Coquitlam-Buntzen Project Water Use Plan

Assessment of Pink Salmon Passage in Lower Coquitlam River

Implementation Year 5

Reference: COQMON #4

Study Period: August – September 2015

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ASSESSMENT OF PINK SALMON PASSAGE IN LOWER COQUITLAM RIVER

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EXECUTIVE SUMMARY

Two important questions were raised during the development of the Coquitlam-Buntzen Water Use Plan (WUP) related to fish migration through the lower Coquitlam River, which were:

1) Are there any Pink Salmon (*Oncorhynchus gorbuscha*) access issues associated with low flows during early run migration in the lower Coquitlam River; and if so

2) At what flows are passage issues resolved/improved?

These questions were based on information contained within a fisheries technical report in 2001 by Jarvis and reviewed by the WUP Consultative Committee. The report suggests that Pink Salmon passage through the lower Coquitlam River may be impeded below river flows of 2.8 cubic meters per second (cms).

The objectives of this study was to assess adult Pink Salmon passage in the lower Coquitlam River by identifying key index sites that appeared to have the potential to restrict Pink Salmon migration during summer low flows. The second objective was to determine at what flows each barrier is eliminated or reduced.

This 2015 report is the fifth in a series of information collected during the typical Pink Salmon migration and spawning season which is every second (odd) year, (2007, 2009, 2011, 2013 and 2015). Pink Salmon have a two year life cycle and Coquitlam River Pink Salmon abundance peaks in odd numbered years, with only incidental reports of Pink Salmon spawning in even numbered years.

The methodology used for the 2015 study was the same as that used in previous years. Specifically, the 2007 assessment had identified seven index sites that had the potential of restricting Pink Salmon migration during low summer flows, five of these 2007 sites were included in the 2015 study. Two monitoring sites, index site 1 and index site 3B, had been discontinued in 2013 as they were deemed to not represent impediments to Pink Salmon passage. A further two sites were added to the 2013 study, index site 1A and 3C, which continued to be assessed in 2015.

Jarvis (2001) reported that Pink Salmon migration may be restricted at flows below 2.8cms. For the purpose of this study, there are two locations along the lower Coquitlam River that in-stream flows are accurately estimated:

1) Immediately downstream of the Coquitlam Dam (CQD) outlet, which is the practical limit to upstream Pink Salmon migration and spawning.

2) At the Water Survey of Canada (WSC) gauge in the lower reach of the Coquitlam River adjacent to the CPR rail bridge in the City of Port Coquitlam (COQUITLAM RIVER AT PORT COQUITLAM (08MH002) [BC]), which is downstream of the majority of the Pink Salmon spawning habitats.

The estimated lower Coquitlam River flow would be the sum of the water flow released from the upstream Coquitlam Reservoir Dam and any tributary or groundwater inflows which entered the Coquitlam River downstream.

The study spans two operating regimes for Coquitlam Dam flow releases. In 2007, discharge from CQD was released through 2 Fish Water Release Valves (FRV1 and FRV2). The Fish Water Release Valves were left 100% open and discharge varied depending on Reservoir elevation. The Fish Water Release Valves could release up to 1.7cms and the minimum flow was ordered to be 0.8cms. This was the treatment 1 Flow Regime. The treatment 2 Flow Regime, which commenced October 2008, specified a CQD Target Release of 2.7cms in August and 2.22cms in September with a reduced in stream Target Release of 1.1cms for both months and excludes precipitation and tributary contribution but are below the 2.8cms previously mentioned for unimpeded migration. In the 2007 study year discharge is significantly lower due to the Treatment 1 specifications. 2015 was an interesting year because it was the driest on record and BCH implemented the reduced in stream Flow Release Targets (Wilson 2016).

Throughout the study period flows at the WSC site were observed at rates averaging 2.6cms to 2.8cms with the exception in 2007 and 2015 when discharge levels from the Coquitlam Reservoir Dam were reduced to minimum requirements for treatment 1 and 2 for spillway maintenance in 2007 and in 2015 due to conservation measures put in place to conserve reservoir levels. The average flows during 2007 and 2015 varied from 1.68cms to 2.44cms recorded at the Water Survey Canada gauge.

Over the course of the five years of study there was no evidence that the migration of Pink Salmon was impeded or restricted at any of the index monitoring sites, even during the treatment 1 flow year of 2007 and the Reduced Instream Flow Release Year 2015. Aside from the observation of no noticeable accumulations of holding salmon downstream of the index sites themselves, additional support for this conclusion was based on the observation that Pink Salmon would arrive adjacent to their spawning grounds immediately downstream of the Coquitlam Reservoir Dam (Swoboda Spawning Channel) relatively early in the migration period.

Considering the first arrivals preferentially entered upper river holding and spawning areas during the lowest flows of the season, at a similar proportion to those that migrated later during medium and high flows, it strongly suggests that early season flows observed to date, do not significantly impede the migration of Pink Salmon.

Observations in 2007 and 2015, warmer than average summers, suggested Pink Salmon moved through the lower Coquitlam River to their spawning grounds without noticeable delay. The 2007 and 2015 survey also recorded that a significant proportion, 71% and 76% respectively, of Pink Salmon selected mainstem (in contrast to tributary or side channel habitats) spawning habitat (Macnair 2015). This suggests that Pink Salmon migration through the lower Coquitlam River to their upper

river spawning areas was not impeded and the main stem of the river remained attractive spawning habitat even with higher than average water temperatures.

Summer low flows do not appear to affect the efficacy of early returning Pink Salmon migration. Observations indicate the treatment 2 flow regime with a consistent contribution from CQD releases (2.2 to 2.7cms) improved passage at all the index sites as indicated by the early season fish distribution numbers in the upper reaches of the Coquitlam mainstem. The higher base flows provided by the treatment 2 flow regime provided improved depth, velocity and temperature at all index sites, which resulted in increased available spawning habitat and Pink spawners being in better physical condition to migrate, hold and spawn successfully. The treatment 2 flow regime from CQD is critical when tributary and precipitation contributions are minimal during hot and dry summers if utilized at the upper maximum target requirement of 2.2cms to 2.7cms which provides greater availability of spawning habitat and accessibility to upper reaches where there is quality spawning and rearing habitat.

Considering that the average number of early migrating Pink Salmon represent a small portion (<2%) of the total population (Table 11), consideration should be to review August and September CQD water releases if promoting unimpeded Pink Salmon migration is desired. August Treatment 2 flows are now targeted at a maximum flow of 2.7cms (CQD) and are in fact reduced in September to 2.2cms (CQD). It would be beneficial to consider modifying flows to generally conform to Pink Salmon upstream migration timing which appears to initiate in early August, although low in numbers but increasing through early September and strongly increases after mid-September, peaking in early October and completed in late October.

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1.0 INTRODUCTION

This 2015 study represents the final assessment year of a five, odd-year monitoring study, commencing in 2007 and ending in 2015, of Pink Salmon passage in the lower Coquitlam River.

1.1 Background

This study represents a component of the monitoring program BC Hydro has undertaken as partial fulfillment of its commitments made during the Coquitlam-Buntzen Water Use Plan (WUP) process. In 2003, the Coquitlam-Buntzen Water Use Plan consultative committee agreed to a set of operating conditions for the review period ending in 2016. The recommended operations include the release of two flow regimes from Coquitlam Reservoir Dam (CQD), (Table 1). Prior to June 1998, flow releases from the dam ranged from 0.06 to 0.5cms (Decker, 2009). From June 1998 to May 2005 a minimum flow release of 0.57cms from CQD was ordered (Province of BC, 1998). In May 2005 the minimum flow release from CQD was increased to 0.8cms. The flow release from Coquitlam Dam was provided through 2 Fish Water Release Valves that were kept 100% open. Release varied depending on the Reservoir Elevation (time of year) until completion of dam seismic upgrades in 2008. BC Hydro's transition to the treatment 2 Flow Regime of between 1.1 to 5.9cms (CQD) commenced on October 22, 2008 (Table 1) in which target flow releases from CQD were prescribed on a monthly or partial month basis (Province of BC, 2005).

A fisheries technical document was reviewed by the WUP Consultative Committee that indicated main stem passage was restricted at flows below 2.8cms (Jarvis 2001). A report prepared by Jarvis (2001) provided historical evidence that main stem salmon spawning migration had been restricted in the Coquitlam River during summer low flows when discharges were less than 100cfs (2.8cms). In 2003, Pink Salmon returns were primarily observed in late September to early October although it has been documented that Pink Salmon runs in the Fraser River can access tributaries as early as August (Macnair, Lewis, 2003). With the increased Pink Salmon escapements in recent years, there is potential access issues for migrating adults in late summer during low flows. Based on recommendations from the Coquitlam/Buntzen Water Use Plan (WUP) Consultative Committee and the approved WUP monitoring program, the purpose of this study is to monitor the migration of returning Coquitlam River adult Pink Salmon to determine if there are any flow related migration barriers and at what flows can they be mitigated. With the issue of the revised Coquitlam/Buntzen Water Act Order in 2005, the monitoring and assessment study of Pink Salmon migration was to continue in odd year spawning cycles commencing in 2007 and extending through the end of the WUP review in 2015.

As a component of the WUP monitoring program the initial 2007 assessment was conducted to monitor Pink Salmon passage and determine if there were flow related migration barriers, either partial or complete, in the lower Coquitlam River. The 2007 assessment confirmed 7 index monitoring sites throughout the Coquitlam River that were identified as potential fish passage barriers during the

treatment 1 flow regime which had been releasing between 0.57-1.7cms since 1998. This flow regime continued until the completion of the Coquitlam Dam seismic upgrade in 2008 when BC Hydro transitioned to the treatment 2 flow regime, of between 1.1 to 5.9cms (CQD) starting on October 22, 2008 (Table 1).

The 2009 study year had significantly higher flows in the river during early Pink Salmon migration due to higher than predicted flows from the recently replaced CDQ Low Level Outlet Gate (LLOG3). Initial flow releases from CQD LLOG3 were based on a theoretical discharge rating curve. For the 2009 study period the rating curve for the new gate was not accurate leading to flow releases during the period being approximately 2.0cms above the 2.7 to 2.2cms target flows during the early Pink Salmon migration in August and early September. Based on field calibration the discharge rating curve was revised with refinement of flows to within the target levels beginning September 16, 2009 (Hunter, 2009).

The 2011 monitoring year was indicative of expected discharge targets of 2.2 - 2.7cms from CQD during the treatment 2 flow regime with a mean daily flow of 2.1cms to 2.9cms, maximizing stream flow contribution during the early run of the migration which occurred the first week of September (Dodd, 2011).

During the 2013 study year the treatment 2 flow regime from the CQD gate, identified as Low Level Outlet Gate 3 (LLOG3) provided a consistent contribution to stream flow of 2.2 to 2.6cms from August 25th to September 30th and within targeted releases for the treatment 2 flow regime. The 2013 survey year replaced two monitoring sites which included site 1 and Site 3B. Site 1 was replaced because re-assessment and previous surveys in 2009 and 2011 determined it no longer represented a fish passage barrier. Site 3B was replaced since in-stream habitat improvements were completed by the Department of Fisheries and Oceans (DFO) in the summer of 2012 to improve flow and stream depth to the right side channel. The addition of two index sites were identified for the 2013 assessment and were incorporated into monitoring due to depth and flow constraints, these sites are identified as 1A and 3C.

Throughout the 2015 monitoring study, flow contribution from CQD LLOG3 gate was reduced to the treatment 2 reduced instream flow release of 1.1cms with an average daily mean flow of 1.4cms during the monitoring period due to lower than expected reservoir levels as inflows to the reservoir in 2015 were observed to be the lowest on record from an extended period of hot, dry conditions throughout the south coast of British Columbia. Treatment 2 target flow releases started September 23rd, which coincided with precipitation events.

The following table provides details on the annual treatment 1 and treatment 2 discharges from CQD as targeted by BC Hydro.

Table 1 - Annual schedule for release amounts from CQD, note: August and September current and targeted discharges (BC Hydro 2003). The highlighted values occur during the monitoring period.

Coquitlam Reservoir Dam Release Schedule				
Date	**Treatment 1 Approximate discharge based on FRV1 and 2 fully open (cms)**	**Treatment 2 River Flow Target (cms)**	**Treatment 2 River Lower Flow Target (cms)**	**Species Driver and Priority for Coquitlam River releases**
1-Jan	1.0	5.9	3.6	Chinook Spawning
15-Jan	1.0	2.9	2.9	Chinook Spawning
Feb	1.0	2.9	1.8	Chinook Spawning
Mar	0.8	4.3	1.1	Steelhead Spawning
Apr	0.8	3.5	1.1	Steelhead Spawning
May	1.1	2.9	1.1	Steelhead Spawning
June	1.4	1.1	1.1	Steelhead Parr
July	1.4	1.2	1.1	Steelhead Parr
Aug	1.1	2.7	1.1	Steelhead Parr
Sept	0.8	2.2	1.1	Steelhead Parr
Oct	0.8	6.1	3.6	Chinook Spawning
Nov	1.1	4.0	1.5	Chinook Spawning
Dec	1.1	5.0	2.5	Chinook Spawning

1.2 OBJECTIVES:

The assessment was conducted from late August to no later than October 1st each Pink Salmon migration year (odd year) starting in September 2007 and extended though to October 2015.

The two primary objectives of this monitoring study are to:

(1) Monitor the migration of early returning Pink Salmon in odd years (2007-2015) to determine if there are any flow related migration barriers in the lower Coquitlam River mainstem corridor**.**

(2) To determine at what flows each barrier is eliminated or reduced.

In order to answer the primary objectives above there are two alternative hypotheses that are tested:

(1) Early run Pink Salmon migration is not restricted during low inflows to the lower Coquitlam River.

(2) Changes in flow do not influence the efficacy of Pink Salmon migration.

The following table summarises Year 5 (2015) findings by answering the main objective of this study;

Table 2 - COQMON#4 – Assessment of Pink Salmon Passage in Lower Coquitlam River

Primary Objective	Management Question	Alternative Hypothesis	Year 5 (2015) Findings
To monitor Pink Salmon migration during low flows and assess at what flows migration is improved (if necessary)	Are there any Pink Salmon access issues associated with low flows during early run migration in the lower Coquitlam River; and if so	H_1: Early Pink Salmon migration is not restricted during low inflows to the Coquitlam River	H_1 - Early returning Pink Salmon are not restricted during lower flows to the upstream spawning habitat of Coquitlam River. Low flows do have potential to affect off channel access. See section 5.1 for results.
	At what flows are passage issues resolved and/or improved?	H_2: Changes in flow do not influence the efficacy of Pink Salmon migration	H_2 - Pink Salmon were able to migrate successfully to the upstream habitat in reach 4 throughout treatment 1 and 2 flow regimes. See section 5.2 for results.

2.0 STUDY AREA

The study area on the Coquitlam River is 12.9km in length and consists of seven potential passage index sites that are monitored. The lower end of the study area is defined by the upstream (north) edge beginning upstream of the Pitt River Road Bridge and extends upstream to the base of the Coquitlam Dam (CQD), (Figures 1 & 2). Adult Pink Salmon typically select spawning habitat within the main channel (mainstem spawning) and disproportionately utilize spawning habitat areas in the upper reaches of the Coquitlam River. However it has also been reported that on average 30 to 40% of returning Pink Salmon access side channels or tributaries of the Coquitlam River (off channel spawning) habitat since monitoring of the Coquitlam River began in 2003 (Decker 2009). This study primarily investigates issues related to Pink Salmon migration through the mainstem Coquitlam River therefore Pink Salmon access into tributaries, off channel habitat or enhanced spawning habitat sites was not addressed and may be subject worth future consideration given the significant portion of the Pink Salmon population that utilizes these habitats in some years. The number of index sites monitored for Pink Salmon passage remained relatively consistent from the initial study year of 2007, with the following modifications. Site 1 was discontinued in 2013, because re-assessment of this site and previous assessments in 2009 / 2011 determined that it no longer represented a fish passage obstruction. Site 3B located adjacent to the Al Grist Memorial Hatchery was also discontinued in 2013 after in stream habitat improvements were completed by The Department of Fisheries and Oceans (DFO) in the summer of 2012. To compensate for the discontinuance of these two index sites, the

2013 preliminary assessment identified two new potential monitoring sites, 1A and 3C, the first site is located under the Kingsway CPR bridge and the second site is located downstream of Al Grist Memorial Hatchery which has been included in the study design since that year. The following index sites are identified as:

Index Site 1 - (49'15.830 N -122'47.075 W) located off McAllister Ave and Maple Street in Port Coquitlam. Site discontinued monitoring after 2011.

