Columbia River Project Water Use Plan

Arrow Reservoir Wildlife Management Plan

Arrow Feasibility Study of High Value Habitat for Wildlife Physical Works

Implementation Year 2

Reference: CLBWORKS-29B

Study Period: 2016

LGL Limited
environmental research associates
Sidney, BC

August 11, 2016

EA3714

KINBASKET AND ARROW LAKES RESERVOIRS

Monitoring Program No. CLBWORKS-29B
Arrow Feasibility Study of High Value Habitat for Wildlife Physical Works




2016 Update

Prepared for

BC Hydro

BC Hydro Generation
Water Licence Requirements
6911 Southpoint Drive
Burnaby, BC

BC Hydro Reference No. Q8-7971

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August 11, 2016

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Suggested Citation:

Hawkes, V.C. and K. Tuttle. 2016. CLBMON-29B. Arrow Feasibility Study of High Value Habitat for Wildlife Physical Works. 2016 Update. LGL Report EA3714. Unpublished report by LGL Limited environmental research associates, Sidney, B.C., for B.C. Hydro Generation, Water Licence Requirements, Burnaby, BC. 86 pp. + Appendices.

Cover photos:

From left to right: Examples of habitats found in the drawdown zone of mid- and lower Arrow Lakes Reservoir: Beaton Arm, Edgewood South, Lower Inonoaklin Road, and lower-elevation gravel ponds at Burton Creek. All photos May and June 2016.

EXECUTIVE SUMMARY

This document provides updated prescriptions for physical works designed to improve wildlife habitat suitability in the drawdown zone of Arrow Lakes Reservoir. The proposed physical works will increase wildlife habitat suitability either directly by creating habitat or indirectly by improving existing (and marginal) wildlife habitat in the drawdown zone of mid- and lower Arrow Lakes Reservoir. These physical works will meet the objectives of both the Columbia River Water Use Plan and of CLBWORKS-29B, which are to identify enhancement opportunities to improve wildlife habitat in the drawdown in the mid and lower Arrow Lakes Reservoir. The prescriptions provided within are intended to provide a fairly high-level overview of each of the three options and additional work will be required following the selection of one or more physical works for implementation (i.e., a detailed design and cost estimate will need to be prepared). There are project-related activities that have not been included in the costs estimates including an Archaeological Impact Assessment, acquisition of permits and approvals, final engineering design, First Nation and stakeholder engagement, and post-construction inspections etc. The costs associated with each prescription were developed in regard to only constructing the physical works. A more detailed cost estimate and timeline will need to be prepared prior to implementing any of the physical works.

The development of the original wildlife physical works prescriptions was accomplished through an assessment of wildlife data collected for CLBMON-11B1 as well as an evaluation of where physical works projects could feasibly be implemented. In 2010, a meeting was held with various stakeholders including BC Hydro, the Fish & Wildlife Compensation Program–Columbia Region, and the British Columbia Ministry of Environment to discuss several wildlife physical works projects and those projects were prioritized for prescription development. In 2011, each of the prioritized sites was further assessed in the field to determine the feasibility of implementing the physical works projects. This involved an assessment of topography, elevation, hydrology, substrate, disturbance potential, existing wildlife use, site ownership, and access. These factors were considered when finalizing the site selection and developing the site-specific prescriptions. In 2016, the original prescriptions were updated to reflect data collected at each site between 2012 and 2015 and based on additional considerations associated with permitting, regulatory requirements, and public accessibility of the physical works.

Three wildlife physical works are proposed for the drawdown zone of mid- and lower Arrow Lakes Reservoir. Each of the proposed projects has the potential to increase the ecological value of the drawdown zone for wildlife, but do have potential risks. The proposed works at Burton Creek are associated with the lowest level of ecological risk as the area identified for the works is a relatively unproductive field dominated by an invasive species of grass (i.e., Reed Canarygrass) that would be converted to shallow wetland habitat. The project proposed for Lower Inonoaklin Road is associated with a moderate level of ecological risk, primarily because the hydrology of the site has not been studied and there is chance that the existing wetland at the site requires some level of recharge from reservoir inundation or via ground-water seepage from the reservoir to the wetland when reservoir elevations are high enough. The project at Edgewood South is associated with the greatest level of ecological risk as the currently

productive wetland at the site could be negatively affected, resulting in reduced productivity at the site and the loss of an existing functional shallow wetland habitat. For all sites, an archaeological investigation is required prior to initiating the projects.

If all three proposed projects were implemented the total area of shallow wetland habitat created in the drawdown zone would be approximately 4.1 ha in two locations (2.8 ha at Burton Creek and 1.3 ha at Edgewood South) and an additional 6.2 ha would be retained at Lower Inonoaklin Road. Implementing the physical works at Burton Creek would require the construction of a dike ~390 m long and 0.5 to 1.8 m high and minor excavation (30 to 50 cm) to create a pond. Three dikes would be required at Lower Inonoaklin Road ranging in length from 63 to 129 m, all of which would be 1 to 1.5 m in height; excavation is not required at Lower Inonoaklin Road. Excavation and dike construction would be required at Edgewood South with a single dike ~115 m long and 1 to 1.5 m high.

Each physical works is designed to protect the created or enhanced shallow wetland habitat from reservoir inundation for a greater proportion of the year (relative to current conditions). If the physical works were built to the specifications indicated in this report, shallow wetland habitat would be available for 175 to 200 days per year (assuming that wildlife would use those habitats between April 1 and October 31 for a total period of use of 214 days). This represents an increase of between 0 and 96 days, depending on how the reservoir is managed.

The Class C cost estimates (+50%/-15%) presented in Hawkes and Howard (2012) have been updated and range from ~$352K for the Lower Inonoaklin Road project to ~$1M for the Burton Creek project [redacted] The cost estimates as presented are only estimates; actual costs should be determined prior to implementing each project.

The wetlands at Lower Inonoaklin Road and Edgewood South are currently considered to be productive – they provide habitat for many species of wildlife and vegetation. The area proposed for physical works at Burton Creek is relatively homogeneous and would be improved with the addition of wetland habitat. The Burton Creek site is also highly visible to the public, as it is situated next to the highway and in an area frequented by people. Both the Edgewood and Lower Inonoaklin Road sites are accessible, but less so compared to Burton. The overall costs associated with Burton Creek are higher, but the improvements to existing habitats are deemed to be greater than both Edgewood and Lower Inonoaklin Road.

Based on the anticipated benefits, assumed ecological risks, and overall cost of the proposed projects, the three projects are ranked (in order of priority) as follows: 1) Burton Creek; 2) Lower Inonoaklin Road, 3) Edgewood South. This order differs from the recommendation of Hawkes and Howard (2012) and is due largely to the visibility of the site and the overall enhancement to existing habitat that could be realized at Burton Creek. The current ecological function of Lower Inonoaklin Road and Edgewood South is considered to be greater than that of the proposed physical works location at Burton Creek and the level of ecological risk increases with decreasing priority (i.e., Edgewood South has higher risk than Burton Creek).

The current state of each site (from an ecological perspective) is summarized below. The expected impacts to each ecological component at each site were used to assess the overall ecological risk of the project when prioritizing the projects. A green arrow

indicates presumed benefit to an ecological component, yellow double-ended arrows indicate that there is not likely to be a change. Green triangle indicates little overall risk with presumed net ecological benefit, yellow triangle indicates uncertainties remain with the potential of negative effects, and red triangle indicates higher potential for negative impacts.

Category	Component	Location and Expected Direction of Change With Physical Works					
		Burton Creek	Change	Lower In. Rd.	Change	Edgewood South	Change
Project Overview	Existing Habitat	VDZ	SWH	SWH	None	SWH	None
	Proposed Habitat	SWH	In place of VDZ	SWH	None	SWH	Expansion of Area
	Restoration Approach	Habitat Creation		Habitat Protection		Habitat Enhancement	
	Total Area (ha)	0	⇧ 2.8	6.2	⇔ 0 (6.2 ha)	0.13	⇧ 1.17
	Water Depth (m)	0	⇧ 0.5 - 1.5	0 - 1.5	⇔ 0 - 1.5	0 - 1.5	⇔ 0 - 1.5
	Temporal Availability (days-year; range)	73 - 214	⇧ 161 - 214	57 - 174	⇧ 112 - 214	69 - 214	⇧ 165 - 214
	Change to Existing Values	Increase habitat heterogeneity via wetland creation with commensurate increases to species richness; biodiversity. Net benefit to wildlife/habitat in DDZ.		Retention of existing shallow wetland habitat value, but inundation occurs later in year. Hydrology of site unknown. Requires investigation.		Increase total area of shallow wetland habitat in the drawdown zone, but existing habitat could be negatively affected.	
	Overall Risk of Project (in terms of ecological benefit)	Low ▲	Area is a grassy field with low species diversity. Works will increase habitat suitability.	Moderate ▲	Existing wetland unlikely to be negatively affected unless berms preclude recharging of wetland.	Moderate to High ▲ or ▲	Potential for negative impact to existing functional wetland.
	Project Summary	Creation of ~2.8 ha of wetland habitat in an area currently dominated by a grassy meadow with low habitat heterogeneity. Wetland habitat would increase habitat suitability even for those groups already associated with a high overall rating (see below).		Existing wetland would be retained, but protected from inundation until later in the year, making habitat available for wildlife longer. The hydrology of the site requires further investigation.		Expanding the wetland would create a larger wetland habitat, which will benefit many species, but there is a risk that the existing wetland could be negatively impacted.	
	Project Priority and Benefit	1	Greatest potential for increasing ecological value of DDZ.	2	Good value, high probability of increasing ecological value of DDZ, but some uncertainties remain.	3	Highest overall risk to ecological integrity of existing habitat. Large upside possible, but risk too great.
Cost	Estimated Cost ($1,000's) +50%/-15%	1032		352		405	

Overall, the ability to improve wildlife habitat in the drawdown zone of mid and lower Arrow Lakes Reservoir is limited by topography and hydrology. Much of the drawdown zone is steep and/or rocky and does not provide the opportunity to implement physical works. Areas that are relatively flat have been identified for physical works.

In addition to the physical works proposed in this report, wildlife improvement strategies such as the erection of bat boxes, bat condos, or snags (real or fake, with bark), establishment of floating nesting islands in the constructed physical works, and erection of bird nesting boxes should be considered. These strategies will improve wildlife habitat suitability by providing habitat features that are currently limited in the drawdown zone of mid-and lower Arrow Lakes Reservoir. In addition to improving habitat suitability of the drawdown zone by creating, protecting, or enhancing wetland habitat, installing wildlife enhancements at each wetland location will further improve the overall suitability and function of wetland habitats in the drawdown zone of mid- and lower Arrow Lakes Reservoir.

Key Words: Arrow Lakes Reservoir, wildlife physical works, Little Brown Myotis, Western Skink, Rubber Boa, shallow wetland habitat, bats, habitat enhancement, drawdown zone

ACKNOWLEDGEMENTS

The authors express their appreciation to the following individuals for their assistance in coordinating and conducting this study: Margo Sadler and Susan Pinkus (BC Hydro). Reviews on a previous version of this document were provided by Margo Sadler (BC Hydro), Susan Pinkus (BC Hydro) and Ian Robertson. Nathan Hentze (LGL Limited) provided input on birds in mid- and lower Arrow Lakes Reservoir. Julio Novoa (LGL Limited) assisted with the production of maps and site schematics.

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1.0 INTRODUCTION

The Columbia River Water Use Plan was developed as a result of a multi-stakeholder consultative process to determine how to best operate BC Hydro's Mica, Revelstoke and Keenleyside dam facilities to balance environmental values, recreation, power generation, culture/heritage, navigation and flood control. The goal of the Water Use Plan is to accommodate these values through operational means (i.e., patterns of water storage and release) and non-operational physical works in lieu of changing reservoir operations to address specific interests. During the Water Use Planning process, the Consultative Committee supported the implementation of physical works (revegetation and habitat enhancement) in the mid-Columbia River in lieu of changing reservoir operations to help mitigate the impact of Arrow Lakes Reservoir operations on wildlife and wildlife habitat. In addition, the Consultative Committee recommended the use of monitoring to assess the effectiveness of these physical works in enhancing habitat for wildlife.

Hawkes and Howard (2012) proposed five wildlife physical projects for mid- and lower Arrow Lakes Reservoir:

1. Habitat Creation: Burton Creek wetland creation
2. Habitat Enhancement: Lower Inonoaklin Road wetland retention
3. Habitat Enhancement: Edgewood South wetland habitat enhancement
4. Habitat Enhancement: Edgewood North Western Skink and Rubber Boa habitat improvement
5. Habitat Enhancement: Dog Creek fish habitat enhancement

Preliminary prescriptions were developed by Hawkes and Howard (2012) for 1, 2, and 3 and following a stakeholder meeting in 2010, the Fish and Wildlife Compensation Program – Columbia Basin, developed an enhancement prescription for Western Skink (*Plestiodon skiltonianus*) and Rubber Boa (*Charina bottae*) at Edgewood (i.e., number 4, above; McKinnon and Hill 2011). Work associated with number 5 was not pursued as it was associated with fish habitat enhancement and did not meet the terms of the Order which was focused on birds and wildlife.

The recommendations of the Consultative Committee resulted in the development of CLBMON-11B, an 11-year monitoring program comprised of two distinct components:

1. CLBMON-11B: Wildlife Effectiveness Monitoring of Revegetation and Wildlife Physical Works, Arrow Lakes Reservoir; and
2. CLBWORKS-29B: Arrow Lakes Reservoir: Study of High-Value Wildlife Habitat for Potential Enhancement and Protection.

These two components were combined to assess the efficacy of revegetation and wildlife physical works prescriptions and to identify wildlife habitat enhancement and restoration opportunities to enhance the suitability of wildlife habitat in the drawdown zone of mid- and lower Arrow Lakes Reservoir. This document is an update to the 2012 report by Hawkes and Howard and further considers the feasibly of alternatives one, two, and three (i.e., Burton Creek, Lower Inonoaklin Road, and Edgewood South) in light of additional information (collected between 2011 and 2015) and consideration of changes to water license requirements and other dam safety considerations.

2.0 OBJECTIVES

The primary objectives of CLBWORKS-29B are:

1. Identify high-value habitat along the drawdown zone of lower and middle reaches of the Arrow Lakes Reservoir for protection;
2. Identify habitat enhancement opportunities along the drawdown zone of the lower and middle reaches of the Arrow Lakes Reservoir; and
3. Provide recommendations for enhancing or protecting high-value wildlife habitat along the drawdown zone of the lower and middle reaches of the Arrow Lakes Reservoir.

Given the time lag between the preliminary feasibility assessment and implementation of wildlife physical works in mid- and lower Arrow Lakes Reservoir, an updated feasibility assessment was requested by BC Hydro for the three recommended alternatives. The updated feasibility assessment includes the following important factors identified in other wetland projects in BC Hydro reservoirs:

- Acquisition of conservation water licenses for any water retention structures (requires the calculation of the amount of water impounded and the height of any dam or berm);
- Assessment of dam safety considerations (based on revised Provincial Dam Safety Guidelines), including the designation of regulated versus non-regulated dam and any ongoing maintenance requirements;
- Recommendation of a high-level review of archaeological potential (not an AOA or an AIA);
- Any changes to permitting or regulatory requirements;
- Seasonality of expected improvements, including the presence of water and stability of water (i.e., assessment of potential for sink habitat for amphibians and reptiles, or birds);
- Properties maps and assessment of requirements for License of Occupation on crown lands (as applicable); and
- Revised timelines and cost estimates.

3.0 STUDY AREA

The Hugh Keenleyside Dam, completed in 1968, impounded two naturally occurring lakes to form the Arrow Lakes Reservoir, an approximately 230-km long section of the Columbia River drainage between Revelstoke and Castlegar, B.C. (Carr et al. 1993, Jackson et al. 1995). Two biogeoclimatic zones occur within the study area: the Interior Cedar Hemlock (ICH) and the Interior Douglas-fir (IDF). The reservoir has a north-south orientation, and is set in the valley between the Monashee Mountains in the west and Selkirk Mountains in the east. Arrow Lakes Reservoir has a licensed storage volume of 7.1 million acre feet (BC Hydro 2007). The normal operating range of the reservoir is between 418.64 m and 440.1 m above sea level (m ASL). All proposed physical works are located in mid- and lower Arrow Lakes Reservoir (Figure 3-1).

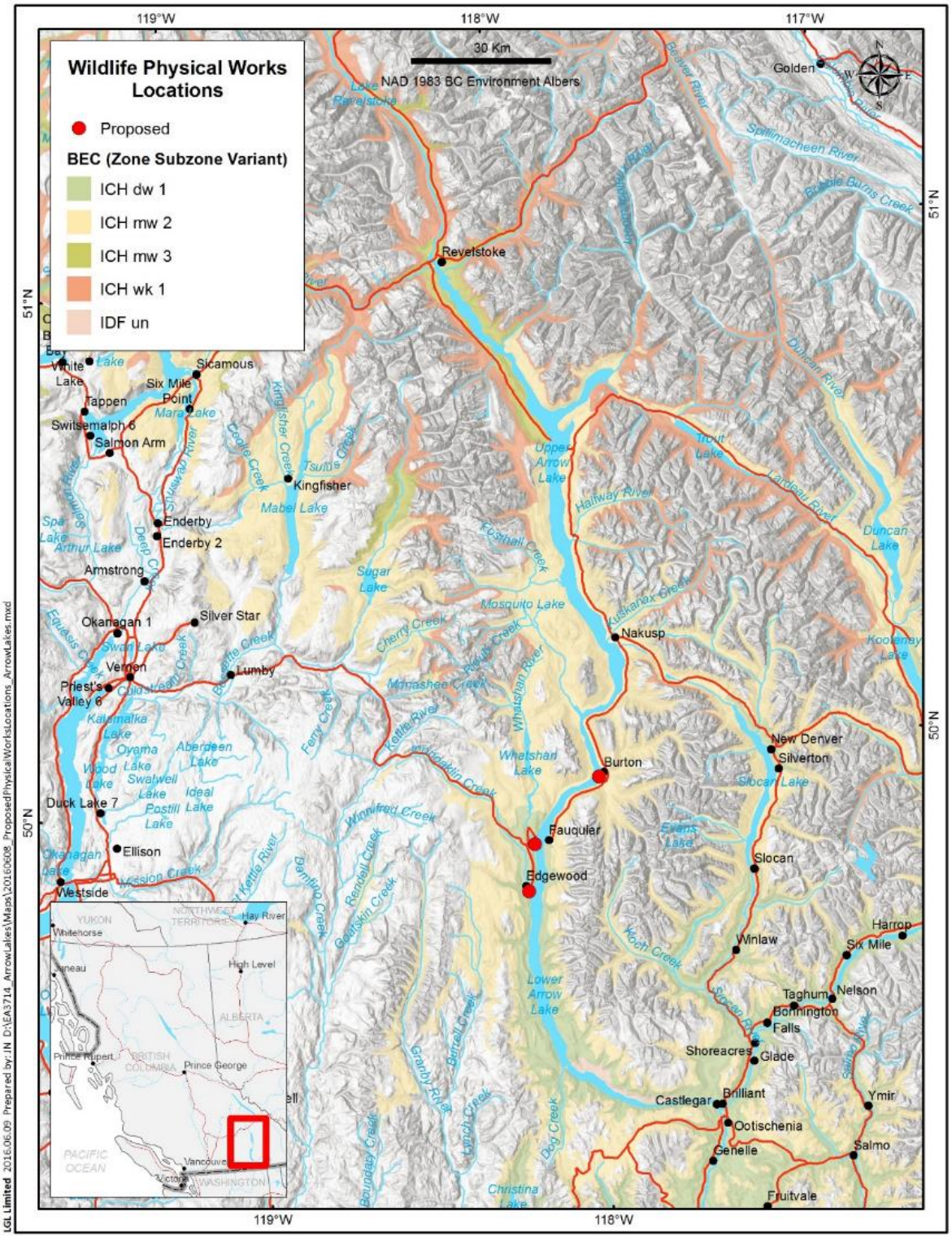

Figure 3-1: Location of proposed wildlife physical works in the drawdown zone of Arrow Lakes Reservoir

4.0 METHODS

4.1 Prescription Development

Wildlife habitat enhancement prescriptions were developed for several sites that were deemed to have the highest feasibility of implementation. The feasibility assessment was completed in 2010 at a meeting with several stakeholders including BC Hydro, the Fish & Wildlife Compensation Program–Columbia Region, and the Ministry of Environment (see Hawkes et al. 2011). In advance of preparing the prescriptions for each site, a site visit was conducted to obtain additional data on several aspects of the sites that were required when finalizing the prescriptions. Additional data collected between 2012 and 2015 were used to update the current site conditions and field inspections (visuals) were completed in 2016 to facilitate this update. Additional desk-top based work occurred to update changes to permitting and regulatory requirements and to revise timelines and cost estimates.

The prescriptions developed in 2012 were based on an assessment of (1) topography, (2) elevation, (3) substrate, (4) hydrology, (5) disturbance, (6) ownership, (7) wildlife habitat, and (8) access (see Hawkes and Howard 2012). In addition to these eight factors, the following were also considered for this update:

1. Conservation Water Licence;
2. Provincial Dam Safety Guidelines;
3. Archaeology;
4. Accessibility/visibility to/by the public;
5. Assessment of potential for habitat to be a source or sink for amphibians, reptiles, and birds;
6. Property ownership (cadastral) assessments; and
7. Revised timelines and cost estimates.

4.2 Fundamentals of Ecological Restoration

The long-term goal of restoration projects is the establishment of a self-sustaining ecosystem that is in equilibrium with the surrounding landscape. Restoration can be an effective tool for returning a degraded ecological system close to its pre-disturbed condition, or more realistically, to a desired ecologically appropriate state that is defined in the context of current and future conditions (e.g., climate, land use, constraints, etc.; [Palmer et al. 2006, Choi 2007]). Restoration can also prevent continued environmental degradation, which can improve habitat quality and function, particularly in heavily impacted ecosystems such as those found in the drawdown zones of hydroelectric reservoirs.

Ideally, habitat restoration is intended to restore the habitat value of an area by attempting to create a sustainable and functioning ecosystem rather than simply revegetating or planting vegetation within disturbed areas. A functioning ecosystem is not restricted to vegetation, but also includes chemical and physical components such as hydrological, soil, wildlife functions, and the interaction of all natural habitat components. Restoration may occur actively or passively. While passive restoration

relies exclusively on the forces of nature to enhance and repair disturbed ecosystem functions, active restoration requires anthropogenic actions and physical alterations of the landscape.

4.3 Generic Restoration Strategies

Ecological restoration has defined strategies that provide guidance for restoration projects (e.g., Johnson et al. 2003). Each of these (general) strategies is described below. Five of the six strategies require manipulation of some kind to create a habitat that is ecologically superior to the present state. The other approach (the no-intervention approach) leaves ecological changes to nature. The outcome of this approach may or may not lead to the development and establishment of a desirable ecosystem.

1. No Intervention: In the no intervention approach, ecosystem recovery is left to natural processes; however, the outcome of this approach is unpredictable and may not resemble pre-disturbance conditions (Cairns 1991). It is possible that the ecosystem may degrade further or that the realized end point of natural recovery through no intervention creates an undesirable ecosystem.

2. Conservation: Conservation is based on the premise that disturbances can continue to occur in a way (e.g., using science-based development strategies) that minimizes or avoids damage to the biodiversity of the system. Conservation represents a relevant approach for mid and lower Arrow Lakes Reservoir because portions of the drawdown zone contain habitat attributes that are important to the preservation of biodiversity and there will continue to be pressure on the system through natural resource extraction and the maintenance of the reservoirs.

3. Creation of New Ecosystem: This is the development of a new ecosystem that did not previously exist (NRC 1992, Simenstad and Thom 1992). Creation of a new ecosystem is intended to emulate the present condition of an existing functioning reference ecosystem and requires both physical (e.g., topographic, hydrologic) as well as biotic (e.g., vascular plants) elements. Although created ecosystems may eventually become self-maintaining, there is considerable uncertainty about the outcome. Created ecosystems typically require ongoing management (Cairns 1991, Simenstad and Thom 1992) and all will require post-implementation monitoring to ensure that the development trajectory of the ecosystem is consistent with the goals and objectives associated with the restoration project.

4. Enhancement of Selected Attributes: Enhancement differs from restoration in that only one or several attributes are improved rather than the whole system. Attributes are characteristics that are correlated with, and can serve as, indicators of ecosystem structure and function. In general, enhancement is considered at the population, community, ecosystem, and landscape levels (as appropriate).

5. Restoration to Improved, Pre-Disturbance, or Historical Condition: Knowledge of the pre-disturbance condition is essential to successful restoration. However, the pre-disturbance condition is difficult to define precisely and is commonly referred to in the literature as the original, undisturbed condition (Cairns 1991, NRC 1992, Jordan et al. 1997). The pre-disturbance condition is the condition *thought* to have previously existed in the watershed prior to the onset of disturbance (of any kind). Historic condition is the condition *known* to have previously existed in the watershed. The goal of restoration to

historic condition is to establish a community that is ecologically superior to the present degraded system and resembles the original system in certain carefully defined ways (Cairns 1991). Simenstad and Thom (1992) note that the opportunity for successful restoration to historic condition is high as long as the primary characteristics delineating the habitat type(s) are still effective at that site (e.g., functional riparian habitat, presence of snags and older forest, habitat corridors providing connectivity between riparian and upland habitat). If some, or all, of these characteristics have been altered or lost, the prospects for restoration to historic condition are greatly diminished.

6. Protection to Maintain a Desirable State: Protecting existing habitat attributes can be an effective restoration tool. Protection helps prevent further degradation of areas that may currently be in or developing towards a desirable ecosystem state. Protection is distinct from conservation because protection assumes that disturbances to the existing and surrounding areas will cease. Protection could take the form of preserving specific habitat polygons on the landscape to retain specific habitat features that are important to wildlife. Similarly, habitats that have the capability of becoming important to many or sensitive wildlife species can also be considered for protection.

Because habitats in the drawdown zone of mid- and lower Arrow Lakes Reservoir exist in an environment that is subject to semi-predictable and annual impacts, it is impossible to return habitats in the drawdown zone to a pre-disturbance or even historical condition. Therefore, restoration of habitats (as defined above) is not possible. Despite the persistence of impacts to habitats in the drawdown zone there is ample evidence that ecological communities (e.g., vegetation and wildlife communities) persist in the drawdown zone and some wildlife species use features within the drawdown zone to fulfill their life requisites (e.g., amphibians use ponds in the drawdown zone for breeding, ungulates make use of several mineral licks, and several species of mammals forage in the drawdown zone [Hawkes et al. 2009, 2010, 2011]). This suggests that habitat suitability (for some species) in the drawdown zone is high, but only seasonally. Given the assumed low value of most habitat in the drawdown zone, doing nothing (i.e., the no intervention approach) is not optimal. By doing something (i.e., implementing a wildlife physical works), habitat availability will be increased, which will result in an overall increase in habitat suitability. A combination of no intervention and continued impact will either limit the overall habitat suitability of the drawdown zone by perpetuating the semi-predictable annual loss of habitat associated with increasing reservoir elevations or contribute to further degradation of habitat quality in some areas (e.g., Dog Creek) via erosion or sedimentation.

Because of the semi-predictable and annual impacts of reservoir operations on habitats in the drawdown zone, there is a need to either enhance existing habitats in the drawdown zone or create new habitats to improve wildlife habitat suitability. Therefore, it is recommended that wildlife physical works be implemented in the drawdown zone of mid- and lower Arrow Lakes Reservoir using techniques associated with the creation or enhancement of habitats while adopting a restoration framework (e.g., Harwell et al. 1999) that considers conservation (i.e., acceptance that enhanced or created habitats will exist within a matrix of continued disturbances). This approach is likely to be met with the highest degree of success, with success defined as the creation or persistence of ecosystems within the drawdown zone that are available to and used by many species of wildlife for much of the year. Metrics of success will vary from project to

project and must be articulated prior to implementing the proposed physical works. In this report, those metrics form the prescriptions developed for each physical works project, and the metrics of success (i.e., the performance measures) are provided for each prescription.

4.4 Regulations

Several regulations and federal or provincial acts must be considered when developing a restoration program. An overview of the current regulations and federal or provincial acts that are likely to apply (all or in part) to the proposed physical works projects is provided Appendix A. These regulations and federal or provincial acts must be considered when implementing any or all of the proposed physical works.

5.0 RESULTS: PROPOSED PHYSICAL WORKS

The outcome of the stakeholder meeting in 2010, coupled with field assessments between 2009 and 2011 resulted a list of five physical works projects for areas in and adjacent to the drawdown zone of mid- and lower-Arrow Lakes Reservoir. All five projects are intended to create or enhance habitats in the drawdown zone of mid- and lower Arrow Lakes Reservoir and all proposed projects can be defined as conservation-based projects because they will be implemented in a setting that will continue to be associated with a high degree of disturbance. The goal of the projects is to create or enhance habitats that can function despite the continued disturbance.

Three of the proposed projects address wildlife habitat in the drawdown zone, one addresses wildlife habitat immediately adjacent to the drawdown zone, and one addresses fish habitat and instream works.

