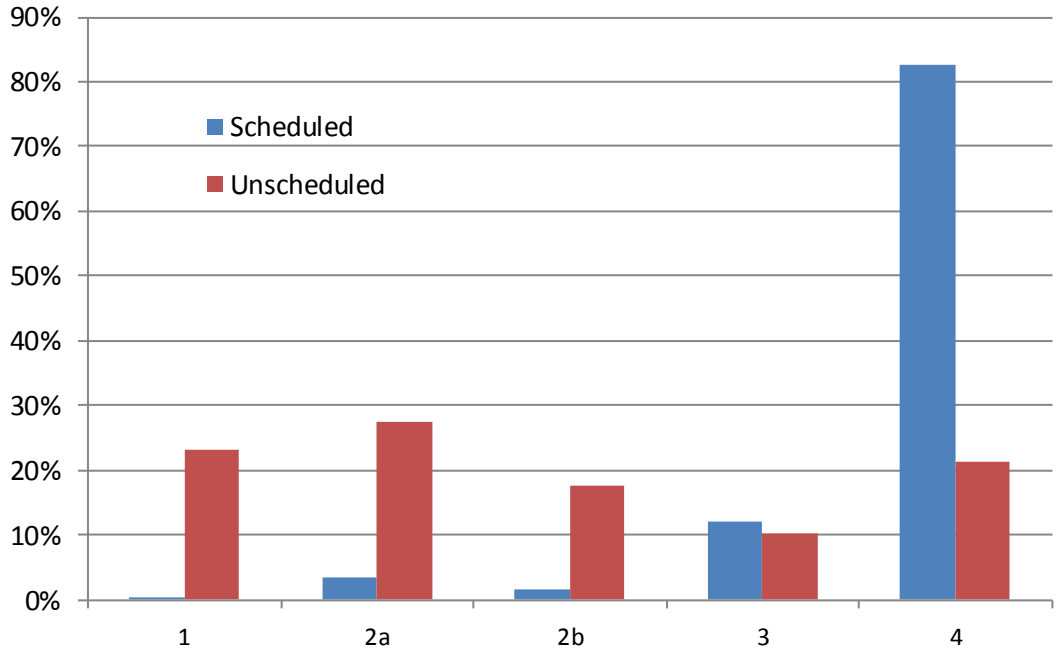

Figure 4 Stranding distribution by Reach, 2004-2013, highlighting the difference between scheduled and unscheduled rampdowns.

Table 5 Species and age class stranding composition by Reach and Site 2012-2013

Index Site Code and Reach							
Species Stranded	**R1**	**R2a**	**R2b**	**R3**	**R4**	**Total**	**% Comp**
Coho Salmon (age 0)	56	158	34	340	1236	1824	86.6%
Coho Salmon (age 1+)			2		3	5	0.2%
Steelhead (age 0)	2	25	32	2	5	66	3.1%
Steelhead (age 1+)	1	17		3	3	24	1.1%
Chinook Salmon (age 0)					2	2	0.1%
Chum Salmon (Age 0)			37		100	137	6.5%
Chum Adult	15	22				37	1.8%
Threespine Stickleback			3			3	0.1%
Longnose Dace			2			2	0.1%
Crayfish			1	1	2	4	0.2%
Tailed Frog				2		2	0.1%
	74	**222**	**111**	**346**	**1351**	**2106**	**100%**
Percentage stranded by reach	**3.5%**	**10.5%**	**5.3%**	**16.4%**	**64.2%**		

Table 6 Yearly site by site comparison of stranded fish during all rampdown events, 2004-2013. T1 = Treatment 1, T2 = Treatment 2

