Coquitlam-Buntzen Water Use Plan

Coquitlam River Rampdown Fisheries Impact Summary

Implementation Year 10

Reference: COQMON-2

Study Period: May 1, 2014 – April 1, 2015

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Executive Summary

This report summarizes rampdown events occurring on Lower Coquitlam River for the water year May 1, 2014 to April 1, 2015. A total of 9 rampdown events were monitored during the annual survey period: six scheduled rampdowns; May 1, June 1-3, September 1, November 1, 2014, January 15 and April 1, 2015 and one unscheduled rampdown on June 26, 2013, November 12 and December 17-18, 2014

The 2014-2015 water year was the sixth 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 reduction in flow volume. Additionally, they are predictable due to their scheduled operational dates. The removal of the temporary dam safety 149m maximum allowable reservoir operating level in 2008, following commissioning of the new dam, increased reservoir storage and has led to a reduction in the frequency of large scale flow releases and subsequent full river rampdown fisheries impact surveys.

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 six scheduled rampdowns stranded a total of 2736 fish, 2655 of which were salvaged alive. The three unscheduled rampdown events produced a total of 253 stranded fish. The total number of fish stranded for all rampdowns, 2989, was the largest observed since surveys were initiated in 2001. The majority of stranded fish (91.2.%) observed during fish salvage operations were juvenile coho salmon.

Modifications to the June rampdown were initiated in 2013 in order to reduce the increasing number of mortalities and stranding observed during this event. This rampdown alone has been responsible for over 70% of all stranding over the past 6 years due to its timing at the height of coho fry emergence and the large decrease in discharge; dropping from 2.9m^3sec to 1.1m^3sec (a 64% reduction in flow). The modified rampdown method was successful in reducing mortalities from 24.4% and 36.7% in 2011 and 2012 to 4.7% in 2013 and 2.5% in 2014.

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

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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 Water District (GVWD) 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, for electricity generation, located in Indian Arm, Burrard Inlet (Figure 1) (BC Hydro 2005).

The Lower Coquitlam River watershed covers an area of approximately 80 km^2 and has its source at the Coquitlam Dam located within the GVWD 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 3.00 m^3/s and 0.60 m^3/s) 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 Lower Coquitlam Fish Productivity Index (COQMON-7) 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 Normal Maximum Reservoir Operating Level (MROL) depends on the time of year. It is expected that the increased reservoir capacity will reduce the frequency of 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 3 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.

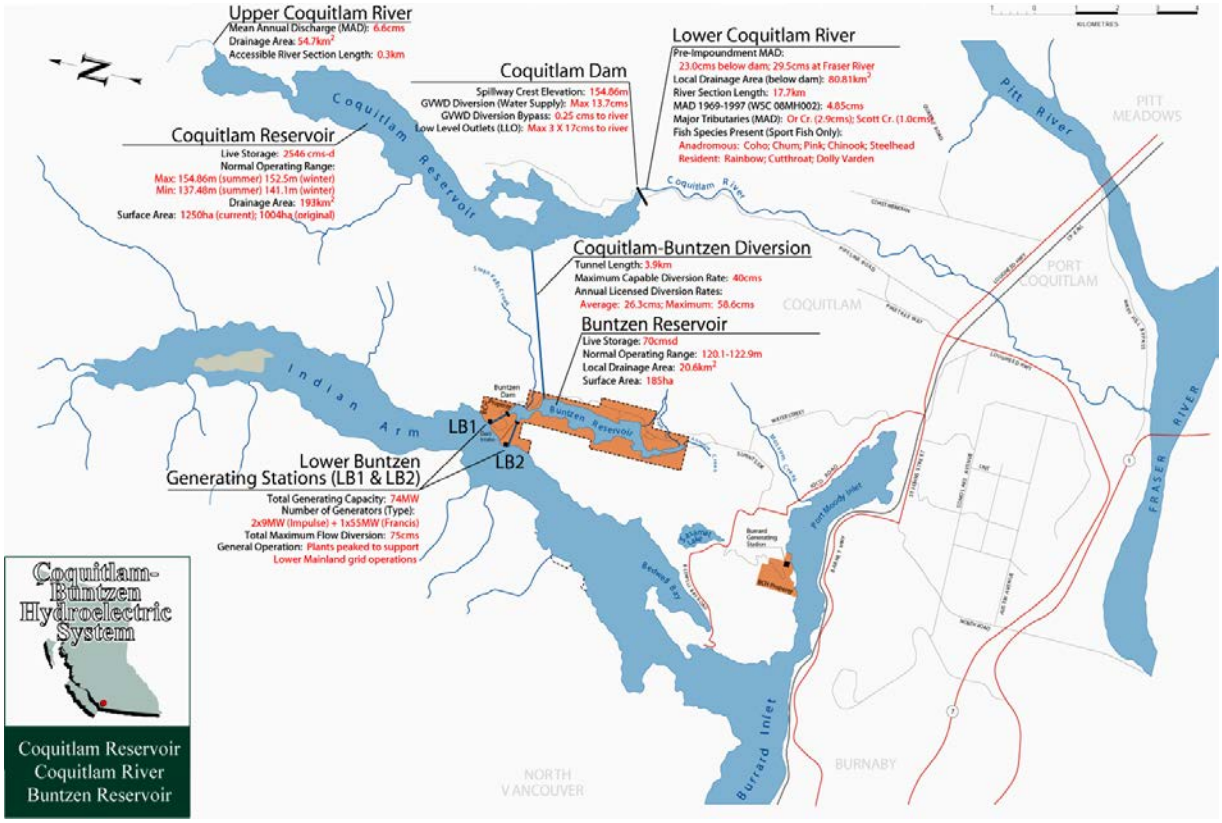

Figure 1 Coquitlam-Buntzen Reservoir, Diversion and Generating System. Map adapted from BC Hydro. Coquitlam-Buntzen Water Use Plan Monitoring Program Terms of Reference Revision 1: December 14, 2006

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 3 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 of the area, 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 and incubation 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 2014-2015. *Estimated flow is based on monthly flow transects performed to confirm flow target compliance. Scheduled gate changes normally occur on the first of each month with the exception of the January 15 flow reduction. Table adapted from BC Hydro. Coquitlam-Buntzen Water Use Plan Monitoring Program Terms of Reference Coquitlam Dam Flow Release Interim Ramping Rate Monitoring. Revision 1: December 14, 2006

		Reservoir Diversion Schedule (m^3/sec)					
		Domestic Water		Coquitlam Dam Releases			
				Treatment 1	Treatment 2		
Month	Year	Target	Min	Target	Target	Estimated*	Min
April	2014	12.0	10.8	0.8	3.5	3.7	1.1
May	2014	12.0	11	1.0	2.9	2.6	1.1
June	2014	12.0	10.9	1.4	1.1	1.1	1.1
July	2014	18.0	15.8	1.4	1.2	1.2	1.1
August	2014	23.0	20.2	1.1	2.7	2.5	1.1
September	2014	23.0	20.9	0.8	2.2	2.0	1.1
October	2014	12.0	10.8	0.8	6.1	6.2	3.6
November	2014	12.0	10.8	1.1	4.0	4.2	1.5
December	2014	11.9	10.7	1.1	5.0	5.1	2.5
Jan 1-15	2015	11.9	10.7	1.0	5.9	5.9	3.6
Jan 15-31	2015	11.9	10.7	1.0	2.9	2.8	2.9
March	2015	11.9	10.7	1.0	4.3	4.6	1.1
April	2015	12.0	10.8	0.8	3.5	3.3	1.1

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. Remote gate operation was added to the Coquitlam Dam Low Level Outlet Gates in September 2013. The gate movements are controlled remotely from BC

Hydro's Real Time Operations Center. Fish stranding assessment and salvage crews co-ordinate activities through the operations center and remain in contact during ramp down operations. . The 1st remotely controlled rampdown was done on November 1, 2013.

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. Steps are implemented at 0.5hr intervals. Adapted from BC Hydro. Generation operating order COQ/LBD 4G-24v5. August 30, 2013

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 2 & 3). 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 3 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 1). 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 3). 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 the Lower Coquitlam River and its flow can greatly influence fish stranding 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 site established in Reach 4 (Appendix 3, 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 2 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 May 1, 2014

On May 1, 2014 in response to the new flow regime (Treatment 2), Low Level Outlet releases from Coquitlam Dam were scheduled to be reduced from 3.5 m^3/s to 2.9 m^3/s The scheduled rampdown began at approximately 0900hr and was completed by 1100hr. Following completion of the flow reduction river stage elevation dropped approximately 2.0 centimetres downstream of Reach 4 and 3.0 centimetres in Reach 4 (Figure 2). No stranding was observed.

