Coquitlam Water Use Plan

Coquitlam Dam Flow Release Interim Ramping Rate

COQMON#2

Study Period: April 1, 2007 – March 31, 2008
Report Date: May 2008

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Living Resources Environmental Resources
Coquitlam River Rampdown Summary
April 1, 2007 – March 31, 2008

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for

BC Hydro

Burnaby, BC.

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Executive Summary

This report summarizes rampdown events occurring on the Lower Coquitlam River during April 1, 2007 to March 31, 2008. A total of three rampdown events were monitored during the annual survey period: July 26-27, 2007, November 22-23, 28-29, 2007 and December 19-21, 2007. Areas previously identified as susceptible to de-watering and fish stranding were visually inspected by survey crews during each rampdown event. Stranded fish were removed by dip netting, or were captured using gee-type minnow traps. A total of 386 fish were salvaged over the course of the 3 rampdown events, mortalities observed totaled 36. Redd stranding was also monitored during susceptible time periods (ie fall spawning). An estimated 10 redds were stranded following the November spill event.
Acknowledgements

This project was supported by BC Hydro Water Licence Requirements. Alf Leake, Dave Hunter and Brent Wilson (BCHydro) kindly provided data and maps and assistance in the field. Thank you to field technicians Matt Townsend, Stu Barker and Kris Kehler

BC Hydro operations staff for access to the gate house and updates on all gate closures.
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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 km² 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, and 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 five 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 and its influence on mitigating fish stranding on the Coquitlam River (table 1). The ramping rate currently established under the Coquitlam Water Use Plan (WUP) has the goal of minimizing the impact of stranding during rampdowns, while maintaining operational feasibility (BC Hydro 2005).

The three Low Level Outlet (LLO) gates on the Coquitlam Dam can cumulatively discharge approximately 50 m³/sec. Interim BC Hydro dam safety constraints stipulate a maximum reservoir elevation of 149 m, beyond which spill releases must be initiated to ensure dam integrity.
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. The total survey area incorporates approximately 14 river kilometers. Appendix A identifies stranding index sites and classifies areas within the sites identified as high (A - red), medium (B - blue), or low (C - green) risk. Due to the size of the study area and the infrequent occurrence of ramping events, some sections of the river have received little investigation. Areas that are not highlighted on the map 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 6 years and have been determined by survey crews to have minimal stranding risk, therefore, they are not included in any rampdown assessments.

Stranding is identified by three categories:

1. Adult stranding of spawning salmon, confined to active spawning period (Oct.- Jan.) depending on species

2. Redd stranding during active spawning period (Oct.-Jan.)

3. Juvenile stranding (fry, parr and smolt), potential risk exists year round

Mortalities of adults and juveniles during rampdown events can result from fish being caught in pools or ephemeral channels which dewater during release reductions, leaving 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. Dam releases during the fall may temporarily give access to spawning areas which dewater following release reduction. This can impact redds by leaving them stranded, and rendering incubated eggs unviable.
2.0 Methods

During spill reductions, locations susceptible to stranding risk are assessed during daylight hours by crews of between two and four people. Due to the short duration of most rampdown events and the large amount of habitat potentially affected, only locations that are most susceptible are assessed. Susceptible areas are visually surveyed several times over the course of the rampdown event to assess at what point stranding becomes evident. All isolated pools are assessed for fish and initial attempts at salvaging are conducted with dip nets. Areas that are difficult to net by hand or are known to strand large numbers of fish are fished overnight with baited minnow traps.

Site assessments are also linked to dam operations through the three LLO gates and their stages and sites are assessed with respect to which LLO gate is being shut and the specific gate elevation. LLO gates are classed A-C; A= first gate to close, B= second gate to close, C= third and last gate to close (Table 1). Survey crews keep in constant contact with gate operators during rampdown events to ensure proper survey timing during dewatering (Table 1).

<table>
<thead>
<tr>
<th>Gate</th>
<th>Step</th>
<th>From</th>
<th>To</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting Gate</td>
<td>1</td>
<td>5' 0&quot;</td>
<td>0' 0&quot;</td>
<td>Continuous gate change until closed</td>
</tr>
<tr>
<td>Second Gate</td>
<td>2</td>
<td>5' 0&quot;</td>
<td>3' 10&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Second Gate</td>
<td>3</td>
<td>3' 10&quot;</td>
<td>2' 10&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Second Gate</td>
<td>4</td>
<td>2' 10&quot;</td>
<td>2' 0&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Second Gate</td>
<td>5</td>
<td>2' 0&quot;</td>
<td>1' 4&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Second Gate</td>
<td>6</td>
<td>1' 4&quot;</td>
<td>0' 9&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Second Gate</td>
<td>7</td>
<td>0' 9&quot;</td>
<td>0' 3&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Second Gate</td>
<td>8</td>
<td>0' 3&quot;</td>
<td>0' 0&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
<td>9</td>
<td>5' 0&quot;</td>
<td>3' 10&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
<td>10</td>
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<td>2' 10&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
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<td>2' 10&quot;</td>
<td>2' 1&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
<td>12</td>
<td>2' 1&quot;</td>
<td>1' 10&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
<td>13</td>
<td>1' 10&quot;</td>
<td>1' 7&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
<td>14</td>
<td>1' 7&quot;</td>
<td>1' 4&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
<td>15</td>
<td>1' 4&quot;</td>
<td>1' 1&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
<td>16</td>
<td>1' 1&quot;</td>
<td>0' 10&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
<td>17</td>
<td>0' 10&quot;</td>
<td>0' 8&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
<td>18</td>
<td>0' 8&quot;</td>
<td>0' 7&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
<td>19</td>
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<td>0' 6&quot;</td>
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</tr>
<tr>
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<td>0' 6&quot;</td>
<td>0' 5&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
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<td>0' 5&quot;</td>
<td>0' 4&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
<td>22</td>
<td>0' 4&quot;</td>
<td>0' 3&quot;</td>
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</tr>
<tr>
<td>Final Gate</td>
<td>23</td>
<td>0' 3&quot;</td>
<td>0' 2&quot;</td>
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</tr>
<tr>
<td>Final Gate</td>
<td>24</td>
<td>0' 2&quot;</td>
<td>0' 1&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
<td>25</td>
<td>0' 1&quot;</td>
<td>0' 0.5&quot;</td>
<td>0.5 hr change</td>
</tr>
<tr>
<td>Final Gate</td>
<td>26</td>
<td>0' 0.5&quot;</td>
<td>0' 0&quot;</td>
<td>0.5 hr change</td>
</tr>
</tbody>
</table>

