Columbia River Project Water Use Plan

Monitoring Program Terms of Reference

ARROW LAKES RESERVOIR OPERATIONS MANAGEMENT PLAN

- **CLBMON-36 Kinbasket and Arrow Lakes Reservoir: Nest Mortality of Migratory Birds due to Reservoir Operations**

Revision
December 10, 2014

Monitoring Study CLBMON-36

Kinbasket and Arrow Lakes Reservoirs: Nest Mortality of Migratory Birds due to Reservoir Operations

1.0 MONITORING PROGRAM RATIONALE

1.1 Background

Riparian habitats cover less than 1% of the landscape in western North America (Knopf et al. 1988) but support a disproportionate number of bird species (Knopf & Samson 1994; Skagen et al. 2005). It has been reported that 95% of riparian habitat in North America has been degraded or destroyed as a result of human activities (Dahl 1990; Noss et al. 1995). Loss and degradation of riparian habitat has been linked to the population declines of many migratory birds (DeSante & George 1994; Ohmart 1994).

Riparian habitats along the impounded portions of the Columbia River provide important nesting habitat for birds (Andrusiak & Simpson 1994; Boulanger et al. 2002). In Kinbasket Reservoir, 27 species of birds nested in the reservoir drawdown zone, and 54 species were found to breed in the drawdown zone of Revelstoke Reach, at the north end of the Arrow Lakes Reservoir (CBA 2013). Reservoir operations are known to directly affect as many as 28 of the species that nest in these drawdown zones via nest flooding (CBA 2013).

In the Kinbasket Reservoir, significant areas of riparian habitat occur along Canoe Reach, Columbia Reach and Bush Arm (Hawkes et al. 2007), however there is little information available with respect to bird use in the drawdown zone. Due to the operation of these reservoirs, birds that rely on the drawdown for breeding habitat are vulnerable to rising water levels during spring and early summer through inundation of breeding and foraging habitat, by flooding of active nests (Jarvis 2003; CBA 2013), or by creating drowning hazards for recently fledged juvenile birds (CBA 2013). Further, the loss of breeding habitat may increase competition for available breeding territories, causing density-dependent decline in site productivity.

During the Columbia River Water Use Planning Process (WUP), the Consultative Committee (CC) identified nest flooding as a key issue. One of the concerns identified was whether the drawdown zones function as a population sink, reducing the overall productivity and viability of bird populations that breed in these habitats. To address these uncertainties, the CC proposed that a study be undertaken to (1) determine the use of riparian habitats by breeding birds in the drawdown zone, (2) determine the degree and significance of nest failure caused by the operations of the Kinbasket and Arrow Lakes Reservoirs, (3) investigate the direct and indirect impacts of reservoir operations on the productivity and survival of birds that utilize riparian habitat within the drawdown zone, (4) inform and evaluate the effectiveness of physical works and revegetation efforts to enhance nesting success and bird productivity, and (5) assess the implementation of the soft constraints[1] and any

[1] Soft constraints governing daily operational use of water (e.g., timing, magnitude, rate) were made to meet the different or combined needs of various interests within the range of the hard constraints (e.g., turbine capacity, treaty agreements)

incremental impacts resulting from the addition of unit 5 at Revelstoke Dam. These data will also help refine the habitat models developed previously for birds nesting in the drawdown zone of Revelstoke Reach (Axys Environmental Consulting 2002).

The CLBMON-36 monitoring program was initiated in 2008. After three years of experience with the program, minor revisions to the Scope of Services were implemented in 2011, primarily to increase clarity of the management questions and hypotheses. Some details were altered in the methodology, most notably the language was altered to allow radio-telemetry as an option for monitoring juvenile survivorship.

In early 2014 following multi-year data analysis from CLBMON-36 (CBA 2012), and in consideration of related feedback, BCH re-assessed the ToR and has now revised it substantially. The objective of this revision is to improve the study's capacity to address the original requirements defined by the Consultative Committee and to address shortcomings in the framing of the initial management questions. This revision includes refining and removing some of the management questions which were originally either formulated in a way that was not possible to answer, or were too general to effectively address the consultative committee's specific concerns. The next section summarizes the rationale of the key changes from the original 2008 TOR, included in this TOR Revision.