Coquitlam Rampdown June 1-3, 2014

From June 1-3, 2014 in response to the current flow regime (Treatment 2), the Low Level Outlet (LLO) release from Coquitlam Dam was scheduled to be reduced from 2.9 m3/s to 1.1 m3/s. In light of high numbers of stranded fish and mortalities during past scheduled flow reductions on this date (June 2011 and 2012), a decision was made to extend the flow reduction over three days instead of performing the entire flow reduction over a single day. It was hoped that a more gradual flow reduction would potentially result in fewer stranded fish, but more importantly fewer mortalities due to stranding. This extended flow reduction period was first attempted in 2013 and was successful in significantly reducing stranding mortality (Figure 3).

The scheduled flow reductions were performed over 3 days, each beginning at approximately 0930hr. June 1st saw the flow decrease from 2.9-2.12 m3/s, flow on June 2nddecreased from 2.12 – 1.55 m3/s and June 3rd saw a decrease from 1.55 – 1.06m3/s. This staggered flow reduction reduced the daily stage elevation drop in Reach 4 dramatically. Flow reductions in 2011 and 2012 for this gate change dropped flow in Reach 4 approximately 16.0 cm in 2-3 hours. The maximum daily river stage reduction this year was 5.5 cm on June 1 and 2, 2014 (Appendix 1).

The act of spreading the flow reduction out over three days appears to have been successful, as the ratio of salvaged fish to mortalities was low. Figure 3 shows the results of the past four scheduled flow reductions on this date. During the June 1-3 rampdown observations of stranded fish reached a single rampdown high of 2713 fish (all coho fry with the exception of 5 Chinook, Table 3), while the mortality rate dropped from 24.4% and 36.7% in 2011 and 2012 respectively to only 3.0% in 2014.

Based on the results of this second attempt at a modified ramping operation, we can conclude that it has been a success. The results again showed a large reduction in the mortality rate, though there was an increase in the total amount of fish stranded. It is recommended that this operational approach to the June scheduled rampdown be repeated in the future.

Coquitlam Rampdown September 1, 2014

On September 1, 2014 LLO releases from Coquitlam Dam were scheduled to be reduced from 2.7 m^3/s to 2.2 m^3/s. The scheduled rampdown began at approximately 0900hr and was completed by 1030hr. Total flow river stage reduction was 2 centimetres in Reach 4 and between 1-2 centimetres downstream of Reach 4 (Figure 2). A total of 7 steelhead fry were salvaged in Reach 2b.

Coquitlam Rampdown November 1, 2014

On November 1, 2014 the LLO release from Coquitlam Dam was scheduled to be reduced from 6.1 m^3/s to 4.0 m^3/s. The scheduled rampdown began at approximately 0945hr and was completed by 1200hr.

River stage elevation downstream of Or Creek dropped approximately 4.0 centimetres following completion of the flow reduction (Figure 2) 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 7.0 cm over the course of the rampdown with an average decrease of 3.0 cm/hr no stranding was observed.

Coquitlam Rampdown January 16, 2015

On January 16, 2014 the LLO release from Coquitlam Dam was scheduled to be reduced from 5.9 m^3/s to 2.9 m^3/s. The scheduled rampdown began at approximately 0930hr and was completed by 1230hr. Upstream of Or Creek (Reach 4), river stage dropped a total of 15 centimetres following completion of the flow reduction and had a maximum hourly decrease of 5.0 cm/hr (Figure 2, Appendix 1). No stranding was observed during this rampdown.

Coquitlam Rampdown April 1, 2015

On April 1, 2015 in response to the current flow regime (Treatment 2), 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 0900hr and was completed by 1030hr.

Upstream of Or Creek (Reach 4), river stage dropped a total of 5.0 centimetres following completion of the flow reduction and had a maximum hourly decrease of 2.0 cm/hr (Table 1). Downstream of Or creek river stage dropped between 2.0 and 3.0 centimetres. Stranding was observed in three locations in Reach 4, one location in Reach 2A and one location in Reach 2B (Table 3). A total of 62 fish were observed to be stranded, with 14 of this number mortality. (Table 3). Two species represented all fish stranded; chum fry with a total of 51 stranded and coho fry with a total of 11.

Following the completion of gate changes, a flow transects was taken, at the Reach 4 site established 300m D/S Coquitlam Dam, This transect produced a flow estimates of 3.58 m^3s, this estimate is within the targeted range for the Treatment 2 flow release of 3.5 m^3s.

Table 3 Fish stranding by species, age class and Reach during scheduled rampdowns 2014-2015. Co 0 = Coho fry. Cm 0 = Chum fry. Pk 0 = Pink fry. St 1 = Steelhead parr/smolt

			Reach						Stage Reduction (cm)		
Date	**Sp**	**Salv/Mort**	**1**	**2a**	**2b**	**3**	**4**	**Total**	**R4**	**R2b**	**R1**
1-May-14	n/a	n/a						0	3	2	2
1-Jun-14	Co 0	s		60	430	323	217	1030	5	3	3
1-Jun-14	Co 0	m				12	9	21			
2-Jun-14	Co 0	s		143	77	52	117	389	4.5	2	2
2-Jun-14	Co 0	m			5	6	11	22			
3-Jun-14	Co 0	s	853	84	122		117	1176	5.5	4	3
3-Jun-14	Co 0	m	24					24			
3-Jun-14	Ck 0	s	5					5			
1-Sep-14	St 0	s			7			7	3	2	2
1-Nov-14	n/a	n/a							7	4	4
15-Jan-15	n/a	n/a									
1-Apr-15	cm 0	s		12	17		11	40	5	3	2
1-Apr-15	Co 0	s		2	6			8			
1-Apr-15	cm 0	m			7		4	11			
1-Apr-15	Co 0	m			3			3			
Total Stranded			**882**	**301**	**674**	**393**	**486**	**2736**			
Salvaged			**858**	**301**	**659**	**375**	**462**	**2655**			
Mortality			**24**	**0**	**15**	**18**	**24**	**81**			

3.2 Unscheduled Rampdowns

Three unscheduled rampdown occurred on Coquitlam River during the 2014-2015 monitoring program.

Coquitlam Rampdown June 26, 2014

As part of regularly scheduled Coquitlam Dam maintenance, a trash rack cleaning was scheduled for June 26-27, 2014. In order for the maintenance to be performed the target flow release from the Coquitlam Dam LLO gate needed to be diverted to the Metro Vancouver fish valve. During this flow transfer there is a possibility of: a) the fish valve not being able to provide enough flow to meet the June target of 1.1 m3/s due to malfunction, and b) flow transfer mistiming leading to a brief decrease in the river stage elevation downstream. To monitor any potential mishap a fish salvage crew was on site to survey the river for any fish stranding and estimate the discharge.

The initial June 26, 2014 flow transfer from the LLO gate to the Metro Vancouver fish valve saw the river stage elevation drop by 0.5 centimetres. The flow release estimate following the transfer was 1.21 m3/s, which is within the target range. This barely perceptible change still managed to strand some fish as 33 coho fry were salvaged in Reach 4.

The following day, June 27, the flow transfer was repeated in reverse, with the LLO gate opened simultaneously as the fish valve was closed. During this transfer the flow from both sources did not overlap as planned, which resulted in a brief 20 minute period where the river stage dropped rapidly in Reach 4. The stage elevation went from 11 centimetres to 5 centimetres over a period of 20 minutes which resulted in some stranding in Reach 4. A total of 95 coho fry were observed to be stranded, 22 of which died as a result. Fortunately the reduction was brief and any stranded fish not observed during this rampdown were quickly inundated and out of danger. Future flow transfers will have to be managed so that they overlap in order to avoid a repeat of this situation.

It is estimated that the discharge during this 20 minute window fell to approximately $0.70m^3sec$. Following the resumption of full flow release the river stage elevation returned to 11 centimetres with a flow transect estimating the discharge at 1.37 m3/s.

Coquitlam Rampdown November 10-11, 2014

On November 10 and 11, 2014 a rampdown from a spill that had been ongoing since November 4, 2014 was initiated at Coquitlam Dam. Commencing at 0900hr on November 10, the first two of the three LLO gates open were ramped down at the prescribed ramping rate which was completed at approximately 1530hr. The final gate

closure on November 11 also began at 0900hr and was completed at 1500hr. (see Table 2 and 3 for river stage elevation reduction during rampdown).

The timing of the spill coincided with peak spawning for Chum salmon in Coquitlam River. This, combined with the duration of the spill, (1 week) meant that there was a high risk of redd and adult stranding.

Adult Chum were found stranded in 3 separate areas in Reach 1 and 2a for a total of 18 fish, all were salvaged live and returned to the river with the exception of one fish. Reach 1 and 2a were also the areas where the majority of redd stranding occurred, as 13 of 17 redds were observed here (Table 4). The remainder of the stranding was dominated by juvenile Steelhead and Coho; a total of 26 were observed stranded with 16 salvaged live and returned to the river (Table 4). In total 58 stranded fish were observed over the two day period.

Reach specific river stage dropped a maximum of between 69 and 50 centimetres over the course of the rampdown on the first day and between 18 and 9 centimetres on day two (Appendix 1).