Index Site 1A - (49'15.941 N -122'46.902 W) New site for 2013 and 2015. Located under the CPR rail bridge crossing at Kingsway Street in Port Coquitlam.

Index Site 2A - (49' 16.276 N – 122' 47.075 W) located at the foot of Prairie Avenue east and Shaughnessy Street in Port Coquitlam.

Index Site 2B - (49' 16.585 N – 122 46.620 W) extends upstream 30m and downstream 55m of Patricia Street pedestrian bridge in Port Coquitlam.

Index Site 2C - (49' 19.621 N – 122' 46.346 W) located 85m downstream of Galette Park access and Pipeline Road, Coquitlam.

Index Site 3A - (49' 19.632 N – 122' 46.344 W) located at Upper Coquitlam River Park, 120m upstream of the diving board hole pool.

Index Site 3B - (49' 20 .251 N – 122' 46.263 W) located 60m upstream of the Al Grist Memorial Hatchery at Metro Vancouver watershed boundary. Site discontinued monitoring after 2011.

Index Site 3C - (49' 20 .230 N – 122' 46.251 W) New Site for 2013 and 2015. Located 60m downstream of the Al Grist Memorial Hatchery off Pipeline Road.

Index Site 4 - (49' 21. 041 N – 122' 46.452 W) located at the Coquitlam mainstem and Swoboda channel confluence, access south of Grant's Tomb pond.

The following watershed information further describes the Coquitlam River basin below the Dam:

- Watershed code: 100-024500-00000-00000-000
- Geo-data BC Trim Map reference: 092G037, 092G027, 092G026
- Watershed size : 237 km^2
- River length from mouth to Coquitlam Dam: 17 km
- Study area: 12.9 km
- Coquitlam River mean annual discharge: 4.6cms (McPhee 2003)
- Major Tributaries: Or Creek MAD=2.9cms, Scott/Hoy Creek MAD=1.0cm (McPhee 2003)

Figure 1 – Passage index site locations 1A, 2A and 2B located in the lower portion of the Coquitlam River. (source: Google Earth)

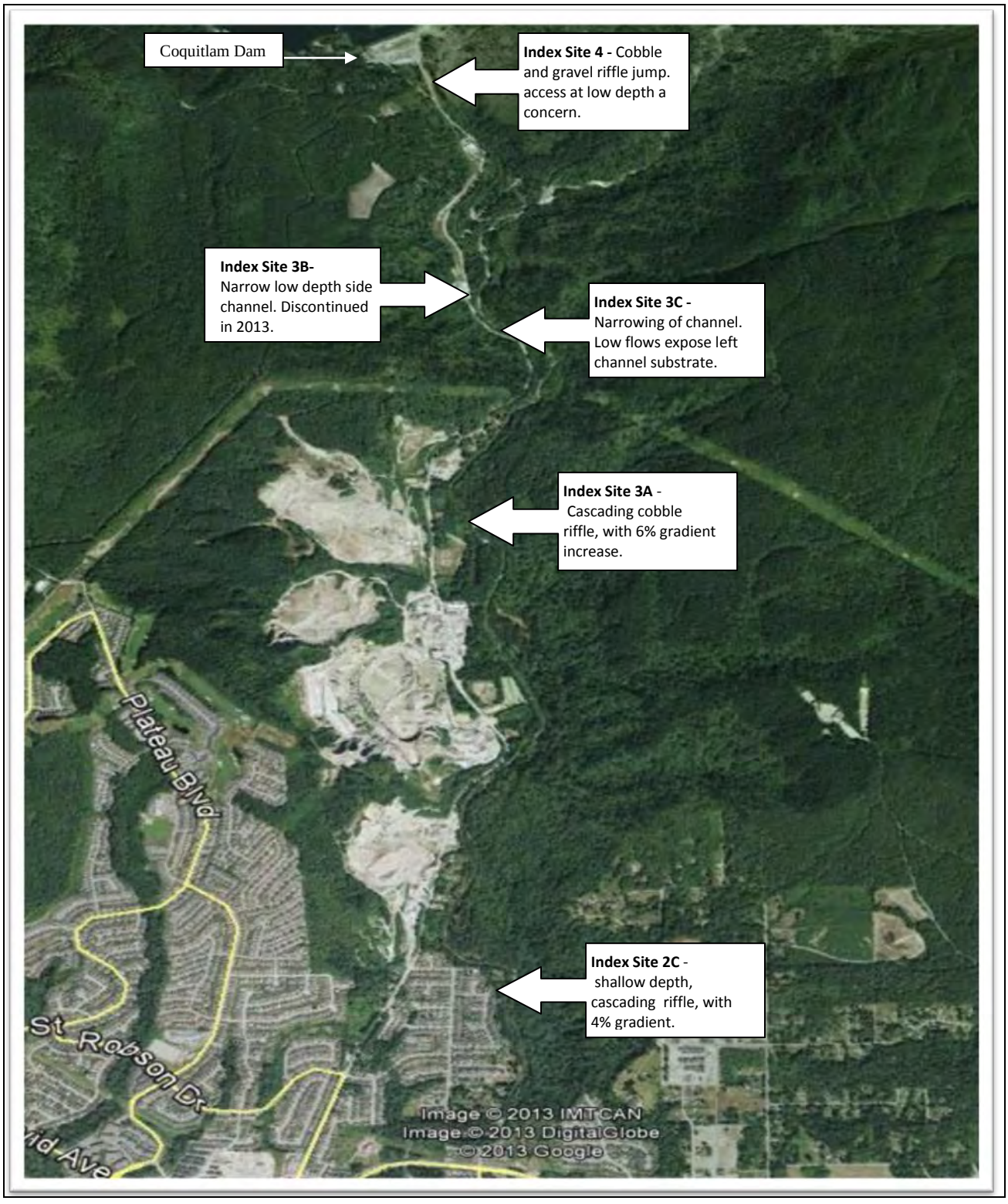

Figure 2 –Passage index site locations 2C, 3A, 3C and 4 located in the upper portion of the Coquitlam River. (source: Google Earth)

3.0 METHODS

The objective undertaken for the 2015 assessment was to monitor previously identified index sites that had the potential to affect salmon passage in the mainstem Coquitlam River and to identify any new index sites that could potentially be a passage barrier to migrating Pink Salmon. In 2007 seven sites were identified and GPS located as monitoring sites as indicated in the study area section of this report. For any new sites the entire river was surveyed at summer low flows, prior to the arrival of the first observed migrating Pink Salmon, and added to the index site list according to the physical parameters indicating passage could be an issue. The 2013 preliminary assessment identified two new monitoring sites, 1A and 3C, during early season reconnaissance. The first site is located under the Kingsway CPR bridge and the second site is located downstream of Al Grist memorial hatchery. Site 1 was discontinued because re-assessment of this site and previous assessments in 2009 to 2011 determined that it no longer represented an obstruction to fish passage. Site 3B located upstream of the Al Grist memorial hatchery was also discontinued after in stream habitat improvements were completed by the Department of Fisheries and Oceans (DFO) in the summer of 2012 to improve flow and depth to the right side-channel.

The sites were monitored from late August to no later than October 1st, with a maximum of six surveys conducted to determine if low flows impeded or restricted Pink Salmon passage. For safety reasons site surveys were performed during daylight hours and visual observations were considered adequate from the stream bank. A variety of techniques have been used to assess adult stream passage usually at critical stream reaches such as shallow riffles and low depth glides (Bjornn and Reiser 1991). A site assessment card which provides an overview of each index site on observation days is filled out and kept on record, a blank assessment card can be reviewed in appendix III. Field assessment data collected primarily focused on stream temperature, water depth and velocity which is collected using a Swoffer model 2100 series current velocity meter. Maximum and minimum depths and velocity is collected at intervals dictated by the wetted width of the channel. For wetted widths less than 10m, collection points were taken every meter. For wetted widths greater than 10m, depth and velocity data was collected every 2 to 3 meters.

Velocity measurements were collected at 60% of the total depth and presented as meters per second. Depth measurements were collected perpendicular to the width of the channel and is represented as an average and maximum stream depth. Air and stream temperature data was collected once per index site at a mid-depth water level in the center of the channel using a handheld digital thermometer. Additional data parameters were also collected such as wetted width of the stream channel, measured distance across the wetted portion of the stream channel. Gradient data was collected using a Suunto clinometer and represented as a percent value. Substrate composition (Table 3) and weather conditions as well as photo documentation was also collected.

The following table identifies the substrate classification used for the assessment at Index sites.

Table 3- Bed Material (substrate) Size Distribution

Class	Size
Fines	<2mm
Gravels	2 - 64mm
Cobbles	64 - 256mm
Boulders	>256
Rock	>4000mm
(Kaufmann and Robinson(1993)	

Other physical conditions monitored at the index sites included description of the barrier type, length, width, plunge pool depth and jump height. Observations of holding (sedentary) and or migrating (active) Pink Salmon spawners were enumerated downstream and upstream of the index site locations and their overall physical condition and health was documented. Visual monitoring of migration attempts were conducted by two trained technicians from the stream bank for a maximum of a 30 minute observation period when fish were present.

Daily minimum, mean and maximum discharge data information was provided from Water Survey Canada, site 08MH002 hydrometric data station located at Kingsway Road bridge in Port Coquitlam and operated by Environment Canada. Coquitlam Dam releases were provided by BC Hydro. Precipitation data was provided by Metro Vancouver weather station located at the base of Coquitlam Dam. Communication and data exchange with other BC Hydro monitoring crews conducting adult salmon assessments of the Coquitlam River were ongoing to determine Pink Salmon distribution and other potential monitoring sites that may restrict or impede passage.

4.0 RESULTS

2015

Throughout the 2015 monitoring study (Aug -Sept), flow contribution from Coquitlam Dam (CQD) was significantly reduced to the treatment 2 reduced in stream flow release minimum of 1.1cms (CQD) with an average daily mean flow contribution of 1.4cms (WSC Port Coquitlam) recorded during August 25th to September 30th. Low flows were mainly due to lower than expected reservoir levels caused by a low snowpack and an extended period of hot, dry conditions throughout the south coast region of British Columbia. Tributary flows were observed to be minimal during early season reconnaissance and these low flows continued well into September until the onset of fall rains.

The first Pink Salmon observed in the study area was on August 2nd, before formal monitoring of Pink Salmon migration began. It was observed upstream of Index site 4, the site immediately downstream of the CQD, during a period of extended minimum flow release from the CQD and with a lower Coquitlam River flow of 1.42cms as measured at the WSC, Port Coquitlam.

The lowest flow recorded during the field assessment at the Water Survey Canada hydrometric station during the study period occurred on September 11th with a stream flow of 2.73cms (WSC Port Coquitlam) which was early into to the migration period with 40 Pink Salmon observed throughout the index sites. Of the total Pink Salmon observed, 28 Pink Salmon were observed upstream of index site 3A and the 2 were enumerated upstream of index site 4, indicating that passage was not impeded or restricted at any of the index monitoring sites as indicated by fish distribution numbers in the upper reaches.

Significant numbers of Pink Salmon did not begin to migrate through the lower Coquitlam River until mid and late September when a series of higher flow, rainfall driven events occurred. Earlier precipitation events occurred in late August with 101.8mm (Appendix 4) recorded from August 28th to 31st (Figure 3) and did not appear to attract significant numbers of Pink Salmon into the Coquitlam River. 244mm of precipitation fell during the month of September accounting for 6 rain induced flow events which coincided with significant numbers of Pink Salmon migrating after the September 21st precipitation event. This suggests that in 2015 there was a small early component of the Coquitlam River Pink Salmon population that entered the river prior to mid-September, the dominate migration occurs after mid-September and the timing of this later component is not strongly affected by flows in the Coquitlam River prior to mid-September.

Stream temperatures ranged from 12^{o}C to 16.7^{o}C throughout the study period and fell within the acceptable threshold of between 7.2^{O}C to 15.6^{o}C (Appendix 1) for Pink Salmon migration. The following figure (Figure 3) illustrates the average daily discharge contribution from the Coquitlam Dam, tributaries and precipitation amounts between August 25th and September 30th 2015.

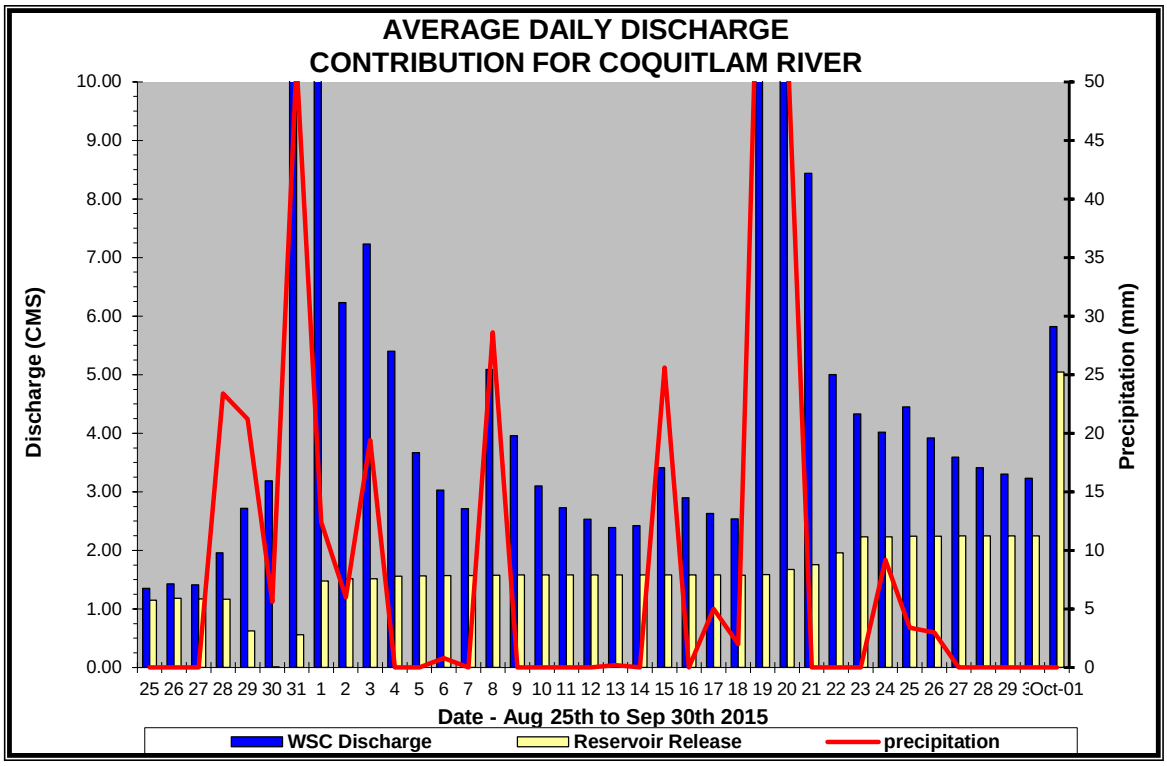

Figure 3 – CQD valve release, precipitation and WSC average daily river discharge, Aug 25th to Sept 30th 2015, (source: WSC Port Coquitlam, Stuart 2015, Harrison 2015)

2013

The treatment 2 flow regime from the CQD gate, identified as Low Level Outlet Gate 3 (LLOG3), provided a consistent contribution to stream flow of 2.39cms from August 25th to September 30th with an average daily discharge of 2.83cms recorded at the WSC monitoring site (Figure 4). The arrival of the first Pink Salmon was observed August 7th and located upstream of index site 4 during a discharge of 3.16cms (WSC Port Coquitlam). During the monitoring period the lowest stream discharge recorded was on September 15th at a discharge of 2.59cms in which 255 Pink Salmon were observed throughout the mainstem and of those 63 were enumerated upstream of index site 4 indicating that depth and velocity for passage was adequate to reach the upper habitat of the Coquitlam mainstem (WSC Port Coquitlam) (Macnair 2013).

