Columbia River Project Water Use Plan

Kinbasket and Arrow Reservoirs Revegetation Management Plan

Debris Mounds and Wind Row Construction Pilot Program

Implementation Year 7

Reference: CLBWORKS-1

Final Annual Report

Study Period: 2015

LGL Limited environmental research associates

Sidney, BC

January 22, 2016

KINBASKET AND ARROW LAKES RESERVOIRS REVEGETATION MANAGEMENT PLAN

CLBWORKS-1 Kinbasket Reservoir Revegetation Program

Year 7 – 2015
Debris Mounds and Wind Row Construction Pilot Program

Final Report

Prepared for

BC Hydro

British Columbia Hydro and Power Authority

Vancouver, B.C.

Prepared by

Virgil C. Hawkes, M.Sc., R.P.Bio.
LGL Limited environmental research associates
9768 Second Street
Sidney, British Columbia, V8L 3Y8

January 22, 2016

LGL LIMITED
environmental research associates

Suggested Citation:

Hawkes, V.C. 2016. CLBWORKS-1 Kinbasket Reservoir revegetation program: year 7 – 2015. Debris mound and wind row construction pilot program. Annual Report. Unpublished report by LGL Limited environmental research associates, Sidney, B.C. for BC Hydro Generations, Water License Requirements, Burnaby, B.C., 35 pp.

Cover photos

From left to right: Debris in the drawdown zone of Kinbasket Reservoir at Hope Creek, Chatter Creek, and in Bush Arm. Photos © Virgil C. Hawkes.

EXECUTIVE SUMMARY

To mitigate for the varied effects of reservoir operations on vegetation establishment and development in the drawdown zone of Kinbasket Reservoir, BC Hydro implemented CLBWORKS-1, a 10-yr, reservoir-wide restoration program to enhance sustainable vegetation growth in the drawdown zone of Kinbasket Reservoir for ecological and social benefits. In 2015, a physical works trial was initiated to test the efficacy of mound creation in functioning both as a receptor site for revegetation (live stakes and sedge plugs) and to protect habitats cleared of wood debris, which should promote the natural re-establishment of vegetation in the drawdown zone. The physical works included the removal of wood debris, the use of wood debris to construct mounds, and the removal of wood from existing ponds in the drawdown zone. If successful, these physical works could function to increase vegetation cover and in turn help improve aesthetics, control dust, contribute to the protection of known cultural heritage sites from erosion and human access, enhance littoral productivity and create wildlife habitat.

The 2015 pilot project to construct mounds and wind rows and clean ponds of wood debris in the drawdown zone of Kinbasket Reservoir resulted in the construction of seven mounds in two locations, the cleaning of three previously wood-choked ponds in one location, and the removal of 6,957 m^2 of wood from all areas. An additional 763.3 m^2 of uncleared land was incorporated into the physical works features created at the Bush Arm Causeway. In terms of the construction process and creation of physical works, the pilot project can be viewed as successful. However, the longer-term structural viability of the mounds and wind rows will not be known until there is another high water year in Kinbasket Reservoir. Similarly, the efficacy of the mounds and wind rows to function as suitable receptors for vegetation cannot be assessed until at least one growing season has passed. The survivorship of live stakes and transplanted sedges will be assessed during the 2016 growing season during field work for other monitoring program (e.g., CLBMON-10 or CLBMON-11A). Whether the cleaned ponds get used by amphibians, water-associated birds, or other wildlife will need to be assessed over time. It is likely that amphibians and birds will use the ponds in 2016 and assessments will be made during field work for CLBMON-11A and CLBMON-37.

For the most part, the nine objectives associated with CLBWORKS-1 in 2015 were met either in part or in full. Logistical constraints contributed to the implementation of physical works at two of the five sites identified and low water levels in 2015 precluded assessments of reservoir impacts on the mounds or of the ability of mounds to exclude wood debris shoreward of the constructed islands and windrows. Limited planting occurred in 2015, so the efficacy of various planting methods cannot be assessed at this time.

The following recommendations are made for future consideration:

1. The removal of wood from ponds should provide highly suitable wetland habitat in the drawdown zone of Kinbasket Reservoir. However, there is a high probability that wood could cover the wetlands again if the ponds are not adequately protected. The installation of a log boom around the Bush Arm Causeway North site is recommended to ensure the protection of the ponds, mounds, and islands built in this location. Alternatively, additional mounds could be built to keep wood out of the wetlands. If additional mounds are built, wood debris will likely need to be transported from other

areas of the drawdown zone and existing ecological values (e.g., high plant diversity), and other monitoring programs (e.g., CLBMON-61) will need to be considered.

2. For future iterations of CLBWORKS-1, the use of at least two excavators is recommended. This will reduce the amount of time required to construct the physical works at each location and create efficiencies in terms of wood debris movement and mounding. Multiple excavators are recommended whenever mounds are being constructed in specific locations to protect shoreward values. Using additional machinery will reduce the overall impact to the ground and ensure materials are delivered and piled in specific locations.
3. Sites not treated in 2015 (Chatter Creek, Hope Creek, Goodfellow Creek) should be considered for future iterations of CLBWORKS-1. However, it is recommended that these works be postponed until the ability of existing mounds to withstand high reservoir levels can be assessed.
4. The prescriptions developed in 2015 focused solely on Bush Arm. Additional opportunities exist in other parts of Kinbasket Reservoir (e.g., Valemount Peatland) and site-specific prescriptions for future consideration could be prepared for those locations.
5. An assessment of live stakes and sedge transplants is recommended in 2016 to assess the utility of either or both of these methods to jump start the revegetation process on the mounds and in the drawdown zone surrounding the mounds (i.e., in the areas cleared of wood debris).
6. In addition to assessments of live stakes planted in the fall of 2015, additional live stakes and sedges could be planted in the spring of 2016 to assess whether there is a difference in growth and survivorship of fall vs. spring planted live stakes.
7. The use of a drone to acquire site specific and timely aerial photography of the mounds was very useful and additional photos of the mounds should be acquired in the spring of 2016. Those photos could be compared to the photos taken immediately following mound construction and pond clearing to assess whether there was any erosion or other changes associated with the features created or enhanced.
8. The productivity of the cleaned ponds should be determined. This could be accomplished during work associated with CLBMON-61. At a minimum, temperature, conductivity, and dissolved oxygen data loggers should be installed in at least one of the cleaned ponds to determine if the physicochemical properties of the cleaned pond are similar to other ponds in the drawdown zone.
9. Certain aspects of CLBWORKS-1 were not implemented completely in 2015. For example, testing various methods of vegetation establishment on the mounds was not possible in 2015 and should be considered for future iterations of CLBWORKS-1.