	Site A		Site B		Site C		Site D		Site E		Total	Total	Total	%
Year	Salv	Mort	Salv	Mort	Salv	Mort	Salv	Mort	Salv	Mort	Strand	Salv	Mort	Morts
2012-2013	65	9	143	79	85	24	322	28	847	504	2106	1462	644	30.6%
2011-2012	154	9	164	21	3	11	65	88	1071	338	1924	1457	467	24.3%
2010-2011	103	6	389	21	39	25	78	13	134	26	834	743	91	10.9%
2009-2010	21	0	40	2	0	0	5	0	45	13	126	111	15	11.9%
2008-2009	31	5	33	9	49	12	12	0	13	0	164	138	26	15.9%
2007-2008	67	6	32	11	199	17	20	1	65	1	419	383	36	8.6%
2006-2007	39	14	3	4	47	80	36	4	0	0	227	125	102	44.9%
2005-2006	95	0	0	0	1	9	0	7	85	6	203	181	22	10.8%
2004-2005	75	2	10	0	13	9	0	0	48	0	157	146	11	7.0%
Total	**585**	**42**	**671**	**68**	**351**	**163**	**216**	**113**	**1461**	**384**	**6160**	**4746**	**1414**	**23.0%**
T1	307	27	78	24	309	127	68	12	211	7	1170	973	197	16.8%
T2	343	24	736	123	127	60	470	129	2097	881	4990	3773	1217	24.4%

4.2 Rampdowns and Flow Release Targets

Since the introduction of Treatment 2 there has been no reduction in the total number of unscheduled rampdowns (Table 7). 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, this has not been evident in the past four years of monitoring. Under Treatment 1 Coquitlam River averaged 3.2 unscheduled rampdowns per year, under Treatment 2 the average is 3.6 per year. Of the 18 unscheduled rampdowns since the initiation of Treatment 2, five have been full three LLO gate release rampdowns, the remainder have been due to dam maintenance and for experimental flows designed to attract Kokanee smolt migration.

Flow transects performed throughout the 2012-2013 monitoring year indicate that flow releases from Coquiltam Dam have been consistently within the targeted range throughout the monitoring year; with the exception of the described (in Sec. 3-1) gate malfunction incident of May 28, 2012, and a two day period following the January 16, 2013 flow reduction.

On January 16, 2013, following the completion of gate changes at COQ LLO, two flow transects were taken, one at the Reach 4 site established 300m D/S Coquitlam Dam, and the other in the LLO gate tunnel. These transects produced flow estimates of 2.54 m^3s and 2.55 m^3s. Both of these estimates are below the target range for the Treatment 2 flow release of 2.9 m^3s and outside of the error range of 10%. The following day BC Hydro dispatched a crew to increase the gate elevation in LLO 1 at Coquitlam Dam, this brought the discharge up to the target flow of 2.9m^3s.

Stranding was minimal during the January 16, rampdown (8 stranded fish observed and 2 tadpoles) and it is unlikely that the below target discharge directly resulted in the observed stranding as the river stage elevation was only 1.0 centimetre lower due to the below target flow release. This event contrasts with the May 28, 2012 LLO gate malfunction during which the river stage elevation dropped between 3.0-4.0 centimetres below normal at the most sensitive time of year for stranding.

Table 7 Number of rampdown per year 2001-2013

Monitoring Year	Unscheduled	Scheduled
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
2011-2012	3	5
2012-2013	4	5
	41	**24**

4.3 Fish Productivity Impacts

Stranding influence on fish production in Coquitlam River is likely to be minimal for all species with the exception of coho and possibly steelhead juveniles. For pink and chum fry the impact is negligible. Decker et. al. 2011 reports the estimated average annual outmigrating population for chum and pink fry for the 2003-2011 period is 2,816,900 and 340,000 respectively. Contrast this with a total of 69 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/parr mortalities per year due to rampdowns is 3 and 7 respectively, or less than 0.1% of the estimated population. However, in light of the impacts on coho fry, and to a lesser extent, steelhead fry in the past two monitoring years, there may be cause for concern.

