Columbia River Water Use Plan

Monitoring Program Terms of Reference

- **CLBMON-49: Lower Columbia River Effects on Wintering Great Blue Herons**

Revision 2
December 31, 2014

CLBMON-49
Lower Columbia River Effects on Wintering Great Blue Herons Monitoring Program Terms of Reference

1.0 MONITORING PROGRAM OVERVIEW

1.1 Background

The Great Blue Heron (*Ardea herodias*) is a large colonial-nesting bird that lives throughout North and Central America. In British Columbia, there is a coastal subspecies, *Ardea herodias fannini*, and an interior sub-species, *Ardea herodias herodias* (Campbell et al. 1990). Both sub-species are blue-listed by the province, and the provincial *Wildlife Act* provides year-round protection for herons and their nests (Gebauer and Moul 2001). Herons and their nests are also protected under the federal *Migratory Birds Convention* Act, and the coastal sub-species is listed as a species of Special Concern under Schedule 1 of the federal *Species at Risk Act*. In the Columbia Basin, the interior sub-species of the Great Blue Heron (GBH) forages in wetlands and along the margins of lakes and slow-moving rivers (Machmer & Steeger 2004). The herons often nest in old deciduous forest stands, such as black cottonwood, but also use coniferous stands. Some interior Great Blue Herons migrate south during the winter; however, other herons stay in the Columbia Basin and forage where water remains open throughout the winter (Machmer, 2003).

From October through February during most recent winters, Great Blue Herons have congregated at Waldie Island downstream of the Hugh Keenleyside Dam near Castlegar (Machmer 2001, 2002, 2003) (Figure 1). Machmer (2003 p. 18) suggested that Great Blue Herons have likely assembled at Waldie Island "*when shallow water foraging habitat and access to fish prey is limited elsewhere, because of high water elevations, freezing conditions, and human and other forms of disturbance*." The report provided six recommendations (Machmer, 2003 p. 20):

i. BC Hydro maintain water elevations at or below approximately 421.0 m [420.7 m][1] elevation during November and December.

ii. BC Hydro maintain water elevations at or above 418.7 m [418.4 m][1] from March to July to discourage access and reduce disturbance from people and dogs during the nesting season.

iii. Consider the purchase of Breakwater Island, the mainland foreshore and the adjacent wetland and manage the area to a) minimize disturbance to wintering heron aggregations, b) promote heron breeding activity, c) protect other wetland-dependent species, and d) replace signage and enforce trail regulations regarding leashing of pets.

[1] The elevation recommendations of 421.0 m and 418.7 m were based on elevations recorded at the Robson gauge. Using the Norns Creek discharge rating curve, the respective elevation constraints are 420.7 m and 418.4 m.

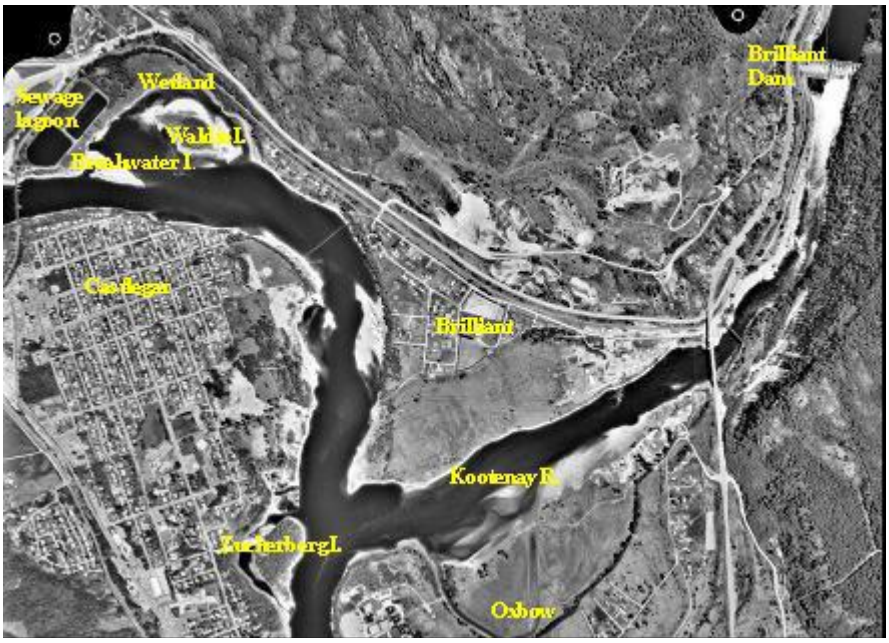

Figure 1 – Location of Waldie Island near Castlegar, BC on the lower Columbia River

iv. Develop regulations barring use of motorized watercraft near Waldie Island.

v. Initiate an awareness campaign about the breeding use of Waldie Island by herons to minimize disturbance during the incubation and chick-rearing periods and encourage heron viewing from a safe distance.

vi. Given the observed relationship between great blue herons and flows in the Columbia System, it is recommended that this issue be considered in the context of the Columbia Water Use Plan.