Coquitlam Rampdown December 16-17, 2014

On December 17 and 18, 2014 a rampdown from a spill that had been ongoing since December 11, 2014 was initiated at Coquitlam Dam. Commencing at 0830hr on December 17, the first two of the three LLO gates open were ramped down at the prescribed ramping rate which was completed at approximately 1530hr. The final gate closure on December 18 also began at 0830hr and was completed at 1400hr.

Stranding was observed in all reaches with the exception of Reach 3. A total of 67 fish were observed stranded over the two day rampdown period, with 54 mortalities and 13 salvaged alive and returned to the river. Reach 1 and 2a were the areas where the majority of the stranding occurred, with 39 of 67 fish (58%) stranded here (Table 1). Stranding was dominated by Steelhead fry, 47 of 67, 70%; 10 coho fry and 9 steelhead smolts, one longnose dace was also observed. No adult salmon or redds were found stranded in any areas of Coquitlam River. Coho salmon would have been the only adult species susceptible to stranding as all other species had finished spawning at this point in the year. Reach specific river stage dropped a maximum of between 55 and 34 centimetres over the course of the rampdown on the first day and between 1 and 7 centimetres on day two (Appendix 1).

Table 4 Fish stranding by species, age class and Reach during unscheduled rampdowns 2014-2015. Co 0 = Coho fry. Cm 0 = Chum fry. Pk 0 = Pink fry. St 1 = Steelhead parr/smolt

			Reach						Stage Reduction (cm)		
Date	**SP**	**Salv/Mort**	**1**	**2a**	**2b**	**3**	**4**	**Total**	**R4**	**R2b**	**R1**
26-Jun-14	Co 0	s					33	33	0.5	0	0
26-Jun-14	Co 0	s					73	73	6.0	0	0
26-Jun-14	Co 0	m					22	22			
10-Nov-14	Co 0	s	4	7				11	69	50	65
10-Nov-14	St 0	s					2	2			
10-Nov-14	Co 0	m		3		2		5			
10-Nov-14	St 0	m		1				1			
11-Nov-14	St 1+	s		2			1	3	18	9	11
11-Nov-14	Cm Adult	s	16	1				17			
11-Nov-14	TSS	s	1					1			
11-Nov-14	Crayfish	s		3				3			
11-Nov-14	Lamprey	s	10					10			
11-Nov-14	St 1+	m		3	1			4			
11-Nov-14	Cm Adult	m		1				1			
11-Nov-14	Redds		11	2			4	17			
17-Dec-14	n/a								66	41	59
18-Dec-14	Co 0	s					2	2	66	41	59
18-Dec-14	St 0	s	4		4			8	66	41	59
18-Dec-14	St 1+	s	1				2	3	66	41	59
18-Dec-14	Co 0	m		3	3		2	8	66	41	59
18-Dec-14	St 0	m	11	17	11			39	66	41	59
18-Dec-14	St 1+	m	1	1			4	6	66	41	59
18-Dec-14	Dace	m		1				1	66	41	59
Total Stranded			**48**	**43**	**19**	**2**	**141**	**253**			
Salvaged			**36**	**13**	**4**	**0**	**113**	**166**			
Mortality			**12**	**30**	**15**	**2**	**28**	**87**			

4.0 Discussion

4.1 Stranding Risk

In this, the sixth full year of rampdown monitoring under Treatment 2 (2014-2015), the total of 2989 stranded fish observed was the largest amount since surveys were initiated in 2001, Table 5. As has been the case since Treatment 2 was initiated, the majority of stranding in Coquitlam River is the result of fish salvages occurring in the month of May or early June (including scheduled and unscheduled events). Of these events, the scheduled June 1 flow reduction has been by far the main contributor to fish stranding. This one rampdown has been responsible for 72% of all stranding observed on Coquitlam River in the past four years and in 2014-2015 was responsible for 89% of all stranding.

Adult Coho escapement in Coquitlam River is also concentrated in Reach 4. Typically between 65-75% of all Coho spawning occurs in this Reach (Shick et. al. 2014). This heavy spawning concentration, combined with the fact that May and June represent peak emergence for Coho fry, adds another level of risk for rampdowns at this time of year.

The June flow adjustment of 2.9 m^3/s to 1.1 m^3/s represents a significant loss of flow volume and river stage in the uppermost reach of Coquitlam River. While areas downstream of Reach 4 may or may not be significantly impacted at this time of year from a scheduled flow reduction (depending on freshet and local rainfall), Reach 4 is always very vulnerable. The June flow reduction in Reach 4 is equivalent to 62% of the total flow volume in this section of Coquitlam River. Reach 4 is above the buffering influence of Or Creek, and has virtually no 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 an increase depending on rainfall or freshet conditions) in river stage in the areas below Or Creek.

In years 3 & 4 of Treatment 2 the ratio of salvaged fish to mortalities was the second and third worst on record (Table 6), with a 30.6% and 24.3% mortality rate for all stranded fish observed. This is well above average compared to the mean mortality rate of 15.9% for all rampdowns (using 2004-2015 data, Table 5). The high mortality rate in years 3 and 4 was primarily a result of the scheduled June rampdown. The ramping rate established for the June flow reduction called for the entire LLO gate operation to be done in 2 hours which can result in a rapid decrease of river stage, approximately 15.0-16.0cm in this short period of time.

In light of high numbers of stranded fish and mortalities during past scheduled flow reductions on this date, a decision was made to modify the rampdown by extending the flow reduction over three days. It was calculated that a more gradual flow reduction would result in fewer stranded fish, and more importantly, fewer mortalities due to stranding.

The act of spreading the flow reduction out over three days appears to have been successful in reducing the mortality rate but not the total amount of fish stranded. The reduction in mortality indicated in Figure 3 shows the impact of the past two scheduled flow reductions on this date. The mortality rate dropped from 24.4% and 36.7% in 2011 and 2012 to only 4.5% in 2013 and 5.6% in 2014 (Table 5). However, the number of fish stranded during the June rampdowns has risen over the same period. Table 6 shows the increase in stranding since 2012 for the June rampdown, though it is important to note that this increase may be completely independent of the ramp rate and may be more closely correlated to – for example – the amount of coho fry present in Coquitlam River. Nevertheless, this does illustrate that regardless of the ramp rate, stranding of coho fry during the June rampdown will continue to be an issue under the current flow regime.

As discussed, the fact that the June rampdown reduces the flow release to Coquitlam River by 62% at a sensitive time appears to be the central cause of stranding. In addition, the fact that the flow reduction reduces the discharge to a yearly low of 1.1 m^3/s is likely problematic. Salmon fry depend on spring freshet conditions to provide an increase in flow to accommodate migration within and from their natal grounds (Hartman, 1982). At this time of year the natural flow pattern for streams and rivers in the South Coast region is an increase in discharge, not a severe and rapid reduction. Therefore, the June rampdown represents the opposite of the conditions that migrating fry depend on for survival.

The total decrease in river volume in Reach 4 is high during the January 15, June 1 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 of 0.04-0.03 metres depending on Reach, but stranded 98 fish primarily due to below average flow in Coquitlam River at the time of the flow reduction. Stranding during this rampdown has only been witnessed on one other occasion, with 7 stranded fish observed in 2014 (Table 5).

Table 5 Yearly site by site comparison of stranded fish during all rampdown events, 2004-2015. T1 = Treatment 1, T2 = Treatment 2

	Reach 1		Reach 2a		Reach 2b		Reach 3		Reach 4		Total	Total	Total	%
Year	Salv	Mort	Salv	Mort	Salv	Mort	Salv	Mort	Salv	Mort	Strand	Salv	Mort	Morts
2014-2015	895	36	314	30	663	29	375	20	575	52	2989	2822	167	5.6%
2013-2014	0	0	318	12	0	0	428	5	300	32	1095	1046	49	4.5%
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	**1545**	**87**	**1446**	**189**	**1099**	**216**	**1341**	**166**	**3183**	**972**	**10244**	**8614**	**1630**	**15.9%**
T1	307	27	78	24	309	127	68	12	211	7	1170	973	197	16.8%
T2	1238	60	1368	165	790	89	1273	154	2972	965	9074	7641	1433	15.8%

Other flow reductions where widespread stranding was observed was the April 1, 2015 rampdown and all three unscheduled rampdowns (Table 3 & 4) The April 1 scheduled rampdown occurs at the peak of chum and pink fry emergence when millions of these fry are in the river, many congregating in shallow margins along the river banks which elevates the stranding risk. However, despite the presence of large numbers of fry during these two flow reductions, stranding is nowhere near as problematic as the June 1 flow reduction. Typically pink and chum fry migrate almost immediately from Coquitlam River following emergence, whereas coho fry remain in the river. This fact likely plays a significant role in reducing the risk of stranding for chum and pink fry.

Table 6 Stranding with daily totals for the June rampdown 2011-2015.

	Day 1	Day 2	Day 3	Total
2011	1355			1355
2012	1377			1377
2013	171	396	400	967
2014	1051	411	1205	2667
2015*	1259	2404		3704

As the results of the spring and summer rampdowns demonstrate, a strong 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 (September 21 – March 21) are the least likely to strand fish. Data on stranding by season given in Table 8 shows that fall and winter rampdowns strand an average of 27 and 15 fish per rampdown respectively, while the average for spring and summer is 332 and 76 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).