Key Words: CLBWORKS-1, physical works, restoration, revegetation, mounds, topographic heterogeneity, drawdown zone, Kinbasket Reservoir

ACKNOWLEDGEMENTS

The following individuals are acknowledged for their contribution and support of this project in 2015. Funding was provided by BC Hydro (CO# 90203). Mark Sherrington, Margo Sadler, Philip Bradshaw, Dave Polster, Carrie Nadeau, Dean Den Biesen, David Vaillant, Glen Mullins (BC Hydro), Mike Miller, Jamie Fenneman, Julio Novoa, Doug Adama (LGL), Murray Chapple (Sterling Lumber), Dave Craig (Spaz Logging), Alan Peatt (ONA), Zachary Wilson (OKIB), Nicole Kapell, Pauline Eugene (KNC), Adam Neil, Len Edwards (Splatsin) Matthew Ward (Golden Fire Jumpers), Taylor Davis (Terra Remote Sensing).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

The drawdown zone of a hydroelectric reservoir is a challenging environment for plants and animals, particularly when the annual change in reservoir elevation can be as much as 39 m. Flooding and flow alteration resulting from varied reservoir operations create complex disturbances that can modify entire ecosystems, with effects extending upstream and downstream of the dam (Nilsson *et al.* 1991; Hill *et al.* 1998; Luken and Bezold 2000; Van Geest *et al.* 2005, Poff and Zimmerman 2010, Ye *et al.* 2012). Currently, little is known about the influence of dam operations on the structural and functional components of the terrestrial and semi-terrestrial plant communities that establish on reservoir shorelines within the zone of water level fluctuation (i.e. the drawdown zone). In 2007, BC Hydro initiated a monitoring program (CLBMON-10) to assess the distribution and spatial extent of existing vegetation communities in the drawdown zone of Kinbasket Reservoir. The results of that study indicate that substantial portions of the drawdown zone are vegetated to some degree, with habitats higher in elevation associated with a higher cover of vegetation and increased species richness and diversity (Hawkes and Gibeau 2015). Despite this, vast areas of the drawdown remain sparsely vegetated or completely devoid of vegetation. Several factors contribute to this lack of vegetation including the timing, duration, and frequency of inundation, substrate type, soil moisture and nutrient regimes, erosion and deposition of sediment associated with wave action and reservoir flows, and wood debris accumulation and scouring.

To mitigate for the varied effects of reservoir operations on vegetation establishment and development in the drawdown zone of Kinbasket Reservoir, BC Hydro implemented CLBWORKS-1, a 10-yr, reservoir-wide restoration program to enhance sustainable vegetation growth in the drawdown zone of Kinbasket Reservoir for ecological and social benefits (BC Hydro 2008). Between 2008 and 2011, a total of 69.15 ha in 19 treatment areas in the drawdown zone of Kinbasket Reservoir was planted by Keefer Ecological Services (Keefer et al. 2007, 2008, 2010, 2011). Eight different revegetation prescriptions were applied during this time, but plug seedling treatments, particularly those involving Kellogg's sedge (*Carex lenticularis*) alone or mixed with other species, dominated the planting regime (Hawkes et al. 2013). CLBMON-9, an effectiveness monitoring study of the revegetation efforts, occurred between 2008 and 2013 (Yazvenko 2008; Yazvenko et al. 2009; Fenneman and Hawkes 2012, Hawkes et al. 2013). The results of CLBMON-9 indicate that the revegetation program was unsuccessful and did not contribute to enhancing sustainable vegetation growth in the upper elevations of the reservoir.

More recent efforts to enhance the vegetation in the upper elevations of Kinbasket Reservoir appear to have achieved greater short-term success. For example, larger sedge plugs (i.e., larger than those used between 2008 and 2011) planted at an ecologically suitable site in Bush Arm in 2013 (Adama 2015) and a log boom installed around a wetland in the Valemount Peatland following the clearing of wood debris in 2014 (Hawkes 2015a) have both contributed to either an increased cover of vegetation (sedge transplants) or the re-establishment of native vegetation in drawdown zone (wood removal and protection with a log boom).

In 2015, a physical works trial was initiated to test the efficacy of mound and windrow[1] creation to function both as a receptor site for revegetation (live stakes and sedge plugs) and to protect habitats cleared of wood debris, which should promote the natural re-establishment of vegetation in the drawdown zone. This document describes the physical works prescriptions implemented in Bush Arm of Kinbasket Reservoir during fall 2015. The physical works included the removal of wood debris, the use of wood debris to construct mounds, and the removal of wood from existing ponds in the drawdown zone. If successful, these physical works could function to increase vegetation cover and in turn help improve aesthetics, control dust, contribute to the protection of known cultural heritage sites from erosion and human access, enhance littoral productivity, and create wildlife habitat. The enhancements align with BC Hydro's Water Use Plan Consultative Committee's (WUP CC) support of a reservoir-wide planting and enhancement program in lieu of operational changes (BC Hydro 2005). The work implemented in 2015 builds on the restoration efforts that occurred between 2007 and 2014 under previous iterations of CLBWORKS-1.