The five proposed projects are:

1. Habitat Creation: Burton Creek wetland creation
2. Habitat Enhancement: Lower Inonoaklin Road wetland retention
3. Habitat Enhancement: Edgewood South wetland habitat enhancement
4. Habitat Enhancement: Edgewood North Western Skink and Rubber Boa habitat improvement
5. Habitat Enhancement: Dog Creek fish habitat enhancement

Detailed prescriptions are only provided for only the first three projects. A work plan was developed for Edgewood North Western Skink (*Plestiodon skiltonianus*) and Rubber Boa (*Charina bottae*) habitat improvement by the Fish & Wildlife Compensation Program–Columbia Region (McKinnon and Hill 2011) based on discussions between LGL, BC Hydro, and the B.C. Ministry of Environment in 2010. The Dog Creek fish habitat enhancement project does not meet the terms of the Order, as it is not specific to birds and wildlife. As such the Edgewood North and Dog Creek prescriptions are not detailed in this update. The location of each of the five proposed projects is indicated in Figure 3-1.

The three physical works proposed for the lower reaches of Arrow Lakes Reservoir are:

1. Habitat Creation: Burton Creek wetland creation;

2. Habitat Enhancement: Lower Inonoaklin Road wetland habitat retention; and
3. Habitat Enhancement: Edgewood South wetland habitat enhancement.

All sites are easily accessed using existing roads. Once the wetland projects are completed additional wildlife habitat enhancements could be implemented including the erection of bat boxes and bird nest boxes, and the placement of coarse woody debris. Some of the wetland habitat created may also be suitable for the placement of artificial islands. The prescriptions included in this document have been updated from Hawkes and Howard (2012) and are more refined than those presented in 2012. However, more detail is likely necessary prior to the implementation of one or more of the proposed works. Regardless, based on previous experience with similar projects, the implementation of projects like those proposed requires site-specific modifications that are best made in the field during the implementation (construction) phase.

6.0 BURTON CREEK WETLAND CREATION

6.1 Overview

The proposed physical works location is located adjacent to Highway 6 and is accessible via Robazzo Road and is highly visible from the highway. The proposed project at Burton Creek will create ~2.8 ha of shallow wetland habitat through a combination of site excavation and dike construction. The elevation of the proposed physical works occurs between 437 and 440 m ASL. Over the past nine years, Arrow Lakes Reservoir has exceeded 437 m ASL between April 1 and October 31 for 0 (2015) to 141 days (2008). To reduce the potential for site inundation (and to promote the stability of the wetland habitat), the proposed dike will be ~390 m in length and a have a top elevation of 439 m ASL, which will be possible through the construction of dike that varies in height from 50 to 180 cm. If built to a height of 439 m ASL, the dike will protect the created wetland from reservoir inundation for ~195 days per year (max: 214 days; min: 161 days based on a review of reservoir elevations recorded over the last nine years) assuming that wildlife will be most likely to use the constructed wetland between April 1 and October 31 (n=214 days). The project will improve wildlife habitat suitability through the creation of a currently limited habitat type (shallow wetland habitat) that is affected by reservoir operations or that was lost when upper and lower Arrow Lakes were impounded.

Anticipated benefits will be for wildlife including birds, amphibians, reptiles, mammals (bats), insects (dragonflies) and fish (among others). Species with provincial or federal conservation designation that will benefit from this project include the provincially blue-listed and COSEWIC species of Special Concern, Western Toad (*Anaxyrus boreas*); the provincially blue-listed Townsend's Big-eared Bat (*Corynorhinus townsendii*) and Fringed Myotis (*Myotis thysanodes*); and the COSEWIC endangered Little Brown Myotis (*Myotis lucifugus*) (listed February 27, 2012). The relatively homogeneous habitat that would be replaced with wetland habitat suggests little to no risk with this particular physical works. However, there is always a risk that the created habitat will not function as desired and require future interventions to increase productivity or habitat suitability for wildlife and vegetation.

As depicted in Figure 6-8 (see Section 6.10.3), two excavations are planned with the total volume of water calculated for each excavation estimated at 3,464.9 m^3 and 6,946.3 m^3 (Total for the site 10,411 m^3). A total of 3,464.9 m^3 could potentially be

impounded behind the proposed dike. The volumes were calculated using the 2014 Digital Elevation model for Burton Creek, a proposed dike height of 439 m ASL, and the delineation of the proposed excavations in a GIS. The excavations will occur across an elevation gradient of 437.2 m to 439.5 m (larger excavation, mean 438.4 m ASL) and 437.5 m and 440.4 m (smaller excavation, mean 439.2 m ASL). Constructing a dike to 440 m ASL increases the total volume of water impounded behind the dike from 3,464.9 m^3 to 14,481.1 m^3, which could have implications related to Dam Safety Regulations. This is also the licensed maximum of Arrow lakes Reservoir, which is rarely reached. It is recommended that the dike be built to 439 m ASL to fit within the current definition of a dam that is exempt from current Dam Safety Regulations and that still provides valuable habitat for wildlife for more than 90% of the year considered (i.e., 195 of 214 days between April 1 and October 31).

6.2 Rationale

The Burton Flats area contains several human-excavated ponds that are used annually by Western Toads as breeding habitat (Figure 6-1). However, these ponds occur at fairly low elevations (~432 to 435 m ASL) and can be inundated by the second or third week of May, which can affect the development of the eggs into tadpoles and potentially the development of tadpoles into metamorphs. The creation of shallow wetland habitat that is closer to the treeline and protected by a dike will provide valuable Western Toad breeding habitat that is not prone to inundation in May. The provision of stable shallow wetland habitat in the drawdown zone (but at higher elevations) is one way to mitigate the effects of reservoir operations on a species with both provincial and federal conservation designation.

6.3 Site Description

Burton Creek is located south of Burton, B.C. on the east side of Arrow Lakes Reservoir. The proposed physical works location is centred at 11 U 435757 E and 5536952 N. The approximate location of the physical works project at Burton Creek is shown in Figure 6-1. The location of Burton Creek relative to Arrow Lakes Reservoir is shown in Figure 3-1.

Figure 6-1: **Photograph of Burton Creek taken in spring 2010.** The proposed location of the wildlife physical works in the drawdown zone of Arrow Lakes [redacted]. Caribou Creek and Burton Creek are shown in the top of the image. The existing lower elevation ponds are visible on the left side of the image. Reservoir elevation: 433.28 m ASL (date pf photo May 13, 2010).

The site is generally flat and slopes gently to the west with a west to southwest aspect. The elevation of physical works location at the Burton Creek site ranges from ~436 m ASL to >440 m ASL.

6.4 Land Ownership

The area identified for the proposed physical works at Burton Creek is identified as Provincial Crown Land and lies entirely within BC Hydro's Water License area for Arrow Lakes Reservoir. Adjacent land parcels are either held by BC hydro or are privately owned (Figure 6-2). The private parcel (3.17 ha) is currently is currently for sale (MLS list $385,000.00 CDN).

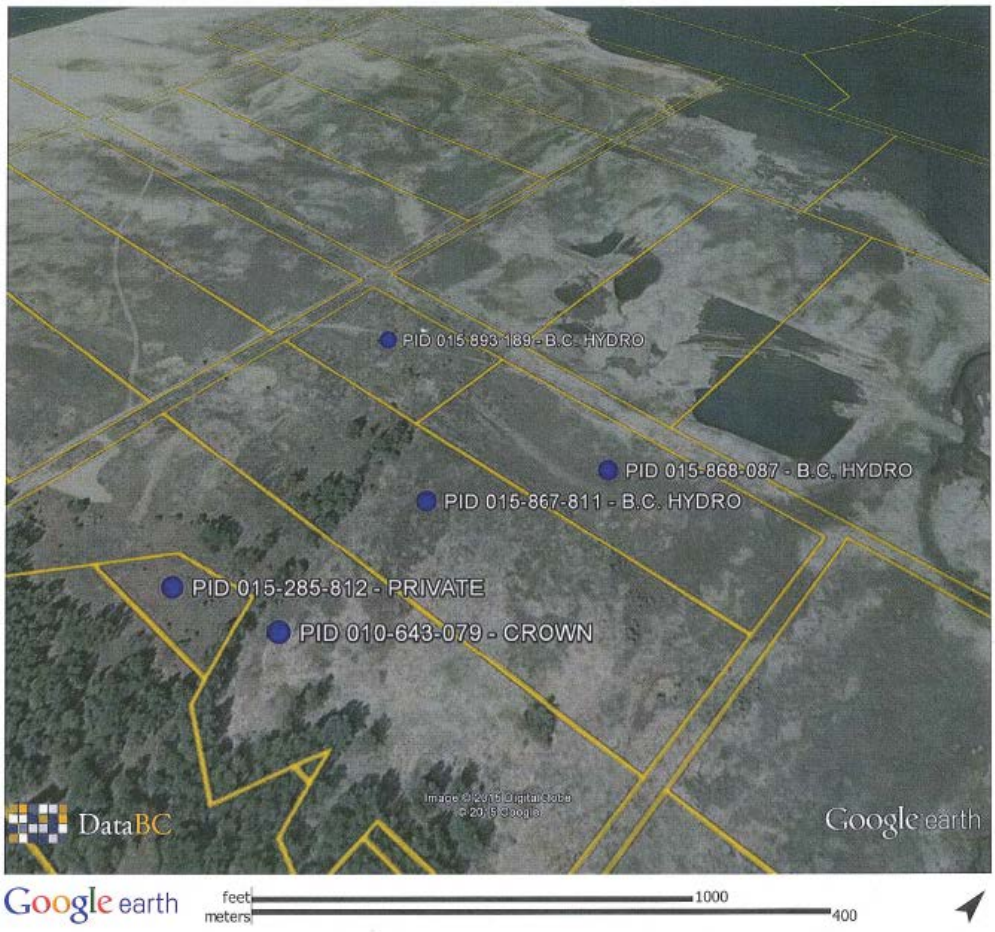

Figure 6-2 **Land ownership on and adjacent to the proposed physical works location at Burton Creek.** The proposed project would occur in PID 010-643-049, PID 015-867-811, and PID 015-866-087.

6.5 Current Site Conditions

Site conditions were assessed at Burton Creek in early May 2016 and again in early June, 2016. The conditions at the site are consistent with the description provided by Hawkes and Howard (2012), which is repeated herein. The only notable changes that have occurred to the site are the removal / die-off of Black Cottonwood live stakes that were planted as part of the CLBWORKS-2 revegetation program (but natural ingrowth was observed (M. Sadler, pers. obs.) and some of the depressions that typically hold water were dry, which could be a function of the low reservoir elevations that occurred in 2015. Overall the site proposed for physical works is a homogeneous habitat characterized by dry soils and high (near 100%) cover of grass. Overall the site has is topographically homogenous with little change in relief aside from a slight downward slope from the treeline to the reservoir.

In some years, the proposed site may include a wet depression near the treeline and a high cover of non-native grasses (Reed Canarygrass [*Phalaris arundinacea*]). The topography of the site limits the spatial extent of the wet depression. Based on the biophysical habitat mapping completed in 2010 (Hawkes et al. 2011), the proposed site is located primarily in the PC-UW-BE (grass dominated mesic; upland shrub; sand or

small gravel) habitat with a smaller portion in the CR-PC (cottonwood riparian; grass-dominated mesic) community. The overall habitat suitability for wildlife of the site is currently low because of the ephemeral nature of the wetted grass area, the high cover of Reed Canarygrass, and the limited temporal availability of the habitat due to reservoir inundation. Overall habitat suitability of the site is also diminished due to a high level of seasonal use by humans for unauthorized recreational activities.

6.5.1 Vegetation

Areas situated lower (between 434 and 438 m ASL) in the drawdown zone at Burton Creek support a diverse assemblage of annual and early seral plant species, which is typical of much of the drawdown zone of the Arrow Lakes Reservoir. Much of the substrate of the site is relatively coarse (e.g., sands, gravels, etc.), and the vegetation is reflective of this. Species found commonly throughout these lower elevation habitats include *Carex lenticularis*, *Equisetum arvense*, *Veronica peregrina*, *Collomia linearis*, *Potentilla norvegica, Rorippa palustris, Carex aperta*, *Juncus bufonius*, *J. filiformis*, *Alopecurus aequalis* and *Cerastium nutans*, while at slightly higher elevations, weedy species such as *Phalaris arundinacea, Crepis tectorum, Elymus repens*, *Trifolium aureum*, *T. arvense*, *Scleranthus annuus* and *Poa compressa* become more abundant. Eastern portions of the site, near Hwy 6, are dominated by a slow-moving creek and support a very different vegetation community. This area is dominated by *Calamagrostis canadensis* and *Phalaris arundinacea* and supports a small assemblage of species that are typical of finer soils and moister conditions (e.g., *Galium palustre*).

Vegetation mapping of select sites in the drawdown zone was completed for CLBMON-33 (Enns et al. 2009; Miller et al. 2015). The plant communities that exist at Burton Creek closely parallel the elevation of the drawdown zone, with the BE (Beach non- to sparsely-vegetated sands or gravels) community dominating the lowest elevations (434 to 436 m ASL), the PC (Reed Canarygrass-Lenticular Sedge Mesic) community dominating the middle elevations (436 to 438 m ASL), and the RH (Redtop–Hare's-foot Clover upland) community dominating the uppermost (>438 m ASL) elevations. The landscape of the Burton Creek site contains numerous shallow, permanently flooded pools and sloughs that provide suitable habitat for pond-breeding amphibians such as Western Toads, but these occur at elevations < 434 m ASL and tend to be flooded for much of the year (with the timing, frequency, and duration a function of annual reservoir management).

The BE community occurs on well-drained, sandy or gravely flats and is very sparsely vegetated. The few plants that do occur are largely waifs from nearby established plant communities and include Reed Canarygrass, Lenticular Sedge, and a variety of rushes.

In the common and widespread PC community, which is found in abundance throughout the reservoir, the vegetation is dominated by extensive, dense, and often pure stands of Reed Canarygrass, with lesser components of species such as Lenticular Sedge, Common Horsetail, tumble-mustards, Small Bedstraw, Yellow Monkey-flower, Field Mint, forget-me-nots, Common Dandelion, and mosses. Additional species of plants, including several other species of *Carex*, can occur in this community but are uncommon and areas with extensive disturbance (especially due to grazing by geese) are often invaded by a wide variety of exotic annual weeds.

The RH community is found on well-drained soils in the high-elevation bands where there has been no accumulation of woody debris. This plant community has relatively high species diversity and contains woody vegetation (tree seedlings, shrubs) as well as a variety of native and introduced forb and grass species. The woody vegetation is characterized by species such as Douglas-fir, Western Hemlock, Western Redcedar, Western White Pine, Black Locust, Trembling Aspen, and Grand Fir, while the shrub layer contains species such as mountain-ash, roses, and alder. The grass and forb layer is dense and contains Redtop, Timothy, Junegrass, Poverty Oatgrass, and Bluebunch Wheatgrass. Introduced, weedy vegetation is common in this community (but is not as dominant as in the LO or Blue wild rye – log zone community), with Hare's-foot Clover being particularly abundant. Examples of the habitat types that occur at Burton Creek are shown in Figure 6-3.

Figure 6-3. Burton Creek before (left, May 2008) and after (right, September 2008) inundation. Photos © Krysia Tuttle

The proposed physical works location is a dry grassy field, as such there are no aquatic macrophytes present.

6.5.2 Wildlife

Species of songbirds, raptors, waterfowl and wetland-associated birds, amphibians, reptiles, insects, spiders, bats, and ungulates (deer and moose) have been documented from the site. Three to five species of mammals have been documented using the drawdown zone at Burton Creek during spring and summer (based on incidental observations made during fieldwork for CLBMON-11B1 [see Hawkes et al. 2011]). During aerial surveys conducted in February 2011 and 2012, unspecified deer tracks were documented in the drawdown zone in 2011, and have been incidentally noted in 2013 and 2015. In general, use of the drawdown zone at Burton Creek by ungulates and other large mammals is limited, which is likely related to the high level of human use and proximity of the site to the highway. Since 2009, 103 species of birds, 16 species of mammals (including nine species of bats[1]), three species of amphibians (including the blue-listed Western Toad, a COSEWIC species of Special Concern), and two species of

[1] One of the most frequently documented bats at the Burton Creek site is the little brown myotis (*Myotis lucifugus*), which was emergency listed under Species at Risk Act as Endangered (Dec. 17, 2014) due to the potential threat of White Nose Syndrome (a fungus caused by *Geomyces destructans*).

reptiles have been documented at Burton Creek. Details can be found in Hawkes and Tuttle (2009, 2010) and Hawkes et al. (2010, 2011a, 2011b, 2015).

The proposed wildlife physical works site may be used by some species of pond-breeding amphibians although none have been documented to date (see Hawkes and Tuttle 2009, 2010; Hawkes et al. 2011a). Garter snakes (Western Terrestrial and Common) have been observed using the habitats in and adjacent to the wet depression, especially in areas where coarse woody debris (CWD) has accumulated. The overall suitability of the site is currently low because of the ephemeral nature of the wetted areas in the proposed physical works footprint, the high cover of Reed Canarygrass, and the limited temporal availability of the habitat due to reservoir inundation. The spatial extent of the wet depression is also currently limited due to the topography of the site.

The site proposed for physical works at Burton Creek does is not waterfowl habitat until it becomes inundated, which usually occurs in June; post-impoundment, the shallow, leading edge of the wetland may be used by waterfowl. Shorebird habitat is also not available at the site proposed for the physical works. It is expected that both groups of birds will benefit from the creation of shallow wetland habitat in the drawdown zone of Arrow Lakes Reservoir. Shorebirds, waterfowl, grebes, and loons have been documented from the Burton Creek area (mainly in the vicinity of the revegetation prescriptions applied under CLBWORKS-2) with as many as 19 species documented since 2009 (Table 6-1). It is likely that a created wetland would be used by some of these species.

Table 6-1. Species of grebe, loon, shorebirds, and waterfowl documented from the Burton Creek area between 2009 and 2015. These species were documented during songbird point count surveys conducted for CLBMON-11B1.

Group	Common Name	Scientific Name	2009	2010	2011	2013	2015
Grebes	Horned Grebe	*Podiceps auritus*		1			
Loons	Common Loon	*Gavia immer*		1	5	12	1
	Pacific Loon	*Gavia pacifica*			1		
Shorebirds, Gulls, Auks and Allies	California Gull	*Larus californicus*			2	8	19
	Killdeer	*Charadrius vociferus*	7		29		
	Long-billed Curlew	*Numenius americanus*			2		
	Ring-billed Gull	*Larus delawarensis*	2	6	106		
	Spotted Sandpiper	*Actitis macularius*	7	1	15	20	9
Waterfowl	Blue-winged Teal	*Anas discors*			2		
	Bufflehead	*Bucephala albeola*			14		
	Canada Goose	*Branta canadensis*	43	15	88	214	47
	Cinnamon Teal	*Anas cyanoptera*				2	
	Common Merganser	*Mergus merganser*	2	12	8	1	9
	Gadwall	*Anas strepera*			1		
	Green-winged Teal	*Anas crecca*		1			
	Hooded Merganser	*Lophodytes cucullatus*		1	1		
	Mallard	*Anas platyrhynchos*	4	1	34	3	22
	Northern Shoveler	*Anas clypeata*			1		
	Wood Duck	*Aix sponsa*		4			
		Total Species (per year)	**6**	**10**	**15**	**7**	**6**

6.5.3 Soil/Geology

A review of the *Soils of Nelson Area British Columbia, Soil Survey Report No. 28* (Jungen 1980) indicates the soils at this site are glaciofluvial deposits of the Glenlily Association. The soils of the Glenlily Association have developed in well-sorted, loose to semi-compact glaciofluvial deposits. The deposits are greater than 1.5 m in depth, very gravelly and cobbly in the surface with minor stones, and non-calcareous. Textures are moderately coarse at the surface and grade to very coarse with depth. Orthic Dystric Brunisol is the typical soil development with significant inclusions of Degraded Dystric Brunisol or Orthic Humo-Ferric Podzol. Glenlily soils are moderately acid, have low cation exchange capacities, and have low to moderate base saturation percentages. Solum depths are typically shallow, usually less than 40 cm. Glenlily soils are rapidly drained.

The soils at the tree line at Burton Creek are characterized as fine to coarse sands without large volumes of compacted boulders and gravels with interstitial silt. In some areas, lenticular deposits of darker silt loams that are fine textured but moist have been deposited throughout boulder matrix. The soils in the 438 to 436 m ASL are a combination of silts and clays mixed with sand shifting to mainly very fine sands between 436 and 434 m ASL (K. Enns, pers. comm., Delphinium Holdings Inc.).

Keefer et al. (2008) reported that the soils at Burton Creek are fine to coarse depositional materials and soil texture is silt loam and sandy loam at the sample sites. Overall, the site is well to rapidly drained and coarse fragment content varies between 0 and 50 per cent.

Prior to finalizing the detailed design of the physical works project, the soils in the area should be better defined and a grain size analysis should be conducted. This analysis will determine if the native materials will provide adequate water retention capability or if a fine-grained material will need to be brought to the site.

6.5.4 Hydrology

The Burton Creek wildlife physical works site occurs entirely within the drawdown zone of Arrow Lakes Reservoir. The hydrological features of the Burton Creek site include several large human-made gravel extraction ponds situated below 434 m ASL, and a small stream that originates in the forest adjacent to the highway, flows in a northerly direction, and drains into the reservoir. Burton and Caribou Creeks flow into the reservoir to the north of the proposed physical works site and will not be affected by the proposed project. The water table at Burton Creek appears to be close to the surface in several locations, including the proposed physical works location, which if it were not inundated by the reservoir on an annual basis would be an ephemeral wetland.

6.6 Goals and Objectives

The primary goal of the proposed wildlife physical works at Burton Creek is to create ~2.8 ha of shallow wetland habitat in the drawdown zone that is available to wildlife for at least 195 days per year (depending on reservoir elevations). A review of reservoir elevations for the last nine years (2007 to 2015) indicates that if this physical works is built, it will be available to wildlife for an average of 195 days per year (max = 214 days; min = 66 days; SD = 44.6 days). This is based on the assumption that wildlife will be most likely to use the constructed wetland between April 1 and October 31 (n = 214 days per year). A secondary goal is to meet the direction provided under the Water Use Plan to

identify enhancement opportunities in the mid- and lower Arrow Lakes Reservoir under CLBWORKS-29B.

Creating shallow wetland habitat in the drawdown zone will improve the ecology of the drawdown zone by improving habitat suitability for wildlife and vegetation. The specific objectives of the proposed wildlife physical works are to:

1. Increase the spatial and temporal availability of shallow wetland habitat for wildlife in the drawdown zone of Arrow Lakes Reservoir;
2. Improve habitat complexity in the drawdown zone of Arrow Lakes Reservoir;
3. Improve wildlife habitat suitability by creating habitat that will benefit several groups of wildlife including migratory birds (e.g., staging area), nesting birds (e.g., waterfowl, shorebirds), pond-breeding amphibians, reptiles (snakes), bats, insects (Odonata), and mammals (e.g., mink [*Mustela vison*], River Otter [*Lontra canadensis*]);
4. Reduce the cover of Reed Canarygrass in the drawdown zone to promote the growth of native plants through a terrestrial revegetation program that will follow the completion of the physical works; and
5. Revegetate the created wetland habitat with native aquatic macrophytes and riparian vegetation.

6.7 Target Site Conditions

The target site conditions of the proposed wildlife physical works include the creation of ~2.8 ha of shallow wetland habitat that will range in depth from 0 to 1.5 m. The type of wetland created will consist of open water with submerged and floating macrophytes and will resemble the existing wetland habitat at Edgewood South (Figure 6-4), but will be bigger and have more vegetation.

Figure 6-4: Existing pond/wetland habitat at Edgewood South in 2011 (left) and 2016 (right).

The wetland will be revegetated with native plant species found commonly throughout Arrow Lakes Reservoir such as *Carex lenticularis*, *Equisetum arvense*, *Veronica peregrina*, *Collomia linearis*, *Potentilla norvegica, Rorippa palustris, Carex aperta*, *Juncus bufonius*, *J. filiformis*, *Alopecurus aequalis* and *Cerastium nutans*.

6.8 Seasonality of Expected Improvements

Seasonality of expected improvements was considered for the period April 1 to October 31 as this is the time of year when wildlife are active and the area is likely to be snow and ice-free. The typical hydrograph of Arrow Lakes Reservoir includes rapid filling in the spring with high-water achieved between June and August (usually early July) followed by a decline in late July of early August through September (Figure 6-5). Depending on the depth of the water table at the site, the excavated ponds may fill with ground water, precipitation (snow/rain), or potentially from water from the stream to the east of the proposed location. Additional inputs would occur when the reservoir exceeds the height of the berm. The proposed physical works should be designed to retain water so that pond-breeding amphibians could breed in the ponds in April and May and the excavated areas would be wetted from April through inundation in most years. The elevations of the excavations are such that typical reservoir operations will not inundate the ponds until June or July, which would provide enough time for eggs to hatch and tadpoles to develop (see below).

Based on the mean elevation of each excavation (see Section 6.7), the lower excavation could be inundated as early June 10 (based on a review of reservoir elevation data between 2007 and 2015) and remain inundated until the end of August (Figure 6-5). The upper elevation excavation could be inundated from the end of June through the 3rd week of August. This assumes that a dike is built between the two excavations to a height of 439 m ASL.

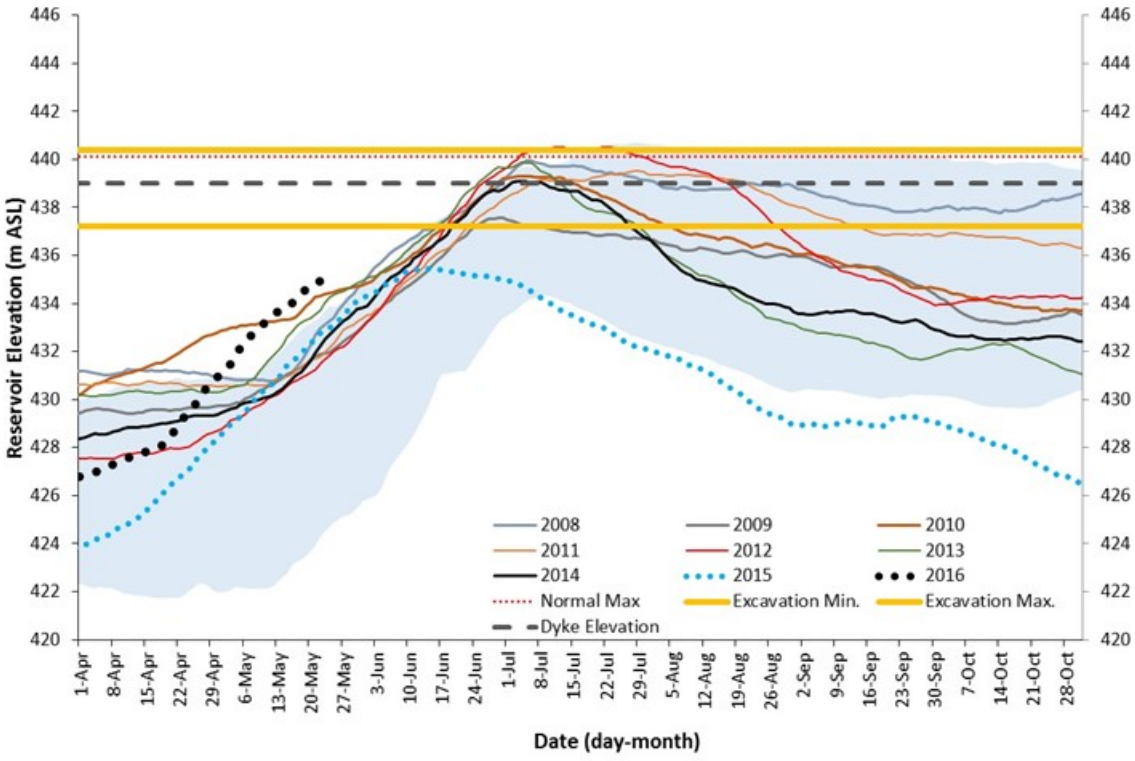

Figure 6-5: Timing of inundation (date) for the lower and upper excavations proposed at Burton Creek. The yellow solid lines represent the lowest and highest elevation associated with the excavations and the grey dashed line represents the height of the dike between the

two areas. Annual hydrographs for April 1 to Oct 31 and years 2008 through 2015 (through May 21, 2016).

6.8.1 Anticipated effects of physical works on Wildlife

6.8.1.1 Amphibians

Current reservoir operations in Arrow Lakes Reservoir do not appear to negatively affect amphibians (Hawkes et al. 2015). For example, Western Toad and Columbia Spotted Frog typically lay eggs in late April or early May. Eggs hatch in 3 to 12 days and free swimming tadpoles develop rapidly allowing them to move within ponds, even when inundated. Recent observations (June 2016) confirm that Western Toad tadpoles occupy the leading edge of Arrow Lakes Reservoir, even as reservoir elevations increase. Because of their mobility and the timing of breeding and development, it is unlikely that habitat enhancement/creation at the Burton Creek site will negatively affect pond-breeding amphibians. However, creating additional shallow wetland habitat in the drawdown zone of Arrow Lakes Reservoir will enhance the suitability of the drawdown zone for amphibians by providing more of a currently limited habitat type. Data from Kinbasket Reservoir supports this statement. In fall 2015 ponds were cleared of wood debris and enhanced during work associated with CLBWORKS-1. In spring 2016, Western Toads had used those ponds for breeding – an observation that had not been made in all years of study under CLBMON-37 or CLBMON-58 (i.e., since 2008).