As per recommendations (i), (ii), and (vi), the BC Hydro's Columbia Water Use Plan considered the relationship between Great Blue Herons and the flows for whitefish (*Prosopium williamsoni*) (BC Hydro, 2005a). Each December, BC Hydro releases higher flows from the Lower Arrow Lake Reservoir for whitefish and the incubation of whitefish eggs while addressing requirements under the international Columbia River Treaty.

To address "*whether there was an operational link between the mountain whitefish flows and impacts to herons on Waldie Island*" (BC Hydro, 2005a pp. 7-120), the Consultative Committee developed a sub-objective to "*maximize winter refuge habitat for Great Blue Heron at Waldie Island.*" (BC Hydro, 2005a pp. 4-23) and outlined two monitoring projects (BC Hydro, 2005b pp. CC-16):

Monitoring Project 1 - Monitoring of the effects of winter flows and river stage (November 15 to March 1) on Great Blue Heron use of the Waldie Island Area (replication of Pandion Study (Machmer 2002, 2003)).

Monitoring Project 2 - Mark and recapture study of Great Blue Herons (juveniles) nesting in colony adjacent to Revelstoke Reach to determine whether birds from this population winter at Waldie Island (November 15 to March 1).

For Monitoring Project 1, regarding winter flows, the Committee suggested three years of monitoring "*to assess the response of herons to flow and stage regime from the Hugh Keenleyside Dam during the winter period due to its potential effects on availability of shallow-water foraging and winter refuge habitats*" and to "*provide information on habitat use and feasible mitigative actions*."

For Monitoring Project 2, regarding the mark and recapture study, the Committee suggested five years of monitoring to "*address uncertainty related to the importance of Waldie Island as a wintering area for the Great Blue Herons that nest near Revelstoke*", and to "*address question around whether these represent the same individuals that may be susceptible to influences of both reservoir and downstream flow operations.*"

As per BC Hydro's revised 2012 Terms of Reference (TOR), Monitoring Project 2 was omitted from this monitoring study due to First Nations cultural concerns and concerns of stakeholders including the risk of injuring herons during the capture process. Furthermore, even if the live-capture methods were known to be safe and reliable, it would be challenging and costly to capture enough herons to enable statistically or ecologically meaningful conclusions.

Subsequent to the Terms of Reference being revised in 2012 a three-year study to address Monitoring Project 1 (i.e., "the operational links between mountain whitefish flows and impacts to herons on Waldie Island") was launched over the winter of 2013–2014. This was the first systematic study of this heron population since 2003–2004 (Machmer and Steeger 2004) and included eight management questions. While progress has been made toward answering several of the questions, results from the first year of the study (Hentze et al. 2014) have shown that ten years after the original studies the narrow focus on Waldie Island and the current low number of Great Blue Herons wintering there are no longer adequate to answer some of the management questions as they were written in the revised 2012 TOR (BC Hydro). Specifically, the focus on Waldie Island means the study is constrained by a very small habitat patch (~0.008 km^2) for a species that can make daily and seasonal movements in the order of kilometers and hundreds to thousands of kilometers, respectively. Furthermore, the low number of herons observed (maximum count 7) on the island in the first year of study (i.e., 2013/2014) will not permit the study team to address the main purpose of this study: i.e., "the operational links between mountain whitefish flows and impacts to herons on Waldie Island" (BC Hydro 2005a).

An additional consideration for a study in which management questions were also posed as testable hypotheses was the inability to experimentally influence the key variable: i.e., rate of release from the Hugh Keenleyside Dam. For this reason and those mentioned above, BC Hydro has re-assessed the TOR and made substantial revisions to it. In the following section the rationale for the key changes to the 2012 revised TOR are summarized.