Table 1 Interim ramping schedule for Coquitlam Dam Low level outlets gates during release reductions.
Dewatered areas are classified according to index sites lettered A-E, including two to three specific rampdown sub-areas in each index site (Appendix A). 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 A for site maps and descriptions). All sites surveyed typically contain many small depressions and areas where fish and spawning habitat are susceptible to stranding. Isolated pools are examined and their location recorded so that they can be returned to 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 returned to areas of the river not affected by the flow reduction.

River stage elevation changes were monitored at several sites during the course of rampdown events. Stage reductions were determined by survey crews at hourly visual inspections of staff gauges located in reach 1, reach 2a and reach 2b (Appendix B). These gauges were monitored from the onset of flow reductions to the end of daily salvage operations (which are called off at the onset darkness). River stage elevation was also monitored using hourly flow data from the Water Survey of Canada (WSC) gauge located in Port Coquitlam (08MH002). Data from this source was used to compare natural stage change during rain events, with flow reductions from Coquitlam Dam (Figs 4-8).

The area of each 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 was included, meaning areas within the ramp site that do no 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 (Table 6 & 9, see Appendix A for ramp site descriptions).
3.0 Results

3.1 Rampdown July 25-26, 2007

Spilling from one LLO at Coquitlam Dam had been ongoing for three days, when a rampdown of the one gate was scheduled for July 25, 2007. Commencing at 10:00 on July 25, one gate was ramped down at the prescribed ramping rate. The flow reduction was complete by 19:00 on the same day. This rampdown occurred at a particularly vulnerable time for coho fry populations in Coquitlam River, which had completed full emergence at the beginning of July, and were very active foraging and feeding along the margins of Coquitlam River.

Due to the fact that only one gate had been opened, some areas normally impacted by flow reductions did not require monitoring because they had not been inundated by the release flow (E1, D1, A3, A2, B2, see Appendix A). Net salvage and minnow trap salvage were carried out by crews to assess the extent of stranding. A total of 195 fish were salvaged and 11 mortalities were observed over the two day period (Table 2). Total fish stranded per metre of dewatered area (including only those areas where stranding was observed) was 0.074 (Table 3)

The reduction in river stage elevation is shown in Figure 1 and Table 4. The Port Coquitlam WSC site recorded an average stage drop of 3.1cm per hour, and the R2a site recorded an average drop of 2.0cm per hour.

![Figure 1 Port Coquitlam WSC rampdown discharge curve July 25-26, 2007.](#)
**Index Site A:**

July 25-26 - Sites A2 and A3 were not inundated during the flow release, therefore no stranding was observed in these areas. Seven minnow traps were set in site A1 on July 25 at 18:00 and recovered the following morning at 08:00. Salvage recoveries included 15 coho parr, 2 threespine sticklebacks and 1 cotid (sp.). Mortalities observed in site A1 include 1 coho parr, and 2 threespine sticklebacks (table 2).

Table 3 shows the total fish stranded and mortalities per square metre. The total surface area of dewatered substrate in site A1 is 1450 metres. Fish stranded per square metre was 0.014, which is the lowest total for all sites where stranding was observed.

**Index Site B**

July 25 – No stranding observed. Site B1 remained wetted following full gate closure. Lower section of B2 was not inundated, upper section of B2 was monitored regularly throughout the day, with no stranding observed.

**Index Site C**

July 25 – Site C1 was monitored continuously for several hours during the rampdown due to past stranding problems. A survey crew spent over four hours salvaging fry and parr from cobble/boulder pools (see Appendix A for photo). A total of 99 coho fry, 2 coho parr, 2 lamprey, 1 crayfish, and 1 dace were salvaged. Mortalities observed included 4 coho parr and 6 coho fry (Table 2). Total fish stranded per square metre was 0.167 with a total area of dewatered substrate amounting to 690 square metres (Table 3). This area had the highest concentration of mortalities at 0.014 per square metre.