1.2 Rationale and summary of key revisions

The principal changes resulting in this revised TOR are as follows:

- Removal of Management Question E. This question addressed the potential indirect impact of reservoir operations on bird productivity, caused by changes to habitat. It has been omitted because changes to habitat as a result to reservoir operations have not been measurable even by dedicated monitoring projects.

- Removal of Management Question F. This question addressed the impacts of reservoir operations on regional populations. It was removed because it is not considered key to identifying meaningful mitigation approaches for nest mortality that results from reservoir operations. Further, significant regional sampling, which is prohibitively expensive, would be required to answer this question.

- Amalgamation and simplification of Management Questions I and J into Management Question K below. These questions related to the design and effectiveness of habitat treatments to improve productivity of the drawdown zone. Because the habitat treatments were not successfully delivered, these questions could not be answered. These questions were combined as a single new question that is not contingent on the success of habitat treatments, but still addresses the important topic of habitat management in the drawdown zone.

Please refer to Table 36-3 for other key changes and the rationale for their inclusion into this revised TOR.

1.3 Management Questions

This monitoring program is designed to address key management questions relating to the extent to which reservoir water levels affect the nesting success of birds breeding in the drawdown zones of the Kinbasket Reservoir and Arrow Lakes Reservoir, and the significance of nest flooding to bird populations. The management questions to be addressed include:

A. Which bird species breed in the drawdown zones and how are they distributed among the drawdown zone habitat classes?

B. What are the seasonal patterns of habitat use by birds nesting in the drawdown zones?

C. Do reservoir operations affect nest survival?

D. What are the causes of nest failure in the drawdown zone, and how do they differ among species, among habitat classes, and across elevation (i.e., position in drawdown zone)?

E. O*riginal question e deleted*[2]

F. O*riginal question f deleted*[3]

G. Do reservoir operations affect juvenile survival when water levels inundate post-fledging habitat?

H. How can the operations of the Kinbasket and Arrow Reservoirs be optimized to reduce nest submersions and/or improve avian productivity?

I. Original Q*uestion I has been amalgamated into K below*[4]

J. Original Q*uestion* J *has been amalgamated into K below*[5]

K. Can drawdown zone habitats be managed to improve nest survival and/or site productivity? If so, how?

1.4 Management Hypothesis

The management hypotheses to be tested by this study are:

H_1: Inundation of nesting habitat caused by reservoir operations does not affect nest survivorship.

H_{1A}: Nest survivorship in the drawdown zone is not different from nest survivorship above the drawdown zone.

H_{1B} : This management hypothesis was removed.

[2] The original question E was: “Do reservoir operations indirectly affect nesting success by altering nesting habitat (vegetation characteristics, habitat configuration)?”
[3] The original question F was: “If reservoir operations negatively affect the nesting success, what is the significance of these impacts on bird populations?”
[4] The original question I was: “Provide recommendations for physical works projects and revegetation efforts to increase nesting success and juvenile survival in the Kinbasket Reservoir and Revelstoke Reach.”
[5] The original question J was: “Evaluate the effectiveness of revegetation efforts and physical works projects implemented during the course of this monitoring program for improving nesting success or juvenile survival.”

$H_{1C;}$ Nest survivorship does not differ across elevations in the drawdown zone.

$H_{1D;}$ Rates of nest flooding do not differ across elevations in the drawdown zone.

H_2: Inundation of post-fledging habitat does not affect juvenile survival.

H_{2A}: Juvenile survival in the drawdown zone does not differ from juvenile survival above the drawdown zone.

1.5 Key Water Use Decision Affected

The key operating decisions affected by this monitoring program are the operating regimes for the Kinbasket Reservoir and the implementation of soft constraints for the Upper Arrow Lakes Reservoir/Revelstoke Reach. For the Kinbasket Reservoir, this monitoring program will assess the impact of reservoir operations on the nesting success of breeding birds, and evaluate whether operational changes will improve reproductive success. For Revelstoke Reach, operational changes will be limited to soft constraints that govern daily operations such as timing, magnitude and flow rate as opposed to hard constraints that include reservoir and turbine capacities, spillway rating, licensing requirements and Columbia River Treaty obligations.