Stream temperatures were a potential concern and were unseasonably high averaging 19^{o}C to 20^{o}C in August to mid-September, resulting from an extended period of hot, dry conditions throughout the south coast region, acceptable temperature thresholds are considered to be between 7.2^{o}C to 15.6^{o}C, (Bjornn and Reiser 1991). During the early migration period the treatment 2 flow regime provided adequate flows for passage when migration is most critical due to the lack of precipitation, low summer flows and the reduced September target release from 2.7cms to 2.2cms from the CQD (Figure 4).

Sixteen days of precipitation were recorded during the monitoring period for a total of 383mm (Appendix 4) recorded at the CQD weather station which represents the upper and mid-river area (3A to index site 4) and during the same period 250mm was recorded at the Como Lake weather station (Environment Canada, 2013) representing the lower river, 1A to 2C index sites. The following figure (Figure 4) illustrates the average daily discharge contribution from the CQD, tributaries and precipitation amounts between August 25th and September 30th 2013, as well the total river discharge at WSC station.

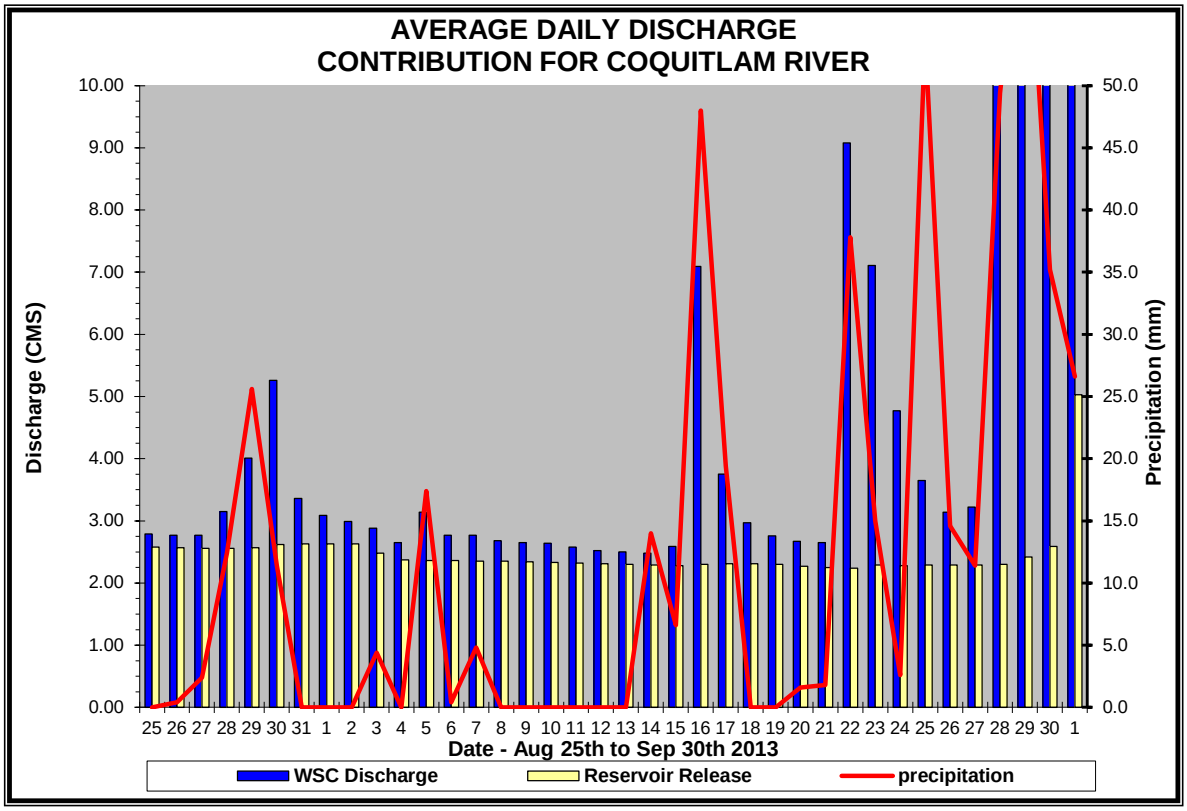

Figure 4 – Coquitlam Reservoir Dam valve release, precipitation and WSC average daily river discharge, Aug 25th to Sept 30th 2013, (source: WSC Port Coquitlam, Fournier 2013, Dunkley 2013)

2011

The treatment 2 flow regime from the newly installed CQD gate identified as Low Level Outlet Gate 3 (LLOG3) provided a consistent contribution to stream flow of 2.3cms from August 25th to September 25th with an average minimum daily discharge of 3.5cms (Figure 5) recorded at the WSC monitoring site.

The first Pink Salmon observed was on August 22nd, upstream of Index site 4 during a flow of 2.86cms (WSC, Port Coquitlam). During the monitoring period the lowest stream flow recorded was on September 3rd at 2.62cms (WSC, Port Coquitlam) (Figure 5) at which time 44 Pink Salmon were

observed throughout the river and of those 31 were enumerated in Swoboda Channels upstream of index site 4 (Macnair 2011). Passage was not impeded or restricted at any of the index monitoring sites during the lowest stream flow as indicated by fish distribution numbers in the upper reaches. During the early migration period the treatment 2 flow regime provided adequate passage flows when migration is most critical due to the lack of precipitation and low summer flows.

Six days of precipitation were recorded during the monitoring period for a total of 78.6mm recorded at the Douglas College weather station adjacent to the mid-river (Index site 2B) area and during the same period 186mm (Appendix 4) of precipitation was recorded at the CQD weather station located at the base of the dam (Figure 5).

Stream temperatures varied throughout the study period from 13 ^{O}C to 16 ^{O}C which falls within the temperature threshold for Pink Salmon migration (Bjorn and Resier,1991). The following figure (Figure 5) illustrates the average daily discharge contribution from the CQD, tributaries and precipitation amounts between August 25th and September 30th 2011, also included is total discharge at the WSC station.

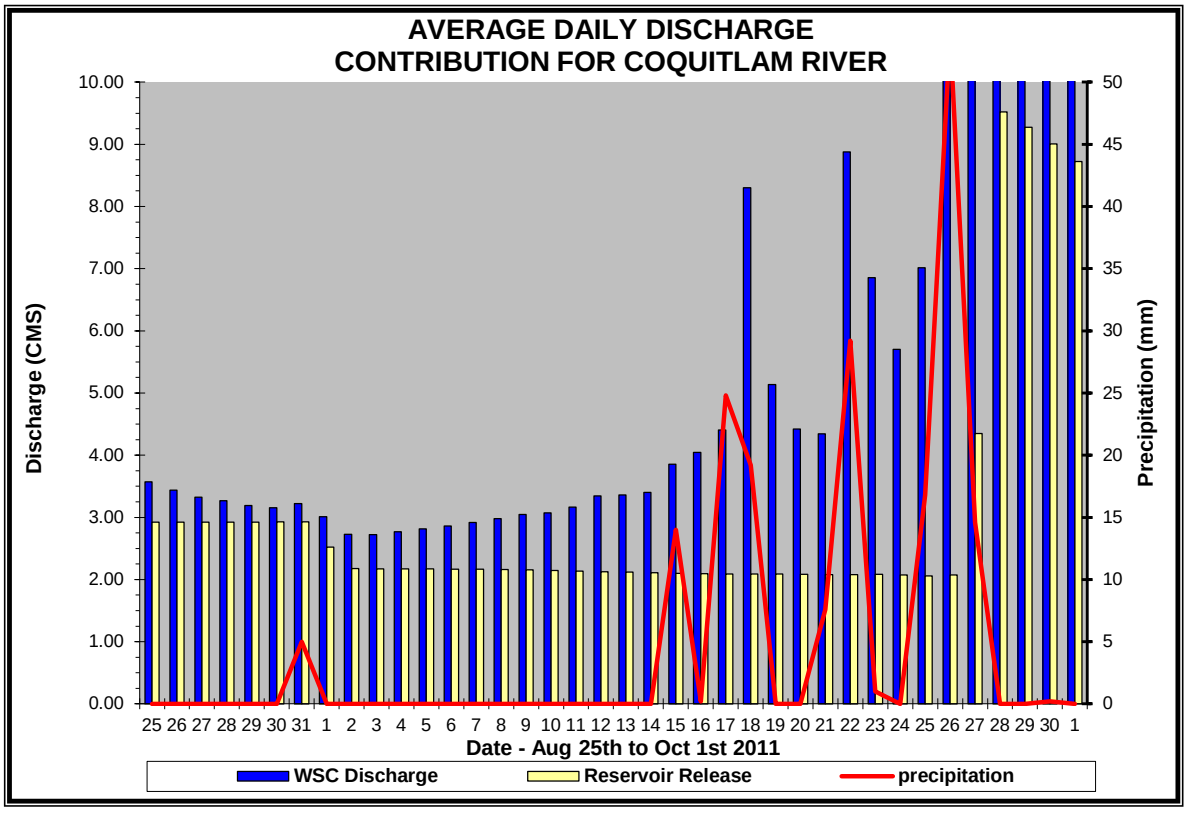

Figure 5 – CQD valve release, precipitation and WSC average daily river discharge, Aug 25th to Sept 30th 2011, (source: WSC Port Coquitlam, Dunkley,2011)

2009

The Coquitlam Dam treatment 2 flow regime trial commenced October 22, 2008 with flow releases during the period averaging 3.8cms (Figure 6).

Based on the yet complete BC Hydro revision of the CQD flow release facility flow rating criteria, this scenario provided significantly higher flows. Discharge averaged 2.0cms above the recommended target of the treatment 2 (Table 1) flow regime. An adjustment was made to the rating curve September 16, 2009 to ensure releases were within +/- 10% of the September 2.2cms target (Hunter, 2009).

The lowest discharge rate during the August 25th to September 30th period was recorded in the range of 2.6cms (Figure 6) which occurred during the latter half of September after the adjusted discharge rate for treatment 2 (WSC Port Coquitlam). The first Pink Salmon observed was on August 7th upstream of Index site 4 during a flow of 5.43cms. During this flow, no Pink Salmon were observed to be impeded or restricted at any of the index monitoring sites.

Ten days of precipitation were recorded during the monitoring period for a total of 82.8mm (Figure 6). Stream temperatures fluctuated from 17^{O}C to 19.5^{O}C in late August to mid-September and cooling off to 15^{O}C in late September. The following figure (Figure 6) illustrates the average daily discharge contribution from the CQD, tributaries and precipitation amounts between August 25th and September 30th 2009.

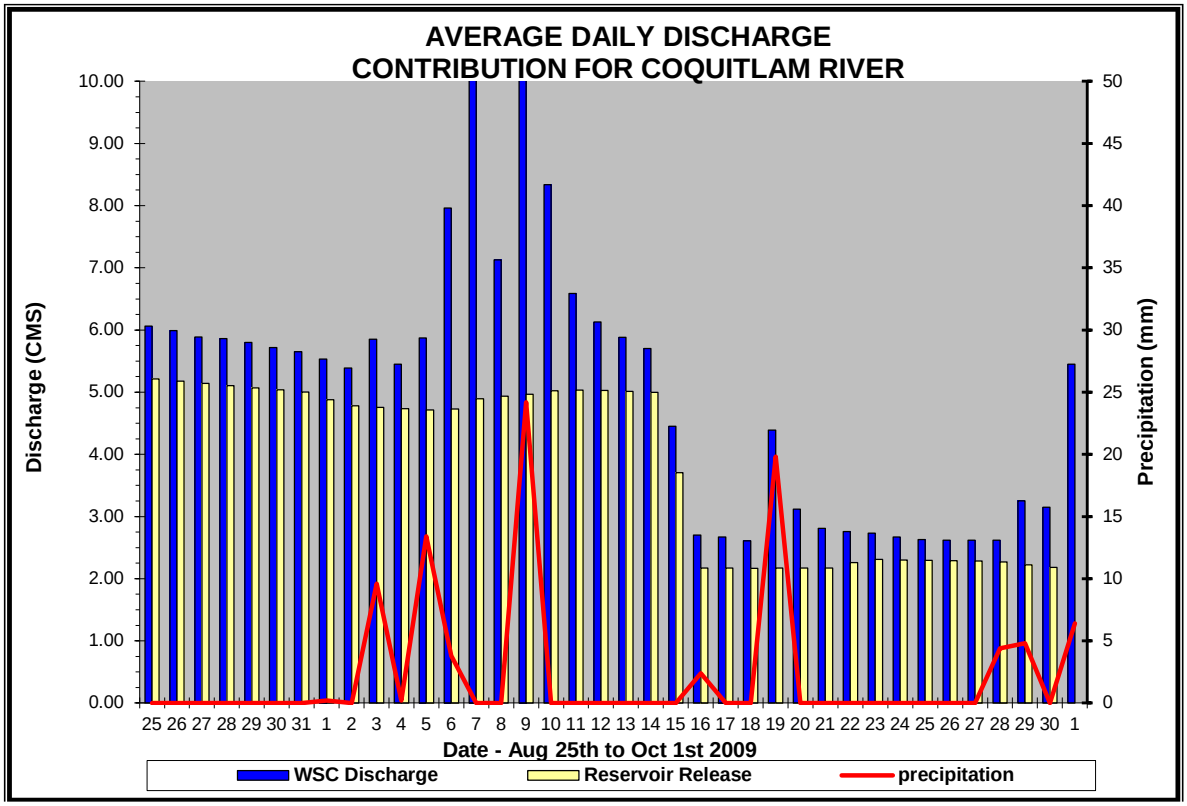

Figure 6 – CQD valve release, precipitation and WSC average daily river discharge, Aug 25th to Sept 30th 2009, (source: WSC Port Coquitlam, Hunter 2009, Henwood 2009)

2007

Discharge from CQD was restricted to 0.89cms so that work could be completed on the Dam spillway from September 7th to September 19th, 2007. Water was released by the two fish release valves in accordance to treatment 1 flow regime and in addition two lake pumps and a 12" line distributed flow to the mainstem of Coquitlam River (Figure 7). This scenario provided significant low flow level observations during the monitoring period.

The first few Pink Salmon were observed on September 8th at index 3B and upstream of index site 4 in the Swoboda channels during a flow of 1.25cms (WSC Port Coquitlam). The lowest flow recorded was 1.09cms on September 14th at Water Survey Canada hydrometric station and at this time 5 Pink Salmon were observed migrating at index site 3A and upstream of index site 3B indicating that stream depth and velocity were adequate for migration.

Eleven days of precipitation were recorded during the monitoring period for a total of 106mm (Appendix 4). It was observed that precipitation induced flow events instigated migration during late September with a significant portion of Pink Salmon migration occurring after the increase in precipitation and CQD releases.

During the monitoring period stream temperatures vary from 16^{O}C to 19^{O}C and fell within the temperature threshold (Appendix 1) for Pink Salmon migration. Although low numbers of Pink Salmon were migrating during August 25th to September 31st, observations indicate passage was not impeded or restricted at any of the index monitoring sites during the lowest stream discharge as indicated by visual observations, the maximum depth, and velocity recorded at each index site. The following figure (Figure 7) illustrates the average daily discharge contribution from the CQD, WSC station, tributaries and precipitation amounts between August 25th and September 30th 2007.