Figure

p

Examples of habitats uses by Western Toads. Right: Tadpoles were among the floating wood debris at the leading edge of Arrow Lakes Reservoir, Burton Creek on June 5, 2016 when Arrow Lakes Reservoir was at ~ 436.2 m ASL; and left: evidence of Western Toad Breeding in a recently (fall 2015) enhanced wetland in Kinbasket Reservoir (elevation 752.32 m ASL; right). Photo date: May 3, 2016

6.8.1.2 Birds

Certain species of bird are known to nest in the drawdown zone of Arrow Lakes Reservoir including Killdeer (*Charadrius vociferus*) and several species of sparrow (e.g., Savannah Sparrow, *Passerculus sandwichensis*). Very few data are available for the elevation of bird nests in the drawdown zone at Burton Creek. However, a single Savannah Sparrow nest was documented in 2015 at an elevation of ~ 438.4 m ASL. Working in Revelstoke Reach, Cooper Beauchesne and Associates Ltd. have documented Savannah Sparrow Nests from 435.44 m to 439. 30 m ASL (median = 437.2 m ASL; n = 22) and Killdeer from 433.16 m to 442.21 m ASL (median 436.7 m; n = 32; H. van Oort,

pers. comm.). Although some level of mortality has been reported (due to reservoir operations or predators, for example), not all nests fail. The elevation of the proposed physical works at Burton Creek aligns with the median elevation of Savannah Sparrow and Killdeer nests reported for Revelstoke Reach. Given the low incidence of known nesting in the drawdown zone at Burton Creek, the infrequent bird detections within the proposed physical works location, and the predominance of Reed Canarygrass at the site, it is unlikely that the physical works will negatively affect birds. However, additional data collected for CLBMON-11B1[2] in 2016 should be reviewed to determine if this statement holds true.

Waterfowl use of the proposed physical works location is limited to the periods when it is inundated by the reservoir. Adding water to the site results in the use of shallow areas by waterfowl. For example, in 2016 Gadwall (*Anas strepera*), American Wigeon (*Anas americana*), and Mallards (*Anas platyrhynchos)* were observed in the shallow margins of the reservoir. Creating a wetland is expected to increase habitat suitability for waterfowl and shorebirds at Burton Creek.

6.8.1.3 Mammals

Mammals observed at the Burton Creek site include ungulates (deer), River Otter, small mammals (e.g., Meadow Vole), and several species of bat (based on analysis of data collected by autonomous recording units). Of the mammal species present at Burton Creek, bats are the most likely to benefit from the creation of wetland habitat. Our current understanding of the use of Burton Creek by bats indicates that as many as nine species of bat could be using the site between June and September (see Table 6-2). Relative to both Edgewood South and Lower Inonoaklin Road, bat activity (based on the number of recordings per hour) at Burton Creek was greater, but fewer potential species were documented (nine vs. 11 at both Edgewood and Lower Inonoaklin Road). Bat data were collected from habitats to the south and west of the site proposed for physical works at Burton Creek, and largely over terrestrial habitats. The addition (creation) of wetland habitat at Burton Creek will improve the overall suitability of the site for bats due to an increase in habitat heterogeneity and associated (anticipated) increases in food availability (aerial insects). Data collection on the use of the proposed physical works site by bats is ongoing (as part of CLBMON-11B) with data collection proposed for the period May through September 2016. Bat enchantments (e.g., bat houses, condos, and snags) may increase the overall suitability of the created habitat at Burton Creek for bats.

6.9 Performance Measures

Because the habitat present pre-construction will differ from that present post-construction, a pre- vs. post-use by specific species of wildlife will not provide for a meaningful assessment of effectiveness. Rather, an index of habitat function is suggested to assess the effectiveness of wetland creation to increase the suitability of the drawdown zone for wildlife at Burton Creek. The index should be based on post-construction monitoring data to describe the use of the created wetland by waterfowl,

[2] Work associated with CLBMON-11B1 in 2016 includes searching for and documenting the location and productivity of nests in the drawdown zone at Burton Creek, Lower Inonoaklin Road and Edgewood South.

shorebirds, songbirds, amphibians, and bats and on the species composition and cover of aquatic macrophytes. Macroinvertebrate species composition should also be considered in the development of an index that describes wetland productivity and function.

The following performance measures are suggested to guide the collection of data with which to assess the success of the proposed wildlife physical works project at Burton Creek:

1. Creation of at least 2.0 ha of new wetland habitat in an area dominated by grass species (i.e., no current wetland habitat).
    a. Temporal availability of wetland overlaps with the migratory bird (particularly wetland-associated species) and amphibian breeding seasons (May-August). The permanence of the wetland should be assessed (i.e., is the wetland available each year and for how long?)
    b. Minimum depth of pond required to support amphibian breeding and larval development (20 to 100 cm).
2. Wetland productivity:
    a. Successful establishment of native macrophytes (planted or natural) into newly created wetlands within five years. “Successful establishment” is defined here as continuous species presence for at least two years. Currently there are no macrophytes at the site proposed for physical works.
    b. Successful natural establishment of native macroinvertebrates (e.g., odonates, cladocerans, gastropods) into newly created wetlands within 5 years. “Successful establishment” is defined here as continuous species presence for at least two years. The current biomass of macroinvertebrates at this site is nil.
    c. Evidence of breeding by amphibians (specifically Western Toad). The number of egg strings or masses should be counted on an annual basis following the implementation of the physical works. Egg development should be tracked to determine if eggs metamorphose into froglets or toadlets. Western Toads currently breed in the ponds situated at elevations <434 m ALS, but do not breed at the site proposed for physical works.
    d. Evidence of use of the wetland by waterfowl and shorebirds. Waterfowl have been observed using the area proposed for physical works, but only when inundated by Arrow Lakes Reservoir. For example Mallard (*Anas platyrhynchos*), Barrow's Goldeneye (*Bucephala islandica*), and Common Merganser (*Mergus merganser*) were observed at the Burton Creek site in July 2016 (J. Gatten, LGL Limited Biologist, pers. obs.).
    a. Evidence of use of habitat enhancements (e.g., nest boxes, floating islands) by target waterfowl species (which will need to be determined) following completion of construction.
    e. Evidence of use of the constructed wetland by bats (as determine by autonomous recording units) and use of enhancements such as bat boxes, snags, or other enhancements).

f. No reduction in the species composition of bats at the Burton Creek site, which currently includes up to nine species (Table 6-2).

Table 6-2. Bat species documented[1] using bat detectors at the Burton Creek area in 2015. The bat detectors were situated near, but not directly in the area proposed for physical works. The species in this table should be considered a good representation of the use of the Burton Creek area by bats, but see footnote.

Scientific Name	Common Name	BC CDC	COSEWIC	SARA
Corynorhinus townsendii	Townsend's Big-eared Bat	Blue	--	--
Eptesicus fuscus	Big Brown Bat	Yellow	--	--
Lasiurus cinereus	Hoary Bat	Yellow	--	--
Lasionycteris noctivagans	Silver-haired Bat	Yellow	--	--
Myotis californicus	California Myotis	Yellow	--	--
Myotis evotis	Long-eared Myotis	Yellow	--	--
Myotis lucifugus	Little Brown Bat	Yellow	Endangered	1-E (2014)
Myotis volans	Long-legged Myotis	Yellow	--	--
Myotis yumanensi	Yuma Myotis	Yellow	--	--

[1]bat species presence is based on a probability of presence via the analysis of acoustic signature recordings. Because of the difficulty associated with assigning species identification based solely on the use of acoustic signatures, this species list may not be accurate (e.g., Myotis species are often grouped due to the overlap in the frequency of their acoustic signatures).

3. No measurable increases greater than 25 per cent from baseline conditions (which will be 0) in cover and diversity (species richness and evenness) of key undesirable macrophyte species over 10 years in the constructed wetland and on the associated dikes and mounds. Key undesirable species include Eurasian Water-milfoil (*Myriophyllum spicatum*) and Reed Canarygrass.
4. Little to no erosion of the dike as determined by immediate post-construction monitoring and subsequent integrity checks by a qualified engineer.

6.10 Description of Work

6.10.1 Approach

The proposed physical works will create wetland habitat in an area dominated by grasses. This will be achieved by constructing a dike ~390 m long and ~0.5 to 1.5 m in height that will not only retain water on the upstream side, but will also keep the water level in reservoir from flooding the area as frequently. To create this habitat at the lowest cost, local materials will be used to the extent possible.

6.10.2 Construction Methods

The method of construction will generally consist of excavation using hydraulic excavators and transport of the materials using dump trucks. This material will then be dumped in lifts and compacted to a suitable density. Following compaction a hydraulic excavator will form the final shape of the features and place the erosion protection or other material on the dike. The final step in construction will involve planting, which will be performed primarily by individuals using shovels.

Most of the project will be constructed using materials currently located on the site. All excavated materials will remain on the site. This excavated material will be used to

construct the dike and land forms. It is expected that the following material will be brought to the site:

- Rock for providing erosion protection on the reservoir side of the dike and spillway;
- Fine-grained soils may be required to improve the soil retention capabilities of the ponds/wetlands; and
- Plants and seeds for vegetating the site (this will be covered under CLBWORKS-2 funding).

The construction will be inspected periodically by a representative of the engineer to confirm that the works are constructed in accordance with the design.

Riprap materials will be hard, durable, angular quarry rock of a quality that will not disintegrate upon exposure to water or the atmosphere. Riprap will be 300 mm diameter minus (subject to current and wave erosion analysis). The fill and pond-bottom material will ideally be a pit run gravel containing a minimum of 10 per cent fine material (fine material has particle sizes less than 0.075 mm). Slightly more permeable material may also be acceptable depending on local site conditions. It is likely that the addition of riprap to the drawdown zone will enhance habitat for small mammals and reptiles, which is considered a positive ancillary benefit of the proposed physical works.

The dike will be constructed of fine materials that will either be retrieved from the site or transported to the site from a nearby borrow pit. Numerous layers of this material will be laid down to construct the dikes, with each layer being thoroughly compacted using a compactor; repeated driving over the material by rock trucks and excavators will further contribute to its compaction. Once the dike is built, the outer face will be armoured with coarse rip-rap and the inner face will be coated with a layer of organic material that will act as a substrate for the establishment of vegetation.

The dike will be equipped with an armoured spillway that will allow water to move in a downhill direction towards the reservoir. The spillway will be situated at an elevation 30 to 40 cm lower than the top elevation of the dike.

Structural loads on the proposed dike structure will consist primarily of maintenance equipment loads, hydrostatic forces, and wave and erosive forces. To resist these loads, the dike will be constructed of well-graded material. This material will be compacted to a suitable level to minimize future settlement and seepage through the dike. Additionally, to distribute vehicle loads, reduce seepage, and prevent erosion the dike will be constructed at relatively gentle side slopes of 6 (horizontal) to 1 (vertical) or flatter. To resist erosive wave forces, the reservoir side of the dike may need to be faced with riprap rock armouring.

Environmental loads on the proposed physical works will depend on annual fluctuations in weather conditions and the reservoir operating regime. The impact of wave wash will be the primary environmental force acting on the dike. Once reservoir levels exceed the height of the dike, wave erosion should decrease, but as reservoir levels recede, wave wash will again impact the dike until water levels are below the base of the dike. Compaction of the materials used in the dike and armouring the dike with riprap will reduce the erosive force of waves.

This project design will take into consideration the following functional criteria:

- The seepage rates of the material used to construct the dike and the soils that will form the bottom of the pond will be checked to determine if the feature will adequately retain water;
- The dike and pond features (including plantings) will be designed so that the removal of sediment will be possible with conventional excavation equipment. This will include providing adequate running surface widths on the top of the dike;
- The compaction of the dike fill materials will be specified so that detrimental settlement will not occur;
- Erosion protection will be provided to prevent erosions as a result of current and wave forces; and
- The spillway through the dike will be designed for the 100-year return period storms event flow without overtopping the dike in other locations.

6.10.3 Construction Schematics

The Burton Creek proposed physical works project is illustrated in Figure 6-8 and a profile of the dike and ponds is provided in Figure 6-8.

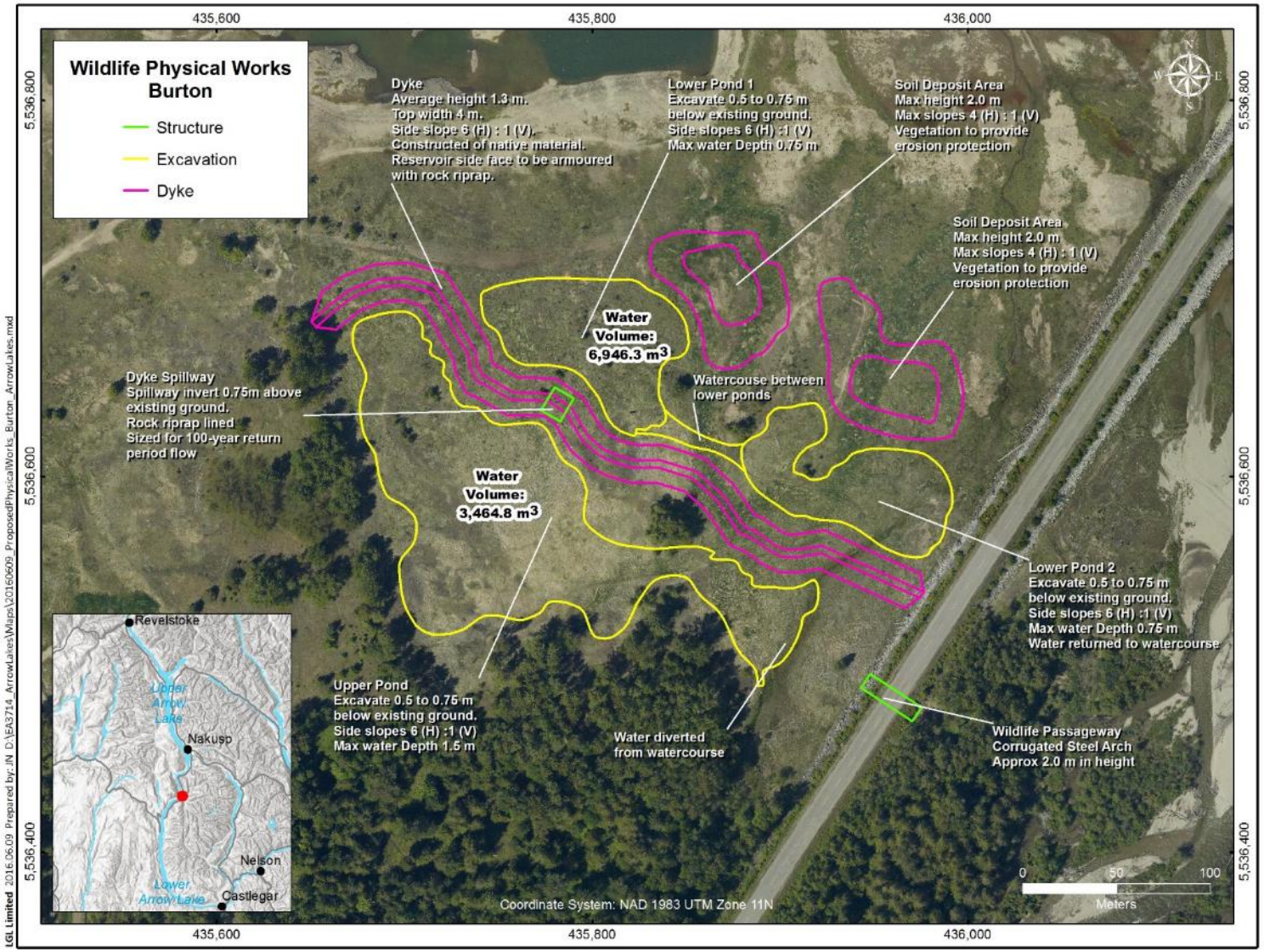

Figure 6-7: **Schematic of proposed physical works project in the drawdown zone of Arrow Lakes Reservoir at Burton Creek.** The location of the ponds and dike are approximate

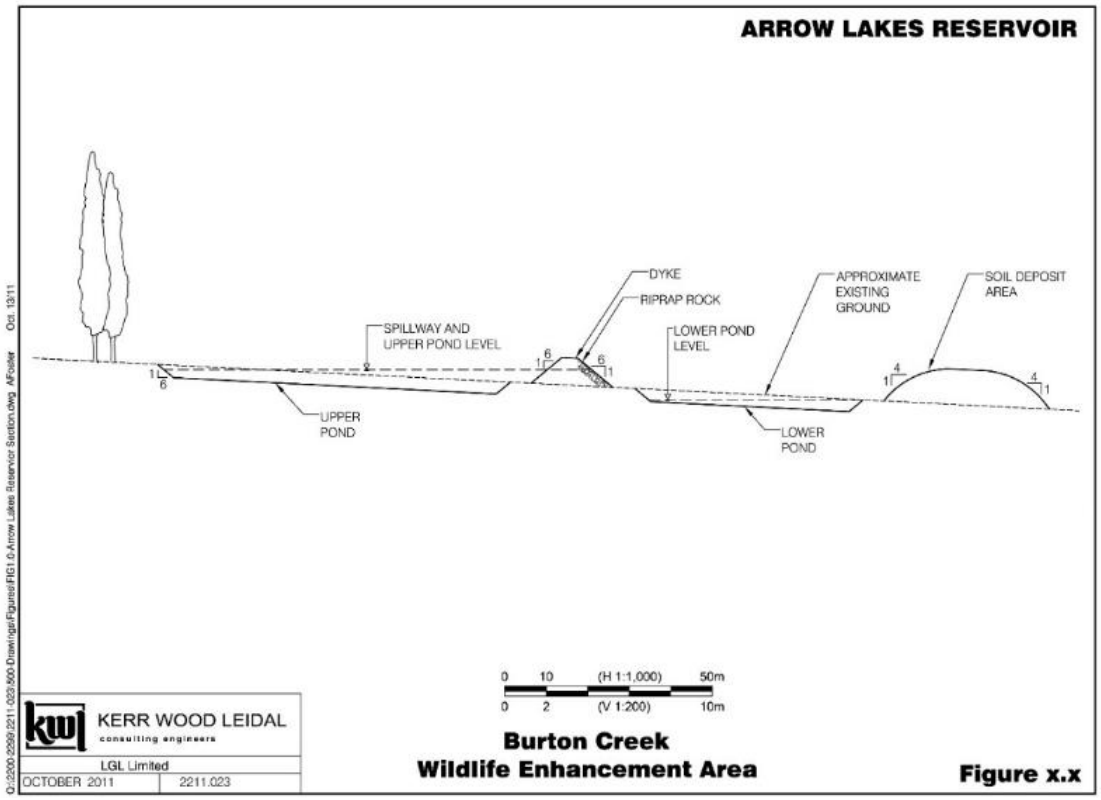

Figure 6-8: **Cross-section of the proposed physical works project in the drawdown zone of Arrow Lakes Reservoir at Burton Creek**

6.10.4 Construction Schedule

The proposed schedule for the Burton Creek physical works project depends on when funds are made available to do the work and reservoir elevations to be able to conduct the work in dry conditions. A generic schedule is provided (see Section 6.11.12) as a guide and will be adjusted as needed. At present, construction is planned for the period April 30 to June 30 in a given calendar year provided that all required studies (archaeology, engineering), stakeholder engagement, and permit acquisition occur in the preceding months and are in completed and in place prior to the start of construction.

The proposed schedule will not impact fish because the project location is situated near the treeline and all proposed ground disturbance activities will be completed before the site is inundated.

6.10.5 Cost Estimate

A Class C site estimate has been prepared for the Burton Creek wetland creation project using information from a comparable-sized project. A Class C budget is an estimate prepared with limited site information and is based on probable conditions affecting the project. It represents the summation of all identifiable project component costs. It is used for program planning, establishing a more specific definition of needs, and obtaining approval in principle. The estimate has been derived from unit costs for similar projects. Actual project costs may be higher or lower and will vary depending on

numerous factors, including material availability, contractor competition, and site conditions during construction period. The Class C cost estimate for the Burton Creek wetlands is provided in Table 6-3. [redacted]

There are project-related activities that have not been included in the costs estimate including an Archaeological Impact Assessment, acquisition of permits and approvals, final engineering design, First Nation and stakeholder engagement, and post-construction inspects etc. The costs below were developed to demonstrate the costs associated with constructing the physical works only. A more detailed cost estimate and timeline should be prepared for this project if it proceeds.

Table 6-3: **Class C cost estimate for the proposed physical works project in the drawdown zone of Arrow Lakes Reservoir at Burton Creek.** L.S.: lump sum; c.m.: cubic metre; l.m.: linear metre; s.m.: square metre

Item	Description	Unit	Estimated Quantity	Unit Rate ($)	Total Estimate	Comment
1	**General**					
1.01	Mobilization and Demobilization	L.S.	1	15,000	$ 15,000.00	
1.02	Bonding and Insurance (1.5% of Other Tasks)	L.S.	1	7,000	$ 7,000.00	
1.03	Diversion, Erosion and Sediment Control	L.S.	1	10,000	$ 10,000.00	
1.04	Survey Layout of Works	L.S.	1	5,000	$ 5,000.00	
	SUBTOTAL FOR TASK				**$ 37,000.00**	
2	**Earthworks**					
2.01	Pond Excavation	c.m.	16,400	8.0	$ 131,200.00	*It is assumed that the on-site excavated material will be suitable for dike construction.*
2.02	Hauling of Material	c.m.	16,400	3.0	$ 49,200.00	
2.03	Subgrade Preparation	s.m.	7,600	2.0	$ 15,200.00	
2.04	Berm/Fill Area Construction c/w Compaction	c.m.	16,400	5.0	$ 82,000.00	
	SUBTOTAL FOR TASK				**$ 277,600.00**	
3	**Drainage Works and Structures**					
3.01	Riprap Armouring	c.m.	900	100	$ 90,000.00	
3.02	Fish Habitat Gravel	c.m.	120	150	$ 18,000.00	
3.03	CSP Wildlife Passageway	l.m.	25	1,500	$ 37,500.00	
3.04	Planting	L.S.	1	15,000	$ 15,000.00	
	SUBTOTAL FOR TASK				**$ 160,500.00**	
				SUBTOTALS - All Tasks	**$ 475,100.00**	
	Environmental Monitoring				$ 30,000.00	
	[redacted]				[redacted]	
	Engineering & Construction Management	10%			$ 47,510.00	
	Contingencies	20%			$ 95,020.00	
				Total Estimate (excl. tax) +50%/-15%	**$ 1,032,630.00**	

6.11 Considerations

6.11.1 Reservoir Operating Regime

Reservoir operations are predictable yet variable. Assessing the hydrograph of the reservoir for the years 2008 to 2016 (partial; Figure 6-5) provides an indication of the potential construction window, which could extend from April 1 to June 24. Based on the project planning provided in Section 6.11.12, this should provide enough time to plan and execute the work. There are years (e.g., 2015) when the construction could have occurred at any time between April 1 and Oct 31 due to low reservoir levels. The project reservoir elevations for Arrow Lakes should be reviewed prior to construction to determine the best window in which to operate.

6.11.2 Public Safety

Appropriate signage will be erected prior to and during construction. Given that the area identified for the proposed physical works is not commonly used by people, there is little to no risk associated with public safety. An environmental monitor will be onsite during construction and will ensure that the public remains a safe distance from the site during construction activities. The creation of wetland habitat will have a lower risk to the public than the existing reservoir.

6.11.3 Wildlife

The proposed project will ultimately benefit wildlife; wildlife habitat creation is the main objective of this project. The proposed construction site was evaluated for nesting birds in 2015 and none were found. Additional work is occurring in 2016 and the results of those surveys should be reviewed prior to establishing the construction window. If nests are found in the area in 2016, nest searching should occur prior to work starting at the site.

6.11.4 Fisheries

At present the site does not provide fisheries values for most of the year (i.e., when the reservoir is < 436 m ASL). During periods of the year when the site is inundated, there may be some value to fish. The proposed project will create a wetland of ~2.8 ha that will be inundated for the portion of the year that the reservoir exceeds ~439 m ASL. Burton and Caribou Creeks provide habitat for Kokanee salmon (*Oncorhynchus nerka*) and other fish species (see Section 9.1), which start staging at the mouth of the creeks in mid to late September. At this time of year Arrow Lakes Reservoir is usually at its highest and may or may not exceed ~438 m ASL (see Figure 6-5). There is some potential for fish to become stranded in the wetland; however, the size and depth of the created habitat should not contribute to increased mortality rates or have a negative effect on fish populations in Arrow Lakes Reservoir. Furthermore, Kokanee will return to their spawning stream in the fall with little potential of straying to novel habitats such as a constructed wetland.

6.11.5 Archaeology

The proposed physical works will involve some ground disturbance activities, although most of the work will involve removing existing vegetation and woody debris from the

site where the wetland will be created. Ground disturbance depth will be in the 50 to 100 cm range. An archaeological assessment was not completed as part of the development of the prescription nor is it included in the cost estimate. The location of the proposed physical works area near the mouth of a large waterway, on exposed flats adjacent to Burton and Caribou Creeks, and in proximity to known archaeological sites suggests that the proposed physical works location has high archaeological value. Current information indicates that an Archaeological Impact Assessment should be completed prior to the implementation of physical works at this location.

6.11.6 Recreation

The Burton Creek area is associated with a high level of recreational use in the form of camping, all-terrain vehicle use, and daily activities such as dog walking. The area has been impacted from gravel extraction activities (at lower elevations) and the remnant pits are used in the spring for mud-bogging, an activity that should be discouraged due to the use of those ponds by pond-breeding amphibians (Western Toad). The recreational value of Burton Creek has been considered and the area proposed for excavation and dike construction is not typically used for camping because much of it is a wet depression.

6.11.7 Summary of Agency, First Nations, and Stakeholder Consultation

In fall 2010 a meeting with BC Hydro, the Ministry of Environment, and the Fish & Wildlife Compensation Program–Columbia Region was held in Nelson BC to disuses the proposed wildlife physical works and to prioritize the projects. Additional consultation with agencies, First Nations, and local stakeholders will be required prior to the implementation of the proposed physical works.

The Burton Creek area is used by members of the community, but the proposed physical works will not affect the area that is typically used, which is situated to the west. There is private property near to the proposed project area that gets used as a helicopter landing site. The proposed physical works will not affect that property. First Nation and stakeholder engagement would be required for the implementation of this project given the high degree of interest thus far in rehabilitation of the Burton Creek area.

6.11.8 Codes and Standards

The Burton Creek wildlife enhancement project will be constructed in accordance with the following codes and standards;

- Good engineering practice;
- Engineering components will be designed by professional engineers and/or professional geoscientists registered with the Association of Professional Engineers and Geoscientists of BC;
- Growing soil medium and plant specifications will be designed by professional ecologists registered with the Association of Professional Biology of BC.

6.11.9 Maintenance

The expected maintenance for this project will include the following:

- Removal of invasive vegetation;
- Removal of deposited sediment; and
- Inspection of constructed features for signs of instability and erosion.

The frequency of this maintenance will be determined based on monitoring of the field conditions. We estimate that this maintenance will initially occur on an annual basis, but will occur less frequently as the site stabilizes.

6.11.10 Monitoring Requirements

6.11.10.1 During construction

In addition to the inspection described in Section 6.11.9, monitoring during construction will consist of environmental monitoring and archaeological monitoring (contracted separately). The purpose of this monitoring will be to ensure that the appropriate environmental protection measures, including flow diversions and sediment control, are in place. Additionally, prior to construction fish and wildlife within the construction zone will be relocated. Removal and relocation of fish and wildlife will be done according to the stipulations of a wildlife sundry permit.

6.11.10.2 Post construction

Post-construction monitoring will involve monitoring the integrity of the physical works and the effectiveness of the physical works in meeting the ecological objectives of the project (see Section 6.8). An annual site inspection will occur to document the following:

- Dike integrity;
- Sedimentation rates; and
- Erosion and slope stability.

Effectiveness monitoring will occur as part of CLBMON-11B/CLBWORKS-29B and will include the monitoring of aquatic macrophytes, bats, pond-breeding amphibians, riparian and terrestrial vegetation, and aquatic insects (see Hawkes et al. 2010 for the monitoring protocol). Monitoring protocols from CLBMON-37 and CLBMON-11B may also be implemented or adapted to assess whether the performance measures listed in Section 6.8 have been met. Other species may be the focus of monitoring depending on the final design of the wetland.

6.11.11 Permitting and Regulatory Requirements

Numerous laws and rules govern water use, protection, conservation, and sustainability in British Columbia. Currently, the Ministry of Environment, the Ministry of Forests, Lands, and Natural Resources Operations, the Ministry of Health, and other provincial agencies manage and protect water in BC.

The *Water Sustainability Act* (WSA) was brought into force on February 29, 2016 to ensure a sustainable supply of fresh, clean water that meets the needs of B.C. residents today and in the future.

The *Water Protection Act* (WPA) protects B.C.'s water by reconfirming the Province's ownership of surface and groundwater, clearly defining limits for bulk water removal,

and prohibiting the large-scale diversion of water between major provincial watersheds and/or to locations outside of the province.

The *Environmental Management Act* (EMA) regulates industrial and municipal waste discharge, pollution, hazardous waste and contaminated site remediation. EMA provides the authority for introducing wastes into the environment, while protecting public health and the environment. The Act enables the use of permits, regulations and codes of practice to authorize discharges to the environment and enforcement options, such as administrative penalties, orders and fines to encourage compliance. Guidelines and objectives for water quality are developed under EMA.

