Coquitlam-Buntzen Water Use Plan

Monitoring Program Terms of Reference

- COQMON#6 – Lower Coquitlam River Temperature Monitoring

Initial submission: October 24, 2005
Revision 1: December 14, 2006
Terms of Reference for the Coquitlam-Buntzen Water Use Plan Monitoring Programs

Introduction
This document outlines the Coquitlam-Buntzen Water Use Plan (WUP) Terms of Reference for the monitoring programs as per the Coquitlam-Buntzen Order under the Water Act, dated 21 April 2005.

This Revision 1 document contains the detailed Terms of Reference for the eight monitoring programs for the Coquitlam-Buntzen WUP approved based on the below schedule Table 1.

<table>
<thead>
<tr>
<th>Monitoring Program</th>
<th>1st Submission</th>
<th>Revision 1</th>
<th>Rescinded</th>
<th>Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>COQMON#1</td>
<td>24 Oct 2005</td>
<td></td>
<td></td>
<td>3 Jan 2006</td>
</tr>
<tr>
<td>COQMON#2</td>
<td>24 Oct 2005</td>
<td></td>
<td></td>
<td>3 Jan 2006</td>
</tr>
<tr>
<td>COQMON#3</td>
<td>24 Oct 2005</td>
<td>8 Feb 2006</td>
<td>8 Mar 2006</td>
<td></td>
</tr>
<tr>
<td>COQMON#4</td>
<td>24 Oct 2005</td>
<td></td>
<td></td>
<td>3 Jan 2006</td>
</tr>
<tr>
<td>COQMON#5</td>
<td>24 Oct 2005</td>
<td></td>
<td></td>
<td>3 Jan 2006</td>
</tr>
<tr>
<td>COQMON#6</td>
<td>24 Oct 2005</td>
<td></td>
<td></td>
<td>3 Jan 2006</td>
</tr>
<tr>
<td>COQMON#7</td>
<td>24 Oct 2005</td>
<td>8 Feb 2006</td>
<td></td>
<td>8 Mar 2006</td>
</tr>
<tr>
<td>COQMON#8</td>
<td>24 Oct 2005</td>
<td></td>
<td></td>
<td>3 Jan 2006</td>
</tr>
</tbody>
</table>

Table 1. Coquitlam-Buntzen monitoring program Terms of Reference submission and approval schedule.

The attached Terms of Reference includes the revised Lower Coquitlam River Habitat Suitability Criteria Development entitled Lower Coquitlam River Habitat Requirements Study (COQMON#3) and increased implementation costs for COQMON#5 – Coquitlam River Periphyton and Benthic Invertebrate Monitoring, COQMON#7 – Lower Coquitlam River Fish Productivity Index, and COQMON#8 – Lower Coquitlam River Substrate Quality Assessment based an extended WUP review period resulting from the delayed implementation of the Treatment 2 flow release.

1) COQMON#1: Assessment of Fisheries Access to Streams Tributary to Coquitlam Reservoir. The objective of this study is to identify fish use and/or fish habitat potential in each of the three streams identified with potential fish access issues (BC Hydro 2000) and to recommend physical works and/or operational constraints to restore fish access for all operations.

2) COQMON#2: Coquitlam Dam Flow Release Interim Ramping Rate Monitoring. The objective of this monitoring program is to report on the fish stranding impacts in the lower Coquitlam River associated with the implementation of the interim ramping rate protocol for the Coquitlam Dam.

3) COQMON#3: Lower Coquitlam River Fish Habitat Requirements Study. The objective of this study is to identify any changes to the habitat suitability criteria used...
in the Coquitlam-Buntzen Water Use Plan calculations of weighted useable area of habitat, and refine the habitat-flow relationships and flow release targets developed in the WUP.

4) COQMON#4: Assessment of Pink Salmon Passage in Lower Coquitlam River. The objective of this study is to monitor the migration of returning pink salmon in odd years to determine if there are any flow-related partial or complete migration barriers in the lower Coquitlam River corridor.