1.1 Project Rationale

The construction of mounds to increase the heterogeneity of otherwise homogeneous habitats has contributed to the success of ecological restoration projects in a variety of ecosystems (Ewing et al. 2002; Bruland and Richardson, 2005; Werner and Zedler 2007; Hough-Snee et al. 2011). With respect to the drawdown zone of hydroelectric reservoirs, the use of debris mounds to increase topographic heterogeneity[2] was discussed during the Revegetation Technical Review in December 2014, a workshop to review the status of the revegetation and associated effectiveness monitoring programs in Kinbasket and Arrow Lakes Reservoir that occurred between 2007 and 2014. The application of these methods (mound creation) in a semi-aquatic (reservoir) ecosystem to increase topographic heterogeneity and promote the establishment and development of vegetation communities requires testing, which is the premise of this pilot study.

1.2 Goals, Objectives, and Scope

The goal of this pilot project was to design, build, and assess the efficacy of constructed debris mounds and windrows for establishing self-sustaining riparian vegetation communities. It is hypothesized that planted mounds and windrows will promote the natural establishment of vegetation in the upper elevations of the drawdown zone (i.e., 750 to 754 m ASL) and that vegetation will naturally establish at wood debris removal sites. Further, it is hypothesized that terrestrial or wetland habitat behind the mounds and windrows will be protected from erosion via wind and wave action and from scouring and compaction associated with wood debris. If conditions allowed, existing habitat features were incorporated into site prescriptions at each site. These uncleared areas provide a source of seeds for vegetation community expansion and increase the overall suitability of the site for wildlife. Post-construction monitoring is required as the ability of constructed debris mounds and windrows to enhance vegetation establishment and development in the drawdown zone of a hydroelectric reservoir is untested. Further, the extent to which

[1] A mound is defined as the systematic piling of wood debris and substrate into a tetrahedron-shaped pile. A wind row is similar to a mound, but is more linear in shape.
[2] Topographic heterogeneity is the pattern of elevation over a specific area and the contribution of various process (e.g., geological, hydrological, biological) that contribute to the development of a complex three-dimensional landscape that influences the composition and function of ecological processes (Larkin et al. 2006)

'natural filters' (e.g., presence of wood debris, erosion, deposition, wave action, wind, substrate compaction, and human activity) impact the effectiveness of the mounds and windrows to enhance sustainable vegetation growth needs to be better understood:

To assess the potential impacts of these parameters on the integrity of the mounds and windrows, BC Hydro drafted the following objectives for CLBWORKS-1 in 2015:

1. Identify potential sites for assessing the application of windrows and mounds for enhancing vegetation and wildlife habitat in Kinbasket Reservoir;
2. Prepare site-specific construction specifications and restoration prescriptions for each pilot area;
3. Implement the restoration prescriptions at each site as per the site-specific construction specifications;
4. Specify pre- and post-treatment monitoring requirements (to be carried out under CLBMON-9 and CLBMON-11A) that will assess the efficacy of constructed debris mounds and windrows for establishing self-sustaining riparian vegetation communities. This will include an assessment of the:
    a. structural integrity of constructed wood debris and soil mounds and windrows in full reservoir pool conditions with the active natural processes on the reservoir (e.g., wave erosion); and
    b. the methods to establish vegetation on constructed wood debris and soil mounds/ windrows;
5. inform BC Hydro on how reservoir operations affect the structural integrity of wood debris and soil mounds/ windrows and determine if mitigation strategies can be developed to reduce these impacts;
6. Test methods to establish vegetation on constructed wood debris and soil mounds/ windrows;
7. Inform BC Hydro on to what extent constructed wood debris and soil mounds/ windrows exclude floating woody debris from the parts of the drawdown zone shoreward of the constructed islands and windrows;
8. Establish vegetation on the constructed mounds/ windrows and integration with the Kinbasket Debris Removal Program (CLBWORKS-16); and
9. Assess the effectiveness of the CLBWORKS-1 program including the effects of treatment methods and site-specific attributes using a cataloguing approach.

2 STUDY AREA

2.1 Physiography

The Columbia Basin in southeastern British Columbia is bordered by the Rocky, Selkirk, Columbia, and Monashee Mountains. The headwaters of the Columbia River begin at Columbia Lake in the Rocky Mountain Trench, and the river flows northwest along the trench for about 250 km before it empties into Kinbasket Reservoir behind Mica Dam (BC Hydro 2007). From Mica Dam, the river continues southward for about 130 km to Revelstoke Dam, then flows almost immediately into Arrow Lakes Reservoir behind Hugh Keenleyside Dam. The entire drainage area upstream of Hugh Keenleyside Dam is approximately 36,500 km^2.

The Columbia Basin is characterized by steep valley side slopes and short tributary streams that flow into Columbia River from all directions. The Columbia River valley floor elevation ranges from approximately 800 m near Columbia Lake to 420 m near Castlegar. Approximately 40 per cent of the drainage area within the Columbia Basin is above 2,000 m elevation. Permanent snowfields and glaciers predominate in the northern high mountain areas above 2,500 m elevation. About 10 percent of the Columbia River drainage area above Mica Dam exceeds this elevation.

2.2 Climatology

Precipitation in the basin is produced by the flow of moist, low-pressure weather systems from the Pacific Ocean that move eastward through the region. More than two-thirds of the precipitation in the basin falls as winter snow. Snow packs often accumulate above 2,000 m elevation through the month of May, and continue to contribute runoff long after the snow pack has melted at lower elevations. Summer snowmelt is reinforced by rain from frontal storm systems and local convective storms. Runoff begins to increase in April or May and usually peaks in June to early July, when approximately 45 per cent of the runoff occurs. The mean annual local inflow for the Mica, Revelstoke and Hugh Keenleyside projects is 577 m^3/s, 236 m^3/s and 355 m^3/s, respectively.

Air temperatures across the basin tend to be more uniform than precipitation (Figure 2-3). The summer climate is usually warm and dry, with the average daily maximum temperature for June and July ranging from 20–25°C.

