Columbia River Project Water Use Plan

Monitoring Program Terms of Reference

LOWER COLUMBIA RIVER FISH MANAGEMENT PLAN

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

24 October 2007

TERMS OF REFERENCE FOR THE COLUMBIA RIVER PROJECT WATER USE PLAN MONITORING PROGRAMS LOWER COLUMBIA RIVER FISH MANAGEMENT PLAN

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-49 Lower Columbia River Effects on Great Blue Heron: a 4-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 Submission Information

Name of Monitoring Program	Order Clause Fulfilled	Submitted with this Package	Previously Submitted To CWR	Submission Date	Leave to Commence
CLBMON-42 Lower Columbia River Fish Stranding Assessment and Ramping Protocol	Schedule E: 2.a	No	Yes	10 September 2007	No
CLBMON-43 Lower Columbia River Sculpin and Dace Life History Assessment	Schedule E: 2.b	Yes	No	26 October 2007	No
CLBMON-44 Lower Columbia River Physical Habitat and Ecological Productivity Monitoring	Schedule E: 2.c	Yes	No	26 October 2007	No
CLBMON-45 Lower Columbia River Fish Population Indexing Surveys	Schedule E: 2.d	No	Yes	10 September 2007	No
CLBMON-46 Lower Columbia River Rainbow Trout Spawning Habitat Assessment	Schedule E: 2.e	Yes	No	26 October 2007	No
CLBMON-47 Lower Columbia River Whitefish Spawning Ground Topographic Surveys	Schedule E: 2.f	Yes	No	26 October 2007	No
CLBMON-48 Lower Columbia River Whitefish Life History and Egg Mat Monitoring	Schedule E: 2.g	Yes	No	26 October 2007	No
CLBMON-49 Lower Columbia River Effects on Great Blue Heron	Schedule E: 2.h	Yes	No	26 October 2007	No

2.0 MONITORING PROGRAM RATIONALE

The trophic productivity and ecological health of the lower Columbia River and, therefore, the quality and quantity of large river habitat are partially dependent on the operation of Hugh L. Keenleyside (HLK) Dam. As such, the Columbia River Water Use Plan Consultative Committee (WUP CC) recognized operational impacts of the dam on fish productivity of the lower river as a key environmental concern to be addressed during the water use planning process.

The WUP CC initially explored ways of achieving specific elements of a preferred fish hydrograph for the lower Columbia River through modifying operation of Arrow Lakes Reservoir. However, it became apparent that BC Hydro would have only limited operational flexibility to unilaterally change flows in the lower Columbia River given the need to meet prescribed weekly flow releases at the border under the Columbia River Treaty (CRT). The WUP CC did not consider the existing flexibility to be biologically significant and, therefore, focused on more substantial flow changes that could be made by deviating from CRT flows through annual negotiations with the U.S. These included:

- rainbow trout protection flows, which involve stabilizing or increasing flows from 01 April to 30 June to minimize dewatering and potential egg losses of mid-timed spawning rainbow trout, and
- mountain whitefish flow, which involve limiting maximum flows during the peak spawning period (1 to 20 January) and smoothing flows until hatch (end March) to minimize subsequent egg dewatering and mortality, and maintaining February/March total stage changes less than 0.5 m.

Water levels in the lower Columbia River are typically managed to limit high flows in January and to stabilize or increase flows through to the end of June; flows increase through the summer and flow fluctuations are allowed in the fall as a treaty trade-off for whitefish flows.

During the development of flow management recommendations, it was recognized that there are significant data gaps regarding the effects of flow shaping on the physical environment and ecological productivity of the lower Columbia River. Monitoring projects were designed to examine the effectiveness of these flow options, and to address existing data gaps between flows and other endpoints of interest[1] (Table 1).

The key objectives of the Lower Columbia Monitoring Program are to: 1) evaluate the effects of whitefish and rainbow trout flow conditions on the lower river and, 2) provide a physical and ecological health barometer against which the Middle Columbia monitoring program can be evaluated.

Rainbow Trout Protection Flows

Prior to 1992, the typical flow regime below HLK Dam was characterized by declining discharge over the March to May period, and increasing discharge over the June to July period. This discharge pattern resulted in reduced water levels at Norns Creek Fan (a primary rainbow trout spawning area), causing a significant number of rainbow trout redds constructed at higher elevations to become dewatered when flows were subsequently reduced. Since 1993, BC Hydro has successfully negotiated Non-Power Use Agreements with the U.S., in consultation with the fish agencies, with the aim of providing better flow regimes for rainbow trout spawning below HLK Dam than would normally occur under the CRT operations. BC Hydro has secured these flow changes by providing 1 MAF of storage from Arrow Lakes Reservoir in July-August for U.S. salmon flow augmentation.

An important objective of rainbow trout protection flow is to maintain minimum river levels at Norns Creek Fan between 1 April and 30 June to ensure that eggs deposited after 1 April

[1] A parallel study in the Middle Columbia River will assess the environmental benefits of the establishment of a year-round 142m^3s^{-1} minimum flow release from Revelstoke Dam.

remain wetted until fry emergence occurs, which is typically by the end of June. These flows are designed to minimize potential egg losses for the mid-timed rainbow spawners (April and May) by providing stable or increasing discharge over this period. This is typically achieved by delivering flows between 15 and 20 kcfs from HLK Dam. The initial discharge is set so that there is a high probability that the downstream river level can be maintained until the end of the spawning and incubation period without causing Treaty storage to draft below planned levels under the CRT.

The implementation of the rainbow trout flow policy in the lower Columbia River has coincided with a general increasing trend in rainbow trout population abundance over the past 10 years. While there may be many reasons for this population increase, BC Hydro and the fish agencies view this as a successful management strategy in protecting rainbow trout populations in the lower river. However, the WUP CC recognized that a significant tradeoff exists between providing protection flows in the lower Columbia to protect rainbow trout spawning and incubation, and its negative impact on other interests upstream in Arrow Lake Reservoir and mid Columbia River (i.e., vegetation, wildlife, large river habitat) due to the additional 1 MAF of storage in spring. Because of potential benefits that could be achieved upstream if annual provision of the protection flows were halted, the WUP CC discussed whether it is essential that this flow management be implemented every year to maintain or enhance these populations. It was recognized that a long-term commitment to monitoring would be required to better understand the linkage between rainbow trout flow implementation and population abundance.

Whitefish Flow Management

Despite over a decade of implementing whitefish flow management actions in the lower Columbia River, there remains uncertainty regarding the relationship between flow conditions and egg mortality, and the significance of egg loss to the productivity of the whitefish population. The WUP CC recognized that resolution of this uncertainty is critical for establishing winter flow release regimes for HLK and Brilliant dams.