1.2 Rationale and Summary of Key Revisions

In order to address the limitations of this study, the principal change to this TOR is to add a strong habitat suitability component to what has been a count based study. The low numbers of GBH (maximum count 7) are well below the minimum necessary to address the study's management questions. In support of a regional habitat suitability approach, BC Hydro will broaden the spatial focus of the study to include other areas in the Kootenay region where GBH are known to overwinter and compare the attributes of those habitats with the habitat at Waldie Island and the surrounding Castlegar area. This methodology will allow investigators to describe in more detail than previously, the habitat attributes at Waldie Island and other sites in the Kootenay region, and allow them to assess how operations affect the amount of habitat that is available to GBHs, as opposed to relying on seasonal counts of an uncommon species in a very small area of its potentially available winter habitat. Adding a habitat suitability element to the continuing count-based study is the most effective way to reach the original goal of CLBMON-49 which is to measure how changes in BC Hydro's operations (i.e., changes in water elevation and flow) affect heron habitat at Waldie Island.

In order to justify the altered approach, the management questions as ordered in the 2012 Terms of Reference (BC Hydro 2012) are presented below along with recommendations for deleting, combining or restating them:

1) How does the flow *regime* in the lower Columbia River influence the number of Great Blue Herons that roost on Waldie Island between November 15 and March 1?

   This management question is deleted. It is not possible to confidently address questions regarding how flows affect the number of GBH's at Waldie Island in the project's timeframe without being able to manipulate flows experimentally. Furthermore, even if flow manipulation was feasible, the recent count results at Waldie Island are not sufficient to establish a meaningful cause and effect relationship between flows and heron numbers.

2) *Are there operational* changes *that could improve Waldie Island as a roosting location for Great Blue Herons?*

   Based on the occurrence of winter herons in other local areas, the focus only on Waldie Island is no longer justified. This question is thus being merged with the very similar Management Question #7. A new management question is shown below as Management Question #10.

3) *Where are the shoreline areas that* are *used by Great Blue Herons?*

   This question remains unchanged.

4) *How does the flow regime affect the area,* distribution*, and attributes of shoreline areas?*

   This question remains unchanged.

5) *How does the flow regime in the lower* Columbia *River influence the total number of Great Blue Herons that forage along the shorelines in the vicinity of Waldie Island?*

   This management question is deleted. As per Management Question #1, experimental manipulation of BC Hydro's operations and sufficient sample size are required in order to answer this management question in the timeframe allocated for this study. Furthermore, nocturnal heron surveys would be required because herons forage at night which would raise the cost and risks to personnel, of this study substantially.

6) *How does the flow regime in the lower Columbia River influence the distance between Great Blue Herons that are foraging* in *shoreline areas (i.e., the number of herons foraging/site)?*

   This management question is deleted. As per Management Questions #1 and #5, the study team requires experimental manipulation of BC Hydro's operations and sufficient sample size in order to answer this management question. In addition, without specific studies to address prey availability, and the effects of flow on prey availability, the current methods would still not answer the question. There is no straightforward way to examine prey abundance within the constraints of this program, so the study must assume that fish presence or absence is not a factor affecting the availability of suitable habitat for foraging. Such an assumption is, of course, likely to compromise either a positive or negative finding.

7) *Are there operational changes that could improve* the *availability of suitable shoreline areas for the Great Blue Herons from Waldie Island?*

   This question is being merged with the very similar Management Question #2. A new management question is shown below as Management Question #10.

8) *Are there physical works that could improve the* availability *of shoreline areas for the Great Blue Herons from Waldie Island?*

   Rephrased to: Are there physical works that could improve the availability of suitable shoreline areas for Great Blue Heron on Waldie Island and in the Castlegar area?

   Herons do not appear to be 'from' Waldie Island. The question is rephrased to reflect shoreline availability to herons in the general area and makes no distinction about the origins of any observed GBH.

9) *How does the suitability of winter habitat on Waldie Island and in the Castlegar area compare to habitat used by wintering Great* Blue *Herons elsewhere in the surrounding region?*

   This is a new management question that reflects the expanded study area. By assessing attributes of heron distribution and habitat utilization elsewhere in the region in winter, the study team can better assess the comparative conditions for roosting and foraging herons in the Castlegar and Waldie Island area. Once that is known, it is more straight forward to infer how flow regime might affect those

conditions, which, ultimately, is what Management Questions #1, #5, and #6 (i.e., the ones that are deleted) were trying to address.

10) *Are there operational changes that could improve* habitat *availability and suitability for Great Blue Herons at Waldie Island and in the Castlegar area?*

This is a newly proposed management question that merges the earlier Management Questions #2 and #7. Their original focus was operational changes that could improve roosting habitat and the availability of shoreline areas respectively. Roosting habitat is often on shoreline areas (individuals were more often observed roosting on shorelines areas than in trees during Year 1 field studies), so to eliminate redundancy these questions should be integrated. A further broadening of the question scope from Waldie Island to the Castlegar area is warranted as suitable and available habitat exists outside of Waldie Island proper that is also potentially affected by river elevation and flows. The new wording of this question is sufficient to cover roosting habitat, foraging habitat, the suitability of these habitats relative to shoreline availability and how they are affected by flows.