Coho fry populations are typically the hardest hit with respect to stranding, estimates of total fry productivity (based on fall standing stock estimates 2006-2011) range from 21,000 to 105,000 with a mean of approximately 53,000 (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 observed stranded in the 2012-2013 monitoring year, (1826) was compared to the 2011 standing stock estimate (105,200), this would represent approximately 1.8% of the population. This level of loss could have the potential to have an impact on the coho fry population. The impact on Steelhead fry is not quite as dramatic; using the total number observed stranded (66) in the 2012-2013 monitoring year and comparing it to the 2011 standing stock estimate (40,921), gives a potential loss of 0.16% of the population due to stranding.

The estimated 300 chum redds that were stranded following the November 11-12 rampdown do have the potential to make an impact on chum fry production. If we assume that all the redds observed stranded had a full brood of eggs deposited in them, the loss of 300 redds out of a rough estimate of 13,600 redds created (based on 2011 escapement data, 2012 data not available) would amount to a loss of approximately 2.2% of the potential fry production, not an insignificant amount for a single event. However, it is important to note that none of the stranded redds were examined for redds, nor is it likely that all the stranded redds identified contained eggs. Furthermore, the estimate of total redds created is very rough and is based on the assumption that the proportion of males/females is 50% and all that females created only one redd.

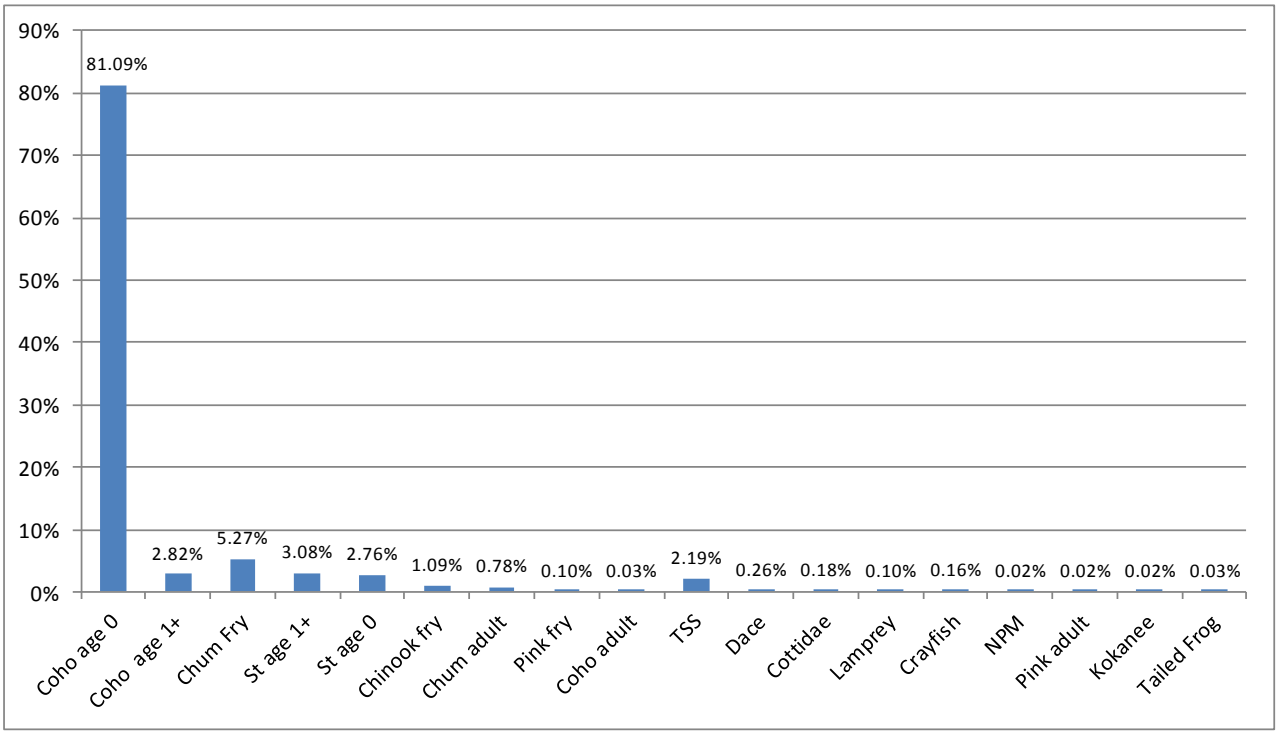

Figure 5 Stranding distribution by species and age class, 2004-2013, all rampdowns.

