Columbia River Project Water Use Plan
Lower Columbia River Fish Management Plan

Monitoring Programs Annual Report: 2010
Implementation Period: September 2009 to August 2010

- CLBMON-42 Lower Columbia River Fish Stranding Assessment and Ramping Protocol
- CLBMON-43 Lower Columbia River Sculpin and Dace Life History Assessment
- CLBMON-44 Lower Columbia River Physical Habitat and Ecological Productivity Monitoring
- CLBMON-45 Lower Columbia River Fish Population Indexing Surveys
- CLBMON-46 Lower Columbia River Rainbow Trout Spawning Habitat Assessment
- CLBMON-47 Lower Columbia River Whitefish Spawning Ground Topographic Survey
- CLBMON-48 Lower Columbia River Whitefish Egg Monitoring & Life History Study
- CLBMON-49 Lower Columbia River Effects of Whitefish Flows on Great Blue Heron & Winter Use of Waldie by Great Blue Heron

Conditional Water Licences for Kinbasket storage (27068 and 39432), Mica diversion (39431), Revelstoke diversion and storage (47215), and Arrow storage (27066)

August 30, 2010
1 Introduction

This document provides a summary of the status and results of monitoring programs and physical works being implemented under the Lower Columbia River Fish Management Plan of the Columbia River Water Use Plan (WUP) to 31 August 2009, as per the Columbia River Order under the Water Act, dated 26 January 2007. There are eight monitoring programs included within this Management Plan:

- CLBMON-42 Lower Columbia River Fish Stranding Assessment and Protocol
- CLBMON-43 Lower Columbia River Sculpin and Dace Life History Assessment
- CLBMON-44 Lower Columbia River Physical Habitat and Ecological Productivity Monitoring
- CLBMON-45 Lower Columbia River Fish Population Indexing Surveys
- CLBMON-46 Lower Columbia River Columbia Rainbow Trout Spawning Habitat Assessment
- CLBMON-47 Lower Columbia River Whitefish Spawning Ground Topographic Survey
- CLBMON-48 Lower Columbia River Whitefish Egg Monitoring & Life History Study
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2 Background

The water use planning process for BC Hydro’s Columbia River project was initiated in August 2000 and completed in June 2004. The conditions proposed in the WUP for the operation of the project reflect the June 2004 consensus recommendations of the Columbia River WUP Consultative Committee (CC).

In July 2006, the Columbia River Draft WUP was submitted to the Comptroller of Water Rights (CWR). The draft WUP was sent out to regulatory agencies, First Nations and interested stakeholders for review. In January 2007, the CWR approved the final WUP and issued an Order to BC Hydro to implement the conditions proposed in the Columbia River WUP and prepare the monitoring programs and physical works Terms of Reference (TOR).

An addendum to the Columbia River WUP was submitted to the CWR in July 2007 after an Environmental Assessment Certificate was issued for the Revelstoke Unit 5 Project. The addendum proposes additional terms and conditions for the Columbia
River WUP, as recommended by the Revelstoke Unit 5 Core Committee in December 2006, to address incremental impacts of the operation of the fifth generating unit at Revelstoke Dam.

In August 2007, the CWR accepted the Columbia River Project WUP Addendum resulting from the Revelstoke Unit 5 Project, and issued amendments to the Columbia River Implementation Order to include the commitments made by BC Hydro to undertake additional monitoring programs and physical works associated with the Revelstoke Unit 5 Project.

The following table outlines the dates that TOR for the Lower Columbia River Fish Management Plan were submitted to and approved by the CWR.

Table 1. Dates of Lower Columbia River Fish WUP TOR submissions and approvals by the Comptroller of Water Rights

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<th>Monitoring Programs/ Physical Works TOR</th>
<th>Original TOR Submission</th>
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As outlined in the Columbia River WUP, the CC recommended a full review of the Plan 13 years after implementation, unless results of the monitoring program suggest an earlier review is appropriate or significant risks are identified that could result in a recommendation to change operations.

BC Hydro will convene a multi-party panel five years after commencing the implementation of this WUP to evaluate the effectiveness of operations and physical works in meeting the stated objectives for Arrow Lakes Reservoir and the lower Columbia River. The outcomes from this process will be used to assess any potential need to review the Arrow Lakes Reservoir component of this WUP. If a replacement
Non-Treaty Storage Agreement (NTSA) is negotiated within this 5-year period, it is also recommended that agreement provisions and implications be reported out through this panel. Signing of a new NTSA is not a trigger for panel evaluation or a review of this Water Use Plan recommendation to change operations.

3 Schedule

The following table (Table 3-1) outlines the current schedule for the monitoring programs being delivered under the Lower Columbia River Fish Management Plan of the Columbia River WUP.

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Legend: ● = Program to be undertaken/initiated in identified year, u/w = Project is underway, ✓ = Program completed for the year, × = Program started, but encountered operational or hydrological delays.

4 Columbia River WUP Monitoring Programs – Lower Columbia River Fish Management Plan

This section summarizes the status of the monitoring programs being implemented under the Lower Columbia River Fish Management Plan of the Columbia River Water Use Plan, as per the Order under the Water Act, dated January 26, 2007.

4.1 CLBMON-42 Lower Columbia River Fish Stranding Assessment and Ramping Protocol

4.1.1 Management Questions

The key management questions addressed by this monitoring program are:

1) Is there a ramping rate (fast vs. slow, day vs. night) for flow reductions from HLK that reduces the number of fish stranded (interstitially and pool) per flow reduction event in the summer and winter?

2) Does wetted history (the length of time the habitat has been wetted prior to the flow reduction) influence the number of fish stranded (interstitially and pool) per flow reduction event for flow reductions from HLK?

3) Can a conditioning flow (a temporary, one step, flow reduction of approximately 2 hours to the final target dam discharge that occurs prior to the final flow change) from HLK reduce the stranding rate of fish?
4) Can physical habitat works (i.e., recontouring) reduce the incidence of fish stranding in high risk areas?

5) Does the continued collection of stranding data, and upgrading of the lower Columbia River stranding protocol, limit the number of occurrences when stranding crews need to be deployed due to flow reductions from HLK?

4.1.2 Overview

The primary objective of this monitoring program is to collect fish stranding data to assess the impact of flow reductions and flow ramping rates from Hugh L. Keenleyside (HLK) Dam on the native fish species of the lower Columbia River. Secondary objectives include: (1) reducing (through risk management strategies) the number of occurrences when stranding crews need to be deployed with flow reductions; (2) determining ramping rates for flow reductions that reduce the stranding rate of fish at different times of the year; (3) determining whether the wetted history influences the stranding rate of fish for flow reductions; (4) determining whether a conditioning flow reduction from HLK reduces the stranding rate of fish; and (5) determining whether physical habitat manipulation reduce the incidence of fish stranding in the lower Columbia River.