1.3 Revised Management Questions for CLBMON-49

This section reiterates the intent of the Consultative Committee and specifically lists the management questions that will be answered by this revised study.

The intent of Monitoring Project 1 as outlined by the Consultative Committee is to:

- Address "*whether there was an operational link between the mountain whitefish flows and impacts to herons on Waldie Island;*"
- *"Assess the response of herons to flow and stage regime from the Hugh Keenleyside Dam during the winter period due to its potential effects on availability of shallow-water foraging and winter refuge habitats,"* and
- "*Provide information on habitat use and feasible mitigative actions*."

The monitoring project for CLBMON-49 will address the following management questions:

1) The original Management Question # 1 deleted.[2]

2) The original Management Question # 2 incorporated into the new Management Question #10.[3]

3) Where are the shoreline areas that are used by Great Blue Herons?

[2] The original Management Question # 1 was: "How does the flow regime in the lower Columbia River influence the number of Great Blue Herons that roost at Waldie Island between November 15 and March 1?"

[3] The original Management Question # 2 was: "Are there operational changes that could improve Waldie Island as a roosting location for Great Blue Herons?"

4) How does the flow regime affect the area, distribution, and attributes of shoreline areas?

5) The original Management Question # 5 deleted.[4]

6) The original Management Question # 6 deleted.[5]

7) The original Management Question # 7 incorporated into the new Management Question #10.[6]

8) This management question has been rephrased: Are there physical works that could improve the availability of suitable shoreline areas for Great Blue Heron on Waldie Island and in the Castlegar area?[7]

9) How does the suitability of winter habitat on Waldie Island and in the Castlegar area compare to habitat used by wintering Great Blue Herons elsewhere in the surrounding region?

10) Are there operational improvements that could improve habitat availability and suitability for Great Blue Herons at Waldie Island and in the Castlegar area?

1.4 Management Hypotheses for CLBMON-49

The three null hypotheses proposed in the 2012 Terms of Reference have been removed. As discussed above, and given the operating constraints outlined in the Consultative Committee report (BC Hydro, 2005a), there are no opportunities for manipulative experiments to evaluate the effect of water elevations on Great Blue Herons at Waldie Island. Furthermore, due to the low number of herons observed (maximum count 7) in the first year of study (2013–2014) combined with the change in methodology to include habitat suitability data into what previously was primarily a count-based study, the null hypotheses that were proposed in the 2012 TOR (BC Hydro) are no longer relevant, or testable.

1.5 Key Water Use Decision Affected

The key operating decisions affected by this monitoring program are the following:

Should the winter flow releases from Arrow Lakes Reservoir be altered to mitigate potential impacts of high river elevations on overwintering Great Blue Herons in the vicinity of Waldie Island?

[4] The original Management Question **#** 5 was: “How does the flow regime in the lower Columbia River influence the total number of Great Blue Herons that forage along the shorelines in the vicinity of Waldie Island?”

[5] The original Management Question # 6 was: “How does the flow regime in the lower Columbia River influence the distance between Great Blue Herons foraging in shoreline areas (i.e. the number of herons foraging/site)?”

[6] The original Management Question **#** 7 was: “Are there operational changes that could improve the availability of suitable shoreline areas for the Great Blue Herons from Waldie Island?”

[7] The original Management Question **#** 8 was: “Are there physical works that could improve the availability of shoreline areas for the Great Blue Herons from Waldie Island?”

The monitoring project will provide information on how the current flow regime in the lower Columbia River affects the foraging ecology and overwinter survival of Great Blue Herons.

The monitoring project might suggest changes to the flow regime that would improve the availability of shoreline winter foraging areas for Great Blue Herons.

The project would also consider whether there are physical-works projects that would enhance or create suitable shallow-water foraging areas for the over-wintering Great Blue Herons.

2.0 Monitoring Program Proposal

2.1 Objectives and Scope

The broad objectives given to this monitoring program by the Consultative Committee are to:

- Address whether there is an operational link between the mountain whitefish flows and impacts to herons on Waldie Island;
- To assess the response of herons to flow and stage regime from the Hugh Keenleyside Dam during the winter period due to its potential effects on availability of shallow-water foraging and winter refuge habitats, and
- Provide information on habitat use and feasible mitigation actions.