July 25 – At site C2 survey crews net salvaged 22 coho fry. No mortalities were observed. This area was minimally inundated and was nearly completely dewatered upon arrival at 10:00. Total fish stranded per square metre was 0.040 with a total area of dewatered substrate amounting 550 square metres (Table 3).
Index Site D

July 25 – No stranding was observed in site D. Site D1 was not sufficiently inundated and no observations were made in site D2.

Index Site E

July 25-26 – Four traps were set in site E3 and were checked twice during the course of the day. These traps were also left overnight and rechecked on the morning of the July 26. Forty-two coho parr, 4 threespine sticklebacks, 4 cotid (sp.) and 3 dace were salvaged (Table 2).

This site has the smallest area of dewatered substrate at 150 square metres and the highest concentration of stranding with 0.353 per square metre (Table 3).

<table>
<thead>
<tr>
<th>Index Site Code</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>B1</th>
<th>B2</th>
<th>C1</th>
<th>C2</th>
<th>D1</th>
<th>D2</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salvaged</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coho Parr/smolt</td>
<td>15</td>
<td>2</td>
<td></td>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>59</td>
</tr>
<tr>
<td>Trout Parr/smolt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Coho fry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>121</td>
</tr>
<tr>
<td>Lamprey</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td>Crayfish</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Cotid (sp.)</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>1</td>
</tr>
<tr>
<td>Dace</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>

| Mortalities     |    |    |    |    |    |    |    |    |    |    |    |    | 11   |
| Coho Parr/smolt | 1  |    |    |    |    |    |    |    |    |    |    |    | 5    |
| Trout Parr/smolt|    |    |    |    |    |    |    |    |    |    |    |    | 0    |
| Coho Fry        |    |    |    |    |    |    |    |    |    |    |    |    | 6    |

<table>
<thead>
<tr>
<th>Risk Class</th>
<th>A/B</th>
<th>A/B</th>
<th>A</th>
<th>A</th>
<th>A</th>
<th>A</th>
<th>A</th>
<th>A/ B</th>
<th>A/B</th>
<th>A</th>
<th>A</th>
<th>A/ B/C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate Class</td>
<td>B/C</td>
<td>B/C</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>B/C</td>
<td>B/C</td>
<td>B/C</td>
<td>C</td>
<td>B/C</td>
<td>B/C</td>
</tr>
</tbody>
</table>
### Table 3
Stranded fish and mortalities per square metre for rampdown sites where stranding was observed.

<table>
<thead>
<tr>
<th>Site</th>
<th>Dewatered area m²</th>
<th>Total stranded</th>
<th>Mortalities</th>
<th>Stranded/m²</th>
<th>Mortalities/m²</th>
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<tbody>
<tr>
<td>A1</td>
<td>1450</td>
<td>20</td>
<td>1</td>
<td>0.014</td>
<td>0.001</td>
</tr>
<tr>
<td>C1</td>
<td>690</td>
<td>115</td>
<td>10</td>
<td>0.167</td>
<td>0.014</td>
</tr>
<tr>
<td>C2</td>
<td>550</td>
<td>22</td>
<td>0</td>
<td>0.040</td>
<td>0.000</td>
</tr>
<tr>
<td>E3</td>
<td>150</td>
<td>53</td>
<td>0</td>
<td>0.353</td>
<td>0.000</td>
</tr>
<tr>
<td>Total</td>
<td>2840</td>
<td>210</td>
<td>11</td>
<td>0.074</td>
<td>0.004</td>
</tr>
</tbody>
</table>

### Table 4
River stage elevation change for two sites on Coquitlam River during gate closure.

<table>
<thead>
<tr>
<th>Time</th>
<th>Stage</th>
<th>Time</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
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<td>38.58</td>
<td>900</td>
<td>8.24</td>
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<tr>
<td>1245</td>
<td>38.50</td>
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</tr>
<tr>
<td>1445</td>
<td>38.44</td>
<td>1100</td>
<td>8.19</td>
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<tr>
<td>1745</td>
<td>38.41</td>
<td>1200</td>
<td>8.10</td>
</tr>
<tr>
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</tr>
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9 hours 0.28m
12 hours 0.37

2.0cm per hour 3.1cm per hour
3.2 Rampdown November 22, 28, 2007

Spilling from all three LLO gates at Coquitlam Dam had been ongoing since November 7, 2007 when a rampdown of two gates was scheduled for November 22, 2007. Commencing at 08:40 on November 22, two gates were ramped down at the prescribed ramping rate. The flow reduction was complete at approximately 14:00 on the same day. Initial flow release occurred at a potentially vulnerable time for adult chum salmon which reached peak spawning activity during the first week of November. The risk of potential redd stranding was a concern if chum salmon began to spawn in areas wetted by the flow release. Survey crews monitored potential redd stranding areas during the flow release period (November 7-21), and during flow reduction. The third and final gate was ramped down on November 28, 2007 at the prescribed rate A total of 108 fish were salvaged, and 16 mortalities were observed over the entire rampdown period (Table 5). Total fish stranded per metre of dewatered area was 0.0025 (Table 6). The reduction in river stage elevation is shown in Figure 2 and Table 7. The average reduction in elevation was higher for all sites during the initial gate closures. Site R2a had the slowest decrease in river stage during both gate closures at 3.7cm/hr and 1.9cm/hr respectively (Table 7).