The Columbia River WUP CC agreed on four actions that could provide the greatest potential gains to wild indigenous fish populations in the lower Columbia River (BC Hydro 2005a, 2005b). Two of these actions were related to fish impacts associated with flow regulation at HLK and included:

- Explore opportunities to minimize the frequency and magnitude of flow reductions and develop a flow reduction protocol and standard methods for assessment, data collection and mitigation responses to manage fish stranding impacts.

- Conduct flow ramping studies to determine appropriate ramping rates to minimize pool and interstitial stranding.

It was recommended that the above strategy and associated monitoring program was an acceptable approach to addressing the impacts of flow reductions at HLK on fish stranding in the lower Columbia River.

Monitoring Indicators:

a) Program will monitor the number of fish stranding incidences in the lower Columbia River (where dictated by the lower Columbia River Stranding Protocol) when flow reductions occur from HLK.

b) Program will monitor the number of fish stranded after utilizing various ramping rate experiments.

c) Program will monitor whether fish stranding continues to occur at locations where gravel bar re-contouring has been conducted.

The approach of this monitoring program is to continue stranding surveys within the study area over the period of the Columbia WUP. These stranding surveys will be
undertaken as required through the implementation of the lower Columbia River Stranding Protocol – including future updates.

In addition, flow ramping studies will continue for a period of time as warranted by interpretation of the results. The flow ramping program was initiated through negotiation with Fisheries and Oceans Canada (DFO), and the program was further examined by the Columbia WUP CC. BC Hydro meets with the Columbia Operations Fish Advisory Committee (COFAC) annually to review the results of the flow ramping program and to receive direction on future study/monitoring requirements. As such, the primary objective of the monitoring program is to meet the requirements of the regulatory agencies, and, if agreed to by the regulatory agencies, to approach the Comptroller of Water Rights for sign off on meeting the requirements of this component of the Columbia WUP in an earlier time period.

Finally, where appropriate, physical habitat works in the form of gravel bar re-contouring will be considered for areas where a high rate of fish stranding occurs. Similar work has been undertaken previously in the study area, and further work will be considered if proposed flow ramp rates do not reduce the rate of stranding, or high risk areas are identified through the stranding surveys.

4.1.3 Status

This monitoring program was initiated in August 2007, and will be carried out over 13 years. Program reports for Year 1 (2007/2008), Year 2 (2008/2009) and Year 3 (2009/2010) have been received by BC Hydro and are attached.

A summary of the flow ramping studies conducted on the Lower Columbia and Kootenay rivers (2004 to 2007) was undertaken and presented to COFAC at their 24 June 2008 meeting. The presentation included a summary of the flow ramping data that has been collected to date, as well as a detailed power analysis to determine “where we are at” with regards to answering the objectives of the monitoring study. A summary of the annual stranding assessment results was also presented for both the lower Columbia and Kootenay rivers. Following the presentations, it was concluded by the committee that flow ramping studies in the lower Columbia River should cease until a full review of all related information (e.g., ramping studies, stranding assessment data, and grey literature) could be completed.

The lower Columbia River Stranding Surveys component of the monitoring program will be conducted annually until 2019.

Feasibility to identify and assess potential areas for physical habitat manipulation will be conducted using information from the ramping studies and stranding surveys, with physical habitat manipulation being implemented (pending DFO approval) in eight of twelve years (from Years 3 to Year 13). Effectiveness monitoring would be conducted in Years 6 through 13.

4.1.4 Interpretation of Data

a) Lower Columbia Fish Stranding Assessment
From 1 April 2009 to 1 April 2010, the Columbia River mean hourly discharge from HLK and Arrow Lakes Hydro (ALH) ranged from a minimum of 15 kcfs (31 March 2010) to a maximum of 63 kcfs (10 December 2010). During this period, there were 14 operational flow reduction events from HLK/ALH affecting the lower Columbia River. An annual summary was completed in the spring, providing both a compilation of all the information collected for the year as well as interpretation of results relative to previous annual summaries. In July 2010, the annual summary for the 2009/2010 field year was presented to COFAC.

We conducted 11 fish stranding assessments during the 14 reduction events. There was an approximate 29% decrease in isolated fish observed between the summary period of 2008/2009 (n = 13,093) and the present summary period 2009/2010 (n = 9,294). Of these fish stranded, 946 sport fish (rainbow trout and mountain whitefish) were sampled or observed. All the sportfish were juveniles or young of year.

The majority of the fish (77.1%) were identified from pools located at the Genelle Mainland site, the Norn’s Creek Fan site, the Lions Head site and the Millennium Park site. The remaining 22.9% of the isolated fish were found at the Fort Sheppard Launch site, Tin Cup Rapids site, CPR Island site, Zuckerberg Island site, Gyro Boat Launch site, Casino Road Bridge (LUB downstream) and the two sites on the Kootenay River. Fish were not observed at the remainder of the sites visited during the monitoring period (Table 2). These data represent the primary locations of stranded fish. Stranding locations that have re-contouring potential are undergoing further analysis under the Lower Columbia River Fish Stranding Protocol Review.

Experts from CLBMON-43 Lower Columbia River Sculpin and Dace Life History Assessment cross-trained the fish stranding crews in sculpin and dace identification for this reporting period. This led to a more detailed analysis of stranding effects on provincial and federally listed species.

The only Provincially “Red-listed” species observed during the present study was Umatilla Dace. We found Umatilla Dace stranded at Kootenay River sites (91%), Genelle mainland and Fort Sheppard Launch. We found the Columbia Sculpin, classified as a species of “Special Concern” by the Species at Risk Act and the Committee on the status of Endangered Wildlife in Canada, at Norn’s Creek Fan, Kootenay River and Genelle mainland (98%).

b) Lower Columbia River Ramping Protocol

No ramping experiments were conducted during this last reporting period. The draft recommendations from the Lower Columbia River Fish Stranding Protocol Review suggest that there have been enough experiments done, between the Duncan and Lower Columbia, to provide adequate direction to BC Hydro.

c) No physical works, in the form of gravel bar re-contouring, occurred during the second year of the program. We will refine the locations and types of physical works that may need to be conducted through the Lower Columbia River Fish Stranding Protocol Review process.
4.2 CLBMON-43 Lower Columbia River Sculpin and Dace Life History Assessment

4.2.1 Management Questions
The key management questions addressed by this monitoring program are:

1) How do water level fluctuations (diel and seasonal) in the lower Columbia River affect the distribution and habitat use of sculpins and dace, especially the listed species?