Mountain whitefish spawn in the lower Columbia and Kootenay rivers during early winter with peak spawning typically occurring during the first three weeks of January each year (see Figure 1, RLL 2001). Eggs are broadcast into the water column, and are distributed throughout a variety of locations and depths depending on river flow conditions during spawning. Flows supplied to the river from HLK and Brilliant dams into the lower Columbia River during whitefish reproductive period are typically high during the peak mountain whitefish spawning period and decline to an annual minimum by 01 April. Flows can vary widely during the spawning and egg incubation periods, and have been observed to dewater whitefish eggs.

The conceptual approach to whitefish flow management is to stabilize (to the degree possible) regulated flow releases into the lower Columbia River during whitefish reproduction. This requires additional agreements outside of the CRT, including 1) the Whitefish Operating Agreement, which allows storage at Kinbasket and Arrow Lakes reservoirs during the January to reduce Arrow outflow, and 2) the Fall Provisional Storage Agreement and March Whitefish Flow Agreement, which allows for a provisional draft of Arrow Lakes Reservoir and higher releases during the fall in compensation to the U.S. for lost energy benefits associated with stabilization of winter flow.

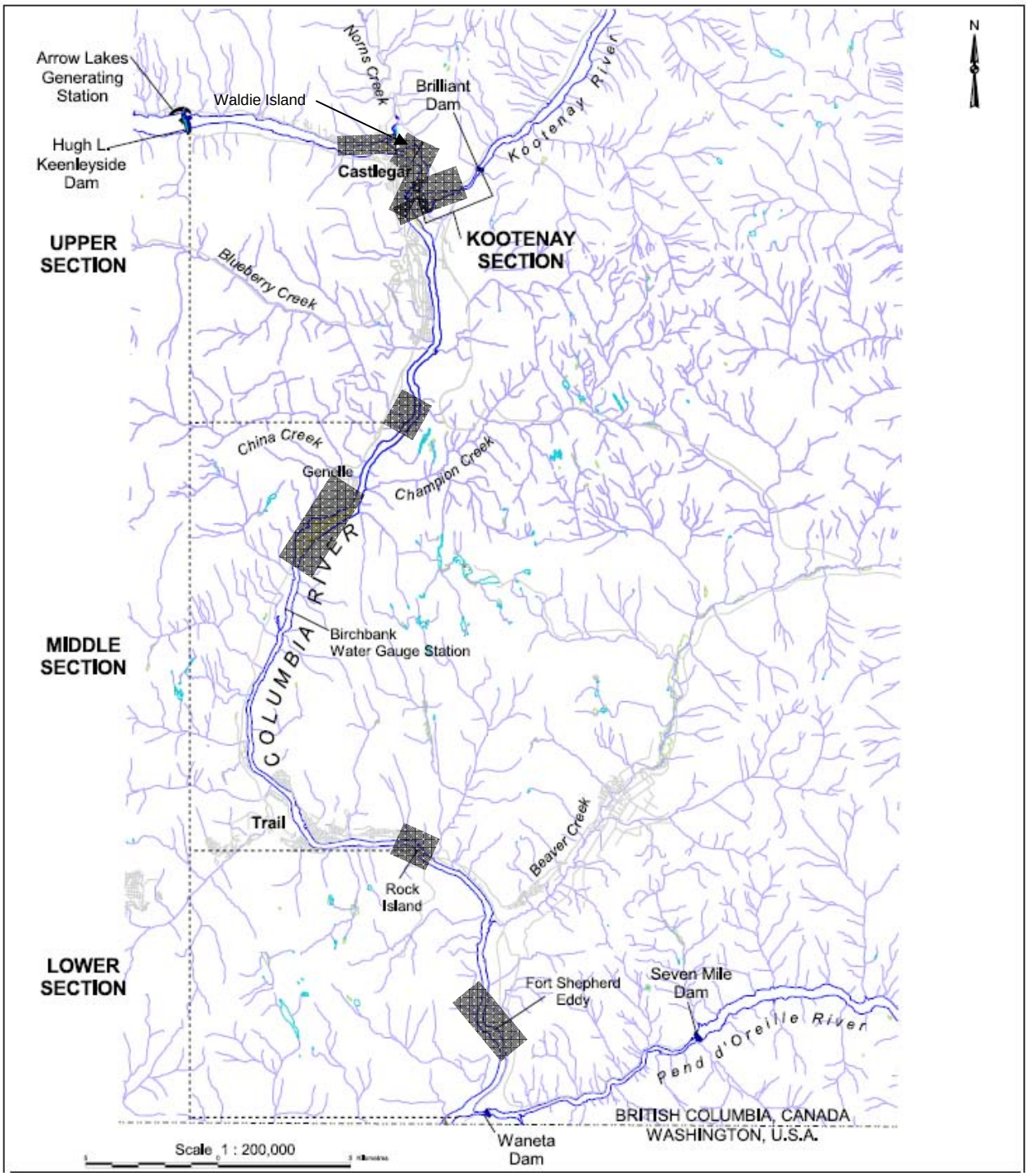
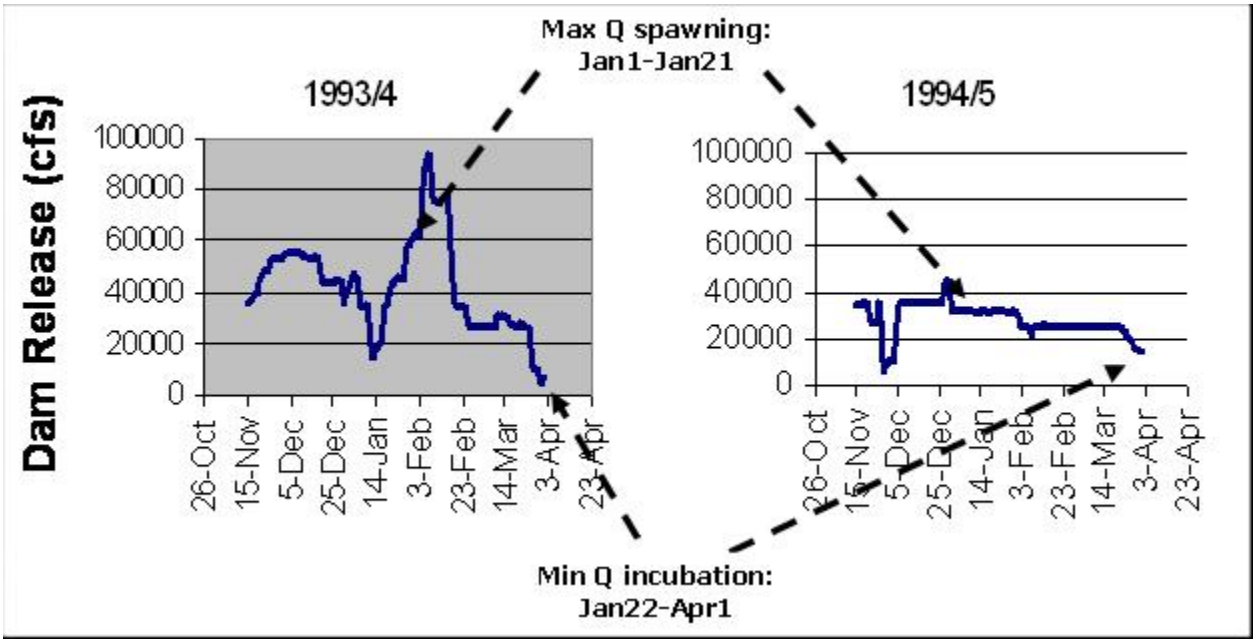


