Columbia River Water Use Plan

Kinbasket and Arrow Lake Reservoirs Revegetation Management Plan

Monitoring Program Terms of Reference

CLBMON-11A Wildlife Effectiveness Monitoring of Revegetation in Kinbasket Reservoir

Revision 1
June 13, 2017

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1.0 Monitoring Program Overview

1.1 Background

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, culture/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 2005a, b) and was approved by the Comptroller of Water Rights in January of 2007 (Comptroller of Water Rights 2007).

The CC supported reservoir-wide revegetation programs for the Kinbasket and Arrow Lakes reservoirs to increase vegetation growth in the drawdown zones in lieu of maintaining lower reservoir levels. This was to be achieved by applying a variety of prescriptions at sites within the Kinbasket Reservoir and Arrow Lakes drawdown zones.

The CC also recommended effectiveness monitoring to ensure that the revegetation efforts provided the intended environmental benefits[1]. The CC further noted that monitoring the effectiveness of vegetation would also inform on uncertainties about the use of the drawdown zone by wildlife species and about the effects of reservoir operations. The effectiveness of the revegetation programs for wildlife is monitored under two similar programs: Kinbasket Reservoir (CLBMON-11A; Wildlife Effectiveness Monitoring of Revegetation in Kinbasket Reservoir) and Arrow Lakes Reservoir (CLBMON-11B; Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir).

1.2 Rationale and key revisions

The principal objective of CLBMON-11A, an 11 years monitoring program initiated in 2008 (BC Hydro 2008), is to assess the effectiveness of revegetation efforts[2] (prescribed under CLBWORKS-1 – Kinbasket Reservoir Revegetation) at improving habitat for wildlife in the drawdown zone of Kinbasket Reservoir. A technical review workshop regrouping representatives of BC Hydro, First Nations, contractors and agencies was conducted in the winter of 2014. One of

[1] Please refer to BC Hydro (2008), Program Rationale, p. 5, for additional details.
[2] The words 'revegetation efforts' refer to a variety of revegetation planting efforts (type and species) in different locations undertaken under CLBWORKS-1 before 2014. The words 'revegetation prescriptions' refer to the specific works (log booms and wood mounds) since implemented to foster revegetation in Canoe Reach and Bush Arm.

the conclusions of that technical review was that most revegetation efforts in the Kinbasket area have proven ineffective to date, and that hence it was not possible to assess the effects of revegetation on wildlife use.

Several alternative treatments aimed at improving vegetation in the Kinbasket drawdown zone were considered, two of which have since been implemented on a small scale basis: a log boom in a small embayment near Canoe Reach to exclude woody debris piling up on the foreshore, and wood mounds / windrows coupled to live stakes to promote natural revegetation by the Bush Arm causeway[3].

This document provides updated Terms of Reference (TOR) to monitor the effectiveness of wildlife habitat utilization in response to revegetation in Kinbasket Reservoir (CLBMON-11A). The original monitoring program involved seasonal wildlife surveys of small mammals, ungulates, birds, arthropods, amphibians and reptiles. Small mammals and ungulates surveys have now been removed from these updated TOR. This is due to the lack of revegetation success of the previous works and the scale of the new works, which cover too small an area to influence habitat use by mammals (which would not be good indicators of revegetation success at that spatial scale). Amphibians and reptiles are only monitored through incidental observations as they are the focus of two separate studies in the same area (CLBMON-37 and CLBMON-58).

Moreover, the recent implementation of the two prescriptions (2014 and 2015) precludes the detection of certain trends. Thus one management question ("Are revegetation efforts negatively impacting wildlife in the drawdown zone? For example, does revegetation increase the incidence of nest mortality in birds or create sink habitat for amphibians?") was omitted as natural cycles and environmental variables would not allow enough time to assess the effects, negative or otherwise, of the prescriptions on bird mortality and amphibian habitat sinks. It is now replaced by another one focusing on diversity and abundance of arthropods, amphibians and birds.