5) COQMON#5: Coquitlam River Periphyton and Benthic Invertebrate Monitoring. The objective of this study program is to develop a predictive model for evaluating periphyton and invertebrate benefits associated with Lower Coquitlam River flow alternatives.

6) COQMON#6: Lower Coquitlam River Temperature Monitoring. The objective of this monitoring program is to identify if and how temperature in the lower Coquitlam River is influenced by reservoir operations.

7) COQMON#7: Lower Coquitlam River Fish Productivity Index. The objective of this monitoring program is to determine the fisheries benefits of two test flows and to enable a better understanding of trade-offs between fisheries, domestic water and power generation for the benefit of future water planning processes.

8) COQMON#8: Lower Coquitlam River Substrate Quality Assessment. The objective of this monitoring program is to evaluate the effectiveness of the flushing flow provisions outlined in the LB1 WUP to increase fish productivity through improved substrate quality in the lower Coquitlam River.

Physical works terms of reference will be delivered in a separate package.
Coquitlam-Buntzen Water Use Plan

Monitoring Program Terms of Reference

Summary

1.0 Background

In 2003, the Coquitlam-Buntzen Water Use Plan (LB1 WUP) consultative committee (CC) agreed on a set of operating conditions for the review period ending in 2016. The recommended operations include the release of two flow regimes from Coquitlam Dam (see Figure 1-1): Treatment #1 will continue the release schedule of two fish valves fully open (this flow agreement has been in place since 1999, releasing between 0.8-1.7m$^3$s$^{-1}$). Upon dam seismic upgrade completion in 2007, Treatment #2 will take effect, releasing 1.1-5.9m$^3$s$^{-1}$ depending on the time of year (see Table 1-1).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3 yrs Base (2FVC)</td>
<td>baseline smolt monitoring</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 yrs STP6</td>
<td>Dam Modifications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Treatment #2 - STP6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1-1: Treatment schedule recommended by the Consultative Committee for LB1 WUP review period to 2015$^1$.

$^1$ Note that recommendations from the Monitoring Committee in 2006 will result in extending Treatment 1 to September 2007, and Treatment 2 to September 2016.
Table 1-1: Annual schedule for release amounts as agreed by the Consultative Committee. Note that 2FV dam release amounts are average and affected by reservoir elevations, resulting in variation similar to, but not equal to those summarized.

<table>
<thead>
<tr>
<th>Date</th>
<th>Domestic Water Target</th>
<th>Domestic Water Min</th>
<th>2 Fish Valves Current</th>
<th>&quot;Share the Pain 6&quot; Target</th>
<th>&quot;Share the Pain 6&quot; Min</th>
<th>Species Driver and Priority for Coquitlam River Releases</th>
</tr>
</thead>
<tbody>
<tr>
<td>01-Jan</td>
<td>11.9 10.7</td>
<td>1.0</td>
<td>5.9 3.6</td>
<td>Chinook Spawning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-Jan</td>
<td>11.9 10.7</td>
<td>1.0</td>
<td>2.9 2.9</td>
<td>Chinook Incubation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb</td>
<td>11.9 10.7</td>
<td>1.0</td>
<td>2.9 1.8</td>
<td>Chinook Incubation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar</td>
<td>11.9 10.7</td>
<td>0.8</td>
<td>4.3 1.1</td>
<td>Steelhead Spawning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr</td>
<td>12.0 10.8</td>
<td>0.8</td>
<td>3.5 1.1</td>
<td>Steelhead Spawning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>12.0 11.0</td>
<td>1.1</td>
<td>2.9 1.1</td>
<td>Steelhead Spawning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun</td>
<td>12.0 10.9</td>
<td>1.4</td>
<td>1.1 1.1</td>
<td>Steelhead Parr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jul</td>
<td>18.0 15.8</td>
<td>1.4</td>
<td>1.2 1.1</td>
<td>Steelhead Parr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug</td>
<td>23.0 20.2</td>
<td>1.1</td>
<td>2.7 1.1</td>
<td>Steelhead Parr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sep</td>
<td>23.0 20.9</td>
<td>0.8</td>
<td>2.2 1.1</td>
<td>Steelhead Parr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct</td>
<td>12.0 10.8</td>
<td>0.8</td>
<td>6.1 3.6</td>
<td>Chinook Spawning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov</td>
<td>12.0 10.8</td>
<td>1.1</td>
<td>4.0 1.5</td>
<td>Chinook Spawning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec</td>
<td>11.9 10.7</td>
<td>1.1</td>
<td>5.0 2.5</td>
<td>Chinook Spawning</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In addition to Coquitlam Dam flow releases for fish interests, the CC also agreed to increased water diversion from Coquitlam Reservoir for Greater Vancouver Regional District (GVRD) for drinking water.