Table 8 Showing the relationship between seasonal timing and stranding risk all rampdowns, 2004-2013 and 2012-2013. Totals represent stranded salmonids only.

2001-April 2013		Life Stage When Stranded				
Season	Rampdowı	Adult	Fry	Smolt/Parr	Total	Average
Spring (Mar 23-June 22)	19	17	4262	71	4350	229
Summer (June 23-Sept 22)	10	4	980	79	1063	106
Fall (Sept 23 - Dec 22)	16	83	176	141	400	25
Winter (Dec 23 - Mar 22)	12	1	45	120	166	14

2012-2013		Life Stage When Stranded				
Season	Rampdowı	Adult	Fry	Smolt/Parr	Total	Average
Spring (Mar 23-June 22)	4	0	1746	7	1753	438
Summer (June 23-Sept 22)	3	0	223	15	238	79
Fall (Sept 23 - Dec 22)	1	37	57	4	98	98
Winter (Dec 23 - Mar 22)	1	0	5	3	8	8

2001-Oct 2008 (Treatment 1)		Life Stage When Stranded				
Season	Rampdowı	Adult	Fry	Smolt/Parr	Total	Average
Spring (Mar 23-June 22)	2	0	247	55	302	151
Summer (June 23-Sept 22)	2	0	199	64	263	132
Fall (Sept 23 - Dec 22)	7	55	73	102	230	33
Winter (Dec 23 - Mar 22)	7	1	75	95	171	24

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 four years under Treatment 2 only 31.0% of stranded fish have been observed during scheduled rampdowns downstream of Or Creek supports this conclusion at the present time.

Though the majority of stranding (65.4% in 2012-2013), is observed under only one of the scheduled rampdowns (end of May early June flow reduction from 2.9 to 1.1 m^3sec.), it is recommended that all rampdowns continue to be monitored by survey crews during the upcoming monitoring year. The potential for stranding definitely exists, and has been documented on all scheduled rampdown dates, though 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 2012-13 monitoring year with a total of 4 events and 39.9% of all stranding. 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 of Treatment 2, but this has not been the case the past three years.

Stranding sites examined under the previous flow regime have been reevaluated under the new Treatment 2 conditions. The results of the fourth year under Treatment 2 demonstrate that some formerly susceptible areas may now be considered low risk for stranding. Additionally, new areas have been identified during scheduled rampdowns and those new areas 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 ramping rate established under Treatment 2 appears to be effective at minimizing stranding during both scheduled and unscheduled rampdowns with the exception of The May 31 rampdown. The May scheduled rampdown, and rampdowns that occur at the critical time period (Spring- Summer) may need to have their ramp rates reexamined. Certainly the results indicate that the May 31 rampdown could benefit from a more gradual flow reduction. In addition, this particular rampdown should undergo a reassessment of its minimum target flow. The May 31 reduction does not fit the natural hydrograph for the watershed (according to WSC Gauge 08MH141 Coquitlam River above Coquitlam Lake). Flows are normally high and rising during the Month of May and June, but this is not reflected in Reach 4, where instead flows drop significantly. A higher minimum flow target for June would have the potential to prevent a significant amount of stranding.

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 potentially require larger rampdown crews, and a modified ramp rate to ensure that high numbers of juvenile mortalities do not occur.

With respect to the management questions outlined in the introduction, results to date indicate that fish continue to be stranded under the revised ramping rate protocol. In addition, the risk of fish stranding has increased since the introduction of Treatment 2 flow regime despite careful adherence to the ramping protocol. Although fish will

continue to be stranded regardless of ramp rate, 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 rates, minimum flow targets 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.