Finally, testing management null hypotheses is no longer required; focusing on the management questions should address the uncertainties brought forward by the CC. Formal statistical hypothesis testing, or Null Hypothesis Significance Testing (NHST) has been omitted as it is not well suited to addressing these questions and distracts from more informative analyses. The rationale for dropping NHST as a formal requirement to address Management Hypotheses is that it has long been under attack for its usefulness (e.g., Carver 1978; Johnson 1999) and is increasingly being questioned in the peer-reviewed scientific literature, one of the main criticisms being that its binomial nature is not suited to experimental studies (Hurlbert and Lombardi 2009). Moreover results based on NHST are often misinterpreted (Wainer and Robinson 2003) and focusing on NHST may in some cases result in ignoring the magnitude of effects and their precision (Nagawa and Cuthill 2007).

The original TOR Management Hypotheses have been updated to fit the current status of the study and reformulated as Management Questions. The detail and structure contained in the original hypotheses is retained.

[3] Please refer to Hawkes (2016, 2017) for a full description of the two revegetation prescriptions.

1.3 Management Questions

This monitoring program is designed to address key management questions relating to the effectiveness of revegetation prescriptions at improving wildlife habitat in the Kinbasket Reservoir. This monitoring study focuses on how revegetation prescriptions impact the abundance of arthropods, as these are considered a fundamental component of the food chain, particularly for small mammals (e.g., shrew, bats), birds and amphibians; it also assesses how effectively the revegetation prescriptions enhance bird habitat.

The management questions addressed by this monitoring program are:

1. How effective are the revegetation prescriptions at enhancing and increasing the drawdown zone habitat use by wildlife such as birds and amphibians?
2. To what extent does revegetation increase the availability of invertebrate prey (e.g., arthropods) in the food chain for birds and amphibians?
3. How do revegetation prescriptions affect the diversity and abundance of arthropods, amphibians and birds?
4. Which revegetation method is the most effective at enhancing or increasing the utilization of wildlife habitat in the drawdown zone?

1.4 Key Water Use Decision Affected

The key water use planning decision affected by the results of this monitoring program is whether revegetation is effective at enhancing wildlife habitat and reducing any negative effect of reservoir operations on wildlife in lieu of changes to reservoir operations. Results from this study will support more informed decision making with respect to the need to balance the requirements of wildlife species dependent on riparian areas with other values such as recreational opportunities, flood control, and power generation.

2.0 Monitoring Program Proposal

2.1 Objectives and Scope

The objectives of this study are to:

1. Assess whether the revegetation prescriptions in the drawdown zone of Kinbasket Reservoir improve habitat for wildlife.
2. Report and provide recommendations in Year 10 (2018) on the effectiveness of the revegetation prescriptions on improving habitat for wildlife in the drawdown zone.

The revegetation prescriptions being assessed are implemented in various locations in Canoe Reach and along the Bush Arm Causeway. Results from this study and related studies will be evaluated during Year 10 to assess effectiveness of the revegetation program. A list of related studies is presented in Table 11A-1. Table 11A-2 summarizes Columbia Water Use Plan Orders relevant to the CLBMON-11A monitoring program.

Table 11A-1: List of monitoring studies and physical works related to CLBMON-11A.

Management Plan/Study	Description
Kinbasket and Arrow Lakes Reservoirs Revegetation Management Plan	
CLBWORKS-1: Kinbasket Reservoir Revegetation Program	Revegetation of sites in the drawdown zone of Kinbasket Reservoir between 741 m and 754 m. Addenda Phases 5 and 6 detail works specific to debris boom and debris mounds.
CLBMON-9: Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis	10-year study to assess the effectiveness of the revegetation efforts in Kinbasket Reservoir and assess the effects of the current operating regime on existing vegetation communities.
CLBMON-10: Kinbasket Reservoir Inventory of Vegetation Resources	10-year program to assess and map spatial extent, structure and composition of existing vegetation communities at the landscape scale within Kinbasket Reservoir.
Arrow Lakes Reservoirs Operations Management Plan and Mica Units 5 and 6 Projects Commitments	
CLBMON-36: Kinbasket and Arrow Lakes Reservoirs Nest Mortality of Migratory Birds due to Reservoir Operations	10-year study to assess impacts of reservoir operations on nest mortality. Effectiveness monitoring of physical works on nesting success included within the CLBMON-36 program.
CLBMON-37: Kinbasket and Arrow Lakes Amphibian and Reptile Life History and Habitat Use Assessment	10-year study (2008-2018) to assess impacts of reservoir operations on amphibians and reptiles and their habitats. Study years alternate with CLBMON-58 from 2010 to 2018. Effectiveness monitoring of physical works on amphibian and reptiles included in CLBMON-37 and CLBMON-58.
CLBMON-58: Kinbasket Reservoir: Monitoring of Impacts on Amphibians and Reptiles from Mica Units 5 and 6 in Kinbasket Reservoir	4-year study (2011-2017) to assess impacts of reservoir operations on amphibians and reptiles and their habitats. Study years alternate with those of CLBMON-37. Effectiveness monitoring of physical works on amphibians and reptiles included in CLBMON-37 and CLBMON-58.