Figure 1 **Map of the Columbia River below Hugh Keenleyside dam showing the study area boundaries, known whitefish spawning areas (grey hatched boxes), Great Blue heron overwintering habitats at Waldie Island, and reach breakdown used for whitefish population index monitoring program initiated in 2001, and proposed for the whitefish adaptive management program.**

Operationally, whitefish flow management is achieved by minimizing the difference between the maximum flow during the peak spawning period (January 1 -21, Q_{Smax}) and the minimum flow prior to egg hatch (January 22 – Apr 1, Q_{Imin}). The relative degree of flow stabilization (and risk of egg loss) is indexed by a simple hydrologic metric, Q_{Smax}-Q_{Imin} (see Figure 2). As a result of annual variation in hydrology, power demand, dam operating conditions, and other factors that govern the flow regime of the Columbia River, there is variation in the success of stabilization efforts. Figure 3 shows the relative degree of stabilization achieved prior (1984-1994) to and after (1995-2005) implementation of whitefish flow management actions.



Flow Stabilization Index (Q_{Smax}-Q_{Imin}) = **Maximum Flow (Jan 1 to Jan 21)** - **Minimum Flow (Jan 22 to Apr 1)**

Figure 2 **Example of computation of the Q_{smax}-$Q_{i\ min}$ flow stabilization index and patterns of daily flow releases from Hugh Keenleyside Dam during whitefish reproduction periods before (1993/4) and after (1994/5) the implementation of WFM practices.**

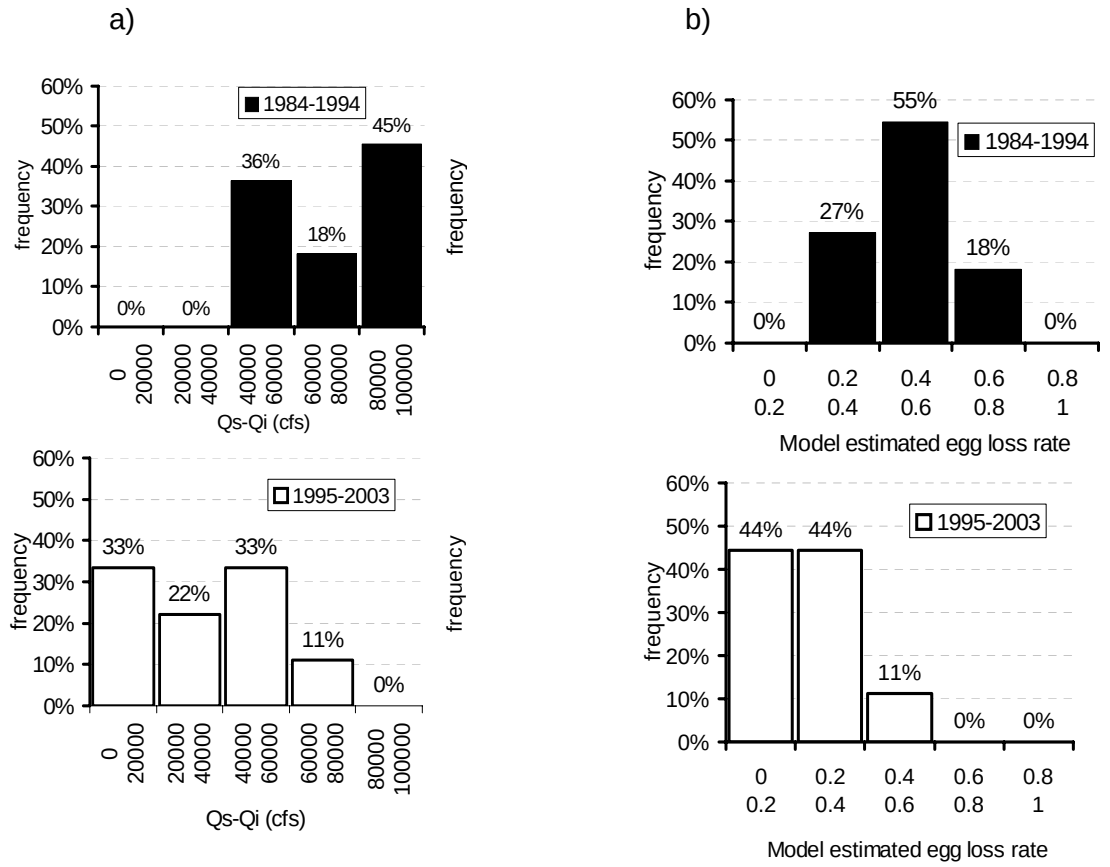


Figure 3 **Distributions of flow stabilization index ($Q_{Smax} - Q_{Imin}$) and modelled egg losses for periods before and after the implementation of WFM. a) $Q_{Smax} - Q_{Imin}$ is difference between the maximum spawning flows during peak spawning (Jan 1 – Jan 21, Q_{Smax}) and the minimum egg incubation flows (Jan 22- Apr 1, Q_{Imin}) for historical operation (1984-1994, black bars) and during WFM implementation (1995-2005, white bars); b) Estimated egg loss observed prior to (black bars) and after (white bars) the implementation of WFM .**

The biological rationale for whitefish flow management is based on three hypotheses that link the physical effects of flow variation to inter-annual abundance of the adult population:

H_1: Management of flow in the lower Columbia River during peak spawning (Jan 1- Jan 21) and stabilization of post spawning flows (22 Jan -01 Apr) will reduce egg losses resulting from dewatering.

H_2: Reduced egg losses increase the recruitment of young-of-the-year whitefish

H_3: Increased young-of-the-year recruitment results in a stable or increasing abundance of the reproductively active adult whitefish population (i.e., F.L. >250 mm)

To determine the effectiveness of whitefish flow management for conserving whitefish populations, the WUP CC recommended a 13-year phased adaptive management program (Figure 4). In Phase 1 of the program, standard whitefish flows will be implemented for five years to provide a total of 12 continuous years (2000-2012) of population index monitoring

coincident to implementation of this flow regime (Years 1–7 Pre-Water Use Plan; Years 8-12 under the Water Use Plan). The objectives of this phase of the program are to: 1) extend time series of systematic whitefish population monitoring to allow quantitative assessment of the influence of WFM on the whitefish population, and 2) fill critical gaps in understanding about the life history, biology, and spawning habitats of whitefish to support management hypotheses testing. Winter flows will be actively managed through the existing flow management framework with the objective of providing an egg loss risk exposure consistent with that observed during the period of implementation (1995-2003, Figure 3). Continuation of fish population index surveys will provide uninterrupted time series of population data. Biological monitoring will be implemented to improve understanding of the whitefish life history and reproductive biology, as well as better description of the physical characteristics of key spawning locations. These data will be combined with historical information for the refinement of the existing egg loss model, to test key model assumptions, or to, where possible, modify the model to provide more reliable egg loss estimates.

