Columbia River Project Water Use Plan

Kinbasket and Arrow Lake Reservoirs Revegetation Management Plan

Monitoring Program Terms of Reference

CLBMON-11B Wildlife Effectiveness Monitoring of Revegetation and Wildlife Physical Works in Arrow Lakes Reservoir

Revision 1
June 29, 2017

CLBMON-11B – Wildlife Effectiveness Monitoring of Revegetation and Wildlife Physical Works in Arrow Lakes Reservoir
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1.0 MONITORING PROGRAM RATIONALE

1.1 Background

Riparian habitats in British Columbia and North America have been disproportionately degraded or destroyed by human activities (Campbell et al. 2001, Noss et al. 2001). Dams and reservoir operations have played a significant role in the estimated loss of 87% of high wildlife-value riparian habitat within the Columbia Basin (Moody et al. 2006, Utzig and Schmidt 2011). In British Columbia, about one-half of forest-dwelling terrestrial vertebrate species use riparian habitats during at least one life history stage (Bunnell et al. 1999).

The Columbia River Water Use Plan (WUP) was developed as a result of a multi-stakeholder consultative process to determine how to best operate BC Hydro's Mica, Revelstoke, and Keenleyside facilities in order to balance environmental values, recreation, power generation, cultural/heritage values, navigation, and flood control. The WUP process followed the guidelines established by the Government of British Columbia (BC Hydro 2000; Government of British Columbia 1998) and involved a number of interest groups, First Nations, government agencies and other stakeholders, collectively referred to as the Consultative Committee (CC). Initiated in 2000, the WUP was completed in 2004 (BC Hydro 2005) and was approved by the Comptroller of Water Rights (CWR) in January of 2007 (Comptroller of Water Rights 2007).

During the WUP planning process, a number of reservoir operating alternatives were explored to balance environmental and social values in the Columbia system. While several of these alternatives included changes to the operating regime of the Arrow Lakes Reservoir (specifically maintaining lower, more stable reservoir levels during the spring, summer and fall), the CC recognized that physical works or revegetation in lieu of operational changes may be a more cost-effective means of achieving environmental and social benefits given the value of the foregone power generation associated with these alternatives. Consequently in lieu of maintaining lower reservoir levels, the CC supported the following projects to enhance wildlife habitat in the Arrow Lakes Reservoir (Figure 1-1):

1. A program to increase vegetation growth in the drawdown zone (CLBWORKS-2);
2. Scoping studies to evaluate the feasibility of physical works projects for protecting, enhancing or creating wildlife habitat in the drawdown zone in Revelstoke Reach (CLBWORKS-29A), and in the Upper and Lower Arrow Lakes Reservoir (CLBWORKS-29B); and
3. Informed by projects in 2 (above), Wildlife Physical Works (WPW) projects were implemented by separate programs in Revelstoke Reach

(CLBWORKS-30A), and in the Upper and Lower Arrow Lakes Reservoir (CLBWORKS-30B).

CLBWORKS-2 was a multi-year program throughout the entire Arrow Lakes Reservoir (Figure 1-1) aimed at increasing vegetative cover to meet a number of environmental and social objectives including: (1) maximize vegetation growth in the drawdown zone; (2) provide benefits to littoral productivity and wildlife habitat; (3) improve shoreline stability and control dust; (4) increase the diversity of native plants, particularly those of interest to First Nations; and (5) provide increased protection for known archaeological sites, where possible. These objectives were pursued by applying a variety of treatments at suitable sites including sedge plugs and cottonwood stakes (Keefer *et al*. 2008, Keefer *et al*. 2009, Keefer Ecological Services Ltd. 2010, Keefer Ecological Services Ltd. 2011, Hawkes *et al.* 2014)**.**

In Phase 1 of CLBWORKS-29A (Revelstoke Reach; Figure 1-1), forty-four potential enhancement sites were reviewed, and after an extensive consultation process, eight candidate sites were recommended to BC Hydro for further consideration (Golder 2009a). BC Hydro short-listed five of these sites for further study under the second phase of CLBWORKS-29A, with two WPW projects being accepted for implementation. Both WPW projects were designed to protect productive wetlands that were vulnerable to erosion in Revelstoke Reach: the WPW at Site 6A was designed to prevent an erosion channel from working towards the Airport Marsh; and the WPW at Site 15A reinforced a failing berm at Cartier Bay. Under CLBWORKS-30A, WPW6A was completed in 2013, and WPW15A was completed in 2016.

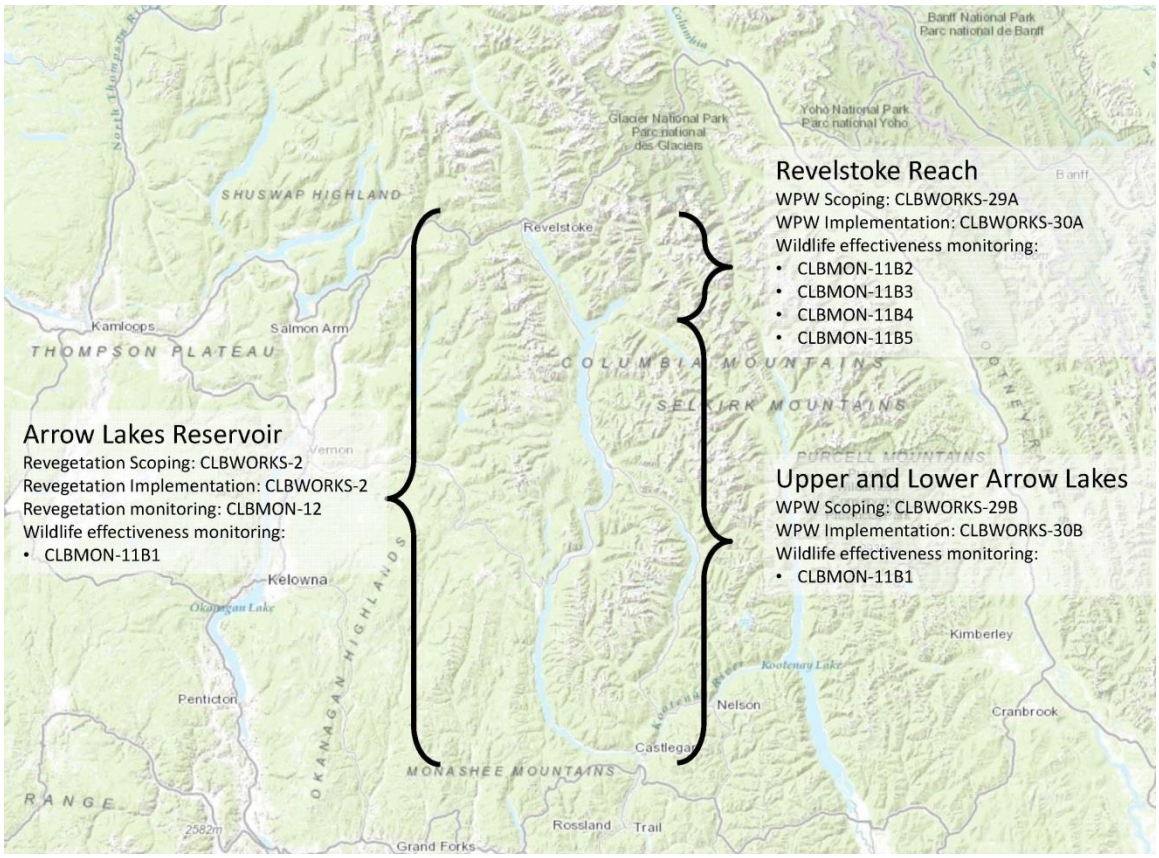
CLBWORKS-29B (Upper and Lower Arrow Lakes; Figure 1-1) identified potential wildlife enhancement prescriptions and protection plans for three sites, but none have yet been developed for implementation. CLBWORKS-30B Implementation is conditional on receiving approval from the CWR.

In association with the above CLBWORKS projects, the CC recommended effectiveness monitoring to evaluate whether the revegetation treatments and WPW projects in the Arrow Lakes Reservoir provide the intended environmental benefits. Effectiveness monitoring is being conducted under:

1. Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis (CLBMON-12), initiated in 2008; and
2. Arrow Lakes Reservoirs Effectiveness Monitoring of Revegetation and WPW (CLBMON-11B), initiated in 2009.

CLBMON-12 is a 10-year program that specifically evaluates plant survival and monitors representative revegetation sites under the various revegetation treatments throughout the entire Arrow Lakes Reservoir. CLBMON-12 also assesses changes in existing vegetation communities at the site (local) level in response to the soft constraints operating regime of the Arrow Lakes Reservoir.

Figure 1-1: A map of the Arrow Lakes Reservoir depicting Revelstoke Reach and the Upper and Lower Arrow Lakes, and the geographic scope of individual projects referenced in this document.



Note that the CLBMON-11B studies monitor effectiveness of both Revegetation projects and Wildlife Physical Works (WPW) projects, although CLBMON-11B modules in Revelstoke Reach are more specialized

CLBMON-11B is a series of studies (modules) that monitor the effectiveness of the revegetation (CLBWORKS-2) and the WPW projects (CLBWORKS-30A, CLBWORKS-30B) with respect to improving the suitability of habitats for wildlife in the Arrow Lakes Reservoir drawdown zone. Five modules were created for CLBMON-11B, which allowed project approaches to be tailored to particular wildlife groups and regions:

- CLBMON-11B1 (Wildlife Effectiveness Monitoring and Enhancement Area Identification for the Lower and Mid-Arrow Lakes Reservoir) is an ongoing module that focuses on effectiveness monitoring in the Upper and Lower Arrow Lakes for both revegetation treatments and WPW projects (Figure 1-1). There is no specialization in the scope of this module, but to avoid overlap with other modules, its primary focus is on habitat enhancements in the Upper and Lower Arrow Lakes.
- CLBMON-11B2 (Arrow Lakes Reservoir: Revelstoke Reach Spring Songbird Effectiveness Monitoring) specifically monitored effectiveness of habitat modifications for the needs of neotropical migrant songbirds during the spring migration. This module focused on Revelstoke Reach where these birds become concentrated in the drawdown zone, particularly during the spring migration as neotropical migrants might benefit from revegetation.

Field study for this module is completed as part of 11B, however since 2012, this component has been delivered as part of CLBMON-39 (Neotropical Migrant Use of Arrow Lakes Reservoir) under the Arrow Reservoir Operations Management Plan.

- CLBMON-11B3 (Revelstoke Reach Western Painted Turtle Monitoring Program) was a module that focused specifically on the Western Painted Turtle population in Revelstoke Reach. Field study under this module is completed.
- CLBMON-11B4 (Monitoring Wetland and Riparian Habitat in Revelstoke Reach in Response to Wildlife Physical Works) monitors the special case of the drawdown zone wetland habitats in Revelstoke Reach, which have high importance for wildlife, and are subject to modification or protection via CLBWORKS-30A WPW projects.
- CLBMON-11B5 (Effectiveness Monitoring of Wildlife Enhancement Structures in Arrow Lakes Reservoir) is a new module added to this TOR revision to monitor wildlife enhancement structures (e.g., bird nest boxes, bat roost structures) in Revelstoke Reach constructed under CLBWORKS-30A and in the Arrow Reservoir under CLBWORKS-30B.