Table 7 Species and age class (salmonids only) stranding composition by Reach 2014-2015

Species stranded	R1	R2a	R2b	R3	R4	Total
Coho (age 0)	881	302	646	395	503	2727
Steelhead (age 0)	15	18	22		2	57
Steelhead (age 1+)		6	1		7	14
Chum (age 0)		12	24		3	39
Chinook (age 0)	5					5
Total Stranded by reach	**901**	**338**	**693**	**395**	**515**	**2842**
Percentage stranded by reach	**31.7%**	**11.9%**	**24.4%**	**13.9%**	**18.1%**	

Table 8 Stranding results of scheduled rampdowns since the introduction of Treatment 2.

		Scheduled Rampdowns								
Date	**Status**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Total**
15-Jan	Salvaged	-	0	0	0	5	10	0	0	**15**
	Mortality	-	0	0	0	2	10	0	0	**12**
01-Apr	Salvaged	-	0	0	0	1	129	28	48	**206**
	Mortality	-	0	0	0	0	15	0	14	**29**
01-May	Salvaged	-	0	0	-	0	100	0	95	**195**
	Mortality	-	0	0	-	0	3	0	21	**24**
01-Jun	Salvaged	-	20	55	1355	1377	967	2600		**6374**
	Mortality	-	0	19	331	506	46	67		**969**
01-Sep	Salvaged	-	0	0	98	0	0	7		**105**
	Mortality	-	0	0	82	0	0	0		**82**
01-Nov	Salvaged	0	0	11	0	0	0	0		**11**
	Mortality	0	0	2	0	0	0	0		**2**

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 discharge of 2.3 m^3/s respectively, while those in the fall and winter return to a discharge flow of 4.7 m^3/s. The higher discharge results in an elevated river stage which can keep areas vulnerable to stranding wetted.

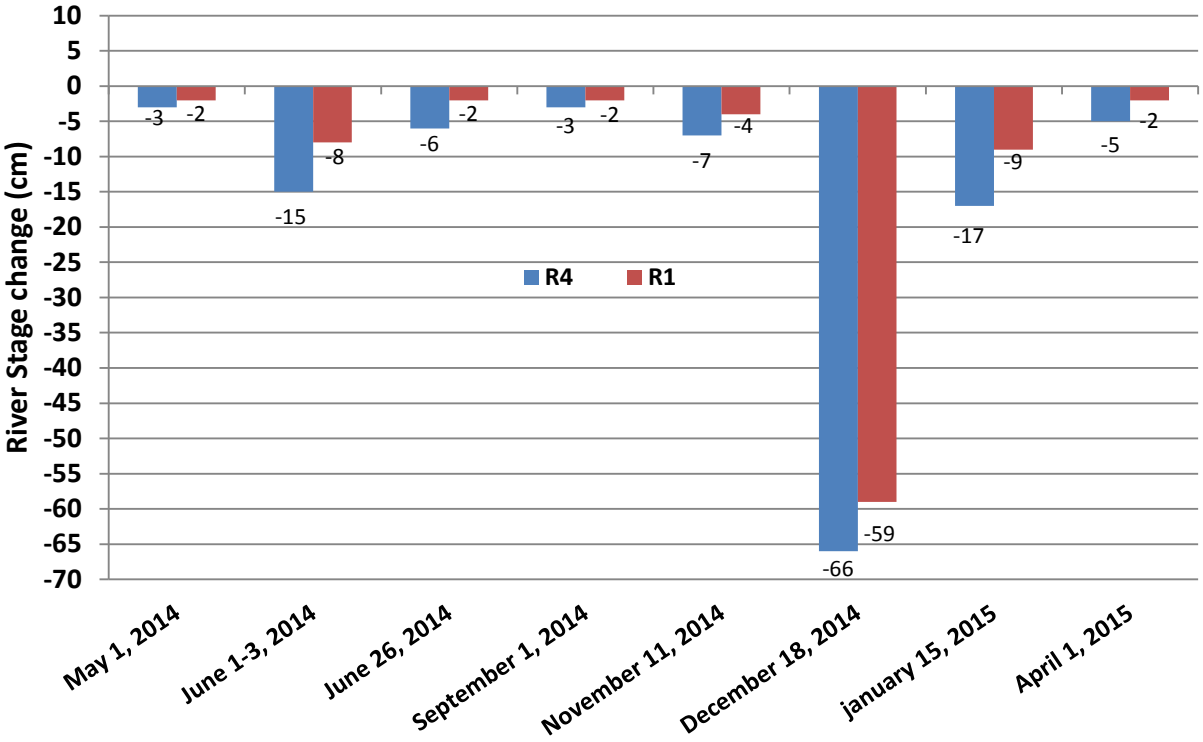

Figure 2 Comparison of Reach 4 with Reach 1 river stage change. Total river stage change during all rampdowns 2014-2015.

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 the entire study period, representing 85.75% of all stranded fish between 2004-2015 (Figure 5). In Year 6 coho fry represented 93.6% of all stranding observations. Overall, salmonids accounted for 96% of all stranded fish for the 2004-2015 period (Figure 5).

Table 9 Showing the relationship between seasonal timing and stranding risk all rampdowns, 2001-2015. Totals represent stranded salmonids only.

2001-April 2015		Life Stage When Stranded				
Season	# Rampdowns	Adult	Fry	Smolt/Parr	Total	Average
Spring (Mar 23-June 22)	25	17	8184	89	8290	332
Summer (June 23-Sept 22)	13	4	925	64	993	76
Fall (Sept 23 - Dec 22)	21	83	283	197	563	27
Winter (Dec 23 - Mar 22)	12	1	53	121	175	15

Figure 3 illustrates the increase in the past few 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 four monitoring years (Figure 3). In addition, during the first year under Treatment 2, the flow releases from the LLO gate at Coquitlam Dam were approximately 20-40% over the target due to a miscalculation in the stage discharge curve at the LLO gate. Therefore, there was consistently more water and a higher river stage in Coquitlam River, likely leading to less stranding as a result.

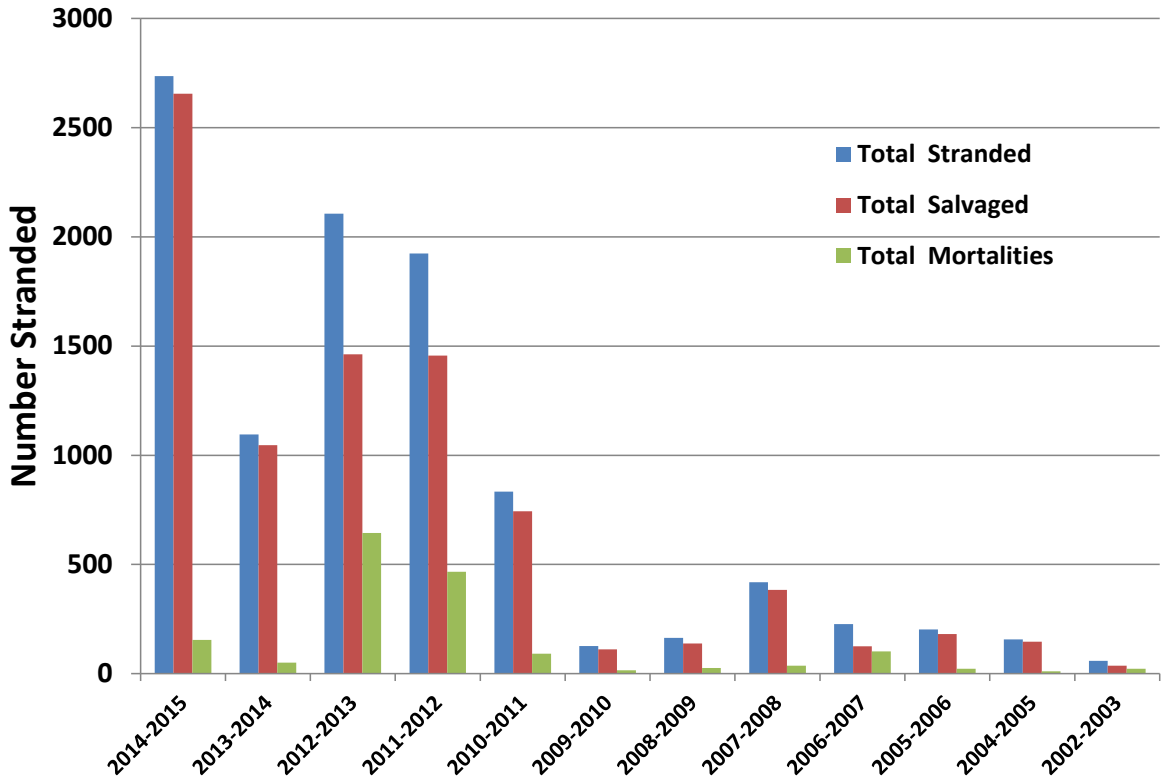

Figure 3 Number of fish salvaged and mortalities for all rampdowns 2002-2015.