The CC also made provisions in the LB1 WUP to address uncertainties through long-term monitoring, and to facilitate Treatment #2 flow releases through Coquitlam Dam gate improvements.
Figure 1-2: Coquitlam-Buntzen System components and attributes
1.1 Monitoring Program Summary

1.1.1 Program Objective

To address uncertainties related to the effectiveness of the LB1 WUP operating constraints, the CC recommended that a monitoring program be implemented for the duration of the review period. The overall objective of the monitoring program is to provide the level of information required for future water planning processes on the Coquitlam-Buntzen system to recommend a Coquitlam Dam release regime that fits within the parameters of the LB1 WUP agreement: between the annual water budgets of Treatment #1 and Treatment #2 (or STP5\(^2\) whichever is more desirable to fish).

1.1.2 Program Approach

Although the approach varies between study programs, the program in general attempts to address key uncertainties and evaluate the effectiveness of the Water Use Plan operations. The most important indicator of effectiveness will be the productive response of fish species in the Lower Coquitlam River. In lieu of unknown productivity relationships, predictions of habitat response in Reaches 2 and 3 (see BC Hydro 2003a for reach summaries) to flow alternatives were reviewed in WUP deliberations. The validity of these predictions as proxies for fish production will be evaluated at the end of the WUP review period.

To inform the monitoring approach, a power analysis (Higgins et. al. 2002) was conducted that described the ability of a monitoring program to measure a response to a flow change. It concluded that 15 years of monitoring in reaches 2 and 3 would be required to obtain a reliable result. Although lower reaches (i.e. reaches 0 or 1) are extremely productive for fish in the Coquitlam River, the effect size used in the analysis showed that lower sites would not be a reliable indicator of response to dam releases upstream. Therefore, the Consultative Committee agreed that the focus of the monitoring program would be on the upper reaches of the Lower Coquitlam River. There are several other components of the monitoring program (e.g. Interim Ramping Rate Monitoring, Pink Salmon Passage and the Substrate Quality Assessment) that conduct at least some aspects of their monitoring in the lower reaches in recognition that impacts of operations affect the entire Lower Coquitlam River.

The flow treatments were developed to address habitat requirements for various key species life histories throughout the year, predominantly steelhead and chinook salmon. However, because chinook are in low abundance, coho, chum and pink salmon will be used as indicators in the monitoring program and chinook will be monitored where possible.

---

\(^2\) STP5 or “Share the Pain” 5 was an alternative tentatively approved for implementation by the Consultative Committee in 2002 (BC Hydro 2002), and the agreement by the CC at the time was not amended when the CC refined the alternative to STP6 (Treatment #2).
1.1.3 Program Summary

This package outlines eight monitoring programs being implemented during the review period. The objectives and monitoring indicators to be reported to BC’s Comptroller of Water Rights are listed below:

- **COQMON#1 – Assessment of Fisheries Access to Streams Tributary to Coquitlam Reservoir:** The objective of this study is to identify fish use and/or fish habitat potential in each of the three streams identified with potential fish access issues (BC Hydro 2000) and to recommend physical works and/or operational constraints to restore fish access for all operations.
  
  **Monitoring Indicator:** Barrier to fish passage identified (yes/no)

- **COQMON#2 – Coquitlam Dam Flow Release Interim Ramping Rate Monitoring:** The objective of this monitoring program is to report on the fish stranding impacts in the lower Coquitlam River associated with the implementation of the interim ramping rate protocol for the Coquitlam Dam.
  