The CC was also concerned with potential negative effects of whitefish flow management on overwintering habitats used by Great Blue herons in the lower Columbia River. Monitoring has indicated a heron aggregation during the fall and early winter periods near to and upstream of the confluence of the Kootenay and Columbia rivers. This period corresponds to a period of high and variable flow releases prior to whitefish spawning, which are operationally required to allow stabilized flows during the peak of whitefish reproduction. To address this concern, a monitoring program was recommended to better understand seasonal patterns of heron movement and how the whitefish flow management effects shallow-water foraging habitat utilization by Great Blue heron.

At the end of Phase 1, an Interim Analysis of the biological effectiveness of whitefish flows will be conducted. Annual flow data, egg loss risk estimates, patterns of young of the year recruitment, and trends in abundance of the adult population will be analyzed to test the three primary conceptual hypotheses linking flow management to biological effects on whitefish populations. The primary objectives of the Interim Analysis will be to: 1) document the relationship between winter flow conditions, egg dewatering and the population response of whitefish under the WFM regime, and 2) support a decision regarding experimental suspension of whitefish flow management in Phase 2 of the adaptive management program (see Figure 4).

In Phase 2 of the program, an experimental suspension of flow management was recommended as option by the CC, where deemed safe and informative to do so. The objective will be to increase the contrast in annual egg loss conditions more aggressively to test the biological response of the population without flow protection. The target level of winter flow stabilization is that observed prior to implementation of whitefish flow management (Figure 3). During Phase 2 of the program, adult population index monitoring will continue for an additional 7 years to provide a total of 20 years of systematically collected population data. In the final year of Phase 2, a comprehensive data synthesis will be undertaken. A Final Synthesis will integrate results from all aspects of the program to re-test the three conceptual hypotheses underpinning whitefish flow management, and to contrast biological responses of whitefish under the two alternative winter flow management regimes. The Final Synthesis will be used to inform the decision regarding the long-term continuation of protection flows during the planned review of the Columbia River Water Use Plan.

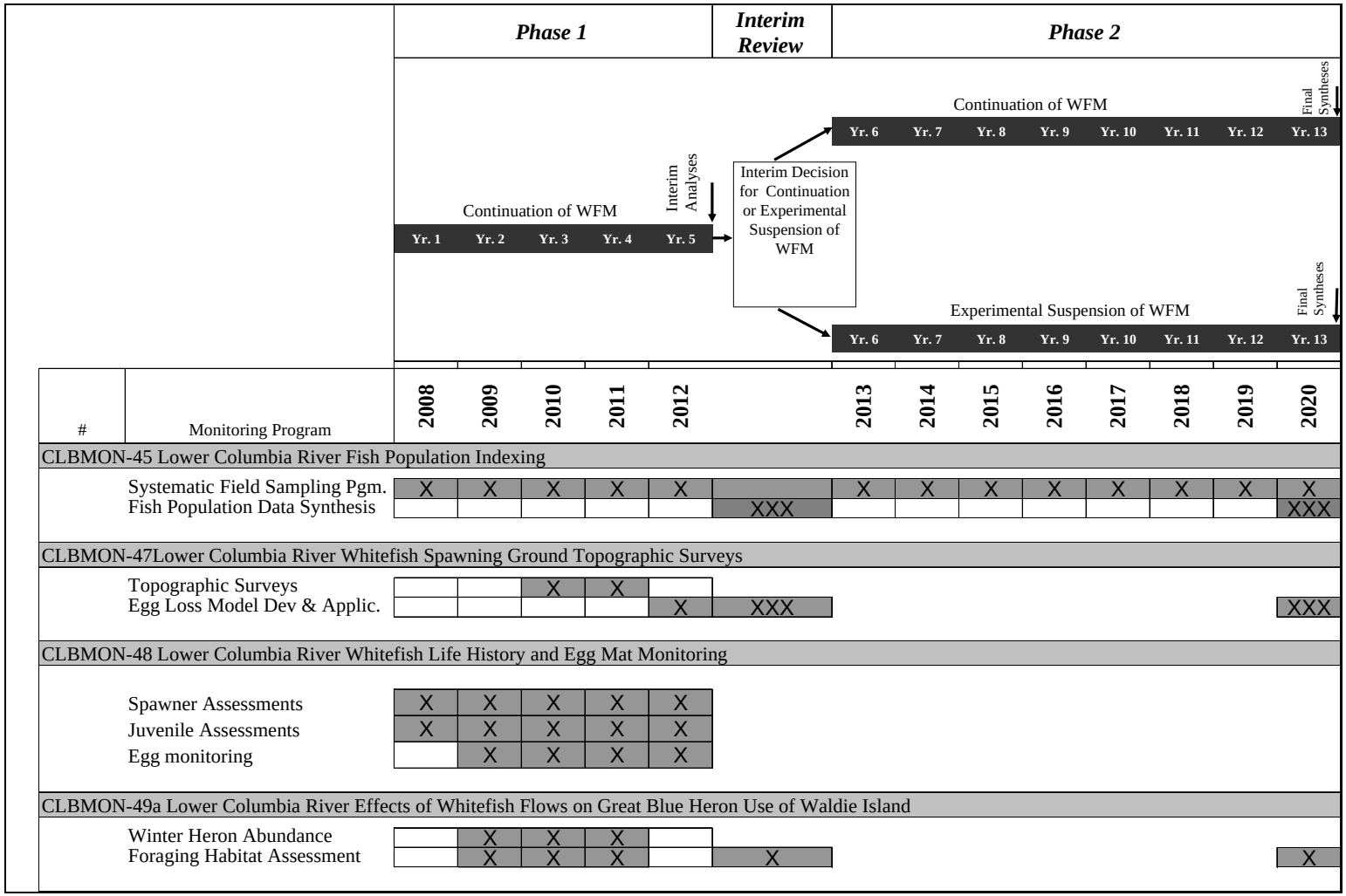


Figure 4 **Conceptual approach and annual schedule for the implementation of monitoring programs and key activities for the evaluation of the biological effectiveness of WFM for the conservation of the mountain whitefish population in the lower Columbia River.**

Monitoring Study No. CLBMON-49 Lower Columbia River Effects on Great Blue Heron

1.0 MONITORING PROGRAM RATIONALE

1.1 Background

The Great Blue Heron (*Ardea herodias*; GBH) is a large colonial nesting bird that occurs throughout North and Central America. In British Columbia, two subspecies are recognized; *Ardea herodias fannini* occurs along the coast and *Ardea herodias herodias* occurs in the interior (Campbell et al. 1990). Regarded as a species of high management concern (Gebauer & Moul 2001), GBH are protected under the international *Migratory Birds Convention Act* enforced by the Canadian Wildlife Service and the provincial *Wildlife Act.* Great Blue Heron have been identified as a species of concern under the Species at Risk Act.