This information will help determine the magnitude and significance of nest flooding and guide the development of recommendations with respect to reservoir operations and physical works required to enhance nesting success. These data will also help to evaluate the effectiveness of the works undertaken.

2.0 Monitoring Program

2.1 Monitoring Objectives and Scope

The objectives of this monitoring study are to:

1) Identify how drawdown zone habitats are used by breeding birds in Kinbasket Reservoir and Revelstoke Reach.
2) Evaluate how the operations of the Kinbasket and Arrow Lakes Reservoirs influence nest survival.
3) Evaluate how the operations of the Kinbasket and Arrow Lakes Reservoirs influence juvenile survival.
4) Original objective 4 combined into objective 6[6]
5) Original objective 5 combined into objective 6[7]

[6] The original objective 4 was “Provide recommendations to reduce nest mortality and increase juvenile survival and productivity for birds breeding in the drawdown zones.”
[7] The original objective 5 was “Evaluate how the operations of the Kinbasket and Arrow Lakes Reservoirs influence nesting habitat availability and quality.”

6) Assess how habitat management in the drawdown zones can be used to increase productivity, or reduce negative impacts of reservoir operations.
7) Establish a nest flooding risk model for Kinbasket Reservoir and Revelstoke Reach.

This monitoring program was designed to occur annually over a 10 year period in order to provide a long-term dataset on habitat use, nest success, survival and productivity. The program was initiated in 2008 (Year 1). In 2012 (Year 5), an interim review of the data and progress took place, consisting of a complete initial examination of the first five years of data. During the final years of the program, monitoring will continue, and multi-year analyses will be refined. Final results from this study (2017, Year 10), and related studies, will be evaluated to assess the impacts of reservoir operations, the implementation of soft constraints and the effectiveness of physical works to meet the wildlife objectives set by the Consultative Committee.

2.2 Approach

This monitoring program will follow the same general approach for both Kinbasket Reservoir and Revelstoke Reach.

To assess the biogeography of the breeding bird communities within the drawdown zone, and to monitor nest and site productivity, new study plots will be established in the drawdown zone and monitored throughout the nesting season each year. Random plot location is not feasible for this type of study, given the scale and remoteness of the reservoirs, and the need to repeatedly monitor plots throughout the field season. Study plots will be systematically chosen to ensure the full range of recognized drawdown zone habitat classes are monitored, while accommodating practical access requirements. Plots will be visited throughout the breeding season (early-May to early August) at a frequency that is adequate for monitoring active nests, when present (Martin and Geupel 1993). The nests of all bird species encountered will be documented and monitored throughout the breeding season to determine whether the eggs hatch and the nestlings fledge in order to calculate nest success and failure rates.

In addition to the community-level monitoring outlined above, the productivity of select individual species will be studied in detail. Specifically, a focal species approach will be used to study juvenile survivorship using radio telemetry. Additionally, focal species data gathering and analyses can be used to compare productivity within the drawdown zone against productivity above the drawdown zone. Choice of focal species will depend on their abundance in each reservoir, but for the study of juvenile survival should include study of one ground-nesting species and one shrub-nesting species.

2.3 Methods

<u>Task 1: Project Coordination</u>

Project coordination involves the general administration and technical oversight of the program, which will include, but may not be limited to: 1) budget management, 2) program team management, 3) logistics coordination, 4) technical oversight of fieldwork, data analysis and report preparation, 5) facilitation of data transfer among

other investigations associated with the Arrow Reservoir Operations Management Plan and the Kinbasket and Arrow Reservoir Revegetation Management Plan, 6) permit applications, and 7) liaison with regulatory agencies, as required.

Any necessary research permits will be obtained from the Ministry of Environment and Canadian Wildlife Service. Protocols will be updated and submitted along with future permit requests and will be made available for review by animal care committees.

A safety plan must be developed and submitted to BC Hydro for all aspects of the study involving field work, in accordance with BC Hydro procedures and guidelines. Specific safety training may be required (e.g. first aid, small boat operation).