Summary of Recommendations

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

- Develop reach specific flow transects to estimate the influence of tributary inflow on rampdown fisheries impact surveys. Install a staff gauge in Or Creek and begin to monitor discharge there in order to establish the influence of this tributary on stranding (From 2012 report). **(*A staff gauge to monitor flow in Or Creek during ramp event s was installed in February 2013).***

- The ramp rate for the May 31 flow reduction should be modified to be more gradual. **(*This recommendation was followed up with a modified three day gate closure in from June 3-5, 2013, with very promising results It reduced the mortality rates witnessed in 2011 and 2012 of 24.4% and 36.7% to only 5.0%*).** Future rampdowns for this time period will continue to use the modified gate closure operation due to the successful implementation in 2013. The Coquitlam River Consultative Committee approved this approach when presented with the results in November 2013.

- During scheduled rampdowns fish salvage crews should focus efforts in Reach 4, due to the elevated risk of stranding in this area.

6.0 Literature cited

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

April 30, 2012

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0930	.27	1000	.73	1000	7.95	
1030	.25	1200	.78	1100	7.96	
1300	.24	1300	.81	1200	7.99	
1400	.235	1400	.83	1300	8.05	
1500	.23	1600	.89	1400	8.09	
1600	.23	1715	.93	1600	8.14	
				1800	8.18	
				2100	8.19	
4.0		20.0		24.0		Max Stage Reduction/increase (cm)
2.0		3.5		6.0		Max Stage Reduction/increase (cm/hr)

May 28, 2012

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
1030	.22	1000	.69	1000	7.92	
1120	.18	1200	.66	1100	7.93	
1150	.14	1300	.65	1200	7.89	
1230	.06	1400	.62	1300	7.87	
1330	.08	1600	.62	1400	7.84	
1530	.08	1730	.64	1600	7.84	
1700	.11			1800	7.84	
				2100	7.86	
0.16m		0.07m		0.09m		Max Stage Reduction (m)
9 cm/hr		3 cm/hr		3 cm/hr		Max Stage Reduction (cm)/hr

January 16, 2013

R4 Staff Gauge		R2B Staff Gauge		R1 WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0930	0.40	0930	0.71	1000	7.96	
1030	0.35	1100	0.70	1200	7.94	
1130	0.30	1300	0.65	1400	7.89	
1230	0.24	1430	0.63	1600	7.86	
1330	0.23	1600	0.62	1800	7.86	
1530	0.23			2000	7.86	
	17.0		9.0		10.0	Max Stage Reduction (cm)
	6.0		3.3		3.0	Max Stage Reduction (cm)/hr

April 2, 2013

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge		Or Creek		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0830	.30	0800	.75	1000	no data	0800	0.50	
0930	.29	1000	.75	1100		1000	0.50	
1000	.28	1200	.74	1200		1200	0.50	
1230	.28	1400	.73	1300		1500	0.49	
1330	.28	1600	.73	1400		1630	0.49	
1530	.28			1600				
	2.0		2.0				1.0	Max Stage Reduction (cm)
	2.0		1.0				0.5	Max Stage Reduction (cm)/hr

Appendix 2 Total daily and hourly river stage reductions by staff gauge unscheduled rampdowns.

April 23, 2012

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0800	.31	0800	.81	0900	7.99	
0900	.30	1100	.79	1100	7.97	
1000	.27	1300	.77	1300	7.95	
1100	.22	1500	.77	1500	7.93	
1200	.16	1600	.77	1700	7.94	
1300	.14			1900	7.95	
1600	.14			2100	7.95	
5.0hrs		5.0hrs		6.0hrs		Total time
17.0cm		4.0cm		6.0cm		Total Stage Reduction (m)
3.4cm/hr		0.8cm/hr		1.0cm/hr		Stage Reduction (cm)/hr

