Columbia River Project Water Use Plan
Monitoring Program Terms of Reference

LOWER COLUMBIA RIVER
FISH MANAGEMENT PLAN

• CLBMON-45 Lower Columbia River Fish Indexing Surveys

31 August 2007
1.0 OVERVIEW

This document presents Terms of Reference for the effectiveness monitoring programs for the Lower Columbia River Fish Management Plan (Table 1). These programs will evaluate the effects of whitefish and rainbow trout flow conditions on the lower Columbia River and provide a physical and ecological health barometer against which the lower Columbia River monitoring programs can be evaluated.

This document provides detailed Terms of Reference for the following programs:

1) CLBMON-42 Lower Columbia River Fish Stranding Assessment and Ramping Protocol: a 13-year program to monitor planned and opportunistic flow reductions to establish impacts of flow reductions on fish populations in the lower Columbia River and the required operational procedures to mitigate ramping impacts.

2) CLBMON-43 Lower Columbia River Sculpin and Dace Life History Assessment: a 5-year program to monitor the life history and habitat use of sculpin and dace, in particular species listed under the federal Species at Risk Act and the BC Wildlife Act, in the lower Columbia River in relation to seasonal operations at Keenleyside Dam.

3) CLBMON-44 Lower Columbia River Physical Habitat and Ecological Productivity Monitoring: a 12-year program to monitor physical habitat parameters, periphyton and benthic invertebrates below Keenleyside Dam to evaluate net change in trophic productivity and overall ecological health in relation to rainbow trout and mountain whitefish flow regimes.

4) CLBMON-45 Lower Columbia River Fish Population Indexing Surveys: a 13-year program to monitor trends in the biological characteristics, distribution and abundance of mountain whitefish, rainbow trout and walleye populations in the lower Columbia River in relation to rainbow trout and mountain whitefish flow regimes.

5) CLBMON-46 Lower Columbia River Rainbow Trout Spawning Habitat Assessment: a 10-year program to monitor the relative abundance, distribution, spawning site selection and timing of rainbow trout spawning in the lower Columbia River in relation to rainbow trout and mountain whitefish flow regimes.

6) CLBMON-47 Lower Columbia River Whitefish Spawning Ground Topographic Surveys: a 3-year program to monitor spawning locations of whitefish in the lower Columbia River using detailed topographic surveys to improve the effectiveness of the whitefish flow regime in the lower Columbia River.

7) CLBMON-48 Lower Columbia River Whitefish Life History and Egg Mat Monitoring: a 5-year program to monitor whitefish life history, including spawning and egg mat sampling in the lower Columbia River, to establish the effectiveness of the current whitefish flow regime on egg survival, juvenile recruitment, and adult populations.
8) CLBMON-49a Lower Columbia River Effects of Whitefish Flows on Great Blue Heron Use of Waldie Island: a 3-year program to monitor the effects of whitefish flows on the availability of Great Blue Heron habitat in the vicinity of Waldie Island.

9) CLBMON-49b Lower Columbia River Winter Use of Waldie Island by Great Blue Heron: a 3-year program to determine the importance of Waldie Island as an overwintering site for juvenile and adult heron from the Revelstoke colony.

Table 1  
Lower Columbia River Fish Management Plan Monitoring Program Terms of Reference

<table>
<thead>
<tr>
<th>Name of Monitoring Program</th>
<th>Order Clause Fulfilled</th>
<th>Submitted with this Package</th>
<th>Previously Submitted To CWR</th>
<th>Submission Date</th>
<th>Leave to Commence</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLBMON-42 Lower Columbia River Fish Stranding Assesment and Ramping Protocol</td>
<td>Schedule E: 2.a</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>CLBMON-43 Lower Columbia River Sculpin and Dace Life History Assessment</td>
<td>Schedule E: 2.b</td>
<td>No</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>CLBMON-44 Lower Columbia River Physical Habitat and Ecological Productivity Monitoring</td>
<td>Schedule E: 2.c</td>
<td>No</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>CLBMON-45 Lower Columbia River Fish Population Indexing Surveys</td>
<td>Schedule E: 2.d</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>CLBMON-46 Lower Columbia River Rainbow Trout Spawning Habitat Assessment</td>
<td>Schedule E: 2.e</td>
<td>No</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>CLBMON-47 Lower Columbia River Whitefish Spawning Ground Topographic Surveys</td>
<td>Schedule E: 2.f</td>
<td>No</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>CLBMON-48 Lower Columbia River Whitefish Life History and Egg Mat Monitoring</td>
<td>Schedule E: 2.g</td>
<td>No</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>CLBMON-49a Lower Columbia River Effects of Whitefish Flows on Great Blue Heron Use of Waldie Island</td>
<td>Schedule E: 2.h</td>
<td>No</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>CLBMON-49b Lower Columbia River Winter Use of Waldie Island by Great Blue Heron</td>
<td>Schedule E: 2.h</td>
<td>No</td>
<td>No</td>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>
Monitoring Study No. CLBMON-45
Lower Columbia River Fish Indexing Surveys