In the Columbia Basin, valley bottom riparian and wetland areas provide important breeding and wintering areas for interior GBH (Machmer & Steeger 2003). They forage in wetlands and along the margins of lakes and slow-moving rivers, and breed in mature black cottonwood or coniferous stands. During fall and winter, some interior GBH may migrate south; however, many remain in the Columbia Basin and forage around open-water areas throughout the winter months.

From late October until late February, GBH are known to aggregate in the vicinity of Waldie Island, near Castlegar, BC (Figure CLBMON-49-1) downstream of the Hugh Keenleyside Dam (Machmer 2001, 2002, 2003). Data collected over a three-year period suggests high river flows and water elevations during the early winter period limits the availability of suitable shallow-water foraging habitat down stream of the Hugh Keenleyside Dam (Machmer 2003). 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 the Hugh Keenleyside 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 their observations, Machmer (2003) recommended that BC Hydro modify the flow regime of Hugh Keenleyside 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.

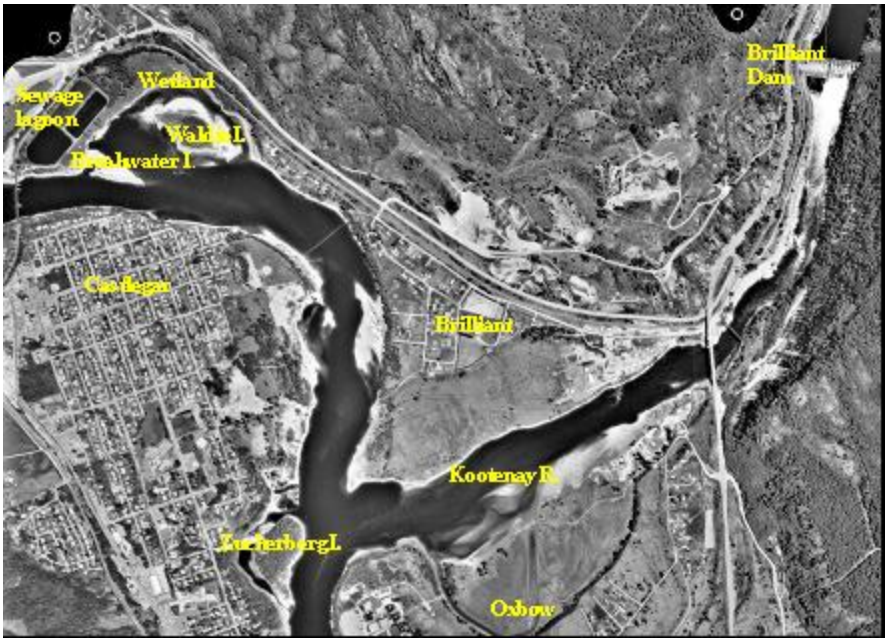


Figure CLBMON-49-5 Location of Waldie Island on the lower Columbia River

During the Columbia River Water Use Planning Process (WUP), the Consultative Committee sought to address concerns related to the impacts that the flow regime of Keenleyside 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. These 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.

The latter two objectives were initially proposed as a separate study from the first three objectives; however this Terms of Reference seeks to address all five objectives under a single monitoring program.

1.2 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?

1.3 Management Hypothesis

There are four hypotheses that will be tested under this monitoring program. The first hypothesis (and sub-hypotheses) is associated with evaluating habitat-related impacts of flow manipulations made during the early winter period relative to the low, stable flow conditions during the whitefish flow period.

H_1: Higher and more variable river flows and water elevations during the early winter period (prior to implementation of the whitefish flow regime) cause a reduction in overwintering habitat for winter aggregations of GBH using Waldie Island.

- H_{1A}: There is a significant change in the spatial extent of foreshore habitat on Waldie Island for roosting by GBH.

- H_{1B}: There is a significant change in the quality and quantity of suitable shallow-water foraging habitat on Waldie Island and surrounding areas (as measured from physical characteristics of forage locations, including spatial extent, location, water depth, water velocity).

- H_{1C}: There is a significant change in the abundance of fish prey at forage locations (as measured by total and species-specific fish densities).

The second hypothesis is associated with testing whether GBH exhibit behavioural flexibility in their foraging ecology in response to changes in foraging habitat. It is assumed that GBH will display a certain degree of flexibility either by foraging over a greater area, moving to less crowded habitats or targeting other food sources. However, if foraging habitat is limiting, changes in the availability of suitable foraging habitat could cause the birds to use poorer quality habitat, reducing the rate at which they replenish their energy reserves or cause the birds to leave the area in search of more suitable foraging habitat.

H_2: A reduction in the quality and quantity of foraging habitat causes a change in the foraging ecology of GBH at Waldie Island (i.e., shifting use of foraging habitat and prey species, reduced foraging efficiencies/opportunities, or increased intra-specific competition).

The third management hypothesis is associated with the importance of Waldie Island as an overwinter refuge for GBH that breed in the Revelstoke Colony. The concern is that GBH utilizing these two sites are affected by operations of both the Hugh Keenleyside Dam in the winter and of the Arrow Lakes during the breeding season.

H_3: Great Blue Heron that nest at the Revelstoke colony overwinter in the Waldie Island area.

The fourth management hypothesis is associated with the use of foraging habitat along Revelstoke Reach by GBH from the Revelstoke breeding colony.

H_{4a}: Great Blue Heron at the Revelstoke nesting colony rely on riparian/wetland areas along Revelstoke Reach for foraging during the breeding season.

H_{4b}: Changes in water surface elevations of Arrow Lakes Reservoir during the GBH breeding season negatively affect the availability of suitable riparian/wetland foraging areas.

H_{4c}: Changes in the availability and suitability of foraging habitat along Revelstoke Reach influence the foraging ecology of GBH nesting at the Revelstoke colony.

1.4 Key Water Use Decision Affected

The key operating decisions that may be affected by this monitoring program are whether:

1) early winter flow releases from Arrow Lakes Reservoir should be altered to mitigate impacts of high river flows on overwintering GBH in the vicinity of Waldie Island. The monitoring program will provide information needed to better understand how the current flow regime in the lower Columbia River affects the foraging ecology and overwinter survival of GBH, and what changes may be required to manage and protect important winter habitat for the dependent GBH population; and

2) changes in the operating regime of Arrow Lakes Reservoir should be considered during the next review of the Columbia River Water Use Plan. Specifically, the monitoring program will inform on the potential impacts of the current reservoir operation regime on the foraging ecology of GBH that nest at the Revelstoke colony.

2.0 MONITORING PROGRAM PROPOSAL

2.1 Objectives and Scope

The primary objectives of this monitoring program are to:

1) assess the response of winter GBH populations on Waldie Island to potential impacts of high flows/river stage during the winter period on foraging habitat,

2) address uncertainties related to whether GBH from the Revelstoke nesting colony are the same individuals as those observed at Waldie Island, and

3) assess whether the foraging ecology of these birds is being negatively affected by operation of Arrow Lakes Reservoir during the breeding season.