June 21, 2012

R4 Staff Gauge		R2B Staff Gauge		WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0500	0.80	0530	1.00	0600	8.22	
0700	0.65	0700	0.96	0800	8.09	
0830	0.49	0930	0.86	1000	8.00	
1000	0.37	1030	0.80	1200	7.94	
1200	0.29	1300	0.74	1400	7.90	
1400	0.19	1530	0.68	1600	7.86	
1500	0.15	1700	0.66	1800	7.86	
1600	0.14			2000	7.88	
	66.0		34.0		36.5	Total Stage Reduction (cm)
	9.0		4.5		6.5	Max Stage Reduction (cm)/hr

August 21, 2012

R4 Staff Gauge		R2B Staff Gauge		R1 WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0500	0.79	0530	0.93	0600	8.12	
0600	0.66	0700	0.83	0800	7.96	
0700	0.54	0845	0.75	1000	7.90	
0800	0.49	1100	0.71	1200	7.87	
1330	0.30	1430	0.63	1400	7.83	
1600	0.21	1700	0.61	1600	7.79	
				1800	7.75	
				2000	7.75	
	58		31		37	Total Stage Reduction (cm)
	13		9		10	Max Stage Reduction (cm)/hr

November 11, 2012

R4 Staff Gauge		R2B Staff Gauge		R1 WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0800	0.62	0800	1.07	0800	8.36	
0900	0.52	1000	0.94	1000	8.33	
1030	0.44	1145	0.82	1200	8.10	
1130	0.38	1400	0.82	1400	8.06	
1330	0.34	1600	0.84	1600	8.04	
1530	0.34			1800	8.06	
				2000	8.09	
	28.0		23.0		32.0	Max Daily Stage Reduction (cm)
	10.0		7.0		13.5	Max Stage Reduction (cm)/hr

November 12, 2012

R4 Staff Gauge		R2B Staff Gauge		R1 WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0800	0.33	0800	0.86	0800	8.12	
0900	0.32	1000	0.84	1000	8.12	
1030	0.31	1200	0.81	1200	8.09	
1200	0.30	1400	0.80	1400	8.05	
1400	0.30	1600	0.80	1600	8.03	
1500	0.30			1800	8.03	
				2000	8.03	
	3.0		6.0		9.0	Max Daily Stage Reduction (cm)
	1.0		2.0		2.0	Max Stage Reduction (cm)/hr

Flow release target table

		Flow Transect Location				
Date	**SG**	**Reach 4**	**Tunnel**	**Target**	**Difference cms**	**Difference %**
28-May-12	0.08	0.98		1.1	-0.1	89%
28-May-12	0.11	1.12		1.1	0.0	102%
19-Jun-12	0.19	1.82		1.1	0.72	165%
19-Jun-12	0.15	1.48		1.1	0.38	135%
21-Aug-12	0.21	2.45		2.7	-0.25	91%
31-Dec-12	0.415		5.8	5.9	-0.1	98%
31-Dec-12	0.415	5.87		5.9	-0.03	99%
16-Jan-13	0.23	2.54		2.9	-0.36	88%
16-Jan-13	0.25		2.55	2.9	-0.35	88%
18-Jan	0.26	2.9		2.9	0	100%
5-Mar-13	0.34	4.63		4.3	0.33	108%
2-Apr-13	0.28	3.44		3.5	-0.06	98%

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

Scheduled Rampdowns

	Index Site Code													
Fish Salvaged	**A1**	**A2**	**A3**	**B1**	**B2**	**C 1**	**C2**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**Total**
Coho Fry							3		4	6	95	573	353	**1034**
Coho parr														**0**
Chinook Fry														**0**
Steelhead Parr												2		**2**
TSS													21	**21**
St Fry									2	1				**3**
Kokanee 1+											1			**1**
Coho adult											1			**1**
Pink Fry													1	**1**
Crayfish													2	**2**
Lamprey														**0**
Total	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**6**	**7**	**97**	**575**	**377**	**1065**
Total Site	**0**			**0**		**3**		**13**			**1049**			