In Year 6 stranding was concentrated in the lower reaches of Coquitlam River for the first time since Treatment 2 was initiated, with Reach 1 accounting for 31.7% of all stranding (Table 6). This trend is the opposite of prior years under Treatment 2 as Reach 3 and 4 normally see 50-70% of all stranding. Prior to 2014-15 there had been only minimal stranding in Reach 1 and 2a during scheduled rampdowns. Stranding has been observed on only 5 of 36 scheduled rampdowns to date in these two Reaches. However, it is important to note that the increase in stranding in Reach 1 is entirely due to the June 1 flow reduction. The majority of unscheduled rampdowns involve large flow

releases, often seeing flow reductions of all 3 LLO gates on Coquitlam River which can release up to 40-45 m^3/s of water per second, therefore the stranding impact tends to extend to the entire river length.

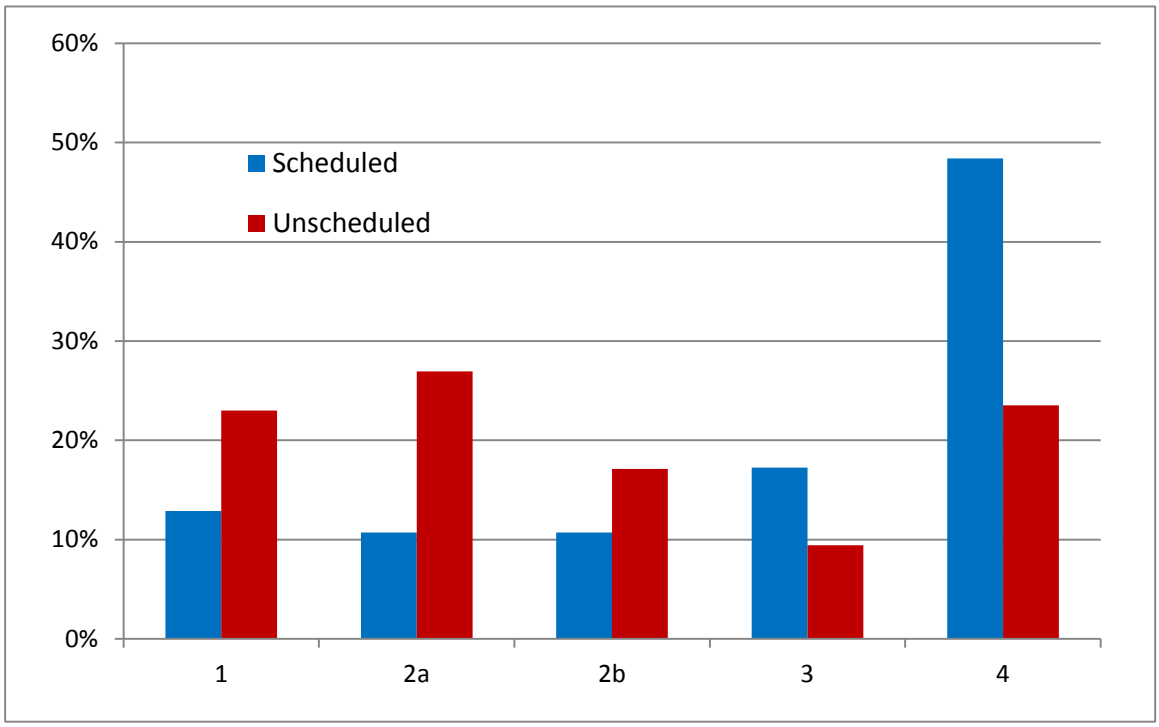

Figure 4 Stranding distribution by Reach, 2004-2015 highlighting the difference in stranding distribution between scheduled and unscheduled rampdowns.

4.2 Rampdowns and Flow Release Targets

Since the introduction of Treatment 2 there has been only a minimal reduction in the total number of unscheduled rampdowns (Table 10). It was anticipated that removal of the temporary dam safety 149m maximum allowable reservoir operating level (in place during Treatment 1 2001-2009) would reduce the number of unscheduled spill events. Under Treatment 1 Coquitlam River averaged 3.7 unscheduled rampdowns per year, under Treatment 2 the average is 3.2 unscheduled rampdowns per year. With respect to full LLO spills a reduction has been evident in the past five years of monitoring. Under Treatment 1 Coquitlam River had 14 full LLO spills in seven years (2002-2009), under Treatment 2 there have been only 8 (as of June 2015) In the past seven years of monitoring. Of the 22 unscheduled rampdowns since the initiation of Treatment 2, 8 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 2014-2015 monitoring year indicated that flow releases from Coquiltam Dam have been consistently within the targeted range

(estimated flows must be within 10% for the targeted value) throughout the monitoring year (Table 1).

Table 10 Number of rampdown per year 2001-2015

Monitoring Year	Scheduled	Unscheduled
2014-2015	6	3
2013-2014	6	1
2012-2013	5	4
2011-2012	5	3
2010-2011	6	5
2009-2010	5	5
2008-2009	3	1
2007-2008	n/a	5
2006-2007	n/a	4
2005-2006	n/a	6
2004-2005	n/a	3
2003-2004	n/a	3
2002-2003	n/a	1
2001-2002	n/a	1
Total	**36**	**45**

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. Schick et. al. 2014 reports the estimated average annual outmigrating population for chum and pink fry for the 2003-2013 period is 2,248,900 and 958,000 respectively. Contrast this with a total of 79 chum mortalities and zero pink mortalities observed during rampdowns for the same period. Coho and steelhead smolt population estimates for the same period average 14,479 and 4242 per year respectively (Schick et. al. 2014). The estimated average number of coho and steelhead smolt/parr stranded per year due to rampdowns is 17 and 15 respectively, or less than 0.4% of the estimated population. However, in light of the impacts on coho fry, and to a lesser extent, steelhead fry in the past four monitoring years, there may be cause for concern.

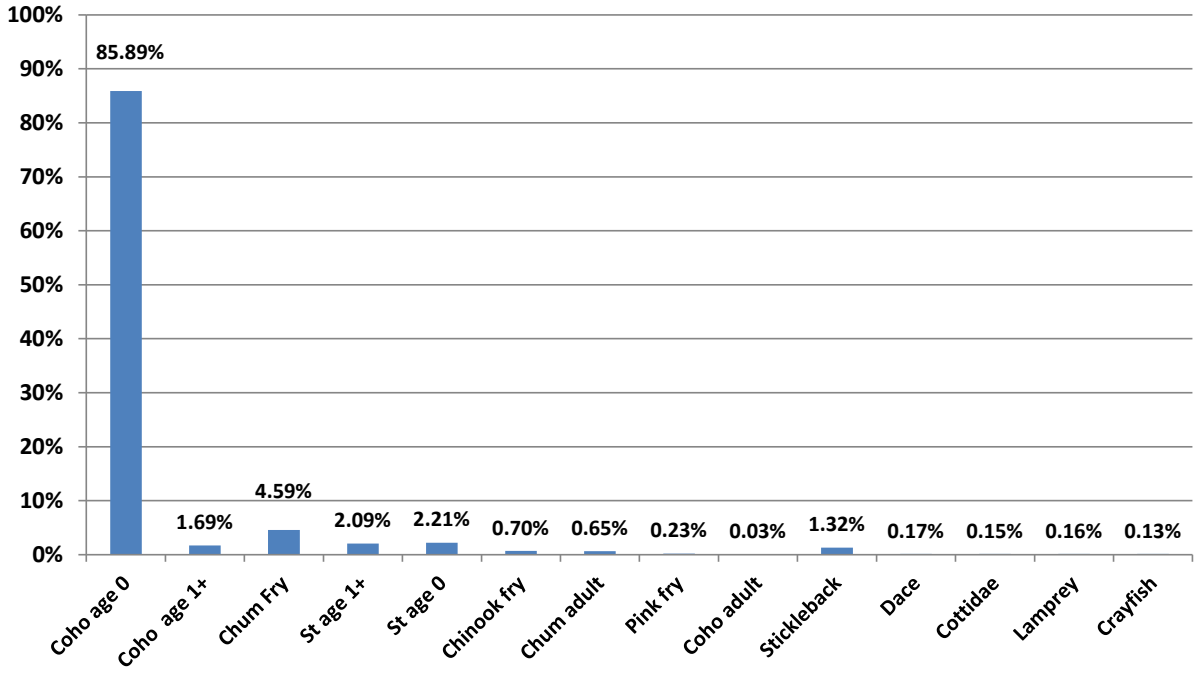

Figure 5 Stranding distribution by species and age class, 2004-2015, all rampdowns. In addition one kokanee, pink adult and northern pike minnow have been found.