  **Monitoring Indicator:** Stranding risk (number of fish stranded per area of dewatered habitat measured).

- **COQMON#3 – Lower Coquitlam River Fish Habitat Requirements Study:** The objective of this study is to identify any changes to the habitat suitability criteria used in the Coquitlam-Buntzen Water Use Plan calculations of weighted useable area of habitat, and refine the habitat-flow relationships and flow release targets developed in the WUP.
  
  **Monitoring Indicator (a):** Habitat suitability for species of interest
  
  **Monitoring Indicator (b):** Flow target (Coquitlam Dam releases) for LB1 WUP

- **COQMON#4 – Assessment of Pink Salmon Passage in Lower Coquitlam River:** The objective of this study is to monitor the migration of returning pink salmon in odd years to determine if there are any flow-related partial or complete migration barriers in the lower Coquitlam River corridor.
  
  **Monitoring Indicator:** Number of days of unimpeded access

- **COQMON#5 – Coquitlam River Periphyton and Benthic Invertebrate Monitoring:** The objective of this study program is to develop a predictive model for evaluating periphyton and invertebrate benefits associated with Lower Coquitlam River flow alternatives.
  
  **Monitoring Indicators (short term):** Seasonal results of benthos monitoring;
  
  **Monitoring Indicators (long term):** Modeled results of benthos abundance and diversity indicators.

- **COQMON#6 – Lower Coquitlam River Temperature Monitoring:** The objective of this monitoring program is to identify if and how temperature in the lower Coquitlam River is influenced by reservoir operations.
  
  **Monitoring Indicator (a):** Deviation of temperature regime from natural examples.
  
  **Monitoring Indicator (b):** Correlation between temperature and reservoir operations

- **COQMON#7 – Lower Coquitlam River Fish Productivity Index:** The objective of this monitoring program is to determine the fisheries benefits of two test flows and to enable a better understanding of trade-offs between fisheries, domestic water and power generation for the benefit of future water planning processes.
**Monitoring Indicator (a):** Smolt per spawner (stock productivity) for coho salmon and steelhead.
**Monitoring Indicator (b):** Fry per spawner for chum and pink salmon.

- COQMON#8 – Lower Coquitlam River Substrate Quality Assessment: The objective of this monitoring program is to evaluate the effectiveness of the flushing flow provisions outlined in the LB1 WUP to increase fish productivity through improved substrate quality in the lower Coquitlam River.
  **Monitoring Indicator:** Substrate quality (areal fraction of fine sand)

Physical works terms of reference will be delivered in a separate package.

### 1.2 Monitoring Cost Summary

The following table describes the costs associated with the monitoring program proposals in this document. It is assumed that the funding for this program will be initiated in 2006. Note that resources not spent in 2005 will be carried forward to the next year where warranted. Based on revised terms of references (COQMON#3) and revised implementation schedules resulting from physical works delays, the budgets and the review period have increased for this program beyond those originally approved. The revised average annual cost is $212K, with an expected inflated total program cost of $2,542K over the 12-year (2005-2016 inclusive) review period. This is 43% higher than what was approved in the LB1 WUP (total inflated approved costs were $1,781K), although only 12% of this is due to the recent program changes. The remainder of the cost variance is due in-part to an unanticipated shortfall in partnership funding associated with the smolt enumeration program, a sub-component of the Lower Coquitlam River Fish Productivity Index study program. In addition to the shortfall, several items identified during the Terms of Reference review were added to the program to improve the power and consistency of monitoring the effectiveness of the operational changes. These included an annual standing stock assessment, an expansion of the periphyton and benthic invertebrate monitoring program, and an annual survey of substrate quality, as requested by agency representatives.