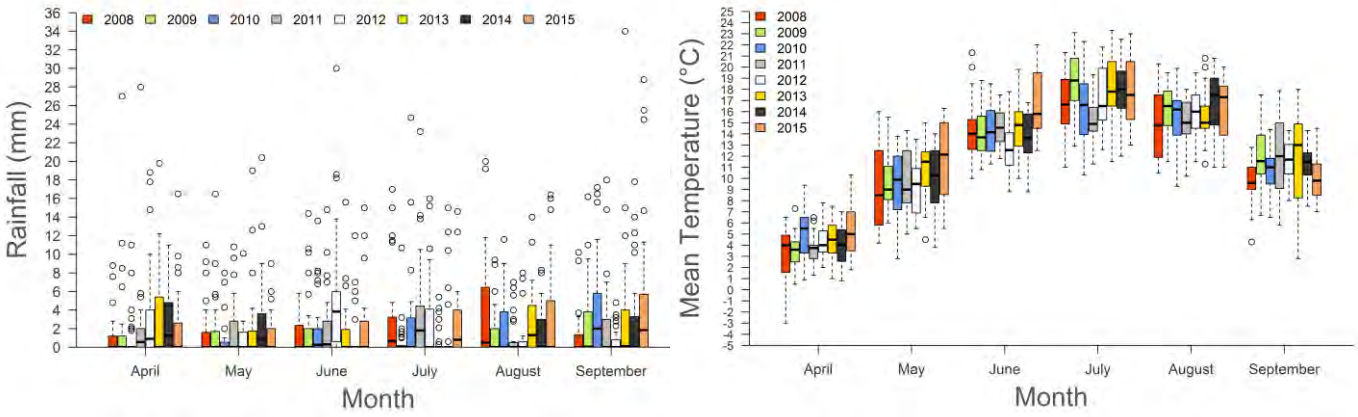

Figure 2-1: Daily precipitation (mm, left) and temperature (°C, right) for April through September, 2008 to 2015 as measured at Mica Dam. Data source: Environment Canada (http://climate.weather.gc.ca/index_e.html)

Wind can influence where wood debris accumulates in the drawdown zone. For Bush Arm (the location of the 2015 physical works, see below), the wind flows predominantly in an east-west pattern, particularly between July and October when reservoir elevations are typically the highest (Figure 2-2 and see Section 2.3). Wind flow patterns were taken into consideration when constructing the mounds and wind rows at the Bush Arm Causeway.

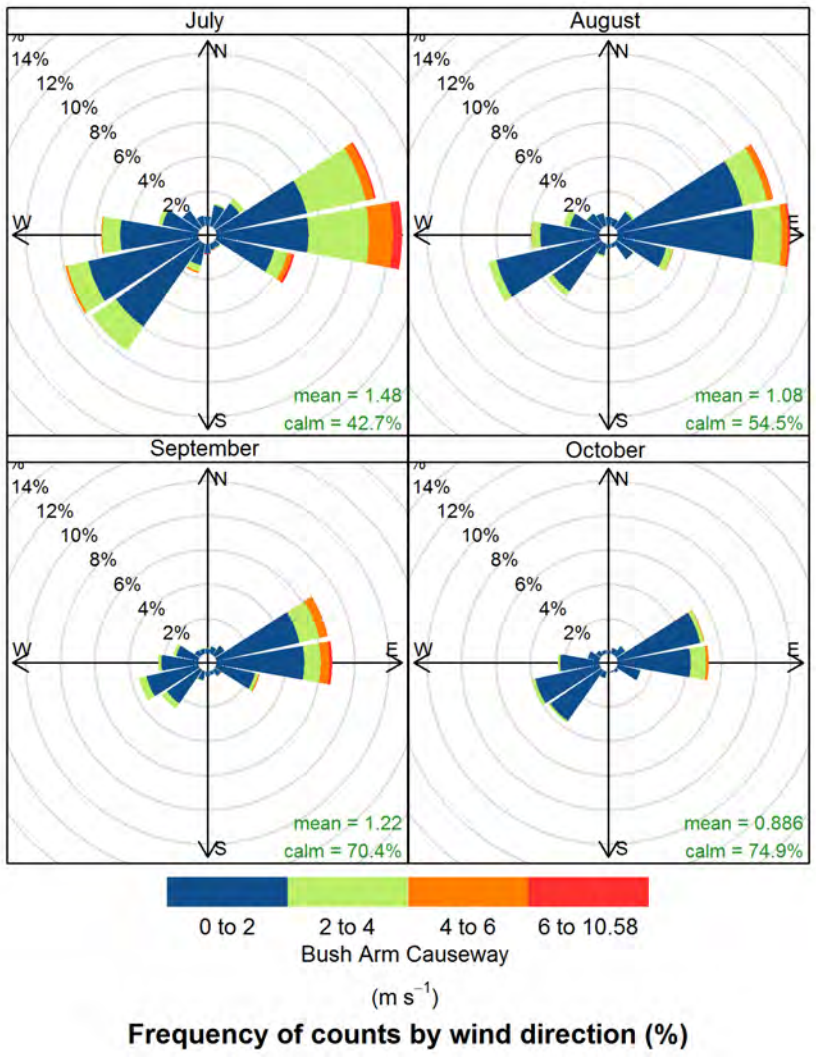

Figure 2-2: Direction of prevailing winds in Bush Arm between July and October 2015. Wind direction is generally to the east in the direction of the physical works locations at the Bush Arm Causeway. Data obtained by LGL weather station deployed near the Bush Arm Causeway South location

2.3 Kinbasket Reservoir

The approximately 216 km long Kinbasket Reservoir is located in southeastern B.C., and is surrounded by the Rocky and Monashee Mountain ranges (Figure 2-3). The Mica hydroelectric dam, located 135 km north of Revelstoke, B.C., spans the Columbia River and impounds Kinbasket Reservoir. The Mica powerhouse, completed in 1973, has a generating capacity of 1,805 MW, and Kinbasket Reservoir has a licensed storage volume of 12 million acre feet (MAF; BC Hydro 2007). The normal operating range of the reservoir is between 707.41 m and 754.38 m elevation, but can be operated to 754.68 m ASL with approval from the Comptroller of Water Rights. A hydrograph of Kinbasket Reservoir between 2008 and 2014 is shown in Figure 2-4.