Table 11A-2: Columbia Water Use Plan Orders relevant to this monitoring program

Clause in Columbia Order	Terms	Corresponding WUP Project
Schedule A – Kinbasket Reservoir		
1.a)	*"works for a reservoir-wide planting program to enhance sustainable vegetation growth within the drawdown zone of Kinbasket Reservoir to benefit fish, wildlife, aesthetics, dust control and recreation"*	CLBWORKS-1
2.a)	*"evaluate plant survival and monitor representative planting sites under the various revegetation treatments in Kinbasket Reservoir"*	CLBMON-9
2.b)	*"assess and map vegetation distribution by elevation and identify riparian wildlife habitat within Kinbasket Reservoir"*	CLBMON-9 and 10
2.c)	*"monitor wildlife utilization patterns in response to revegetation efforts in Kinbasket Reservoir"*	CLBMON-11A
6.a)	*"monitor the effects of reservoir operations on the nesting success of breeding birds (in particular species listed under the federal Species at Risk Act and BC Wildlife Act) in the drawdown zone to determine the significance of nest mortality and provide recommendations on physical works required to mitigate adverse impacts in Kinbasket Reservoir: and*	CLBMON-36
6.b)	*"monitor the life history and habitat use of reptiles and amphibians in the drawdown zone to determine the relative abundance, distribution and seasonal patterns of habitat use in relation to Kinbasket Reservoir operations.*	CLBMON-37 and 58

2.2 Approach

An effectiveness monitoring program should be designed to determine how well management activities, decisions, or practices meet their intended objectives (Houde et al. 2005; Noon 2003). Key to designing an effectiveness monitoring program is the selection of statistically testable response variables appropriate to the objectives of the management action (Machmer and Steeger 2002). Recognizing that monitoring the response variables for all species of interest is not feasible, an effectiveness monitoring program must focus on indicator species, taxa, or ecological processes; however the selection of the specific indicators can be a challenging task (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 keystone species, species at risk, species sensitive to specific habitat requirements, species of management concern, or species that can be monitored easily (Feinsinger 2001); moreover their selection should be appropriate to the spatial scale. The selection of indicator species must also take into consideration environmental factors external to the monitoring program such as inter and intra-specific competition, predation, climatic change, disease, seasonal precipitation rates, and reservoir operations. As such, it is desirable to monitor several indicator species over an extended period of time.

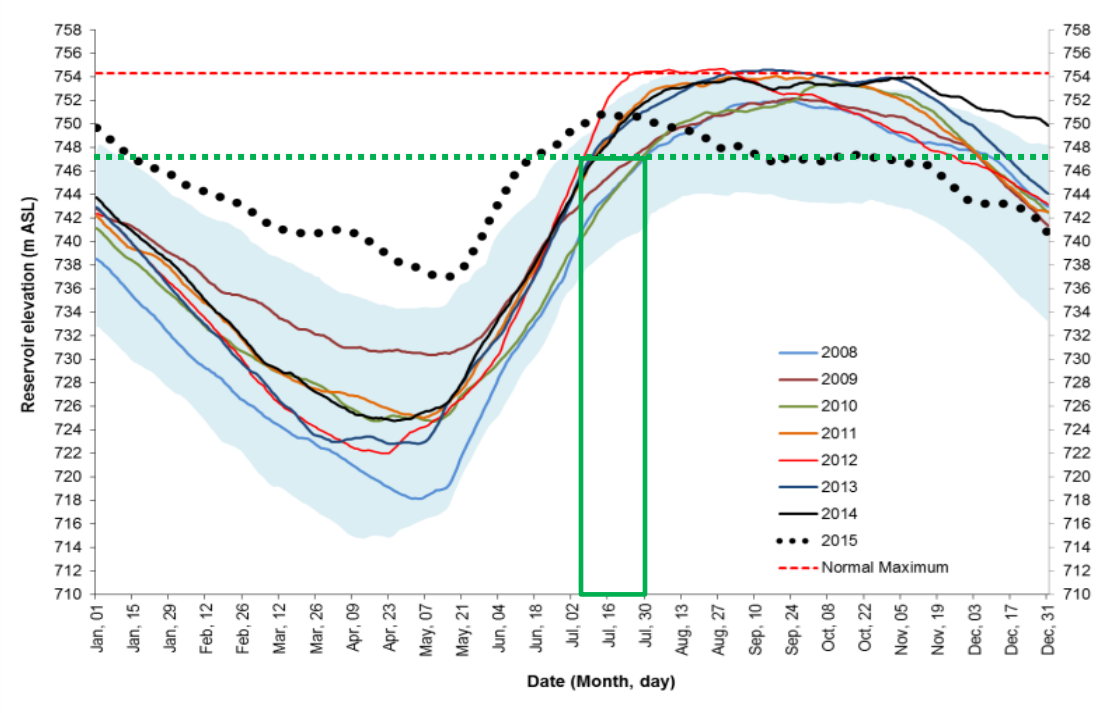
In selecting indicator species, it is also important to have some preliminary information to aid in the appropriate selection (Noon 2003). A list of potential indicators species is shown in Table 11A-3, based on the data from the ongoing monitoring program to date (Wood et al. 2016) , wildlife concerns identified in the Columbia WUP report (BC Hydro 2005b), expert opinion, and the ability to dovetail effectiveness monitoring with concurrent monitoring programs.