2) What seasonal and diel habitat shifts do sculpins and dace (especially the listed species) make in response to water level fluctuations?

3) Do the operations of Hugh L. Keenleyside Dam alter these natural movements? Specifically, does this risk of stranding increase?

4) Which operations, and at what season, pose the highest risk of stranding or interference with the normal life cycles of sculpins and dace?

4.2.2 Overview
The primary objective of this monitoring program is to provide information on the life history and habitat use of six species of shallow-water dwelling fish (four sculpins and two dace with special emphasis on Columbia sculpin and Umatilla dace) in the lower Columbia River that may be affected by water level fluctuations resulting from daily and seasonal operations of HLK Dam. More specifically, information will be collected on the spawning habitats used by Umatilla dace and the timing of their spawning period, the abundance of Columbia dace and the habitats used by this species, and the importance of flooded areas at the confluence of tributaries and the main river as nurseries for young-of-the-year sculpins and dace. These nursery areas are the key habitat component of the shorthead sculpin (C. confusus) that are likely to be affected by the operations of HLK Dam.

During the Columbia River WUP process, the CC noted that the lack of biological information precluded explicit consideration of shallow-water dwelling threatened and endangered fish species in the lower Columbia River. Specifically, data were too limited to assess the potential risks to threatened/endangered sculpins and dace species, as may be posed by the seasonal operations of Hugh L. Keenleyside (HLK) Dam. Consequently, the CC recommended a study to determine the relative abundance, distribution, life histories, and habitat use of sculpins and dace in the lower Columbia River between HLK Dam and the US border. The goal of the study is to provide a qualitative assessment of the risks that the operation of HLK Dam may pose for federally listed species of sculpin and dace.

Monitoring Indicators:

a) Program will monitor how water level fluctuations (diel and seasonal) in the lower Columbia River affect the distribution and habitat use of sculpins and dace, especially listed species.

b) Program will monitor what seasonal and diel habitat shifts sculpins and dace (especially listed species) make in response to water level fluctuations.
c) Program will monitor if the operations of HLK Dam alter the natural movements of these species and pose an increased risk of stranding.

d) Program will monitor which operations, and at what season, pose the highest risk of stranding or interference with the normal life cycles of sculpins and dace.

This monitoring program will use existing information on the life history and ecology of sculpins and dace as a basis for selecting monitoring sites in the Columbia River below HLK Dam. After the literature review is complete, the methodologies will be developed to resolve any data collection obstacles encountered in earlier studies. Passive sampling procedures such as snorkel surveys, view tubes, D-ring or drift net sampling, and nest or egg traps may be used. Electrofishing may be used as a means to collect adults of each species.

4.2.3 Status

This project began in December 2008 with the initiation of an extensive literature review on the 4 sculpin (prickly; shorthead; Columbia; torrent) and 2 dace (Umatilla; longnose) species identified in the Terms of Reference. We completed the draft literature review in 2009 and finalized it in 2010 releasing it with the 2010 data report. Field work began in February 2009 in several Okanagan drainages in order to collect life history information from non-regulated river systems. The life history knowledge and lessons learned from the Okanagan sampling were then used for the October 2009 initiation of the Columbia River sampling program. In July 2010, the Literature Review and Year 1 data report were released.

4.2.4 Interpretation of Data

A winter tagging session took place in and around the Similkameen River in February 2009. The purpose was to insert PIT tags into pre-spawn adults so that they could be relocated during a summer sampling period. We implanted sculpins and dace (> 45 mm in length) with PIT tags and tracked seasonally with a portable PIT antenna system. In total, 596 Columbia sculpin, 146 torrent sculpin, 11 prickly sculpin and 57 longnose dace received PIT tags in the Similkameen watershed with <1% mortality and <0.01% tag loss in the first 24 hours. During 2009 we detected 41% of these fish at least once. Detection success ranged by site (13-57%), season (3-44%), and species (3-58%). Movement and habitat use are described for all the species in spring, summer and fall, as data allows. In general, Columbia and torrent sculpin used the available water depths and velocities but they selected the largest least embedded substrate available. The average length of movements between seasons for Columbia and torrent sculpin were 61 m and 43 m, and most made short (<30 m) movements in all seasons. The second year report describes the temporal and biophysical characteristics of Columbia and prickly sculpin nests. The timing of Columbia sculpin spawning varied by a month among sites but daily water temperatures of 8°C appeared to trigger spawning. Our 2009 results within the Similkameen watershed provide an example of how sculpins and dace respond to natural seasonal water level fluctuations and will help interpret our lower Columbia River results in 2010. The 2010 program will focus on gathering life history information on Umatilla dace and shorthead sculpin and assessing how the seasonal operations of HLK affect sculpin and dace species.
4.3 CLBMON-44 Lower Columbia Physical Habitat and Ecological Productivity Monitoring

4.3.1 Management Questions
The data collected will be used to generate time series data of habitat variables that can be used to form a logical chain of inference from flow to habitat and ecological productivity to fish populations. The data collected will be combined with data from related monitoring programs in the lower Columbia River and used to examine primary hypotheses about change in fish populations.

Physical Habitat Monitoring
The key management questions addressed by the physical habitat monitoring program are:

1) How does continued implementation of whitefish and rainbow trout flows during winter and spring, and fluctuating flows during fall affect water temperature in the lower Columbia River? What is the temporal scale (diel, seasonal) of water temperature changes? Are there spatial differences in the pattern of water temperature response?

2) How does continued implementation of whitefish and rainbow trout flows during winter and spring, and fluctuating flows during fall affect the seasonal and inter-annual range and variability in river level fluctuation in the lower Columbia River?

3) How does continued implementation of whitefish and rainbow trout flows during winter and spring, and fluctuating flows during fall affect electrochemistry and biologically active nutrients in the lower Columbia River?

Ecological Productivity Monitoring
The key management questions addressed by the ecological productivity monitoring program are:

1) What is the composition, abundance, and biomass of epilithic algae and benthic invertebrates in the lower Columbia River?

2) What is the influence of the whitefish and rainbow trout flows during winter and spring, and fluctuating flows during fall on aquatic that determine the abundance, diversity, and biomass of benthic invertebrates?