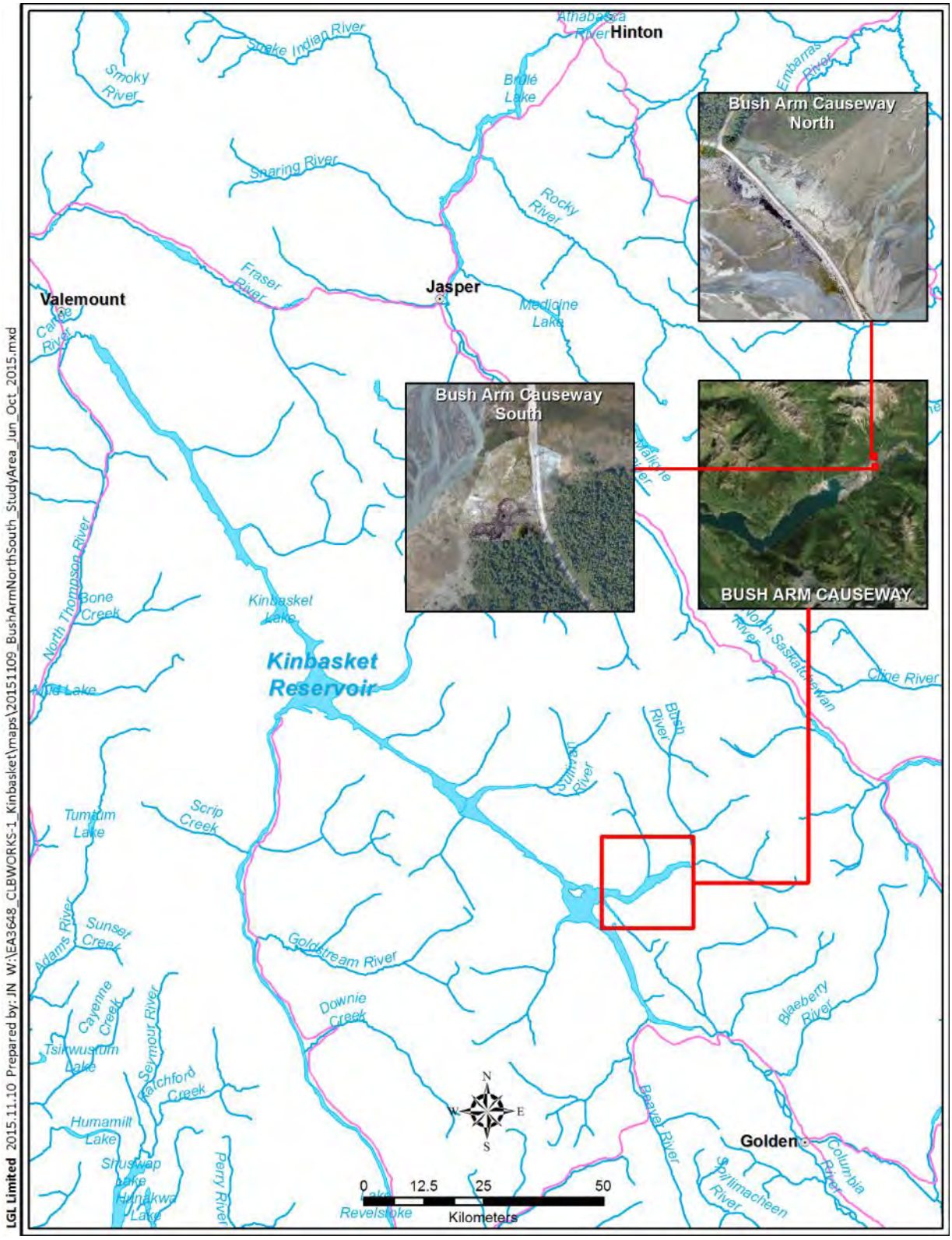

Figure 2-3: Location of 2015 physical works project locations relative to Kinbasket Reservoir.