<table>
<thead>
<tr>
<th>Study Ref#</th>
<th>Terms of Reference Proposals</th>
<th>Program Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Assessment of Fisheries Access to Streams Tributary to Coquitlam Reservoir</td>
<td>$10,260</td>
</tr>
<tr>
<td>2</td>
<td>Coquitlam Dam Flow Release Interim Ramping Rate Monitoring</td>
<td>$87,235</td>
</tr>
<tr>
<td>3</td>
<td>Lower Coquitlam River Fish Habitat Requirements Monitoring Program</td>
<td>$82,992</td>
</tr>
<tr>
<td>4</td>
<td>Assessment of Pink Salmon Passage in Lower Coquitlam River</td>
<td>$37,241</td>
</tr>
<tr>
<td>5</td>
<td>Coquitlam River Periphyton and Benthic Invertebrate Monitoring</td>
<td>$168,739</td>
</tr>
<tr>
<td>6</td>
<td>Lower Coquitlam River Temperature Monitoring</td>
<td>$22,791</td>
</tr>
<tr>
<td>7</td>
<td>Lower Coquitlam River Fish Productivity Index</td>
<td>$1,925,301</td>
</tr>
<tr>
<td>8</td>
<td>Lower Coquitlam River Substrate Quality Assessment</td>
<td>$208,346</td>
</tr>
<tr>
<td><strong>Total – All Components</strong></td>
<td><strong>$2,542,905</strong></td>
<td></td>
</tr>
<tr>
<td><strong>WUP Approved Budget</strong></td>
<td><strong>$1,772,666</strong></td>
<td></td>
</tr>
</tbody>
</table>

% Variance from Approved 43%
1.3 Monitoring Program Delivery

The LB1 WUP was ratified in 2003 and was ordered by the BC Comptroller of Water Rights (CWR) in April 2005. Current implementation of Treatment 1 flows are in effect until 2007 when gate modifications and dam seismic upgrades will be complete and Treatment 2 flows will be instated and monitored.

After 9 years of Treatment 2 monitoring, the review period will conclude and the results of the monitoring program will be deliberated. A recommendation on the basis of the monitoring results pertaining to the flow release regime needed to meet the objectives laid out in the LB1 WUP will be provided to the CWR by BC Hydro on behalf of the monitoring committee. The recommendation will be constrained between the annual water budgets of Treatment 1 and Treatment 2 per the agreement made by the Consultative Committee as outlined in the consultative committee report (BC Hydro 2003).
2.0 COQMON#6 – Lower Coquitlam River Temperature Monitoring

2.1 Monitoring Program Proposal

2.1.1 Background

The Coquitlam Reservoir operations can influence downstream river temperatures through low level outlet releases that draw water from different temperature zones of the reservoir, depending on reservoir elevation. Because temperature is highly variable and highly dependant on environmental influences, the consultative committee involved in developing the Coquitlam-Buntzen Water Use Plan (LB1 WUP) agreed to put the issue of temperature aside while a long term data set was collected and operational influences could be better understood.

This study outlines a three-year monitoring program that incorporates all information collected to date and provides an assessment as to the effects of reservoir operations on downstream temperatures. This data will be available for consideration in future water planning processes on the lower Coquitlam River.

2.1.2 Management Questions

The main question to be addressed in this monitoring program is:

*How do reservoir operations affect lower Coquitlam River temperature regimes?*

The study will attempt to address this question by evaluating temperature monitoring data throughout the Coquitlam system, and determining if there are correlations to reservoir operations.

2.1.3 Summary of Alternative Hypotheses

The following hypotheses will be tested in this study:

$H_1$: There is no significant correlation between lower Coquitlam River temperature and Coquitlam Reservoir operations.

Through analysis of temperature and operational data, a correlation between the two will be tested in this study.

$H_2$: The temperature gradient from reservoir to river in the Coquitlam basin is not significant in comparison to other lower Fraser River tributary lake to river examples.

In addition to monitoring temperature in the lower Coquitlam River, this study will assess other temperature monitoring available in unregulated lower Fraser River tributaries to determine if there is a detectable variation between examples.
2.1.4 Key Water Use Decision Affected

Unlike the Lower Coquitlam River, Coquitlam Reservoir operations were not subjected to environmentally motivated constraints, due in part to a lack of understanding as to the impacts of reservoir operations on reservoir and river ecosystems. The results of this study may influence how reservoir operations are managed, or what physical works are required, to minimize potential impacts, where warranted, and where practical in the context of the overall value the issue represents.