Table 1: Relationships of other WLR monitoring studies and physical works to CLBMON 11B modules

Related WLR Monitoring Studies & Physical Works	11B1 Entire Arrow Lakes Reservoir (Wildlife)	11B2 Revelstoke Reach (Spring Habitat Songbirds)	11B3 Revelstoke Reach (Turtles)	11B4 Revelstoke Reach (Wetland & Riparian Habitat)	11B5 Entire Arrow Reservoir (Bat houses and nest boxes)
Revegetation monitoring (CLBMON 12)	✓	✓	n/a	✓	✓
Bird nest mortality and productivity (CLBMON-36)	✓	✓	n/a	n/a	n/a
Amphibian and reptile habitat use (CLBMON-37)	n/a	n/a	✓	n/a	n/a
Neotropical migrant use of Arrow Lakes Reservoir (CLBMON-39)	n/a	✓	n/a	n/a	n/a
CLBWORKS-2: a program to increase vegetation coverage in the drawdown zone	✓	✓	n/a	✓	n/a
CLBWORKS-29A: Scoping studies to evaluate feasibility to protect wetlands in Revelstoke Reach (Site 6A at Airport Marsh and Site 15A at Cartier Bay)	n/a	✓	n/a	✓	n/a
CLBWORKS-29B: Scoping studies to evaluate feasibility to protect wetlands in Upper and Lower Arrow Lakes Reservoir	✓	n/a	n/a	n/a	n/a
CLBWORKS-30A: The implementation of wildlife physical works in Revelstoke Reach including bird nest boxes and bat roost structures	n/a	✓	n/a	✓	✓
CLBWORKS-30B: The implementation of wildlife physical works in Lower Arrow Reservoir including bird nest boxes and bat roost structures.	✓	n/a	n/a	n/a	✓

1.2 Revision Rationale

Initially, all CLMBON-11B modules were conducted under a single Terms of Reference (TOR). During the course of initial monitoring under CLBMON-11B some indicator species or sampling approaches proposed in the original TOR were found to be ineffective or to lack biological relevance in assessing the effectiveness of revegetation and wildlife physical works. Plans and schedule for wildlife physical works projects have also evolved. Consequently, the TORs for CLBMON-11B drafted in 2009 required updating to reflect improvements to

approaches, the addition of modules, and to more correctly identify the differing specifics relevant to each project module.

This revised TOR provide objectives, management questions, and methods specific to each module and updated to better reflect the Orders and the study designs chosen for implementation. Consequently, some of the Management Questions are revised in this TOR revision, with corresponding changes to methods and monitoring components. The following is an overview of the revisions to the TORs of CLBMON-11B. Module specific TOR details are provided in subsequent chapters for CLBMON-11B1, CLBMON-11B4, and CLBMON-11B5. Module specific TORs have not been written for completed modules that were conducted under the original TOR for CLBMON-11B (modules 2 and 3).

1.3 Revision Overview

The TOR revision does not alter the scope of CLBMON-11B, which addressed several components of the Columbia WUP Orders (Table 2); rather, the purpose of this TOR revision is to:

1. provide a more detailed description of each module and clearly distinguish which objectives and management questions are applicable to each;
2. update methods and approaches to reflect adjustments made based on initial field results, and
3. add study-specific Management Questions and refine the original Management Questions to fit the specific context of each module.

Specific individual revised TOR's are revised and specified for each CLBMON-11B module in separate chapters.

Table 2: Columbia Water Use Plan Orders relevant to the CLBMON-11B monitoring program. Note that for wildlife effectiveness monitoring, "mid Columbia River" and "Revelstoke Reach" are used interchangeably

Clause in Columbia Order	Terms	Corresponding WUP Project
Schedule C – Vegetation		
1.a)	*"Works for a planting program to enhance sustainable vegetation growth within the drawdown zone of the mid Columbia River to benefit fish, wildlife, aesthetics, dust control and recreation"*	CLBWORKS-2
Schedule C - Fish and Wildlife Monitoring		
5.a)	*"monitor wildlife utilization patterns in response to revegetation efforts in the mid Columbia River"*	CLBMON-11B2
5.h)	*"monitor specific areas identified as providing high value wildlife habitat to determine opportunities for protection and enhancement within the Revelstoke Reach"*	CLBWORKS-29A CLBMON-11B2 CLBMON-11B3

6.a)	*"feasibility study to determine physical work alternatives and recommend options to improve conditions for nesting and migratory birds and wildlife in general within the drawdown zone of Revelstoke Reach"*	CLBWORKS-29A
Schedule D – Revegetation		
1.a)	*"works for a reservoir-wide planting program to enhance sustainable vegetation growth within the drawdown zone of Arrow Lakes Reservoir to benefit fish, wildlife, aesthetics, dust control and recreation*	CLBWORKS-2
2.a)	*"monitor wildlife utilization patterns in response to revegetation efforts in Arrow Lakes Reservoir"*	CLBMON-11B1, CLBMON-11B2
Schedule D – Fish And Wildlife Monitoring		
5.c)	*"monitor specific areas identified as providing high value wildlife habitat to determine opportunities for protection and enhancement within the Arrow Lakes Reservoir"*	CLBMON-11B1, CLBMON-11B2, CLBMON-11B3 (as per CLBWORKS-29B addendum dated April 15, 2009)
6.a)	*"feasibility study to review physical works options to improve conditions for nesting and migratory birds and wildlife in general within the Arrow Reservoir drawdown zone"*	CLBWORKS-29B
Conditional List		
4.a)	*"physical works to improve conditions for nesting and migratory birds and wildlife within the drawdown zone of Revelstoke Reach"*	CLBWORKS-30A
7.a)	*"physical works to improve conditions for nesting and migratory birds and wildlife in general within the drawdown zone of Arrow Reservoir"*	CLBWORKS-30B

1.4 Management Questions

CLBMON-11B evaluates the response of several wildlife taxa and habitat elements to wildlife habitat enhancements. Module-specific Management Questions are presented separately in the TORs of each of the CLBMON-11B modules. In addition to being specified to modules, new Management Questions have been created to address topics formerly specified under the Management Hypotheses (see below).

1.5 Management Hypotheses

The module TORs no longer includes management hypotheses. The management hypotheses in the original CLBMON-11B TOR were updated to fit the current status of the study and reformulated as module-specific Management Questions. The scope, detail, and structure contained in the original Management Hypotheses is retained and heightened in the new Management Questions, allowing the biological effects of interest to be more thoroughly analyzed via multiple approaches that are adaptive to analytical circumstance (e.g., flexibility in choice of parameters and response measures, and flexibility in study approaches).

1.6 Key Water Use Decisions Affected

Results from this program will aid in more informed decision making with respect to the need to balance the requirements of wildlife dependent on wetland and riparian habitats with other values such as recreational opportunities, flood control and power generation.

The key water use planning decision affected by the results of this monitoring program is whether revegetation and wildlife physical works are effective at enhancing wildlife habitat. Results from this program will also assist in refining the approaches and methods for enhancing wildlife habitat.

2.0 Monitoring Program Overview

Here we outline the elements of the TOR that are common to all CLBMON-11B modules.

2.1 Objectives and Scope

The CC provided the following direction with respect to the revegetation and wildlife physical works effectiveness monitoring program (BC Hydro 2005):

"Seasonal wildlife surveys (point counts, nest searches, ground track counts) to document wildlife use (birds, ungulates, bears) of revegetated areas. To also include effectiveness monitoring of wildlife physical works in Arrow"; and

"There is uncertainty about current utilization of the drawdown zone by wildlife species and the effects of reservoir operations. Monitoring will inform on the effects of revegetation efforts in Kinbasket and Arrow Lakes reservoirs on wildlife utilization patterns, and the effectiveness of Arrow Lakes Reservoir physical works on wildlife habitat quality and quantity"

The objectives of CLBMON-11B are to:

1. Assess the effectiveness of the revegetation program (CLBWORKS-2) with respect to wildlife use of the drawdown zone of the Arrow Lakes Reservoir.
2. Assess the effectiveness of the wildlife physical works projects (CLBWORKS-30A, CLBWORKS-30B) at improving and/or sustaining conditions for nesting and migratory birds and wildlife in the drawdown zone of Arrow Lakes Reservoir.
3. Provide recommendations on revegetation or wildlife physical works methods or techniques most likely to be effective at enhancing or protecting the productivity of wildlife habitat.
4. Monitor specific areas identified as providing high value wildlife habitat to determine opportunities for protection and enhancement within the Arrow Lakes Reservoir.

2.2 Approach

An effectiveness monitoring program is designed to determine how well management activities, decisions or practices meet their intended objectives (Marcot 1998; Noon 2003). Key to designing an effectiveness monitoring program is the selection of response variables appropriate to the objectives of the management action (Machmer & Steeger 2002); however, the selection of

indicators can be challenging (Andersen 1999). The selection of indicator species/processes should be guided by their sensitivity to the management practice, the ease of collecting data, and the usefulness of the information. Potential indicators may include habitat attributes, keystone species, species at risk, species sensitive to specific habitat requirements, species of management concern, or species that can be monitored easily (Feinsinger 2001); their selection should also be appropriate to the required spatial scale.

The selection of indicators must also take into consideration factors of influence that are external to the monitoring program such as inter and intra-specific competition, predation, climatic change, disease, seasonal precipitation rates, and reservoir operations. For both wildlife physical works and revegetation, significant lead time is required after work is completed for restored ecosystems to stabilize, or revegetation to grow to maturity. It is therefore desirable to monitor effectiveness of such projects using several indicator taxa over an extended period of time.

For each CLBMON-11B module, monitoring focuses on specific wildlife taxa (e.g., CLBMON-11B2, CLBMON-11B3, CLBMON-11B5), or wildlife taxa that are expected to respond measurably to the proposed habitat enhancement treatments, if successful (e.g., birds, bats, arthropods, etc. in CLBMON-11B1), and on habitat attributes related to suitability (e.g., water temperature, site productivity, habitat structure for CLBMON-11B4).

2.3 TOR Revision Review

The key revisions to the TOR components for each of the studies that make up CLBMON-11B are summarized in tables in each module-specific chapter (below). The CLBMON-11B TOR revisions were reviewed independently by (1) Ministry of Forests, Lands & Natural Resources (2) the Canadian Wildlife Service, (3) Ktunaxa Nation Council, (4) the Okanagan Nation Alliance, and (5) The Splatsin and Simpcw First Nations.

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CLBMON-11B1 Wildlife Effectiveness Monitoring and Enhancement Area Identification for the Upper and Lower Arrow Lakes Reservoir

4.0 Monitoring Program Rationale

During the Columbia WUP process, the CC supported the implementation of revegetation (CLBWORKS-2) and wildlife physical works (CLBWORKS-30A and CLBWORKS-30B) in the Columbia River in lieu of changes to reservoir operations to help mitigate the impacts of Arrow Lakes Reservoir operations on wildlife and wildlife habitat. The CC suggested using an adaptive approach to create habitat for native wildlife, including nesting habitat for birds. In addition, the CC recommended monitoring to assess the effectiveness of these physical works at enhancing or protecting habitat for wildlife (BC Hydro 2005).