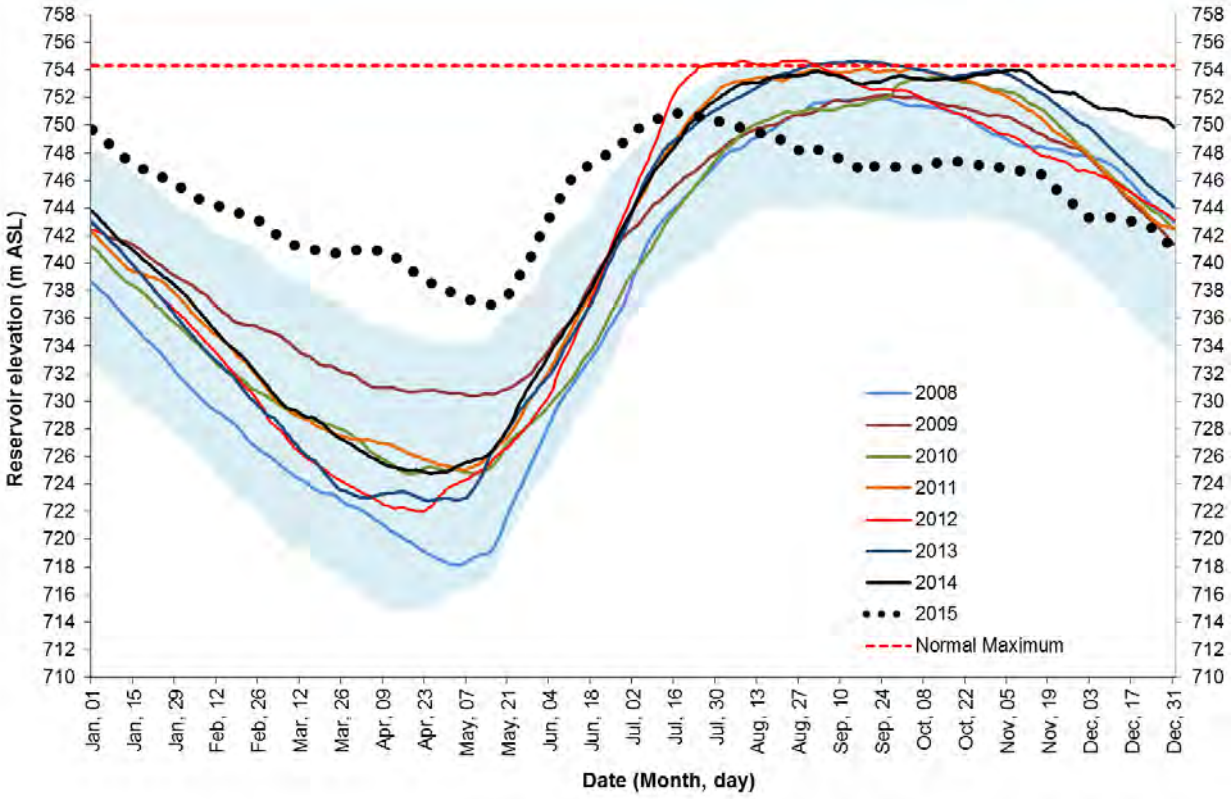

Figure 2-4: Kinbasket Reservoir elevations 2008 to 2015. The shaded region delineates the 10th and 90th percentile in reservoir elevation (1977 to 2015).

Five areas (Figure 2-5) were selected for the CLBWORKS-1 pilot study based on the following criteria:

1. They were readily accessible by land and water, meaning it would be relatively easy to get equipment and people into each site;
2. Each site has an abundance of wood debris on site that can be used to build the mounds and wind rows;
3. Each site has been treated in the past under CLBWORKS-1 using revegetation applications. These sites were selected for that part of the program because of their position in the drawdown zone (upper 5 m), their topography (relatively flat or gently sloping), and because some of the drawdown zone in those locations was vegetated, suggesting that they would be suitable receptor sites;
4. Each site is adjacent to upland forest. This is important because of the potential for existing seed banks or plants to migrate into the drawdown zone after the mounds and wind rows have been built. If the mounds and wind rows effectively protect portions of the drawdown zone or provide suitable substrates for vegetation establishment and development, then the areas behind the mounds and wind rows could be colonized naturally;
5. Each site represents a slightly different mix of exposure, slope, aspect, substrate type, and wood debris accumulation potential or history. Each site also has different existing wildlife habitat suitability. Having different sites representing different conditions will

help determine which combinations of site characteristics are associated with the highest degree of success; and

6. Low potential for habitat manipulations to result in or contribute to fish stranding.

In 2015 reservoir elevations were lower than anticipated for the fall field work, which precluded the use of a tug and barge to transport equipment to each location. For this reason only the two Bush Arm Causeway sites (Causeway North and Causeway South) were treated (Figure 2-4; Figure 2-5).