Coho fry populations are typically the hardest hit with respect to stranding, estimates of total fry productivity (based on fall standing stock estimates 2003-2012) range from 21,000 to 105,000 with a mean of approximately 56,101 (Schick 2014). 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 2014-2015 monitoring year, (2727) was compared to the 2014 coho fry standing stock estimate (a yearly estimate of the total number of fry in the system in late summer) of 44,507, this would represent approximately 6.1% of the population (Figure 6). This level of loss could have the potential to have an impact on the coho fry population. This is a rough estimate using the only available data but does provide a useful illustration and is comparable between years. The impact on Steelhead fry is not quite as dramatic; using the total number observed stranded (23) in the 2014-2015 monitoring year and comparing it to the 2014 standing stock estimate (32,746), gives a potential loss of 0.07% of the population due to stranding.

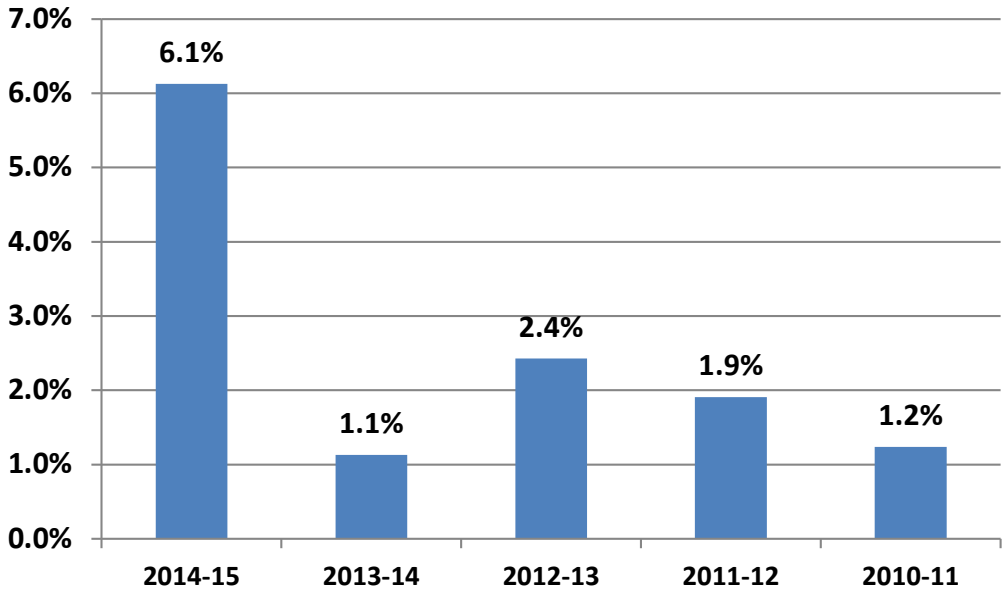

Figure 6 Estimated potential impact of rampdowns on coho fry population in Coquitlam River. Values represent the estimated proportion of the total population of coho fry that could be eliminated due to rampdowns each year.

5.0 Conclusions and Recommendations

The results of the past 6 years of rampdown monitoring clearly indicate that fish stranding and mortalities due to stranding have increased under Treatment 2. An analysis of the results from Table 5 show that under Treatment 1 survey crews observed an average of 254 stranded fish and 39 mortalities per year, while under Treatment 2 this has risen to 1512 stranded fish and 239 mortalities. The cause of this increase is likely related to two main factors:

1. An increase in the number of rampdowns per year due to monthly flow changes at Coquitlam Dam. Treatment 1 had an average 2.7 rampdowns per year (all unscheduled), while under Treatment 2 the average has risen to 8.3 per year.

2. Increase in rampdowns at critical time period for emerging juvenile fish. Scheduled rampdowns in April, May, and June occur at peak emergence for fry in Coquitlam River, which results in a consistent, yearly elevation in the risk of stranding. As discussed in Sec. 4.1, the June rampdown alone has been responsible for 71% of all stranding over the past six years.

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 June scheduled rampdown. The June rampdown, may need to have its ramp rate and operational procedures reexamined and altered. The first step taken towards this undertaken in 2013 has had some very promising results, as mortalities have dropped significantly. This alteration is purely an operational one (spreading out the rampdown over two or three days) and the results indicate that the June rampdown may also benefit from a more gradual flow reduction as stranding was still high despite the drop in mortality. In addition, this particular rampdown should undergo a reassessment of its minimum target flow. The June 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 flows instead drop significantly. A higher minimum flow target for June would have the potential to prevent a significant amount of stranding.

As Table 7 clearly demonstrates, fish stranding under scheduled rampdowns in Coquitlam River is heavily concentrated in the June 1 rampdown, with regular, but far more limited stranding during the April 1 and May 1 rampdowns. For this reason it would be reasonable if monitoring for fish stranding be dropped for at least the January and November rampdowns, both of which pose virtually no stranding risk and certainly pose no threat to fish productivity.

Outside of the June flow reduction, the risk of stranding appears to be minimal during most scheduled rampdowns downstream of Reach 4. This is due to the fact that the

scheduled releases under Treatment 2 do not inundate large areas of habitat, flow releases are maintained at a constant rate each month, and flow reductions are generally small in proportion to the amount of flow in the entire river.

Though the majority of stranding each year (89% in 2014-2015), is observed during only one scheduled rampdown, it is recommended that all rampdowns, with the exception of the November and January scheduled 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 primarily in Reach 4. 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 Reach 4 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.

Stranding sites examined under the previous flow regime have been reevaluated under the new Treatment 2 conditions. The results of the sixth 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.

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 the past few years show that 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

- The ramp rate for the June flow reduction should be modified to be more gradual in addition, a reexamination of the target flow level of 1.1 should be considered.

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

- Monitoring for fish stranding be dropped for at least the January and November rampdowns, both of which pose virtually no stranding risk and certainly pose no threat to fish productivity.

- Future June 1 scheduled rampdowns should continue to use the modified gate closure operation due to the successful implementation in 2013 and 2014. The Coquitlam River Consultative Committee approved this approach when presented with the results in November 2013.

6.0 Literature cited

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

May 1, 2014

R4 Staff Gauge		R2B Staff Gauge		R1 WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0900	0.29	0930	0.70	0900	7.84	
1000	0.28	1130	0.69	1200	7.83	
1100	0.27	1300	0.68	1300	7.82	
1200	0.26	1430	0.67	1500	7.81	
1330	0.26	1530	0.67	1800	7.81	
1500	0.26					
	3.0		3.0		3.0	Max Stage Reduction (cm)
	1.0		1.0		1.0	Max Stage Reduction (cm)/hr

June 1 2014

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0830	.23	0900	.59	0900	7.74	
0900	.22	1030	.58	1100	7.74	
1000	.19	1200	.57	1200	7.73	
1100	.18	1400	.56	1400	7.71	
1200	.175	1600	.56	1600	7.705	
1600	.175			1800	7.705	
	5.5		3.0		3.5	Max Stage Reduction (cm)
	3.0		1.0		1.0	Max Stage Reduction (cm)/hr

June 2 2014

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0830	.175	0900	.56	1000	7.71	
0930	.17	1030	.56	1100	7.71	
1000	.16	1200	.55	1200	7.70	
1100	.14	1400	.54	1400	7.69	
1200	.12	1600	.53	1600	7.68	
1600	.12			1800	7.68	
	5.5		3.0		3.0	Max Stage Reduction (cm)
	2.0		1.0		1.0	Max Stage Reduction (cm)/hr

June 3 2014

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0830	.12	0900	.53	1000	7.68	
0930	.12	1030	.53	1100	7.68	
1000	.11	1200	.52	1200	7.67	
1100	.09	1400	.51	1400	7.67	
1200	.08	1600	.50	1600	7.665	
1600	.08			1800	7.665	
	4.0		3.0		1.5	Max Stage Reduction (cm)
	2.0		1.0		1.0	Max Stage Reduction (cm)/hr

September 1, 2014

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0800	0.21	0900	0.56	0800	7.79	
0930	0.21	1000	0.56	1000	7.80	
1030	0.19	1200	0.55	1200	7.79	
1200	0.18	1400	0.55	1400	7.78	
1330	0.18	1600	0.55	1600	7.78	
1530	0.18			1800	7.78	
	3.0		1.0		2.0	Max Stage Reduction (cm)
	2.0		0.5		1.0	Max Stage Reduction (cm)/hr

November 1, 2014

R4 Staff Gauge		R2B Staff Gauge		R1 WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0900	0.39	0800	0.68	0800	7.98	
1030	0.38	1000	0.68	1000	7.98	
1130	0.36	1130	0.66	1200	7.97	
1230	0.35	1400	0.66	1330	7.96	
1500	0.33	1600	0.65	1600	7.95	
1630	0.32	1700	0.64	1800	7.94	
				2000	7.94	
	7.0		4.0		4.0	Max Daily Stage Reduction (cm)
	2.0		1.0		1.0	Max Stage Reduction (cm)/hr