![Figure 2 Port Coquitlam WSC rampdown discharge curve November 22 and November 28, 2007](image-url)
Index Site A:

November 7-21 (pre-rampdown surveys) – This site is the most susceptible to redd stranding due to the heavy concentration of spawning chum salmon and large areas of substrate suitable for spawning that become wetted during flow releases. Chum salmon were observed spawning in marginal areas during pre-rampdown surveys (Nov. 14, 19). At total of 22 chum salmon and 20-30 potential redds were observed in areas that would become dewatered following LLO gate closure.

November 22, - Following closure of two LLO gates survey crews were able to positively identify 8 stranded redds in this site. One trout parr and 1 dace were salvaged by survey crews (see Table 5 for all stranding numbers).

November 28 – Following closure of the final LLO gate survey crews hand salvaged 3 adult chum salmon and 1 trout parr. One coho fry and 1 lamprey mortality were also observed. Three minnow traps were set in site A1 on the evening of the 28th. The following morning 7 trout parr, 6 coho fry and 10 threespine stickleback were salvaged from the traps. No further stranding was observed.

Index Site B

November 22– Stranding was observed in site B2 during initial 2 gate flow reduction, 1 adult chum, 11 trout par, one trout fry, 1 lamprey and 1 dace were salvaged. Two redds were also identified as stranded. Mortalities observed included 3 coho fry, 2 trout parr and 1 trout fry. Site B1 remained fully wetted following gate closure.

November 28– No stranding observed. Site B2 does not become inundated at one LLO gate opening, Site B1 was receiving sub-surface flow following complete gate closure, with no stranding risk noted.

Index Site C

November 22– No stranding observed due to Site C1 remaining fully wetted following gate closures. Site C2 is usually a chronic stranding problem during the first two gate closures, but appeared to have not been inundated when surveyed on November 22. Possibility exists that river morphology has changed in this site, reducing stranding risk.

November 28– Site C1 was monitored continually throughout the day on November 28 due to chronic stranding problems noted in previous rampdowns. A total of 21 trout parr, 14 trout fry, 4 dace and 2 crayfish were salvaged.
Mortalities included 5 trout par and 1 trout fry. Total fish stranded per square metre was 0.0681, total area of dewatered substrate is 690 square metres (Table 6). This area had the highest concentration of mortalities at 0.0087 per square metre.

**Index Site D**

November 22– No stranding was observed in site D during the first two gate closures.

November 28– Ground surveys did not reveal any stranding in site D. Two traps were set in site D3 on November 28 and the following morning 8 coho fry, and 6 trout fry were salvaged from the traps. One trout parr mortality was recovered on November 29.

**Index Site E**

November 22 - No stranding observed.

November 28– One mortality observed in Site E3 was identified as an adult Kokanee salmon (220mm). This is the first occasion of this species being found in a rampdown survey. Three traps set in Site E3 salvaged 6 coho fry and 1 crayfish. Two traps set in site E2 salvaged 1 coho fry and 1 threespine stickleback.

**Table 5** Stranding survey results for rampdown November 22 and 28 showing salvaged fish and mortalities by species and site. Stranded redds are not include in the salvaged total

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<th>A2</th>
<th>A3</th>
<th>B1</th>
<th>B2</th>
<th>C1</th>
<th>C2</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>E1</th>
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| **Total**       | 108|

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Coquitlam River Rampdown Summary April 1, 2007 – March 31, 2008
### Table 6
Stranded fish and mortalities per square metre for all rampdown sites Nov. 22,28.

<table>
<thead>
<tr>
<th>Site</th>
<th>Dewatered area m²</th>
<th>Salvaged</th>
<th>Mortalities</th>
<th>Total stranded</th>
<th>Stranded/m²</th>
<th>Mortalities/m²</th>
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**Total**: 43375 108 16 124 0.0025 0.0004

### Table 7
Showing river stage elevation reductions for all recording sites.

**Thursday, November 22, 2007**

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<th>Site</th>
<th>Time</th>
<th>Stage</th>
<th>Site</th>
<th>Time</th>
<th>Stage</th>
<th>Site</th>
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<th>Time</th>
<th>Stage</th>
<th>Site</th>
<th>Time</th>
<th>Stage</th>
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7 hours 0.31m 7 hours 0.26m 7 hours 0.32m 9 hours 0.41m

4.42cm per hour 3.7cm per hour 4.6cm per hour 4.6cm per hour

**Wednesday, November 28, 2007**

<table>
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<tr>
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<th>Site</th>
<th>Time</th>
<th>Stage</th>
<th>Site</th>
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<th>Stage</th>
<th>Site</th>
<th>Time</th>
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<td>1.08</td>
<td>R1 WSC</td>
<td>1500</td>
<td>7.89</td>
</tr>
<tr>
<td>R2B</td>
<td>1600</td>
<td>38.35</td>
<td>R2A</td>
<td>1600</td>
<td>38.35</td>
<td>R1</td>
<td>1700</td>
<td>1.06</td>
<td>R1 WSC</td>
<td>1600</td>
<td>7.88</td>
</tr>
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<td>R2B</td>
<td>1530</td>
<td>38.36</td>
<td>R2A</td>
<td>1700</td>
<td>38.35</td>
<td>R1</td>
<td>1700</td>
<td>1.06</td>
<td>R1 WSC</td>
<td>1700</td>
<td>7.86</td>
</tr>
</tbody>
</table>

8 hours 0.29m 8 hours 0.15m 8 hours 0.28m 12 hours 0.29m

3.6cm per hour 1.9cm per hour 3.5cm per hour 2.4cm per hour
3.3 Rampdown December 18-19, 2007

Introduction

Spilling from all three LLO at Coquitlam Dam had been ongoing since December 6, 2007, when a rampdown of all three gates was scheduled for December 18-19, 2007. Commencing at 09:30 on December 18, two gates were ramped down at the prescribed ramping rate. The flow reduction was complete at approximately 17:00 on the same day. The third and final gate was ramped down on the following day, December 19, 2007, at the prescribed rate.