Task 2: Monitoring Habitat Use, Nest Success, Survival and Productivity

a) Site Selection

Habitats in the drawdown zones of Revelstoke Reach and the Kinbasket Reservoir will be stratified using drawdown zone habitat mapping data (e.g., CLBMON-10). Permanent plots will then be established annually in representative habitats with the aim of maximizing spatial replication over time. Plot size will vary with nest density; habitats with high nesting density will be smaller than those with low nest density. Consideration will be given to site accessibility, personnel safety, and sampling efficiency in the selection of sampling plots.

b) *Nest Success*

Monitoring plots will be surveyed repeatedly throughout the breeding season from early-May to early-August. All nests located on the ground or in the shrub layer (< 3 m above ground) will be searched for and monitored. The nests of all bird species encountered will be documented. Active nests will be monitored twice a week to determine whether the nests hatched eggs and fledged young, and to identify causes of observed nest failures. Data on clutch size, brood size and parasitism by cowbirds will be collected where possible and precautions will be taken to avoid any negative influence by the observers on nesting success (Martin et al. 1997).

c) Focal Species Study

At least two focal species will be used to study how reservoir operations impact juvenile survival; one species will be a ground-nesting species, and the other will nest in shrubs. Radio-telemetry will be used to monitor the survival of juvenile birds post-fledging. Tagged juveniles will be monitored daily where possible, and followed until they die, or until the transmitter fails, or until the juveniles have clearly reached independence. Focal species research may also require color-marking birds to examine habitat use, dispersal or recruitment. All birds captured will be handled in compliance with provincial animal handling protocols (Resources Inventory Committee 1998) and using methods approved by the Simon Fraser University Animal Care Committee.

Task 3: Data Analysis

A brief summary of the data collected during each year will be provided in an annual progress report. This will include a summary of sampling effort expended and an overview of the data. The intent of the data summary is to provide a synopsis of the sampling effort and results and to ensure data is checked on an annual basis. Comprehensive analysis of the data will be ongoing.

A range of analysis and statistical methods are expected to be required. The choice of statistical methods must be clearly stated and justified. It is expected that nest survivorship models will be implemented to make inferences about nesting success (Mayfield 1961; Shaffer 2004).

Task 4: Reporting

A brief progress report will be prepared annually. In Year 10, the most relevant new and previously reported results will be presented in a separate final report addressing each of the management questions.

Annual reporting:

Annual reports will provide three types of information: (1) a brief account of the annual progress, (2) a review of the progress in the multi-year dataset, and (3) an account of updated analyses. The annual progress summary will be brief and include the locations of field work, sampling effort, a high level account of what was observed and monitored (e.g., numbers and types of nests located and monitored, a review of nest outcomes), and a record of the conditions encountered (e.g., weather, reservoir operations, notable relevant observations unique to the year). The review of multi-year progress will review the status of the multi-year dataset, and highlight targets for the following year. The analysis section will showcase progress being made towards addressing the management questions, for example, by testing the management hypotheses. Such analyses may be draft results, or final results, depending on the circumstances (e.g., need for additional data or additional analysis). Annual reports will contain a detailed Executive Summary, followed by a brief Introduction, Methods, Results, Discussion, References, and Appendices.

Manuscripts prepared for peer-review publication will be submitted along-side annual reports, and referenced as a separate document.

Digital deliverables to BC Hydro will include

- A database of nest observations;
- A database of juvenile survival data.

As part of the Canadian Migration Monitoring Network, the capture-banding data will be submitted annually to the Canadian Wildlife Service in the appropriate format (MS Excel).

Also in each year of the study, sampling protocols will be developed/updated describing the location of study plots in the Revelstoke Reach and Kinbasket Reservoir.

The final report:

A technical report will be prepared following the completion of Year 10. This report will include:

- an executive summary;
- an introduction;
- a brief overview of the project methods;
- a detailed overview of how each management question and hypothesis has been addressed. This section will refer to peer-reviewed reports, or similar stand-alone documents (e.g., manuscripts in draft form), or to new analyses, each presented in detail in their own appendix;
- a discussion of the final results, knowledge gaps, and recommendations.