	Index Site Code													
Mortalities	**A1**	**A2**	**A3**	**B1**	**B2**	**C 1**	**C2**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**Total**
Coho Fry							4		17	36	116	170	43	**386**
St Fry							7		4	14				**25**
Crayfish												1		**1**
St Parr											2	1		**3**
Total	**0**	**0**	**0**	**0**	**0**	**0**	**11**	**0**	**21**	**50**	**118**	**172**	**43**	**415**
Total Site	**0**			**0**		**11**		**71**			**333**			

Unscheduled Rampdowns

	Index Site Code													
Fish Salvaged	**A1**	**A2**	**A3**	**B1**	**B2**	**C 1**	**C2**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**Total**
Coho Fry	118	7		2	135			40			7	15		**324**
Chinook Fry	13				21			11						**45**
Chum Fry	13				3									**16**
Dace	2													**2**
Adult pink										1				**1**
cottidae					2									**2**
Lamprey					1									**1**
Total	**146**	**7**	**0**	**2**	**162**	**0**	**0**	**51**	**0**	**1**	**7**	**15**	**0**	**391**
Total Site	**153**			**164**		**0**		**52**			**22**			

	Index Site Code													
Mortalities	**A1**	**A2**	**A3**	**B1**	**B2**	**C 1**	**C2**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**Total**
Coho Fry	8			3	4			16			3	2		**36**
Chinook Fry					1			1						**2**
Chum Fry	1			1	1									**3**
St Fry					11									**11**
NPM		1												**1**
Total	**9**	**1**	**0**	**4**	**17**	**0**	**0**	**17**	**0**	**0**	**3**	**2**	**0**	**53**
Total Site	**10**			**21**		**0**		**17**			**5**			

Appendix 4 Site descriptions and photographs

Reach 1

Site A1: This area is characterized by densely treed and shrubby river margins that contain many depressions that form isolated pools. The substrate is mainly soil and vegetated cover, along with some areas of exposed gravel and cobble.
Total Area: 3800m^2

Figure 6 Site A1 showing gravel bar separating river mainstem (left) with isolated pool (right), following rampdown June 1 2012.

Figure 7 Showing trench dug to allow water from river mainstem to flow into isolated pool.