To assess the effectiveness of the revegetation and wildlife physical works programs BC Hydro has been undertaking several monitoring programs including CLBMON-11B dedicated to monitoring the effectiveness of the habitat enhancements with respect to wildlife use and productivity. CLBMON-11B has multiple specialized modules: CLBMON-11B1, CLBMON-11B2, CLBMON-11B3, CLBMON-11B4, and CLBMON-11B5. The original Terms of Reference (TOR) for CLBMON-11B did not portray the differences across its modules. To add clarity, this chapter provides a revised TOR specific to the CLBMON-11B1 module.

CLBMON-11B1 is a multi-year study taking place in the drawdown zone of Arrow Lakes Reservoir; because other modules monitor effectiveness of revegetation and physical works in Revelstoke Reach, most of the CLBMON-11B1 monitoring occurs in the Upper and Lower Arrow Lakes basins (i.e., from Beaton Arm to Castlegar; Figure 1-1). The CLBMON-11B1 program was initiated in 2009 and continues through 2019. CLBMON-11B1 monitors key indicators over multiple years before, and/or following, the implementation of habitat enhancements. The CLBWORKS-2 revegetation program was completed in 2011; WPW in the Upper and Lower Arrow (CLBWORKS-30B) have not yet been implemented but are anticipated to occur in 2018.

Initial results from CLBMON-11B1 and from other WUP wildlife studies have informed adjustments to focal taxa and sampling approaches to ensure that the study effectively addresses the Management Questions. The need for such adjustment was identified in the original 2009 TOR. This revised TOR identifies the module-specific scope and objectives of CLBMON-11B1, including revision to the Management Questions. For details regarding the specific changes made to revise the TOR for CLBMON-11B1, please refer to Appendix 1.

4.1 Objectives

The objectives for CLBMON-11B1 are to:

1. Assess the effectiveness of the revegetation program (CLBWORKS-2) with respect to wildlife use of the drawdown zone of the Arrow Lakes Reservoir.
2. Assess the effectiveness of the wildlife physical works projects (CLBWORKS-30A, CLBWORKS-30B) at improving and/or sustaining conditions for nesting and migratory birds and wildlife in the drawdown zone of Arrow Lakes Reservoir.

3. Provide recommendations on revegetation or wildlife physical works methods or techniques most likely to be effective at enhancing or protecting the productivity of wildlife habitat in the drawdown zone of the Upper and Lower Arrow Lakes Reservoir.
4. Monitor specific areas identified under CLBWORKS-29B as providing high value wildlife habitat to determine opportunities for protection and enhancement within the Arrow Lakes Reservoir.

4.2 Management Questions

The revised management questions for CLBMON-11B1 are:

1. Were the revegetation projects effective at increasing wildlife utilization or enhancing the suitability of wildlife habitat to a biologically meaningful extent?
    a. How did the revegetation projects affect the productivity (measures of biomass, or reproductive success) of wildlife habitat in the drawdown zone?
    b. What were the conditions at the revegetation study sites in terms of wildlife habitat suitability at the time of project initiation?
    c. How did revegetation modify the area (m^2) or the suitability of wildlife habitat based on: comparisons between treated and untreated areas, vegetation change over the course of the monitoring study, and available baseline data on vegetation structure?
    d. Did revegetation affect songbird utilization of habitat as measured by species richness and/or relative abundance, based on: comparisons between revegetated and untreated areas, and/or vegetation change over the course of the monitoring study?
    e. Did revegetation affect bat utilization of habitat as measured by relative activity levels and estimated species richness recorded by remote acoustic detectors, based on: comparisons between revegetated and untreated areas, and/or vegetation change over the course of the monitoring study?
    f. Did revegetation affect terrestrial arthropod abundance (e.g., biomass, catch per unit effort, etc.) and species richness, based on: comparisons between revegetated and untreated areas, and/or vegetation change over the course of the monitoring study?
    g. Did revegetation affect ungulate utilization of habitat as measured by indices of use (e.g. pellet counts, tracks and occupancy), based on: comparisons between revegetated and untreated areas, and/or vegetation change over the course of the monitoring study?
2. Were the wildlife physical works projects effective at increasing wildlife utilization or enhancing the suitability of wildlife habitat to a biologically meaningful extent?
    a. How did the wildlife physical works projects affect the productivity of aquatic or terrestrial wildlife habitat in the treated drawdown zone sites?

b. What were the baseline conditions at the wildlife physical works study sites in terms of aquatic and terrestrial wildlife habitat productivity and habitat quality?
c. How did wildlife physical works projects change the area (m^2) or increase the suitability of habitat for wildlife?
d. Did wildlife physical works projects change the utilization of the drawdown zone by birds as a measured by species richness, abundance and nest productivity?
e. Did wildlife physical works projects change the utilization of the drawdown zone by bats as measured by relative activity levels and estimated species richness recorded by remote acoustic detectors?
f. Did wildlife physical works projects change the abundance (e.g., biomass, catch per unit effort, etc.) and species richness of arthropods in the drawdown zone?

3. Did the revegetation methods result in changes to wildlife habitat for songbirds or bats as measured by indices of habitat suitability and site productivity (e.g., arthropod biomass, catch per unit effort, etc.), based on comparisons between revegetated and untreated areas, and of revegetated areas over the course of the monitoring study?
4. Did the methods used for wildlife physical works result in changes to wildlife habitat for songbirds and bats as measured by indices of habitat suitability and site productivity (e.g. arthropod biomass)?
5. Which revegetation or wildlife physical works methods or techniques (including methods or techniques not yet implemented) are likely to be most effective at enhancing or protecting the productivity of wildlife habitat in the drawdown zone?

5.0 Monitoring Program

5.1 Summary of the Revegetation and Wildlife Physical Works Programs

The revegetation program (CLBWORKS-2) treated the upper elevations (434 m - 440 m) of the drawdown zone by planting plug seedlings (primarily sedge), live staking (primarily black cottonwood), seeding, and fertilization between 2008 and 2011. A detailed summary of revegetation methods can be found in Miller *et al.* (2016 Appendix 10.1). CLBMON-11B1 has sampled at both treatment and control areas at four revegetation sites (Burton Creek, Edgewood, East Arrow Park (discontinued due to failure of revegetation), Lower Inonoaklin Road (added in 2011), and at two reference sites (Beaton Arm and Mosquito Creek) since 2009. This monitoring will continue at appropriate intervals throughout the rest of the study.

Opportunities for potentially using physical works for enhancement or protection of drawdown zone habitats in the Upper and Lower Arrow Lakes Reservoir were identified under CLBWORKS-29B. Additional sites were also identified during the early stages of the CLBMON-11B1 program[1]. Three potential WPW sites have

[1] Due to the overlap between the wildlife surveys required for CLBMON-11B1 and CLBWORKS-29B, the wildlife monitoring component of these studies was delivered together under CLBMON-11B1, with separate analysis reported under CLBWORKS-29B.

bene identified: Edgewood, Burton Creek, and Lower Inonoaklin Road (Hawkes and Tuttle 2016).

The development of selected WPW sites under CLBWORKS-30B is expected to occur in 2018. Prior to 2017, CLBMON-11B1 conducted pre-works monitoring at all three potential WPW sites. Post-works monitoring will occur once works have been implemented. It is expected that modifications to pre-works monitoring will be made as necessary if the geographic scope or siting of physical works projects are adjusted.

5.2 Methods

An overview of the CLBMON-11B1 methodological approach is provided below; more detailed accounts of these methods can be found in the annual reports for CLBMON 11B1 (Hawkes *et al.* 2010, 2011, 2012, 2014, Adama and Hawkes 2015).

5.2.1 Task 1: Project Coordination

Project coordination involves the general administration and technical oversight of the program, which includes, but may not be limited to: 1) budget management; 2) program team management; 3) logistics coordination; 4) technical oversight for field and analysis components; 5) facilitation of data transfer among other investigations associated with the Arrow Reservoir Operations Management Plan; 6) permit applications as required; 7) liaison with regulatory agencies as required; 8) adjust sampling design or methodology as required in consultation with BC Hydro; and 9) maintenance of an Occupational Safety and Health (OSH) program and safety plan for all aspects of the study in accordance with WorkSafeBC (WCB) and BC Hydro procedures and guidelines.

5.2.2 Task 2: Wildlife Monitoring

Design. CLBMON-11B1 is a multi-year study collecting a long term data set at revegetation sites and potential wildlife physical works sites. Drawing inferences about the effectiveness of revegetation treatments and/or physical works projects require data to be gathered over a time period sufficient to enable revegetation to mature and ecological communities impacted by physical works projects to stabilize. Initially, 11 years were scheduled for this study. It may be necessary to extend some monitoring components beyond the 11-year timeline in order to gain adequate post-works monitoring data.

Where possible, replication of treatments will be maximized (e.g., for revegetation treatments), but it is recognized that effectiveness monitoring is limited in this respect. Wildlife Physical Works projects are not spatially replicated and a Before-After design will be used.

Baseline data are not available for revegetation treatments. Sampling of focal taxa to monitor revegetation effectiveness is conducted in every sampling year at drawdown zone treatment sites (where revegetation prescriptions have been applied), drawdown zone control sites (similar sites where revegetation has not been applied), and at upland reference sites. Monitoring upland reference sites provides an opportunity to contextualize changes in focal taxa by tracking regional or natural variation.

In the absence of baseline data, paired sampling in permanent treatment and control plots will enable an evaluation of the effectiveness of revegetation prescriptions to benefit wildlife and enhance wildlife utilization in the drawdown zone of the reservoir. Control sites were selected to be within 100 m of treatment sites, at similar elevation and of similar habitat type.

Monitoring at potential WPW sites was initiated in 2009 at two sites (Edgewood and Burton Creek), and additionally at Lower Inonoaklin Road in 2010. Implementation of physical works projects is expected to occur in 2018. A comparison between baseline pre-work data and post-work data will be used to determine the effectiveness of wildlife physical works for wildlife.

Baseline sampling of focal taxa is being implemented at potential WPW sites and at upland reference sites distinct from those used for revegetation effectiveness. Between 2009 and 2016 the same focal taxa used to assess revegetation effectiveness were used to gather before-works baseline data at Edgewood and Burton Creek. Sampling at Lower Inonoaklin Road began with bats in 2010, with songbirds added in 2011 and terrestrial arthropods added in 2016. Sampling design, focal taxa and monitoring of abiotic conditions will be adjusted as appropriate once specific wildlife physical works sites and project details are determined, to ensure that monitoring is well matched to the nature of the project(s).

Schedule. During each sampling year, fieldwork will be conducted between March and September. The monitoring program was initiated in 2009. Revegetation monitoring is planned to occur annually for 11 years ending in 2019. Effectiveness monitoring of WPW sites was delayed by scheduling of implementation under CLBMON-30B, and has been extended to conclude in 2021 (Table 3).

Sampling of particular taxa at particular treatment, control and reference sites, and sampling design more generally, has been and will continue to be adjusted over time as necessary. Reasons for adjusting the sampling effort or design may include revegetation failure, changing nature of WPW, changing likelihood of WPW project implementation, addressing identified data gaps, or to enable more effective deployment of project resources. Such decisions and their associated rationales, as well as detailed descriptions of current sampling design and approaches are described in the annual reports for CLBMON-11B1.