3) Are organisms that are used as food by juvenile and adult whitefish and rainbow trout in the lower Columbia River supported by benthic production in the lower Columbia River?

4.3.2 Overview
Over the past decade, BC Hydro has attempted to stabilize water releases from HLK Dam during the whitefish and rainbow trout spawning seasons (January through March and April through June, respectively) to minimize egg losses in the lower Columbia River. To address existing uncertainties around the effectiveness of these flows to whitefish and rainbow trout populations in the lower Columbia River, the WUP CC supported continued implementation of the current flow management strategies (contingent on successful negotiations with the U.S.), as well as the option of testing the effectiveness of whitefish flows by re-introducing the historical flow.
regime after a total of 12 continuous years of systematic baseline data collection (BC Hydro 2005a).

The WUP CC considered monitoring of flows and other habitat variables to be essential for supporting future decisions on water release strategies at HLK Dam, and recommended the implementation of a monitoring program to document physical habitat characteristics and ecological productivity of the lower Columbia River. The goal of the monitoring program is to use the resulting data to make inferences about the linkage between the implementation of whitefish and rainbow trout flows and overall ecological health of the river. In addition, the collection of physical habitat and ecological productivity data was viewed as a fundamental information requirement for supporting other monitoring programs associated with the lower Columbia River Fish Management Plan. The physical habitat and ecological productivity study complements parallel monitoring programs being implemented in the mid Columbia River, as well as ongoing large river fish indexing programs that provides an annual metric on the ecological productivity of the mid and lower Columbia River.

The objective of the Physical Habitat component of this monitoring program is to monitor water temperature, stage, electrochemistry and nutrient levels in the lower Columbia River to allow tracking of potential changes in physical habitat and ecological health as a result of flow conditions. The Ecological Productivity component will monitor periphyton and benthic invertebrates to assess potential changes in trophic productivity and overall ecological health of the lower Columbia River resulting from the continued implementation of mountain whitefish and rainbow trout flow agreements.

**Monitoring Indicators**

a) Program will monitor the changes in water electrochemistry and biologically active nutrients due to seasonal operations of HLK Dam.

b) Program will monitor the changes in composition, abundance and biomass of epilithic algae and benthic invertebrates due to seasonal operations of Hugh Keenleyside Dam.

This monitoring program involves preparation of artificial substrates and associated rigging to allow for sampling under different velocity and depth scenarios, including desiccated conditions. Monitoring of water temperature and river stage will be conducted in each of the three reaches established for ecological productivity monitoring in a total of five index locations. Seasonal water quality sampling will be conducted at the beginning and the end of the sample collection for the ecological productivity study at each index location, primary tributaries and at three supplemental times throughout the year.

An electronic database will be developed and maintained to preserve the information collected during the Lower Columbia River Physical Habitat and Ecological Productivity program. The database will be compatible with a similar system being developed for the mid Columbia River and must be able to facilitate the testing of hypotheses about physical habitat or ecological productivity changes.
4.3.3 Status

This monitoring program began in June 2008, and will continue through 12 years. We delivered the second year report in July 2010. The third year of sampling is currently underway with summer sampling completed and fall sampling occurring through September and October, 2010.

4.3.4 Interpretation of Data

This study focuses on benthic productivity and investigates how various environmental parameters influence periphyton and macroinvertebrate communities. The primary field work, conducted in 2009 from June to October, coincided with the summer growing season and measured the different physical, chemical, and biological parameters at different temporal intervals and at multiple locations.

Lower Columbia River flows below HLK Dam and Kootenay River flows below Brilliant Dam contributed respectively 58% and 39% of annual mean flows observed at the Birchbank gauging station. Water levels fluctuated from 2.1 m to 3.2 m. Underwater imagery of native substrates revealed rocky substrates with grain sizes typically in the cobble, gravel, and sand range at most stations. At water quality index stations, mean water temperature was slightly warmer at the Kootenay River station at 14.9°C compared to 13.6°C at Columbia River stations. Water temperature ranged widely (2 - 19°C) during the study period at tributary stations. Mean dissolved oxygen concentrations at water quality index stations were consistently high, ranging from 10.3 mg/L to 10.9 mg/L for the entire study period. Median pH measurements were quite uniform across stations ranging from 7.3 to 8.1. Mean specific conductance measurements were highest at the Kootenay River (134 µs/cm) and lowest generally at smaller tributary stations such as Norns Creek (33 µs/cm). Mean total dissolved solids ranged from a low of 24 mg/L at Norns Creek to a high of 87 mg/L at Champion Creek. Most (87%) total suspended solid concentrations were below the method quantification limit of 1 mg/L and the maximum concentration measured was 2 mg/L. Turbidity values were low at all stations and sampling events, only ranging from 0 NTU to 4.0 NTU. Periphyton chlorophyll a concentrations (µg/cm²) ranged from 0.03 to 8.32 in 2009. No significant differences were observed in periphyton chlorophyll a concentrations by incubation period or by depth strata. Differences in total diatom cell density and biovolume were minor by incubation period, by depth strata, and by reach. Benthic macroinvertebrate total abundance and total biomass across incubation period, depth strata, and reach were even more variable than periphytic diatom total density and biovolume. Benthic macroinvertebrate species relative abundance was largely dominated by Trichoptera (40%), Chironomidae (34%), and Diptera (12%).

4.4CLBMON-45 Lower Columbia River Fish Population Indexing Surveys

4.4.1 Management Questions

The key management questions addressed by this monitoring program are:

1) What is the abundance, growth rate, survival rate, body condition, age distribution, and spatial distribution of sub-adult and adult whitefish, rainbow trout and walleye in the lower Columbia River?

2) What is the effect of inter-annual variability in the whitefish and rainbow trout flow regimes on the abundance, growth rate, survival rate, body
condition and spatial distribution of sub-adult and adult whitefish, rainbow trout and walleye in the lower Columbia River?

4.4.2 Overview

Since 1995, BC Hydro has attempted to ‘stabilize’ water releases from HLK Dam during the whitefish and rainbow trout spawning seasons (January through June) to minimize egg losses in the lower Columbia River. The stabilization for whitefish is intended to reduce flow during peak spawning periods to encourage spawning at lower water level elevations and protect eggs through emergence. For rainbow trout, the protection flows are aimed to minimize potential egg losses for mid-timed rainbow spawners (April and May) by providing stable or increasing discharge over this period. Provision of these flows is subject to annual negotiations with the U.S. to implement mutually beneficial changes to flows required under the Columbia River Treaty.