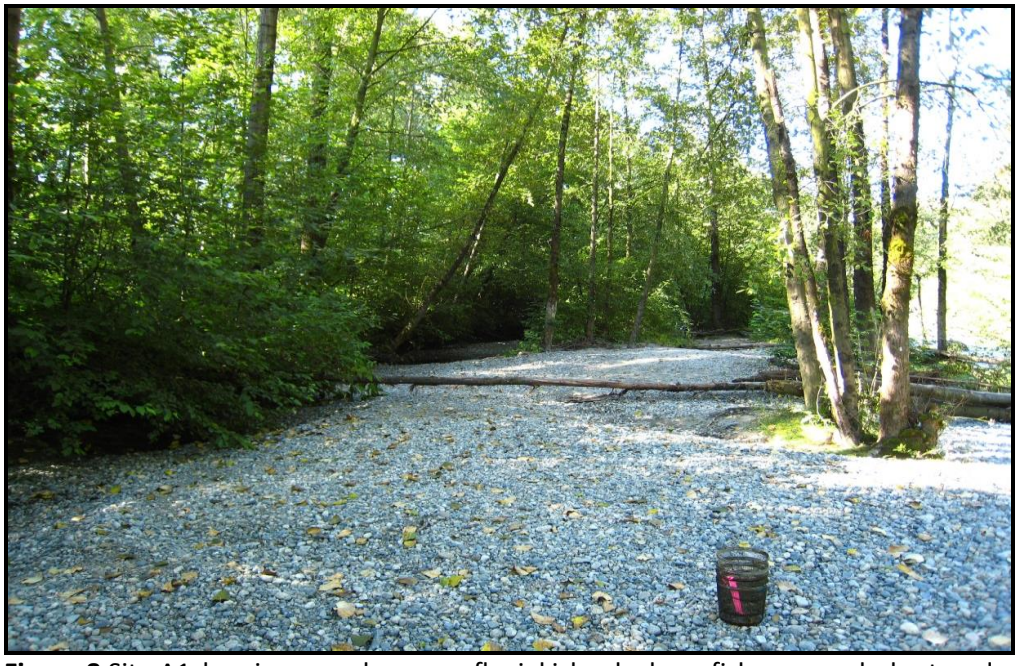

Figure 8 Site A1showing gravel area on fluvial island where fish are regularly stranded

Site A2: These areas are characterized by large expanses of exposed gravel and cobble suitable for spawning adjacent to the river, accompanied by moderately treed areas with numerous depressions that form isolated pools when dewatering. These areas represent a hazard for stranding of both adults, juveniles and redds due to the

combination of off channel habitat and spawning gravel that is wetted during flow releases.
Total Area: 19000m^2

Site A3: This area is primarily a large gravel and cobble fan with gently sloping topography. There are several areas where large isolated pools form during rampdowns.
Total Area: 4800m^2

Site B1: This area is a side channel that is normally wetted except at very low flows (below 3.00cms WSC gauge Port Coquitlam). It is a gravel and cobble substrate, that drains quickly and leaves behind many isolated pools. It rarely completely dewaters, so is only a stranding risks when flow in the river is very low.
Total Area: 270m^2

Site B2: This area is a long narrow partially treed platform with a combined soil, gravel and vegetated substrate. It strands adults, juveniles and redds. This site only becomes inundated during a full three LLO release, and is one of the earliest sites to begin dewatering.
Total Area: 3000m^2

Figure 9 Site B2, showing isolated pool formed during flow reduction, this site strands juveniles, adults and redds. Substrate is primarily mud and soil.

Site C1: This site is a long side channel composed of gravel and cobble substrate. It drains rapidly and forms many isolated pools that do not retain water well. This site experienced the highest number of stranding during the past two years
Total Area: 690m^2

Figure 10 View of site C1 side channel that is wetted during single gate openings. This site typically has the highest incidence of stranding on Coquitlam River.

Site C2: The area is densely covered in shrubs. The substrate is very muddy with vegetated ground cover. Juveniles were regularly stranded in this area until the 2007/2008 rampdown period, which often requires the use of minnow traps for salvage. Morphological changes may have reduced the risk of stranding at this site.
Total Area: 550m^2

Reach 3

Site D1: This area is densely vegetated with trees and shrubs. It is primarily a narrow river margin, with mud and soil substrate.
Total Area: 1000m^2

Site D2: This area is densely vegetated with trees and shrubs. It is primarily a narrow river margin with cobble and boulder substrate and relatively steep banks.
Total Area: 600m^2

Site D3: This area is a short, narrow platform densely grown in with trees and shrubs, it has a combined soil, gravel and vegetated substrate. Isolated pools form during flow reductions, stranding juveniles which are best removed using minnow traps due to the dense concentration of roots within the pools.
Total Area: 665m^2

Reach 4

Site E1: This area is adjacent to a rearing pond that overflows during dam releases. Juveniles spill over the pond and can become stranded. Substrate is mainly cobble and gravel intermixed with moderately treed areas.
Total Area: 1900m^2

Site E2: This area consists of narrow river margins that are densely treed and shrub covered. Many isolated pools form close to the river mainstem during gate closure. Observations over the past 3 years indicate that many of these pools remain wetted year round due to their proximity to the river channel.
Total Area: 1800m^2

Site E3: This area, situated near the dam face, is densely covered in trees and shrubs. Isolated pools are minimal, but juveniles are often caught in the area of dense vegetation during dewatering.
Total Area: 6000m^2

Figure 11 Dry channel isolated puddle where stranded chum fry were observed, April 2, 2013. Site of chum spawning during spill event October 16-November 14, 2012.