November 10, 2014

R4 Staff Gauge		R2B Staff Gauge		R1 WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0900	1.09	0900	1.30	0900	8.75	
1030	0.89	1100	1.15	1000	8.74	
1230	0.69	1330	0.96	1100	8.63	
1400	0.52	1430	0.89	1200	8.48	
1600	0.50	1630	0.80	1400	8.26	
				1600	8.12	
				1800	8.10	
	69.0		50.0		65.0	Max Daily Stage Reduction (cm)
	13.3		12.7		15.0	Max Stage Reduction (cm)/hr

November 11, 2014

R4 Staff Gauge		R2B Staff Gauge		R1 WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0900	0.50	0900	0.80	0900	8.08	
1030	0.46	1100	0.79	1100	8.08	
1430	0.40	1300	0.77	1200	8.07	
1600	0.33	1530	0.75	1400	8.05	
1700	0.32	1630	0.73	1600	8.00	
		1800	0.70	1800	7.97	
	18.0		9.0		11.0	Max Daily Stage Reduction (cm)
	4.7		2.0		2.5	Max Stage Reduction (cm)/hr

December 17, 2014

R4 Staff Gauge		R2B Staff Gauge		R1 WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0830	1.05	0800	1.12	0900	8.67	
1000	0.88	1030	1.05	1100	8.50	
1130	0.76	1200	0.95	1300	8.37	
1230	0.71	1430	0.84	1500	8.15	
1400	0.61	1600	0.78	1700	8.06	
1500	0.50			1800	8.05	
	55.0		34.0		52.0	Max Daily Stage Reduction (cm)
	8.0		6.7		11.0	Max Stage Reduction (cm)/hr

December 18, 2014

R4 Staff Gauge		R2B Staff Gauge		R1 WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0900	0.48	0830	0.76	0900	8.06	
1200	0.41	1200	0.74	1100	8.05	
1400	0.37	1330	0.72	1300	8.03	
1500	0.37	1600	0.69	1500	8.00	
				1700	7.99	
				1800	7.99	
				2000	8.02	
	11.0		7.0		7.0	Max Daily Stage Reduction (cm)
	2.3		1.3		1.0	Max Stage Reduction (cm)/hr

April 1, 2015

R4 Staff Gauge		R2B (at Galette)		WSC Staff Gauge		
Time	Stage (m)	Time	Stage (m)	Time	Stage (m)	
0830	.34	0900	.74	0800	7.93	
0930	.33	1030	.73	1000	7.93	
1000	.31	1200	.72	1100	7.93	
1100	.30	1400	.72	1200	7.92	
1330	.29	1600	.71	1400	7.91	
1530	.29			1600	7.91	
				1800	7.91	
	5.0		3.0		2.0	Max Stage Reduction (cm)
	2.0		1.0		1.0	Max Stage Reduction (cm)/hr

Appendix 2 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 7 Site A1 showing gravel bar separating river mainstem (left) with isolated pool (right), following rampdown June 1 2012.

Figure 8 Showing trench dug to allow water from river mainstem to flow into isolated pool.

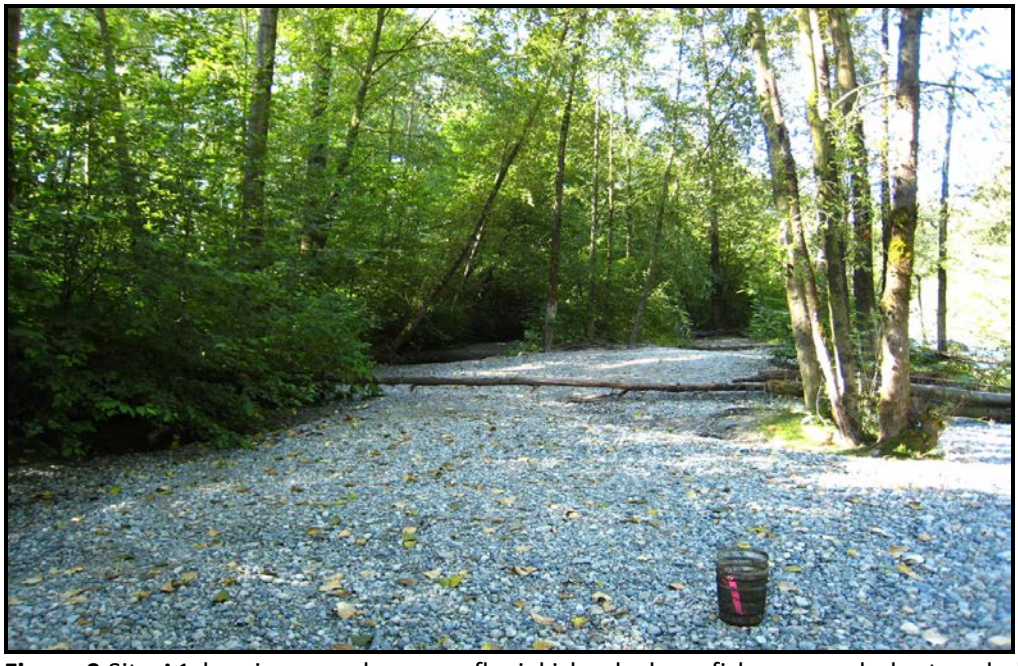

Figure 9 Site A1showing gravel area on fluvial island where fish are regularly stranded

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

Reach 2A

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 10 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 11 View of site C1 side channel that is wetted during single gate openings. This site typically has one of 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. River Morphology changes may have reduced the risk of stranding at this site.
Total Area: 550m^2

<u>Reach 2B</u>

Site C3: This site is a small side channel composed of gravel and cobble substrate. It drains slowly and forms many isolated pools that do not retain water well. This site experiences only minimal stranding.
Total Area: 60m^2

Site D1: This area is long side channel that completely dewaters during the June flow reduction. It is a gravel cobble substrate combined with some deeper pools
Total Area: 300m^2

Site D2: Parts of this area are densely vegetated with trees and shrubs, though It is primarily a narrow river margin with cobble and boulder substrate.
Total Area: 60m^2

Reach 3

Site D3: This area is a combination of a long, narrow platform densely grown in with trees and shrubs, as well as a small side channel that is permanently wetted. 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

Site D4: This area is a small series of pools, with a gravel substrate. Some of the pools are quite deep <30cm and attract coho fry and steelhead fry and smolts.
Total Area: 40m^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: 900m^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: 340m^2

Appendix 3 Coquitlam River Rampdown Site Maps

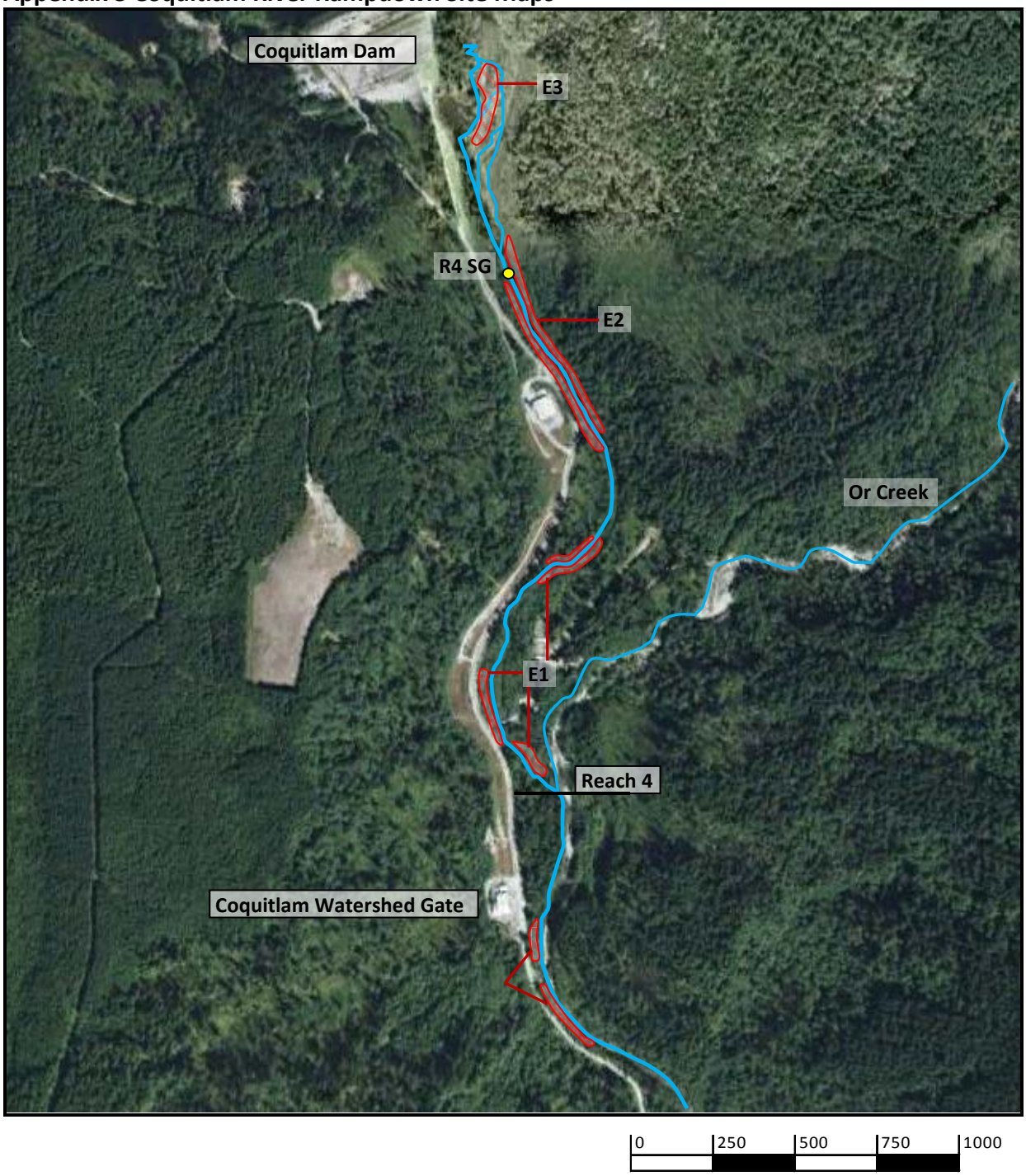

Figure A
Coquitlam River Stranding Reach 4 and 3.