This monitoring program has been designed to take place over three consecutive winters starting in 2013–2014 and ending after the 2015–2016 winter. It will address the program's management questions through habitat analysis and Great Blue Heron counts at Waldie Island, other areas near Castlegar, and other locations within the Kootenay Region during the period of the project.

2.2 Methods

2.2.1 Task 1: Project Coordination

Project co-ordination involves the general administration and technical oversight of the program, which will include, but may not be limited to the following:

i. budget management,

ii. management of project team,

iii. co-ordination of logistics and safety,

iv. technical oversight of field work, data collection, and data analysis, and

v. facilitation of information transfer among other investigations.

2.2.2 Task 2: Sampling Program

2.2.2.1 Monitoring of the Overwintering Heron Population

The proposed monitoring program for CLBMON-49 will assess whether operational activities (water flow and elevation) related to the Hugh Keenleyside Dam have an impact on the habitat availability and suitability to wintering Great Blue Herons downstream of the dam (Waldie Island and Castlegar areas). The methods utilized will involve counting herons and collecting habitat data at monitoring locations surveyed around Castlegar in Year 1 of the study (Hentze et al. 2014), and at pre-selected areas in the greater Kootenay region (see Site Selection below). At each site the study team will collect data on heron abundance (number of individuals), heron behaviour (e.g., foraging, preening, resting), heron location relative to physical features (e.g., water edge, in tree, on field), shoreline habitat and biophysical attributes (e.g., water chemistry, turbidity, substrate), and associated environmental information (e.g., air temperature, wind speed, precipitation). Additional data on water flow rates and water elevation in the Castlegar area will be provided by BC Hydro. Climate data will be compiled from Environment Canada. Data collected during this study will inform management recommendations related to operations or physical works. The proposed methods will address habitat availability in the Castlegar area at different water elevations, and will determine the suitability of that habitat in a regional context.

Similar investigations will occur throughout the Kootenay Region (e.g., Revelstoke, Creston Valley Wildlife Management Area, Invermere) to determine the relative importance of Waldie Island for overwintering Great Blue Herons.

2.2.2.2 Site Selection

Heron counts will continue in Years 2 and 3 at the Waldie Island area downstream of Hugh Keenleyside Dam as per the 2012 Terms of Reference, but at an increased frequency. In addition to obtaining these count data, additional sites in the Kootenay Region will be visited to assess the availability and suitability of wintering habitat. To determine where these sites will be located, there will be an assessment of maps of potential wintering heron habitat and the incorporation of heron distributions based on existing data (i.e., Christmas Bird Count and eBird) and local knowledge.

Christmas Bird Count data provide somewhat-standardized counts of birds from within specific regions over multiple years (but they are restricted to the mid-December to early January time period). These data may be used to determine where winter aggregations may occur on a coarse-scale. Based on these counts, areas can be categorized as having high, moderate, or low winter heron counts relative to the surrounding region. At least six areas spanning the range of heron counts will be selected. Within each of these areas eBird outputs and local knowledge will be used to determine specific sampling sites. A preliminary map of these areas showing the distribution of counts from regional Christmas Bird Counts with heron presence is shown in Figure 2. This area is being expanded to include adjacent areas of the Columbia watershed in northern Washington State. No field work is planned in Washington State.