The proposed approach entails monitoring the response of the proposed taxa in treated sites, control sites (non-revegetated sites at similar elevations, substrates, as treated sites), and in reference sites (sites above the drawdown zone). This approach entails comparisons of indicator species abundance, diversity, and habitat use between treated and untreated sites in the drawdown zone and reference sites outside the drawdown zone.

2.3 Methods

The sampling methods will focus on assessing the effectiveness of revegetation prescriptions through monitoring responses to vegetation by terrestrial arthropods, birds, and amphibians/reptiles in the upper section of the drawdown zone (747 m – 754 m). The sampling window will vary by taxa and reservoir water levels. On average, water levels reach an elevation of 747 m by the second to third week of July, although water levels have recently reached 747 m as early as the first week of July (Figure 11A-1). Water levels may continue to rise to an elevation of 754 m (full pool), which is usually attained in early August. In recent years water levels have not returned below 747 m until early December although that level was reached in early November in 2015 (Figure 11A-1).

Figure 11A-1: Kinbasket hydrograph. Shaded area is 10th-90th percentile, 1976-2015. Green rectangle includes 2008-2014 summer period when the 747 m level is first reached. Dashed green line is approximate 747 m elevation. Figure modified from Wood et al. 2016, Figure 3-1.



2.3.1 Task 1: Project Coordination

Project coordination involves the general administration and technical oversight of the program, which will include, but may not be limited to: 1) budget management; 2) program team management; 3) logistics coordination; 4) technical oversight 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.

The logistics of the surveys described in this study need to take into account other wildlife and vegetation studies (Table 11A-1) that occur concurrently to coordinate the location of sample sites, prevent interference between studies, and facilitate transfer of information.

The necessary research permits must be obtained from the Ministry of Environment and Canadian Wildlife Service prior to the initiation of fieldwork. Protocols detailing the sampling methods and animal handling/tagging procedures, where applicable must be submitted along with future permit requests and 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 will be required (e.g., first aid, small boat operation).

2.3.2 Task 2: Work Plan

A work plan (or sampling plan) detailing the effectiveness monitoring methods and schedule must be submitted to BC Hydro Water License Requirement staff prior to commencement of field work. The purpose of the work plan is to 1) design a sampling strategy that specifies the required sampling effort and intensity; 2) identify the location of treatment areas, controls, and reference sites[4]; 3) review and update the list of proposed indicator species (Table 11A-3); 4) offer clear predictions of changes in biota (abundance trends, etc.) to assess the effectiveness of prescriptions; 5) clearly identify statistical methods for data analyses; and 6) ensure that the wildlife and vegetation monitoring programs are coordinated. The work plan will need to consider how the sampling effort is stratified, and should employ a randomized design where possible. Considerations for stratification include river reach (Bush Arm, Kinbasket, Canoe Reach), treatment, treatment method, elevation band, biogeoclimatic zone, substrate and topography.