Figure B
Coquitlam River Stranding Reach 3 and 2b

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

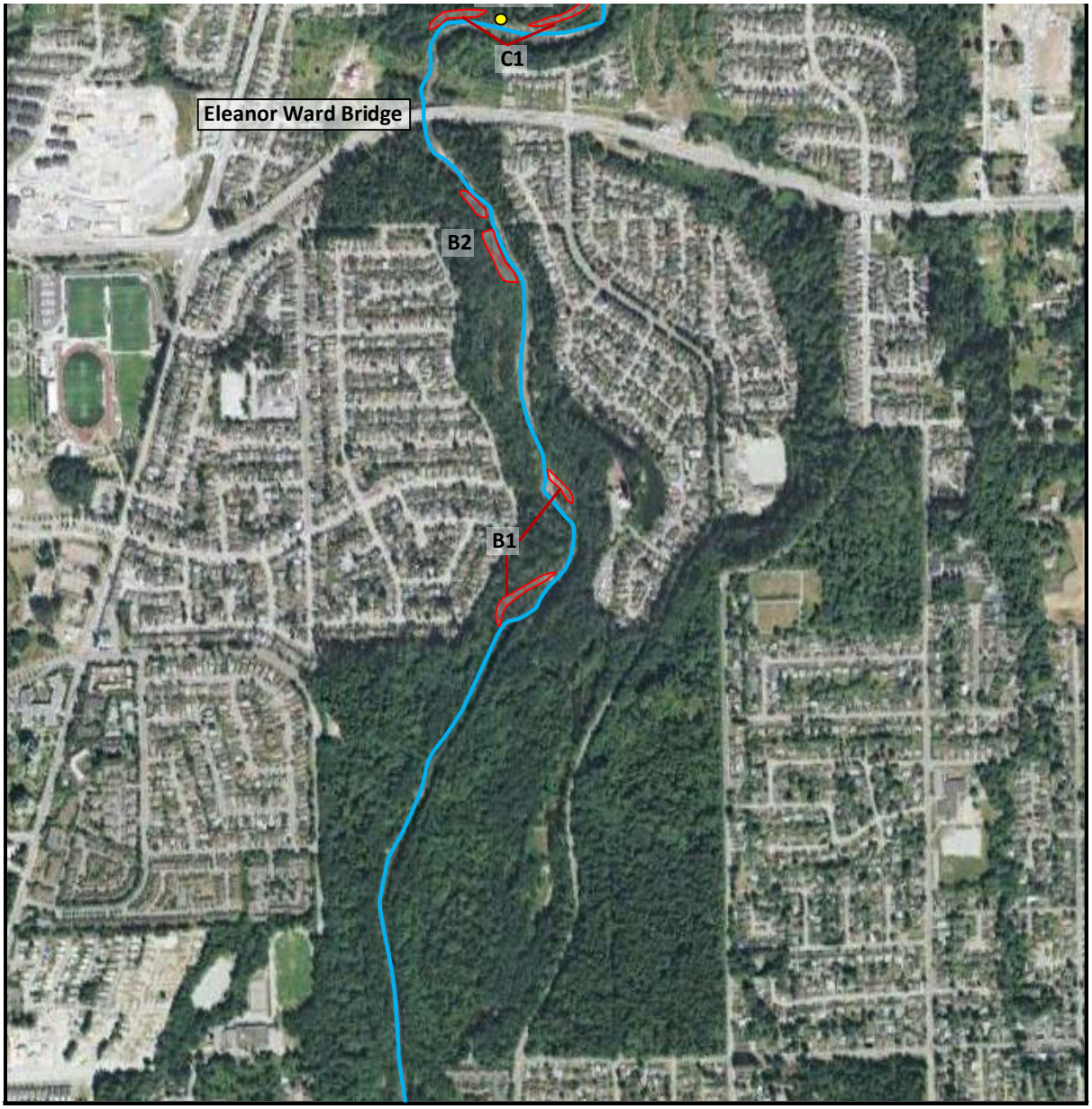

Figure D

0 250 500 750 1000

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

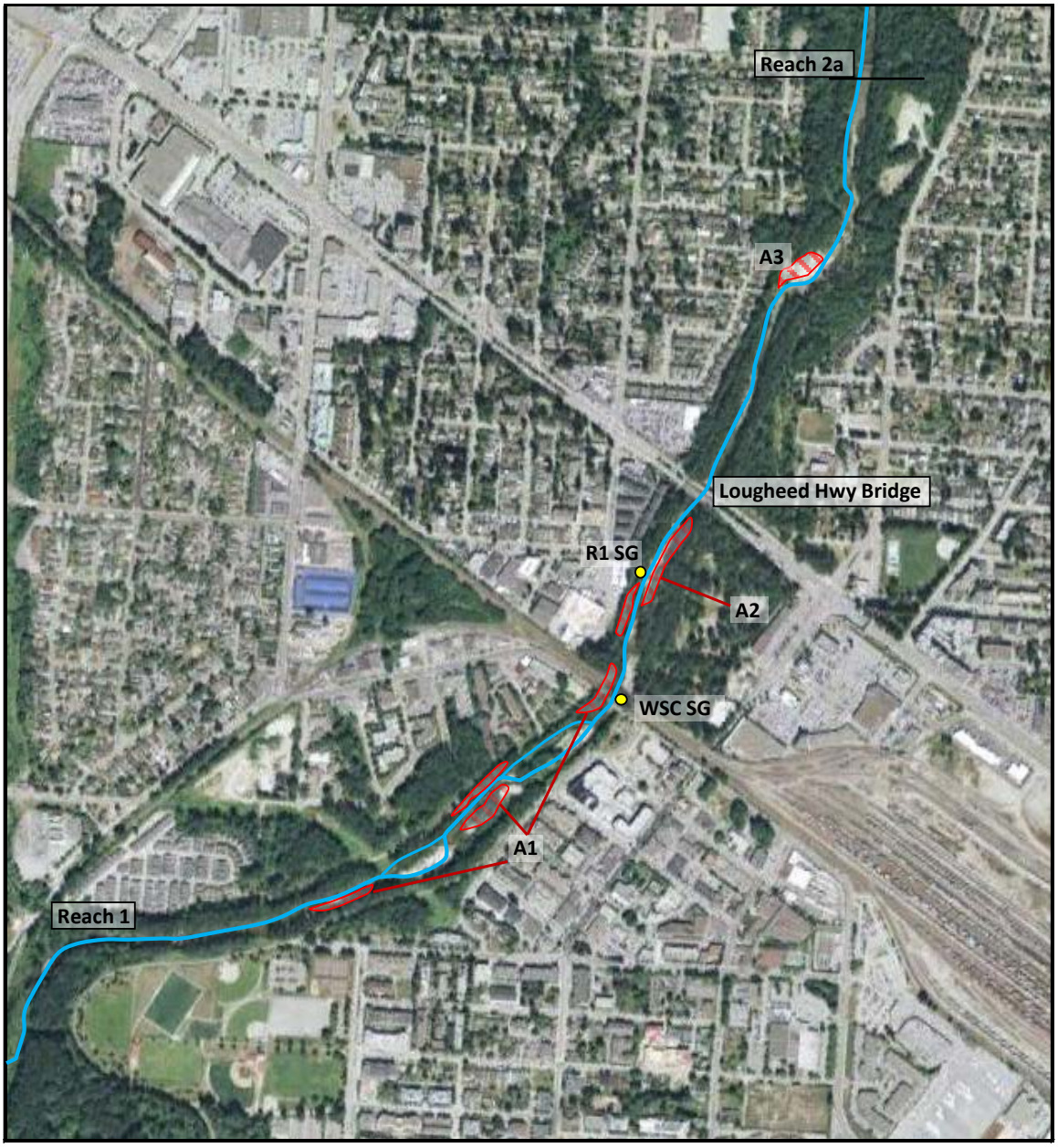

Figure E

Coquitlam River Stranding, Site A, Reach 1.