Field Data. Field data collection will primarily focus on the distribution, abundance, and/or productivity of wildlife at revegetation Treatment/Control plots, and at physical works sites. Data will also be collected on wildlife habitat, and aspects related to changes in habitat. The primary field data are detailed further below.

Habitat monitoring at revegetation sites has been conducted under CLBMON-12 and another WLR project (CLBMON-33); data and results from those studies will be available for inclusion in the CLBMON-11B analyses. Additional habitat data for revegetation monitoring may be necessary under the CLBMON-11B program (e.g., to qualify treatment intensity, for analysis purposes). Different monitoring approaches may be required depending on the sites selected for WPW implementation. Pre-works baseline and post-works monitoring for WPW effectiveness at these sites may (in addition to monitoring of focal taxa listed above) include: aquatic macrophyte and macroinvertebrate sampling, abiotic

indices of water quality and primary productivity, use of riparian function/condition metrics, and assessment of area, temperature and temporal availability of shallow water habitat.

Terrestrial arthropods tend to respond rapidly to environmental change making them particularly useful in experimental studies (McGeogh 1998, Schowalter 2006), especially where treatments were administered over small areas. Terrestrial arthropods, although much less commonly used to monitor environmental qualities than their aquatic counterparts, perform a wide variety of ecological functions and are an important food source for many vertebrate taxa (e.g. birds, amphibians, bats). The trophic linkages between vegetation, arthropods, and songbirds support the inclusion of terrestrial arthropods as a focal taxon. Terrestrial arthropod abundance and diversity could be expected to increase with increasing vegetation structure and diversity (e.g. Humphrey et al. 1999, Söderström et al. 2001). Terrestrial arthropods are being sampled via two methods: pitfall traps and malaise traps. Detailed current terrestrial arthropod sampling methods are provided in Sharkey *et al.* (2016). Terrestrial arthropod sampling has occurred during all sampling years.

Songbirds are effective indicators of environmental conditions because they occupy an extremely diverse range of niches within an ecosystem including high trophic niches (DeSante and Geupel 1987; Temple and Wiens 1989). Songbird diversity and relative abundance are being monitored using time-constrained variable-radius point count surveys. Point counts (following methods in Resources Inventory Committee 1999) have been conducted every sampling year since 2009. Nest searches are used to assess avian productivity. Nest searches and monitoring was introduced in 2015 to better understand the productivity of songbird populations in areas potentially affected by revegetation and wildlife physical works. Detailed current methods for both point counts and nest searches are described in Sharkey *et al.* (2016).

Waterbirds may respond rapidly to changes in habitat quality associated with several of the physical works projects, and were also recognized as a high management priority by the CC. Specifically, concerns focused on the loss of available breeding and migratory habitat and the direct loss of nests due to flooding due to high water levels. Waterbird species richness and relative abundance will be assessed using ground-based observational surveys at physical works sites where suitable habitats are concerned. Additionally, nest searches and brood observations will allow waterbird productivity to be monitored.

Bats are important indicators of wetland restoration outcomes. There are important trophic linkages between vegetation, flying arthropods, and bats. Like many birds, bats in British Columbia forage exclusively on arthropods (Nagorsen and Brigham 1993), which are predicted to respond to revegetation and physical works prescriptions in Arrow Lakes Reservoir. Improved technology for remotely monitoring bats along with their conservation status supported their addition to this study as a focal taxon. To assess the diversity, distribution and relative abundance of bats, remote acoustic detectors have been deployed in treatment and control polygons since 2010, and at potential WPW sites and reference sites since 2016. Detailed methods are provided in Sharkey *et al.* (2016).

Ungulates can be effectively monitored using a variety of census methods (e.g. spring pellet count surveys, aerial surveys, and snowtrack transects; RISC 2006). The initial CLBMON-11B program used aerial surveys to monitor ungulates, but this method was quickly aborted because it is poorly suited to monitoring localized effects at treated sites. Pellet count surveys were also initiated, and aborted, because the treatments were too small to have population-level impacts, so intense quantitative measurement of relative usage was deemed unnecessary. Evidence of ungulate (and other terrestrial mammal) usage has been and will continue to be documented anecdotally during site visits. Structured quantitative approaches to monitoring relative abundance of ungulate usage at treatment and control sites remain an option for ungulate monitoring in throughout the remainder of the CLBLMON-11B1 study for effectiveness monitoring of the revegetation program.

Table 3: Summary of works and sampling schedule for CLBMON-11B1. Note that all planned bird monitoring will include point count and nest searching techniques

CLBMON 11B1 Schedule (✓– completed; P – planned; WPW – wildlife physical works; RV – re-vegetation, PC = Point Counts, NS = Nest Search and Nest Monitoring)													
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
RV implementation	✓	✓											
WPW implementation										P*			
Pre-RV (all)	Not collected												
Post-RV - Birds	PC	PC	PC	PC	PC	PC+NS	PC+NS	PC+NS	P	P	P		
Post-RV - Other	✓	✓	✓	✓	✓	✓	✓	✓	P	P	P		
Pre-WPW - Birds			PC		PC		PC+NS	PC+NS	P	P*			
Pre-WPW - Other	✓	✓	✓	✓	✓	✓	✓	✓	P	P*			
Post-WPW - Birds											P*	P	P
Post-WPW - Other											P*	P	P

* scheduling subject to change depending on timing of WPW implementation

5.2.3 Task 3: Data Analysis

Data analyses will, as appropriate to each data set, assess the effects of habitat enhancements on measures of wildlife abundance, species richness, habitat suitability, and/or productivity (e.g., nest survival). Potentially confounding factors such as reservoir levels and weather will be considered in the analyses as necessary. A range of analyses or statistical methods are expected to be required. Modeling will, where possible, be used to explore interactions among environmental variables and wildlife utilization of habitat. The choice of statistical or other methods of analysis must be clearly stated and justified.

In some cases the nature of the revegetation or works projects, or of focal wildlife species, has precluded study designs with sufficient statistical power or appropriate spatial replication. This will be assessed during the study as appropriate, and discussed in the final report for this study. In these cases, descriptive analyses will be conducted, and the extent of inferences from statistical analysis will be discussed.

Data will be summarized and analyzed following each field season. Detailed multi-year data analyses will be conducted at Year 12 in conjunction with the final report, or later, for any components that continue past Year 12 for additional post-works monitoring.

5.2.4 Task 4: Reporting

Reports will follow the standard format for WUP monitoring projects. All reports will be provided 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.

Locations and associated data on plant and animal observations will be submitted to the MoE Wildlife Species Inventory (WSI) in the required format. Species at Risk observations will be submitted to the BC Conservation Data Centre in the required format.

Annual Report. Following every season in which fieldwork is undertaken, an Annual Report will be produced which summarizes the methods and sampling design employed, the data obtained, a brief description/analysis of the year's data in the context of the multi-year dataset, recommendations as appropriate. Annual reports will include:

1. An executive summary
2. A description of the project background
3. A description of the methods, sampling design and sampling effort employed, highlighting any changes
4. Important results
5. Discussion and recommendations
6. Maps of the study areas and locations of the study plots.
7. A digital appendix with:
    a. MS Excel spreadsheet of coordinates for survey sites
    b. A database in MS Excel or MS Access of all data collected
    c. GPS data and GIS coverage's (Arc shapefiles).

d. Digital images

Final Report. A final technical report will be prepared at the conclusion of the study. The final report will focus on presenting data and results most relevant to addressing each management question. An appropriate level of detail in methods can potentially provide high level accounts, allowing details to be provided as reference materials presented in appendices or other stand-alone reports (e.g., annual reports). It is anticipated that the results and discussion will comprise a major part of the report, with the latter having subsections addressing each management question. Below is a suggested report outline:

1. An executive summary
2. Introduction - A description of the project background, including the objectives and management questions being addressed.
3. Methods - A description of the study area, methods, sampling design and sampling effort employed. A focus should be on providing a clear account of the details salient to understanding types of data (e.g., response measures), and their limitations (e.g., years of study, spatial replication (sample size), and confounding circumstances). Methodological details that are secondary to understanding the results (e.g., calibrations, technical details, supporting maps), can be referenced and provided in appendices if appropriate. Care should be taken to minimize redundancies.
4. Results – The results should only include an overview of data and analyses directly referenced in the Discussion; additional supporting results can be provided in appendices. It is anticipated that primary results will include multi-year comparrisons (before-after comparisons, time series data) and spatial contrasts (e.g., treatment vs. control), which may or may not include temporal components. It is also anticipated that some results may be more descriptive and less data-driven; it may be appropriate to include detailed vignettes related to descriptive results as appendices, complete with photographic materials.
5. Discussion – The discussion will have subsections addressing each Management Question, drawing from results, supporting documents, and appendices as necessary.
6. Appendices – This section can include supporting maps (e.g., of the study plots), and supporting information for methods and results.
7. A digital appendix with:
   a. MS Excel spreadsheet of coordinates for survey sites
   b. A database in MS Excel or MS Access of all data collected
   c. GPS data and GIS coverage's (Arc shapefiles)
   d. Digital images

Data. A multi-year relational database will be submitted including tables of sampling locations, sample effort (e.g., survey details), and observations.

5.3 Interpretation of Results

A key outcome of this monitoring program will be to determine how revegetation and wildlife physical works affects the species richness and relative abundance of songbirds, arthropods, bats and ungulates, and measures of wetland function and productivity

during the time-period monitored. A positive relationship between treatments and habitat utilization or species abundance/richness will suggest a positive treatment effect.

5.4 Study Design Limitations

Monitoring changes in wildlife populations and habitats can be complicated by numerous factors and limitations in study design or sampling strategy. Despite efforts to reduce these limitations, this monitoring program has several constraints. First, reservoir operations (water levels, filling and drafting rates) vary between seasons and between years, which may reduce the ability to correlate specific revegetation and wildlife physical works to the relative abundance and species richness of indicator taxa chosen for this study. Second, as habitats may take several years or even decades to change in response to wildlife physical works, or for revegetation to mature, the duration of the monitoring program may not be sufficient to detect changes in the response of indicator taxa to habitat enhancement initiatives.

6.0 Budget

Total Revised Program Cost $1,326,387.

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CLBMON-11B2 Wildlife Effectiveness Monitoring of Revegetation and Wildlife Physical Works on Spring Migrants in Revelstoke Reach

This module monitored effectiveness of revegetation and physical works projects in Revelstoke Reach (Figure 1-1) with respect to spring habitat use by songbirds during migration. Field data collection for this module has been completed so no specific TOR was revised for CLBMON-11B-2.

CLBMON-11B3 Wildlife Effectiveness Monitoring of Western Painted Turtles in Revelstoke Reach

This module monitored western painted turtle population which was protected by physical works as Site 6A in Revelstoke Reach (Figure 1-1). Field data collection for this module has been completed so no specific TOR was revised for CLBMON-11B-3.

CLBMON-11B4 Effectiveness Monitoring of Wetland and Riparian Habitat in Revelstoke Reach in Response to Wildlife Physical Works

8.0 Monitoring Program Rationale

During the Columbia WUP process, the CC supported the implementation of revegetation (CLBWORKS-2) and wildlife physical works (CLBWORKS-30A and CLBWORKS-30B) in the Columbia River in lieu of changes to reservoir operations to help mitigate the impacts of Arrow Lakes Reservoir operations on wildlife and wildlife habitat. The CC suggested using an adaptive approach to create habitat for native wildlife, including nesting habitat for birds. In addition, the CC recommended monitoring to assess the effectiveness of these physical works at enhancing or protecting habitat for wildlife (BC Hydro 2005).