Other relevant provincial legislation includes:

The *Dike Maintenance Act*; and

Dam Safety Regulation of the *Water Sustainability Act.*

Based on an assessment of the current Dam Safety regulations, the proposed physical works at Burton Creek includes the establishment of a minor dam and as such, is exempt from regulation because it less than 7.5 m in height and impounds less than 10,000 m^3. Refer to Dam Safety Regulation 40/2016, Part 1, Section 2. The Comptroller of Water Rights could determine that the structure is not exempt from regulation. The total volume of impounded water will need to be recalculated based on the final design of the proposed physical works at Burton Creek. Any required post-construction dike maintenance will also need to be detailed in the final site plans

Conservation Water Licence

The current water licence for Arrow Lakes allows BC Hydro to store water for purposes related to power production. The proposed physical works will retain water that is being used for an alternate purpose from that currently covered by the water licence. Because the physical works retain water for a conservation purpose, a Conservation Water Licence is required.

Other regulatory requirements to consider include the Navigation Protection Act (it is likely that the proposed project would be defined as a minor works and be exempted from the Navigation Protection Act) and the Wildlife Act (a wildlife sundry permit is required to capture, handle, or salvage wildlife including amphibians and fish). See Appendix A for a summary of applicable acts and regulations.

6.11.12 Project Planning

A project planning flowchart is provided in Figure 6-9 that illustrates the need to complete the project before late June, when the elevation of Arrow Lakes Reservoir is generally at its highest level of the year (Figure 6-5). The exact timing of the steps in Figure 6-9 will likely be modified based on the timing of project approval, but for the purposes of the illustration, timing is associated with the beginning of the fiscal year (i.e., April 1) and considers the average elevation of the reservoir over the last nine years (2007 through 2015).

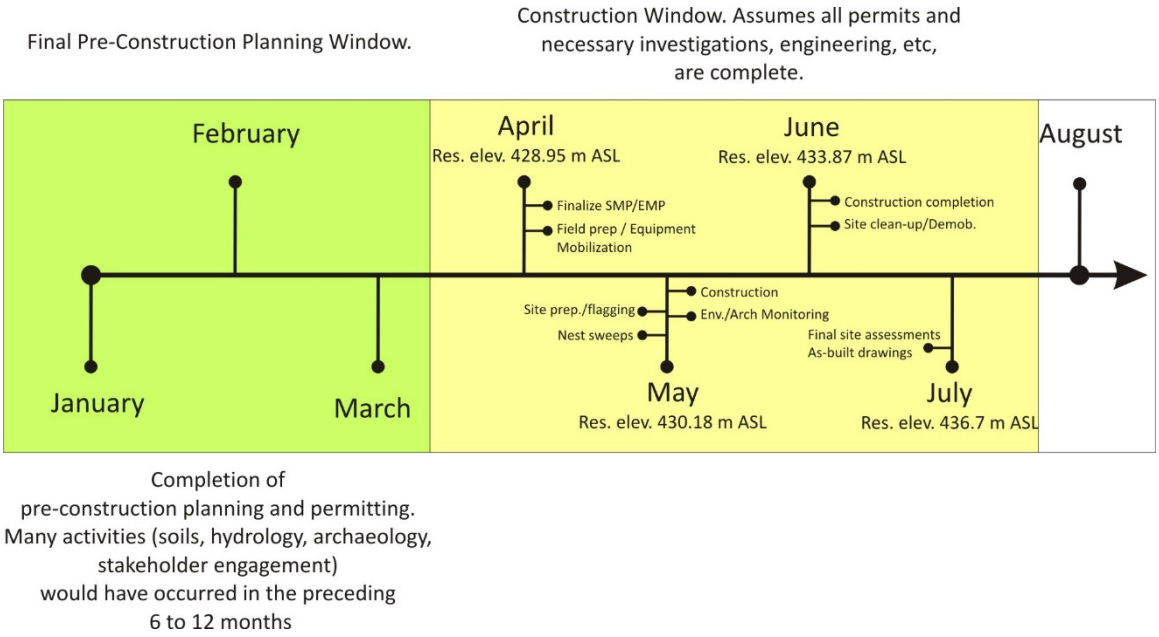

Figure 6-9: **Project planning flowchart illustrating timing (months) for pre-construction and construction windows. Most of the pre-construction work will have occurred in the 6 to 12 months preceding January of the year of construction. Activities post-August will include the development and implementation of a post-construction monitoring program to test the effectiveness of the physical works to enhance wildlife habitat suitability in the drawdown zone of Arrow Lakes Reservoir.** Reservoir elevations are month-end averages over the past nine years and used as a guide only.

6.11.13 Construction Plan

A detailed construction plan will be developed once all approvals and funding are in place. In general, the project should be constructed when the reservoir is low enough that the site is accessible with light and heavy equipment for the duration of construction, which is estimated at approximately five weeks [based on a similar project completed by LGL Limited and Kerr Wood Leidel (KWL) in the drawdown zone of Diversion Reservoir on Vancouver Island (see Hawkes and Fenneman 2010)]. Suitable reservoir elevations typically occur between mid-February and mid-May (Figure 6-5). If construction occurs in April and/or May, some consideration of wildlife, particularly ground-nesting birds and pond-breeding amphibians will be required.

Prior to construction the project will be designed and assembled in a complete tender ready package for public tender. Bids from contractors will be reviewed and analyzed and the project will be awarded to the contractor deemed to provide the best overall value for the project.

The construction plan will consider the following:

- Site access
- Permits and Regulations
- Archaeology
- Safety

- Schedules
- Material (types and sources)
- Costs (including an archaeological assessment, if required)
- Monitoring (environmental)
- Post-construction cleanup

As part of the tender package the contractor will be required to install the appropriate erosion protection works prior to earth works construction. This will include silt fencing and the installation of bypass pumping works.

An environmental management plan (EMP) that addresses site safety and environment concerns will be developed for the proposed physical works. The EMP will also contain information related to environmental monitoring, incident reporting, construction schedules, and mitigation strategies for incidents.

7.0 LOWER INONOAKLIN ROAD WETLAND RETENTION

7.1 Overview

The proposed site is comprised of an existing narrow, linear pond with a soft mud bottom. To the west the wetland is bordered by upland habitat dominated by grasses and weedy species and some woody debris. To the east, a partially vegetated gravel bar protects the wetland from inundation for some of the year. The south end of the site is an area referred to as Porcupine Island because of the recent cottonwood planting that occurred there. Immediately upland of the site is a private residence. Site access is possible via Lower Inonoaklin Road, but visibility (with respect to the public) is limited as the site is not adjacent to a main road and there appears to be limited use of the area by the public at present.

The elevation of the proposed physical works occurs between 434 and 440 m ASL. Over the past nine years, Arrow Lakes Reservoir has exceeded 434 m ASL between April 1 and October 31 for 42 (2015) to 157 days (2008). To reduce the potential for site inundation (and to promote the stability of the wetland habitat), the proposed physical works will include the construction of three dikes (63 m, 128 m, and 171 m long, respectively). Each dike will be built to an elevation of ~438.5 m ASL with spillways at ~438 m ASL. The existing wetland area is approximately 6.2 ha. The proposed physical works project will protect existing wetland habitat from reservoir inundation and make it available for a longer period of time each year (between 40 and 55 days per year, depending on reservoir operations). The construction of the dikes is expected to protect the existing wetland from inundation for ~174 days per year (max: 214 days; min: 112 days based on a review of reservoir elevations recorded over the last nine years) assuming that wildlife will be most likely to use the constructed wetland between April 1 and October 31.

The project will improve wildlife habitat suitability through the increased availability of a currently limited habitat type (shallow wetland habitat) that is affected by reservoir operations. Anticipated benefits will be for wildlife including birds, amphibians, reptiles, mammals (bats), insects (dragonflies) and fish. Species with provincial or federal conservation designation that will benefit from this project include the provincially blue-listed and COSEWIC species of Special Concern Western Toad (*Anaxyrus boreas*), the provincially blue-listed Townsend's Big-eared Bat (*Corynorhinus townsendii*) and Fringed Myotis (*Myotis thysanodes*), and the federally (Species at Risk Act) listed Endangered little brown myotis (*Myotis lucifugus*) (listed December 17, 2014).). The existing wetland at Lower Inonoaklin Road is unlikely to be affected by the proposed physical works; however, if the wetland is recharged via inundation, there is a risk a reduction in water supply could impact the wetland over time. For example, in 2015, maximum reservoir elevations were only 435.48 m ASL and the total wetted area of the wetland at Lower Inonoaklin was visibly reduced in 2016. Although more work is required to properly assess the hydrology of the wetland at this location, it appears that reservoir inundation contributes (at least in part) to the volume of water retained in the wetland.

As depicted in Figure 7-7 (see Section 7.10.3), three minor excavations and construction of three mounds are planned. The excavations may not be necessary if existing materials near the location of the proposed mounds can be used to fill the gaps between high points to an elevation of 438 m ASL. Alternatively, material will be brought to the site to avoid the need for any excavations. The total volume of water retained in the

excavations (should they be necessary) will occur entirely within existing depressions/wetlands that occur in the drawdown zone. There is potential for the excavations to retain between 2,651.8 m^3 and 17,499.7 m^3 of water. However, none of these excavations constitute impoundments as the water is not retained behind a dike. The mounds should be built between existing points of high land with the goal of precluding inundation of the wetland at Lower Inonoaklin until later in the year. The volumes of water retained in each excavation were calculated using the 2010 Digital Elevation model for Lower Inonoaklin Road, a proposed mound elevation of 438 m ASL, and the delineation of the proposed excavations in a GIS. The excavations will occur across an elevation gradient of 433.6 m to 437 m.

7.2 Rationale

Certain areas of the drawdown zone, through a combination of topography, location, and elevation, provide high quality shallow wetland habitat for part of the year prior to reservoir inundation. One of these areas is situated at the base of Lower Inonoaklin Road and is one of the more productive sites in mid- and lower Arrow Lakes Reservoir (based on an assessment of the diversity and abundance of wildlife and vegetation species using the area). Lower Inonoaklin Road has been treated under CLBWORKS-2, Arrow Lakes Revegetation Program and the planting of cottonwood stakes and various sedges at this site has been successful. The proposed project at Lower Inonoaklin Road would protect the existing shallow wetland habitat from reservoir inundation for a greater duration of each year (40 to 55 days per year relative to current conditions) through the construction of several low-lying mounds. The project will increase the suitability of the site for wildlife by extending its temporal availability on an annual basis.

7.3 Site Description

The Lower Inonoaklin Road site is located immediately south of Needles, B.C. on the west side of the Arrow Lakes Reservoir. The proposed physical works location is centered at 11 U 420302 E 5523907 N. The approximate location of the physical works project at Lower Inonoaklin Road is shown in Figure 7-1. The location of Lower Inonoaklin Road relative to Arrow Lakes Reservoir is shown in Figure 3-1.

Figure 7-1: **Existing shallow wetland habitat at Lower Inonoaklin Road, south of Needles, B.C. on the west side of the Arrow Lakes Reservoir.** Photo © Virgil C. Hawkes

The site is generally flat and slopes gently to the west with a west to southwest aspect. The elevation of the Lower Inonoaklin Road site ranges from ~ 434 m ASL to > 440 m ASL. As reservoir elevations increase, the site gets inundated from the south (Figure 7-2).

Figure 7-2: **Overview of Lower Inonoaklin Road on May 7, 2016 (left; res. elev. 432.62 m ASL) and June 5, 2016 (right; res. elev. 436.2 m ASL) showing the advancement of the reservoir and increased vegetation growth.**

7.4 Land Ownership

The area identified for the proposed physical works at Lower Inonoaklin Road is identified as Provincial Crown Land and it lies entirely within BC Hydro's Water License area for Arrow Lakes Reservoir (Figure 7-3).

Figure 7-3 Land ownership on and adjacent to the proposed physical works location at Lower Inonoaklin Road. The proposed project would occur n PID 012-826-014

7.5 Current Site Conditions

7.5.1 Vegetation

Areas situated lower in the drawdown zone at Lower Inonoaklin Road support a diverse assemblage of annual and early seral plant species, which is typical of much of the drawdown zone of the Arrow Lakes Reservoir. Much of the substrate of the site is relatively coarse (e.g., sands, gravels), and the vegetation is reflective of this. Species found commonly throughout these lower elevation habitats include *Carex lenticularis*, *Equisetum arvense*, *Veronica peregrina*, *Collomia linearis*, *Potentilla norvegica, Rorippa palustris, Carex aperta*, *Juncus bufonius*, *J. filiformis*, *Alopecurus aequalis* and *Cerastium*

nutans, while at slightly higher elevations, weedy species such as *Phalaris arundinacea, Crepis tectorum, Elymus repens*, *Trifolium aureum*, *T. arvense*, *Scleranthus annuus* and *Poa compressa* become more abundant. This area is dominated by *Calamagrostis canadensis* and *Phalaris arundinacea* and supports a small assemblage of species that are typical of finer soils and moister conditions (e.g., *Galium palustre*).

Lower Inonoaklin Road was recently treated under CLBWORKS-2 with cottonwood stakes and sedge plugs planted in the higher elevations around the shallow wetland habitat. The preservation of the shallow wetland habitat will not affect the trees or sedges planted under CLBWORKS-2.

Aquatic macrophytes observed at Lower Inonoaklin Road include Stonewort (*Chara sp.)* and Small Pondweed (*Potamogeton pusilus*; Miller and Hawkes 2014).

7.5.2 Wildlife

Wildlife use of the site is extensive, with songbirds, raptors, water birds, amphibians, reptiles, insects, spiders, bats, and ungulates (deer and moose) having been documented. Thirteen species of mammals have been documented at Lower Inonoaklin Road during spring and summer surveys (based on incidental observations made during field work for CLBMON-11B1 (see Hawkes et al. 2011). A single White-tailed Deer was documented in the drawdown zone near Lower Inonoaklin Road in 2011, but no mammals were observed in 2012. In general, use of the drawdown zone at Lower Inonoaklin Road by ungulates and other large mammals is limited, which is likely related to the proximity of the site to human private residences which border the reservoir. In 2011, 77 species of birds, 13 species of mammals (including 11 species of bats[3] including the endangered little brown myotis [*Myotis lucifugus*]), three species of amphibians (including the blue-listed Western Toad [*Anaxyrus boreas*], a COSEWIC species of Special Concern), and three species of reptiles (Western Terrestrial Garter Snake [*Thamnophia elegans*], Common Garter Snake [*Thamnophis sirtalis*], and Northern Alligator Lizard [*Elgaria coerulea*]) were documented. In 2015 a Northern Rubber Boa (*Charina* bottae) was documented at the site and in June 2016, a Western Skink (*Plestiodon skiltonianus*) was observed. Both the latter species observed are listed as species of Special Concern under the Species at Risk Act.

Multiple species of waterfowl and shorebirds have been documented using the wetland at Lower Inonoaklin Road (during surveys associated with CLBMON-11B1). Since 2011, 19 species of grebe, loon, shorebirds, and waterfowl have been observed in the wetland and adjacent shoreline habitats (Table 7-1). It is not known if waterfowl are nesting at the site, but young of the year have been observed and both killdeer and Spotted Sandpiper nests have been documented on the gravel bars surrounding the wetland.

[3] One of the most frequently documented bats at the Lower Inonoaklin Road site is the little brown myotis (*Myotis lucifugus*), which was emergency listed under Species at Risk Act as Endangered (Dec. 17, 2014) due to the potential threat of White Nose Syndrome (a fungus caused by *Geomyces destructans*).

Table 7-1. Species of grebe, loon, shorebirds, and waterfowl documented from the wetland at Lower Inonoaklin Road between 2011 and 2015. These species were documented during songbird point count surveys conducted for CLBMON-11B1.

Group	Common Name	Scientific Name	2011	2013	2015
Grebes	Red-necked Grebe	*Podiceps grisegena*	1		
Loons	Common Loon	*Gavia immer*	2	3	1
Shorebirds, Gulls, Auks and Allies	Killdeer	*Charadrius vociferus*	29	21	10
	Spotted Sandpiper	*Actitis macularius*	13	8	16
	Wilson's Phalarope	*Phalaropus tricolor*		3	
Waterfowl	American Wigeon	*Anas americana*	10	4	2
	Blue-winged Teal	*Anas discors*	11		2
	Bufflehead	*Bucephala albeola*	16	3	
	Canada Goose	*Branta canadensis*	40	26	28
	Common Goldeneye	*Bucephala clangula*		2	
	Common Merganser	*Mergus merganser*			2
	Gadwall	*Anas strepera*		2	
	Green-winged Teal	*Anas crecca*	2		
	Hooded Merganser	*Lophodytes cucullatus*		1	
	Lesser Scaup	*Aythya affinis*		1	
	Mallard	*Anas platyrhynchos*	11	24	11
	Northern Shoveler	*Anas clypeata*	3	1	
	Redhead	*Aythya americana*		1	
	Ring-necked Duck	*Aythya collaris*		1	
		Total Species (per year)	**11**	**15**	**8**

7.5.3 Soil/Geology

Soils of the Arrow Lakes Reservoir are variable and range in nutrient content and physical characteristics from extremely nutrient- and moisture-poor silt remnants occurring between boulders, to moist sandy-silty soils of the undulating alluvial fans, to rich upland loam soils that are residual from pre-development of the reservoir. Soils are nutrient poor except at high elevation (Gibeau and Enns 2008). Gibeau and Enns (2008) provide a general description of the soils of Arrow Lakes Reservoir but not specifically for Lower Inonoaklin Road. It is recommended that a detailed analysis of the soils at this site be conducted prior to implementing the proposed physical works.

Keefer et al (2009) revegetated a portion of Lower Inonoaklin Road in 2009 and noted that the soils in the cottonwood treatment area were comprised of large cobbles. There are no site-specific data for the habitat immediately adjacent to the shallow wetland habitat, but the substrate in the existing wetland could be described as silt/clay mud with some sand.

7.5.4 Hydrology

The main hydrological feature at the Lower Inonoaklin Road site is a large shallow wetland habitat that is situated at ~437 m ASL. A small drainage ditch is situated alongside the Lower Inonoaklin Road and water flow through this ditch appears to be intermittent, although there may be subsurface flow during the spring. There may also be a spring in the area and a more detailed hydrological assessment is required.

7.6 Goals and Objectives

The primary goal of this proposed physical works is to preserve ~6.2 ha of existing shallow wetland habitat in the drawdown zone of Arrow Lakes Reservoir by constructing three dikes of varying length (63 m, 128 m, and 171 m) to an elevation of ~438.5 m ASL. This will create shallow wetland habitat that is available to wildlife for a minimum of ~174 days per year (max: 214 days; min: 140 days based on a review of reservoir elevations recorded over the last nine years) assuming that wildlife will be most likely to use the constructed wetland between April 1 and October 31. A secondary goal is to meet the direction provided under the Water Use Plan to identify enhancement opportunities in the mid- and lower Arrow Lakes Reservoir under CLBWORKS-29B.

Preserving shallow wetland habitat in the drawdown zone will improve the ecology of the drawdown zone by improving habitat suitability for wildlife and vegetation. The specific objectives of the proposed wildlife physical works are to:

1. Increase the temporal availability of shallow wetland habitat for wildlife in the drawdown zone of Arrow Lakes Reservoir. The construction of mounds will enable the shallow wetland habitat to persist longer into the summer, which will improve habitat suitability for pond-breeding amphibians, bats, reptiles, certain species of birds, semi-aquatic mammals, and some terrestrial mammals;
2. Improve habitat complexity in the drawdown zone of Arrow Lakes Reservoir; and
3. Vegetate the constructed dikes with native sedges (not shrubs and/or trees because they could affect the integrity of the dikes).

7.7 Target Site Conditions

The existing site conditions associated with the shallow wetland habitat at Lower Inonoaklin Road provide high-suitability wildlife habitat, particularly for waterfowl, shorebirds, and pond-breeding amphibians. Increasing the duration of availability of this habitat on an annual basis will further enhance the suitability of the site for wildlife. The proposed physical works will have little effect on the current site conditions (which is the desired effect) and we do not anticipate increases in the cover of native plants (with the exception of planting the dikes) nor do we foresee the introduction of non-native aquatic macrophytes into the shallow wetland habitat. The resulting habitat would appear very much like it does on an annual basis between April and October in Figure 7-1. Additional hydrological work is required to determine whether the hydrology of the site will be altered by increasing the height of the mounds around the wetland.

7.8 Seasonality of Expected Improvements

Seasonality of expected improvements was considered for the period April 1 to October 31 as this is the time of year when wildlife are active and the areas is likely to be snow and ice-free. The typical hydrograph of Arrow Lakes Reservoir includes rapid filling in the spring with high-water achieved between June and August followed by a decline in late August or early September (Figure 7-4). The proposed physical works at Lower Inonoaklin Road are intended to retain existing habitat features at the site and prolong the timing on inundation of the existing wetland. With a dike height of 438 m ASL,

inundation will commence in mid- to late June and the wetland could be inundated until mid-July or as late as early September depending on reservoir operations.

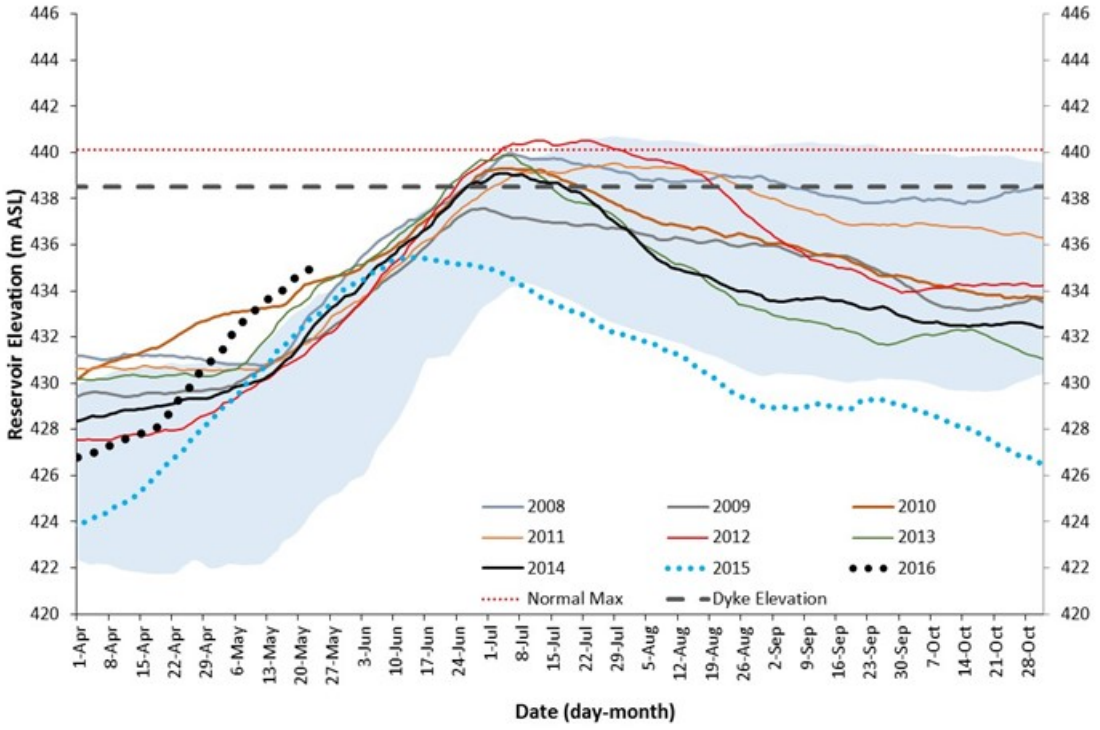

Figure 7-4: **Annual hydrographs for Arrow Lakes Reservoir for the period April 1 to Oct 31 and years 2008 through 2015 (through May 21, 2016).** The dashed horizontal line represents the top elevation of the proposed dikes (438 m ASL).

7.8.1 Anticipated effects of physical works on Wildlife

7.8.1.1 Amphibians

Reservoir operations in Arrow Lakes Reservoir do not appear to negatively affect amphibians. For example, Western Toad and Columbia Spotted Frog typically lay eggs in late April or Early May. Eggs hatch in 3 to 12 days and free swimming tadpoles develop rapidly allowing them to move within ponds, even when inundated. Recent observations of Western Toad tadpoles and metamorphs at Lower Inonoaklin Road in early June 2016 (when reservoir elevations were 435 to 436 m ASL and inundating the wetland at Lower Inonoaklin Road) suggest that inundation does not affect the development of tadpoles. Because of their mobility and the timing of breeding and development and the limited impact to existing wetland habitat at Lower Inonoaklin Road, it is unlikely that habitat enhancement/creation at the Lower Inonoaklin Road site will negatively affect pond-breeding amphibians. It is more likely that the suitability of the wetland will remain unchanged for amphibians or suitability could be somewhat improved because of the longer period of availability and increased stability of wetland habitat, an assumption that will require testing following the implementation of the proposed works.

7.8.1.2 Birds

Certain species of bird are known to nest in the drawdown zone of Arrow lakes Reservoir including Killdeer (*Charadrius vociferus*) and several species of sparrow (e.g., Savannah Sparrow, *Passerculus sandwichensis*). Very few data are available for bird nests in the drawdown zone at Lower Inonoaklin Road. However, data collected in 2015 indicate that five species of birds (Spotted Sandpiper, Red-eyed Vireo, Chipping Sparrow, American Robin, and Willow Flycatcher) were nesting and adjacent to the wetland in existing vegetation or the revegetated area. Of these, Spotted Sandpiper, and American Robin nested at elevations <440 m ASL (Spotted Sandpiper @ 436 m to 436.5 m ASL; American Robin @ 436 m ASL; Figure 7-5).

A Killdeer nest was observed at near the proposed physical works site at Lower Inonoaklin Road in May 2016 in the area revegetated under CLBWORKS 2 (in the southeast portion of Figure 7-5; M. Sadler, S. Pinkus, BC Hydro, pers. obs.). The elevation of the proposed physical works at Lower Inonoaklin Road overlaps with the median elevation of Savannah Sparrow and Killdeer nests reported for Revelstoke Reach (see Section 6.8.1.2). Depending on reservoir elevations and the location of nests, some nest mortality associated with reservoir operations may occur. However, if nests are within the confines of the existing wetland following the implementation of the physical works, the probability of nest mortality resulting from reservoir elevations is greatly reduced. Additional data collected for CLBMON-11B1 in 2016 should be reviewed to determine whether birds continue to nest in and adjacent to the proposed physical works locations.

Figure 7-5: Distribution of bird nests in and adjacent to the drawdown zone at Lower Inonoaklin Road (2015). Only contours ≤ 440 m ASL are shown. REVI = Red-eyed Vireo; WIFL = Willow Flycatcher; AMRO = American Robin, SPSA = Spotted Sandpiper; CHSP = Chipping Sparrow.

The implementation of physical works may benefit waterfowl by contributing the more stable habitat that is available longer. At a minimum, the use of the wetland and adjacent habitats by shorebirds and waterfowl will not change as the physical works are intended to increase the availability of the wetland to wildlife, including shorebirds and waterfowl.

7.8.1.3 Mammals

Mammals observed at the Lower Inonoaklin Road site include ungulates (deer), small mammals (e.g., Meadow Vole), and several species of bat [based on analysis of data collected by Autonomous Recording Units]. Of the mammal species present at Lower Inonoaklin Road, bats are the most likely to benefit from the increased temporal availability of wetland habitat. Our current understanding of the use of Lower Inonoaklin by bats indicates that as many as eleven species of bat could be using the site between June and September. Relative to both Edgewood South and Burton Creek, bat activity (based on the number of recordings per hour) at Lower Inonoaklin was greater than Edgewood but less than Burton Creek. The same number of species were documented at Edgewood with nine reported for Burton Creek. The maintenance of wetland habitat at Lower Inonoaklin Road will improve the overall suitability of the site for bats for the majority of the active season (e.g., April 1 to October 31), particularly as it relates to foraging opportunities. Data collection on the use of the proposed physical works site by bats is ongoing (as part of CLBMON-11B4) with data collection proposed for the period May through September 2016. Two Autonomous Recording Units are currently deployed – one at the north end of the site and one at the south end. Data from the Autonomous Recording Units will be collected in September and analysed during fall 2016.

7.9 Performance Measures

The effectiveness of the proposed physical works at Lower Inonoaklin Road should be assessed using an index of habitat function that is based on post-construction monitoring data to describe the use of the wetland by waterfowl, shorebirds, songbirds, amphibians, and bats and on the species composition and cover of aquatic macrophytes. Macroinvertebrate species composition should also be considered in the development of an index that describes wetland productivity and function. Some of these data could be compared to pre-construction data (e.g., bats, macrophytes, amphibians and reptiles), while other data (e.g., hydroperiod, water depth) will be based solely on post-construction data (unless this information is collected prior to project implementation).

The following performance measures are suggested to guide the collection of data with which to assess the success of the proposed wildlife physical works project at Lower Inonoaklin Road:

2. Spatio-temporal availability
    a. Maintenance of current spatial extent of the wetland at Lower Inonoaklin Road.

b. Maintenance of the temporal availability of wetland that overlaps with the migratory bird (particularly wetland-associated species) and amphibian breeding seasons (May-August). The permanence of the wetland should be assessed (i.e., is the wetland available each year and for how long?)

c. Hyrdoperiod and depth of wetland does not change more that 25% from pre-construction condition (there is likely to be natural annual variation related to precipitation and reservoir elevations).