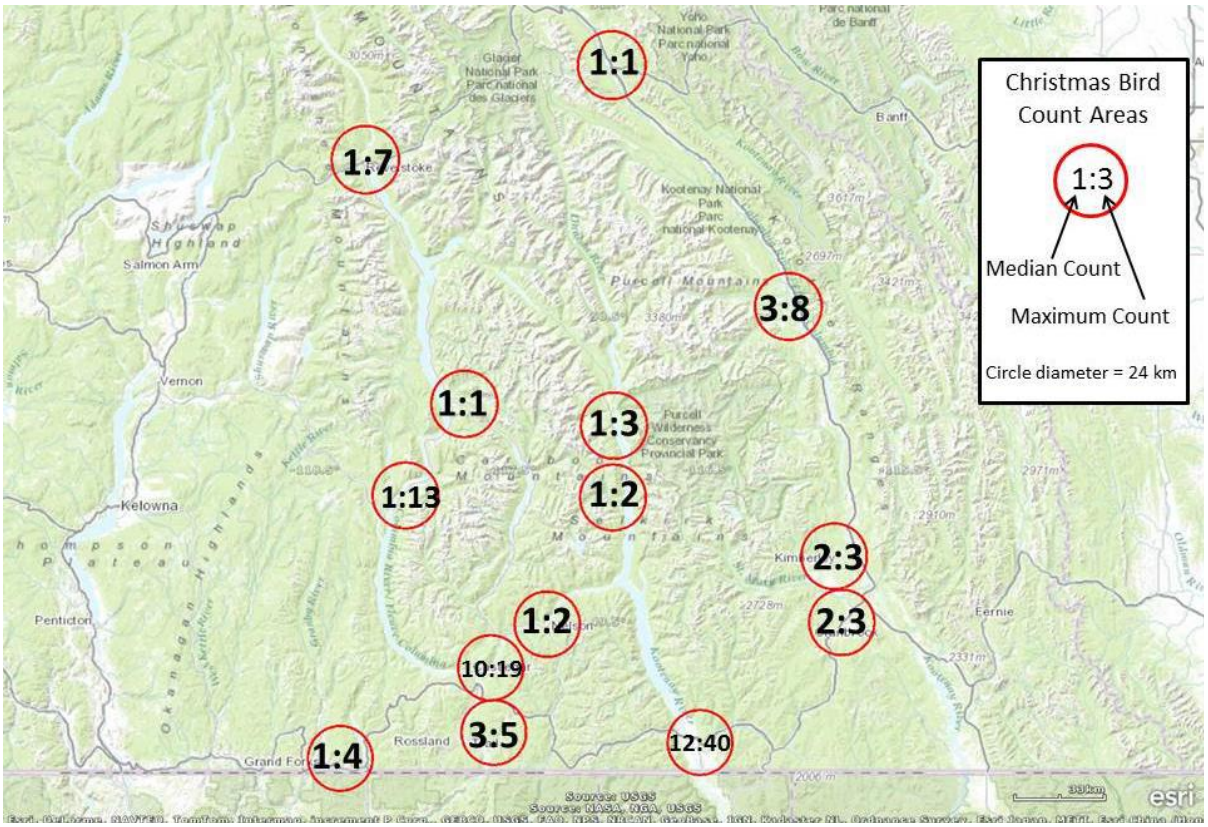

Figure 2: Median and maximum counts of Great Blue Herons from all Kootenay region Christmas Bird Counts where heron presence was reported

From Figure 2, Creston and Castlegar have high abundances of herons relative to the surrounding areas. Nakusp, and Invermere have moderate numbers, and the remaining sites have low numbers. A sampling plan may look to assess winter habitat availability from Castlegar, Creston, Nakusp, Invermere, Revelstoke, and Kimberley. Selecting these sites will help to ensure that habitat data are obtained from areas with high, moderate and low abundances of herons, which is presumed to be an indication of habitat availability and suitability. Note that there is a tendency for more herons to be observed in the southern Kootenays in the winter, which is likely related to warmer temperatures and less snow. This assumption requires testing and will be considered when determining winter habitat suitability.

Because the emphasis is broadening to include a habitat suitability assessment to address the project's management questions and the attributes important for wintering herons remain unknown, it is difficult to provide numerical data to support the selection of six or more sites for habitat sampling. Based on the Christmas Bird Count Data it appears there are at least 14 areas where herons have been observed in the winter. Many of these areas are associated with few records and are presumed to provide little to no wintering habitat for herons. Six sites were selected for habitat studies because (1) this number represents a realistic number of sites that could be accessed and sampled in a single 12 day field session, (2) the sites selected are representative of areas where high, moderate, or low numbers of herons have been historically observed in winter, and (3), sampling six of 14 known "winter" locations represents approximately 43 per cent of the mapped sites. Within those sites,

100 per cent of the high abundance sites will be sampled (Castlegar and Creston), approximately 50 per cent of the moderate sites will be sampled (Nakusp and Kimberley), and although a lower proportion of low sites are proposed (approximately 30 per cent), the sites selected are representative of the range of habitats available (as is presently known) in the winter in the Kootenay region.

2.2.2.3 Heron Observations; Abundance and Distribution

Upon arriving at a site, all visible shoreline and surrounding trees will be surveyed for heron presence and abundance (RISC 1998a). Initial scans will be conducted by naked eye, and with the aid of 8x or 10x binoculars. Herons are large and conspicuous birds when perched in the open; however, they can be considerably less visible when perched in trees or tucked into shoreline rocks or vegetation. For this reason, a more detailed scan using a 20-60x spotting scope will also be conducted (RISC 1998a). The total number of herons present (if any) will be recorded, and whenever possible, each individual will be aged based on plumage characteristics.