Environmental and vegetation data can be obtained under CLBMON-9, which describes intra-community changes of existing and enhanced vegetation communities in the drawdown zone. Data from CLBMON-9 include species composition (i.e., distribution, distribution and vigour), cover, abundance and biomass of existing and enhanced vegetation communities, as well as sites and soil characteristics. Data are collected following provincial sampling standards (Resources Inventory Committee 1998c)[5].

[4] Reference areas are sites that have naturally revegetated. These differ from control (untreated) sites which are sites that could benefit from revegetation but are left untreated to act as a control for monitoring

[5] readers requiring more information about specific methods and standards used in that study are enjoined to refer to the 2013 CLBMON-9 report available at https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/southern-interior/clbmon-9-yr4-2013-12-19.pdf

Table 11A-3: List of indicator species/species groups and sampling methodology for monitoring the effectiveness of revegetation prescriptions in Kinbasket Reservoir.

Species	Rationale	Response Variable	Suggested Methods	Reference	Related WUP Monitoring Program
Arthropods	Arthropods are an important prey base for amphibians, birds, and small mammals. Establishing vegetation cover will provide suitable habitat for multiple life history requirements resulting in increased abundance and species diversity.	• Relative Abundance • Species Diversity	• Pitfall traps • Sweeps • Hand Searching	• (Resources Inventory Committee 1998a) • (Finnamore et al. 2001)	N/A
Amphibians Reptiles*	Establishing vegetation cover will provide foraging habitat and may enhance breeding habitat	• Relative Abundance • Species Diversity	• Visual Encounter Surveys • Incidental observations	• (Resources Inventory Committee 1998b) • (Heyer et al. 1994) • (Resources Inventory Committee 1999a)	CLBMON-37 CLBMON-58
Birds **	The establishment of willow and sedge/grass communities will provide nesting habitat and foraging habitat.	• Nest success • Relative Abundance • Species richness	• Nest surveys • Incidental observations • Point Count Surveys • Line Transect Surveys	• (Martin & Geupel 1993; Mayfield 1961) • (Resources Inventory Committee 1999b)	CLBMON-36

*Western toad, Columbia spotted frogs, Pacific tree frogs, long-toed salamanders, and garter snakes
***Birds*: including, but not limited to: Yellow Warbler, Wilson's Warbler, Orange-Crowned Warbler, Dark-Eyed Junco, Savannah sparrow, Canada Goose, Mallard, American Widgeon, Cinnamon Teal, Pied-billed Grebe, Sora, Marsh Wren, Red-winged Blackbird, Yellow-headed Blackbird, Grey Catbird, Common snipe, Killdeer, Greater Yellow Legs, Lesser Yellow Legs.

2.3.3 Task 3: Terrestrial Arthropods Sampling

Sampling terrestrial arthropods is recommended as they 1) are an important prey base for many species of amphibians, birds, and small mammals; 2) are relatively easy to sample; and 3) provide a means of estimating the overall productivity of a site. As the abundance of arthropods can fluctuate significantly in response to seasonal conditions (e.g., weather, plant phenology); it will be necessary to consider these effects in developing the sampling plan (Task 2). This will likely require obtaining multiple samples during the sampling window to account for seasonal variability.

2.3.4 Task 4: Amphibian and Reptile Sampling

Visual surveys will be conducted to complement the data from CLBMON-37 and CLBMON-58. These projects are delivered separately from CLBMON-11A.

2.3.5 Task 5: Avian sampling

The present study informs on nest presence and success, and species richness among vegetation treatments (revegetation prescription, control and/or reference). Surveys will focus on breeding birds whenever possible as their use of vegetated areas likely reflects more aspects of their life history than transient birds. More extensive nest surveys are conducted under CLBMON-36 (Kinbasket and Arrow Lakes Reservoir: Nest Mortality of Migratory Birds due to Reservoir Operations) to monitor the use of treatments in the drawdown zone by migratory birds. That study compares nesting success, productivity rates and juvenile survival of birds in treated/untreated/reference sites, and is delivered separately from CLBMON-11A.

2.4 Data analyses

The work plan shall clearly demonstrate how the data addresses the management questions and objectives. Variability at the landscape and local scales (e.g., seasonal weather variability, site disturbance, and regional population dynamics) must be anticipated to the extent possible. Environmental and vegetation data obtained under CLBMON-9 will be made available as needed.