3. Wetland productivity:

a. Maintenance of native macrophytes. Additional data are required to ensure the current species list in Miller and Hawkes (2014) is complete.

b. Continued use of the wetland by breeding by amphibians (specifically Western Toad). The number of egg strings or masses should be counted on an annual basis following the implementation of the physical works.

c. Continued use of the wetland by waterfowl and shorebirds and no reduction in species composition (assuming some level of inter-annual variation as suggested by Table 7-1).

d. Evidence of use of habitat enhancements (e.g., nest boxes, floating islands) by target waterfowl species (which will need to be determined) following completion of construction.

e. Continued use of the wetland by bats (as determined by autonomous recording units) and use of any enhancements such as bat boxes, snags, or other enhancements) by bats.

f. No reduction in the species composition of bats at Lower Inonoaklin Road, which currently includes up to 11 species (Table 7-2).

Table 7-2. Bat species documented[1] using bat detectors at the Lower Inonoaklin Road area in 2015. The bat detectors were situated near the area proposed for physical works. The species in this table should be considered a good representation of the use of the Lower Inonoaklin Road area by bats, but see footnote.

Scientific Name	Common Name	BC CDC	COSEWIC	SARA
Corynorhinus townsendii	Townsend's Big-eared Bat	Blue	--	--
Eptesicus fuscus	Big Brown Bat	Yellow	--	--
Lasiurus cinereus	Hoary Bat	Yellow	--	--
Lasionycteris noctivagans	Silver-haired Bat	Yellow	--	--
Myotis californicus	California Myotis	Yellow	--	--
Myotis ciliolabrum	Western small-footed Myotis	Blue	--	--
Myotis evotis	Long-eared Myotis	Yellow	--	--
Myotis lucifugus	Little Brown Bat	Yellow	Endangered	1-E (2014)
Myotis thysanodes	Fringed Myotis	Blue	Data Deficient	3 (2005)
Myotis volans	Long-legged Myotis	Yellow	--	--
Myotis yumanensi	Yuma Myotis	Yellow	--	--

[1]bat species presence is based on a probability of presence via the analysis of acoustic signature recordings. Because of the difficulty associated with assigning species identification based solely on the use of acoustic signatures, this

species list may not be accurate (e.g., Myotis species are often grouped due to the overlap in the frequency of their acoustic signatures).

4. No measureable change in wetland productivity. Wetland productivity will need to be determined prior to the implementation of the proposed physical works and will be require calculating productivity using dissolved oxygen, conductivity, temperature and local meteorological data. No measureable change means that there will be no measureable decrease in either primary productivity within five years of the implementation of the physical works that can be directly attributed to the physical works. A measureable change will be assumed to be a change of 25 per cent or greater.
5. No measurable increases greater than 25 per cent from baseline conditions in cover and diversity (species richness and evenness) of key undesirable macrophyte species over 10 years. Key undesirable species include Eurasian Water-milfoil (*Myriophyllum spicatum*) and Reed Canarygrass (*Phalaris arundinacea*).
6. Little to no erosion of the mounds as determined by immediate post-construction monitoring and subsequent integrity checks by a qualified engineer.

7.10 Description of Work

7.10.1 Approach

The proposed physical works will protect ~6.2 ha existing wetland habitat from reservoir inundation for a greater proportion of each year relative to current conditions. This will be achieved by constructing three dikes 63 m, 128 m, and 171 m long, respectively and ~1 to 1.5 m in height in low-lying areas adjacent to the existing wetland. To create this habitat at the lowest cost, local materials will be used to the extent possible.

7.10.2 Construction Methods

The method of construction will generally consist of excavation using hydraulic excavators and transport of the materials using dump trucks. This material will then be dumped in lifts and compacted to a suitable density. Following compaction a hydraulic excavator will form the final shape of the features and place the erosion protection or other material on the mounds. The final step in construction will involve planting, which will be performed primarily by individuals using shovels.

Most of the project will be constructed using materials imported to the site. Ideally this material would be located in a nearby borrow pit. It is expected that the following materials will be brought to the site:

- Fine materials for the base of each mound;
- Plants and seeds for vegetating the site;
- Rock for providing erosion protection on the reservoir side of the mound and spillways; and
- Fine-grained soils may be required to improve the soil retention capabilities of the ponds/wetlands.

The construction will be inspected periodically by a representative of the engineer. This inspection will be to confirm that the works are constructed in accordance with the design.

Riprap materials will be hard, durable, angular quarry rock of a quality that will not disintegrate upon exposure to water or the atmosphere. Riprap will be 300 mm diameter minus (subject to current and wave erosion analysis). The fill and pond-bottom material would ideally be a pit run gravel containing a minimum of 10 per cent fine material (fine material have particle sizes less than 0.075 mm). Slightly more permeable material may also be acceptable depending on local site conditions.

Mounds will be constructed of fine materials that will either be retrieved from the site or transported to the site from a nearby borrow pit. Numerous layers of this material will be laid down to construct the mounds, with each layer being thoroughly compacted by a compactor; repeated driving over the material by rock trucks and excavators will further contribute to its compaction. Once the dikes are built, the outer face will be armoured with coarse rip-rap and the inner face will be coated with a layer of organic material that will act as a substrate for the establishment of vegetation.

The mound at the lower elevation (south end of the wetland) should be equipped with an armoured spillway that will allow water to move in a downhill direction towards the reservoir. The spillways will be situated 30 to 40 cm lower than the top elevation of the dikes. The final engineering specifications will dictate whether this is required.

Structural loads on the proposed dike structure will consist primarily of maintenance equipment loads, hydrostatic forces, and wave and erosive forces. To resist these loads the mounds will be constructed of well-graded material. This material will be compacted to a suitable level to minimize future settlement and seepage through the dikes. Additionally, to distribute vehicle loads, reduce seepage, and prevent erosion the dikes will be constructed at relatively gentle side slopes of 6 (horizontal) to 1 (vertical) or flatter. To resist erosive wave forces the reservoir side of the dikes may need to be faced with riprap rock armouring.

Environmental loads on the proposed physical works will depend on annual fluctuations in weather conditions and the reservoir operating regime. The impact of wave wash will be the primary environmental force acting on the dike. Once reservoir levels exceed the height of the dikes, wave erosion should decrease, but as reservoir levels recede, wave wash will again impact the dikes until water levels are below the base of the dikes. Compaction of the materials used in the mounds and armouring the mounds with riprap will reduce the erosive force of waves.

This project design will take into consideration the following criteria:

- The seepage rates of the material used to construct the dikes and the soils that will form the bottom of the pond will be checked to determine if the feature will adequately retain water;
- The dikes and pond features (including plantings) will be designed so that the removal of sediment will be possible with conventional excavation equipment. This will include providing adequate running surface widths on the top of the dikes;

- The compaction of the dike fill materials will be specified so that detrimental settlement will not occur;
- Erosion protection will be provided to prevent erosion as a result of current and wave forces; and
- The spillways through the dikes will be designed for the 100-year return period storms event flow without overtopping the dikes in other locations.

7.10.3 Construction Schematics

The proposed physical works project for Lower Inonoaklin Road is illustrated in Figure 7-7 and a cross-section of the proposed dikes is provided in Figure 7-7. The distance between dikes (~130 m and 69 m) and the installation of spillways will ensure that the velocity of water flowing into the wetlands will not impact the existing conditions of the wetland (i.e., the creation of a dendritic channel is not anticipated).

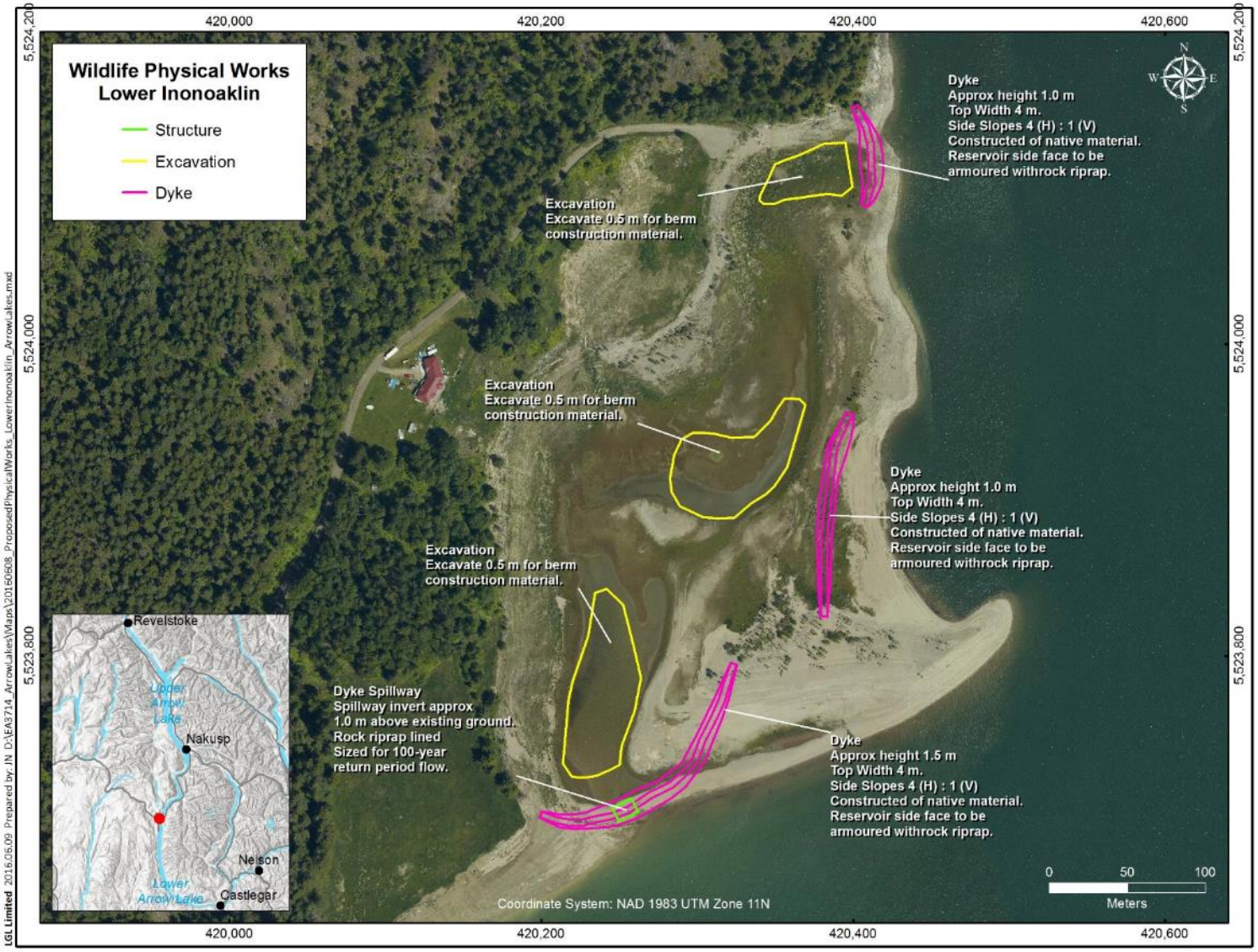

Figure 7-6: **Schematic of proposed physical works project in the drawdown zone of Arrow Lakes Reservoir at Lower Inonoaklin Road.** The location of each dike and excavation areas is approximate

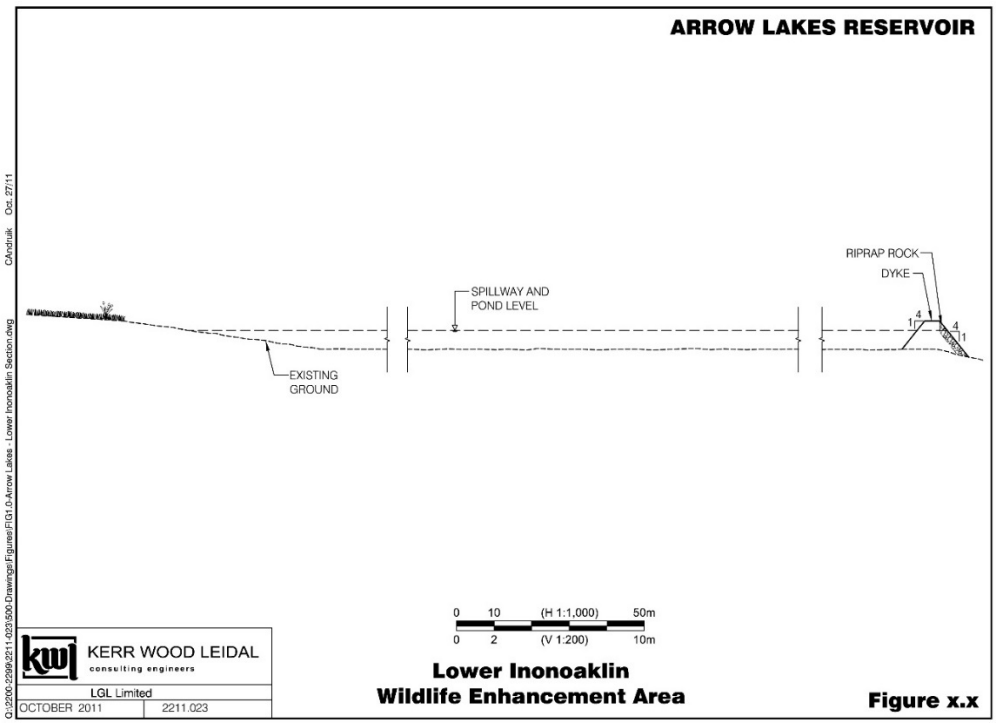

Figure 7-7: Cross-section of the proposed physical works project in the drawdown zone of Arrow Lakes Reservoir at Lower Inonoaklin Road

7.10.4 Construction Schedule

The proposed schedule for the Lower Inonoaklin Road wildlife physical works depends on when funds are made available to do the work. A generic schedule is provided as a guide and will be adjusted as needed. Activities and timeframes associated with an Archaeological Impact Assessment and acquisition of permits has not been factored into the generic schedule. The generic schedule is based on having completed pre-work activities and having obtained necessary permits and approvals.

Quarter 1: January to March. Contract development and tendering.

Quarter 2: April to June. Mobilization, construction, environmental monitoring, demobilization. Some revegetation with sedges and aquatic macrophytes could occur.

Quarter 3: July to September. Revegetation. Immediate post-construction monitoring.

Quarter 4: October to December. Revegetation (live staking) if required. Reporting and development of a long-term monitoring program that is either developed specifically for the wildlife physical works sites or that builds on programs currently being implemented in the drawdown of Arrow Lakes Reservoir (e.g., CLBMON-11B1, CLBMON-11B4, CLBMON-37).

7.10.5 Cost Estimate

A Class C site estimate has been prepared for the Lower Inonoaklin Road shallow wetland habitat preservation project and was estimated using information from a

comparable-sized project. A Class C budget is an estimate prepared with limited site information and is based on probable conditions affecting the project. It represents the summation of all identifiable project component costs. It is used for program planning, establishing a more specific definition of needs, and obtaining approval in principle. The estimate has been derived from unit costs for similar projects. Actual project costs may be higher or lower and will vary depending on numerous factors including material availability, contractor competition, and site conditions during the construction period. The Class C cost estimate for the Lower Inonoaklin Road project is provided in Table 7-3.

There are project-related activities that have not been included in the costs estimate including an Archaeological Impact Assessment, acquisition of permits and approvals, final engineering design, First Nation and stakeholder engagement, and post-construction inspects etc. The costs below were developed to demonstrate the costs associated with constructing the physical works only. A more detailed cost estimate and timeline should be prepared for this project if it proceeds.

Table 7-3: Class C cost estimate for the proposed physical works project in the drawdown zone of Arrow Lakes Reservoir at Lower Inonoaklin Road. L.S.: lump sum; c.m.: cubic metre; l.m.: linear metre; s.m.: square metre

Item	Description	Unit	Estimated Quantity	Unit Rate ($)	Total Estimate	Comment
1	**General**					
1.01	Mobilization and Demobilization	L.S.	1	12,000	$ 12,000.00	
1.02	Bonding and Insurance (1.5% of Other Tasks)	L.S.	1	3,445.50	$ 3,445.50	
1.03	Diversion, Erosion and Sediment Control	L.S.	1	10,000	$ 10,000.00	
1.04	Survey Layout of Works	L.S.	1	2,000	$ 2,000.00	
	SUBTOTAL FOR TASK				**$ 27,445.50**	
			Units	**Cost / Unit ($)**	**Estimate**	
2	**Earthworks**					
2.01	Subgrade Preparation	c.m.	4,100	2.0	$ 8,200.00	*Assume 20 min round trip + $5/m^3*
2.02	Import Fill Material	c.m.	4,700	25.0	$117,500.00	
	SUBTOTAL FOR TASK				**$ 125,700.00**	
3	**Drainage Works and Structures**					
3.01	Riprap Armouring	c.m.	960	100	$ 96,000.00	
3.02	Planting	L.S.	1	8,000.0	$ 8,000.00	
	SUBTOTAL FOR TASK				**$ 104,000.00**	
	SUBTOTALS - All Tasks				**$ 257,145.50**	
	Environmental Monitoring				$ 18,000.00	
	Engineering & Construction Management	10%			$ 25,714.55	
	Contingencies	20%			$ 51,429.10	
	Total Estimate (excl. tax) +50%/-15%				**$ 352,289.15**	

7.11 Considerations

7.11.1 Reservoir Operating Regime

Reservoir operations are predictable yet variable. Assessing the hydrograph of the reservoir for the years 2008 to 2016 (partial; Figure 7-4) provides an indication of the potential construction window, which could extend from April 1 to 10 June or June 24. Based on the project planning provided in Section 7.13, this should provide enough time to plan and execute the work. There are years (e.g., 2015) when the construction could have occurred at any time between April 1 and Oct 31 due to low reservoir levels. The project reservoir elevations for Arrow Lakes should be reviewed prior to construction to determine the best window in which to operate.

7.11.2 Public Safety

Appropriate signage will be erected prior to and during construction. Given that the area identified for the proposed physical works is not commonly used by people, there is little to no risk associated with public safety. An environmental monitor will be on site during construction and will ensure that the public remains a safe distance from the site during construction activities. The construction of the dikes should not pose a risk to the public.

7.11.3 Wildlife

The proposed project will ultimately benefit wildlife because wildlife habitat retention/preservation is the main consideration of this project. The proposed project area was evaluated for nesting birds in 2015 (Figure 7-5). Additional work is occurring in 2016 and the results of those surveys should be reviewed prior to establishing the construction window. Data on the use of the site by bats was collected in 2015 with additional data collection occurring in 2016. The occurrence of shorebirds and waterfowl has been documented during songbird point count surveys for CLBMON-11B1. Neither bats, shorebirds, nor waterfowl should be negatively affected by the proposed physical works and ultimately all will benefit from the increased availability and stability of shallow wetland habitat in the drawdown zone. To ensure birds are not impacted during construction nest searching should occur prior to work starting at the site.

7.11.4 Fisheries

At present the site does not provide fisheries values for most of the year. During periods of the year when the site is inundated, there may be some value to fish. The proposed project should reduce the amount of time that fish are able to access the site, which is not considered to be a detriment to fish.

7.11.5 Archaeology

The proposed project will not likely include ground-disturbing activities. However, because of the level terrain and proximity of the site to other known archaeological sites, an Archaeological Impact Assessment will be required at this site prior to the implementation of the proposed physical works.

7.11.6 Recreation

The Lower Inonoaklin Road area receives limited recreational use. The proposed physical works may temporarily affect that use. There are no recreational concerns post construction.

7.11.7 Summary of Agency, First Nations, and Stakeholder Consultation

In fall 2010 a meeting with BC Hydro, the Ministry of Environment, and the Fish & Wildlife Compensation Program–Columbia Region was held in Nelson B.C. to disuses the proposed wildlife physical works and to prioritize the projects. Additional consultation with agencies, First Nations, and local stakeholders will be required prior to the implementation of the proposed physical works.

There is private property near the proposed project area, but the proposed physical works will not affect the property.

7.11.8 Codes and Standards

The Lower Inonoaklin Road shallow wetland habitat preservation project will be constructed in accordance with the following codes and standards:

- Good engineering practice;
- Engineering components will be designed by professional engineers and/or professional geoscientists registered with the Association of Professional Engineers and Geoscientists of BC; and
- Growing soil medium and plant specifications will be designed by professional ecologists registered with the Association of Professional Biology of BC.

7.11.9 Maintenance

The expected maintenance for this project will include the following:

- Removal of invasive vegetation; and
- Inspection of constructed features for signs of instability and erosion.

The frequency of this maintenance will be determined based on monitoring of the field conditions. We estimate that this maintenance will initially occur on an annual basis but will occur less frequently as the site stabilizes.

7.11.10 Monitoring Requirements

7.11.10.1 During construction

In addition to the inspection described in Section 7.11.9, monitoring during construction will consist of environmental monitoring and archaeological monitoring. The purpose of this monitoring will be to ensure that the appropriate environmental protection measures including flow diversions and sediment control are in place. Additionally, prior to construction fish and wildlife within the construction zone will be relocated. Removal and relocation of fish and wildlife will be done according to the stipulations of a wildlife sundry permit.

7.11.10.2 Post construction

Post-construction monitoring will involve monitoring the integrity of the physical works and the effectiveness of the physical works in meeting the ecological objectives of the project. An annual site inspection will be conducted to document the following:

- Dike integrity;
- Sedimentation rates; and
- Erosion and slope stability.

Effectiveness monitoring will occur as part of CLBMON-11B1/CLBWORKS-29B using methods developed for CLBMON-11B4 and will include the monitoring of pond-breeding amphibians, bats, riparian and terrestrial vegetation, and aquatic macrophytes (see Hawkes et al. 2010 for the monitoring protocol).

7.12 Permitting and regulatory Requirements

Numerous laws and rules govern water use, protection, conservation and sustainability in British Columbia. Currently, the Ministry of Environment, the Ministry of Forests, Lands, and Natural Resources Operations, the Ministry of Health, and pother provincial agencies manage and protect water in BC.

The *Water Sustainability Act* (WSA) was brought into force on February 29, 2016 to ensure a sustainable supply of fresh, clean water that meets the needs of B.C. residents today and in the future.

The *Water Protection Act* (WPA) protects B.C.'s water by reconfirming the Province's ownership of surface and groundwater, clearly defining limits for bulk water removal, and prohibiting the large-scale diversion of water between major provincial watersheds and/or to locations outside of the province.

The *Environmental Management Act* (EMA) regulates industrial and municipal waste discharge, pollution, hazardous waste and contaminated site remediation. EMA provides the authority for introducing wastes into the environment, while protecting public health and the environment. The Act enables the use of permits, regulations and codes of practice to authorize discharges to the environment and enforcement options, such as administrative penalties, orders and fines to encourage compliance. Guidelines and objectives for water quality are developed under EMA.

Other relevant provincial legislation includes:

The *Dike Maintenance Act*; and

Dam Safety Regulation of the *Water Sustainability Act.*

Based on an assessment of the current Dam Safety regulations, the proposed physical works at Lower Inonoaklin Road does not prescribe the retention of water in addition to what occurs there naturally. As such, this project should be exempt from the Dam Safety Regulation. Similarly if the project includes the establishment of a minor dam that is less than 7.5 m in height and impounds less than 10,000 $m^3$and as such, it will likely be exempt from regulation. Lastly, if excavations are required and the total volume of water retained behind the low-level mounds exceeds 10,000 m^3, an application under the Water Sustainability Act may be required. Refer to Dam Safety Regulation 40/2016,

Part 1, Section 2. The Comptroller of Water Rights could determine that the structure is not exempt from regulation. In this case, the dikes proposed for construction are not designed to impound water. They are designed to prevent water from inundating the wetland at Lower Inonoaklin Road until they are over-topped by the reservoir (if elevations exceed 438 m ASL). If excavations occur at the site, the total volume of impounded water will need to be recalculated based on the final design of the proposed physical works at Lower Inonoaklin Road. Any required post-construction dike maintenance will also need to be detailed in the final site plans

Conservation Water Licence

The current water licence for Arrow Lakes allows BC Hydro to store water for purposes related to power production. The proposed physical works is not intended to retain water in addition to what occurs there naturally. However, if additional water is stored, it will be used for an alternate purpose from that currently covered by the water licence. Because the physical works may retain water for a conservation purpose, a Conservation Water Licence may be required.

Other regulatory requirements to consider include the Navigation Protection Act (it is likely that the proposed project would be defined as a minor works and be exempted from the Navigation Protection Act) and the Wildlife Act (a wildlife sundry permit is required to capture, handle, or salvage wildlife including amphibians and fish). See Appendix A for a summary of applicable acts and regulations.

7.13 Project Planning

A project planning flowchart is provided in Figure 7-8 that illustrates the need to complete the project before late June, when the elevation of Arrow Lakes Reservoir is generally at its highest level of the year (Figure 7-4). The exact timing of the steps in Figure 7-8 will likely be modified based on the timing of project approval, but for the purposes of the illustration, timing is associated with the beginning of the fiscal year (i.e., April 1) and considers the average elevation of the reservoir over the last five years (2007 through 2015).

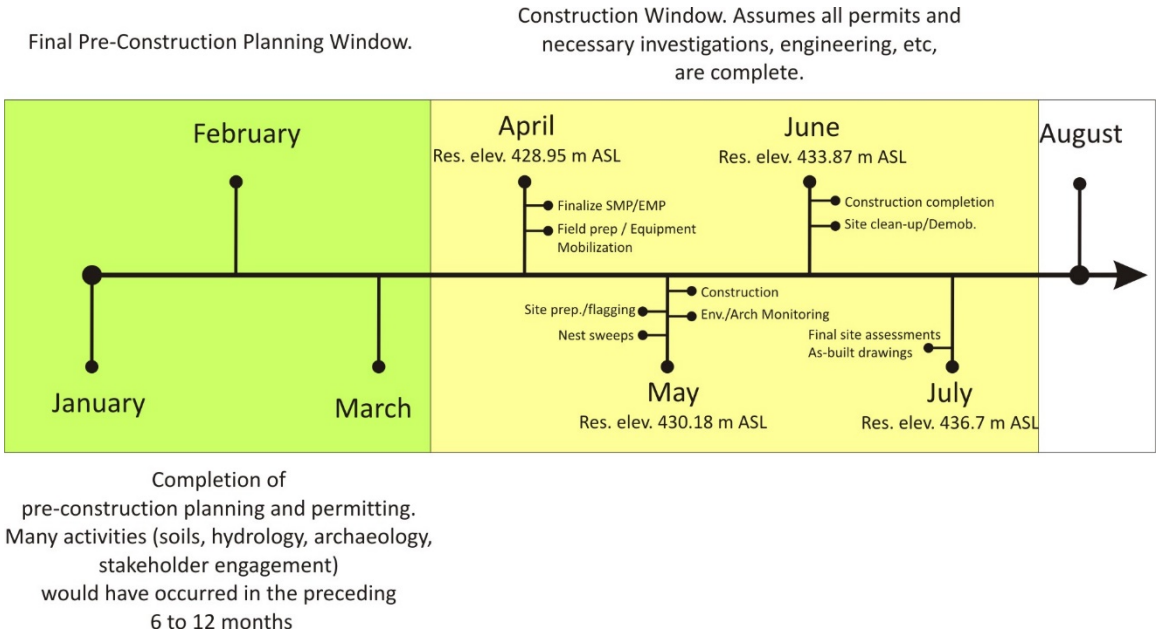

Figure 7-8: **Project planning flowchart illustrating timing (months) for pre-construction and construction windows. Most of the pre-construction work will have occurred in the 6 to 12 months preceding January of the year of construction. Activities post-August will include the development and implementation of a post-construction monitoring program to test the effectiveness of the physical works to enhance wildlife habitat suitability in the drawdown zone of Arrow Lakes Reservoir.** Reservoir elevations are month-end averages over the past nine years and used as a guide only.

7.14 Construction Plan

A detailed construction plan will be developed once all approvals and funding are in place. In general, the project should be constructed when the reservoir is low enough that the site is accessible with light and heavy equipment for the duration of construction, which is estimated at approximately five weeks (based on a similar project completed by LGL Limited and KWL in the drawdown zone of Diversion Reservoir on Vancouver Island (see Hawkes and Fenneman 2010). Suitable reservoir elevations typically occur between mid-February and mid-May (Figure 7-4). If construction occurs in April and/or May, some consideration of wildlife, particularly ground-nesting birds and pond-breeding amphibians will be required.

Prior to construction the project will be designed and assembled in a complete tender-ready package for public tender. Bids from contractors will be reviewed and analyzed and the project will be awarded to the contractor deemed to provide the best overall value for the project.

The construction plan will consider the following:

- Site access
- Permits and Regulations
- Archaeology
- Safety

- Schedules
- Material (types and sources)
- Costs (including an archaeological assessment, if required)
- Monitoring (environmental)
- Post-construction clean-up

As part of the tender package the contractor will be required to install the appropriate erosion protection works prior to earth works construction. This will include silt fencing and the installation of bypass pumping works.

An environmental management plan (EMP) that addresses site safety and environment concerns will be developed for the proposed physical works. The EMP will also contain information related to environmental monitoring, incident reporting, construction schedules, and mitigation strategies for incidents.

8.0 EDGEWOOD SOUTH WETLAND ENHANCEMENT

8.1 Overview

This proposed project would enhance/create ~1.3 ha of shallow wetland habitat. The existing wetland would be enlarged through the construction of a dike ~115 m long and built to an elevation of ~439.2 m ASL adjacent to Eagle Creek. Excluding periods of reservoir inundation, the water depths in the shallow wetland habitat will not vary from those currently observed at the site, which range from 0 to ~1.0 m.