Field observations will be limited to Waldie Island and Revelstoke Reach and surrounding areas. This monitoring program will be carried out over four years. A pilot study is proposed in Year one of the study.

2.2 Approach

The approach of the study has been revised from that originally recommended by the Consultative Committee. This study was initially proposed as two separate studies, as described above. In this Terms of Reference, these studies have been combined because the methods employed will provide the data to address the objectives of both studies. Further, there are significant administrative, economic and practical efficiencies to be gained by combining the studies under a single Term of Reference.

Winter Monitoring of Great Blue Heron

The original approach recommended by the Consultative Committee was to replicate the fall/winter monitoring program conducted by Machmer (2001, 2002, 2003). However, it is unlikely this approach would provide the data required to assess (1) whether high flow conditions during the pre-whitefish flow period affect the quality and quantity of foraging habitat and habitat selection of GBH, and (2) whether there is a critical flow/elevation threshold where foraging is significantly affected. The revised approach 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).

Recent advances in GPS technology allow for the collection of large amounts of highly accurate location data (Millspaugh & Marzluff 2001). Increased performance and reduced weight facilitates the use of this technology on mid-sized birds (Biro et al. 2002; Fukuda et al. 2004; Weimerskirch et al. 2002). GBH will be captured and radio tagged using a lightweight GPS data logger (e.g. Sirtrak [www.sirtrack.com], or Televilt [www.televilt.se]). The data loggers can be customized to allow for remote uploading of data, incorporate a drop-off mechanism, which can be preprogrammed to release at a preset date and time, and be accompanied by a UHF/VHF radio transmitter for retrieving the unit. The GPS data loggers will also provide the necessary data to address whether

the GBH observed at Waldie Island are the same individuals as those from the Revelstoke nesting colony (H_3).

The GPS data loggers will be fitted to GBH captured during the fall as they begin to arrive at Waldie Island. GBH can be captured humanely using either rocket nets (King et al. 1998; Parris 1977), or box traps (Simpson & Kelsall 1978). Noose mats have recently been used to capture smaller shorebirds species (McGowan & Simons 2005; Mehl et al. 2003, and A. Pomeroy pers. comm.), and may provide an effective means of capturing GBH with some design modification (R. Butler, pers. comm.). Decoys (Crozier & Gawlik 2003) and bait stations (Parris 1977) can be employed to increase capture efficiency. A pilot study is proposed in Year 1 (2009) to determine the most effective means of capturing and assess the use of the GPS data loggers on GBH.

Habitat availability along the Columbia River downstream of Hugh Keenleyside Dam will be modeled using digital elevation to model shallow-water GBH foraging habitat in relation to river flow and stage. These data will be supplemented with ground data (substrate, ground cover, water depth) environmental data (weather conditions, air temperature, and precipitation), and flow data (water elevations, flow rates). Habitat use versus availability analysis will be facilitated from GBH locations obtained from the GPS data loggers (Erickson et al. 2001). These data will also facilitate a much more detailed analysis of GBH foraging ecology than would be attainable from visual observations or from traditional radio telemetry. These data will also determine whether alternate foraging sites (e.g., inland streams or fields) are used by GBH in response to reduced habitat availability.

Observation 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 following a similar monitoring approach employed by Machmer (2001; 2002; 2003). Date of arrival will not be obtained from GPS data loggers, as the 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.

Prey abundance will be assessed using data obtained from the following studies: CLBMON #45 (Lower Columbia Fish Population Index Surveys), CLBMON #46 (Lower Columbia Rainbow Trout Spawning Assessment), and CLBMON #48 (Lower Columbia Whitefish Egg Monitoring and Life History Studies).

Monitoring Habitat Use of the Revelstoke Colony

This component of the study was recommended by the Consultative Committee to determine whether GBH that nest at the Revelstoke colony overwinter in the Waldie Island area, and whether changes in water surface elevations of Arrow Lakes Reservoir during the GBH breeding season negatively affect the availability of suitable foraging areas in the drawdown zone of Revelstoke Reach. The Consultative Committee recommended this study to gain a better understanding of the factors that may be contributing to the apparent declining trend in GBH abundance, and assess the impact the operations of the Arrow Lakes Reservoir may have on GBH.

To ensure consistency and integration of study results with the Waldie Island GBH monitoring program, the design and duration of this monitoring program has been revised from that originally envisioned by the Consultative Committee. Modifications include the use of GPS telemetry, as it provides a more an efficient means to determine whether GBH at the Revelstoke Colony overwinter at Waldie Island. This will be facilitated by affixing GPS data loggers to GBH captured at Waldie Island in late fall (as described above), which will be retained until the following summer to track their movement to breeding sites. The data loggers will be dislodged from the animals prior to their summer post-nuptial molt using a preprogrammed drop-off mechanism and retrieved using a UHF or VHF radio receiver.

To address the Consultative Committee concerns regarding whether Arrow Lakes Reservoir operations are negatively affecting GBH foraging in Revelstoke Reach during the breeding season, GBH foraging behaviour will be monitored over three years throughout the nesting season to obtain information on use and location of important feeding areas by GBH at the Revelstoke colony. This approach will entail ground-based surveys to monitor GBH abundance and distribution throughout Revelstoke Reach, and describe foraging habitat characteristics and foraging behavior in relation to varying water levels. Although this approach will not provide the data obtained from the GPS data loggers, the intent of this monitoring program will be to provide information on the potential impacts of the current reservoir operation regime on the foraging ecology of GBH. If GPS telemetry data is obtained from GBH at the Revelstoke colony (originally captured and tagged at Waldie Island), the telemetry data will be used to assess habitat selection and determine habitat selection functions. Additional data will be acquired from the Arrow Lakes Reservoir Shorebird and Waterbird Monitoring Programs (CLBMON #38 and CLBMON #40, respectively).

2.3 Methods

2.3.1 Task 1: Project Coordination

Project coordination involves the general administration and technical oversight of the program, which will include, but may not be limited to: 1) budget management, 2) program team management, 3) logistics coordination, 4) technical oversight in field and analysis components, and 5) facilitation of data transfer among other investigations associated with the Lower Columbia Fish Management Plan and Arrow Reservoir Operations Management Plan, as required.

Permits will be obtained from the Ministry of Environment and Canadian Wildlife Service. Specific protocols for this project will be developed outlining animal capturing methods, animal handling procedures, and animal tagging techniques. These protocols will be submitted along with the permit requests and will be made available for review by the appropriate animal care committees.