2.2 Monitoring Program Proposal

2.2.1 Objective and Scope

The objective of this monitoring program is to identify if and how temperature in the lower Coquitlam River is influenced by reservoir operations. Temperature monitoring will be conducted continuously for three years, in each reach of interest below the dam. Additional temperature monitoring by the Greater Vancouver Regional District in the Coquitlam Reservoir will be integral to the program. Also, existing temperature data for adjacent and/or similar lake-headed tributaries to the lower Fraser River will be used to analyze the degree of influence operations has on river temperature. Candidate streams with known temperature monitoring programs include: Pitt River/Lake, Harrison River/Lake, and Cultus River/Lake. Others may be added to replace or enhance the list of comparisons.

2.2.2 Approach

After the initial start-up phase, there are three components to this study

- **Temperature monitoring**: three years of direct continuous instream sampling of river temperature will be undertaken on a reach by reach basis, including one air monitoring station at the mid-point of the river length between the dam and confluence with the Fraser River;

- **Information review and collation**: using data from the GVRD Coquitlam Reservoir temperature monitoring platforms, BC Hydro reservoir, inflow and outflow monitoring, and from independent or government sponsored monitoring programs on lake-headed streams in the lower Fraser drainage area, data will be summarized and prepared for analysis;

- **Analysis**: to test each hypothesis, analysis of the downstream temperatures as it correlates with operations and reservoir temperatures at depth will be conducted AND analysis of the deviation of downstream temperatures from the reservoir as it varies from other typical non-regulated circumstances will also be conducted.

2.2.3 Methods

The field component of this monitoring program is currently under way, although data summary and analysis have not been conducted to date. Therefore, these study methods must be implemented consistently with previous efforts.
2.2.3.1 Preparation and Data Summary

In preparation for the study, a database (in excel or MS Access) will be set up to support the data requirements of the program, which include the following fields of information:

- Date/time;
- Daily minimum/maximum/average temperature by watershed/site/depth (if reservoir);
- Daily minimum/maximum/average operations data – reservoir elevation, reservoir inflows, outflows, and lower Coquitlam River flows by site; and

All data collected to date (since 2000) on the Coquitlam Reservoir and lower Coquitlam River relevant to this study will be gathered and summarized in the database. There are several known sources for this information that would provide this information on request:

- Operations and lower Coquitlam River flow data – all years: BC Hydro (contact the study coordinator);
- Lower Coquitlam River temperature monitoring (a) 2000-2002: BC Ministry of Environment (contact the study coordinator); (b) 2004-present: BC Hydro (contact the study coordinator); and
- Coquitlam Reservoir temperatures by depth and site – 2001-present: GVRD (contact David Dunkley);

For temperature data from other watersheds being used in the analysis of variation, there are several potential sources for this information, including DFO hatchery staff in systems such as Pitt River and Cultus Lake where hatcheries exist. It is essential that the needs of this study program be communicated at the start of the monitoring period, and that the information exchange is initiated to ensure long term cooperation.

2.2.3.2 Temperature Monitoring

There are 6 sites for monitoring identified for this study as outlined in Table 2-1:
Table 2-1: Temperature monitoring locations in the Lower Coquitlam River

<table>
<thead>
<tr>
<th>Site #</th>
<th>Northing</th>
<th>Easting</th>
<th>Reach</th>
<th>Location Discription</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5455330</td>
<td>0514812</td>
<td>0</td>
<td>LB 40m downstream Red Bridge @ R0 staff gauge site</td>
</tr>
<tr>
<td>2</td>
<td>5458154</td>
<td>0516235</td>
<td>2</td>
<td>RB downstream Patricia Footbridge boulder cluster mid-riffle</td>
</tr>
<tr>
<td>3</td>
<td>5465046</td>
<td>0516599</td>
<td>3</td>
<td>RB upstream Coquitlam Hatchery intake</td>
</tr>
<tr>
<td>4</td>
<td>5463055</td>
<td>0516692</td>
<td>3 (Air)</td>
<td>RB RST Location at log jam</td>
</tr>
<tr>
<td>5</td>
<td>5465457</td>
<td>0516619</td>
<td>3 (Or Creek)</td>
<td>60m upstream confluence midstream under boulder</td>
</tr>
<tr>
<td>6</td>
<td>5466718</td>
<td>0516464</td>
<td>4</td>
<td>R4 Staff Gauge site under boulder</td>
</tr>
</tbody>
</table>