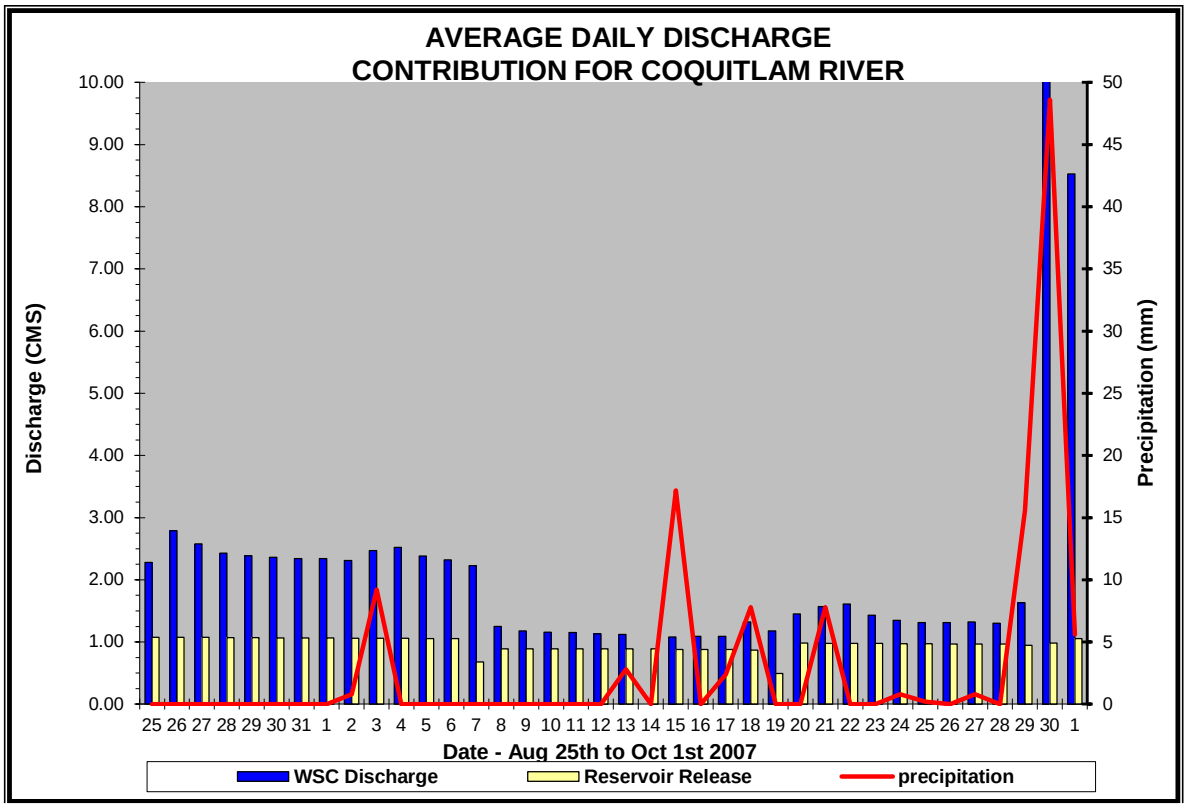

Figure 7 – CQD valve release, precipitation and WSC average daily river discharge, Aug 25th to Sept 30th 2007, (source: WSC Port Coquitlam, Hunter 2007, Dunkley 2007)

4.1 Reach 1 ~ Index site 1 - 1A

Index site 1 **(49'15.830 N -122'47.075 W)** is located west of McAllister Ave in Port Coquitlam for assessment years 2007 to 2011 and was replaced by Index site 1A **(49'15.941 N -122'46.902 W)** for the 2013 and 2015 assessment years because it was determined that the location no longer represented a fish passage obstruction as most migrating Pink Salmon avoided accessing this side channel and likely migrated through the mainstem channel.

Index site 1 is characterized as a shallow depth side channel (Figure 9) that is accessible from the mainstem through a narrow, shallow side channel (Figure 10). There is a mid-river vegetated island that splits the channel from the mainstem and the dominant flow is located on the left bank side of the river. The substrate is a mix of gravel and small to medium size cobble. This site has the potential to restrict salmon passage at low flows due to shallow stream depth and low velocities in the right bank side channel (Figure 8 & 9). Access to this side channel is through a shallow low gradient narrow channel (Figure 11). As identified in the 2007 assessment, discharge rates lower than 0.9cms, the side

channel may have the potential to constrict access for early returning Pink Salmon due to shallow water depth and low velocity (Ducharme 2007).

The 2007 assessment identified an average wetted width of 5.4m and an average stream depth of the side channel at 0.18m and a maximum depth of 0.20m during the lowest monitored discharge of 1.09cms (WSC, Port Coquitlam). A few carcasses were observed in the side channel in physically good shape (Figure 9) during late September, but no evidence of redd construction was observed.

During the 2009 assessment the wetted width averaged 19m and the average stream depth was measured at 0.26m to a maximum depth of 0.44m (Table 4) during a flow of 2.65cms (WSC Port Coquitlam). Higher than anticipated flows during late August to mid-September provided sufficient depth and velocity for early migrating Pink Salmon through this index site (Figure 6).

The 2011 field survey measured an average wetted width of 19.4m with an average stream depth of 0.22m and a maximum depth of 0.25m (Table 4). Passage through this section likely occurs in the mainstem left bank channel as this area provides sufficient velocity and depth for Pink Salmon migration at various flow rates (Figure 8 & 9). Due to the low numbers of Pink Salmon observed migrating through the side channel it was recommended for the 2013 assessment to discontinue monitoring as it was no longer considered a passage barrier.

Figure 8 – Index site 1- upstream mainstem view, adjacent to side channel access.
The red arrow indicates the Coquitlam River mainstem channel.
Sept.14.07. Discharge rate = 1.09cms (WSC Port Coquitlam)

Figure 9 - Index Site 1 - upstream view of side channel, Sept 25, 2007
The red arrow indicates a male pink mortality.
Discharge rate = 1.34cms (WSC Port Coquitlam)

Figure 10 - Index Site 1- upstream mainstem view, Sept.21.09
The red arrow indicates side channel access.
Discharge rate = 1.57cms (WSC Port Coquitlam)

Figure 11 – Index site 1 – upstream view of access to side channel, Sept.5.11
The red arrow indicates side channel access
Discharge rate = 2.82cms (WSC Port Coquitlam)

Index site 1A **(49'15.941 N -122'46.902 W)** access is located on the upstream side of the CPR bridge and can be reached off Kingsway Street in Port Coquitlam (Figure 1). The area is characterized as shallow depth riffle habitat with low velocity, a 2% gradient and lacking any stream complexity (Figure 13). The substrate is a mix of gravel and small to medium size cobble. This site has the potential to restrict Pink Salmon passage at low stream flows from the center of the channel to the right bank. Passage through this section likely occurs in a 4 meter wide slot located on the left bank side of the mainstem channel as this area provides sufficient velocity and depth for Pink Salmon migration at various flow rates (Table 4) as observed during earlier assessments.

During the 2015 monitoring study, the assessments identified an average wetted width of 27.7m and the average depth in the main channel between 0.18m to a maximum depth of 0.32m (Table 4) during a discharge of 2.73cms (WSC Port Coquitlam). The 2015 assessment observed several Pink Salmon migrating, staging and spawning throughout this index site (Figure 12) in late September during flows of 3.23cms (WSC Port Coquitlam).

During the 2013 monitoring period the assessment identified a wetted width of 28.7m providing an average stream depth of 0.27 to a maximum depth of 0.85m during the lowest flow of 2.59cms (WSC Port Coquitlam). Migration most likely occurred through a left bank deep slot that was observed and provided a depth of 0.85m during the lowest monitored discharge of 2.59cms and most likely, migrating Pink Salmon choose this route during lower flows (WSC, Port Coquitlam). However, there was a concern that elevated stream temperatures of 18^{O}C to 20^{O}C (Appendix 1) in early August to mid-September could impact migration and residency time, however, the higher temperatures did not appear to affect the physical health and migration of early returning Pink Salmon as they were

observed upstream of index site 4 in good physical shape which indicated the depth, velocity and temperature were adequate for passage to upstream spawning habitat.

The following table summarizes observations for the monitoring period 2007 to 2015 for index sites 1 and 1A.

Table 4 – Index site 1 - 1A data summary, 2007 - 2015

Monitoring date	WSC Mean daily discharge (cms)	Coq Dam discharge (cms)	Wetted width (m)	Avg. wetted Depth (cm)	Max depth (cm)	Max. velocity (m/sec)	Stream temp (C)
14-Sep-07	1.09	0.89	5.4	18.6	20	0.62	17
27-Sep-09	2.65	2.28	19.4	26	44	0.68	14
5-Sep-11	2.82	2.16	19.5	21.5	25	n/a	14
note: 2007,2009, 2011 site 1 monitoring was discontinued, identified as not a passge barrier. Index Site 1A began monitoring in 2013							
15-Sep-13	2.59	2.28	28.7	27.5	85	0.8	19
11-Sep-15	2.73	1.58	27.7	18.3	32	1.22	14.5

Figure 12 - Index Site 1a, Sept.30.15
Discharge = 3.23cms (WSC Port Coquitlam)
The arrow depicts migrating Pink Salmon

Figure 13 - Index site 1a- downstream view, Sept.11.15
Discharge rate = 2.73cms (WSC Port Coquitlam)

Figure 14 – Index site 1a – downstream view, Sept.15.13
The red arrow indicates a deep slot used for migration
Discharge rate = 2.59cms (WSC Port Coquitlam)

4.2 Reach 2 ~ Index site 2A

Access to index site 2A is 120m downstream from Prairie Avenue, west of Shaughnessy Street in Port Coquitlam (**49' 16.276 N – 122' 47.075 W)** (Figure 1). This index site was chosen for monitoring due to its low gradient (0.5%) and shallow depth riffle characteristics that have the potential to impede migration at low flows. Secondly, annual human interference with the construction of a cobble weir across the mainstem has the potential to impede passage during low flows (Figure 20). The substrate is a mix of small to medium size cobble that is compacted and lacks any habitat complexity.

During the 2015 monitoring study, the assessment identified an average wetted width of 29m and the average stream depth between 0.18m to a maximum depth of 0.34m during a flow of 2.73cms (WSC Port Coquitlam) which is sufficient for Pink Salmon migration (Table 5) (Figure 21). The lowest flowrate observed during field observations was 2.39cms which occurred on September 13th and no Pink Salmon were observed holding or migrating at this time. Significant numbers of migrating and spawning Pink Salmon were observed through the index site from September 21st to September 30th with flow rates from 3.23cms to 8.44cms (WSC Port Coquitlam) which provided increased stream depth and available habitat to spawn. Most of the Pink Salmon were observed spawning on the left and right bank edges where stream depth was adequate for staging, spawning and migration (Figure 15). Also a noted observation during the 2015 assessment was that a man made weir was not constructed across the mainstem channel and upstream of index site 2 as was the case in previous year assessments.

Figure 15 - Index site 2a, Sept.30.15
Pink Salmon staging upstream of Index site 2a.
Discharge = 3.23cms (WSC Port Coquitlam)

The 2013 assessment identified an average wetted width of 29m and an average stream depth of 0.20m to a maximum of 0.33m during flows of 2.59cms (WSC Port Coquitlam) which is above the threshold of 0.18m (Appendix 1) for successful Pink Salmon migration. Late August and early September assessments did not observe Pink Salmon migrating or staging through this index site although BC Hydro adult enumeration staff observed over 100 Pink Salmon (Macnair 2013) upstream of the index site during flows of 2.68cms (WSC Port Coquitlam) indicating passage was not impeded.

During the 2011 field survey, the average wetted width during the lowest flow of 2.82cms (WSC Port Coquitlam) was 27m which provided sufficient stream depths of 0.22m to 0.43m for migration. The 2013 assessment observed significantly more Pink Salmon throughout the Coquitlam River and upstream of this index site in early and mid-September, which may be attributed to the consistent flows and regional wide increase in Pink Salmon escapement to the Fraser River basin.

The 2009 assessment had significantly higher flows approximately 2.0cms above the treatment 2 target of 2.2cms due to releases from CQD and work being completed to adjust discharge amounts with the installation of the new LLOG3 gate valve. During the higher flows the average wetted width measured 28m providing an average stream depth of 0.38m to a maximum depth of 0.49m (Figure 61). Dam releases were reduced to the treatment 2 maximum target level of 2.2cms (WSC Port Coquitlam) on September 16th. The September 27th assessment observed a wetted width of 27m and an average stream depth of 0.34m to a maximum depth of 0.45m (Figure 61) (Table 5) (Figure 17). During late August to mid-September, the higher flows in general were evidently beneficial to migration as indicated by early season fish distribution to the upper reaches.

The lowest flow occurred during the 2007 assessment when treatment 1 minimum flows of 1.09cms (WSC Port Coquitlam) provided an average wetted width of 17.3m and stream depths of 0.14m to a maximum depth of 0.31m (Figure 61) (Table 5). No Pink Salmon were observed at this index site at any time during survey days, however, 8 Pink Salmon were observed upstream of this index site in mid-September indicating that mainstem discharge as low as 1.1cms (WSC Port Coquitlam) did not impede migration through this index site. It is probable that any migration during the lower discharge rates occurred in the right side channel edge of the mainstem where depth and velocities were sufficient providing a maximum stream depth of 0.31m to 0.36m (Figure 61) at various flows (Figure 16). This index site was assessed not to be a migration barrier when stream flows were recorded at the lowest discharge of 1.09cms which provided adequate depth and velocity for passage (Table 5) (WSC, Port Coquitlam). Pink Salmon would likely navigate through this index site and would not use it as a staging or spawning area, with the exception of the 2015 study year which observed migrating Pink Salmon staging and spawning throughout and upstream of this index site in late September.

Human interference occurred in 2009, 2011 and 2013 with the construction of a cobble weir across the channel width that could result in a potential migration barrier at low flows (Figure 20). During the 2013 monitoring period with flows of 2.59cms (WSC, Port Coquitlam) the average plunge pool

depth at the weir was 0.27m and the average jump height over the weir was 0.19m indicating that the weir was adequate for passage.

The following table summarizes observations for the monitoring period 2007 to 2015.

Table 5 – Index site 2A data summary

Monitoring date	WSC Mean daily discharge (cms)	Coq Dam discharge (cms)	Wetted width (m)	Avg. wetted Depth (cm)	Max depth (cm)	Max. velocity (m/sec)	Stream temp (C)
14-Sep-07	1.09	0.89	17.3	22	31	n/a	17
27-Sep-09	2.65	2.28	27	34.7	45	0.461	14.1
5-Sep-11	2.82	2.16	29	22.6	43	0.64	15
15-Sep-13	2.59	2.28	29	20.1	33	0.82	19
11-Sep-15	2.73	1.58	28.8	18.4	34	1.03	14.5

Figure 16 - Index Site 2a - upstream view, Sept.14.07
Discharge = 1.09cms (WSC Port Coquitlam)

Figure 17 - Index Site 2a, downstream view Sept 27.09
Discharge = 2.65cms (WSC Port Coquitlam)

Figure 18 - Index site 2a - downstream view, Sept.5.11
Discharge = 2.82cms (WSC Port Coquitlam)
Low depth, riffle area

Figure 19 - Index site 2a - downstream view of shallow riffle, Sept.15.13
Discharge = 2.59cms (WSC Port Coquitlam)

Figure 20 - Index site 2a - upstream view of manmade weir, Sept.09.13
Discharge = 2.65cms (WSC Port Coquitlam)
The arrow identifies breached access point over weir.

Figure 21 - Index site 2a, Downstream view, Sept.11.15
Discharge = 2.73cms (WSC Port Coquitlam)

4.3 Reach 2 ~ Index site 2B

Access to index site 2B is from the pedestrian trail on Patricia Avenue west of Shaughnessy Street in Port Coquitlam. This index site extends upstream 45m and downstream 60m of the Patricia Avenue pedestrian bridge **(49' 16.585 N – 122 46.620 W)** , (Figure 1). This site is characterised as a long, shallow depth glide as the mainstem channel width increases with widening of the channel banks through this section. Additionally, downstream, the wetted width narrows to the right bank into a shallow riffle and into a high velocity chute (Figure 23 & 25). The substrate consists of a mix of compacted gravel and small to medium sized cobble. Clusters of larger cobble and rock on the left channel bank are exposed during low flows forcing the dominant flow to the right channel side of the river. The habitat at this location is likely not suitable for Pink Salmon staging or spawning due to the shallow depth, compacted substrate and lack of habitat complexity. During higher discharge rates, greater than 40cms, it is possible that passage may be impeded due to stream velocity through the narrow chute and may be greater than the recommended threshold criteria of 2.13m/sec (Appendix 1). Velocity data collected during the assessment years indicated that the velocity threshold level of 2.13m/s was not surpassed and migration not impeded, however, there is enough high velocity refuge areas downstream for Pink Salmon to hold (Macnair 2011) until flows are adequate for migration.