A final digital appendix with data from all years including:

- A database of nest observations;
- A database of juvenile survival data.

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. The locations and associated data for significant species such as species at risk will be provided to the Ministry of Environment following the Wildlife Species Inventory (WSI) standards (http://www.env.gov.bc.ca/wildlife/wsi/formats.htm).

2.4 Interpretation of Monitoring Program Results

The data collected in this monitoring program will be used to test hypotheses about how the operating regimes of the Kinbasket and Arrow Lake Reservoirs influence nest survival, juvenile survival, and habitat (availability and quality). The results from this program will be used to address the uncertainty regarding the benefits of minor modifications to operating conditions that could enhance habitat within the drawdown zone to support breeding bird populations. The significance of any impacts of reservoir operations on these populations will be assessed by determining the extent to which water levels influence nest survival, productivity, and juvenile survival. Detailed data on the relationship between habitat features, nest site selection, productivity and survival will inform mitigative efforts aimed at providing habitat for breeding birds in the drawdown zone, and will facilitate the effectiveness of revegetation and physical works in this regard.

2.5 Schedule

This program will be implemented over 10 years with field tasks undertaken in each year of study. The anticipated annual schedule for each key task is presented in Table 36-1. At Year 5, a detailed interim report was produced to assess progress and allow the initial results of this study to be incorporated into plans for wildlife physical works. A final report will be prepared in year 10.

Table 36-1 CLBMON-36 Schedule of Tasks

Tasks	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1. Project Coordination	√	√	√	√	√	√	√	√	√	√	√	√
2a. Nest monitoring	√	√	√									
2b Productivity and survival	√	√	√	√								
3. Data analysis					√	√						
4. Reporting						√	√	√				

2.6 Budget

The total estimated cost is $4,051,349. The average annual cost over 10 years is estimated at $394,603. This is higher than the cost estimated by the WUP Consultative Committee, which estimated an annual budget of $300,000 in 2004. This was due to the amount of monitoring required and the geographic extent of the survey area which includes Bush Arm, Canoe Reach, and Revelstoke Reach.

3.0 References

Andrusiak, L., and K. Simpson. 1994. Big Bend bird survey. Mica Compensation Program, B.C. Hydro, Nelson, BC.

Axys Environmental Consulting. 2002. Mica-Revelstoke-Keenleyside (MCA) Water Use Plan: Breeding Bird and Migratory Shorebird use of the Revelstoke Wetlands. Report prepared for BC Hydro, Water Use Planning. Burnaby, B.C. 86 pp.

Boulanger, J., J. G. Woods, and J. Jarvis. 2002. Songbird use of four floodplain vegetation types in the Revelstoke Reach, Upper Arrow Reservoir, BC, Canada. Report prepared for BC Hydro's Strategic Environmental Initiatives Program, BC Hydro. Burnaby B.C. 27 pp.

Cooper Beauchesne and Associates Ltd (CBA). 2013. CLBMON-36: Kinbasket and Arrow Lakes Reservoirs: nest mortality of migratory birds due to reservoir operations. 5 Year Interim Review Report: 2008-2012. Report prepared for BC Hydro Generation Water License Requirements, Burnaby, B.C. 19 pp + appendices.

Dahl, T. E. 1990. Wetland losses in the United States 1780's to 1980's. US Fish and Wildlife Service. Washington, DC

DeSante, D. F., and T. L. George. 1994. Population trends in the landbirds of western North America. Pages 173-190 in J. J.R. Jehl, and N. K. Johnson, editors. Avifaunal Change in Western North America. Studies in Avian Biology 15.

Hawkes, V. C., C. Houwers, J. D. JFenneman, and J. E. Muir. 2007. Monitoring program No. CLBMON-10 Kinbasket Reservoir inventory of vegetation resources. . Draft Report to BC Hydro. Burnaby, B.C. 77 pp.

Jarvis, J. 2003. Preliminary evaluation of the impact of reservoir operations on nesting birds in the Revelstoke Reach, Upper Arrow Reservoir, Revelstoke, British Columbia, Canada. Report prepared for BC Hydro. Burnaby, B.C.