Two temperature loggers are to be installed at each site, such that they will always remain wetted (except for the air temperature monitoring site #4), avoid vandalism and remain immobile during high inflow events. Loggers will be programmed to continuously collect daily average/maximum and minimum temperature values, and will be maintained (data downloaded, installations reset) every 3-5 months (assuming battery and data capacity can accommodate the data accumulation), with a frequency of no less than 3 times per year. Where sites must be moved to avoid/contend with future vandalism or channel changes, the new sites will be comparable in location and habitat value to the previous site and the location re-surveyed with differential GPS.

2.2.3.3 Information Review and Collation

Each year, water and air temperature monitoring information from lake-headed systems in the lower Fraser River basin will be entered into the database from the sources described above. A map will be prepared that will summarize the locations of the adjacent systems, and their average temperatures. Downstream water temperature deviation from the upstream lake source will be the main focus of this comparison, therefore, the dataset must be comprehensive enough to provide this information.

2.2.3.4 Analysis

To test the hypotheses $H_1$ and $H_2$ above, the following analyses will be conducted in Year 3 of the study:

- **Assessment of Reservoir Operational Influence on downstream Coquitlam River Temperatures**: The degree of correlation between reservoir water temperature at the depth of the low level outlet intakes and downstream temperature will be assessed to determine if it is significant. The temperature depth-profiles in the forebay area will also be evaluated to determine if the outcome of the correlation analysis is due to thermostratification in the forebay, or if the rate of reservoir elevation change is sufficient to create an un-natural temperature release regime.
• Assessment of Downstream Water Temperature Deviation from Reservoir Source: In the context of natural systems, hypothesis $H_2$ will be tested to determine if the Coquitlam River temperature regime is significantly affected by operations, or if either reservoir regulation or temperature profiles in the dam forebay are such that Coquitlam Dam releases are not significantly different from surface releases. An analysis of other basin temperature regimes and the deviation of downstream temperatures from their lake source will be conducted to define ‘natural deviation’ and then in the context of the dataset and variance around the ‘natural deviation’ figure, determine if the deviation shown in the Coquitlam system (at each site) is significant.

2.2.3.5 Reporting

Data reports in Years 1 and 2 will highlight the results of the temperature monitoring, and its comparison to adjacent lake-headed system results. No results of the analysis will be available until Year 3.

In Year 3, all data will be summarized in time series data plots and the full analyses incorporated into the final report for submission to BC Hydro and the monitoring committee. The study will describe the methods, site locations with a map, the results in graphical format, and the analysis procedures and results. The results of the tests of each hypotheses will be summarized, and a discussion on the application of these results will be provided.

2.2.4 Interpretation of Monitoring Results

Correlative tests (Pearson’s r-square value) and tests of significance/variance (t-tests and ANOVA) will be conducted as part of the analysis to determine if there are (a) any relationships between Coquitlam River temperatures and operations; and (b) any operational strategies that can be applied to mitigate or minimize the effects of unnatural release temperatures. The results of the tests will provide the basis of any conclusion as to the issue and/or the mitigation strategy developed from this study.

2.2.5 Schedule

The following schedule provides an indication of the expected timing for reporting purposes:

- October – preparation (Year 1);
- November – data logger installation (Year 1); maintenance (Year 2/3);
- March – data logger maintenance (Years 1-3);
- July – data logger maintenance (Years 1-3);
- November – data logger removal (end of Year 3);
- December - data reports drafted (Years 1/2);
• January – data reports finalized (Years 1/2); summary report drafted (Year 3) and

• February – summary report finalized (Year 3).

Dates above represent an arbitrary starting point.

2.2.6 Budget

This three year monitoring budget has an annual cost of approximately $7.5K, and a total inflated program cost of $23K.