The 2015 assessment indicated no impediments to migration through this index site during the lowest discharge rate of 2.73cms on September 11th. The wetted width averaged 32m and the average stream depth during the lowest flow was 0.31m to a maximum depth of 0.70m which is adequate for Pink Salmon migration (Table 6). 13 Pink Salmon were observed upstream of this index site in late August and early September during rain induced flow events that occurred which increased flows substantially to over 19cms (WSC Port Coquitlam) for seven day period. Significant numbers of Pink Salmon (900+) were observed in mid-September upstream of index site 2B by BC Hydro adult enumeration staff during flows 2.73cms (Macnair 2015) (WSC Port Coquitlam).

During the 2013 field survey, flows were consistent in late August to mid-September with minimal precipitation contribution, averaging 2.53cms (WSC Port Coquitlam) which provided an average wetted width of 32m and an average stream depth of 0.23m to a maximum depth of 0.44m (Figure 61) (Table 6) which was above the recommended minimum depth threshold of 0.18m (Appendix 1) for successful Pink Salmon migration.

The 2011 assessment calculated an average wetted width of 32m and an average stream depth of 0.20m to a maximum depth of 0.32m (Figure 61) during the lowest monitored discharge rate of 2.82cms (Table 6) (WSC, Port Coquitlam). Pink Salmon were first observed upstream of this index site after September 10th by the BC Hydro adult enumeration crew and during a discharge rate of 2.62cms (WSC Port Coquitlam) indicating depth and velocity were sufficient for migration. During higher discharge rates, greater than 40cms (WSC, Port Coquitlam), it is likely that passage may be impeded due to higher stream velocities through this site as indicated by the maximum velocity

threshold criteria for passage of 2.13m/sec (Table 6), (Appendix 1). Velocity data measurements when able to safely obtain measurements were calculated at 0.76 m/sec and fell below the maximum velocity threshold for Pink Salmon migration (Appendix 1).

During the 2009 assessment, the wetted width of the river averaged 32m providing an average stream depth of 0.32m to a maximum depth of 0.44m (Figure 61), (Table 6) during the lowest monitored flow of 2.65cms in late September (Figure 23) (WSC Port Coquitlam). Flows were reduced to the treatment 2 target level to 2.2cms at which time an increase in Pink Salmon migration was observed throughout the system. 34 Pink Salmon were observed holding upstream of this index site after the September 9th assessment by the BC Hydro adult enumeration crew during a discharge rate of 2.65cms. (Table 6) (WSC, Port Coquitlam). Overall, stream temperatures, were significantly higher averaging 18^{O}C to 20.5^{O}C in early September which is above the recommended threshold of 7.2^{O}C to 15.6^{O}C (Appendix 1) for Pink Salmon migration, however stream temperatures fluctuated and remained below the threshold from mid-September to October when an increase in Pink migration numbers was observed.

The 2007 assessment identified the low depth glide area with an average wetted width of 25m and the average stream depth of 0.20m across the channel with a maximum depth of 0.34m (Figure 61) during the lowest flow of 1.09cms (Table 6) (WSC, Port Coquitlam). During the 2007 and 2009 assessments, lower stream flows exposed large clusters of boulder and cobble on the left channel side (Figure 23) forcing the dominant flow to the right channel which provides adequate depth and velocity to migrate upstream of this index site. Overall Index site 2B was observed not to be a migration barrier during the 2007 to 2015 monitoring period as Pink Salmon spawners were enumerated upstream of this index site during the lowest monitored flows which provided adequate depth and velocity for migration during the Treatment 2 flow regime (Table 6).

The following table summarizes observations for the monitoring period 2007 to 2015.

Table 6 – Index site 2B data summary

Monitoring date	WSC Mean daily discharge (cms)	Coq Dam discharge (cms)	Wetted width (m)	Avg. wetted Depth (cm)	Max depth (cm)	Max. velocity (m/sec)	Stream temp (C)
14-Sep-07	1.09	0.89	25.3	20	34	n/a	18
27-Sep-09	2.65	2.28	32	32	44	0.718	14.1
5-Sep-11	2.82	2.16	32	20	32	0.65	15
15-Sep-13	2.59	2.28	32	22.9	44	0.47	18.5
11-Sep-15	2.73	1.58	32	28.7	34	0.41	14.5

Figure 22 - Index site 2b, upstream view, Sept.14.07
Discharge = 1.09cms (WSC Port Coquitlam)

Figure 23 Index site 2b - downstream view Sept 27, 09
Discharge = 2.65cms (WSC Port Coquitlam).

Figure 24 - Index site 2b - upstream v iew, Sept.5.11
Discharge = 2.59cms (WSC Port Coquitlam)

Figure 25 - Index site 2b - upstream view of chute, Sept.5.11
Discharge = 2.82cms (WSC Port Coquitlam)

Figure 26 - Index site 2b - downstream view, Sept.09.13
Discharge = 2.76cms (WSC Port Coquitlam)

Figure 27 - Index site 2b - downstream view, Sept.11.15
Discharge = 2.73cms (WSC Port Coquitlam)

4.4 Reach 2 ~ Index site 2C

Access to index site 2C is located off Pipeline Road and east on Galette Avenue in Coquitlam, situated 65m downstream of the Galette Park entrance **(49' 19.621 N – 122' 46.346 W)** (Figure 2). This site was identified to potentially constrict migration due to the mainstem channel narrowing around a gravel bar located mid channel on the left bank side. A shallow riffle with a slight gradient increase on the right channel side of the gravel bar may have the potential to impede passage at lower flows (Figure 29). The substrate is characterized as a mix of small to medium size gravel, cobble and large scattered boulders that form a scour pool and provide pool habitat at the tail out of the left channel slot. Observations indicate that the narrow left channel likely provides the main access route as it provides a deep slot with a depth range of 0.20m to a maximum depth of 0.74m (Figure 61) during the various flows during the monitoring period (Table 7).

During the 2015 assessment, the average wetted width was 31m providing an average stream depth of 0.31m to a maximum depth of 0.74m (Figure 61) during the lowest monitored flow of 2.73cms (Table 7) (WSC Port Coquitlam) occurring on September 11th. No passage issues were observed at index site 2C and fish distribution numbers upstream indicated that depth and velocity were adequate for Pink Salmon migration. During the reduced dam flow in August, one Pink Salmon was observed upstream of index site 4 and was in good physical shape. The 2015 assessment observed Pink Salmon migrating, spawning and staging (Figure 28) throughout and upstream of index site 2C in Late September, with stream flows fluctuating between 3.23cms and 4.33cms (WSC Port Coquitlam) providing sufficient stream depth and increased spawning habitat availability.

Figure 28 - Index site 2c, upstream view of spawning Pink Salmon
Sept.23.15 - Discharge = 4.33cms (WSC Port Coquitlam)

During the 2013 field survey, flows were consistent in late August to mid-September with minimal precipitation contribution, averaging 2.59cms (WSC Port Coquitlam) which provided an average wetted width of 24m and an average stream depth of 0.39m to a maximum depth of 0.74m (Figure 61) (Table 7) which is above the recommended minimum depth threshold of 0.18m (Appendix 1) for Pink Salmon migration. Significant numbers of Pink Salmon began migrating in mid-September which coincided with precipitation induced flow events that increased flows from 3.23cms to 8.44cms (WSC Port Coquitlam). Observations during the monitoring period indicated that there were no impediments to migration during the lowest discharge rate of 2.59cms with adequate depth, velocity and also the sighting of Pink Salmon holding upstream of index site 2C (WSC, Port Coquitlam) indicate passage was unimpeded. The general health and condition of holding or migrating Pink Salmon was observed to be good with no pre-spawn mortalities observed.

The 2011 assessment identified an average wetted width of 24m and an average stream depth of 0.20m to a maximum depth of 0.57m (Figure 61) during the lowest monitored discharge rate of 2.59cms (Figure 31) (WSC, Port Coquitlam). Pink Salmon were first observed upstream of this index site on September 5th, during a flow rate of 2.82cms indicating depth and velocity were sufficient for migration past index site 2C. Overall, during the lowest daily minimum discharge of 2.59cms (WSC Port Coquitlam) water depth and velocity were adequate for passage to the upper reaches of Coquitlam River.

During the 2009 assessment the wetted width of the river averaged 24m providing a an average stream depth of 0.26m to a maximum depth of 0.45m (Figure 61) during the lowest monitored flow of 2.65cms in late September (Table 7) (WSC Port Coquitlam). Early migration was not impacted with low flows due to higher than anticipated releases from the newly installed dam gate valve that provided an additional 2.0cms over the targeted flow regime of 2.1cms with flows ranging from 5.9cms to 7.4cms (WSC Port Coquitlam). Discharge from the CQD was reduced to the treatment 2 target level of 2.2cms (Table 1) on September 21st at which time an increase in Pink Salmon numbers were observed upstream of index site 2C indicating that flows, stream depth and velocity were sufficient for migration.

For 2007 assessment year, the lowest observed flow of 1.09cms (WSC Port Coquitlam) occurred on September14th with an average wetted width in the right channel riffle of 17m and an average stream depth of 0.15m to a maximum depth of 0.24m (Figure 61) which was adequate for upstream passage (Table 7). Observations of migrating Pink Salmon indicated that the left channel deep slot was the route being primarily utilized with varying stream depths of 0.24m to 0.74m and although only a few Pink Salmon were observed during the assessment, BC Hydro adult enumeration staff observed 5 Pink Salmon (Macnair 2007) upstream of the index site indicating that passage was not impeded during the lowest flow of 1.09cms (Figure 29 & 32) (WSC Port Coquitlam). With the exception of 2007 and 2013, stream temperatures fluctuated between 15^{O}C to 19.5^{O}C (Appendix 1) and the general health and condition of holding and migrating Pink Salmon was observed to be in

good physical condition. The majority of Pink Salmon migrated through this index during late September during short rain induced flow events with flows of 1.34cms to 1.63cms (WSC Port Coquitlam). Observations also indicated that Pink Salmon were heavily pressured by recreational anglers upstream of index site 2C.

The following table summarizes observations for the monitoring period for 2007 to 2015.

Table 7 – Index site 2c data summary

Monitoring date	WSC Mean daily discharge (cms)	Coq Dam discharge (cms)	Wetted width (m)	Avg. wetted Depth (cm)	Max depth (cm)	Max. velocity (m/sec)	Stream temp (C)
14-Sep-07	1.09	0.89	17	14.7	24	n/a	18
27-Sep-09	2.65	2.28	24	26.6	45	0.804	16.1
5-Sep-11	2.82	2.16	24	20	57	1.18	15
15-Sep-13	2.59	2.28	24	39	74	0.18	19.5
11-Sep-15	2.73	1.58	31.2	31.2	74	1.29	15.1

Figure 29 - Index Site 2c, upstream view, Sept.14.07
Discharge = 1.09cms (WSC Port Coquitlam)
The red arrow identifies the deep slot used for migration.

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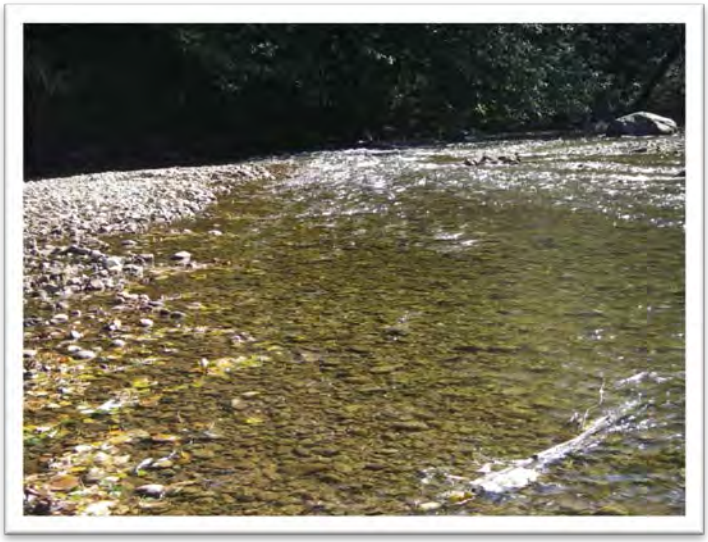


Figure 30 – Index site 2c - downstream view, Sept.27.09
Discharge = 2.65cms (WSC Port Coquitlam).

Figure 31 – Index site 2c - upstream view, Sept.5.11
Discharge = 2.82cms (WSC Port Coquitlam)
The arrow identifies deep slot for migration

Figure 32 – Index site 2c - upstream view, Sept.15.13
Discharge = 2.59cms (WSC Port Coquitlam)
The red arrow indicates the left channel migration route

Figure 33 - Index Site 2c, upstream view, Sept.11.15
Discharge = 2.73cms (WSC Port Coquitlam)

Figure 34 Index site 2c, upstream view, Sept.30.15
Discharge = 3.23cms (WSC Port Coquitlam)

4.5 Reach 3 ~ Index site 3A

Index site 3A is located on Pipeline Road at the Upper Coquitlam River Park. Access to this site is 80m upstream of the diving board hole pool **(49' 19.632 N – 122' 46.344 W)**, (Figure 2). This index site is characterised as a shallow cascading riffle with a 4% grade extending 15m upstream of the cobble riffle. Adjacent to the index site, the mainstem flow is split around a mid-channel vegetated island with the dominant flow in the left channel side and spread across the cobble riffle. To the left of the cobble riffle is a narrow channel that extends upstream 40m and is impassable at lower flows due to the accumulation of a cobble and gravel wedge. During low flows and shallow stream depths, the cobble and rock becomes exposed splitting the channel flow between the right channel riffle and the left channel chute (Figure 35).

During the 2015 assessment the average wetted width was 16m providing an average stream depth of 0.23m to a maximum stream depth of 0.42m (Figure 61) (Table 8) during the lowest monitored flow of 2.73cms (WSC Port Coquitlam) on September 11th (Figure 40). No passage issues were observed at index site 3A and fish distribution numbers upstream (300 +) indicated that depth and velocity were adequate for Pink Salmon migration. No Pink Salmon were observed migrating through this index site in late August when daily average flows were 1.4cms (WSC Port Coquitlam). The first Pink Salmon observed upstream of index site 3A occurred on August 2nd during flows of 1.44cms (WSC Port Coquitlam). Pink Salmon began to migrate in small numbers after seven days of precipitation that occurred in early September with flows averaging 6.3cms (WSC Port Coquitlam).

During the 2013 field survey, flows were consistent in late August to mid-September with minimal precipitation contribution and a daily average flow of 2.59cms (WSC Port Coquitlam) which provided an average wetted width of 16m and an average stream depth of 0.24m to a maximum depth of 0.38m (Figure 61) (Table 8) which is adequate for Pink Salmon passage (Appendix 1). The highest velocity recorded was 1.46m/s during a discharge of 20.6cms (WSC Port Coquitlam) and falls below that maximum recommended velocity of 2.13m/sec for successful Pink Salmon migration (Appendix 1). Index site 3A, although not an impediment to migration, discharge rates below the minimum targeted release of 1.1cms can present a challenge to Pink Salmon as they migrate upstream through the cascading cobble riffle (Figure 38 & 39).

The 2011 assessment identified an average wetted width of 16m and an average stream depth of 0.25m to a maximum depth of 0.47m (Figure 61) (Figure 39) during the lowest monitored discharge rate of 2.82cms (Table 8) (WSC, Port Coquitlam). Thirty Pink Salmon were first observed upstream of this index site on September 5th, during a flow rate of 2.82cms, indicating depth and velocity were adequate for migration. Observations of migrating Pink Salmon indicated that most used the left bank slot to migrate over the cobble riffle as this area provided a reduced gradient and deeper plunge pool for holding (Figure 38).

During the 2009 assessment the wetted width of the cobble riffle measured 14m providing an average stream depth of 0.15m to a maximum depth of 0.31m (Figure 61) (Figure 36) during the lowest monitored flow of 2.65cms on September 27th (Table 8) (WSC Port Coquitlam). Early migration was not impacted with low flows due to higher than anticipated releases from the newly installed CQD gate valve that provided an additional 2.0cms over the targeted flow regime of 2.1cms (WSC Port Coquitlam). Discharge from the dam was reduced to the Treatment 2 target level of 2.2cms (CQD) on September 21st at which time an increase in Pink Salmon numbers were observed upstream of index site 3A indicating that flows, stream depth and velocity were sufficient for migration (Appendix 1).