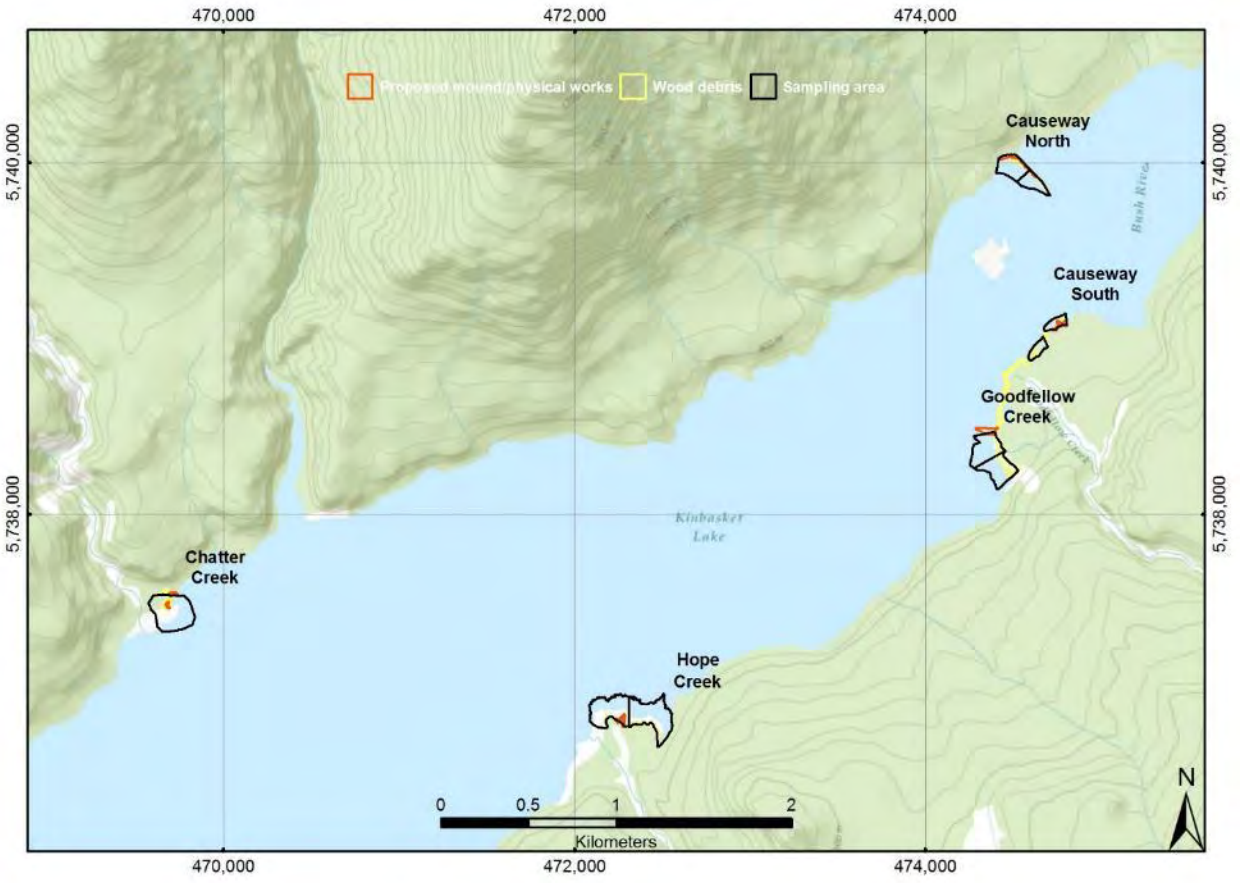

Figure 2-5: Location of proposed physical works locations in Bush Arm, Kinbasket Reservoir

3 GENERAL METHODS

3.1 Rationale and Approach

Wood debris and soil mounds were constructed using available on site materials. In all cases the site-specific prescriptions (Hawkes 2015b, see appendix) were variations of the same construction process of using wood debris and local substrates to create mounds that are elevated above the normal full pool reservoir elevation (i.e., 754.38 m ASL). The shape and size of the mounds varied by site. Similarly, live stakes or sedges for planting were obtained on site, thus only plants adapted to the local environment were used. The actual realized size and configuration of the mounds was dependent on the volume of wood debris available at each site and on site-specific characteristics and objectives.

3.2 Objectives

In general, the objectives for wood debris clearing and mound construction were the same for each of the five sites selected for this pilot program and included:

1. Using existing on-site resources (wood debris and soil / substrate) to create mounds of various shapes and sizes;
2. Planting the mounds with woody-stemmed live stakes (black cottonwood, red-osier dogwood, and willows);
3. Increasing species diversity and cover by placing the mounds close to existing vegetation at the higher elevations of the drawdown zone;
4. Over time, improving wildlife habitat suitability for songbirds by providing nesting and perching habitat and for ungulates by providing browse; and
5. Protecting sensitive habitat or existing vegetation communities where possible.

3.3 Construction Methods

Construction included the excavation and movement of wood debris and substrate using hydraulic excavators. No off-site material was used for mound construction. All excavated material was retained and added to the mounds to assist in mound stabilization and to provide a substrate into which live stakes could be planted.

Debris mound construction required some minor excavation at each site to create a shallow pit that approximated the area of the base of each mound. Additional minor excavations were required to obtain substrates to use in the mounds, particularly where vegetation was planted. Large logs and root wads were placed in the excavation and used to form a 'nest' for the remainder of the material (Figure 3-1). The root wads were placed with roots facing away from the centre of the mound and large logs were interlaced throughout the wads. Smaller wood material was placed in the centre of the nest and overlain with whatever substrate was on site (Figure 3-1). This pattern was repeated until the mound achieved the target elevation for the site, which was generally just at or above the normal operating maximum elevation of 754.38 m ASL. The mounds were comprised primarily of wood with some substrate (approx. 80:20 ratio[3]). Where possible, existing features (existing trees and shrubs) were incorporated into the mounds to increase the suitability and size of the mounds.

[3] The relationship between the ratio of wood to substrate and mound integrity (resistance to erosion), plant establishment and persistence etc. has not been tested.

Figure 3-1: Examples of root wads used in mound construction (left), placement of sill log (to anchor the mound) and cross pieces (top right) and filling in excavation with small woody debris and soil (bottom Right).

Structural loads on the mound structures will consist primarily of hydrostatic forces and wave and erosive forces. The amount and type of loading will depend on weather conditions and the reservoir operating regime. Wave wash and scouring by wood debris will be the primary environmental forces acting on the mound when the reservoir elevation exceeds 753 m ASL. To resist these loads, the sides of the mounds were compacted to a suitable level to minimize future settlement. Additionally, to reduce or prevent erosion the mounds were constructed at relatively gentle side slopes of 6:1 (horizontal:vertical) or flatter. To resist erosive wave forces, the edge of the mound exposed to the prevailing wind was armored with larger logs and root wads.

Site-specific prescriptions were developed prior to the start of construction (Hawkes 2015b) and functioned to guide the creation of habitat features at each site. The final (realized) construction of each feature was dictated by logistical constraints such as the availability of material, site topography, and the incorporation of existing features into the final design.

3.4 Permitting

No specific permits were required for mound construction or monitoring. The physical works were constructed within the drawdown zone of a navigable water as listed on the Scheduled Waters under the Navigable Protection Act (NPA). The proposed physical works were self-assessed against the Minor Works Order of the NPA and following the assessment, it was determined that a Notice to the Minister was not required as the works

were being done for erosion-protection purposes. These kinds of activities are exempted from the NPA review process, provided the proposed works meet all criteria associated with the Minor Works Order of the NPA.

The drawdown zone of Kinbasket Reservoir has some level of archaeological potential, which is elevated by certain landscape features such as creeks, level areas, and terrace margins (P. Vigneault, BC Hydro, e-mail correspondence Sept, 10, 2015). To document any archaeological or heritage resource found during the construction process, archaeological monitories from three First Nations (Ktunaxa, Okanagan Indian Band, and Splatsin) were on site during construction. The monitories followed BC Hydro's guidelines for heritage and archaeology awareness (ENV-028), which included visual assessments of each construction site during excavation and wood debris removal. If artifacts were located, work would stop and the site would be flagged and georeferenced for subsequent follow-up.

Construction occurred outside of the biological window associated with breeding birds and no work was conducted in or about a stream.

Other considerations related to the physical works pilot project (e.g., reservoir operations, public safety, wildlife, and monitoring) are provided in Hawkes (2015b).

Additional site-specific information can be found in Hawkes (2015b and see appendix).