To address existing uncertainties around the effects of flows on whitefish and rainbow trout populations in the lower Columbia River, the WUP CC recommended the continuation of the existing Large River Fish Indexing Program to address data gaps about the effects of dam operations on fish populations in the lower Columbia River.

BC Hydro initiated the Large River Fish Indexing Program in 2001 with the objectives of collecting information on selected index species. Since its initiation, annual implementation of the program has led to the development of systematic monitoring tools to identify and assess the effects of whitefish and rainbow trout flows on downstream fish communities. The information gained from continued implementation of the Fish Indexing Program, in conjunction with monitoring data from related monitoring studies in the lower Columbia River, will allow assessment of the current flow regime to determine its effectiveness at protecting whitefish and rainbow trout populations.

Monitoring Indicators:

a) Program will monitor for changes in the abundance, growth rate, survival rate, body condition, age distribution and spatial distribution of sub-adult and adult whitefish, rainbow trout and walleye in the lower Columbia River.

b) Program will monitor for the effect of inter-annual variability in the whitefish and rainbow trout flow regimes on the abundance, growth rate, survival rate, body condition and spatial distribution of sub-adult and adult whitefish, rainbow trout and walleye in the lower Columbia River.

The methods used in this monitoring program are based on intensive boat electrofishing in the fall over pre-selected index sites. The data are then subject to statistical analysis and used for population estimation, catch-at-age analysis, population modeling, quantitative assessment of temporal patterns in population abundance, mean size-at-age, survival and distribution for each key species to evaluate long-term trends in these parameters. Given the uncertainty about factors that control fish populations, a weight of evidence approach will be applied to interpret fish population index information. Inferences about the patterns and/or trends in fish abundance, growth and survival in relation to the continued implementation of whitefish and rainbow flow will be interpreted in conjunction with
other measurements/monitoring provided by physical habitat and ecological productivity monitoring, as well as spawning assessments and habitat use programs.

### 4.4.3 Status

This monitoring program began in September 2007, and will continue annually over 13 years. The third program report was delivered in July 2010.

### 4.4.4 Interpretation of Data

The primary purpose of the 2009 Phase 9 study was to monitor the life history characteristics, distribution, and population abundance of selected index species in the Lower Columbia River, and compare these results to earlier phases (i.e., 2001 to 2008) of the program.

In 2009, discharge for the Columbia River from early March to mid-November was lower than the average discharge recorded during the same time period from 2001 to 2008; the discharge for the Kootenay River was lower than all previous study years.

In the 2009 study year we recorded 42,463 fish from the four river sections within the LCR. This sample includes captured fish and fish observed and identified to species. Of the 16 species recorded, 11 were classed as sportfish, and three species and two genera were classed as non-sportfish. The highest proportions of fish were recorded in the lower section (44% of the total catch), followed by the upper (29%), middle (17%), and Kootenay sections (10%). Most of the recorded fish (71%) were sculpin and sucker species.


For the 2010 season, sculpin and dace identification training and joint sampling sessions will be conducted with biologists from CLBMON-43 in order to collect more information on provincially and federally listed species.

### 4.5 CLBMON-46 Lower Columbia River Rainbow Trout Spawning and Habitat Assessment

#### 4.5.1 Management Questions

The key management questions addressed by this monitoring program are:

1) Does the implementation of rainbow trout spawning protection flows over the course of the monitoring period lead to an increase in the relative abundance of rainbow trout spawning in the lower Columbia River downstream of Hugh L. Keenleyside Dam?
2) Does the implementation of rainbow trout spawning protection flows over the course of the monitoring period lead to an increase in the spatial distribution of locations (and associated habitat area) that rainbow trout use for spawning in the lower Columbia River downstream of Hugh L. Keenleyside Dam?

3) Does the implementation of rainbow trout spawning protection flows over the course of the monitoring period protect the majority of rainbow trout redds (as estimated from spawning timing) from being dewatered in the lower Columbia River downstream of Hugh Keenleyside Dam?

4.5.2 Overview

The primary objective of this monitoring program is to continue the collection of annual rainbow trout data to qualitatively and quantitatively assess changes in the relative abundance, distribution and spawn timing of rainbow trout in the lower Columbia River. Secondary objectives include: 1) determining whether an earlier transitioning from mountain whitefish flows to rainbow trout spawning protection flows reduces the number of early spawning rainbow trout redds that dewater, and 2) to identify whether spawning habitat in the lower Columbia River is fully utilized.

Since 1993, BC Hydro has successfully negotiated Non-Power Use Agreements with the U.S. with the aim of providing more stable flow regimes for rainbow trout spawning below HLK Dam than would normally occur under Columbia River Treaty operations. In the past, BC Hydro has secured these flow changes by storing an additional 1 MAF in Arrow Lakes Reservoir for release from July to August for U.S. salmon flow augmentation.

The Columbia River WUP CC recommended that BC Hydro continue to pursue the rainbow trout protection flows through negotiations with the U.S. (BC Hydro 2005a, 2005b), and continue annual discussions with regulatory agencies as to timing of transition from whitefish flows to rainbow trout protection flows (typically April 1).

The CC also recommended that annual monitoring be undertaken to monitor the status of the rainbow trout population in the lower Columbia River in response to the continued implementation of the protection flows to better understand the link between the flow management strategy during the spring spawning period and population abundance.

Monitoring Indicators:

a) Program will monitor the relative abundance of rainbow trout observed each year.

b) Program will monitor the relative abundance of rainbow trout redds observed each year.

c) Program will compare rainbow trout population trend data from the Lower Columbia River Indexing program to the relative abundance of rainbow trout and trout redds over the same time period.

This monitoring program involves the use of aerial and boat surveys to track the abundance, distribution and spawn timing of rainbow trout in the lower Columbia River. During these surveys, the number of redds and trout in different sections of the river are documented. In addition, redds that are identified in shallow water are measured for their depth in the water column to estimate the number of redds that
are at risk of dewatering under different spawning flows scenarios (e.g., variation in timing of implementation).

4.5.3 Status

This monitoring program began under WUP in 2008, and will end in 2017. The second year report was completed in January 2010.

4.5.4 Interpretation of Data

The monitoring results indicate the rainbow trout spawning population in the LCR between the HLK dam and the Canada-United States (U.S.) border has increased substantially over the last decade.

We conducted seven aerial surveys from March 23 to May 19, 2009. The aerial surveys included the entire Lower Columbia River from the HLK dam to the US border, and the lower Kootenay River below Brilliant Dam (BRD). In conjunction with the aerial surveys, sixteen boat- and foot-based surveys of the key spawning areas, conducted from February 20 to May 22, confirmed the aerial count and identified shallow redds at risk of dewatering.