To assess the effectiveness of the revegetation and wildlife physical works programs BC Hydro has been undertaking several monitoring programs including CLBMON-11B dedicated to monitoring the effectiveness of the habitat enhancements with respect to wildlife use and productivity. CLBMON-11B has multiple specialized modules: CLBMON-11B1, CLBMON-11B2, CLBMON-11B3, CLBMON-11B4, and CLBMON-11B5. The original Terms of Reference (TOR) for CLBMON-11B did not portray the differences across its modules. To add clarity, this chapter provides a revised TOR specific to the CLBMON-11B4 module, which assesses the effectiveness of wildlife physical works designed to enhance or protect wildlife habitat in the drawdown zone of Arrow Lakes Reservoir at Revelstoke Reach.

Potential Wildlife Physical Works (WPW) projects in Revelstoke Reach were identified and refined through CLBWORKS-29A, a two-year study that evaluated the feasibility of wildlife physical works in the Upper Arrow Reservoir (Revelstoke Dam to Shelter Bay; Figure 1-1). From an initial list of 44 potential projects, two, WPW6A (Airport Outflow) and WPW15A (Cartier Bay), were identified for implementation.

Implementation of the two WPW projects in Revelstoke Reach was carried out under CLBWORKS-30A. Construction of the works at Cartier Bay Site 15A was completed in October, 2016. Construction of the works at the Airport Outflow Site 6A was completed in the fall of 2013.

CLBMON-11B4 was initiated in 2010 and continues until 2020. It assesses the effectiveness of the WPW program at protecting wetland habitat conditions for wildlife in the drawdown zone at Revelstoke Reach (Site 6A and Site 15A). The monitoring involves sampling before-works and after-works characteristics of the affected wetlands. CLBMON-11B4 is part of a suite of monitoring programs that together monitor the effectiveness of wildlife physical works at protecting or enhancing wetland and riparian wildlife habitat, and at benefitting the wildlife that utilize it. CLBMON-11B4 specifically assesses the character of wetland and riparian habitat. Wildlife usage is monitored under CLBMON-11B2 (spring migrant songbirds); CLBMON-36 (nesting birds); CLBMON-37 (reptiles and amphibians); CLBMON-39 (fall migrant songbirds); and CLBMON-40 (waterbirds and raptors).

This revised TOR identifies the scope and objectives of CLBMON-11B4, including the Management Questions that focus its efforts and direct the context

of its outcome. For details regarding the specific changes made to revise the TOR for CLBMON-11B1, please refer to Appendix 2.

8.1 Objectives

The objectives for CLBMON-11B4 are to:

1. Assess the effectiveness of wildlife physical works projects at protecting and maintaining wetland and associated riparian habitat in the drawdown zone of Revelstoke Reach.
2. Provide recommendations about which wildlife physical works methods or techniques are most likely to be effective at protecting or enhancing the productivity of wetland and associated riparian habitat in the drawdown zone of Revelstoke Reach.
3. Provide information on wetland habitat characteristics at potential wildlife physical works sites to assist in refining works designs, as appropriate (outcomes are reported in Hawkes *et al.* 2015.

8.2 Management Questions

The management questions for CLBMON-11B4 are:

1. Are the wildlife physical works projects effective at protecting wildlife habitat quality and quantity for nesting and migratory birds and other wildlife?
    a. What were the pre-existing conditions at the wildlife physical works Sites 6A and 15A in terms of wetland and associated riparian habitat productivity and habitat suitability for nesting and migratory birds and other wildlife?
    b. Did the wildlife physical works at Cartier Bay Site 15A affect the function and productivity of adjacent wetland and associated riparian wildlife habitat as indicated by biomass and species richness of macrophytes and macroinvertebrates, and abiotic indices of productivity?
    c. How did the wildlife physical works projects affect the suitability of wetland and associated riparian habitat for nesting and migratory birds and other wildlife? To address this management question, the results of CLBMON-11B4 will be interpreted in light of results and with data from other relevant studies including some or all of: CLBMON-11B3, CLBMON-37, CLBMON-11B2, CLBMON-36, CLBMON-39, and CLBMON-40.
        i. Did the wildlife physical works at Cartier Bay Site 15A alter the area (m^2) or suitability of wetland and associated riparian wildlife habitat for nesting birds?
        ii. Did the wildlife physical works at Cartier Bay Site 15A alter the area (m^2) or suitability of wetland and associated riparian wildlife habitat for reptiles and amphibians?
        iii. Did the wildlife physical works at Airport Outflow Site 6A alter the area (m^2) or suitability of wetland and associated riparian wildlife habitat for nesting birds?
        iv. Did the wildlife physical works at Airport Outflow Site 6A alter the area (m^2) or suitability of wetland and associated riparian wildlife habitat for reptiles and amphibians?

v. Did the wildlife physical works at Cartier Bay Site 15A affect: erosion; aerial extent of wetland habitat; cover, species richness, and evenness of undesirable macrophyte species; water depth and turbidity?

vi. Did the wildlife physical works at Airport Outflow Site 6A affect: physical signs of erosion; aerial extent of wetland habitat?

2. Which wildlife physical works methods or techniques (including those not yet implemented) are likely to be most effective at enhancing or protecting the productivity and suitability of wetland and associated riparian wildlife habitat in the drawdown zone at Revelstoke Reach?

9.0 Monitoring Program

9.1 Summary of the Wildlife Physical Works Projects

Two wildlife physical works projects have been completed in Revelstoke Reach, Airport Outflow Site 6A and Cartier Bay Site 15A, and these have emerged as sole focus of CLBMON-11B4 monitoring during the final stages of the project. Golder (2009a, 2009b), and for Site 15A Hawkes *et al.* (2015), provide descriptions of how these sites and designs were chosen. The wildlife physical works projects at Sites 6A and 15A are designed to protect existing high value wildlife habitats from degradation. Descriptions of these sites and the associated physical works projects are contained in Golder (2009b).

Airport Outflow Site 6A

Construction at Site 6A was completed in October 2013. The wildlife physical works at Site 6A (Golder 2014) was designed to stabilize an erosion gully to prevent further erosion and potential draining of existing high wildlife habitat values in Airport Marsh. Because the erosion gully/Site 6A are downstream and remote to the Airport Marsh, it can be assumed that the physical works project did not interact with the Airport Marsh. The interaction would only occur if the erosion advanced far enough upstream to reach the wetland and thereby enhance drainage rates. For this reason, monitoring at Airport Outflow Site 6A has included two distinct aspects: erosion monitoring directly at Site 6A; and wetland parameter monitoring at the adjacent Airport Marsh, whose function and productivity the works at Site 6A are designed to protect. Considerable baseline data for the Airport Marsh have been collected via CLBMON-11B's modules 2, 3 and 4, and monitoring at the Marsh is no longer necessary, assuming that erosion is controlled. In the final years of monitoring under CLBMON-11B4, the effectiveness monitoring work will focus entirely on the erosion monitoring directly at Site 6A.

Cartier Bay Site 15A

Construction of the wildlife physical works at Site 15A was completed in October, 2016.

The original plan for wildlife physical works at Site 15A (Golder 2009b) was intended to reinforce the berm where a collapsed box culvert was possibly eroding, and increase the amount of water impounded behind the berm, resulting in an increased area of shallow wetland habitat. This design was altered because there was found to be an unacceptably high ecological risk associated with

increasing the area and depth of wetland habitat (risks summarized in Hawkes *et al.* 2015 and peer reviewed in Polster 2014). The final design (BC Hydro 2015) was revised to address ecological risks, based in part on pre-works monitoring results from CLBMON-11B4. The objective of the final design was to protect the existing high value wetland wildlife habitat in Cartier Bay by stabilizing the collapsed culvert without significantly altering the size or nature of the wetland habitat.

9.2 Methods

An overview of the methods used for this wetland habitat monitoring study is provided below. Detailed accounts of these methods can be found in the annual reports for CLBMON-11B4 (Miller and Hawkes 2013, 2014; Fenneman and Hawkes 2012; Hawkes et al. 2011).

9.2.1 Task 1: Project Coordination

Project coordination involves the general administration and technical oversight of the program, which includes, but may not be limited to: 1) budget management; 2) program team management; 3) logistics coordination; 4) technical oversight in field and analysis components; 5) facilitation of data transfer among other investigations associated with the Arrow Reservoir Operations Management Plan; 6) permit applications as required; 7) liaison with regulatory agencies as required; 8) adjust sampling design or methodology as required in consultation with BC Hydro, and 9) maintenance of an OSH program and safety plan for all aspects of the study in accordance with WCB and BC Hydro procedures and guidelines.

9.2.2 Task 2: Monitoring at Sites 6A and 15A

Design. CLBMON-11B4 is a 10+ year monitoring study assessing the effectiveness of the wildlife physical works at Sites 6A and 15A. The study initially collected baseline data at multiple potential physical works sites, but has not narrowed its focus on the two sites (no further wildlife physical works are anticipated in Revelstoke Reach under the current Order). The basic design of the effectiveness monitoring has been a before-after comparison. CLBMON-11B4 specifically focusses on aquatic wildlife habitat, and has collected response variables including physicochemical attributes, aquatic macrophytes, and aquatic invertebrates. Baseline (before, or pre-works) wetland data will be compared with post-works data at Site 15A to determine the effectiveness of the wildlife physical works projects at protecting existing high value wildlife habitat. Post-work monitoring at Site 6A is not necessary given that the physical works project did not interact with the hydrology of Airport Marsh (see Section 9.1).

Schedule. The wetland habitat monitoring program is being implemented over 10 years of the Columbia River WUP from 2010 to 2019. During each sampling year, fieldwork is conducted during May and June. From 2010-2012 fieldwork was also conducted during August, but higher water levels during this season confounded the results; summer sampling was discontinued after 2012. Sampling schedule may be further adjusted based on the results of each year of monitoring in order to maximize the study's effectiveness. Such decisions and

their associated rationales, as well as detailed descriptions of current sampling design and approaches are described in the annual reports for CLBMON-11B4.

At Cartier Bay Site 15A, pre-works monitoring of wetland habitat parameters under CLBMON-11B4 was conducted at Site 15A in 2010, 2011, 2012 and 2013. Post-works monitoring will occur in 2018, 2019 and 2020. Other WUP studies have conducted pre-works monitoring at Site 15A of: spring migrant songbirds (CLBMON-11B2), fall migrant songbirds (CLBMON-39), migrating and nesting waterbirds (CLBMON-40, and reptiles and amphibians (CLBMON-11B3 and CLBMON-37). Post-works monitoring of these wildlife groups will continue in 2017. Some of the monitoring studies from these programs will extend past the planned 10-year timeline in order to provide sufficient post-implementation monitoring at Cartier Bay including: (1) annual waterfowl monitoring in spring and fall (this also documents timing of spring thaw; CLBMON-40); (2) annual monitoring of amphibians and/or reptiles (CLBMON-37); and (3) extended monitoring of CLBMON-11B4 (as described in this TOR). Data from these other studies will be made available for a detailed final effectiveness monitoring report under CLBMON-11B4.