A range finder will be used to accurately measure distance, and a compass bearing recorded, from the georeferenced observation location to the bird(s). The physical location of each bird (e.g., 4 m from shore in river, 10 m high on outer branch of tree, etc.) will also be noted.

Natural or anthropogenic factors influencing heron use of a site, such as human or wildlife-induced disturbances, will be noted. As Bald Eagles are known predators of Great Blue Herons (Vennesland and Butler 2011), and have the potential to affect heron density and distribution, all eagle observations will be recorded, regardless of their perceived activity.

While one person conducts the initial scan, a second person will document on standardized data sheets the date, site, time of survey (both start and end will be recorded), and environmental conditions of air temperature, relative humidity, and wind speed (measured with a Kestrel portable weather station), and cloud cover, ceiling, and precipitation.

In addition to these surveys, daily observations will be conducted on Waldie Island, Breakwater Island, and the adjacent shorelines by a Castlegar resident. Several residents are interested in the herons, and already collect such data (as was presented in the Year 1 report) from their river-view homes. Daily observations provide greater resolution of counts and shoreline use than the previous once- or twice-monthly surveys could provide. For a stipend to cover expenses, citizen-observers might also be able to check other locations in the vicinity, such as the back channel of Waldie Island, or the sewage lagoons.

2.2.2.4 Behavioural Observations

The behaviour(s) of each heron will be recorded. Thus, each heron observed will have its behaviour categorized as foraging, preening, resting, alert, walking (but not foraging), or flying. This can be done in conjunction with determining the bird’s age and location.

2.2.2.5 Shoreline Habitat and Habitat Suitability

Habitat surveys will be completed at each study site. These surveys will record the same information as that collected in Year 1, with the same methods. At each site observers will take multiple photographs (upstream, downstream, cross-stream, inland, stream bottom and datasheet at a minimum), and record the general physical attributes of the shoreline areas. These include stream habitat type (riffle, rapids, straight run, or pool/back eddy), surrounding vegetation (presence and dominance of vegetation groups: shrubs, deciduous trees, coniferous trees, other [specified]), width of shoreline (from vegetation or road to water's edge), length of shoreline, and locations of sources of disturbance (e.g., roads, walking paths). The periphyton and macrophyte coverage, as well as dominant substrate will also be recorded. Water depth will be recorded using a rule stick to the nearest centimetre, water velocity will be measured using a water flow probe held 40 per cent from the bottom of the stream at the sampling location (turbo-prop mounted to a handle) or using a head rod measurement technique (CABIN 2012) (m/s), water turbidity using a YSI 6-Series Sonde and/or turbidity wedge (NTU), pH, and substrate (dominant substrate). The dissolved oxygen content (mg/L), water temperature (˚C), and specific conductivity (µS/cm) will be measured using a handheld YSI Pro2030 multi-function metre. The parameters to be sampled will give an indication of the productivity potential at each site, which in turn indicates the ability of a site to support healthy invertebrate populations and hence also fish and herons (Table 1). All data will be recorded on standardized datasheets printed on waterproof paper. A minimum of three sampling locations will be chosen at each site for the physical attribute sampling, each separated by ~10 m.

Prior to measuring any streamside variables, a safety assessment will be conducted by the appropriately trained field crew. Given the time of year of these surveys, some shoreline monitoring may not be possible at all sites if ice limits access to shoreline areas or poses elevated safety risks. If such conditions limit surveys at a given point, an alternative safe location will be searched for. Shoreline surveys will be conducted during all field visits.

Table 1: Physicochemical and environmental variables to be collected during shoreline sampling at each survey site. Definitions and justifications for the measured parameters were compiled from the Canadian Aquatic Biomonitoring Network (CABIN 2012) and Guidelines for Interpreting Water Quality Data (RISC 1998b).

Parameter	Definition and Justification
Dissolved Oxygen (mg/L)	Dissolved oxygen (DO) is the amount of oxygen dissolved in water, and is essential for respiratory metabolism of most aquatic organisms. The concentration of DO is a function of daily and seasonal factors such as temperature, photosynthetic activity and river discharge. Higher concentrations of DO are generally considered better for supporting diverse animal communities.
Specific Conductance (µS/cm)	A measurement of the ability of water to conduct an electric current. Conductivity is affected by temperature, and specific conductance is temperature corrected conductivity. Specific conductance values increase with greater ion concentration in the water, and can be used as an alternative measure of dissolved solids. It can be used to indicate potential pollution.