A total of 78 fish were salvaged, and 9 mortalities were observed over the entire rampdown period (Table 8). Total fish stranded per metre of dewatered area was 0.0020 (Table 9). The reduction in river stage elevation is shown in Figure 3 and Table 10. The average reduction in elevation was higher for all sites during the first two gate closures. Site R2a had the slowest decrease in river stage during both gate closures (3.1cm/hr and 2.1cm/hr respectively) (Table 10).

![Figure 3 Port Coquitlam WSC rampdown discharge curve December 18, 19, 2007](image-url)
Index Site A

Dec 18 - Flow reductions from the first two gates produced minimal stranding in Site A. One rainbow fry was salvaged from Site A3, and one rainbow parr mortality was found in Site A1. Two traps were set overnight in a dewatering pool in site A3.

Dec 19 – During final gate closure survey crews observed only 2 stranded fish, both rainbow trout parr mortalities 1 in Site A1 and 1 in Site A2. Traps set overnight in site A3 salvaged 2 rainbow parr and 2 coho parr. Four more traps set overnight in Site A1, these traps resulted in the capture of 4 coho parr, 8 threespine sticklebacks, 3 rainbow parr and 1 rainbow fry.

Index Site B

December 18 – Stranding observed, in site B2 during initial flow reduction. Four rainbow parr, and 2 coho parr were salvaged. Mortalities observed included 1 coho parr, and 2 trout parr. Site B1 remained fully wetted following gate closure.

December 19 – Site B2 is normally not inundated at one LLO gate, however, due to heavy rain falling, combined with snow melt, this site remained partially wetted following the first two gate closures. Many stranded pools did not fully drain due to the continuous rainfall. Fish salvaged during final gate closure included 11 rainbow parr, and 1 dace with 2 rainbow parr mortalities also observed. Site B1 remained fully wetted following final gate closure.

Index Site C

December 18 – No stranding observed. Site C1 remained fully wetted following gate closures. Site C2 is usually a chronic stranding problem during the first two gate closures, but appeared to have not been inundated when surveyed on December 18. Possibility exists that river morphology has changed in this site, reducing stranding risk. This change in the stranding risk for site C2 was also noted during the November 2007 rampdown.

December 19 – Site C1 was monitored continually throughout the day on December 19, due to chronic stranding problems noted in previous rampdowns. A total of 15 rainbow parr, 2 rainbow fry, 1 coho fry, 8 dace, 2 cotidae (sp.) and 3 crayfish were salvaged. Mortalities were limited to 1 rainbow parr. Total fish stranded per square metre was 0.0464 with 690 m² of dewatered substrate (Table 9). This area had the highest concentration of stranding at 0.0464 per square metre.
Index Site D

December 18 – No stranding was observed in site D during the first two gate closures. Three traps were set overnight in site D1.

December 19 – The 3 traps set overnight at site D1 salvaged a total of 56 fish. However, 49 of the fish salvaged (all coho parr, see table 8), were drawn from an isolated pool that did not fully dewater during the course of the rampdown. This pool is medium sized (15-20m²) with a (post rampdown) maximum depth of 0.41m and an average depth of 0.24m. It is fed by subsurface water, plus rain and melt water when available. This pool was monitored for two and half weeks following the rampdown, and maintained its size and depth. Water flows from this pool into the Coquitlam River via a small channel, that was deemed by survey crews to be insufficient in size and depth to allow for passage into, or out of the pool. If this pool is able to maintain its size and depth into the spring, it is conceivable that juvenile fish held within it could survive to migrate during freshet. This pool will need to be monitored continuously to determine if fish within it are at risk.

Index Site E

December 18 - No stranding observed.

December 19 – One coho adult observed stranded in Site E3 was returned to the mainstem. Three traps set in Site E3 salvaged 1 coho parr, 2 rainbow parr and 1 rainbow fry. Two traps set in site E2 and one trap set in site E1 salvaged no fish.

Table 8  Stranding survey results for rampdown December 18,19, 2007 showing salvaged fish and mortalities by species and site.

<table>
<thead>
<tr>
<th>Index Site Code</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>B1</th>
<th>B2</th>
<th>C1</th>
<th>C2</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>Total</th>
</tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>2</td>
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<td>1</td>
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<td>1</td>
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<td></td>
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</tr>
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<td>1</td>
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<td>3</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9</td>
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</tbody>
</table>

| Risk Class      | A/B | A/B | A  | B  | A  | A  | A  | A  | A/B | A  | A/B | A  | A/B/C |
| Gate Class      | B/C | B/C | B  | C  | C  | B/C| B/C| B/C| B/C | C  | B/C | C  | B/C   |
**Table 9** Stranded fish per square metre for all rampdown sites December 18, 19, 2007.