Rainbow trout spawning activity began in late February, but cold water temperatures delayed early spawning in March. By the second week of April water temperatures increased from 2.5 °C to 5.5 °C and spawning increased threefold. The majority of spawning occurred after mid-April and peaked on April 30, with 1,345 redds and 1,823 spawners observed in the Columbia River, and 198 redds and 339 spawners observed in the Kootenay River. These estimates should be considered as minimum spawning effort due to restricted viewing conditions that limited visibility after May 1. On May 4 a separate snorkel survey of Norn’s Creek identified 359 redds and 742 spawners.

The 2009 peak spawner counts are the second highest over the last decade. There are several key spawning areas that LCR rainbow trout utilize each year and provide the most suitable habitat. Rainbow Trout Protection Flows from the HLK dam continue to protect rainbow trout redds from dewatering in the LCR by keeping flows stable, but depending on the flow regime of the Kootenay River, and the amount of early spawning that takes place prior to April 1, redds may still dewater at Genelle downstream of the Kootenay River in the LCR as a result of BRD reductions.

4.6 CLBMON-47 Lower Columbia River Whitefish Spawning Ground Topographic Survey

4.6.1 Management Questions

The key management questions for this monitoring program are associated with uncertainties related to how changes in dam releases influence the area of wetted channel area at key whitefish spawning locations. These questions are:

1) What are the topographic characteristics of the key spawning locations for mountain whitefish in the lower Columbia and Kootenay rivers?

2) What is the hydraulic response of the river to discharge fluctuations at these key spawning locations? How do changes in river discharge influence river
stage, and how does river stage relate to wetted channel area at these key spawning locations?

3) How do daily flow changes contribute to cumulative channel dewatering in key spawning areas over the whitefish reproductive period?

4.6.2 Overview

The Columbia River WUP CC supported the implementation of an adaptive management program for evaluating the effectiveness of the whitefish flow management (WFM) to conserve mountain whitefish populations of the lower Columbia River. An objective of the adaptive management program was to collect better information on the topographic characteristics of whitefish spawning locations, and utilize that information to achieve better understanding of how regulated flow changes create potential risks for egg dewatering in the lower Columbia and Kootenay rivers.

Monitoring has confirmed that whitefish eggs are dewatered by flow changes in the lower Columbia River. However, egg losses estimates derived from field data were not precise enough to support trade-off decision making processes related to WFM implementation. In 2003, a process-based whitefish egg loss model (ELM) was developed on limited field data to improve estimates of the relative risk of egg loss under alternative flow scenarios for WFM planning purposes. The whitefish ELM is now the primary analytical tool for quantifying egg losses that occur as a consequence of changing flow patterns. The model utilizes daily flow data and river cross-section information to model river stage at index spawning areas during spawning and egg development periods. Biological assumptions of the seasonal timing of spawning, development rates of ova and the vertical distribution of deposited eggs in the river channel are incorporated to estimate daily losses of eggs resulting from flow changes. The model provides a transparent quantitative framework for evaluating egg loss risk. However, the WUP CC expressed concern about the reliability of the ELM for quantifying the egg loss resulting from regulated flow changes during the adaptive management program.

A key data gap identified by the WUP CC was the low quality and quantity of topographic data to describe characteristics of whitefish spawning locations. Limited availability of relevant topographic data resulted in the use of as few as one channel cross-section through a representative whitefish spawning area to predict flow dependent changes in river stage and areas of channel dewatering. Limited topographic information at spawning areas contributed to reduced confidence in the degree to which existing data represented the habitats of concern, and overall reliability of egg loss estimates. To reduce this uncertainty, the WUP CC recommended implementing a monitoring program to: a) document topographic characteristics of representative whitefish spawning locations; and b) update the existing whitefish ELM to include new topographic and biological data collected in the whitefish adaptive management program (via CLBMON-48 Lower Columbia River Whitefish Life History and Egg Mat Monitoring, and CLBMON-44 Lower Columbia River Physical Habitat and Ecological Productivity Monitoring).

Monitoring Indicators:

a) Program will monitor for the topographic characteristics at the key spawning locations for mountain whitefish in the lower Columbia and Kootenay rivers.
b) Program will monitor the hydraulic response of the river to discharge fluctuations at these key spawning location (i.e., how will changes in river discharge influence river stage, and how does river stage relate to wetted channel area at these key spawning locations?)

c) Program will monitor how daily flow changes contribute to cumulative channel dewatering in key spawning areas over the whitefish reproductive period.

There are two primary components to the work: 1) field surveys to document topographic characteristics of whitefish spawning habitats, and 2) the updating of the physical and biological assumptions of the ELM.

4.6.3 Status

This monitoring program will begin in November 2010 and will be carried out over three years. The first program report is due in July 2011.

4.6.4 Interpretation of Data

At this time, there are no data to interpret for this monitoring program.

4.7 CLBMON-48 Lower Columbia River Whitefish Egg Monitoring and Life History Study

4.7.1 Management Questions

There are six key management questions addressed by this monitoring program. The first four are aimed at creating an understanding of the general life history, reproductive biology and habitat use by adult whitefish. This information is required to validate and/or refine key assumptions used in the egg loss model. The last two management questions relate to interpretation and measurement of the response of the whitefish population using adult and juvenile index monitoring approaches.

The management questions are:

1) What is the spatial distribution of whitefish spawning activities in the lower Columbia and lower Kootenay rivers? Is there inter-annual variation in spawning habitat use? Is the spatial distribution of spawning locations associated with flow management?

2) What are the physical and hydraulic characteristics of whitefish spawning and egg incubation habitats?

3) What is the seasonal timing of whitefish spawning in the lower Columbia and lower Kootenay rivers? To what extent does the timing and intensity of spawning vary from year to year? Is the timing or intensity of spawning associated with flow management?

4) What is the pattern of egg dispersal at spawning locations? What is the vertical distribution of eggs in the river channel? Is the spatial distribution of eggs related to flow management?
5) What are the pre-spawning and post-spawning seasonal movement patterns of whitefish? How do patterns of sub-adult and adult migration affect the interpretation of annual index monitoring programs?

6) What habitats are juvenile whitefish using in the lower Columbia and lower Kootenay rivers? Is it possible to develop and implement a reliable program for indexing the young of the abundance as a measure of fish cohort strength?