The lowest observed flow of 1.09cms (WSC Port Coquitlam) occurred mid-September 2007 with an average wetted width of 9.9m and an stream depth of 0.15m to a maximum depth of 0.25m (Figure 61), (Table 8). Although there were not significant numbers of migrating Pink Salmon at this time, observations indicated that passage was not impeded as Pink Salmon were observed upstream of index site 3A (Figure 36).

During the 2009 to 2015 assessments the average wetted width was 14m to 16m and provided a stream depth of 0.14m to 0.47m (Figure 61) indicating that there were no impediments to migration at the lowest discharge rates of 2.59cms to 2.82cms (WSC, Port Coquitlam). Discharge flows below 1.1cms can potentially challenge migration due to the gradient increase and shallow water depth across the cobble riffle, however, the index site was not an impediment to upstream migration indicated by pink numbers observed upstream of index site 3A during the lowest flow of 1.09cms (WSC Port Coquitlam).

With the exception of 2007 and 2013, stream temperatures fluctuated between 15^{O}C to 17.3^{O}C and the general health and condition of holding and/or migrating Pink Salmon was observed to be in good physical condition. Increased temperatures of 16^{O}C to 20^{O}C during 2007 and 2013 assessments did not seem to decrease Pink Salmon residency timing or ability to migrate and spawn to the upper reaches.

The following table summarizes observations for the monitoring period for 2007 to 2015.

Table 8 – Index site 3a data summary

Monitoring date	WSC Mean daily discharge (cms)	Coq Dam discharge (cms)	Wetted width (m)	Avg. wetted Depth (cm)	Max depth (cm)	Max. velocity (m/sec)	Stream temp (C)
14-Sep-07	1.09	0.89	9.9	15	25	1.04	18
27-Sep-09	2.65	2.28	14	15.6	31.6	n/a	17.3
5-Sep-11	2.82	2.16	16	25.3	47	1.11	15
15-Sep-13	2.59	2.28	16	23.8	38	0.77	19.5
11-Sep-15	2.73	1.58	16	23.3	42	1.26	16

Figure 35 - Index site 3a, upstream view, Sept.21.07
The red arrow identifies the narrow slot channel
Discharge = 1.54cms (WSC Port Coquitlam)

Figure 36 - Index site 3a - upstream view Sept.27.09.The arrows identify access routes, discharge = 3.4cms (WSC Port Coquitlam)

Figure 37 - Index Site 3a, upstream view, Sept.5.11
Discharge = 2.82cms (WSC Port Coquitlam)

Figure 38 - Index site 3a - passage attempt, Sept 25.13
Discharge = 3.65cms (WSC Port Coquitlam)

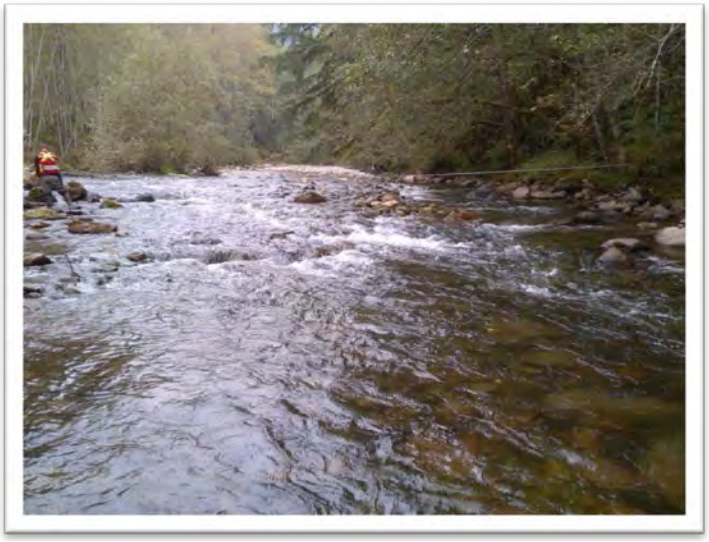


Figure 39 - Index site 3a - upstream view, Sept 15.13
Discharge = 2.59cms (WSC Port Coquitlam)

Figure 40 - Index site 3a - upstream view, Sept.11.15
Discharge = 2.73cms (WSC Port Coquitlam)

4.6 Reach 3 ~ Index site 3B and 3C

Index site 3B is located north on Pipeline Road and adjacent to the Grist - Goeson Memorial Hatchery **(49' 20 .251 N – 122' 46.263 W)**, (Figure 2). This index site was originally identified in 2007, 2009 and 2011 as having the potential to constrict passage in the right bank side channel that runs the length of a vegetated mid channel island bar that extends upstream 200m (Figures 41 & 44). The potential to constrict Pink Salmon migration during low summer flows is a possibility as well the survivability of redds drying up during lower flows. Site 3B was discontinued after in stream habitat improvements were completed by the Department of Fisheries and Oceans (DFO) in the summer of 2012 to improve flow and depth to the right side channel. Index site 3B was replaced by Index site 3C for the 2013 and 2015 assessment years because it was determined that it no longer represented a fish passage impediment, nevertheless most migrating Pink Salmon were observed migrating through the mainstem channel which has sufficient depth and velocity. Both Index sites are described below.

Index site 3B is characterized as a narrow shallow depth side channel (Figures 41 & 44) that is accessible from the mainstem. There is a mid-river vegetated island that splits the channel from the mainstem and the dominant flow is located on the left bank side of the river. The substrate is a mix of gravel and small to medium size cobble. This site has the potential to restrict salmon passage at low flows due to shallow stream depth and low velocities in the right bank side channel (Figures 42 & 43).

The 2011 assessment identified an average wetted width of 10m and an average stream depth of 0.39m to a maximum depth of 0.60m (Table 9) (Figure 44) during the lowest monitored discharge rate of 2.82cms (Table 9) (WSC, Port Coquitlam). The 2011 assessment observed discharge rates ranging from 2.6cms to 6.0cms (WSC Port Coquitlam) providing an averaged wetted width 9.5m and an average stream depth of 0.15m to a maximum of 0.60m which was adequate for passage and spawning. It was observed that the during flows of 2.82cms or greater the side channel was utilised for spawning, however the majority of Pink Salmon migrated in the mainstem during flows below 1.5cms (WSC Port Coquitlam) which may have limited access to the side channel.

During the 2009 assessment the average wetted width measured was 9m providing an average stream depth of 0.15m to 0.21m during a flowrate of 2.65cms (Table 9). At this time 8 Pink Salmon were observed spawning and migrating in the upper section of the side channel (Figure 42 & 43). Early migration was not impacted with low flows due to higher than anticipated releases from the newly installed CQD gate valve that provided an additional 2.0cms over the targeted flow regime of 2.2cms (WSC Port Coquitlam). Discharge from the CQD was reduced to the treatment 2 target level of 2.2cms on September 21st at which time a moderate increase in Pink Salmon numbers were observed upstream of index site 3B indicating that flows, stream depth and velocity were sufficient for migration (Appendix 1.) through this index site.

The 2007 assessment observed minimum flows averaging 1.1cms to 1.63cms (WSC Port Coquitlam) providing a wetted width of 9m and average stream depth of 0.17m to maximum depth of 0.26m (Table 9). During this time, observations indicated that low numbers of Pink Salmon utilized this side

channel for migration or spawning and the majority of the population likely chose the mainstem to migrate to the upper reaches (Figure 41). With the exception of 2007 and 2013, stream temperatures fluctuated between 15^{O}C to 17.3^{O}C (Appendix 1) and the general health and condition of holding and/or migrating Pink Salmon was observed to be in good physical condition. Increased temperatures of 13^{O}C to 20^{O}C during 2007 and 2013 assessments did not seem to decrease Pink Salmon residency time.

Figure 41 - Index site 3b, upstream view, side channel, Sept.22.07. Discharge = 1.54cms (WSC Port Coquitlam)

Figure 42 - Index Site 3b, upstream view, Sept.21.09 Discharge = 2.85 (WSC Port Coquitlam

Figure 43- Index site 3b **-** downstream view of upper section of channel, Sept.27. 09. Discharge = 2.65cms (WSC Port Coquitlam).

Figure 44 - Index site 3b, upstream view, Sept.5.11 Discharge = 2.81cms (WSC Port Coquitlam)

Index site 3C is located north on Pipeline Road and 80m downstream of the Al Grist Memorial Hatchery **(49'20.230 N - 122'46.251 W)** and is a new monitoring site for the 2013 and 2015 assessments. This index site was originally identified in 2001 as having the potential to constrict passage as the channel narrows exposing larger cobble and shallow stream depth from the mid center channel to the left bank. Observations of migrating Pink Salmon indicated that migration was

primarily occurring on the right bank side of the channel as there are a series of large woody debris placements that provide adequate stream depth, velocity and cover for passage (Figure 49).

During the 2015 assessment Pink Salmon were observed migrating and spawning throughout this index site during flows of 3.23cms to 4.33cms (WSC Port Coquitlam) providing a wetted width of 25m and an average stream depth of 0.22m to a maximum depth of 0.48m (Figure 61) (Figures 49 & 50) (Table 9) indicating that depth and velocity were adequate for passage through this index site (Appendix 1). The first Pink Salmon observed upstream of index site 3C occurred on August 2nd, during low flows of 1.44cms (WSC Port Coquitlam) and was in good physical shape.

The lowest discharge recorded during the 2013 assessment was 2.59cms (WSC, Port Coquitlam) providing a wetted width of 25m and a maximum depth range of 0.22m to 0.48m (Figure 61) which is sufficient for Pink Salmon passage (Appendix 1). The first Pink Salmon carcass was observed upstream of this site on September 15th and physical characteristics indicated that it had been in the system for a few weeks indicated by the darkening of the body and scale loss (Figure 48). Observations and pink distribution upstream of this index site throughout the monitoring period indicated that at the lowest discharge flow of 2.59cms migration was not impeded and depth levels were sufficient for upstream migration (Figures 45 & 46) (WSC, Port Coquitlam).

Elevated stream temperatures from 15^{O}C to 22^{O}C were a concern during the 2013 assessment as Pink Salmon were observed migrating as early as August 7th. Although temperatures were considerably above the recommended threshold for Pink Salmon migration (Appendix 1), they were observed to be in good physical condition to migrate, hold and spawn.

With the exception of 2007 and 2013, stream temperatures fluctuated between 15^{O}C to 19.5^{O}C and the general health and condition of holding and/or migrating Pink Salmon was observed to be in good physical condition. The majority of Pink Salmon migrated through this index site during late September during rain induced flow events which average 169mm (Appendix 4) over the study period 2007 to 2015.

The following table summarizes observations for the monitoring period for 2007 to 2015.

Table 9 – Index site 3B and 3C data summary 2007 - 2015

Monitoring date	WSC Mean daily discharge (cms)	Coq Dam discharge (cms)	Wetted width (m)	Avg. wetted Depth (cm)	Max depth (cm)	Max. velocity (m/sec)	Stream temp (C)
14-Sep-07	1.09	0.89	9	19.7	26	n/a	15
27-Sep-09	2.65	2.28	9	15.1	21	n/a	16.5
5-Sep-11	2.82	2.16	10.3	39	60	1.44	15
note: 2007,2009, 2011 site 3B monitoring was discontinued, identified as not a passge barrier. Index Site 3C began monitoring in 2013							
15-Sep-13	2.59	2.28	25	22.5	48	0.91	19.5
11-Sep-15	2.73	1.58	25	22.5	48	0.84	16.7

Figure 45 - Index Site 3c, upstream view, Aug.25.13
Discharge= 2.82cms (WSC Port Coquitlam)

Figure 46 - Index Site 3c, downstream view, Sept.15.13
Discharge= 2.45cms (WSC Port Coquitlam)

Figure 47 – Index site 3c - upstream view, Sept.25.13
Discharge = 3.65cms (WSC Port Coquitlam)

Figure 48 - Index site 3c - salmon carcass, Sept.25.13
Discharge = 3.65cms(WSC Port Coquitlam)

Figure 49 - Index site 3c, upstream view, Sept.11.15
Discharge = 2.73cms (WSC Port Coquitlam)
The Red arrow indicates the migration route

Figure 50 - Index site 3c, downstream view, Sept.11.15
Discharge = 2.73cms (WSC Port Coquitlam)

Figure 51 - Index site 3c, upstream view, Sept.30.15
The red arrow indicates the main migration route during low flows
Discharge = 3.23cms (WSC Port Coquitlam)

4.7 Reach 4 ~ Index site 4

This index site is located in the Coquitlam watershed at the Coquitlam River mainstem and Swoboda channel confluence **(49' 21. 041 N – 122' 46.452 W)**, (Figure 2). Access to this site is located at the base of the CQD, downstream of Grant's tomb rearing pond and Swoboda channel confluence. This index site is primarily influenced by CQD releases and discharge from Swoboda channel as there is minimal tributary contribution. The substrate is a mix of loose gravel and small to medium size cobble. This monitoring site is characterized as a cascading cobble and gravel riffle that is shallow with the cobble becoming exposed and splitting around a mid-channel vegetated island (Figure 52). Dam release flow data is included in Table 10 as it offers a more representative discharge rate for this index site as opposed to the WSC hydrometric station site.

The 2015 assessment observed a reduced flow released from the CQD as conservation measures were introduced to sustain adequate reservoir levels during the drought like conditions and minimal precipitation in the south coast region of British Columbia. The treatment 2 minimal target contribution of flows measured 1.2cms to 1.5cms (CQD) and occurred from June 1st to September 23rd at which time dam releases were increased to the target release of 2.2cms (CQD). During the lowest flow of 1.58cms (CQD) the wetted width measured 15m and provided an average depth of 0.14m to maximum depth of 0.23m (Figure 61) (Figure 56). Index site 4 is primarily influenced by CQD releases, the potential of reduced flows may limit depth and flow distribution across the riffle (Figures 57 & 58), however, during the lowest flows the depth and velocity were sufficient for passage as indicated by observed Pink Salmon upstream of index site 4. The first Pink Salmon observed occurred on August 2nd during a flowrate of 1.44cms (CQD) and was in good physical shape to continue staging in the BC Hydro channels below the CQD fish trap. Observations of Pink Salmon numbers upstream of index site 4 and in the Swoboda channel indicate that migrating Pink Salmon may choose either access route based on available flow or available spawning habitat (Figure 58) as numbers of Pink Salmon enumerated upstream were almost equal in proportion in the mainstem and Swoboda channel.

The lowest discharge recorded during the 2013 assessment was 2.28cms (CQD) providing a wetted width of 14.6m and an average stream depth of 0.16m to 0.27m (Figure 61) (Figures 54 & 55), (Table 10) which is sufficient for Pink Salmon passage (Appendix 1). Pink Salmon were observed as early as August 7th during a flow of 2.74cms (CQD) which continued throughout August and during this time a total of 23 Pink Salmon were enumerated upstream of Index site 4.

The 2011 assessment identified an average wetted width of 10m and an average stream depth of 0.23m to a maximum depth of 0.38m (Figure 61) (Table 10) (Figure53) during the lowest monitored discharge rate of 1.58cms (CQD) (Table 10) which is sufficient for Pink Salmon passage. Mid-September assessments observed higher than normal flows from ongoing precipitation events with the bulk of Pink Salmon migrating in late September to early October.

The 2009 assessment had significantly higher flows approximately 2.0cms above the treatment 2 target of 2.2cms due to releases from CQD and work being completed to adjust discharge amounts with the installation of the new LLOG3 gate valve. During the higher flows the average wetted width measured 15.6m providing an average stream depth of 0.30m to a maximum depth of 0.38m (Figure 61) during flows of 5.2cms (CQD). CQD releases were reduced to the Treatment 2 target level of 2.2cms (WSC Port Coquitlam) on September 16th. The September 27th assessment observed a wetted width of 11.1m and an average stream depth of 0.16m to a maximum depth of 0.21m (Figure 61) (Table 5) which falls within the minimum depth threshold for Pink Salmon migration (Appendix 1). During late August to mid-September, the higher flows in general were evidently beneficial to migration as indicated by early season fish distribution to the upstream spawning habitat.