<table>
<thead>
<tr>
<th>Site</th>
<th>Dewatered area m²</th>
<th>Salvaged</th>
<th>Mortalities</th>
<th>Total stranded</th>
<th>Stranded/m²</th>
<th>Mortalities/m²</th>
</tr>
</thead>
<tbody>
<tr>
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<td>2</td>
<td>16</td>
<td>0.0042</td>
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<td>0.0001</td>
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<tr>
<td>A3</td>
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<td>5</td>
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<td>0.0000</td>
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<td>0</td>
<td>0</td>
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<td>0.0000</td>
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<tr>
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<tr>
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<td>0</td>
<td>0</td>
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<td>0.0000</td>
</tr>
<tr>
<td>E2</td>
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<td>0</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
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<td>4</td>
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<td><strong>43375</strong></td>
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<td><strong>9</strong></td>
<td><strong>87</strong></td>
<td><strong>0.0020</strong></td>
<td><strong>0.0002</strong></td>
</tr>
</tbody>
</table>

**Table 10** Showing river stage elevation reductions for all recording sites, December 18, 19, 2007.

**Tuesday December 18, 2007**

<table>
<thead>
<tr>
<th>R2B (at Galette)</th>
<th>R2A at Hockaday</th>
<th>R1 at Lions Park</th>
<th>R1 WSC Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Stage</td>
<td>Time</td>
<td>Stage</td>
</tr>
<tr>
<td>1000</td>
<td>1.20</td>
<td>1000</td>
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</tr>
<tr>
<td>1100</td>
<td>1.17</td>
<td>1100</td>
<td>38.74</td>
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<tr>
<td>1300</td>
<td>1.08</td>
<td>1300</td>
<td>38.67</td>
</tr>
<tr>
<td>1430</td>
<td>1.00</td>
<td>1430</td>
<td>38.61</td>
</tr>
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<td>1530</td>
<td>0.96</td>
<td>1530</td>
<td>38.59</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td>5.5hrs</td>
<td>0.24m</td>
<td>5.5hrs</td>
<td>0.17m</td>
</tr>
</tbody>
</table>

4.4cm per hour 3.1cm per hour 4.5cm per hour 3.7cm per hour

**Wednesday, December 19, 2007**

<table>
<thead>
<tr>
<th>R2B (at Galette)</th>
<th>R2A at Hockaday</th>
<th>R1 at Lions Park</th>
<th>R1 WSC Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Stage</td>
<td>Time</td>
<td>Stage</td>
</tr>
<tr>
<td>800</td>
<td>0.91</td>
<td>800</td>
<td>38.56</td>
</tr>
<tr>
<td>1000</td>
<td>0.88</td>
<td>1000</td>
<td>38.55</td>
</tr>
<tr>
<td>1200</td>
<td>0.79</td>
<td>1230</td>
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<td>0.75</td>
<td>1330</td>
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</tr>
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<td>1500</td>
<td>0.71</td>
<td>1500</td>
<td>38.42</td>
</tr>
<tr>
<td>1600</td>
<td>0.69</td>
<td>1600</td>
<td>38.41</td>
</tr>
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</tr>
<tr>
<td>7hrs</td>
<td>0.22m</td>
<td>7.5hrs</td>
<td>0.16m</td>
</tr>
</tbody>
</table>

3.1cm per hour 2.1cm per hour 4.3cm per hour 2.1cm per hour
4.0 Discussion

All rampdown assessments during the period April 1, 2007 to March 31, 2008, utilized the interim ramping rate during all gate changes. As per Table 12, impacts on fish populations in the river due to stranding were fairly typical of what has been witnessed during previous rampdown assessments conducted during 2001-2007 (Macnair, 2006). No new areas of stranding were discovered in the 2007/08 survey period and areas identified previously as susceptible continued to strand fish and cause mortalities.

Changes to the morphological structure of one stranding area was observed during the November and December rampdowns. A perennially problematic stranding channel at site C2 (Appendix B) appears to have been reconfigured at the upstream end, leaving it less susceptible to inundation at high flows. During the July rampdown assessment, 22 coho were salvaged from the top end of this rampdown site (recall that the July event was only one LLO gate opening). However, during the November and December events, this site did not experience any stranding despite all LLO gates being opened. In addition, field survey notes taken in November and December both note that the site did not appear to have been inundated to a degree that would allow for fish to gain access. This change may have significantly reduced the risk for stranding at this site, but it should continue to be monitored closely to further confirm this reduced risk.

Table 11 Combined stranding survey results for the rampdown period April 1, 2007 to March 31, 2008 showing salvaged fish and mortalities by species and site.