2.3.2 Task 2: Field Sampling Program

Pilot Study

The first year of this monitoring program will entail a pilot study to evaluate capture techniques, animal handling procedures, harness design, and the utility of the GPS data loggers. The goal of the pilot study will be to capture and tag five GBH in the late fall of 2009. The data loggers will employ a preprogrammed drop-off mechanism and a radio telemetry transmitter (UHF or VHF frequencies) to facilitate the recovery of the data loggers in the summer of 2010. The data loggers will be retrieved by flying the study area using a UHF or VHF receiver to locate the approximate area of the data loggers. Ground crew will be deployed to retrieve the data loggers.

An evaluation of the capture methods and GPS data loggers will be provided in report format, and will include a preliminary assessment of the data. A protocol will also been developed for capturing and handling GBH for use in future years.

Heron Capture and Tagging

Based on the information and experience gained in capturing and tagging GBH from the pilot study, 15 GBH will be captured and tagged annually in the vicinity of Waldie Island in late fall. Upon capture, the birds will be fitted with a lightweight GPS data logger. The general rule for determining the maximum weight of wildlife transmitters is 5% of an animal's body weight (Mech & Barber 2002; Millspaugh & Marzluff 2001; Resources Inventory Committee 1998). As adult GBH weigh between 2.0 to 2.5 kgs (Bayer 1981) data logger packages will be restricted in weight to between 100 and 125 grams. Captured GBH will also be fitted with a reflective colored leg band for visual identification. The age, sex and weight of each bird will be determined at the time of capture.

At a preprogrammed time prior to the beginning of the post-nuptial molt in late summer, the drop-off mechanism will be detonated and the GPS data loggers will be retrieval as described above.

Monitoring of Overwintering Heron

Surveys will be conducted during the winter GBH aggregation to obtain observation information on GBH use of Waldie Island and surrounding areas in relation to river flow and water elevation following procedures described by Machmer (2001, 2002, 2003). Systematic counts of adult and juvenile GBH will be made for comparison with the population benchmark established by previous studies (Machmer 2001, 2002, 2003). Surveys will be conducted from the sewage treatment facility near the north shore of the Columbia River to the Kinnaird area, including Waldie Island, Breakwater Island and surrounding areas near Castlegar, where GBH activity has been consistently noted in the past (e.g., Brilliant Dam, Kootenay Oxbow, Kootenay-Columbia confluence, Zuckerburg Island, Norns Creek, Genelle) (Figure CLBMON- 49-2).The surveys will be conducted twice weekly from 15 November to 31 December, and weekly from 1 January to 21 January, coinciding with the pre-whitefish flow and whitefish flow periods. Observations of foraging activity (e.g., success) will be made during each survey,

including information on numbers of birds, timing of foraging and prey species. Night vision goggles will be used to aid in monitoring foraging activity at night fall and at dusk.

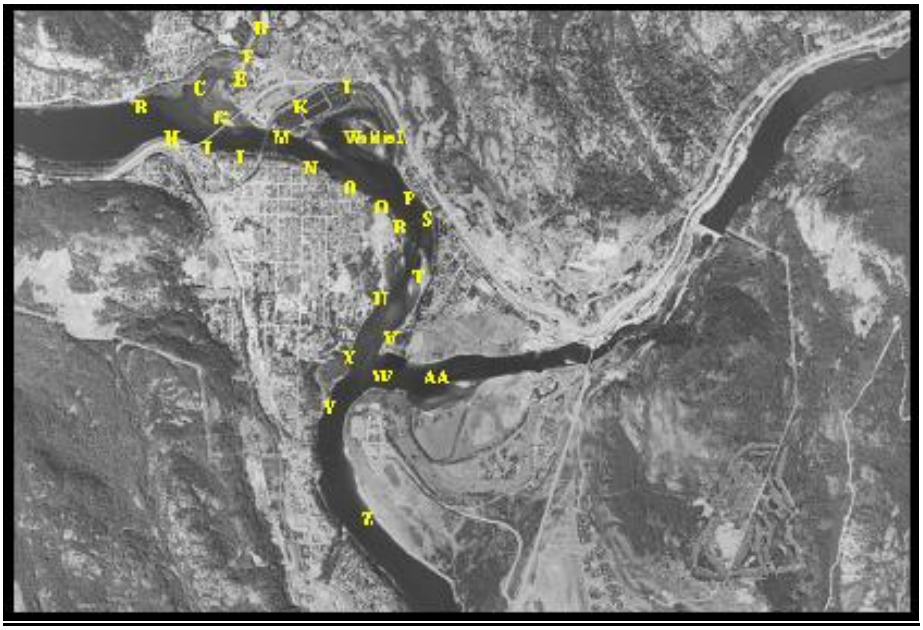


Figure CLBMON-49-6 Locations of off-island forage sites used by Waldie Island GBH (taken from Machmer 2003)

Monitoring of Overwinter Habitat, and Collection of Environmental and River Flow Data

Habitat data will be collected during ground surveys over the course of the winter to verify and supplement the habitat suitability models derived from digital elevation models downstream of Hugh Keenleyside Dam. The objective of the surveys will be to verify the distribution and extent of suitable shallow-water foraging habitat along the lower Columbia River as river flows vary, and determine whether high flows and water levels limit the availability of these habitats during the early winter period. Data collected will include water depth, water velocity, turbidity, water and air temperature, emergent vegetation, ground cover, substrate, and disturbance.

The surveys will be conducted along the lower Columbia River from the sewage treatment facility to the Kinnaird area. The first survey will be carried out during the early winter period when river flows are higher and more variable (early December), preferably when water elevations are expected to be at or exceed 421 m. The survey will be repeated in early January when flows are lower and more stable. While much of the study area is accessible by foot, it is expected that access to some sites will require use of a boat.

As flows and water elevations in the Waldie Island area fluctuate daily and seasonally as a function of releases from Hugh Keenleyside Dam and backwatering effects created by

releases from Brilliant Dam on the Kootenay River, water elevations will be referenced to the Norns Creek Fan Gauge[2]. Data on flow rates, air and water temperature, and precipitation at Hugh Keenleyside Dam will be obtained from BC Hydro for the duration of the study period.

Monitoring Habitat Use during the Breeding Season: Revelstoke Reach

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. Great Blue Herons departing from the colony will be tracked visually to foraging sites. During each observation session, information on GBH numbers, type of foraging habitat (riverine, inland stream, terrestrial), distance from nest, foraging time and frequency, capture rates and prey species will be collected. Time of day and weather conditions will also be recorded during each session. Any sightings of foraging activity by fledglings will be recorded incidentally during each survey. Information on the location, number of birds and habitat type will be collected for each sighting. Night vision goggles will be used to aid in monitoring foraging activity at night fall and at dusk.

A minimum of three reconnaissance-level habitat surveys will be conducted each year to determine the distribution and extent of shallow-water foraging habitat along Revelstoke Reach under different hydrologic conditions. The first survey will be carried out during the early part of the breeding season (April) when reservoir elevations average about 425 m (1395 ft). The survey should be repeated in June and again in mid July, by which time the reservoir is normally at its maximum pool elevation of 440 m (1444 ft).