Knopf, F. L., R. R. Johnson, T. Rich, F. B. Samson, and R. C. Szaro. 1988. Conservation of riparian ecosystems in the United States. Wilson Bulletin 100:272-284.

Knopf, F. L., and F. B. Samson. 1994. Scale perspectives on avian diversity in western riparian ecosystems. Conservation Biology 8:669-676.

Martin, T. E., and G. R. Geupel. 1993. Nest-monitoring plots: methods for locating nests and monitoring success. Journal of Field Ornithology 64:507-519.

Martin, T. E., C. R. Paine, C. J. Conway, W. M. Hochachka, P. Allen, and W. Jenkins. 1997. BBIRD Field Protocol. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, MT.

Mayfield, H. 1961. Nesting success calculated from exposure. Wilson Bulletin 73:255-261.

Noss, R. F., E. T. LaRoe III, and J. M. Scott. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. USDI National Biological Service Biology Report 28. Washington, DC.

Ohmart, R. D. 1994. The effects of human-induced changes on the avifauna of western riparian habitats. Pages 272-285 in J. J.R. Jehl, and N. K. Johnson, editors. Avifaunal Change in Western North America. Studies in Avian Biology 15.

Shaffer, T.L.. 2004. A unified approach to analyzing nest success. The Auk 121:523-540.

Skagen, S. K., R. Hazelwood, and M. L. Scott. 2005. The importance and future condition of western riparian ecosystems as migratory bird habitat. Pages 525-527. Third International Partners in Flight Conference. USDA Forest Service, Asiloma, CA.

Table 36-3 CLBMON-36 Key changes and rationale for their inclusion

CLBMON-36 TOR Revisions		
Section	**Change**	**Rationale**
Overall	Intermittent minor editing	Improve clarity and consistency
Background	Minor changes to wording: updated (data/references); clarified wording about juvenile survival	Improve clarity
Management Questions	Removed Original Question E: Do reservoir operations indirectly affect nesting success by altering nesting habitat (vegetation characteristics, habitat configuration)?	Changes to habitat as a result to reservoir operations have not been measurable even by dedicated monitoring projects.
Management Questions	Removed Original question F If reservoir operations negatively affect the nesting success, what is the significance of these impacts on bird populations?	This question is not considered key to identifying meaningful mitigation approaches for nest mortality that results from reservoir operations. Further, significant regional sampling, which is prohibitively expensive, would be required to answer this question
Management Questions	Combined Original Questions I and J into one new question K	Since habitat treatments were not successfully delivered, these questions could not be answered. The new question is not contingent on the success of habitat treatments, but still addresses the important topic of habitat management in the drawdown zone.
Management Hypotheses	Removed H3 and H4 (including sub-hypotheses)	No longer relevant as original Questions E, F, I and J have been removed
Management Hypotheses	Re-worded H1 and removed H1B	To improve clarity, and better fit with types of analysis required
Management Hypotheses	Added two new Hypotheses related to H1: H1C and H1D	Revised hypotheses capture key information central to addressing management questions
Management Hypotheses	H2 - reworded	To clarify, and adjust according to altered methodologies/sampling design
Monitoring Objectives and Scope	Combined Objective 4 and 5 and generalize topic into a new Objective 6 in this revision	Combined since habitat enhancements may not be realized; we will instead assess how enhancements can be used to increase productivity, or reduce negative impacts of reservoir operations
Monitoring Objectives and Scope	Added one new objective (to create nest flooding model), labelled as Objective 7 in this revision	Added since such a model is a crucial tool for addressing the management questions)

Approach	Modified	To reflect methodological improvements informed by early field work, results and analyses
Tasks	Modified /clarification and corrected errors in numbering	Modified for clarity and consistency with the revised Management Questions
Methods - Site selection	Modification/clarification	To increase site-level replication (and avoid pseudo replication)
Methods - Focal Species	Modification/clarification	Updated to provide more clarity around the juvenile survival piece, and improve latitude to analyze single species productivity data
Methods - Data analysis	Modification	Changed to specify general approach and reporting rather than specifics of analysis