<table>
<thead>
<tr>
<th>Index Site Code</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>B1</th>
<th>B2</th>
<th>C1</th>
<th>C2</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salvaged Coho Parr/smolt</td>
<td>15</td>
<td>2</td>
<td>42</td>
<td>59</td>
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<td></td>
</tr>
<tr>
<td>Trout Parr/smolt</td>
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<td>26</td>
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<td>Coho fry</td>
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<td>2</td>
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<tr>
<td>Dace</td>
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<td></td>
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<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>386</td>
<td></td>
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</tr>
</tbody>
</table>

| Mortalities Coho Parr/smolt | 1 | 4 | 5 |
| Trout Parr/smolt | 2 | 1 | 6 | 6 | 1 | 16 |
| Coho Fry | 1 | 4 | 6 | | | 11 |
| RT Fry | 1 | 1 | | | | 2 |
| Lamprey | 1 | | | | | 1 |
| kokanee | | | 1 | | | |
| TSS | | | | | | 0 |
| Total | A/B | A/B | A | A | A | A | A/B | A/B | A/B | A | A/B/C | 36 |
| Gate Class | B/C | B/C | B | C | C | C | B/C | B/C | B/C | C | B/C | B/C |
Evidence of the difference in stranding rates during the first two gate closures, as opposed to the last, continued to emerge in the 2007-2008 period. A comparison of the total amount of fish salvaged and mortalities between the different stages is presented in Figure 4. The number of fish stranded during the last gate closure totals 194, compared to 17 for the first two gates. Mortality levels are also different with 21 found during the final gate and only 4 for the first two gates. This contrast is likely due to the nature of the majority of the stranding sites along Coquitlam River. Most rampdown sites are inundated at flows under 15cms, which is generally equivalent to one gate opening. Furthermore, most of the areas inundated at higher flows are steep sloping and densely vegetated, meaning they are not as suitable for refuge, and are far less likely to form pools to trap fish when they dewater. The exceptions to this are sites E3, B2, A3 and portions of A2.

Table 12 Coquitlam River fish salvaged and mortalities by site for 2004 – 2008.

<table>
<thead>
<tr>
<th>Year</th>
<th>Site A Salv</th>
<th>Site A Mort</th>
<th>Site B Salv</th>
<th>Site B Mort</th>
<th>Site C Salv</th>
<th>Site C Mort</th>
<th>Site D Salv</th>
<th>Site D Mort</th>
<th>Site E Salv</th>
<th>Site E Mort</th>
<th>Total Salvaged</th>
<th>Total Mortalities</th>
<th>Total Stranded</th>
<th>Ramp Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-2008</td>
<td>67</td>
<td>6</td>
<td>32</td>
<td>11</td>
<td>199</td>
<td>17</td>
<td>20</td>
<td>1</td>
<td>65</td>
<td>1</td>
<td>383</td>
<td>36</td>
<td>419</td>
<td>3</td>
</tr>
<tr>
<td>2006-2007</td>
<td>39</td>
<td>14</td>
<td>3</td>
<td>4</td>
<td>47</td>
<td>80</td>
<td>36</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>125</td>
<td>103</td>
<td>228</td>
<td>2</td>
</tr>
<tr>
<td>2005-2006</td>
<td>95</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>7</td>
<td>85</td>
<td>6</td>
<td>181</td>
<td>22</td>
<td>203</td>
<td>2</td>
</tr>
<tr>
<td>2004-2005</td>
<td>75</td>
<td>2</td>
<td>10</td>
<td>0</td>
<td>13</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>48</td>
<td>0</td>
<td>146</td>
<td>11</td>
<td>157</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>276</strong></td>
<td><strong>22</strong></td>
<td><strong>45</strong></td>
<td><strong>15</strong></td>
<td><strong>260</strong></td>
<td><strong>115</strong></td>
<td><strong>56</strong></td>
<td><strong>12</strong></td>
<td><strong>198</strong></td>
<td><strong>7</strong></td>
<td><strong>835</strong></td>
<td><strong>172</strong></td>
<td><strong>1007</strong></td>
<td><strong>3</strong></td>
</tr>
</tbody>
</table>

Table 12 indicates a steady increase each year in the amount of fish stranded on Coquitlam River. This increase is influenced by a number of factors, including: the number of rampdown events, timing of rampdown events, survey crews finding more stranding areas and increased efficiency in fish salvage. For example, the rampdown in July 2007 occurred at a time when coho fry were very active in the river. The July event had a total of 203 stranded fish (Table 2), which represents nearly half the total of 419 for the entire year (Table 12). One site (site C1), stranded a total of 105 coho fry; this one site alone accounted for 25 percent of all stranding for the year. This illustrates the strong influence that seasonal rampdown timing has on stranding fish.
During the November rampdown it was assumed that many chum redds were created at high water during the spill and subsequently dewatered during the rampdown. Survey crews performed a series of pre-rampdown assessments in order to determine if redds were being made in areas that would subsequently dewater following flow reductions. However, the spill combined with natural inflows was of such duration and intensity that very few distinct redds were visible during the actual rampdown assessment. The visual confirmation of 10 stranded redds (Table 5) could, in fact, be much higher. During the pre-rampdown redd assessment, survey crews estimated a potential total of between 20-30 stranded redds. Taking into account that the water was very turbid and flows were very high, many areas where potential redds were being constructed could not be properly surveyed. It should be noted the issue of redd stranding is independent of ramp rates.

Stage reductions were consistent between rampdowns when measured from the WSC site in Port Coquitlam, (See tables 10, 7 and 4 for all river stage monitoring sites) with Figures 5 and 6 indicating the similarity between reduction rates at WSC. Differences between rates are influenced by a number of factors separate from gate closure, for example: the intensity of rainfall (or lack of) during flow reduction and the amount of natural inflow at the commencement of flow reduction.
As an example, tables 4, 7 and 10 indicate that site R2a has consistently lower rates of stage reduction than all other sites. This is explained by the wetted width at R2a, which is approximately 41m at one gate opening and 44m at three gates. A look the R2b site for contrast (which has the sharpest decrease in stage elevation) has a wetted width of 13m at one gate opening and 17m at three gates. The corresponding difference in rates is reflected by the width of the channel.