Data collected will include habitat type, substrate, ground cover, size of habitat area, water depth and water velocity. Reservoir water elevation data will be obtained from a stage monitoring station installed in Reach 2 of the mid Columbia River under CLBMON #15a Middle Columbia River Physical Habitat Monitoring. Terrestrial shoreline data will be available from the Arrow Lakes Vegetation Inventory (CLBMON #33). While much of the study area is accessible by foot, it is expected that access to some sites will require use of a boat. Additional data will be acquired from the Arrow Lakes Reservoir Shorebird and Waterbird Monitoring Programs (CLBMON #38 and CLMBMON #40, respectively) and from GPS data loggers should GBH captured at Waldie Island return to Revelstoke Reach to breed.

2.3.3 Task 3: Data Analysis

Overwinter Habitat Selection

GPS data loggers will be retrieved at the end of the breeding season prior to the post-nuptial molt (late summer). Telemetry data will be analyzed at three spatial scales to assess overall movement patterns (movement between Waldie Island and breeding colonies; H_3), broad-scale habitat selection, and finer-scale habitat selection to

[2] Note: The recommended late fall/early winter elevation constraint of 421 m was based on observed habitat conditions and GBH use at elevations recorded at the Robson gauge. Using the Norns Creek discharge rating curve, the minimum elevation constraint would be 420.7 m.

determine habitat selection functions (Erickson et al. 2001). Broad-scale habitat selection will be conducted use chi-square analysis to test habitat use versus habitat availability. Logistic regression will be used to determine resource selection functions. These analyses will incorporate water flow data, environmental data (weather patterns), fish abundance, habitat attribute data (substrate, ground cover, water depth, etc.) and habitat availability (as modeled using the DEM using GIS) to assess the effects of river flow and water elevation on the availability of foraging habitat and on the foraging ecology of overwintering GBH (H_1 and H_2).

Monitoring Habitat Use during the Breeding Season: Revelstoke Reach

If GPS telemetry data are obtained from GBH at the Revelstoke colony (originally captured and tagged at Waldie Island), the telemetry data will be used to assess habitat selection and determine habitat selection functions as described above. If GPS telemetry data are not obtained from GBH at the Revelstoke colony, then observational data will be used to determine habitat selection and to test for correlations between forage habitat selection, prey selection, location and distance from the nesting colony, and reservoir water elevations at seasonal and annual time scales (H_4).

A second component of the analysis will be to evaluate whether GBH nesting at the Revelstoke colony are the same individuals that are observed on Waldie Island (H_4), and whether there are other areas in the West Kootenay region that provide important overwintering habitat. This information will be obtained from the GPS telemetry data acquired from GBH tagged on Waldie Island, and assessed using GIS and home range of software.

2.3.4 Task 4: Reporting

Following the pilot study in Year one, a detailed report will be prepared describing the capture and tagging methods employed, and summarizing the results of the GPS telemetry data. A detailed animal capture and tagging protocol will also be included describing the recommended capture techniques and procedures for tagging animals for use in subsequent years.

In Years 2 and 3 of the study, brief annual progress report will be prepared describing the results of GBH capture and tagging. and the effort expended to monitor GBH and survey foraging habitat.

A comprehensive report will be prepared at the conclusion of the study (Year 4), which will include:

- an executive summary;
- a description of the methods employed;
- a data summary;
- a comparison of results among years;

- a detailed summary of the findings as they relate to the ecological hypotheses and the key management questions;

- any recommendations for (i) modifying early winter operations to reduce impacts on the overwintering GBH population at Waldie Island or (ii) undertaking physical works (e.g., enhancing or creating suitable shallow-water foraging habitat capable for supporting fish prey); and

- A digital appendix with:

    - A database of GPS telemetry.

    - A database of Heron monitoring data

    - A database of habitat and environmental data

Reports will follow the standard format for WUP monitoring projects. All reports will be provided in hard-copy (6 copies) 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

Results of the monitoring program will be used to inform on the importance of Waldie Island as a wintering site for GBH from the Columbia Basin population, and whether modifications to the early winter flow regime in the lower Columbia River, or physical works in lieu, should be considered for protection of important foraging habitat. Specifically, the data will help to identify linkages between flow magnitude, physical habitat variables, and forage habitat selection of GBH aggregating at Waldie Island. Analysis of these relationships should provide a better understanding of the relative importance of flow on GBH forage ecology and overwinter survival.

It will be important to integrate the results of this study with other GBH monitoring programs in the Columbia Basin, such as the ongoing GBH monitoring project funded by the Columbia Basin Fish and Wildlife Compensation Program and its partners.

2.5 Schedule

The monitoring study will be conducted over four consecutive years during the implementation of the Columbia River Water Use Plan (Tables CLBMON-1a and -1b). A pilot study to determine the effectiveness of capture techniques will be conducted in the first year (Table CLBMON-49-1a). The capture and tagging of GBH will be undertaken in late October-early November as the birds begin arriving at Waldie Island. Surveys of foraging habitat within the study area will be conducted once during the pre-whitefish flow period when flows are higher and more variable (early December) and again during the whitefish flow period when flows are lower and more stable (early January).

Surveys of foraging habitat within the Revelstoke Reach will be conducted on three occasions to capture conditions between minimum and maximum reservoir elevations.

Monitoring of GBH foraging behaviour will be conducted during the nesting period until such a time that the majority of adults have dispersed from the colony (i.e., August).

2.6 Budget

The average annual cost of the monitoring program is estimated at $153,138. Table CLBMON-49-2 provides a detailed estimate of the distribution of annual costs of monitoring program implementation, assuming a 2% rate of inflation and 5% contingency. The average annual cost of the monitoring program exceeds the estimated annual cost of $80,000 for the two monitoring programs proposed suggested by the Consultative Committee. This difference is due to revisions made to the data collection procedures and scope of the field surveys from that originally envisioned by the Committee. These modifications to study design were considered necessary to increase the intensity and effectiveness of the monitoring, and to improve the quality and informative value of the study.

Table CLBMON-49-1a Schedule for Year 1 – Pilot Study

	2009					2010				
Task	Jan to Aug*	Sept	Oct	Nov	Dec	Jan	Feb	June	July	Aug
1. Project Coordination	√	√	√	√	√	√	√	√	√	√
2a. Capture and tagging			√	√						
2b.Tag Retrieval								√		
3. Data Analysis									√	
4b. Reporting								√	√	√
4a. Prepare Capture Protocol					√	√				

* includes time for making applications for required permits

Table CLBMON-49-1b Schedule for Years 2, 3 and 4 (2011 to 2013)

Task	Sept	Oct to Nov	Dec to Feb	Apr	May	June	July	Aug	Sept	Oct
1. Project Coordination	√	√	√	√	√	√	√	√	√	√
2a. Capture and tagging		√								
2b Winter Monitoring			√							
2c Spring Monitoring				√	√	√	√			
2d. Tag retrieval						√				
3. Data Analysis							√	√		
4. Reporting									√	√

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Personal Communications

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