2.5 Reporting

Progress reports will be prepared following each year of field work and will summarize the methods employed, the data obtained, and important and/or significant results. Recommendations may be included if warranted. A comprehensive report will be prepared in Year 10 (2018).

Annual progress reports will include:

1. A description of the project background
2. A description of the methods by taxa
3. A summary of the sampling effort and preliminary results by taxa including:
    a. A summary of sampling effort
    b. Important results and recommendations (the latter if warranted)
4. Maps of the study areas and locations of the study plots. Plot locations are to be provided as UTM coordinates in an MS Excel spreadsheet
5. A digital appendix with:
    a. MS Excel spreadsheet of UTM coordinates for survey sites
    b. A database of wildlife observations (location data) following BC Governments Wildlife Species Inventory (WSI) standards

Final Report

A detailed technical report will be prepared. It will include:

1. An executive summary
2. A description of the methods employed
3. A data summary

4. A comparison of the results by taxa between years and strata
5. A detailed summary of the findings as they relate to the objectives and key management questions
6. Recommendations for improving revegetation prescriptions to mitigate any negative effects of the reservoir operating regime, if warranted
7. A digital appendix with:
    a. MS Excel spreadsheet of UTM coordinates for survey sites
    b. A database of all data collected by taxa following BC Governments Wildlife Species Inventory (WSI) standards

Reports will follow the standard format for WUP monitoring programs. All reports will be provided in hard-copy and as Microsoft Word and Adobe Acrobat (PDF) format. All map data, including meta data, will also be provided electronically in ARC GIS compatible format. Wildlife data or the location of other significant species such as species at risk will be provided to the Ministry of Environment following the Wildlife Species Inventory (WSI) standards: rare or endangered species are to be reported to the BC Conservation Data Centre following the appropriate data submission format.

2.6 Interpretation of Results

This monitoring program will assess the effectiveness of revegetation prescriptions within the drawdown of Kinbasket Reservoir (between 741 m and 754 m) to enhance wildlife habitat. Whenever relevant, the potential for biologically significant trends or changes will be assessed. The information collected will also provide important data on the occurrence of wildlife species in this remote portion of the province.

2.7 Schedule

The study began in 2008 and will conclude in 2018. The original baseline data were collected in Years 1 and 2, with monitoring occurring every second year since (Tables 11A-4 and 11A-5). The new prescriptions were implemented in 2014 (log boom, Canoe Reach) and 2015 (wood mounds, Bush Arm), and their effectiveness will be assessed in 2016 (report due in 2017) and 2018.

Table 11A-4: Annual schedule of tasks*

Tasks	Apr	May	Jun	Jul	Aug	Jan	Feb	Mar
1) Project Coordination	√	√	√	√	√	√	√	√
~~2) Literature Review and Study Design~~	~~√~~	~~√~~	~~√~~					
3) Arthropod Sampling			√	√	√			
4) Amphibian Sampling			√	√	√			
5) Avian Sampling			√	√	√			
~~6) Small mammals~~			~~√~~	~~√~~	~~√~~			
~~7) Ungulate surveys~~			~~√~~			~~√~~	~~√~~	
8) Data Analysis						√	√	
9) Reporting							√	√

*Tasks 2, 6, and 7 were part of previous iterations of the study and are no longer required.

Table 11A-5: Annual sampling and reporting schedule

Tasks	2008	2009	2010	2012	2014	2016	2018
Project Coordination	√	√	√	√	√	√	√
Literature Review and Study Design	√						
Field Sampling	√	√	√	√	√	√	√
Develop Sampling Protocols	√						
Annual Report	√	√	√		√	√	
Final Report				√			√

2.8 Budget

Total Revised Program Cost $1,778,320.

2.9 Study Design Limitation

a) As conditions on the Kinbasket Reservoir are unpredictable, the sampling program may be altered, interrupted, or curtailed in any given year. Components of the sampling program will be scheduled as required to provide the safest and most efficient delivery.

b) Alternative approaches or methods may be used if they provide a better assessment of the effectiveness of revegetation efforts at improving wildlife habitat in the drawdown zone than those presented in this document.

c) The coordination of the study design, fieldwork, and information exchange between related monitoring programs (Table 11A-1) will be paramount to the success of this project. Communication between the various projects and project leaders will be facilitated by BC Hydro to ensure the success of these projects.

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