The elevation of the proposed physical works occurs between 436.5 and 439 m ASL. Over the past nine years, Arrow Lakes Reservoir has exceeded 436.5 m ASL between April 1 and October 31 for 0 (2015) to 145 days (2008) (average 69.7 days). To reduce the potential for site inundation (and to promote the stability of the wetland habitat), the physical works were designed to expand the total area of the existing wetland and protect it from inundation protect the existing wetland from inundation for ~200 days per year (max: 214 days; min: 165 days based on a review of reservoir elevations recorded over the last nine years) assuming that wildlife will be most likely to use the constructed wetland between April 1 and October 31. This represents an increase of between 0 and 96 days per year depending on reservoir operations.

The project will improve wildlife habitat suitability through the creation of a currently limited habitat type (shallow wetland habitat) that is affected by reservoir operations. Anticipated benefits will be for wildlife including birds, amphibians, reptiles, mammals (bats), insects (dragonflies) and fish. Species with provincial or federal conservation designation that will benefit from this project include the provincially blue-listed and COSEWIC species of Special Concern, Western Toad (*Anaxyrus boreas*), the provincially blue-listed Townsend's Big-eared Bat (*Corynorhinus townsendii*) and Fringed Myotis (*Myotis thysanodes*), and the SARA-listed Endangered species Little Brown Myotis (*Myotis lucifugus*). The proposed physical works at Edgewood South is not without risk – the function of the existing wetland could be negatively affected, reducing the overall benefit of this project for wildlife. Of the three projects described, the proposed works at Edgewood South are associated with the highest overall ecological risk of existing habitat.

As depicted in Figure 8-9 (see Section 8.10.3), one excavation is planned as is the construction of a single dike to an elevation of 439.2 m ASL. The total volume of water retained in the excavation is estimated at 2,235.6 m^3 of water. The volume of water retained in in the excavation was calculated using the 2010 Digital Elevation model for Edgewood, a proposed dike height of 439.2 m ASL, and the delineation of the proposed excavation in a GIS. The excavations will occur across an elevation gradient of 437.4 m to 439.5 m

8.2 Rationale

There are certain areas of the drawdown zone, that through a combination of topography, location, and elevation, provide shallow wetland habitat for part of the year prior to reservoir inundation. One of these areas is situated immediately adjacent to Eagle Creek near Edgewood. However, the total area of shallow wetland habitat is limited at this site and could be expanded via physical works to recontour the site. The

Edgewood South site has an area that has received extensive revegetation under CLBWORKS-2 and the wetland enhancement project would further increase the suitability of the site for wildlife.

8.3 Site Description

The proposed site is situated adjacent to Eagle Creek south of Edgewood BC on the west side of the Arrow Lakes Reservoir (see Figure 3-1). The wetland enhancement site is located in an area that may have once been part of the Eagle Creek drainage basin, but given the dynamic nature of that system, is no longer directly connected to Eagle Creek. A small depression fills with water on an annual basis providing habitat for amphibians, reptiles, insects (dragonflies), mammals (e.g., deer, grizzly bear), and bats. Topography at the site is undulating, with a gradual increase in elevation from the pond back to the upland forest.

The Edgewood South wetland enhancement site is located on the west side of Arrow Lakes Reservoir near the town of Edgewood. The proposed physical works location is centred at 11 U 417757 E and 5514014 N. The approximate location of the physical works project is shown in Figure 8-1.

Figure 8-1: **Small pond (dark blue polygon) in the drawdown zone of Edgewood South, which could benefit from the construction of a dike (red and black polygon).** The potential increase in the ponded area is shown in light blue

Figure 8-2: Aerial view of the existing pond at Edgewood South (photo date May 13, 2010. Res. elev. 432.03 m ASL)

8.4 Land Ownership

The area identified for the proposed physical works at Edgewood South is Crown Land (Figure 8-3) and all work would occur on Crown Land.

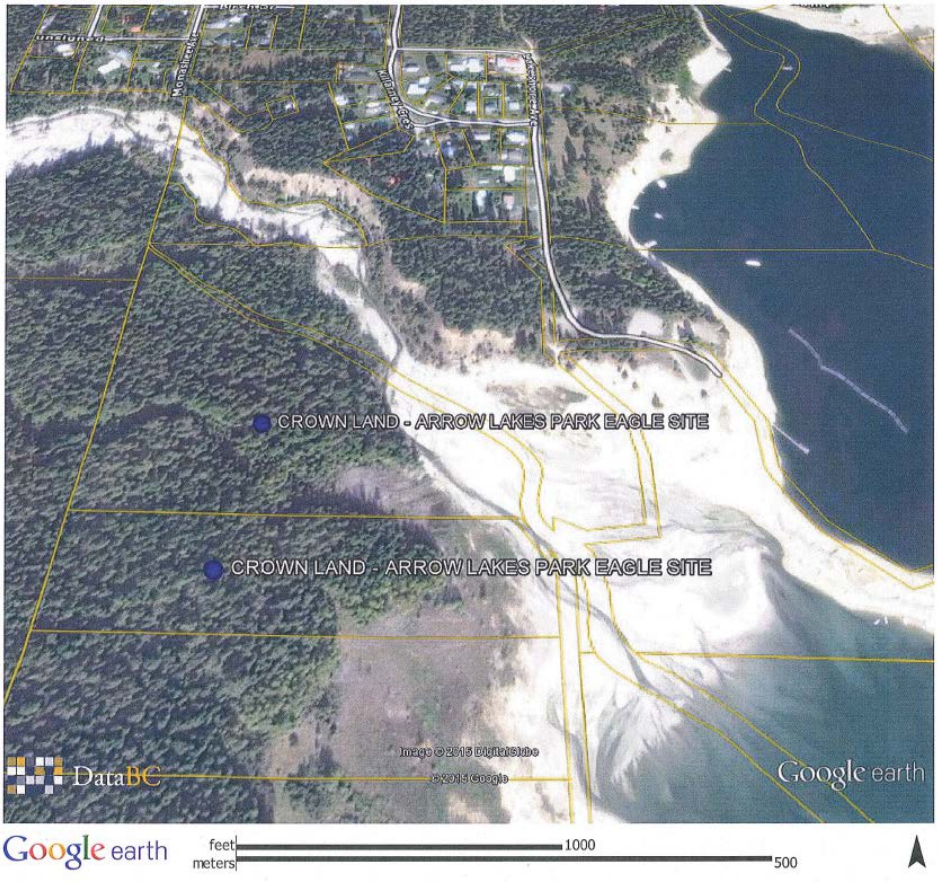

Figure 8-3 Land ownership on and adjacent to the proposed physical works location at Edgewood South. The proposed project would occur on Crown Land

8.5 Current Site Conditions

8.5.1 Vegetation

The lower elevation bands at Edgewood South support a community of annual and early seral species that is typical of similar sandy habitats throughout the Arrow Lakes Reservoir. This community includes common species such as *Alopecurus aequalis*, *Rorippa palustris*, *Veronica peregrina*, *Juncus bufonius, Potentilla norvegica*, *Equisetum arvense* and *Trifolium repens*. In areas where cottonwood stakes have been planted, *Trifolium* and other weedy species of upland habitats, such as *Juncus tenuis, Matricaria discoidea, Poa compressa, Crepis tectorum, Elymus repens* and *Agrostis gigantean* are particularly abundant. Graminoids such as *Phalaris arundinacea, Calamagrostis canadensis* and *Carex lenticularis* are dominant at slightly higher elevations, with *C. aquatilis* and *C. utriculata* appearing alongside these species in saturated or seepy areas. Grassy meadows are fairly widespread throughout the site and dominate much of the middle and upper elevation bands. Isolated clumps and fringing thickets of *Populus balsamifera* ssp.*trichocarpa* and *Salix sitchensis* occur at the highest elevations of the drawdown zone.

The drawdown zone is comprised of sands and gravels and has recently been revegetated with cottonwood and willow stakes. The edges of the drawdown zone are typically covered with woody debris and boulders.

The aquic macrophytes growing in the wetland have not been sampled.

8.5.2 Wildlife

Wildlife use of the site is extensive with songbirds, raptors, water birds, amphibians, reptiles, insects (Odonata), spiders, bats, ungulates (deer and moose), and large mammals (grizzly bear) having been documented from the site. Fifteen species of mammals have been documented at Edgewood South during spring and summer surveys (based on incidental observations made during field work for CLBMON-11B1 (see Hawkes et al. 2011). During aerial surveys conducted in February 2011 and 2012, unspecified deer tracks were documented in the drawdown zone, but no observations were recorded in 2012. In general, use of the drawdown zone at Edgewood South by ungulates appears to be limited. Since 2009, 91 species of birds have been documented, 15 species of mammals (including 11 species of bats), four species of amphibians (including the blue-listed Western Toad (*Anaxyrus boreas*), a COSEWIC species of Special Concern), and three species of reptiles (Western Terrestrial Garter Snake [*Thamnophis elegans*], Common Garter Snake [*T. sirtalis*] and Northern Alligator Lizard [*Elgaria coerulea*]).

Multiple species of waterfowl and shorebirds have been documented in the vicinity of the wetland at Edgewood South (during surveys associated with CLBMON-11B1). Since 2009, 16 species of grebe, loon, shorebirds, and waterfowl have been observed near the area proposed for physical works (Table 8-1). If the physical works project at Edgewood South were to proceed, the expanded wetland area may provide suitable habitat for some of all of these species.

Table 8-1. Species of grebe, loon, shorebirds, and waterfowl documented from the wetland at Lower Inonoaklin Road between 2011 and 2015. These species were documented during songbird point count surveys conducted for CLBMON-11B1.

Group	Common Name	Scientific Name	2009	2010	2011	2013	2015
Grebes	**Western Grebe**	*Aechmophorus occidentalis*				24	
Loons	**Common Loon**	*Gavia immer*			2	8	
Shorebirds, Gulls, Auks and Allies	**California Gull**	*Larus californicus*			1		
	Killdeer	*Charadrius vociferus*	6	2	5	5	8
	Long-billed Dowitcher	*Limnodromus scolopaceus*			1		
	Ring-billed Gull	*Larus delawarensis*			3		
	Spotted Sandpiper	*Actitis macularius*		2	2	7	8
Waterfowl	**American Wigeon**	*Anas americana*			3		
	Blue-winged Teal	*Anas discors*				1	
	Bufflehead	*Bucephala albeola*			2		
	Canada Goose	*Branta canadensis*			6		
	Common Merganser	*Mergus merganser*			10	19	
	Greater White-fronted Goose	*Anser albifrons*		60			
	Lesser Scaup	*Aythya affinis*				1	
	Northern Shoveler	*Anas clypeata*			25		
	Ring-necked Duck	*Aythya collaris*			5	1	
	Total Species (per Year)		**1**	**3**	**12**	**8**	**2**

8.5.3 Soil/Geology

The soils of the proposed site are well-drained and comprised of cobbles and sand (Figure 8-4). A detailed assessment of the soils is required prior to implementing the proposed physical works; however, based on the site conditions, the use of fine particulate material will be required to ensure that the created wetland habitat does not leak.

Figure 8-4: Soils at the proposed physical works site at Edgewood South. Pit depth is ~70 cm

8.5.4 Hydrology

The Edgewood South site is situated in the drawdown zone of Arrow Lakes Reservoir and is inundated on an annual basis. The pond feature is perennial and is likely filled via rainfall, snowmelt, and groundwater. There is a small seepage entering the proposed physical works site from the east, which creates an ephemeral surface flow to the south of the existing pond. Eagle Creek enters Arrow Lakes Reservoir to the north of the proposed physical works site and appears to have flowed through the proposed site, although based on a review of aerial photography the channel appears to have been blocked, probably by a debris flow, which redirected the flow of Eagle Creek to the east and then south around the proposed site. An assessment of the ability of a dike to withstand high freshet flows associated with Eagle Creek is required.

8.6 Goals and Objectives

The primary goal of this proposed physical works project is to enhance/create ~1.3 ha of shallow wetland habitat in the drawdown zone of Arrow Lakes Reservoir by constructing a dike ~115 min length to an elevation of ~439.2 m ASL. This will create shallow wetland habitat that is available to wildlife for ~200 days per year (max: 214 days; min: 185 days based on a review of reservoir elevations recorded over the last five years) assuming that wildlife will be most likely to use the constructed wetland between April 1 and October 31. A secondary goal is to meet the direction provided under the Water Use Plan to identify enhancement opportunities in the mid- and lower Arrow Lakes Reservoir under CLBWORKS-29B.

The specific objectives of the proposed wildlife physical works at Edgewood South are to:

1. Expand the total area of existing shallow wetland habitat in the drawdown zone of Arrow Lakes Reservoir;
2. Increase the spatial and temporal availability of shallow wetland habitat for wildlife in the drawdown zone of Arrow Lakes Reservoir. The construction of a dike and excavation of the area to the west of the existing pond will increase the spatial and temporal availability of shallow wetland, which will improve habitat suitability for pond-breeding amphibians, bats, reptiles, certain species of birds (e.g., wetland-associated songbirds, some waterfowl, and possibly shorebirds, semi-aquatic mammals, and some terrestrial mammals; and
3. Vegetate the constructed dike with native sedges (not shrubs and/or trees because they could affect the integrity of the dikes).

8.7 Target Site Conditions

Shallow wetland habitat at Edgewood South is currently limited, with only a small, though highly productive, wetland available to wildlife. Increasing the total area of shallow wetland habitat will increase the suitability of the drawdown zone for wildlife, including songbirds, amphibians, reptiles, waterfowl, mammals, and insects. The target for vegetation includes the establishment of native plant communities consistent with the surrounding area. The purposeful establishment of aquatic macrophytes is not a target site condition for Edgewood South because the frequency and duration of inundation will likely make it difficult to establish these species and we do not want to introduce species into the drawdown zone that do not already occur there. The existing pond contains some aquatic plants, and the expectation is that over time, those plants will expand into the newly created wetland habitat. The enhanced wetland will resemble the existing wetland (Figure 8-5), but will be larger and have a greater volume of aquatic macrophytes.

Figure 8-5: Existing pond/wetland habitat at Edgewood South (left = 2011; right = 2016)

8.8 Seasonality of Expected Improvements

Seasonality of expected improvements was considered for the period April 1 to October 31 as this is the time of year when wildlife are active and the areas is likely to be snow and ice-free. The typical hydrograph of Arrow Lakes Reservoir includes rapid filling in the spring with high-water achieved between June and August followed by a decline in late August or early September (Figure 8-6). The proposed physical works at Edgewood South are intended to retain existing habitat features at the site and prolong the timing on inundation of the existing wetland. With a dike height of 439.2 m ASL, inundation will commence towards the end of June and the wetland could be inundated until mid-July or as late as the middle of August depending on reservoir operations.

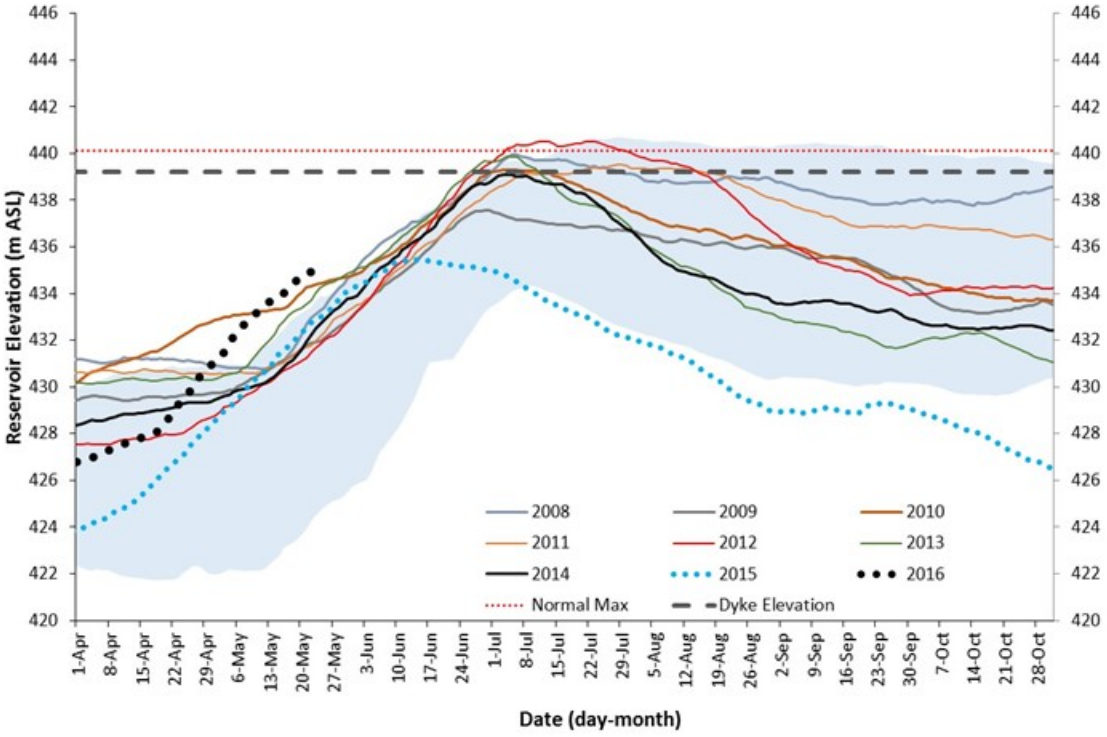

Figure 8-6: Arrow Lakes Reservoir elevations (metres above sea level; m ASL) for 2008 to 2015 and through May 21, 2016. The shaded area represents the 10th and 90th percentile for the period 1969–2015. The dashed horizontal line represents the top elevation of the proposed dike (439.2 m ASL)

8.8.1 Anticipated effects of physical works on Wildlife

8.8.1.1 Amphibians

Current reservoir operations in Arrow Lakes Reservoir do not appear to negatively affect amphibians. For example, Western Toad and Columbia Spotted Frog typically lay eggs in late April or Early May. Eggs hatch in 3 to 12 days and free swimming tadpoles develop rapidly allowing them to move within ponds, even when inundated. Western Toad tadpoles were observed in the wetland at Edgewood South in early June 2016 and adult Columbia Spotted Frogs and Western Toads have been captured there. Because of their mobility and the timing of breeding and development and the limited impact to existing

wetland habitat at Edgewood South, it is unlikely that habitat enhancement/creation will negatively affect pond-breeding amphibians. However, providing additional shallow wetland habitat in the drawdown zone will enhance the suitability of the drawdown zone for pond-breeding amphibians.

8.8.1.2 Birds

Certain species of bird are known to nest in the drawdown zone of Arrow lakes Reservoir including Killdeer (*Charadrius vociferus*) and several species of sparrow (e.g., Savannah Sparrow, *Passerculus sandwichensis*). Very few data are available for bird nests in the drawdown zone at Edgewood South. However, data collected in 2015 indicate that at least two species of birds (Spotted Sandpiper and American Robin) were nesting in and adjacent to the proposed physical works site (Figure 8-7). Of these, Spotted Sandpiper were nesting between 436 and 438 m ASL and American Robin was nesting at elevations > 440.1 m ASL.

Working in Revelstoke Reach, Cooper Beauchesne and Associates Ltd. have documented Savannah Sparrow Nests from 435.44 m to 439. 30 m ASL (median = 437.2 m ASL; n = 22) and Killdeer from 433.16 m to 442.21 m ASL (median 436.7 m; n = 32; H. van Oort, pers. comm.). The elevation of the proposed physical works at Edgewood South overlaps with the median elevation of Savannah Sparrow and Killdeer nests reported for Revelstoke Reach. Depending on reservoir elevations and the location of nests, some nest mortality associated with reservoir operations may occur. However, if nests are within the confines of the physical works (i.e., behind the dike), the probability of nest mortality resulting from reservoir elevations is greatly reduced. Additional data collected for CLBMON-11B1 in 2016 should be reviewed to determine whether birds continue to nest in and adjacent to the proposed physical works locations.

A larger shallow wetland in the drawdown zone is likely to benefit waterfowl and certain species of wetland-associated songbirds. The gravel-based habitat around the wetland is also suitable nesting habitat for Killdeer and Spotted Sandpiper. Other shorebird species such as Greater Yellowlegs (*Tringa melanoleuca*) and Solitary Sandpiper (*Tringa solitaria*) could also take advantage of grass or sedge-dominated habitats near wetlands for foraging.

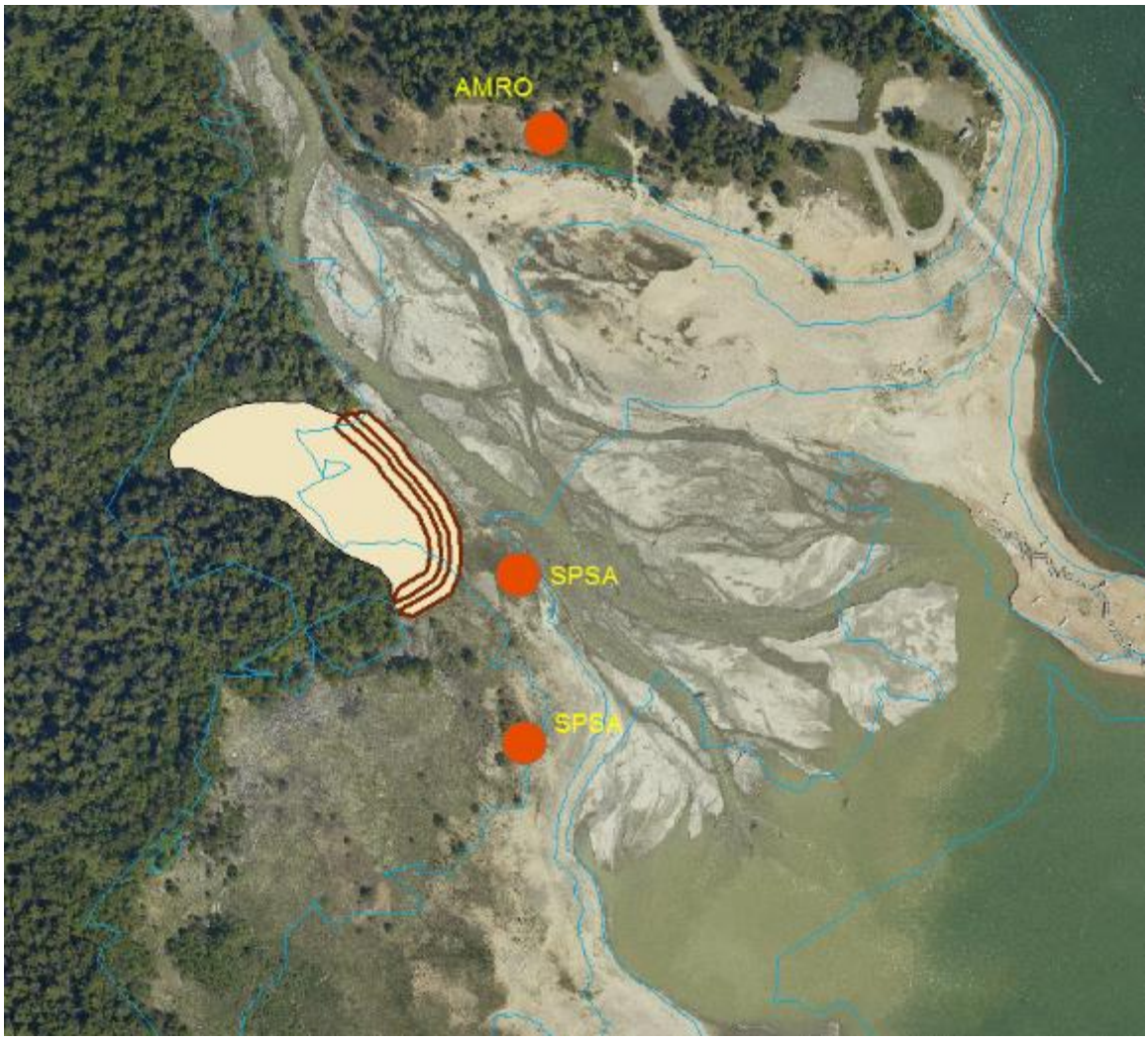

Figure 8-7: Distribution of bird nests documented in and adjacent to the drawdown zone at Edgewood South in 2015. Only contours ≤ 440 m ASL are shown. AMRO = American Robin, SPSA = Spotted Sandpiper. The location of the proposed physical works is shown on the left side of the image

8.8.1.3 Mammals

Mammals observed at the Edgewood South site include ungulates (deer), small mammals (e.g., Meadow Vole), and 11 species of bat (based on analysis of data collected by autonomous recording units; see TABLE)). Of the mammal species present at Burton Creek, bats are the most likely to benefit from the creation of wetland habitat. Our current understanding of the use of the Edgewood South site by bats indicates that as many as eleven species of bat could be using the site between June and September. Relative to both Lower Inonoaklin Road and Burton Creek, bat activity (based on the number of recordings per hour) at Edgewood South was lowest, but the number of species was equivalent to Lower Inonoaklin Road (n=11) and higher than Burton Creek (n=9). Increasing the surface area of wetland habitat at Edgewood South is predicted to improve the overall suitability of the site for bats for the majority of the active season (e.g., April 1 to October 31). Data collection on the use of the proposed physical works site by bats is ongoing (as part of CLBMON-11B4) with data collection proposed for the

period May through September 2016. Two Autonomous Recording Units are currently deployed – one to the southwest of the exiting wetland and one directly west of it. Data from the Autonomous Recording Units will be collected in September and analysed during fall 2016.

8.9 Performance Measures

The effectiveness of the proposed physical works at Edgewood South should be assessed using an index of habitat function that is based on post-construction monitoring data to describe the use of the wetland by waterfowl, shorebirds, songbirds, amphibians, and bats and on the species composition and cover of aquatic macrophytes. Macroinvertebrate species composition should also be considered in the development of an index that describes wetland productivity and function. Some of these data could be compared to pre-construction data (e.g., bats, amphibians), while other data (e.g., macrophytes, waterfowl, hydroperiod, water depth) will be based solely on post-construction data (unless this information is collected prior to project implementation).

The following performance measures are suggested to assess the success of the proposed wildlife physical works project at Edgewood South:

1. Spatial-temporal availability
    a. A measureable increase in the total area of shallow wetland habitat following the implementation of the proposed physical works. The estimated area of shallow wetland created is ~1.3 ha. The created wetland should be approximately this size.
    b. An increase in the temporal availability of wetland overlaps with amphibian breeding season (May-August). The increase should be between 0 and 96 days per year depending on reservoir operations (if reservoir elevations are maintained at elevations below the berm, then the change in temporal availability will be 0 days, or available for all 214 days considered).
    c. Minimum depth of pond required to support amphibian breeding and larval development (20 to 100 cm).
2. Wetland productivity:
    a. Successful natural establishment (expansion) of native macrophytes into newly created wetland area within five years. “Successful establishment” is defined here as continuous species presence for at least two years.
    b. Evidence of use of the wetland by native macroinvertebrates (e.g., odonates, cladocerans, gastropods) within 5 years.
    c. Evidence of breeding by amphibians (specifically Western Toad) in the newly created parts of the wetland. The number of egg strings or masses should be counted on an annual basis following the implementation of the physical works. Egg development should be tracked to determine if eggs metamorphose into froglets or toadlets.
    d. Evidence of use of the wetland by waterfowl and shorebirds. Currently no use of existing wetland by waterfowl reported.

e. Evidence of use of habitat enhancements (e.g., nest boxes, floating islands) by target waterfowl species (which will need to be determined) following completion of construction.

f. Continued use of the wetland by bats (as determined by autonomous recording units) and use of any enhancements such as bat boxes, snags, or other enhancements) by bats.

g. No reduction in the species composition of bats at the Edgewood South site, which currently includes up to 11 species (Table 8-2).

Table 8-2. Bat species documented[1] using bat detectors at the Lower Inonoaklin Road area in 2015. The bat detectors were situated near the area proposed for physical works. The species in this table should be considered a good representation of the use of the Edgewood South area by bats, but see footnote.

Scientific Name	Common Name	BC CDC	COSEWIC	SARA
Corynorhinus townsendii	Townsend's Big-eared Bat	Blue	--	--
Eptesicus fuscus	Big Brown Bat	Yellow	--	--
Lasiurus cinereus	Hoary Bat	Yellow	--	--
Lasionycteris noctivagans	Silver-haired Bat	Yellow	--	--
Myotis californicus	California Myotis	Yellow	--	--
Myotis ciliolabrum	Western small-footed Myotis	Blue	--	--
Myotis evotis	Long-eared Myotis	Yellow	--	--
Myotis lucifugus	Little Brown Bat	Yellow	Endangered	1-E (2014)
Myotis thysanodes	Fringed Myotis	Blue	Data Deficient	3 (2005)
Myotis volans	Long-legged Myotis	Yellow	--	--
Myotis yumanensi	Yuma Myotis	Yellow	--	--

[1]bat species presence is based on a probability of presence via the analysis of acoustic signature recordings. Because of the difficulty associated with assigning species identification based solely on the use of acoustic signatures, this species list may not be accurate (e.g., Myotis species are often grouped due to the overlap in the frequency of their acoustic signatures).