At Airport Outflow Site 6A, pre-works monitoring of wetland parameters at Airport Marsh was conducted under CLBMON-11B4 in 2010, 2011, 2012 and 2013. Post-works monitoring of Site 6A was conducted under CLBMON-11B4 in 2016 (erosion, vegetation regrowth). Post-works monitoring of erosion at Site 6A will continue in 2018, 2019 and 2020. Unless erosion continues to a point where the erosion channel interacts with the Airport Marsh hydrology (e.g., cutting through old Arrow Head highway into the Machete Ponds), post-works monitoring will not include wetland parameters at Airport Marsh. Other WUP studies have conducted pre-works monitoring of wildlife utilization and habitat suitability at Airport Marsh adjacent to Site 6A: spring migrant songbirds (CLBMON-11B2), fall migrant songbirds (CLBMON-39), migrating and nesting waterbirds (CLBMON-40), and reptiles and amphibians (CLBMON-11B3 and CLBMON-37). Post-works monitoring of these wildlife groups and the wildlife enhancement structures (CLBMON-11B5) will continue in 2017.

A synthesis of the results of CLBMON-11B4 and the interconnections with results from these other related studies, and integrated recommendations, will be completed following the final field season in post-WUP period.

Table 5: Summary of works and sampling schedule for CLBMON-11B4

CLBMON 11B4 Schedule (✓– completed; P – planned; WPW – wildlife physical works)											
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
WPW Site 6A				✓							
WPW Site 15A							✓				
Pre-monitoring 6A	✓	✓	✓	✓							
Pre-monitoring 15A	✓	✓	✓	✓							
Post-monitoring 6A							✓		P	P	P
Post-monitoring 15A									P	P	P

Field Data. The riparian and wetland habitat monitoring approach at Site 15A is predicated on the assumption that the per cent cover, biomass, and composition of macrophyte vegetation, and the species richness and abundance of aquatic macroinvertebrates, are effective indicators of wetland productivity, and thus of wildlife habitat quality (see Hawkes *et al.* 2011). The design of this study as a comparison of wetland parameters before and after wildlife physical works requires that the same methods be used to collect data after the works as were used before the works.

Sampling methods used in CLBMON-11B4 to gather data before the wildlife physical works are described in detail by Miller and Hawkes (2014). The rationale for these methods and sampling design is described by Hawkes *et al.* (2011). All post-works monitoring will follow these same methods, with minor adjustments where required to maximize the effectiveness of the study.

The study uses point-intercept samples of wetland physicochemistry, aquatic macrophytes and aquatic invertebrates collected at randomly chosen wetland locations within 1 m from the shoreline (Miller and Hawkes 2014). The number of sampling locations at each wildlife physical works site was chosen based on a power analysis of the number of samples required to distinguish a 25% change in one of the parameters to a statistical power of 0.80. Based on this, 30 sampling locations are monitored at Site 15A and 40 sampling locations at Site 6A (Miller and Hawkes 2013). At each sampling location the following methods are implemented:

Aquatic Macrophyte Sampling (Miller and Hawkes 2014) involves sampling submergent vegetation at each sampling location using a double-headed rake dropped to the bottom of the water column and dragged for 1 m. Two samples are collected at each sampling location. The resulting samples are used to identify and assess relative abundance of submergent plant species, to estimate per cent cover, and to assess total biomass. Floating vegetation is also sampled at each sampling location in two 2 m x 1 m belt transects, using a buoyant 1 m x 1 m quadrat frame constructed from PVC pipe. The resulting samples are used to identify and assess relative abundance of floating plant species, to estimate percent cover, and to assess total biomass.

Emergent and Terrestrial Vegetation Sampling (Miller and Hawkes 2014) involves sampling for emergent and terrestrial plant communities at each sampling location using one 1 m x 4 m belt transect or, if sampling by boat, using two 1 m x 2 m belt transects. The samples are used to identify each plant species present and to estimate their percent cover.

Aquatic Invertebrate Sampling (Miller and Hawkes 2014) formerly sampled at each sampling location via two methods: epipelagic sampling with a dip net; and benthic sampling with a hand-held Ponar grab. Due to low sample sizes, high variability, and high cost of taxanomic sorting, this program will not be implemented for post-works monitoring. Note that higher trophic level wildlife monitoring under CLBMON-37 and CLBMON-40 will continue into the post-works monitoring phase.

Physicochemical Attribute Sampling (Miller and Hawkes 2014) occurs at each sampling location, where the following attributes are recorded:

a. Water depth
b. Substrate type
c. Relative turbidity
d. Dissolved oxygen
e. Conductivity
f. Water temperature within 30 cm of the surface
g. pH

Dissolved oxygen, conductivity and water temperature are also monitored over time using data loggers.

Shallow Wetland Habitat Extent will be mapped for wetlands at each wildlife physical works site. The total areal extent of shallow wetland habitat and duration of its availability (i.e., before inundation) has been estimated previously using orthophotography. For post-works monitoring, the use of a drone may be required to capture imagery to be georeferenced in order to measure the wetland areas.

Erosion Monitoring at Site 6A and Site 15A involves visual checks, standardized photo documentation each year, and some physical marking (e.g., stakes) to identify how the extent of erosion is changing over time. A more detailed examination by an engineer will be conduct in the final year of the project.

9.2.3 Task 4: Data Analysis

Data analyses will assess the effects of wildlife physical works on wetland habitat at each site. A range of analyses and statistical methods are expected to be required. Modeling will, where possible, be used to explore interactions among environmental variables and wildlife utilization of habitat. The choice of statistical or other methods of analysis must be clearly stated and justified.

Data will be summarized and analyzed following each field season. Detailed data analyses will be conducted in the final year (2020) in conjunction with the final report. Analyses in the final report may draw, as appropriate, on results and data from other related monitoring studies including CLBMON 36, CLBMON 37 (CLBMON 11B3 prior to 2017), CLBMON 39, and CLBMON 40.

The objective for physical works at Site 15A was maintain the existing wetland such that no significant change in habitat area, species diversity, distribution or relative abundance occur during the 10 years of monitoring. A performance measure of 'no change' will be assessed using available data. It is understood that wetland habitats fluctuate naturally, and are influenced by reservoir operations; the former clouds ability to make comparisons and the latter must be controlled for. It is also understood that the data assessed will differ greatly in their residual variance (errors), depending on the response measure, so the potential to detect changes associated with the physical works projects may be highly dependent on which measure is being assessed, and the available sample size. However, for the Site 15A project no changes are expected. To qualify statistical results, minimum detectible effect sizes should be estimated for each dependent variable examined, given the observed variability of these measures. Care should be taken to use a correct error distribution (e.g., negative binomial for over-dispersed count data, or Gaussian for measured data, or binomial for presence/absence data etc.). If significant changes are observed, care must be taken to fully explore potential confounding variables, and additionally, the biological significance of the changes needs to be explored and discussed.

9.2.4 Task 5: Reporting

Reports will follow the standard format for WUP monitoring projects. All reports will be provided in 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.

Species at Risk observations will be submitted to the BC Conservation Data Centre in the required format. Invasive Species will be reported to the Invasive Alien Plant Program (IAPP) database.

A synthesis of the results of CLBMON-11B4 and the interconnections with results from these other related studies, and integrated recommendations, will be completed following the final field season.

Annual Reports. Following every season in which fieldwork is undertaken, an Annual Report will be produced which summarizes the methods and sampling design employed, the data obtained, a brief description/analysis of the year's data in the context of the multi-year dataset, and recommendations as appropriate. Annual reports will include:

1. An executive summary
2. A description of the project background
3. A description of the methods, sampling design and sampling effort employed, highlighting any changes
4. Important results
5. Discussion and recommendations
6. Maps of the study areas and locations of the sampling locations.
7. A digital appendix with:
    a. MS Excel spreadsheet of coordinates for sampling sites
    b. A database in MS Excel or MS Access of all data collected

c. GPS data and GIS coverage's (Arc shapefiles).

d. Digital images

Final Report. A final technical report will be prepared at the conclusion of the study. The final report will focus on presenting data and results most relevant to addressing each management question. An appropriate level of detail in methods can potentially provide high level accounts, allowing details to be provided as reference materials presented in appendices or other stand-alone reports (e.g., annual reports). It is anticipated that the results and discussion will comprise a major part of the report, with the latter having subsections addressing each management question. Below is a suggested report outline:

1. An executive summary
2. Introduction - A description of the project background, including the objectives and management questions being addressed.
3. Methods - A description of the study area, methods, sampling design and sampling effort employed. A focus should be on providing a clear account of the details salient to understanding types of data (e.g., response measures), and their limitations (e.g., years of study, spatial replication (sample size), and confounding circumstances). Methodological details that are secondary to understanding the results (e.g., calibrations, technical details, supporting maps), can be referenced and provided in appendices if appropriate. Care should be taken to minimize redundancies.
4. Results – The results should only include an overview of data and analyses directly referenced in the Discussion; additional supporting results can be provided in appendices. It is anticipated that primary results will include multi-year comparisons (before-after comparisons, time series data) and spatial contrasts (e.g., treatment vs. control), which may or may not include temporal components. It is also anticipated that some results may be more descriptive and less data-driven; it may be appropriate to include detailed vignettes related to descriptive results as appendices, complete with photographic materials.
5. Discussion – The discussion will have subsections addressing each Management Question, drawing from results, supporting documents, and appendices as necessary.
6. Appendices – This section can include supporting maps (e.g., of the study plots), and supporting information for methods and results.
7. A digital appendix with:
   a. MS Excel spreadsheet of coordinates for survey sites
   b. A database in MS Excel or MS Access of all data collected
   c. GPS data and GIS coverage's (Arc shapefiles)
   d. Digital images

Data. A multi-year relational database will be submitted including tables of sampling locations, sample effort (e.g., survey details), and observations.

9.3 Interpretation of Results

A key outcome of this monitoring program will be to determine how the wildlife physical works affect measures of wetland function and productivity during the

time-period monitored. Results consistent with the objectives for the physical works at Sites 15A and 6A (i.e. no significant changes to key parameters over time) will suggest a positive protection/maintenance effect of the wildlife physical works.

9.4 Study Design Limitations

Monitoring changes in habitats can be complicated by numerous factors and limitations in study design or sampling strategy. Despite efforts to reduce these limitations, this monitoring program has several constraints. First, reservoir operations (water levels, filling and drafting rates) vary between seasons and between years, which may reduce the ability to correlate specific wildlife physical works to the relative abundance and species richness of indicator taxa (macrophytes and aquatic invertebrates) or other wetland parameters chosen for this study. Second, as habitats may take several years or even decades to change in response to wildlife physical works, or to stabilize following the disturbance of works, the duration of the monitoring program may not be sufficient to detect positive or negative changes in response to habitat protection initiatives.

10.0 Budget

Total Revised Program Cost $323,554.