1.0 MONITORING PROGRAM RATIONALE

1.1 Background

Since 1995, BC Hydro has attempted to ‘stabilize’ water releases from the Hugh L. Keenleyside Dam (HLK) during whitefish and rainbow trout spawning seasons (January through June) to minimize egg losses in the lower Columbia River (LCR) near Castlegar (P. Higgins, BC Hydro, pers. comm.). 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 aim 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 Water Use Plan (WUP) Consultative Committee (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.

In 2001, BC Hydro initiated the Large River Fish Indexing Program to gather information on selected index species (Golder Associates Ltd. 2006). 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 (BC Hydro 2005a).

1.2 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?

1.3 Management Hypotheses

There are three key monitoring hypotheses addressed in this program.
Ho1: There is no change in the population levels of whitefish in the lower Columbia River over the course of the monitoring period.

   Ho1a: There is no change in the abundance of adult and sub-adult whitefish.
   Ho1b: There is no change in the mean size-at-age of sub-adult and adult whitefish.
   Ho1c: There is no change in the mean survival of adult and sub-adult whitefish.
   Ho1d: There is no change in the morphological (condition factor) index of body condition of adult and sub-adult whitefish.
   Ho1e: There is no change in the distribution of adult and sub-adult whitefish.

Ho2: There is no change in the population levels of rainbow trout in the lower Columbia River over the course of the monitoring period.

   Ho2a: There is no change in the abundance of adult and sub-adult rainbow trout.
   Ho2b: There is no change in the mean size-at-age of sub-adult and adult rainbow trout.
   Ho2c: There is no change in the mean survival of adult and sub-adult rainbow trout.
   Ho2d: There is no change in the morphological index of body condition of adult and sub-adult rainbow trout.
   Ho2e: There is no change in the distribution of adult and sub-adult rainbow trout.

Ho3: There is no change in the population levels of walleye in the lower Columbia River.

   Ho3a: There is no change in the abundance of adult and sub-adult walleye.
   Ho3b: There is no change in the mean size-at-age of sub-adult and adult walleye.
   Ho3c: There is no change in the mean survival of adult and sub-adult walleye.
   Ho3d: There is no change in the morphological index of body condition of adult and sub-adult walleye.
   Ho3e: Whitefish and rainbow trout flows do not alter the distribution of adult and sub-adult walleye.

1.4 Key Water Use Decision Affected

The key water use planning decision affected by the results of this monitoring program is the continued implementation of stabilized water releases from the Hugh L. Keenleyside Dam during whitefish and rainbow trout spawning seasons. Results from the completed study and associated inferences from other monitoring programs in the lower Columbia River (Physical Habitat and Ecological Productivity Monitoring, Whitefish Life History/Egg Mat Monitoring Program and Rainbow Trout Spawning
Assessments) will be used to establish the long term operating release requirements for the Hugh L. Keenleyside Dam.

2.0 MONITORING PROGRAM PROPOSAL

2.1 Objective and Scope

The objectives of the lower Columbia River Fish Indexing Program are:

1) To extend time series data on the abundance, distribution and biological characteristics of nearshore and shallow water fish populations in the lower Columbia River.

2) To examine long-term trends in key index fish populations (whitefish, walleye and rainbow trout) during the continued implementation of whitefish and rainbow trout flows in the lower Columbia River.

3) To build upon previous investigations for the further refinement of sampling strategy, sampling program, and analytical procedures to establish a long-term monitoring program for fish populations in the lower Columbia River.

4) To update the existing electronic storage and retrieval system for fish population and habitat monitoring data for the Columbia River.

5) To establish linkages between other biological monitoring programs being undertaken in the lower Columbia River, in particular, the Physical Habitat and Ecological Productivity Monitoring Program.

6) To identify gaps in data and understanding of current knowledge about fish populations and procedures for sampling them, and to provide recommendations for future monitoring and fisheries investigations.