4.7.2 Overview

The Columbia River WUP CC supported the implementation of an adaptive management program to evaluate the effectiveness of the whitefish flow management (WFM) to conserve mountain whitefish populations of the lower Columbia River. A goal of this adaptive management program is to address outstanding biological uncertainties associated with the life history and habitat use of different life stages of whitefish in the lower Columbia and Kootenay rivers.

The purpose of this monitoring program is to collect and refine data regarding the location, timing and depth distribution of mountain whitefish spawning in the lower Columbia River below HLK Dam to improve the annual estimate of egg mortality. Specifically, the key objectives are to: a) improve the understanding of whitefish life history and reproductive ecology; b) document topographic characteristics of representative whitefish spawning locations; and, c) improve the understanding of seasonal changes in the distribution of eggs in the river channel. This information is required in the adaptive management program for the refinement of the WF Egg Loss Model, and to provide auxiliary data and information to support the interpretation of the more systematically collected population time series data obtained through the ongoing Lower Columbia Fish Population Index Surveys (CLBMON-45). Physical data collection and actions to refine the egg loss model are being undertaken through CLBMON-47, Lower Columbia River Mountain Whitefish Spawning Ground Topographic Survey.

Monitoring Indicators:

a) Program will monitor the spatial and timing distribution of whitefish spawning activities in the lower Columbia and lower Kootenay Rivers to see if there is inter-annual variation in spawning habitat use or if the spatial distribution of spawning locations is associated with flow management.

b) Program will monitor the physical and hydraulic characteristics of whitefish spawning and egg incubation habitats, the patterns of egg dispersal and the pre and post-spawning seasonal movements of whitefish.

c) Program will monitor juvenile whitefish use of the lower Columbia and Kootenay Rivers.

The first year of monitoring includes: (1) a radio/acoustic tagging program to track mountain whitefish movements to spawning locations; and, (2) a field sampling program to evaluate the biology, habitat use, relative abundance, and distribution of pre-adult mountain whitefish life stages. This portion of the program will be repeated for a period of five years to identify key spawning periods and spawning locations and to assess other life history characteristics.
Results from the first year of monitoring will be used to begin assessing egg dispersal patterns at key spawning locations. Sampling protocols will be assessed after Year 1 and then those protocols used to sample dispersal patterns for the remainder of the study. In the final year, the results from all five years will be assembled and synthesized, and a final report will be prepared.

4.7.3 Status

This monitoring program was initiated in August 2008, and will be carried out over a 5-year period. The first program report was completed in April 2009. Monitoring in Year 2 of the program focused on the spawning locations to observe activity and delineate egg distribution at five key locations.

4.7.4 Interpretation of Data

Mountain whitefish (*Prosopium williamsoni*) are the most abundant sportfish in the lower Columbia River (defined as the Columbia River from Hugh L. Keenleyside Dam [HLK] to the Canada-US Border). They use this area for all life history functions. Although mountain whitefish do not support a recreational fishery in the lower Columbia River, they do represent an important indicator species in the Columbia River ecosystem. The results of the early 1990s studies conducted by BC Hydro raised concerns by the provincial and federal environmental regulatory agencies about the effects of river regulation by HLK on mountain whitefish reproductive success in the lower Columbia River. These concerns led to the development and initiation of BC Hydro’s Whitefish Flow Management (WFM) program in the winter of 1994/95 and a series of subsequent intensive studies on mountain whitefish life history characteristics conducted annually between 1995 and 1999.

In 2008, BC Hydro initiated Year 1 of a proposed five year CLBMON-48 study program to obtain information on juvenile mountain whitefish abundance and distribution and adult mountain whitefish spawning activity in the lower Columbia River. This information is needed to inform management actions related to the effects of flow regulation on mountain whitefish recruitment success. The data report presents the findings of Year 2. Where warranted or available, the report incorporates data from past studies on mountain whitefish in the study area into the results and discussion as a means to support either present findings or recommendations for the Year 3 study program. Detailed analysis of the data, statistical comparisons, or discussions of study results and how they address the management questions being asked, is deferred until the Year 5 summary report.

The onset and peak of mountain whitefish spawning at CPR Island and the Kootenay River occurred over temporal and temperature ranges similar to those recorded in the 1990s. In the Kootenay River, a bi-modal spawning pattern strongly suggested the presence of two spawning runs. High catch rates of eggs at the CPR Island and lower Kootenay River spawning areas indicated these areas are still used extensively for spawning, relative to previous studies on spawning activity, or data obtained indirectly that indexed spawning intensity based on dewatered eggs. At the Blueberry and Genelle spawning areas, egg catch rates were highest at the onset of sampling and declined steadily over the course of the program, which indicated peak spawning occurred during or prior to the onset of sampling in early December. Egg deposition in the CPR Island and lower Kootenay River spawning areas occurred in essentially the same areas and within the same habitat parameters of depth, substrate
composition, and surface velocity as documented during previous studies in these areas.

Hatch in the CPR Island area likely commenced between early January and mid-February 2010, and occurred later in the Kootenay River than in the other spawning areas sampled. Data collected during previous studies suggested that the hatching and emergence period in the lower Columbia and Kootenay rivers is protracted, and could extend into May. Post-emergent whitefish concentrated in shallow, low gradient habitats with low velocities, and substrates dominated by fines and gravels. Norn's Creek Fan appears to provide important habitat for early larvae.

Catch-rates of juvenile mountain whitefish (age-0 and age-1) were slightly higher during boat electrofishing surveys in Year 2 than in Year 1. This increase may be related to capture efficiency, as overall encounters (captured and observed) were almost identical between years. Juveniles were most abundant in depositional areas within the upper section of the study area. Lower recorded juvenile abundance in the middle and lower sections may reflect the reduced availability of this habitat type in these areas. While data was collected on habitats used by juveniles at night, habitat use during the daytime remains relatively unknown. Their absence in the day from habitats where they are found at night suggests a use of deeper areas in the day.

Boat electrofishing sample sites were selected based on juvenile mountain whitefish abundance and habitat associations identified in previous studies. Lower abundance of age-1 fish in the sample may indicate either lower overall abundance of this cohort or that this age-class uses different habitats than the age-0 cohort. The juvenile tagging survivability study component indicated that juveniles smaller than 150 mm cannot be successfully tagged with acoustic tags. As juveniles 150 mm length are encompassed by the age-1 cohort and may use different habitats than age-0+ fish, an acoustic telemetry program may not adequately address diel migrations of age-0 whitefish.