11.0 References

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CLBMON-11B5 Effectiveness Monitoring of Wildlife Enhancement Structures in Arrow Lakes Reservoir

12.0 Monitoring Program Rationale

During the Columbia WUP process, the CC supported the implementation of revegetation (CLBWORKS-2) and wildlife physical works (CLBWORKS-30A and CLBWORKS-30B) in the Columbia River in lieu of changes to reservoir operations to help mitigate the impacts of Arrow Lakes Reservoir operations on wildlife and wildlife habitat. The CC suggested using an adaptive approach to create habitat for native wildlife, including nesting habitat for birds. In addition, the CC recommended monitoring to assess the effectiveness of these physical works at enhancing or protecting habitat for wildlife (BC Hydro 2005).

To assess the effectiveness of the revegetation and wildlife physical works programs BC Hydro has been undertaking several monitoring programs including CLBMON-11B dedicated to monitoring the effectiveness of the habitat enhancements with respect to wildlife use and productivity. CLBMON-11B has multiple specialized modules: CLBMON-11B1, CLBMON-11B2, CLBMON-11B3, CLBMON-11B4, and CLBMON-11B5. The original Terms of Reference (TOR) for CLBMON-11B did not portray the differences across its modules. CLBMON-11B5 was added to CLBMON-11B in 2016 to centralize the implementation and analysis of monitoring the wildlife enhancement structures.

The wildlife enhancement structures in Revelstoke Reach are constructed under CLBWORKS-30A. Two wildlife enhancement structure installation projects are being carried out under CLBWORKS-30A: nest boxes for cavity-nesting waterfowl (installed in 2013 and 2014; described in detail in Kellner 2013 and Kellner 2014); and maternity roosts for bats (expected to be installed in 2017; Kellner 2016). The effectiveness of these wildlife structures at improving wetland habitat conditions for nesting birds and bats in the drawdown zone at Revelstoke Reach was initiated in 2014 and continues until 2019. The monitoring involves assessing the utilization of the artificial nest and roost structures, exploring the correlates of successful use, and performing maintenance required to keep the structures suitable for use.

12.1 Objectives

The objectives for CLBMON-11B5 are to:

1. Assess the effectiveness of wildlife enhancement structures at enhancing wildlife habitat in the drawdown zone of Arrow Reservoir.
2. Provide recommendations about which wildlife enhancement structure methods or techniques are most likely to be effective at enhancing wildlife habitat in the drawdown zone of Arrow Reservoir.

12.2 Management Questions

The management questions for CLBMON-11B5 are intended to ensure that all response variables relevant to monitoring the effectiveness of wildlife enhancement structures are explored, and that the reasoning behind the analysis is clear. Analysis must be rigorous and appropriate for the nature of the data, but does not necessarily involve statistical hypothesis testing. This TOR does not

include management hypotheses. Formal statistical hypothesis testing is not well suited this study, and distracts from more informative analyses. The management questions for CLBMON-11B5 are:

1. Are the wildlife enhancement structures (waterfowl nest boxes and bat day roosts/maternity structures) effective at enhancing habitat quality and quantity for birds or bats?
    a. How are the waterfowl nest boxes utilized by waterfowl in terms of species present and apparent nesting success?
    b. How are the bat maternity structures utilized in terms of seasonality, intensity of use, species present, and number of days occupied per year?
    c. How does the internal temperature of bat maternity structures affect their successful utilization by bats?
2. Which wildlife enhancement structure methods or techniques (including those not yet implemented) are likely to be most effective at enhancing the productivity and suitability of wildlife habitat in the drawdown zone at Revelstoke Reach?

13.0 Monitoring Program

13.1 Summary of the Wildlife Structure Projects

Wetland-dependent waterfowl and bat species choose nests or roosts relatively close to riparian/wetland habitat where they can forage. While foraging habitat for both species groups appears to be available in the drawdown zone at Revelstoke Reach, and is being enhanced or protected through CLBWORKS-30A, nesting and roosting habitat for tree-dwelling species is lacking. Tree-roosting bats such as little brown Myotis and Northern Myotis require mature trees or snags for day-roosting and maternity-roosting. Tree-nesting duck species require mature trees or snags to provide large enough cavities to accommodate their nests. While revegetation and wetland protection may assist in addressing such losses over the long-term (decades), the use of artificial nest boxes and roost structures can compensate for lost nest and roost sites in the shorter term, or if long-term forest regeneration is not successful.

The regulation of the Columbia River resulted in the loss of much of the valley bottom mature forest habitat that would previously have been used by these species for nesting and roosting, suggests that such habitat is now limiting (Utzig and Schmidt 2011). Utzig and Schmidt (2011) identified bats and waterbirds as two of the species groups that experienced the greatest degree of habitat impact as a result of regulation of the Columbia River, including the Arrow Lakes Reservoir. Consequently, two wildlife enhancement structure projects designed to benefit wildlife that depend on mature forests (e.g., wildlife trees) were identified for construction under CLBWORKS-30A: nest boxes for cavity-nesting waterfowl, and maternity roost structures for bats.

There are several cavity nesting duck species known to frequent Revelstoke Reach. Wood Duck, Common Merganser are confirmed to nest in the area; these and potentially other species are expected to be limited by nest sites and to benefit from the nest box structures. Introduced bird species such as Starling and House Sparrow do not utilize the drawdown zone and are unlikely to benefit.

Nest boxes for cavity-nesting waterfowl were installed in 2013 and 2014 (Kellner 2013 and Kellner 2014). A total of 26 boxes were installed following protocols developed by Ducks Unlimited (Ducks Unlimited 2008). Nest boxes were constructed from cedar planks with two sizes of entrance holes, designed to accommodate both very small cavity-nesting ducks (e.g., Bufflehead), and large cavity-nesting ducks (e.g., Common Merganser). Both nest box designs were installed at each of Downie Marsh, Montana Slough, and Cartier Bay and at various sites on the west shoreline of the middle Columbia River and Revelstoke Reach (Kellner 2013).

Post-installation monitoring and maintenance of these nest boxes occurred in 2013, 2014 (Kellner 2014), and 2016 (Kellner in preparation) and will continue annually through 2019.

Approximately 10 species of bat occur in the Revelstoke area, including two endangered bat species confirmed to be present, Northern Myotis and little brown Myotis (Kellner 2016). The importance of roost site compensation is rapidly increasing for Northern Myotis and little brown Myotis because White Nose Syndrome (WNS), an introduced fungal disease of bats, is spreading towards BC. WNS causes extremely high rates of population decline and has led to the listing of both Northern Myotis and little brown Myotis as Endangered under the federal Species at Risk Act. Mitigation such as providing increased maternity roosting habitat can help to increase the resilience of bat populations not yet affected by WNS, and assist in population monitoring during recovery from WNS.

Day roost/maternity roost structures for bats are currently being designed and are expected to be installed in 2017 under CLBWORKS-30A (see Kellner 2016 for initial design information). Post-installation monitoring and maintenance of these shelters will occur under CLBMON-11B5 in 2018 and 2019.

13.2 Methods

13.2.1 Task 1: Project Coordination

Project coordination involves the general administration and technical oversight of the program, which includes, but may not be limited to: 1) budget management; 2) program team management; 3) logistics coordination; 4) technical oversight in field and analysis components; 5) facilitation of data transfer among other investigations associated with the Arrow Reservoir Operations Management Plan; 6) permit applications as required; 7) liaison with regulatory agencies as required; 8) adjust sampling design or methodology as required in consultation with BC Hydro; and 9) maintenance of an OSH program and safety plan for all aspects of the study in accordance with WCB and BC Hydro procedures and guidelines.

13.2.2 Task 2: Wildlife Enhancement Structure Monitoring

Design. The effectiveness of artificial nest/maternity roosting structures is best measured by whether they are utilized by wildlife, and by the reproductive success of the occupants. Because the wildlife structures provide nesting/maternity roosting habitat where none existed before, baseline data are not relevant to assessing their effectiveness. Pre-installation monitoring was

therefore not conducted for the wildlife structures. Post-installation monitoring assesses whether the structures are being utilized successfully, and monitors key factors expected to influence reproductive success of occupants.

Schedule. Table 7 outlines the construction and monitoring schedule for CLBMON-11B5. The waterfowl nest boxes were installed in 2013 and 2014. Post-installation monitoring of the waterfowl nest boxes occurred in 2014 and 2016, and will continue annually until 2019. The bat maternity structures are expected to be installed in 2017. Post-installation monitoring will occur in 2018 and 2019.

Table 7: Summary of construction and sampling schedule for CLBMON-11B5 (installation tasks implemented under CLBWORKS-30A and CLBWORKS-30B)

CLBMON 11B5 Schedule (✓– completed; P – planned; WS – wildlife enhancement structures)										
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Waterfowl WS Install (Revelstoke Reach)	✓	✓								
Bat WS Install (Revelstoke Reach)					P	P				
Bat WS Install (Lower Arrow)					P					
Waterfowl WS Install (Lower Arrow)					P					
Pre-monitoring WS	Not collected									
Post-monitoring Waterfowl WS		✓		✓	P	P	P			
Post-monitoring Bat WS						P	P	P	P	P

Field data. A detailed account of the methods used to install and monitor the waterfowl nest boxes can be found in Kellner (2013, 2015). Post-installation monitoring and maintenance of waterfowl nest boxes is conducted after nesting season has concluded and includes:

1. Assessing whether each box was utilized in that season.
2. Assessing which species utilized the box (to the extent this can be determined).
3. Assessing whether nesting was successful (to the extent this can be determined).
4. Identifying any evidence of nest predation.
5. Routine maintenance including:
    a. Removal of introduced nesting material.
    b. Replacement of wood chip nesting material.
    c. Tightening or replacing screws and nails as necessary.
    d. Installation of predator guards if there is evidence of nest box predation.

The bat maternity structures are expected to be installed in 2017. The target species for these structures are little brown Myotis, which are known to use bat

boxes as day roosts/maternity roosts, and Northern Myotis which are known to use shingles and artificial bark; bat day roost/maternity roost structure designs will take both species' needs into account. The design of the bat day roost/maternity roost structures and their layout is currently (2016) being developed, based on rapidly evolving information about the relative effectiveness of different structure types (houses, rocket boxes, mini-condos). Methods for post-installation monitoring will be tailored to the specific structures installed but the following general approach is proposed. Final methods will follow the standardized approach currently being developed by the BC Bat Action Team to ensure the broadest possible benefit from the data.

During the season of use (April to October) field study will include:

1. Continuous monitoring of the structures' internal temperatures during season of use.
2. Continuous monitoring of ambient temperature during season of use.
3. Trail camera or switch-box monitoring of day to day usage of the boxes, to assess correlations with internal temperature and structure type.
4. During heat waves, assessing the area beneath structures for evidence of pup mortality.
5. Two exit counts in early summer (before pups become volant) and two exit counts in later summer (after pups become volant), consistent with the BC Bat Network Annual Bat Count monitoring protocol.
6. Collection of guano samples for DNA analysis to identify which bat species are utilizing the structures.

After season of use (October-April), maintenance of structures will be conducted as necessary.

13.2.3 Task 3: Data Analysis

Data analysis, largely of a descriptive nature, will assess the effectiveness of the wildlife enhancement structures. Data will be summarized and analyzed following each field season with a multi-year analysis performed in conjunction with the final report. Analyses in the final report may draw, as appropriate, on results of other related monitoring studies.

13.2.4 Task 4: Reporting

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

Species at Risk observations will be submitted to the BC Conservation Data Centre in the required format. All relevant data will be shared with the BC Bat Action Team and their partners.