The geographic scope of the monitoring program is the approximately 56 km section of the riverine habitat between HLK and the Canada-US border. This study area includes the Kootenay River below the Brilliant Dam and the Columbia-Pend d’Oreille rivers confluence below Waneta Dam (Golder Associates Ltd. 2006). For the purpose of this study, the mainstem Columbia River has been divided into three relatively equal sections, as per previous studies (Table CLBMON-45-1).

Table CLBMON-45-1 Proposed reach boundaries for the Large River Fish Indexing Surveys, as developed by Golder Associates Ltd. (2002).

<table>
<thead>
<tr>
<th>Reach</th>
<th>Reach Boundaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper section</td>
<td>Km 0.0 to Km 23.0</td>
</tr>
<tr>
<td>Middle section</td>
<td>Km 23.3 to Km 40.0</td>
</tr>
<tr>
<td>Lower section</td>
<td>Km 40.3 to the Canada-US border at Km 56.5.</td>
</tr>
<tr>
<td>Kootenay section</td>
<td>Kootenay-Columbia confluence to Brilliant Dam (Km 0.0 to 2.8)</td>
</tr>
</tbody>
</table>
2.2 Approach

The approach of this monitoring program is to apply a systematic fish sampling protocol on an annual basis in the study area over the implementation period of the Columbia WUP. Systematic fish population sampling protocols for the lower Columbia River were established in 2003 and have been implemented each year for the lower Columbia River (Golder Associates Ltd. 2002, 2003, 2004, 2005, 2006).

Using established field sampling and analytical techniques for population estimation, catch-at-age analysis, and population modeling, a quantitative assessment of temporal patterns in population abundance, mean size-at-age, survival, and distribution for each key species will be undertaken to evaluate long-term trends in these parameters under continued implementation of whitefish and rainbow trout flows. 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.

2.3 Tasks

2.3.1 Task 1: Project Coordination

Project coordination will involve the general administrative and technical oversight of the project. This task will include, but not be limited to: 1) budget management, 2) study team management, 3) logistic coordination, 4) technical oversight of field and analysis components, and 5) facilitation of data transfer among other investigators associated with the Lower Columbia River Fish Management Plan.

A safety plan must be developed and submitted to the BC Hydro contact for all aspects of the study involving field work, in accordance with BC Hydro procedures and guidelines. Specific safety training may be required.

2.3.2 Task 2: Field Sampling Program

The objective of the fish sampling task is to implement a program consistent with previous work to monitor abundance, distribution, and biological characteristics of fish populations of the lower Columbia River. The sampling program is intended to meet the following objectives:

- Conduct relative abundance sampling to document spatial variation in the distribution and relative species composition of key fish populations in the shallow water/nearshore of the study area (mountain whitefish, walleye, and rainbow trout);
- Quantitatively estimate the abundance of the key species using a mark recapture approach;
- Document biological characteristics (age structure, size-at-age, length frequency) of key species;
• Collect opportunistic information on habitat conditions for future consideration of habitat use and the effectiveness of fish sampling activities; and,
• Collect fish stomach content samples from representative age classes of whitefish, rainbow trout and walleye (first three years of the WUP) to investigate potential linkages to data collected in the ecological productivity monitoring program.

All biological sampling protocols will be consistent with those previously applied in the lower Columbia River (Golder Associates Ltd. 2006). The fish sampling program should provide an organized and effective way to implement a sequential mark recapture experiment to estimate population abundance of key species present in the study area. Mark recovery data should be analyzed with an appropriate statistical method that allows quantitative description of the uncertainty associated with population estimates. The program will also allow for the efficient collection of relative abundance data to describe spatial distribution and biological characteristics of fish sampled during the field program. The sampling strategy will address issues associated with randomization, intensity and distribution of sampling effort, foreseen limitations on inferences generated from monitoring data, and steps taken to avoid methodological biases in each component of the work. The design of the program should also explicitly integrate with other programs conducted under the Lower Columbia River Fish Management Plan.

All fish collection efforts will be accompanied by detailed sampling of the biological characteristics of the fish populations. Fish captured in the field program should be measured for weight/length, evaluated for sex and sexual maturity (as possible), and appropriate aging structures should be collected in appropriate numbers to sample age structure of the population. Individual coded tags should be applied to all captured fish to provide information for mark recapture estimates of population size and to provide auxiliary information on movement patterns. Analyses of the biological information should include (but not be necessarily limited to): examination of weight-length relationships, length frequency, age structure, and patterns of growth of fish populations in each of the geographic zones of the study area.