During the 2007 assessment, the lowest observed flow was 0.89cms (CQD) and occurred during dam construction when the Coquitlam River was pumped to bypass construction and maintenance of the dam spillway from September 7th to September 19th. The average wetted depth measured 8.3m across the channel providing an average stream depth of 0.18m and a maximum depth of 0.20m (Figure 61) (Table 10). The jump height over the exposed cobble in the left channel riffle fluctuated but on average was measured at 0.22m with an adequate plunge pool depth of 0.31m and a maximum depth of 0.56m. During this time no Pink Salmon were observed staging or migrating although 2 Pink Salmon in good physical shape (Figure 59) were enumerated upstream of the index site by the BC Hydro adult enumeration staff (Macnair 2007). Index site 4 is the most critically impacted index site as on average 32% (Macnair, 2015) of the Pink Salmon population spawning is concentrated in the upper reach in the BC Hydro spawning channels. During the lowest monitored flows migrating Pink Salmon have a choice of accessing index site 4 or alternatively migrating upstream in Swoboda channel (Figure 58) as it is a more favourable and a less challenging migration route. The earliest Pink Salmon observed in this upper reach occurred September 8th during a flow of 1.05cms (CQD) and was enumerated upstream of index site 4 indicting that stream depth and velocity were sufficient for Pink Salmon passage through index site 4 (Figure 61).

With the exception of 2007 and 2013, stream temperatures fluctuated between 15^{O}C to 19.5^{O}C and the general health and condition of holding and / or migrating Pink Salmon was observed to be in good physical condition. Observations of stream temperatures were measured at 13^{O}C to 20^{O}C during 2007 and 2013 assessments which did not seem to decrease Pink Salmon residency time.

The following table summarizes observations for the monitoring period for 2007 to 2015.

Table 10 – Index site 4 data summary, lowest flows from 2007 to 2015. Flow data from Coquitlam Reservoir dam.

Monitoring date	COQ Dam Mean daily discharge (cms)	Wetted width (m)	Avg. Stream Depth (cm)	Max Stream Depth(cm)	Max. velocity (m/sec)	Stream temp (C)
14-Sep-07	0.9	8.3	18.3	20	0.35	16
27-Sep-09	2.28	11.1	16.6	21	n/a	16.5
5-Sep-11	2.16	10	23	38	n/a	14.5
15-Sep-13	2.28	14.6	16.3	27	1.14	20
11-Sep-15	1.58	15	14.7	23	0.94	16.6

Figure 52 - Index site 4, upstream view, Sept.8.07
Discharge = 0.89 cms (Hunter, BC Hydro)

Figure 53 - Index site 4 **-** upstream view Sept 27, 09
Discharge = 2.28cms (Hunter, BC Hydro)

Figure 54 - Index site 4 **-** upstream view, Sept.5.11
Discharge = 2.16cms (Dodd, BC Hydro)

Figure 55 - Index site 4 **-** upstream view, Sept.15.13
Discharge = 2.28cms (Fournier, BC Hydro)

Figure 56 - Index site 4 **-** downstream view, Sept.15.13
Discharge = 2.28cms (Fournier, BC Hydro)

Figure 57- Index site 4 **-** upstream view, Sept.11.15
Discharge = 1.58cms (Harrison, BC Hydro)

Figure 58- Index site 4 **-** downstream view, Sept.11.15
Discharge = 1.58cms (Harrison, BC Hydro)

Figure 59- Index site 4 **-** upstream view, Sept.23.15
Discharge = 1.58cms (Harrison, BC Hydro)
The red arrow indicates Swoboda Channel access

Figure 60 - Index site 4, Sept.30.15
Pink Salmon mortality

5.0 DISCUSSION

The two primary objectives of this monitoring study are to:

(1) Monitor the migration of early returning Pink Salmon in odd years (2007-2015) to determine if there are any flow related migration barriers in the lower Coquitlam River mainstem corridor**.**

(2) To determine at what flows each barrier is eliminated or reduced.

5.1 Objective 1 - low flow passage issues

The first objective was to assess if there were any Pink Salmon passage issues during low flows due to migration barriers in the lower Coquitlam River mainstem corridor. To test this objective, surveys were performed to analyse various flows, depths, velocities and visual observations of migration passage to determine if early returning Pink Salmon were restricted at any of the index sites that were identified as having the potential to cause passage barriers. Monitoring of the index sites throughout the study period generally began during the first week of September or when the first Pink Salmon was observed.

Flows in the Coquitlam River during August and September, particularly in the upper reaches can be limited to water released from the Coquitlam Dam especially during the summer period if there is not significant precipitation events. Inflows from perennial tributaries such as Orr Creek and groundwater inputs from glacial-fluvial sediment based aquifers along the lower river valley all add additional flows to the lower Coquitlam River (Foy, 2015). From observations in the dry summers of 2013 and 2015, less than 1.0cms of flow was added to that released from the Coquitlam Dam over the 12.9 km study area, during these extended low precipitation periods.

The summer of 2015 had a prolonged period of hot and dry conditions with minimal precipitation throughout the south coast of British Columbia. Tributary contributions were minimal and Coquitlam Dam flows were also reduced to the instream flow release lower limit from early July to late September as a conservation measure to preserve the reservoir supply. CQD flows averaged 1.1cms in August and 1.64cms in September until the 23rd of September when spill releases from the dam were increased to a daily average of 2.2cms under the target Treatment 2 flow regime.

The first Pink Salmon observed was on August 2nd and was upstream of index site 4 in the BC Hydro Swoboda spawning channels. The Pink Salmon was captured during a coincidental adult trap program for returning Sockeye Salmon and was observed to be in good physical condition, although, the stream temperature was 19 ^{O}C and above the recommended threshold of 7.2^{O}C to 16^{O}C (Appendix 1) for Pink Salmon migration. This provides some evidence that Pink Salmon migration through the river is possible under low flow, high temperature summer conditions, even in drought years.

Pink Salmon were not observed again until early September after four days of precipitation occurred in late August which temporarily increased flows up to 9.0cms (WSC Port Coquitlam) and decreased

stream temperatures $2^{O}C$ - $3^{O}C$, and during that survey the numbers of observed Pink Salmon remained low, (<100). Significant numbers of Pink Salmon started consistently migrating upstream during the last week of September at which time all index sites were observed not to be an impediment to migration as indicated with 27% (Macnair, 2015) of population observed in Reach 4 upstream of index site 3C and Index site 4 (Table 11). This suggests that in 2015, there was small early component of the Coquitlam River Pink Salmon population that entered the river prior to mid-September. The dominant migration however, occurs after mid-September and the timing of this later component was not strongly affected by flows in the Coquitlam River prior to mid-September (Foy 2015).

What is not known is if Pink Salmon were holding for an extended period in the Fraser River until increased flows and reduced temperatures from the Coquitlam River instigated migration. However the relatively large late August rain event, with the co-incidental rise in flows and decrease in temperature, without a significant movement of Pink Salmon into the spawning grounds, and the fact that Pink Salmon arriving in upper river spawning grounds remained in excellent physical condition, suggested limited time holding downstream. These lines of evidence support the conclusion that Pink Salmon were not holding for a detrimentally long period in the Fraser River, due to constraints on migration posed by low flows or high temperatures in the Coquitlam River (Foy 2015).

Assessments completed in 2011 and 2013 were representative of targeted Treatment 2 flow regime providing an average daily flow of 2.6cms to 2.8cms respectively (WSC, Port Coquitlam) during the monitoring study. During the 2013 assessment, observations of migrating Pink Salmon did indicate some challenges at Index site 3A and index site 4 during the lowest flow of 2.59cms (WSC, Port Coquitlam) however, these index sites were not an impediment to passage as indicated with the maximum depth and velocity being adequate for passage (Figure 28) (Appendix 1). Index site 4 data indicated that passage could potentially become an issue with flows below 1.0cms (WSC Port Coquitlam) as this site is primarily influenced by Coquitlam Reservoir Dam discharge and minimal tributary contribution. During the 2011 assessment, stream depth at three of the four monitoring sites averaged 0.25m during survey days with the lowest monitored flow of 2.82cms which falls within the acceptable range of minimum depth requirements of 0.18m (Appendix 1) for Pink Salmon passage (Figure 61) (WSC, Port Coquitlam). The exception is at index site 1 which recorded the lowest depth of 0.14m, however, Pink Salmon were still able to migrate without great difficulty to upstream habitat through deeper slots in the river that provided enough depth to migrate.

The exception occurred during the 2009 assessment as flows from Coquitlam Dam were much higher than anticipated during early migration and may not be representative of the Treatment 2 flow regime. This provided significantly higher flows averaging 2.0cms (Hunter 2009) above the recommended maximum target of Treatment 2 (Table 1) flow regime of 2.2cms during the early portion of the Pink Salmon migration as no impediments to passage were observed at any of the index sites. Discharges from CQD, LLOG3 valve were corrected by mid-September before significant

numbers of Pink Salmon began migrating. The Pink Salmon adult escapement numbers for 2009 were very robust with an estimated 82% (Macnair 2009) increase in population compared with the 2007 adult escapement numbers and may also be correlated to the increased numbers of Pink Salmon returning to the Lower Fraser River basin suggesting more favourable ocean conditions for that brood year(Appendix 2) .

The 2007 field study represents the Treatment 1 flow regime with reduced flows due to the reservoir release gate valves at the CQD being shut down from September 7th to 19th for Dam construction and spillway maintenance. A temporary pump station was established with a max flow contribution of .89cms (Hunter 2007). During this time less than 40 Pink Salmon were observed throughout the Coquitlam River system with the low numbers affecting the ability to monitor migration and passage through the index sites.

The lowest discharge rate observed was at index site 4 with a flow of 0.89cms (CQD) and impact from tributaries in this area is minimal. Pink spawners were not observed above this index site during the survey days although migrating Pink Salmon have a choice of using the mainstem at index site 4 or accessing Swoboda channel which can be a more favorable and a less challenging migration route. Although monitoring indicated there are no passage issues in the mainstem Coquitlam River, low flows do have the potential to affect off channel habitat use and may limit or restrict access to these sites as observed in 2011 when higher flows occurred in mid-September and 43% of the population was observed accessing off channel habitats which is above the average of 29% (Table 13).

During the 2007 to 2015 field assessment the velocity data collected during the assessment years indicated that the velocity threshold level of 2.13m/s was not surpassed and migration not impeded, however, there is enough high velocity refuge areas downstream for Pink Salmon to hold (Macnair 2011) until flows are adequate for migration. The highest recorded velocity was measured at 1.83m/sec at index site 3A during a mean daily discharge of 21.2cms (WSC, Port Coquitlam). This event coincided with 233mm of precipitation. Although no Pink Salmon were observed migrating at this velocity on the survey day, 1.83m/s was below the threshold for passage criteria of 2.13m/sec (Appendix 1) and indicates that velocities were passable during that period and is also based on the assumption, that there is enough quiet water areas along the river margins available to provide high velocity refuge for Pink Salmon to hold. In comparison, the DFO Habitat Management Unit has adopted a flow velocity value of 1.0 m/sec as a guideline for defining maximum discharge flow suitable for upstream salmon migration (Levy and Slaney 1993), suggesting that if Pink Salmon were migrating upstream that survey day they would have likely been using lower velocity pathways along the channel margins or where coarse substrate promoted lower velocity (Foy, 2015).

Throughout the monitoring study typically only a few Pink Salmon (<20), (Table 11) are observed entering the Coquitlam River system during August and have been observed in the BC Hydro Swoboda and Grant's Tomb spawning channels upstream of index site 4. Pink Salmon distribution numbers indicate that there was adequate flow, depth and velocity for migration through all index sites during

the maximum targeted release flows of 2.7cms from CQD. Overall Pink Salmon were observed to be in good physical condition with minimal pre-spawn mortalities observed although, stream temperature typically fluctuated in late August to mid-September but generally ranged from 14.5^{O}C to 21^{O}C during the 2007 to 2015 study period.
Early season fish distribution numbers indicated that migration was achieved upstream of all index sites demonstrating that at the lowest discharge value of 1.1cms to 2.28cms (WSC) provided adequate depth (Figure 61), velocity and flow for early migrating Pink Salmon (WSC, Port Coquitlam). Stream depth at five of the six monitoring sites on survey days provided sufficient depth for passage during the field assessment with the lowest monitored flow of 1.5cms to 2.59cms and falls within the acceptable range of minimum depth requirements of 0.18m for Pink Salmon passage (WSC, Port Coquitlam) (Appendix 1). The exception is at index site 4 which recorded the lowest average depth of 0.12m and a maximum depth of 0.27m during a daily average flow of 0.89cms however, observations indicate that Pink Salmon were not impeded from upstream migration.

One unconsidered concern raised during the 2007 and 2013 studies was whether observed elevated stream temperatures averaging 19^{O}C daily throughout the assessment period, would affect Pink Salmon migration. Stream temperatures would be expected to be affected by flows released from the Coquitlam Reservoir Dam and annual variations in weather patterns and air temperatures. Stream temperatures of this magnitude are at the higher threshold for Pink Salmon migration based on literature (Bjornn and Reiser 1991) and water temperatures in the lower Coquitlam River would be expected to vary from year to year. With the increased pink escapement numbers, perhaps during warm summers there may be impeded migration, even at flow levels previously observed to not impede migration during cooler summers (Foy, 2015).

Overall, early migrating Pink Salmon were not restricted at any of the index sites during the lower flows in the Coquitlam River. Treatment 2 flows (2.2 - 2.7cms) provided adequate depth and velocities for passage for early migrating Pink Salmon however, with the increased numbers of Pink Salmon returning, maximizing dam discharge contribution during the early run of the migration would be beneficial with the availability of spawning habitat, lower stream temperatures and the ability of Pink Salmon to have a longer residency time to spawn successfully.

Considering that the average number of early migrating Pink Salmon represent a small portion (<2%) of the total population, consideration should be to review August and September CQD water releases, if promoting unimpeded Pink Salmon migration is desired. August Treatment 2 flows are now targeted at a maximum flow of 2.7cms (CQD) and are in fact reduced in September to 2.2cms (CQD). It would be beneficial to consider modifying flows to generally conform to Pink Salmon upstream migration timing which appears to initiate in early August, although low in numbers but increasing through early September and strongly increases after mid-September, peaking in early October and completed in late October.

The following chart Illustrates the maximum depth at each index site during the lowest monitored flow levels over the five-year assessment period.

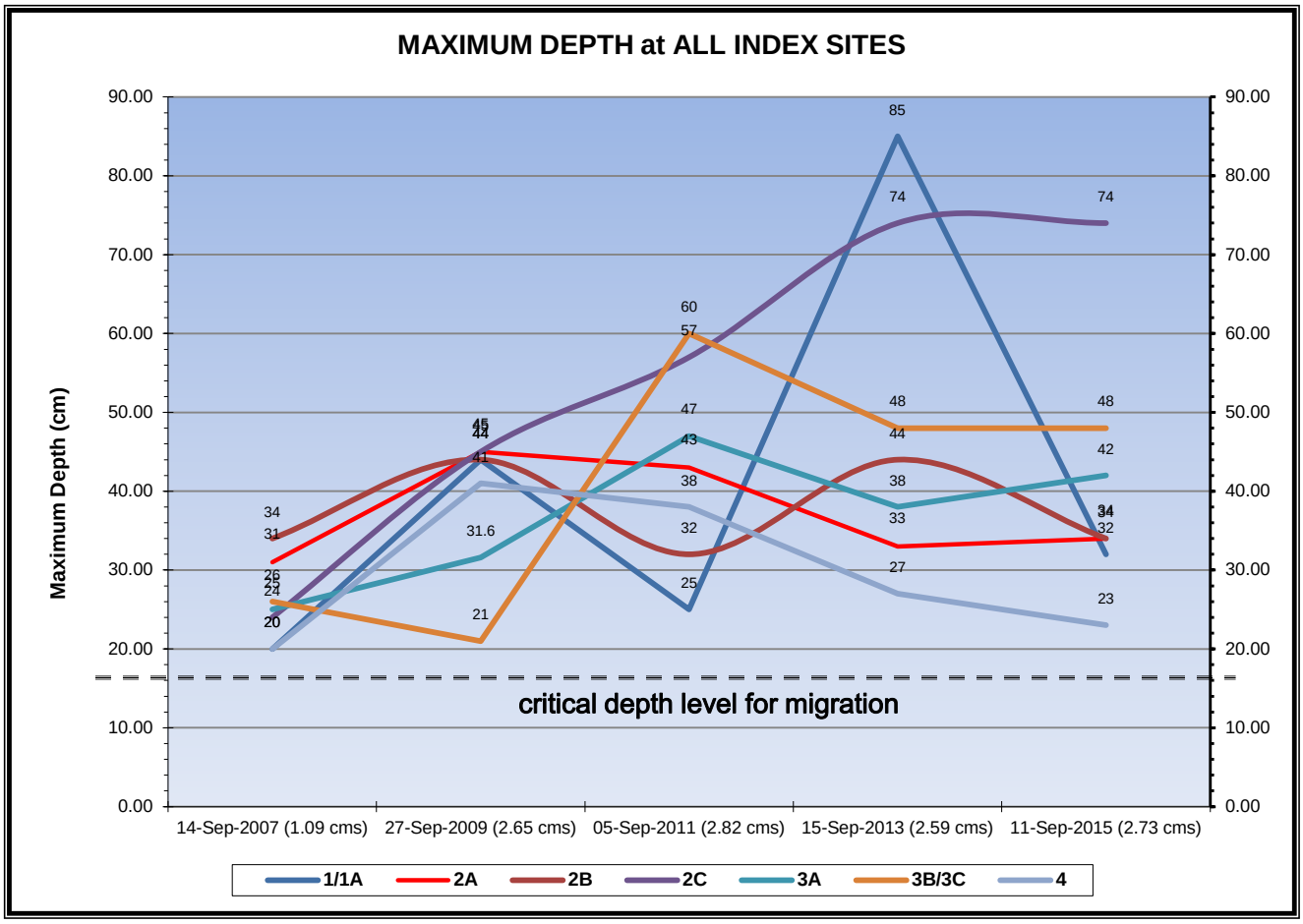


Figure 61 - Illustrates the maximum depth at each index site during the lowest flow levels over the five year assessment period.