3. No measureable change in wetland productivity. Wetland productivity will need to be determined prior to the implementation of the proposed physical works and will be require calculating productivity using dissolved oxygen, conductivity, temperature and local meteorological data. No measureable change means that there will be no measureable decrease in either primary productivity within five years of the implementation of the physical works that can be directly attributed to the physical works. A measureable change will be assumed to be a change of 25 per cent or greater. Productivity will be determined in fall 2016.

4. No measurable increases greater than 25 per cent from baseline conditions in cover and diversity (species richness and evenness) of key undesirable macrophyte species over 10 years. Key undesirable species include Eurasian Water-milfoil (*Myriophyllum spicatum*) and Reed Canarygrass (*Phalaris arundinacea*).

5. Little to no erosion of the dike as determined by immediate post-construction monitoring and subsequent integrity checks by a qualified engineer.

8.10 Description of Work

8.10.1 Approach

This project consists of constructing a dike to reduce the frequency and duration of reservoir inundation of the pond. The location of the pond in the drawdown zone is shown in Figure 8-1. Additional construction (earth movement) could be done to increase the size of the ponded area, which would enhance the suitability of the site for wildlife by increasing the total area of pond/wetland habitat in the drawdown zone. Amphibians, reptiles, birds (songbirds, swifts and swallows, and waterfowl), mammals (including bats) and arthropods (such as dragonflies) would benefit from an increase in wetland habitat. Because the pond is located within the drawdown zone, all proposed work could occur under BC Hydro's existing Water Use Licence.

Further, because the project consists of moving material to create a dike there will be little if any ongoing maintenance required for the project. If the project proceeds, several concerns/questions will need to be addressed prior to implementation, and site-specific plans will need to be prepared. Some of the concerns that will need to be addressed include (1) assessing how long/often the pond will be flooded by the reservoir if a dike is constructed, and (2) determining if and how the proposed project will influence upstream habitats.

8.10.2 Construction Methods

The method of construction will generally consist of excavation using hydraulic excavators and transport of the materials using dump trucks. This material will then be dumped in lifts and compacted to a suitable density. Following compaction a hydraulic excavator will form the final shape of the features and place the erosion protection or other material on the dike. The final step in construction will involve planting, which will be performed primarily by individuals using shovels.

The project will be constructed primarily of material imported to the site. Ideally this material would come from a nearby borrow pit; however, the location of off-site materials is currently unknown. The existing site materials appear to be too permeable to retain water and create the expanded area of shallow wetland habitat. Any material removed from the site will be deposited off site, which will require a permit. Therefore, the proposed dike and the base of the proposed wetland/pond will be constructed of an imported material that has sufficient fine-grained particles. This will ensure that the dike and wetland bottom have low permeability rates. It is expected that the following material will be brought to the site:

- Fine materials for the base of the dike;
- Fine-grained materials to line the excavation area;
- Plants and seeds for vegetating the site;
- Rock for providing erosion protection on the reservoir side of the dike and spillway; and
- Fine-grained soils may be required to improve the soil retention capabilities of the pond/wetland.

Woody debris will need to be removed from the site. We anticipate that some level of coordination with BC Hydro will be required to accommodate this. The construction will be inspected periodically by a representative of the contract engineer. This inspection will be to confirm that the works are constructed in accordance with the design.

Rip-rap materials will be hard, durable, angular quarry rock of a quality that will not disintegrate upon exposure to water or the atmosphere. Rip-rap will be 300 mm diameter minus (subject to current and wave erosion analysis). The fill and pond-bottom material would ideally be a pit run gravel containing a minimum of 10 per cent fine material (fine material has particle sizes less than 0.075 mm). Slightly more permeable material may also be acceptable depending on local site conditions.

The dike will be constructed of fine materials that will either be retrieved from the site or transported to the site from a nearby borrow pit. Numerous layers of this material will be laid down to construct the dike, with each layer being thoroughly compacted by a compactor; repeated driving over the material by rock trucks and excavators will further contribute to its compaction. Once the dike is built, the outer face will be armoured with coarse rip-rap and the inner face will be coated with a layer of organic material that will act as a substrate for the establishment of vegetation.

The dike will be equipped with an armoured spillway that will allow water to move in a downhill direction towards the reservoir. The spillway will be situated 30 to 40 cm lower than the top elevation of the dike.

Structural loads on the proposed dike structure will consist primarily of maintenance equipment loads, hydrostatic forces, and wave and erosive forces. To resist these loads the dikes will be constructed of well graded material. This material will be compacted to a suitable level to minimize future settlement and seepage through the dike. To resist erosive forces the reservoir side of the dike will be faced with riprap rock armouring.

Environmental loads on the proposed physical works will depend on annual fluctuations in weather conditions and the reservoir operating regime. The impact of wave wash will be the primary environmental force acting on the dike. Once reservoir levels exceed the height of the dike, wave erosion should decrease, but as reservoir levels recede, wave wash will again impact the dike until water levels are below the base of the dike. Compaction of the materials used in the dike and armouring the dike with riprap will reduce the erosive force of waves.

The project design will take into consideration the following criteria:

- The seepage rates of the material used to construct the dike and the soils that will form the bottom of the pond will be checked to determine if the feature will adequately retain water;
- The dike and pond features (including plantings) will be designed so that the removal of sediment will be possible with conventional excavation equipment. This will include providing adequate running surface widths on the top of the dike;
- The compaction of the dike fill materials will be specified so that detrimental settlement will not occur;

- Erosion protection will be provided to prevent erosion as a result of current and wave forces and potentially as a result of high freshet levels associated with Eagle Creek; and
- The spillway through the dike will be designed for the 100-year return period storm event flow without overtopping the dike in other locations.

8.10.3 Construction Schematics

The Edgewood South proposed physical works project is illustrated in Figure 8-9 and a cross-section of the proposed dike is provided in Figure 8-9.

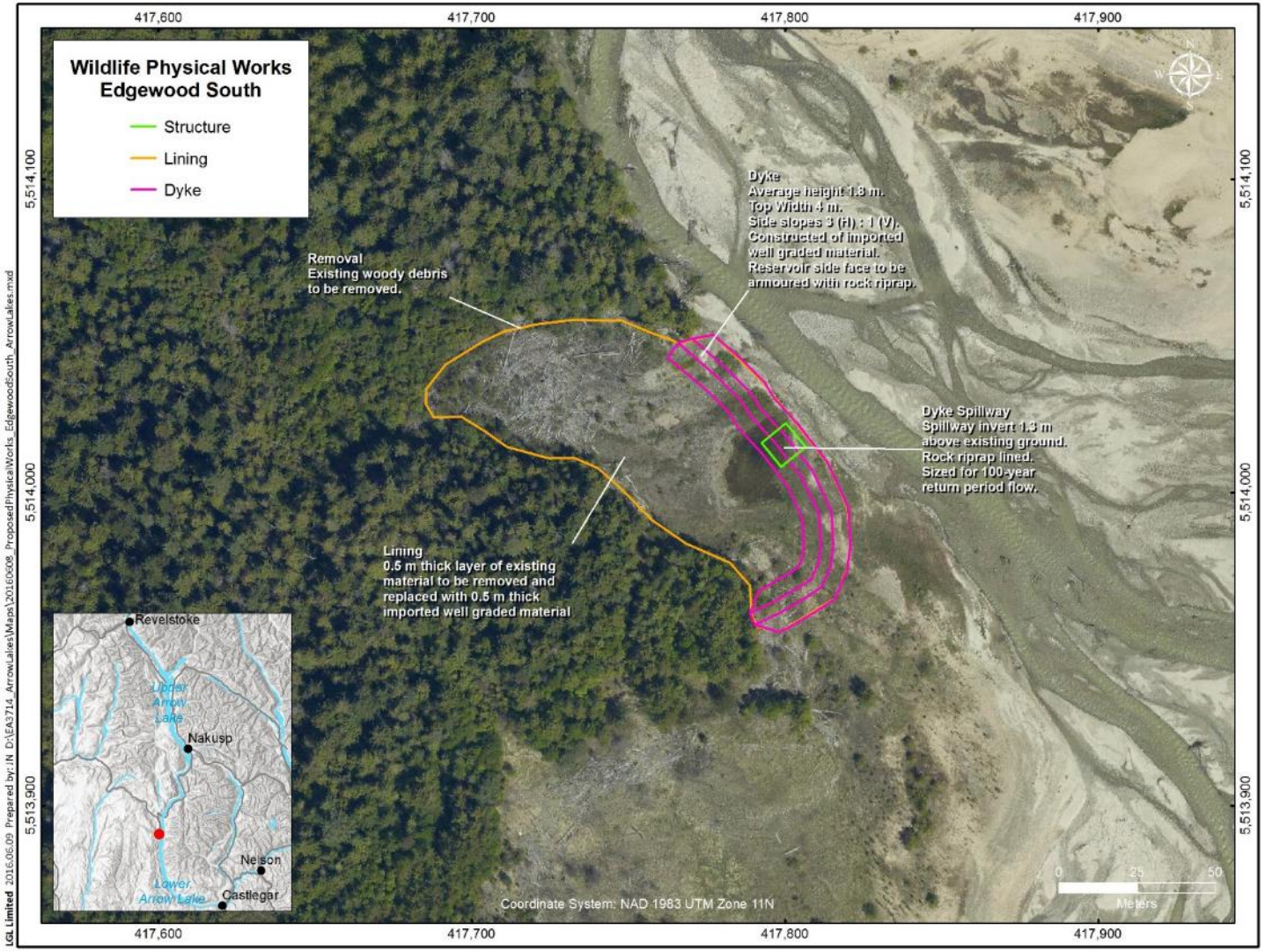

Figure 8-8: **Schematic of proposed physical works project at Edgewood South.** The location of the ponds and dike is approximate

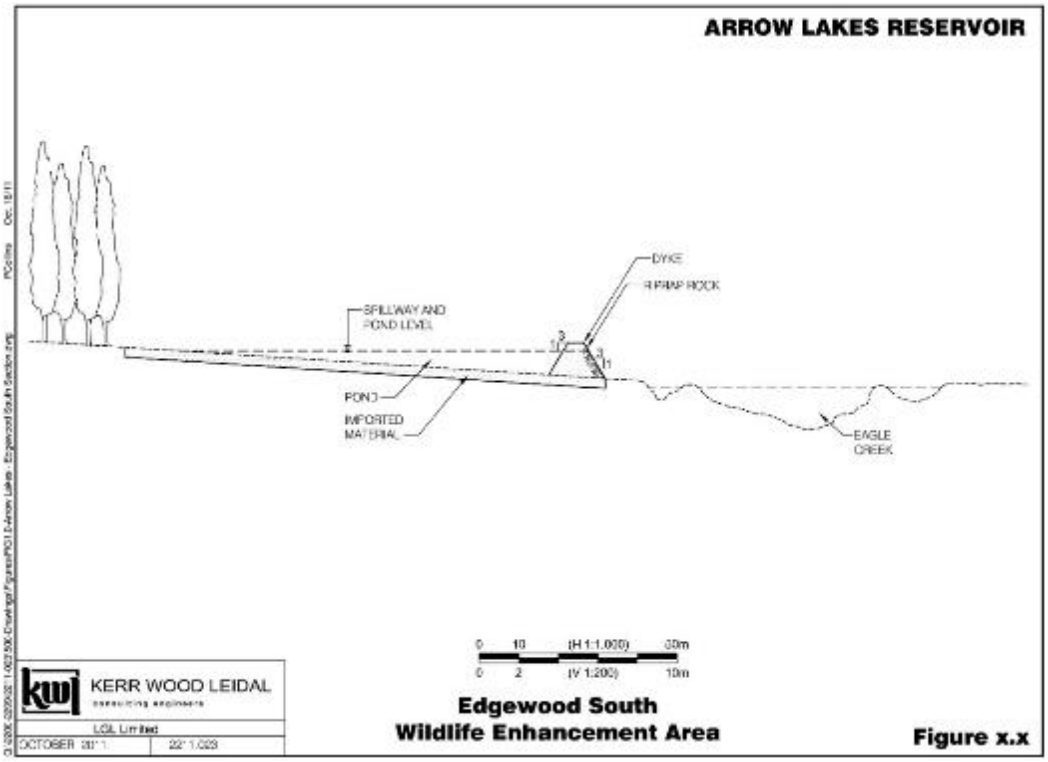

Figure 8-9: Cross-section of the proposed wildlife physical works project at Edgewood South

8.10.4 Construction Schedule

The proposed schedule for the Edgewood South wildlife physical works depends on when funds are made available to do the work. A generic schedule is provided as a guide and will be adjusted as needed.

Quarter 1: January to March. Contract development and tendering.

Quarter 2: April to June. Mobilization, construction, environmental monitoring, demobilization. Some revegetation (sedges, aquatic macrophytes) could occur.

Quarter 3: July to September. Immediate post-construction monitoring.

Quarter 4: October to December. Revegetation (live staking)Reporting and development of a long-term monitoring program that is either developed specifically for the wildlife physical works sites or that builds on programs currently being implemented in the drawdown of Arrow Lakes Reservoir (e.g., CLBMON-11B1, CLBMON-11B4, CLBMON-37).

8.10.5 Cost Estimate

A Class C site estimate has been prepared for the Edgewood South wetland enhancement project using information from a comparable-sized project. A Class C budget is an estimate prepared with limited site information and is based on probable conditions affecting the project. It represents the summation of all identifiable project component costs. It is used for program planning, establishing a more specific definition

of needs, and for obtaining approval in principle. The estimate has been derived from unit costs for similar projects. Actual project costs may be higher or lower and will vary depending on numerous factors including material availability, contractor competition, and site conditions during construction period. The Class C cost estimate for the Edgewood South wetland enhancement project is provided in Table 8-3.

There are project-related activities that have not been included in the costs estimate including an Archaeological Impact Assessment, acquisition of permits and approvals, final engineering design, First Nation and stakeholder engagement, and post-construction inspects etc. Similarly, road improvements may be required to access the site. The costs below were developed to demonstrate the costs associated with constructing the physical works only. A more detailed cost estimate and timeline should be prepared for this project if it proceeds.

Table 8-3: **Class C cost estimate for the proposed wildlife physical works in the drawdown zone of Arrow Lakes Reservoir at Edgewood South.** L.S.: lump sum; c.m.: cubic metre; l.m.: linear metre; s.m.: squire metre

Item	Description	Unit	Estimated Quantity	Unit Rate ($)	Total Estimate	Comment
1	**General**					
1.01	Mobilization and Demobilization	L.S.	1	12,000	$ 12,000.00	
1.02	Bonding and Insurance (1.5% of Other Tasks)	L.S.	1	3,342	$ 3,342.00	
1.03	Diversion, Erosion and Sediment Control	L.S.	1	10,000	$ 10,000.00	
1.04	Survey Layout of Works	L.S.	1	5,000	$ 5,000.00	
	SUBTOTAL FOR TASK				**$ 30,342.00**	
2	**Earthworks**		**Units**	**Cost / Unit ($)**	**Estimate**	
2.01	Excavation and Deposit Off-site	c.m.	3,300	25.0	$ 82,500.00	*Assume 60 min round trip + $5/m^3*
2.02	Import Fill Material	c.m.	4,800	30.0	$144,000.00	
	SUBTOTAL FOR TASK				**$ 178,200.00**	
3	**Drainage Works and Structures**					
3.01	Riprap Armouring	c.m.	330	100	$ 33,000.00	
3.02	Fish Habitat Gravel	c.m.	20	180	$ 3,600.00	
3.03	Planting	L.S.	1	8,000.0	$ 8,000.00	
	SUBTOTAL FOR TASK				**$ 44,600.00**	
	SUBTOTALS - All Tasks				**$ 253,142.00**	
	Environmental Monitoring				$ 12,000.00	
	Engineering & Construction Management	10%			$ 25,314.20	
	Contingencies	20%			$ 50,628.40	
	Total Estimate (excl. tax) +50%/-15%				**$ 405,000.00**	

8.11 Considerations

8.11.1 Reservoir Operating Regime

Reservoir operations are predictable yet variable. Assessing the hydrograph of the reservoir for the years 2008 to 2016 (partial; Figure 8-6) provides an indication of the potential construction window, which could extend from April 1 to 10 June or June 24. Based on the project planning provided in Section 8.13, this should provide enough time to plan and execute the work. There are years (e.g., 2015) when the construction could have occurred at any time between April 1 and Oct 31 due to low reservoir levels. The project reservoir elevations for Arrow Lakes should be reviewed prior to construction to determine the best window in which to operate.

8.11.2 Public Safety

Appropriate signage will be erected prior to and during construction. Given that the area identified for the proposed physical works is not commonly used by people, there is little to no risk associated with public safety. An environmental monitor will be on site during construction and will ensure that the public remains a safe distance from the site during construction activities. The enhancement of shallow wetland habitat at Edgewood South should not pose a risk to the public.

8.11.3 Wildlife

The proposed project will ultimately benefit wildlife because wildlife habitat enhancement is the main consideration of this project.

8.11.4 Fisheries

At present, the site does not provide fisheries values for most of the year. During periods of the year when the site is inundated, there may be some value to fish. The proposed project should reduce the amount of time that fish are able to access the site, which is not considered to be a detriment to fish.

8.11.5 Archaeology

An archaeological assessment has not been completed for the site. It is recommended that archaeological records for the area be reviewed, and that the archaeological potential for the site be assessed. Given the proximity of the site to known archaeological sites, the topography of the site and the proximity to the mouth of a stream, an Archaeological Impact Assessment will be required at this site prior to the implementation of the proposed physical works.

8.11.6 Recreation

The area proposed for the physical works receives limited recreational use and there are no recreational considerations for the site. Noise from construction may impact individuals at the campground on the opposite site of Eagle Creek, but the duration of the impact is expected to be short and all construction activities will occur during the day.

8.11.7 Summary of Agency, First Nations, and Stakeholder Consultation

In fall 2010 a meeting with BC Hydro, the Ministry of Environment, and the Fish & Wildlife Compensation Program–Columbia Region was held in Nelson B.C. to discuss the proposed wildlife physical works and to prioritize the projects. Additional consultation with agencies, First Nations, and local stakeholders will be required prior to the implementation of the proposed physical works.

8.11.8 Codes and Standards

The Edgewood South shallow wetland habitat enhancement project will be constructed in accordance with the following codes and standards:

- Good engineering practice;
- Engineering components will be designed by professional engineers and/or professional geoscientists registered with the Association of Professional Engineers and Geoscientists of BC; and
- Growing soil medium and plant specifications will be designed by professional ecologists registered with the Association of Professional Biology of BC.

8.11.9 Maintenance

The expected maintenance for this project will include the following:

- Removal of invasive vegetation; and
- Inspection of constructed features for signs of instability and erosion.

The frequency of this maintenance will be determined based on monitoring of field conditions. We estimate that this maintenance will initially occur on an annual basis but will occur less frequently as the site stabilizes.

8.11.10 Monitoring Requirements

8.11.10.1 During construction

In addition to the inspection described in Section 8.11.9, monitoring during construction will consist of environmental and archaeological monitoring. The purpose will be to ensure that the appropriate environmental protection measures, including flow diversions and sediment control are in place. Additionally, prior to construction fish and wildlife within the construction zone will be relocated. Removal and relocation of fish and wildlife will be done according to the stipulations of a wildlife sundry permit.

8.11.10.2 Post construction

Post-construction monitoring will involve monitoring the integrity of the physical works and the effectiveness of the physical works in meeting the ecological objectives of the project. An annual site inspection will be conducted to document the following:

- Dike integrity;
- Sedimentation rates; and
- Erosion and slope stability.

Effectiveness monitoring will occur as part of CLBMON-11B1/CLBWORKS-29B using methods developed for CLBMON-11B4 and will include the monitoring of aquatic macrophytes, pond-breeding amphibians, riparian and terrestrial vegetation, and aquatic insects (see Hawkes et al. 2010 for the monitoring protocol).

8.12 Permitting Requirements

Numerous laws and rules govern water use, protection, conservation and sustainability in British Columbia. Currently, the Ministry of Environment, the Ministry of Forests, Lands, and Natural Resources Operations, the Ministry of Health, and pother provincial agencies manage and protect water in BC.

The *Water Sustainability Act* (WSA) was brought into force on February 29, 2016 to ensure a sustainable supply of fresh, clean water that meets the needs of B.C. residents today and in the future.

The *Water Protection Act* (WPA) protects B.C.'s water by reconfirming the Province's ownership of surface and groundwater, clearly defining limits for bulk water removal, and prohibiting the large-scale diversion of water between major provincial watersheds and/or to locations outside of the province.

The *Environmental Management Act* (EMA) regulates industrial and municipal waste discharge, pollution, hazardous waste and contaminated site remediation. EMA provides the authority for introducing wastes into the environment, while protecting public health and the environment. The Act enables the use of permits, regulations and codes of practice to authorize discharges to the environment and enforcement options, such as administrative penalties, orders and fines to encourage compliance. Guidelines and objectives for water quality are developed under EMA.

Other relevant provincial legislation includes:

The *Dike Maintenance Act*; and

Dam Safety Regulation of the *Water Sustainability Act.*

Based on an assessment of the current Dam Safety regulations, the proposed physical works at Edgewood South includes the establishment of a minor dam and as such, is exempt from regulation because it less than 7.5 m in height and impounds less than 10,000 m^3. Refer to Dam Safety Regulation 40/2016, Part 1, Section 2. The Comptroller of Water Rights could determine that the structure is not exempt from regulation. The total volume of impounded water will need to be recalculated based on the final design of the proposed physical works at Edgewood South. Any required post-construction dike maintenance will also need to be detailed in the final site plans

Other regulatory requirements to consider include the Navigation Protection Act (it is likely that the proposed project would be defined as a minor works and be exempted from the Navigation Protection Act and the Wildlife Act (a wildlife sundry permit is required to capture, handle, or salvage wildlife including amphibians and fish). See Appendix A for a summary of applicable acts and regulations.

8.13 Project Planning

A project planning flowchart is provided in Figure 8-10 that illustrates the need to complete the project before late June, when the elevation of Arrow Lakes Reservoir is

generally at its highest level of the year (Figure 8-6). The exact timing of the steps in will likely be modified based on the timing of project approval, but for the purposes of the illustration, timing is associated with the beginning of the fiscal year (i.e., April 1) and considers the average elevation of the reservoir over the last five years (2007 through 2015).

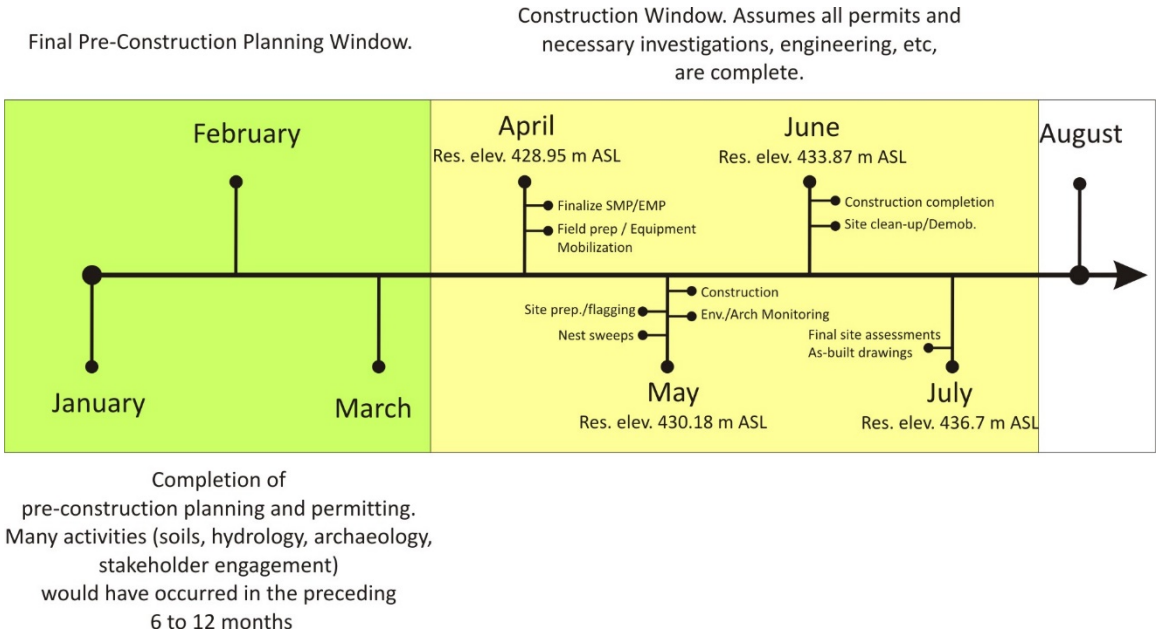

Figure 8-10: **Project planning flowchart illustrating timing (months) for pre-construction and construction windows. Most of the pre-construction work will have occurred in the 6 to 12 months preceding January of the year of construction. Activities post-August will include the development and implementation of a post-construction monitoring program to test the effectiveness of the physical works to enhance wildlife habitat suitability in the drawdown zone of Arrow Lakes Reservoir.** Reservoir elevations are month-end averages over the past nine years and used as a guide only.

8.14 Construction Plan

A detailed construction plan will be developed once all approvals and funding are in place. In general, the project should be constructed when the reservoir is low enough that the site is accessible with light and heavy equipment for the duration of construction, which is estimated at approximately five weeks (based on a similar project completed by LGL Limited and KWL in the drawdown zone of Diversion Reservoir on Vancouver Island [Hawkes and Fenneman 2010]). Suitable reservoir elevations typically occur between mid-February and mid-May (Figure 8-6). If construction occurs in April and/or May, some consideration of wildlife, particularly ground-nesting birds and pond-breeding amphibians will be required.

Prior to construction the project will be designed and assembled in a complete tender-ready package for public tender. Bids from contractors will be reviewed and analyzed and the project will be awarded to the contractor deemed to provide the best overall value for the project.

The construction plan will consider the following:

- Site access
- Permits and Regulations
- Archaeology
- Safety
- Schedules
- Material (types and sources)
- Costs (including an archaeological assessment, if required)
- Monitoring (environmental)
- Post-construction cleanup

As part of the tender package the contractor will be required to install the appropriate erosion protection works prior to earth works construction. This will include silt fencing and the installation of bypass pumping works.

An environmental management plan (EMP) that addresses site safety and environment concerns will be developed for the proposed physical works. The EMP will also contain information related to environmental monitoring, incident reporting, construction schedules, and mitigation strategies for incidents.

9.0 OTHER WILDLIFE PHYSICAL WORKS

9.1 Caribou Creek / Burton Creek Impoundment

A suggestion identified by a stakeholder to create an impoundment to the flow of Caribou Creek / Burton Creek to create a large, stable body of water on the east side of the bridge at Burton was considered. At present, the site is characterized as a large braided confluence of two creeks: Caribou and Burton, both of which flow into Lower Arrow Lake. Small gravel islands, some vegetated, occur within the footprint of the proposed impoundment and grass-dominated habitats occur to the north. Burton and Caribou Creeks contain numerous species of fish including Kokannee (*Oncorhynchus nerka*), Bull Trout (*Salvelinus confluentus*), Rainbow Trout (*Oncorhynchus mykiss*), Mountain Whitefish (*Prosopium williamsoni*), Sculpin (*Cottoidea*), minnow species, Longnose Dace (*Rhinichthys cataractae*), and Lake Chub (*Couesius plumbeus*). The impoundment also coincides with the area delineated for the Columbia River Population of White Sturgeon (*Acipenser transmontanus*; which is all of upper and lower Arrow Lakes); however, it is unlikely that sturgeon use the areas to the east of the bridge, with breeding occurring further north near Revelstoke. Regardless, the high-fisheries values identified for the mouth of both Burton and Caribou Creeks coupled with the permanent loss of valuable upland grass-dominated habitat that provides habitat for garter snakes, and likely for ground-nesting birds, coupled with a lack of additional data suggest that work associated with this suggested physical works not be considered at this time. Additional data collected in 2016 during field work for CLBMON-11B1, CLBMON-11B4, and CLBMON-37 may provide an overview of the habitat quality and use of the area by wildlife.

10.0 SUMMARY

Three wildlife physical works are proposed for the drawdown zone of mid- and lower Arrow Lakes Reservoir. Each of these proposed physical works focuses on the creation, enhancement, or preservation of shallow wetland habitat. The three projects are summarized in Table 10-1. Each of the proposed projects has the potential to increase the ecological value of the drawdown zone for wildlife, but not all are without potential risks. The proposed works at Burton Creek are associated with the lowest level of ecological risk as area identified for the works is a relatively unproductive grass and invasive species dominated field that would be converted to shallow wetland habitat. The project proposed for Lower Inonoaklin Road is associated with a moderate level of ecological risk, primarily because the hydrology of the site has not been studied and there is chance that the existing wetland at the site requires some level of recharge from reservoir inundation or via ground-water seepage into from the reservoir to the wetland when reservoir elevations are high enough. The project at Edgewood South is associated with the greatest level of ecological risk as the currently productive wetland at the site could be negatively affected, resulting in reduced productivity at the site and the loss of a currently functional shallow wetland habitat.

The wetlands at Lower Inonoaklin Road and Edgewood South are currently considered to be productive – they provide habitat for many species of wildlife and vegetation. The area proposed for physical works at Burton Creek is relatively homogeneous and would be improved with the addition of wetland habitat. The Burton Creek site is also highly

visible to the public, as it is situated next to the highway and in an area frequented by people. Both the Edgewood and Lower Inonoaklin Road sites are accessible, but less so compared to Burton. The overall costs associated with Burton Creek are higher as they include budget to purchase adjacent private lands for conservation purposes, but the improvements to existing habitats are deemed to be greater that both Edgewood and Lower Inonoaklin Road. Therefore, the three projects are ranked (in order of priority) as follows: 1) Burton Creek; 2) Lower Inonoaklin Road, 3) Edgewood South. This order differs from the recommendation of Hawkes and Howard (2012) and is due largely to the stakeholder interest in ecological enhancement of the site and the degree of ecological uplift in existing habitat that could be realized at Burton Creek. The current ecological function of Lower Inonoaklin Road and Edgewood South is considered to be greater than that of the proposed physical works location at Burton Creek.