As in Year 1, population estimates could only be determined for one localized area within the upper section. Estimates derived for this area using the modified Schnabel (n = 2824 fish) and sequential Bayes algorithm (n = 3012 fish) techniques were slightly higher and had wider confidence intervals in Year 2 than Year 1. These results suggest that the juvenile mountain whitefish population in this area of the upper section can be indexed by a mark-recapture program. Derivation of population estimates using mark-recapture in other sections of the study area is not considered feasible at this time, due to consistently low recapture rates in the remainder of the upper section and overall low abundance of juveniles in the middle and lower sections.

Results from this monitoring program will help develop management prescriptions for mountain whitefish in the lower Columbia River. The egg collection mat sample program at the secondary spawning sites was exploratory in nature (i.e. aimed mainly at identifying if spawning occurs at these location) and therefore, the initial results require further verification. To identify and characterize early rearing habitats, and to assess whether the availability and suitability of these habitats are affected by flow regimes during hatch, we recommend a systematic sampling of emerging larval mountain whitefish in all sections of the study area throughout the protracted hatching and emergence periods.
The behaviour and distribution of juvenile mountain whitefish may be related to
discharge levels in the lower Columbia River and the amount of inundated
depositional habitat available to rearing juveniles, but this possible linkage requires
further study. The need for additional research into diel migration patterns of
juveniles also was identified.

4.8 CLBMON-49 Lower Columbia River Effects of Whitefish Flows on Great Blue
Heron and Winter Use of Waldie Island by Great Blue Heron

4.8.1 Management Questions
This monitoring program is designed to address the following management questions
as they pertain to a small wintering refuge area (Waldie Island) for GBH in the lower
Columbia River and to the breeding colony of GBH near Revelstoke, BC.

1) Do GBH use Waldie Island as an overwintering area or as a short-term stopover
migrating elsewhere?

2) Does the current early winter flow regime in the lower Columbia River affect the
quality and quantity of overwintering habitat (e.g. foraging, roosting) for GBH and
influence foraging ecology of GBH on Waldie Island?

3) Are there operational changes that could provide for protection of overwintering
habitat to ensure that it can support dependent winter GBH aggregations?

4) Are there ‘physical works’ alternatives in lieu of operational changes that would
benefit GBH overwintering at Waldie Island?

5) Do GBH nesting at the Revelstoke colony use Waldie Island as a winter refuge
site or as a stopover site during migration?

6) What is the regional importance of Waldie Island as a winter refuge area for GBH
that nest at the Revelstoke colony?

7) Does operation of Arrow Lakes Reservoir affect foraging opportunity and success
for GBH breeding at the Revelstoke colony?

4.8.2 Overview
From late October until late February, Great Blue Heron (GBH) are known to
aggregate in the vicinity of Waldie Island, near Castlegar, BC downstream of HLK
Dam. Data collected over a 3-year period suggests high river flows and water
elevations during the early winter period limits the availability of suitable shallow-
water foraging habitat downstream of HLK Dam. From late November to mid
December, outflows from Arrow Lakes Reservoir are increased to provide stable
flows during the late December to late January period in order to protect spawning
whitefish and egg incubation. As there are few other ice-free shoreline areas
downstream of HLK Dam, protracted periods of higher flow releases may be
negatively affecting GBH by reducing available foraging habitat, which in turn is
increasing GBH dependency on Waldie Island and increasing localized competition
for food and resting sites. The island is relatively well protected from predators,
weather and disturbance, and provides suitable roost trees and access to nearby
shallow water foraging habitat. Based on observations, Machmer (2003)
recommended that BC Hydro modify the flow regime of HLK Dam in years of high flows to ensure that some parts of CPR Island and Waldie Island foreshore remain exposed and usable by GBH during the early winter period. A maximum elevation of 421 m was recommended for the period of 15 November to 21 December.

During the Columbia River WUP, the CC sought to address concerns related to the impacts that the flow regime of HLK Dam has on the availability of shallow-water foraging habitat downstream of the dam, and whether GBH that breed in the Revelstoke Colony overwinter on Waldie Island. Two related studies were recommended to (1) confirm the importance of Waldie Island as a winter refuge area; (2) address uncertainty related to the potential impact of high early winter flows on survival of overwintering GBH at Waldie Island; (3) determine whether modifications to the current flow regime should be considered to minimize flow-related impacts on this winter GBH aggregation, (4) determine whether GBH that breed in the Revelstoke Colony overwinter on Waldie Island, and (5) assess whether the operation of Arrow Lakes Reservoir affects the foraging opportunities of GBH breeding at the Revelstoke colony.

**Monitoring Indicators:**

a) Program will monitor the response of winter GBH populations on Waldie Island to potential impacts of high flows/river stage during the winter period on foraging habitat.

b) Program will address whether GBH from the Revelstoke nesting colony are the same individuals as those observed at Waldie Island.

c) Program will monitor whether the foraging ecology of these birds is being negatively affected by operation of Arrow Lakes Reservoir during the breeding season.

This monitoring program will employ the use of GPS telemetry data loggers to obtain a sufficient number of data points to determine habitat selection of GBH and assess the effects of river flow and stage on habitat use (e.g., foraging). The GPS data loggers will be fitted to GBH captured during the fall as they begin to arrive at Waldie Island. Observational data will also be gathered to determine the timing of the arrival and departure of GBH from Waldie Island over the course of the winter. Data loggers will be affixed to animals every fall and retrieved the following summer. In addition, it will be important to monitor the attendance and foraging activity of GBH at Waldie Island (and area) over the course of the winter to detect changes in use patterns in relation to changing river flows and environmental conditions.

In addition to the Waldie Island surveys, there will be monitoring of habitat use during the breeding season in the Revelstoke Reach area of the upper Columbia River. Surveys will be conducted weekly to obtain information on use and location of important feeding areas by GBH at the Revelstoke colony. The surveys should be conducted throughout the nesting season (April to June) until the majority of adults have dispersed from the colony.

**4.8.3 Status**

This monitoring program will be initiated in May 2011, and will be carried out over four years. The first program report is expected in spring 2012. However, in an effort
to adjust current workloads consideration is being given to requesting a delayed start for this project until 2013 or 2014. The delay would not compromise the project overall but information on the project would not be available in time for presentation at the interim review.

4.8.4 Interpretation of Data

At this time there are no data to interpret for this monitoring program.

5 Lower Columbia River Fish Management Plan - Monitoring Program Costs

The following table summarizes the approved costs of the monitoring programs and physical works under the Lower Columbia River Fish Management Plan of the Columbia River WUP, as well as the Actual Costs to July 15, 2010.
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* Red values in parentheses denote overage.