	Aug 15- 30		Sept 1 -30	
Date:	Daily Avg WSC Flow	# Pink	Daily Avg WSC Flow	# Pink Observed
2007	2.39	0	1.5	880
2009	4.37	15	5.08	5281
2011	4.33	6	3.16	2086
2013	3.19	23	3.47	9901
2015	1.59	1	2.61	4750

Note: Sept 16- 30th, 2009, the daily average flow was 2.89

Table 11 - Aug to Sept, 2007 to 2015 WSC average flow rate and pink numbers observed throughout the Coquitlam River.

5.2 Objective 2 - at what flows are passage issues resolved or improved?

The second objective of this report was to assess at what flows the potential passage restrictions would be improved for migrating Pink Salmon. To test this objective information was obtained to determine the range of flow that did not influence the efficacy of migrating Pink Salmon and to determine what the minimum and maximum flows would be for successful migration.

During the 2007 assessment Pink Salmon escapement numbers in the Coquitlam River were very low with less than 2,337 adults returning to spawn (Appendix 2). The 2007 study provided the lowest monitored flow in the Coquitlam River over the 2007 to 2015 monitoring program due to the ongoing construction and maintenance of the Coquitlam Reservoir Dam and spillway. The lowest discharge rate was observed at index site 4 with a flow of 0.89cms (CQD) and during this time, precipitation and tributary contribution was minimal (Appendix 4). BC Hydro adult enumeration staff observed 16 Pink Salmon (Macnair 2007) upstream of index site 4 from late August to mid-September when flows were low averaging <1.0cms (CQD) daily. The sixteen Pink Salmon observed represented 21% of the total population enumerated upstream of Index site 4 indicating that migration was unimpeded to the upper reaches to the BC Hydro, Swoboda spawning channels (Table 12). Flows below 1.0cms (CQD) can have a negative impact on Pink Salmon access to off channel habitat as was the case during the 2007 assessment when 28% (Table 13) of the population was enumerated in off channel sites indicating that 71% of migrating Pink Salmon choose to remain in the mainstem or were unable to access the off channel sites due to low flows. During Treatment 1 flow regime (1.1cms, CQD) data collected through the 2003 to 2007 monitoring program indicated an average of 63.7% (Table 13) of the Pink Salmon population utilized the mainstem for spawning in comparison to treatment 2 flow regimes of 2.2 - 2.7cms, CQD) that occurred from 2009 to 2015 indicating that 70% of the population typically utilized the Coquitlam River mainstem for staging and spawning. Based on the assumption that treatment 2 flow regime with higher flow rates averaging a minimum of 2.2cms to 2.7cms (CQD)

was more beneficial for migrating pink to reach the upstream spawning habitat and be able to hold and spawn successfully.

During the 2009 monitoring program flows averaged 6.3cms (WSC Port Coquitlam) from late August to September 21st when discharge from the newly installed dam gate was reduced to a daily average of 2.7cms from a daily average of 5.3cms (WSC Port Coquitlam). During the early migration of Pink Salmon (Aug 25 - Sept 15), 43% (Macnair, 2009) of the population was enumerated in reach 4 indicating that the higher flowrate was beneficial for migrating Pink Salmon to reach the upper BC Hydro, Swoboda spawning channels. After the September 21st ramp down the daily average flow in the Coquitlam River mainstem averaged 2.78cms (WSC Port Coquitlam) and observations confirmed that there was no evidence of impediments or barriers to migrating adult Pink Salmon at any of the index sites. Overall during the 2009 assessment 34% of the population was observed upstream of Index site 4 (Table 12) with 71.5% of the total population enumerated in the mainstem and 28.5% (Macnair 2009) (Table 13) observed utilizing off channel habitat sites which indicates that the higher base flows from CQD assisted Pink Salmon migration to the upper reaches and accessing off channel habitat as there was a minimal precipitation and a significant increase in escapement of Coquitlam River Pink Salmon (Appendix 4).

The 2011 assessment was an anomaly as only 57% of the population (Table 13) of Pink Salmon were observed in the mainstem Coquitlam River however a significant increase in off channel use was observed with 43% of the pink population enumerated in off channel sites (Macnair 2011). Of that number over 80% of the population were observed in the BC Hydro Swoboda and Grant's tomb spawning channels by the dam (Table 13) (Macnair 2011) during a daily average flow of 3.2cms (WSC Port Coquitlam). Early season fish distribution numbers indicated that migration was achieved upstream of all index sites demonstrating that at the lowest discharge value of 2.82cms throughout the study period provided adequate flow, depth and velocity for early migrating Pink Salmon (WSC, Port Coquitlam).

The 2013 field assessment observed an increase in mainstem habitat use with 78% (Macnair 2013) of migrating Pink Salmon spawning in the mainstem reaches of the Coquitlam River during flows averaging 2.59cms (WSC Port Coquitlam) which is the highest percentage since adult enumeration began in 2003. It should also be noted that during the Treatment 2 flow regime a proportion of adults spawning in reach 4 increased significantly to 43% (Macnair, 2013) (Table 12) of the population compared to treatment 1 flow regime (1.1cms) of 28% (Macnair 2013) of the Pink Salmon population spawning in the upper reaches of Coquitlam River mainstem. The 2013 study period observed the lowest percentage of off-channel use since 2003 and of the off- channel sites, 43% (Table 13) of the Pink Salmon population were observed in the BC Hydro Swoboda channels upstream of index site 3C and index site 4 (Macnair 2013) indicating that the present treatment 2 flow regime was adequate for passage to the upstream habitat. It is probable that the off channel sites were fully populated and the available habitat was limited in 2013 due to the significant escapement numbers of returning Pink

Salmon to the Coquitlam River (Appendix 2) (Macnair 2013). The 2013 flow regime improved migration and continued that trend providing greater access to the upper watershed habitat, specifically in the Swoboda channels located upstream of Index site 4, which presented a greater area of quality spawning habitat (Table 12).

Throughout the 2015 monitoring study, flow contribution from CQD, LLOG3 gate was significantly reduced to the Treatment 2 minimum flow requirement of 1. 1cms (CQD) with an average daily mean flow contribution of 1.4cms (WSC Port Coquitlam) recorded during August 25th to September 30th. Precipitation and tributary flows were observed to be minimal during early season reconnaissance. The first Pink Salmon observed occurred on August 2nd, upstream of Index site 4 during a flow of 1.26cms (CQD) and no other Pink Salmon were observed migrating until September 5th. During the study period the lowest flow recorded at the Water Survey Canada hydrometric station occurred on September 11th with a stream flow of 2.73cms (WSC Port Coquitlam) which was early into to the migration period with 40 Pink Salmon observed throughout the Coquitlam River. Twenty-eight Pink Salmon were observed upstream of index site 3A and the remaining 2 were enumerated upstream of index site 4, during flows of 1.58cms (CQD) indicating that passage was not impeded or restricted at any of the index monitoring sites as indicated by fish distribution numbers in the upper reaches. Significant numbers of Pink Salmon did not begin to migrate until September 23rd when the maximum Treatment 2 target flow for September of 2.2cms (CQD) was implemented. At this time 33% of the population was enumerated upstream of index site 4 and 89% (Macnair, 2015) of the population were observed in the mainstem Coquitlam River. During this time, only 11% (Macnair, 2015) of early migrating Pink Salmon were accessing off channel habitat possibly due to the low flow in the mainstem and low flows from the off channel sites impeding access. After flows were restored to a daily average of 2.24cms (CQD)on September 23rd, 26.7% (Table 12) of the population was observed upstream of index site 4 in the BC Hydro spawning channels. Mainstem spawning occurred throughout all index sites with 76% (Macnair, 2015) of the total population spawning in the mainstem and 24% (Macnair, 2015) of the population enumerated in the off channel sites.

Summer low flows do not appear to affect the efficacy of early returning Pink Salmon migration however, observations indicate the treatment 2 flow regime with a consistent and maximized contribution from CQD (2.2 to 2.7cms), (Table 1) improved passage at all the index sites as indicated by the early season fish distribution numbers in the upper reaches of the Coquitlam mainstem. The higher base flows provided by the treatment 2 flow regime provided sufficient depth and velocity at all index sites, which possibly resulted in Pink spawners being in better physical condition to migrate, hold and spawn successfully. The treatment 2 flow regime from (CQD) is critical when precipitation and tributary contributions are minimal during hot and dry summers. Treatment 2 maximum flow target requirement of 2.2cms to 2.7cms provides greater accessibility to spawning habitat and favourable conditions for staging and successful spawning.

Table 12 - 2013 Coquitlam Pink Salmon Distribution by Reach

Date	Reach 1	Reach2a	Reach 2b	Reach 3	Reach 4	Total
2007 Sept 4 -Oct 27	369	55	155	684	1074	2337
2009 Sept 3 - Oct 28	1201	436	1180	2238	3696	8751
2011 Sept 4 - Oct 25	1316	141	564	1560	4089	7670
2013 Sept 9 - Oct 29	10044	5376	10185	5416	12656	43677
2015 Sept 9 - Oct 25	7088	1846	3887	2265	5506	20592

Source: pink adult spawning enumeration by reach (Macnair 2015)

Table 13 - Coquitlam River Pink Salmon Off Channel Habitat Use

Date	Mainstem	Natural Off Channel Sites	Off-Channel Restoration sites	Off - Channel Sites Combined
2003	55.20%	18.80%	26%	44.80%
2005	64.80%	21.80%	13.40%	35.20%
2007	71.20%	20.30%	8.50%	28.80%
2009	71.50%	13.40%	15.10%	28.50%
2011	57%	23%	20%	43%
2013	77.90%	11.80%	10.30%	22.10%
2015	76%	14%	10%	24%

Source: (Macnair 2015)

6.0 RECOMENDATIONS:

Taking into account that the average number of early migrating Pink Salmon represent a small portion (<2%) of the total population, consideration should be to review August and September CQD water releases, if promoting unimpeded Pink Salmon migration is desired. August treatment 2 flows are now targeted at a maximum flow of 2.7cms (CQD) and are in fact reduced in September to 2.2cms when increased migration occurs (CQD). It would be beneficial to consider modifying flows to generally conform to Pink Salmon upstream migration timing which appears to initiate in early August, although low in numbers but increasing through early September and strongly increases after mid-September, peaking in early October and completed in late October.

The mean annual discharge (MAD) of the Coquitlam River is estimated at 4.6cms (McPhee 2003), Treatment 2 maximum flow of 2.7cms that is targeted for August dam releases represent 58.6% of the Coquitlam MAD, in comparison the September flows of 2.2cms represent 48% of the Coquitlam mean annual discharge, when increasing numbers of Pink Salmon are migrating. It is recommended that August flows be reduced to 2.2cms (CQD) and September flows be increased to 2.7cms (CQD) or splitting the flows to 2.5cms for the months of August and September when the bulk of the Pink Salmon population is beginning migration in the mainstem Coquitlam.

APPENDICES

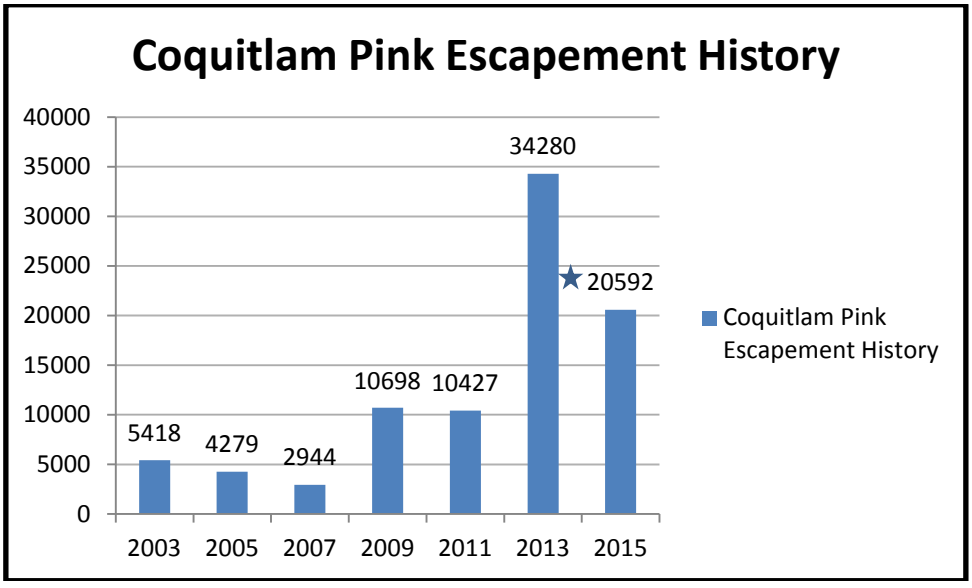
APPENDIX I

[Salmon Passage Criteria Table]

Species	Temperature range (C)	Min. depth (m)	Max Velocity (m/s)
Chinook Salmon	10.6 - 19.4	0.24	2.44
Chum Salmon	8.3 - 15.6	0.18	2.44
Coho Salmon	7.2 - 15.6	0.18	2.44
Pink Salmon	7.2 - 15.6	0.18	2.13
Sockeye Salmon	7.2 - 15.6	0.18	2.13
Steelhead	7.2 - 15.6	0.18	2.44

(Source: Bjornn and Reiser 1991)

APPENDIX II



*(2015 enumeration data is a post season estimate)

APPENDIX III

Site Assessment Field Data 2007 - 2015

Pink Salmon Migration Assessment Data Form

Crew: _____ Photo # _____

Date: _____

Air temp: _____ C

Start Time: _____

End time: _____

Survey # _____ Index Site : _____

WSC _____ m^3/sec Stream Temperature _____ C

Pink observed: _____ at index site

_____ upstream of index site

_____ dowstream of index site

_____ migrating (30minute observation limit)

Over all condition / appearance: _____

Comments: _____

Assessement Data:

Barrier type _____

wetted width (R-L): _____ m Length _____ m

wetted depth (cm):	meter														
	depth														
	velocity														

Pool depth max = _____ pool depth min= _____

Dominate substrate:	Type	sands	gravels	cobbles	boulder	bedrock	
	%						

Gradient: _____ % length surveyed: _____ m

Comments: _____

APPENDIX IV

Upper Coquitlam River Monthly Precipitation Data Table 2007 - 2015

Year	August	September	Totals
2015	124	244.8	368.8
2013	64.8	304.6	369.4
2011	71.2	181.8	253
2009	38.6	6.4	45
2007	27.4	107.6	135
Avg:	65.2	169.04	234.24
Source: Dunkley, Henwood, Stuart, 2007 -2015			

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