Analysis of fish stomach contents will be undertaken to profile diet composition of age classes of the three primary species during the first three years of the study to establish linkages to the data collected from the ecological productivity monitoring study. The first year, starting in 2008, will be investigative in scope and involve analysis and documentation of samples opportunistically collected during earlier phases of the lower Columbia River fish indexing program, collection of baseline samples by age class to supplement existing data, analysis and reporting of results, and design of a sampling program to be implemented in Years two and three. The intent of the design for the sampling program in Years two and three is to establish a sampling protocol that provides data of sufficient reliability to contribute meaningful information to support the weight of evidence approach in assessing the benefits of the whitefish flow regime and to show effects if historical whitefish flows are implemented on an experimental basis in future. The design of the stomach content analysis program should aim to minimize the number of fish sacrificed. Non-lethal methods should be applied to the extent possible and results calibrated through the analysis of mortalities obtained during the fish indexing program with some supplementation of sacrificed fish.
Habitat information will be collected at all fish sampling locations to facilitate the development of a sub-adult/adult fish habitat utilization database for each study area. Habitat variables that are considered significant to fish habitat use and effectiveness of sampling include (but are not limited to): temperature, light intensity (ambient/in situ), depth, water flow velocity, recent flow variation, bank type, meso-habitat type, and proximity to cover. These data are being gathered and archived for future analyses. They are required to further supplement general understanding of fish habitat use in the lower Columbia River and will be used for examining potential factors influencing effectiveness of boat electrofishing in retrospective studies.

Detailed descriptions of fish sampling methods, preferred data analysis techniques, and habitat assessment procedures can be found in Golder Associates Ltd. 2002, 2003, 2004, 2005 and 2006. In all aspects of the field sampling, appropriate precautions must be followed to avoid possible impacts to threatened and endangered stocks in each area (note that there will be the need to apply for a SARA permit for white sturgeon in case of incidental capture).

2.3.3 Task 3: Data Analysis and Archiving

To facilitate effective management of data from the monitoring program, an existing MS ACCESS Lower Columbia Fish Population data base, developed in earlier phases of the program, will be updated. The intent is to build upon the standardized fish population database that has already been developed.

2.3.4 Task 4: Reporting

To facilitate effective management of data from the monitoring program, an annual technical report will be prepared, which will include:

- an executive summary;
- a description of the methods employed;
- a data summary;
- a detailed discussion of the findings as they relate to the management questions and hypotheses; and,
- any recommendations for the refinement of field sampling protocols.

Reports will follow the standard format that is being developed for WUP monitoring programs. All reports will be provided in hard copy and as Microsoft Word and Adobe Acrobat (*.pdf) format, and all maps and figures will be provided either as embedded objects in the Word file or as separate files.

2.4 Interpretation of Monitoring Program Results

Fish population abundance data are key information requirements for judging the effectiveness of the whitefish and rainbow trout flows at benefiting fish populations in the lower Columbia River. Because the factors that control populations are largely unknown, inferences derived from the lower Columbia River fish population index monitoring program cannot be used directly to ascribe fish population response to changes in dam operations. The results from this program will therefore be integrated
with three other monitoring programs of the Lower Columbia River Fish Management Plan (Physical Habitat and Ecological Productivity, Rainbow Trout Spawning Habitat Assessment, Whitefish Life History/Egg Mat Monitoring Study) and used to support weight of evidence inferences regarding benefits of the whitefish and rainbow trout flows for fish. Results from the lower Columbia River Management Program and associated inferences will be used to establish the long term operating release requirements for the Hugh L. Keenleyside Dam.

2.5 Schedule

The Lower Columbia River Fish Population Indexing Surveys monitoring program will be conducted annually during the 13 year implementation period of the Columbia Water Use Plan.

2.6 Budget

The total annual cost the Lower Columbia River Fish Population Indexing Surveys monitoring program is estimated at $165,246. This budget exceeds the WUP CC estimate of $150,000 per year due to the inclusion of a stomach content analysis component, which has been added to investigate potential linkages to data collected in the LCR Physical Habitat and Ecological Productivity monitoring program (CLBMON-44). Table CLBMON-45-2 provides a detailed estimate of the distribution of annual costs of monitoring program implementation, assuming a 2% rate of inflation and 5% contingency.

3.0 References


BC Hydro. 2005b. Columbia River Project, Draft Water Use Plan. 38 pp. + appendices


**Personal Communication**

Paul Higgins, B.C. Hydro, 2006