Table 10-1: **Summary of the physical works projects proposed for implementation in the drawdown zone of mid- and lower Arrow Lakes Reservoir.** VDZ: vegetated drawdown zone; SWH: shallow wetland habitat. Green arrow indicates predicted improvement, yellow no change relative to current conditions, red indicates a possible negative impact. Green triangle indicates proceed, yellow uncertainty remains, red indicates caution as project has risks to existing habitat. * indicates excavations may not be required and if not, a Conservation Water Licence may not be necessary, Supporting documentation is provided in the second part of the table

Category	Component	Location and Direction of Change With Physical Works					
		Burton Creek	Change	Lower In. Rd.	Change	Edgewood South	Change
Project Overview	Existing Habitat	VDZ	SWH	SWH	None	SWH	None
	Proposed Habitat	SWH	In place of VDZ	SWH	None	SWH	Expansion of Area
	Restoration Approach	Habitat Creation		Habitat Protection		Habitat Enhancement	
	Total Area (ha)	0	⇧ 2.8	6.2	0 (6.2 ha)	0.13	1.17
	Water Depth (m)	0	⇧ 0.5 - 1.5	0 - 1.5	0 - 1.5	0 - 1.5	0 - 1.5
	Temporal Availability (days-year; range)	73 - 214	⇧ 19 - 141	57 - 174	⇧17 - 132	69 - 214	⇧ 0 - 131
	Change to Existing Values	Increase habitat heterogenity via wetland creation with commensurate increases to species richness; biodviersty. Net benegit to wildlife/habitat in DDZ.		Retention of existing shallow wetland habiat value, but inundation occurs later in year. Hydrology of site unknown. Requries investigation.		Increase total area of shawllow wetland habitat in the drawdown zone, but existing habitat could be negatively affected.	
	Overall Risk of Project (in terms of ecoloigical benefit)	Low ▲	Area is a grassy field with low species diversity. Works will increase habitat suitability	Moderate ▲	Existing wetland unlikely to be affected unless berms preclude recharging of wetland.	Moderate to High ▲ or ▲	Probability of negative impact to existing functional wetland
	Project Summary	Creation of ~2.8 ha of wetland habitat in an area currently domianted by a grassy meadow with low habitat heterogenity. Wetland hab itat would increase habitat suitaiblity even for those groups assocaited with a high rating (see below).		Existing wetland would be retaind, but protected from inundation unti later in the year. The hydrology of the site requires further investigation.		Expanding the wetland would create a larger wetland habitat, which will benefit many species, but there is a risk that the existing wetland could be negatively impacted.	
	Project Prioty and Benefit	1	Greatest potential for increaseing ecological value of DDZ.	2	Good value, high probaiblity of increasing ecological value of DDZ, but some uncertainities remain.	3	Highest over risk to ecological integrity of existing habitat. Large upside possible, but risk too great.
Cost	Estiamted Cost ($1,000's) +50%/-15%	1032		352		405	

Category	Component	Location and Direction of Change With Physical Works					
		Burton Creek	Change	Lower In. Rd.	Change	Edgewood South	Change
Current Conditions and Assessment of Benefit from Proposed Physical Works	Terrestrial Vegetation	Low	⇔	Moderate	⇔	Low	⇔
	Aquatic Macrophytes	Low/Nil	⇧	Low	⇔	Moderate	⇩ or ⇔
	Waterfowl	Low/Nil	⇧	Moderate	⇧ or ⇔	Low	⇧ or ⇔
	Songbirds	High	⇧ or ⇔	High	⇔	High	⇧ or ⇔
	Amphibians	High	⇧ or ⇔	High	⇧ or ⇔	High	⇩ or ⇔
	Reptiles	Moderate	⇧ or ⇔	High	⇔	High	⇩ or ⇔
	Mammals (incl. bats)	Moderate	⇧ or ⇔	Moderate	⇧ or ⇔	Moderate	⇧ or ⇔
	Aquatic Invertebrates	Low/Nil	? ⇧	Low	? ⇧	No Data	⇩ ? ⇧
	Terrestrial / Aerial Invertebrates	Moderate	⇧ or ⇔	No Data	⇧ or ⇔	Moderate	⇩ or ⇔
	Habitat Diversity	Low	⇧	High	⇧ or ⇔	High	⇩ or ⇔
Species with Conservation Designation	Provincial Blue-list	3	None expected	3	None expected	3	None expected
	COSEWIC Special Concern	1	None expected	3	None expected	1	None expected
	SARA Sched.1	2	None expected	4	None expected	2	None expected
	COSEWIC Endangered	1	None expected	1	None expected	1	None expected
Proposed Dikes	No.	1		3		1	
	Length (m)	390		63 128 171		115	
	Dike Elevation (m ASL; max)	439		438.5		439.2	
	Height (m)	0.5 - 1.8 m		0.5 - 1.5 m		0.5 - 1.5 m	
Impoundments / Ponds	Number of Excavations	2		3*		1	
		6946.3		13,073,9			
	Total Volume of Water (m3)	3,464.8		2,651.8 17,499.7		2,235.6	
Propsoed Earth Works	Soil Mounds	2		0		0	
	Excavation Required?	Yes		No		Yes	
	Excavation Depth	30 to 50 cm		N/A		30 to 50 cm	
	On-site Materials?	Yes		No		No	
	Off-site dumping?	No		N/A		Yes	
Regulations/Permits/Acts		All		All		All	
BMPs		All		All		All	
Conservation Water Licence		Yes		Yes*		Yes	
Archeology	AIA Required?	Yes		Yes		Yes	

11.0 CONCLUSIONS AND RECOMMENDATIONS

The implementation of the proposed physical works projects will address the objectives of CLBWORKS-29B, which include the identification of high-value wildlife habitat along the drawdown zone of the lower and middle reach of the Arrow Lakes Reservoir and the identification of wildlife habitat enhancement opportunities in the same region.

Three wildlife physical works projects are proposed for mid- and lower Arrow Lakes Reservoir, all of which are associated with the creation, preservation, or enhancement of shallow wetland habitat. The total area of shallow wetland habitat created would be approximately 4.1 ha in two locations (2.8 ha at Burton Creek and 1.3 ha at Edgewood South), and an additional 6.2 ha would be preserved at Lower Inonoaklin Road. The Class C cost estimates presented in Hawkes and Howard (2012) have been updated and range from ~$341K for the Edgewood South project to ~$1M for the Burton Creek project [redacted] The cost estimates as presented are only estimates; actual costs should be determined prior to implementing each project.

Each of the proposed projects has the potential to increase the ecological value of the drawdown zone for wildlife, but not all are without potential risks. The proposed works at Burton Creek are associated with the lowest level of ecological risk as area identified for the works is a relatively unproductive grass and invasive species dominated field that would be converted to shallow wetland habitat. The project proposed for Lower Inonoaklin Road is associated with a moderate level of ecological risk, primarily because the hydrology of the site has not been studied and there is chance that the existing wetland at the site requires some level of recharge from reservoir inundation or via ground-water seepage into from the reservoir to the wetland when reservoir elevations are high enough. The project at Edgewood South is associated with the greatest level of ecological risk as the currently productive wetland at the site could be negatively affected, resulting in reduced productivity at the site and the loss of a currently functional shallow wetland habitat. For all sites, an archaeological investigation is required prior to initiating the projects.

There are several uncertainties associated with each of the three proposed physical works projects which need to be addressed prior to the implementation of the projects. These include the need for a detailed soils analysis, hydrology assessment and engineering design at each site and the completion of an archaeological impact assessment. Once these issues have been addressed, the implementation of the proposed physical works should be relatively straight forward.

Based on the anticipated benefits, assumed risks, and overall cost of the proposed projects, the three projects are ranked (in order of priority) as follows: 1) Burton Creek; 2) Lower Inonoaklin Road, 3) Edgewood South. This order differs from the recommendation of Hawkes and Howard (2012) and is due largely to the visibility of the site and the overall enhancement to existing habitat that could be realized at Burton Creek. The current ecological function of Lower Inonoaklin Road and Edgewood South is considered to be greater than that of the proposed physical works location at Burton Creek and the level of risk increases with decreasing priority (i.e., Edgewood South has higher risk than Burton Creek).

Post-construction monitoring of all physical works implemented in the drawdown zone of Arrow Lakes Reservoir is necessary to determine the effectiveness of the approaches taken. Monitoring of the shallow wetland habitats can continue under CLBMON-11B1 or as an expansion of CLBMON-11B4. The purpose of the monitoring programs should be to determine the success of the physical works by assessing seasonal wildlife use and plant community development over time. Post-construction monitoring should also occur at a time scale commensurate with the focal taxa. For example, if an assessment of vegetation species composition and cover is required, sampling may need to occur immediately following construction for several years (to determine survival), and then every five to 10 years to determine persistence and expansion.

Overall, the ability to improve wildlife habitat in the drawdown zone of mid- and lower Arrow Lakes Reservoir is limited by topography. Much of the drawdown zone is steep and/or rocky and does not provide the opportunity to implement physical works. Those areas that are relatively flat have been identified for physical works projects. There are additional areas, such as the mouths of small creeks that flow into the reservoir that could be manipulated to increase the amount of shallow wetland habitat in or adjacent to the drawdown zone of Arrow Lakes Reservoir. However, these projects require further consideration and are not recommended at this time.

12.0 LITERATURE CITED

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13.0 APPENDICES

Appendix A: Applicable Regulations

Golder (2009) provided a summary of the regulations and acts that might apply to physical works proposed for Revelstoke Reach in Arrow Lakes Reservoir. The content from Golder (2009) has been adapted to the physical works projects proposed for mid- and lower Arrow Lakes Reservoir.

Fisheries Act

The *Fisheries Act* is federal legislation that protects all inland waters in Canada. Section 35(1) provides broad prohibition of works that create a "harmful alteration, disruption or destruction" (HADD) of fish habitat unless authorized under Section 35(2) of the Act. Section 36(3) prohibits the deposit of deleterious substances. Works that result in a HADD can be authorized only by the Minister of Fisheries and Oceans Canada (DFO), or his/her designate, in exchange for the development or enhancement of similar habitat such that there is "no net loss" of productive habitat. A HADD could include making a stream inaccessible to fish and damage to or loss of spawning habitat. Upon review of proposed plans by DFO, if it is determined that a HADD will occur, a Subsection 35(2) Authorization for "Works Affecting Fish and Fish Habitat" will be required from DFO. Review of development projects by DFO normally takes between three and six months. A fish collection permit from DFO is required for fish salvages that involve anadromous salmonid species; however, because no anadromous salmon reside in the study area, fish sampling permits fall under the jurisdiction of the British Columbia (B.C.) Ministry of Environment through the *Wildlife Act*.

Amendments to the Fisheries Act came into effect on November 25th 2013. The changes focus on the *Act* protecting the productivity of recreational, commercial and Aboriginal fisheries. The Government is now focusing protection rules on significant threats to the fisheries and the habitat that supports them, while setting clear standards and guidelines for routine projects.

Amendments that were brought into effect in 2013 include:

- Clarification of "Factors" taken into account by the Minister in decision making (e.g., issuing authorizations) or making regulations (e.g., contribution of relevant fish, fisheries management objectives, measures and standard to prevent HADD, public interest);
- Combination of former section 32 (killing of fish by means other than fishing) and section 35 (harmful alteration or disruption, or he destruction of, fish habitat) into the prohibition of "serious harm to fish" (=death of fish or any permanent alteration to or destruction of, fish habitat);
- Changes to the regulatory process;
- Formalization of agreements between regulation-making powers (e.g., Minister, federal and provincial departments);
- Enhanced Compliance and Protection of commercial, recreational and Aboriginal fisheries (e.g., enforceable conditions on authorizations, increasing inspection powers, a duty to notify provision, etc.).

Info from: http://www.dfo-mpo.gc.ca/pnw-ppe/changes-changements/index-eng.html.

Navigable Waters Protection Plan

Arrow Lakes Reservoir is considered to be navigable water. In general, any placement of materials within the inundation zone of the reservoir may constitute a navigation hazard to boats, thereby triggering the federally regulated *Navigable Waters Protection Act* (NWPA). This Act regulates any works built or placed in, on, over, under, through, or across any navigable water. For projects with the potential to impact navigable waters, an application to the Navigable Waters Protection Division (NWPD) under Section 5(1) of the NWPA may be required prior to construction.

The placement of material such as rocks or coarse woody debris in the drawdown zone may become a navigational hazard when the area is inundated. Similarly, the construction of dikes in the drawdown zone may be a navigational hazard at certain times of the year (i.e., when they are under water). In these cases, the NWPA must be considered.

The type of approval required from the NWPD will vary depending on the type and complexity of the proposed work, and will consist of formal approvals and work assessments. The formal approval process is needed when the work is considered to potentially have a significant impact on navigation or when the work is specifically named within the Act. Works named within the Act are bridges, booms, dams, and causeways. Work assessment letters can be issued in cases where the work is not considered to have a significant impact on navigation. Aside from time required by the NWPD to formally review a proposed project (three to six months), the proponent of the work is also required to publically post notification of the work using three means of advertisement (such as local papers) for public input prior to initiation of the work.

It is unlikely any of the proposed wildlife habitat enhancements will trigger a formal review, but projects that involve the construction of dikes in the drawdown zone might need to be reviewed. If the proposed works do require formal approval under the NWPA, the project will also trigger a review under the *Canadian Environmental Assessment Act*.

Water Sustainability Act

British Columbia's new 2014 Water Sustainability Act (WSA) came into effect on February 29th 2016, updated and replaced the historic Water Act. New policy directions and regulations include the protection of stream health and aquatic environments, consideration of water in land use decisions, regulation of ground water use, regulation of water during scarcity, improved security, water use efficiency and conservation, testing and reporting of the current provisions in the Water Act, and establishing a range of governance approaches.

Regulations that came into effect in 2016 include:

- **Water Sustainability Regulation** – This regulation addresses the requirements to allocate both ground and surface water (e.g., application requirements) and identifies the requirements for using water or making changes to a stream in accordance with the regulation. This regulation replaces Parts 1, 2, 5, 6, 7 and 8 and Schedules C and D of the former Water Regulation under the old *Water Act* – which described the procedures related to the acquisition of a water right, the

calculation and payment of water fees and rentals to government, and activities conducted within a stream or a stream channel.

- **Water Sustainability Fees, Rentals and Charges Tariff Regulation** – This regulation specifies the water-related fees for all water uses, including water power. This regulation replaces Parts 3 and 4 and Schedules A and B of the former Water Regulation under the old *Water Act*.
- **Groundwater Protection Regulation**
- **Dam Safety Regulation** – This regulation identifies what dams are regulated and the requirements which must be met by dam owners. This regulation replaces the former Dam Safety Regulation under the old *Water Act*.
- **Water District Regulation** – This regulation establishes Water Districts administrative units used in licensing and management. It was a schedule in the former Water Regulation and is now a separate regulation under the WSA.
- **Violation Ticket and Fines Regulation** (under the *Offence Act*) – This administrative regulation prescribes fines, victim surcharge levies and maximum amounts for violation tickets issued by enforcement officers for offences under a number of provincial statutes. Government updated this regulation to align language with the *Water Sustainability Act*, to change fine amounts for some offences, and to introduce new offenses identified in the WSA and its regulations.

The Water Sustainability Act defines the terms for working around water to minimize the potential risk to aquatic ecosystems. “Changes in and about a stream” is defined in the WSA as any modification to the nature of a stream, including any modification to the land, vegetation and natural environment of a stream or the flow of water in a stream, OR, any activity or construction within a stream channel that has or may have an impact on the a stream or a stream channel. “Works” is defined as anything that can be used to divert, store, measure and convey water (including production of energy). “Stream” is defined as a natural watercourse and can include a lake, pond, river, creek, spring, ravine, gulch, wetland feature or glacier.

To make any changes in and about a stream a licence or approval in accordance with Part 3 of the Water Sustainability Regulation must be obtained. Part 2 (11) of the WSA regulates “use of water” and “changes in or about a stream.”, and Part 6 (127) Regulations —ensures that water quality, fish and wildlife habitat, and the rights of licensed water users are not compromised (MFLNRO 2016). The Regulation allows certain activities to be undertaken when conducted in compliance with the Regulation rather than under the authority of an approval or licence. Under the Regulation, one may carry out a number of routine works, provided that the general conditions and notification requirements are met (MFLNRO 2016). An approval or licence is required in cases involving more complex works, and for the short-term use, storage, or diversion of water.

In addition, the CLBWORKS-29B projects should adhere to the Regional Terms and Conditions and Timing Windows for Changes In and About a Stream (Kootenay Region). It should be noted that the timing window of least risk to fish and fish habitat for all project sites is August 20 to 31. Application to conduct work outside of this window will be required due to the nature of the reservoir’s operating regime. Provincial Guidelines and Best Management Practices should also be followed.

Conservation Water Licence

A water licence and approval, under the Water Sustainability Act, applied for through the Ministry of Forests, Lands and natural Resources Operations (FLNRO), allows for the diversion, use or stage of surface or ground water, and any changes made in and about a stream. A licence (longer than 2 years) or approval (period of up to 24 months) can be issued for water purposes such as agriculture, commerce, habitat conservation, industry, resource, development, power production, water storage and supply. Licences and approvals are subject to provincial (Water Sustainability Act [WSA], Water Sustainability Regulation 2016), local and in some cases federal regulations.

A water licence specifies the water source, the water use purpose, the maximum quantity of water that may be used, the works associated with the water use, as well as where the water can be used. Water use may be restricted to certain times of the year. If the proposed works will occupy Crown land you will be required to provide proof that an authorization for that use of Crown land has been granted, or an application for an authorization to use Crown land has been made. Authorization can be in the form of a Permit Over Crown Land, or a more formal tenure under the *Land Act*. Tenure under the *Land Act* is normally required for larger projects such as waterpower or waterworks. If you require a Crown Land authorization, but do not already have one, you will be prompted to apply for a permit or tenure as part of the water licence application process.

For CLBWORKS-29B, three separate water licences for Conservation Water Use Purposes are required. These projects fall under the Water Sustainability Act (section 2), and "conservation purpose" means the diversion, retention or use of water for the purpose of conserving fish or wildlife and includes the construction of works for that purpose. Specifically, these project s fall under the categories: Conservation – Use of Water (11B) and Conservation – Stored Water (11A).

Process - Applications are made to FrontCounter BC during which it will be reviewed by a Water Manager at MFLNRO. Before any decisions are made the application with undergo both a technical review and consultation with other government agencies and affected parties. The technical review will be conducted to ensure that there is enough water at the source to issue a licence without affecting the existing water rights, harming the water supply or aquatic system. This process involves the consultation and referrals of other private and government agencies including:

- First Nations Interests (contact Band Office on reserve land or contact Ministry of Aboriginal Relations and Reconciliation [Aboriginal Affairs and Northern Development Canada] for land in treaty negotiations);
- Affected private landowners (check both BC Assessment and Land Titles and Survey Authority of BC for property ownership);
- Crown Land (attain a permit [PCL] or Crown land tenure from Ministry of Forests, Lands and Natural Resource Operations);
- Drinking Water and Ministry of Health (attain a Construction Permit from the regional public health engineer [Section 6 of Drinking Water Protection Regulation])
- Ecosystems Section of FLNRO for provincial management of fish and wildlife habitat (Fish Protection Act, Water Act, Guidelines and Best Management Practices);

- Department of Fisheries and Oceans Canada (Sections 35 and 36 of Fisheries Act, Water Notifications and Assessment requirement for Work Near Water, Project Review Application Form [PRAF]) *(FrontCounter BC can assist by submitting a short DFO assessment form in connection with water licence application);
- Forestry Roads under MFLNRO require Road use permits for the transportation of heavy equipment or materials;
- Ministry of Community, Sports and Cultural Development (check if project area falls within an Improvement District); and/or
- Transport Canada, Marine Safety (check the project's potential to affect navigation of waters by vessels – Navigable Water Protection Act).

Required Information - Various information and documents must be provided to FLNRO during the water licence application process (see table below), and the approval of a licence (conditional or final) may have terms and conditions associated with it. Appeals for rejected licences for a project can be made to Environmental Appeal Board, under the Environmental Management Act (EAB). An example of the type of required information is provided below.

Required Information	**Proposed Site**	**Provided Information**
Name and contact info of the applicant or applicant's agent	All sites	LGL Limited/ BC Hydro
Official name of water source	All sites	Arrow Lakes Reservoir
Official name of reservoir if water is to be stored in a reservoir	All sites	Arrow Lakes Reservoir
Water Use Purpose	All sites	Conservation – Stored Water (11A)
Periods of year that water will be diverted	All sites	Year round
Name and location of stream/waterbody from which water may be taken or stored	Burton Creek	Arrow Lakes Reservoir
	Lower In.	
	Edgewood South	
Legal description and Tenure of Land where water is to be used	Burton Creek	Still needed
	Lower In.	
	Edgewood South	
The applicant's title to or interest in the appurtenancy	All sites	Still needed
Location (UTM coordinates)	Burton Creek	11 U 435757 E and 5536952 N
	Lower In.	11 U 420302 E 5523907 N
	Edgewood South	11 U 417757 E and 5514014 N
Detailed description of the proposed works	All sites	See above sections
If water is to be stored by a dam, details of dam's height, length, crest width and max storage volume	Burton Creek	See above sections
	Lower In.	
	Edgewood South	
Written consent from every person on the land title/land tenure where you prose the use of water	All sites	Still needed
Required Documents	**Proposed Site**	**Provided Information**
Map or drawings meeting the Application Drawing Standards	All sites	Still needed

Required Information	Proposed Site	Provided Information
Copy of the lease, or any permit/tenure/authorization to use Crown Land relevant to the locations of water diversion and use	All sites	Still needed
Copy of a letter or proof of authorization, if it is on behalf of another applicant	All sites	Still needed
Water Development Plan (see Appendix)	All sites	Still needed
Topographical Maps of general location of the land where the water is to be used or works constructed	All sites	Still needed
Registered Survey Plan for land where water is intended to be used	All sites	Still needed
Consulting with First Nations	All sites	Still needed

Fees – As of February 29th 2016, there is a one-time application fee (FrontCounter BC) to apply for authorization to divert or use water and for a permit over Crown land – fees are based on how much water is required and how it is used (~$ 250 for Conservation Water Use Purpose). Approved Water Licence holders also must pay annual water rental fees to divert/use the allocation of water (for conservation purposes a flat fee is charged regardless of water quality). For Conservation Water Use Purposes the minimum annual rental fee is $25 flat rate, billed every three years by Water Management Branch [MFLNRO]). Application fees for permits over Crown Land may also apply ($250-500 depending on hectares of Crown Land affect [< 0.5 hectares or over]).

Provincial Dam Safety Guidelines

Under the BC Water Sustainability Act, regulated dams in BC require a water licence and must meet the requirements specified in the Dam Safety Regulation (February 2016). The Dam Safety Regulation sets requirements and best practices for all aspects of dam design, construction, operation, maintenance, removal and decommissioning of dams. The Dam Safety Regulation came into effect on February 29, 2016, replacing the former B.C. Dam Safety Regulation (2000).

A “dam” is defined as a barrier constructed for the purpose of enabling the storage or diversion of water form a stream or aquifer, plus any other works incidental or necessary for the barrier.

There are a number of structures that retain water that are not licensed under the Water Sustainability Act; and therefore Dam Safety Regulations do not apply. Examples include mining structures (e.g., tailings ponds) and structures such as dug-outs (that only contain surface water runoff, snow melt or direct precipitation). Dug-outs that occur from water supplied from a stream and used as a diversion or for the storage of water require a licence, as do dug-outs constructed within in a stream channel (including reservoirs).

Heritage Conservation Act

All archaeological sites on provincial Crown or private land predating A.D. 1846 are automatically protected by the *Heritage Conservation Act* (HCA). Certain sites that have historical or archaeological value (including burials and rock art sites) are protected

regardless of age. This protection includes penalties for unauthorized alterations to a site undertaken without a proper permit in place. Any development for which land altering activities are proposed has the potential to alter archaeological sites. Examples of land altering activities include, but are not limited to excavation, trenching, soil stripping, vehicle/machinery traffic, and dumping of fill, rip-rap, or excavated sediment.

The Archaeology Branch (Ministry of Forests, Land and Natural Resource Operations) is the provincial government agency responsible for administering the HCA, issuing permits, maintaining a database of recorded archaeological sites, and handling referrals from various development agencies. In addition to the provisions outlined in the HCA, the Archaeology Branch has developed a set of guidelines (*British Columbia Archaeological Impact Assessment Guidelines*), or a step-by-step approach for the management of archaeological sites in areas in which development is proposed.

The first step in the archaeological impact assessment process is to identify and assess the archaeological resource potential or sensitivity within a proposed study area. This first step will indicate the need for and scope of any additional archaeological studies (such as an Archaeological Impact Assessment [AIA]). AIAs are conducted under an HCA Section 14 Heritage Inspection Permit issued by the Archaeology Branch. Following review of an AIA permit application by the Archaeology Branch, relevant First Nations are then provided a 30-day period to review the application and submit comments on the methods proposed in the application. Current turnaround time to obtain a Heritage Inspection Permit for a routine AIA is between six and eight weeks. An AIA will provide recommendations for the management of unavoidable and unanticipated impacts to archaeological resources through a variety of mitigation and other measures. Depending on the flexibility of the proposed development, as well as scheduling and cost concerns, it may be possible to avoid an AIA by avoiding land altering activities within areas of high archaeological potential. If further archaeological work is required, it is typically completed under an HCA Section 14 Heritage Investigation Permit.

Other alterations to an archaeological site are permitted under an HCA Section 12 Site Alteration Permit. A Section 12 permit is held by the individual responsible for the site alteration and can include data recovery or mitigative requirements, such as site monitoring or data sampling.

Wildlife Legislation

Both provincial and federal governments administer wildlife legislation relevant to terrestrial and aquatic species. Wildlife legislation that might have a bearing on the proposed physical works projects includes the provincial *Wildlife Act* and the federally regulated *Species at Risk Act*, *Migratory Birds Convention Act*, and associated regulations.

A Wildlife Collection Permit will be required from the B.C. Ministry of Forests, Lands and Natural Resource Operations (FrontCounter BC) to conduct any wildlife (e.g., fish and/or amphibian) salvage work associated with the proposed projects. Fish collection permits for the study area are under the jurisdiction of the provincial government's *Wildlife Act*, and are administered by the Ministry of Forests, Lands and Natural Resources Operations. Such a permit is required for salvaging fish from the footprint area of any proposed works within the wetted area of a stream. Federal Fish Salvage permit is also required from Department of Fisheries and Oceans Canada. The *Species at Risk Act*

permit would be applied only to any identified aquatic and/or terrestrial listed species with critical habitat within the area of the proposed projects.

A specific concern regarding the *Migratory Birds Convention Act* is the potential for disturbance or destruction of nesting sites, which in the areas proposed for enhancement, would involve the disturbance and/or destruction of nests of ground-nesting birds. The government no longer issues any take permits for the destruction of nests; therefore work would have to occur outside of the breeding bird window, or have nest searches completed prior to construction to identify any active nests that would need to be avoided (included adults, eggs, hatchlings and fledglings).

The most appropriate manner for addressing legislative requirements of these statutes is to implement Best Management Practices (BMPs), such as avoiding falling of trees and or clearing of vegetation during the bird nesting window. This window varies with latitude and identified species of concern, but generally includes a period between April 15 and August 31. Typically, once the breeding window is established, a breeding bird survey within the area of development is required if clearing activities are planned during the breeding window. Mitigation will vary by species and specifics related to occupancy of nests and breeding behaviour observed during the breeding bird survey.

Some of the BMPs that will likely be relevant to the proposed physical works projects include the following:

- Timing Windows and Terms and Condition for Changes In and About a Stream Specified by MOE Habitat Officers, Kootenay Region (2009);
- Guidelines for Amphibians and Reptiles Conservation during Urban and Rural Land Environments in British Columbia (2014);
- Best Management Practices for Bats in British Columbia (2016);
- Standards and Best Management Practices for Instream Works, March 2004; and
- Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia (2009).

For instream works, an indication of what requirements are necessary can be obtained by using the provincial government's interactive web tool at http://www.env.gov.bc.ca/wld/instreamworks/index.htm.

Other Legislation

The British Columbia *Weed Control Act* is designed to prevent the proliferation of identified noxious weeds (British Columbia *Weed Control Act*–Chapter 487 RSBC 1996). The *Weed Control Act* includes a list of weeds considered to be noxious throughout the entire province; it also includes a list of weeds considered to be noxious in only certain regions in B.C. BMPs to minimize the potential proliferation of non-native weed species typically include, for example, ensuring that borrow material is locally obtained, and equipment and machinery brought on site is inspected and clean of dirt and weeds prior to construction of the project. This standard weed control measure, in conjunction with the planting of high-quality, weed-free native grass seed mixes and native trees and shrubs, should be implemented to prevent importation and distribution of non-native noxious weeds.