Annual Reports. Following every season in which fieldwork is undertaken, an Annual Report will be produced which summarizes the methods and sampling design employed, the data obtained, a brief description/analysis of the year's

data in the context of the multi-year dataset, recommendations as appropriate. Annual reports will include:

1. A description of the project background
2. A description of the methods, sampling design and sampling effort employed, highlighting any changes
3. Important results
4. Discussion and recommendations
5. A digital appendix with:
    a. MS Excel spreadsheet of coordinates for sampling sites
    b. A database in MS Excel or MS Access of all data collected

Final Report. A technical report will be prepared at the conclusion of the study.

This will include:

1. An executive summary
2. A description of the project background
3. A description of the methods, sampling design and sampling effort employed
4. A data summary
5. A comparison of results across sampling years
6. A detailed summary of the findings as they relate to the management questions
7. A discussion of sources of error and uncertainty
8. Recommendations as they relate to the effectiveness of wildlife enhancement structures for enhancing wetland habitat for wildlife
9. Maps of the study areas and locations of the study sites
10. A digital appendix with:
    a. MS Excel spreadsheet of coordinates for study sites
    b. A database in MS Excel or MS Access of all data collected
    c. Digital images

13.3 Interpretation of Results

A key outcome of this monitoring program will be to determine how the wildlife physical works affect measures of wetland function and productivity during the time-period monitored. Successful utilization of the structures by the target species will be the key measure of success for this project.

13.4 Study Design Limitations

Wildlife use of artificial nesting or roosting structures may take multiple years or even decades to develop and stabilize following their installation. The duration of the monitoring program may thus not be sufficient to detect positive changes.

14.0 Budget

Total Program Cost $244,719.

15.0 References

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Appendix 1 Rationale and Summary of Key Revisions for CLBMON-11B1 Terms of Reference

Early implementation of the five CLBMON-11B modules followed a generalized CLBMON 11B-TOR (BC Hydro 2009). The purpose of this revised TOR is to: (1) provide a more detailed description of each module and clearly distinguish which objectives and management questions are applicable to each; (2) update methods and approaches to reflect adjustments made based on initial field results; and (3) add study-specific Management Questions and refine the original Management Questions to fit the specific context of each study.

The module-specific TOR for CLBMON-11B1 is essentially a new document modified from the original CLBMON-11B TOR. The key revisions that distinguish this CLBMON-11B1 TOR from the original CLBMON-11B TOR are summarized in Table 9.

Table 9: Summary of TOR revisions and their rationale

CLBMON-11B1 TOR Revisions		
Section	**Change**	**Rationale**
Management Questions	Separated questions about revegetation effectiveness from those about wildlife physical works effectiveness	Questions about revegetation and wildlife physical works must be answered separately because they use different taxa, analyses and sampling design
	Reworded Management Questions to add specificity	Better matches the direction provided to BC Hydro via Orders and from the Consultative Committee
	Added new management sub-questions based on the management hypotheses from the original TOR	Adds important detail and structure to the management questions to ensure answers are thorough and draw on all relevant data
Management Hypotheses	Removed management hypotheses, updated them to fit current status of study, and reformulated them as management questions	The data gathered in this study are not always suitable for formal statistical hypothesis testing. The detail and structure contained in the original hypotheses was retained as new management questions
Monitoring Program: Objectives and Scope	Reworded objectives	Original objectives were too general, did not fully reflect the Orders, and lumped objectives related to wildlife physical works with those related to revegetation
Monitoring Program overall	Provided detailed methods specific to CLBMON-11B1	This was not provided in original CLBMON-11B1 TOR and was necessary to reflect current status of the project

CLBMON-11B1 TOR Revisions		
Section	**Change**	**Rationale**
Monitoring Program – focal taxa	Identified and justified focal taxa chosen for this study	Original CLBMON-11B1 TOR suggested but did not confirm focal taxa
	Structured quantitative monitoring of ungulate use and forage sampling discontinued.	Revegetation prescriptions were not designed to provide forage for ungulates; spatial scale of the treatments was inappropriate for affecting ungulate productivity.
	Bat monitoring added in stages, starting in 2010	Bat activity can respond rapidly to localized habitat enhancements, are important indicators of wetland condition, and are currently of key conservation concern
	Added nest searches and nest outcome monitoring to songbird survey methods	Methods are based on learning from CLBMON-36; nest fate is an important indicator of habitat quality for nesting songbirds

The revision to the CLBMON-11B1 TOR primarily improves clarity and specificity to the module; below we discuss the more substantive changes.

The decision to convert Management Hypotheses into Management Questions does not constitute a change to the study's scope, capacity, or intent; the modification will, however, allow greater flexibility and variety in the manner by which the analyses of data are made. In many cases there is insufficient spatial replication of revegetation or WPW treatments for statistical hypothesis testing in the sense portrayed by the former Management Hypotheses. Additionally, these hypotheses were stated as statistical null hypotheses (statements indicating no effect of treatments) which were not specific enough to be tested by robust statistical models. As is usual in ecology, null hypothesis will be implied by the use of inferential (frequentist) statistics, where the particular models are decided after the limits of study design are understood, and following the examination of data. Management hypotheses provide appropriate clarity in terms of analysis direction, whereas it was found that null hypotheses distracted from more informative analyses, and created awkward expectations regarding the appropriate use of statistics. To allow more appropriate analytical options, the management hypotheses in the original TOR have been reformulated as management questions. The detail and structure contained in the original hypotheses was retained and heightened in the new management questions.

The other more substantial changes to the TOR reflect a revision to the choice of key indicator species. It should be noted here, however, that changes to indicator species was anticipated in the original TOR. Due to the potential for unanticipated challenges in the field, the initial 2009 TOR for CLBMON-11B recommended monitoring several indicators initially, and adjusting the choice of indicators or the sampling design based on new information or changing conditions.

CLBMON-11B1's initial focus was on several taxa (i.e. migratory and nesting birds, ungulates, arthropods), based on the assumption that they would likely benefit from the proposed habitat enhancement treatments. These initial taxa and related sampling approaches were adjusted in the following ways:

1. Ungulate data collection was discontinued in stages, with forage surveys discontinued immediately, winter aerial surveys discontinued after 2011, and pellet counts discontinued after 2014 (incidental observations of ungulates and ungulate sign continue to be recorded). Forage production surveys were not initiated because revegetation primarily used plant species not suitable for ungulate forage. Aerial surveys were discontinued because this costly landscape-scale survey method was mismatched with the small size of the revegetation treatments. Pellet count surveys were discontinued because the numeric measurement of use could not be used to support population-level effects, and documentation of usage could be made anecdotally. No further data were necessary to answer Management Questions related to ungulates. Further discussion can be found in Adama and Hawkes 2015.
2. Bat data collection via remote acoustic monitoring was added to the study in stages, with remote acoustic detectors initially deployed in 2010 to sample revegetation sites, and sampling effort expanded in 2015 and 2016 to monitor potential WPW sites. This addition coincides with the changes to the conservation status of bats and also the recognition that bat foraging activity is a measureable and sensitive indicator of the success of wetland restoration projects.
3. Migratory and nesting bird data collection, initially done as point counts, was expanded in 2015 to also include nest searches and nest outcome monitoring. This addition reflects recognition that nest monitoring can provide an easily measured and sensitive indicator of changes to site productivity, which is not necessarily correlated with site usage, and builds upon methodological and biological knowledge gained through the implementation of CLBMON-36, a nest monitoring study in Revelstoke Reach (e.g. van Oort *et al.* 2016).

Appendix 2 Rationale and Summary of Key Revisions for CLBMON-11B4 Terms of Reference

Implementation of the CLBMON-11B studies has followed a broad CLBMON-11B TOR (BC Hydro 2009). The original TOR covered the four separate studies that make up the CLBMON-11B effectiveness monitoring program.[2] The purpose of this revised TOR is:

1. To provide a more detailed description of CLBMON-11B4 and clearly distinguish which objectives and management questions are applicable to it;
2. To update methods and approaches to reflect adjustments made based on initial field results; and
3. To refine the original Management Questions to fit the specific context of this study.

CLBMON-11B4 monitors wetland habitat parameters. The original TOR for CLBMON-11B included wildlife physical works effectiveness monitoring of certain wildlife taxa in Revelstoke Reach. These taxa are covered under other monitoring studies and are not components of CLBMON-11B4: songbirds during spring migration (CLBMON-11B2); ungulates (CLBMON-11B1 covered ungulate monitoring for the entire Arrow Lakes Reservoir); amphibian and reptile habitat use (CLBMON-37); bird nest mortality monitoring (CLBMON-36); Western painted turtles (CLBMON-11B3); and, wildlife habitat monitoring (CLBMON-11B2, CLBMON-36, CLBMON-39, CLBMON-40).

A summary of the key revisions to this CLBMON-11B4 TOR as compared to the original high level CLBMON-11B TOR are detailed in Table 10.

[2] 11B-1 Effectiveness Monitoring of Revegetation and wildlife physical works in the Lower and Mid Arrow Lakes Reservoir; 11B-2 Effectiveness Monitoring of Revegetation and wildlife physical works for Spring Migrants in Revelstoke Reach; 11B-3 Wildlife Effectiveness Monitoring of Western Painted Turtles in Revelstoke Reach (revised to be included in CLBMON 37); 11B-4 Effectiveness Monitoring of wildlife physical works for Wetlands in Revelstoke Reach; 11B-5 Effectiveness Monitoring of Wildlife Enhancement Structures in Revelstoke Reach.

Table 10: Summary of TOR revisions and their rationale

CLBMON-11B4 TOR Revisions		
Section	**Change**	**Rationale**
Objectives	Reworded objectives	Original 11B objectives were too general, did not fully reflect the Orders, and lumped objectives related to wildlife physical works with those related to revegetation
Management Questions	Removing references to effectiveness monitoring of revegetation from Management Questions	CLBMON-11B4 is specifically focussed on wetland habitats influenced by physical works and does not monitor revegetation.
Management Questions	Reworded MQs to add specificity	Better matches the current status of the study and direction provided to BC Hydro via Orders and from the Consultative Committee
Management Questions	Revised management questions based on the management hypotheses from the original TOR	Adds important detail and structure to the management questions to ensure answers are thorough and draw on all relevant data
Management Hypotheses	Removed management hypotheses and reformulated them as management questions	The data gathered in this study are not suitable for formal statistical hypothesis testing
Monitoring Program overall	Provided methods specific to CLBMON-11B4	This was not provided in original 11B TOR and was necessary to reflect current status of the project

The revised TOR for CLBMON-11B4 does not include management hypotheses. The data gathered in this study are designed to address questions about wildlife physical works effectiveness raised by the Consultative Committee. The management hypotheses in the original TOR have are now expressed as management questions. This change does not constitute a change to the study's scope, capacity, or intent; the modification will, however, allow greater flexibility and variety in the manner by which the analyses of data are made. The detail and structure contained in the original hypotheses was retained and heightened in the new management questions. Note that because the physical works at Site 6A was downstream and remote to the habitat it protected (Airport Marsh), it can be assumed that this physical works project did not interact with the habitat at Airport Marsh. This difference is reflected in the depth of detail addressed by the management questions.