Parameter	Definition and Justification
pH	pH is a unit-less measurement of hydrogen-ion concentration in the water, ranging from acidic to basic. Lethal effects on aquatic life occur below pH 4.5 (too acidic) and above pH 9.5 (too basic), and young fish and aquatic insects are especially vulnerable to extreme pH values. Water within a pH range of 6.5 to 9 is optimal for the greatest diversity of aquatic organisms.
Temperature (˚C)	Temperature is the intensity of heat stored in a volume of water. Temperature affects the solubility of compounds which can exacerbate the effects of pollutants. In addition, cold water is more likely to support ice formation which can impact a heron's ability to forage.
Turbidity (NTU)	Turbidity is a measure of the clarity of water due to suspended particulate matter. It is measured in Nephelometric Turbidity Units. More turbid water has greater particulate matter and appears murkier. Water with high turbidity is associated with decreased oxygen levels, decreased photosynthetic activity, disease-causing micro-organisms, reduced growth rates of fish or other aquatic organisms, and cessation of egg and larval development.
Macrophyte and Periphyton coverage	Macrophyte coverage refers to the quantity of rooted aquatic vegetation that was present within the water or its reach, including submergent, emergent, and floating vegetation. Periphyton is a mix of algae, detritus, cyanobacteria and microbes that are attached to submerged surfaces. Together these characterize benthic macroinvertebrate microhabitat.
Substrate Class	Dominant substrate ranges from organic cover to bedrock. Macrophyte and periphyton coverage will be influenced by the substrate type. Herons are expected to be able to utilize most substrates, but certain preferences may exist.
Water Velocity (m/s)	Water velocity is the measure of the speed of water flowing past a specific point in a given period of time. Water velocity may influence a heron's ability to forage.
Presence/Availability of Field Habitat	The presence of fields around each sampling site will be noted as these also provide foraging habitat to herons. As field habitats will only be available to foraging herons when little or no snow is present, the snow depth of these fields (or adjacent surrogates [i.e., roadsides]) will be quantified.

2.2.2.6 Habitat Availability

At all survey locations there will be an assessment of the availability of habitat in proximity to the site. Within a buffer (e.g., 5 km) around each site, the following items will be recorded (1) the presence/proportion of open water, (2) the presence of fields, and (3) the snow depth on the field. In addition, habitat availability will also be assessed. For this study, habitat availability refers specifically to shoal habitat, i.e. areas with water depths of ~ 30 cm. While shoal habitat can be determined for the area downstream of Hugh Keenleyside Dam using a combination of water elevation and LIDAR data, such data are not available at other regional sites. Thus, exposed shoreline is being used as a proxy for habitat availability because it can be measured readily at all sites.

2.2.2.7 Survey Data

All survey data will be provided to BC Hydro in an electronic format that is compatible with BC Hydro/Water License Requirements systems.

2.2.3 Task 3: Data Analysis

The report for each year will include an index of suitability that is based on a combination of heron presence and abundance, habitat data, and proximity to other foraging habitat.

3.0 Budget

Total Revised Program Cost: $268,237

Table 3: CLBMON-49 Key Changes and Rationale for Revised TOR

CLBMON-49 TOR		
Section	**Change From Original TOR to the Current Revised TOR**	**Rationale**
Overall	Intermittent editing	Edited to provide background for study modifications, improve clarity and consistency
Background	Medium changes to wording	Edited to update and clarify
Management Questions	All - minor changes to wording	Edited to improve clarity and consistency
Management Questions	Added Question 9	Added to assess the availability and suitability of winter heron habitat at Waldie Island in the context of similar habitat in the Kootenay Region
Management Questions	Rephrase Questions 2 and 7 into Question 10	Reworded to expand study focus beyond Waldie Island to include Kootenay Region
Management Questions	Rephrase Question 8	Reworded to introduce need to assess habitat suitability and expand the study focus beyond Waldie Island to include the Kootenay Region
Management Questions	Removed Questions 1, 5 and 6	Removed because experimental manipulation of BC Hydro's operations and sufficient sample size are required in order to answer these management questions.
Management Hypotheses	Removed	Removed because experimental manipulation of BC Hydro's operations and sufficient sample size are required in order to address or test these hypotheses.
Objectives and Scope	All – moderate changes to wording	Edited to identify greater emphasis on habitat data and expansion of study area beyond Waldie Island to include the Kootenay Region.
Methods ALL	Modification	Modified to reflect the current methodologies
Methods - Sampling	Modification	Modified to reflect new approach, methods and data collected
Methods – Data Analysis	Major changes to wording	Modified to reflect the changes to methods and approach

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