![Figure 5](image_url)

**Figure 5** Comparison of regulated flow reductions and natural flow reductions for Coquitlam River during the first two gate closures. Port Coquitlam WSC data.

Natural flow reduction versus rampdown flow reductions are compared in Figures 5-8. Natural reductions to river stage elevation are consistently lower than rampdown reductions, however, as per Table 5 there are circumstances where natural reductions do occur at a faster rate. The first 30cm of stage reduction during the natural event on October 7-8, 2007 was at a rate of 6.0cm per hour, the fastest decrease recorded during the 2007-2008 rampdown period. The circumstances of this rapid decline in stage can be explained by the surrounding climatic conditions at the time. This was the first major rain event of the season, dry conditions had prevailed for over 6 weeks and the river was very low. All Coquitlam tributaries were dry or nearly dry and subsurface water retention was depleted. An intense period of rainfall began on October 2, 2007 and continued for four days. Due to the aforementioned conditions, when rainfall ceased, the river rapidly dropped. Compare this to the October 22-24 event which occurred following a more sustained period of rainfall, after tributaries and subsurface
flows had been charged, which allowed for a slower decrease in the flow. In addition, light rain continued to fall during the flow reduction period, further slowing the stage elevation reduction rate.

![Graph](image)

**Figure 6** Comparison of natural and regulated river stage reduction at first two gate closures. Two scenarios are shown, a decrease of the first 30 cm in stage and a decrease until flows are stabilized. Natural flow reductions are represented by the October dates. Port Coquitlam WSC data.

Although ramping rates on Coquitlam River do not always mimic natural flow reductions, (and are not designed to precisely match natural conditions), ramping rates, even at the first two more rapid gate closures, are consistently under 5 cm per hour. During final gate closure stage reduction are consistently between 3.5 and 2 cm per hour. These rates are consistent with other BC Hydro prescribed rates to reduce stranding.

Stranding influence on fish production in Coquitlam River is likely to be minimal based on the results of the past 6 years. For pink and chum fry the influence is negligible. Decker et. al. 2007 reports the estimated average annual outmigrating population for chum and pink fry for the 2003-2006 period is 2,430,000 and 365,000 respectively. Contrast this with a total of 56 chum mortalities and zero pink mortalities observed during rampdowns for the same period. Coho and steelhead smolt population estimates for the same period average 16,070 and 6,774 per year respectively (Decker et. al. 2007). The average number of coho and steelhead smolt mortalities per year due to rampdowns is 4 and 9 respectively.
Figure 6 Comparison of regulated flow reductions and natural flow reductions for Coquitlam River during the final gate closure. Port Coquitlam WSC data.

Figure 7 Comparison of natural and rampdowns river elevation reduction at final gate closure. Two scenarios are shown, a decrease of the first 25cm in stage and a decrease until flows are stabilized. Natural flow reductions are represented by the October dates. WSC data.
5.0 Conclusions and Recommendations

An increase in stranding and mortalities does not indicate that the ramping rate as prescribed needs to be altered. As survey crews find new areas and increase their efficiency at locating and salvaging fish, numbers will likely continue to rise. In addition, as was witnessed during the November and December rampdown surveys, current sites may change and may become more or less hazardous. Furthermore, areas of the river where stranding occurs are constantly shifting meaning that new stranding areas will continually be formed and salvage priorities need to be shifted accordingly.

Operational changes to the timing of the commencement of gate closures was recommended in the 2006-2007 report, based on the negative impacts which occurred as a result of critical stranding occurring after dark, when crews are unable to survey (Macnair 2007). The operational practice of implementing early start times for gate closures, particularly during the winter months, was effectively used during 2007-2008 rampdown period.

The possibility of reducing rampdown likelihood during sensitive fall and spring fisheries periods should be explored with options such as diversion of pre-spills to Buntzen Lake Reservoir to reduce spill frequency. It is expected that a reduction in spill frequency will occur once the dam seismic upgrade is complete and the normal maximum operating level of 155m is reinstated resulting in increased reservoir capacity.

At present the interim ramping rate still appears to be effective. Survey crews have adapted to the ramp rate and are continually increasing their efficiency at salvaging fish. Comparison of rampdown mortalities to fish productivity clearly shows the negligible impact that rampdowns appear to have on fish productivity in Coquitlam River. Minimizing impacts with careful adherence to rampdown schedules and consistent monitoring of potential stranding sites will continue to be the most appropriate means to reduce the fish stranding risk while being operationally feasible.
6.0 Literature cited

BC Hydro 2006, Coquitlam-Buntzen Water Use Plan Monitoring Terms of Reference, January 2006, Burnaby BC


Appendix A  Site descriptions and photographs

**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: 3800m²*

![Site A1 showing gravel area on fluvial island where fish are regularly stranded](image)

**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: 19000m²*

**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: 4800m²*

**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 dewatered, so is only a stranding risk when flow in the river is very low.

**Total Area: 270m²**

**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: 3000m²**

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

**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: 690m²**
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: 550m²*

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: 1000m²*

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: 600m²*

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: 665m²*
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: 1200m²*

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: 1800m²*

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: 6000m²*
Appendix B Aerial Site Photos

Available from BCH upon request.