4 SITE-SPECIFIC PRESCRIPTIONS AND 2015 OUTCOMES

4.1 Bush Arm Causeway - South

4.1.1 Overview

Two distinct but related treatments were applied at the Bush Arm Causeway South site: 1) wood debris removal and 2) mound creation. Wood debris removal was required to obtain wood for mound construction but should also facilitate vegetation regrowth in the cleared areas.

4.1.2 Rationale and Objectives

The expansion of vegetation in the drawdown zone is hindered by the accumulation of wood debris. Transforming wood cover into a substrate suitable for planting live stakes will contribute to the expansion of woody-stemmed species in the drawdown zone. Removing wood debris from portions of the drawdown zone will contribute to the natural establishment of vegetation. Overtime, extending the cover of trees and other vegetation in the drawdown zone will enhance the suitability of the drawdown zone for wildlife.

The objectives for wood debris removal, windrow, and mound construction at Bush Arm Causeway South include the objectives listed in Section 3.2 and the following:

1. Create a wood debris mound extending from the high water mark (tree edge) that extends in to the drawdown zone that links current high points; and
2. Assess the efficacy of wood debris removal at this location in promoting the establishment and development of vegetation.

4.1.3 Site Description

The Bush Arm Causeway South site is located in the southeast corner of Bush Arm at ~63 km along the Bush Forest service Road, at the southwest end of the causeway (Figure

2-5). The topography at the site is undulating with some naturally occurring high points that provide habitat for trees (cottonwood). Elevation at the site ranges from 751 to 755 m ASL. A conservative estimate of the volume (m^3) of wood debris available at the site prior to construction was 7,157 m^3. Additional site-specific information on the Bush Arm Causeway site can be found in Hawkes (2015b). Pre-construction site photos (July and September 2015) are provided below (Figure 4-1).

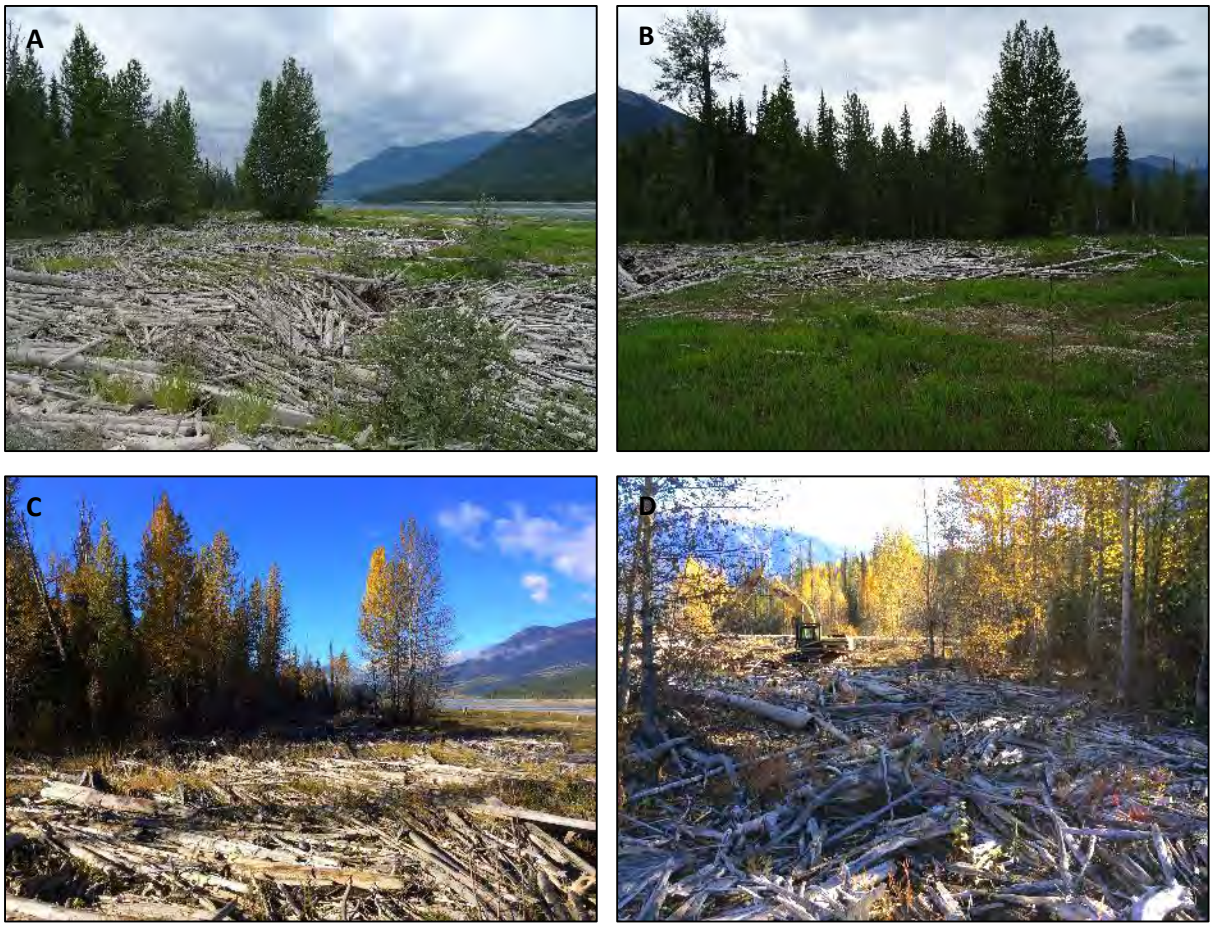

Figure 4-1: Examples of vegetation cover and wood debris distribution at the Bush Arm Causeway South site prior to construction in summer 2015 (A and B) and during construction in the fall (C and D). Summer photos dated July 15, 2015; fall photos dated Sept. 28, 2015.

4.1.4 Construction

Work occurred between September 28 and October 1, 2015. Prior to the scheduled start date, the excavator (Caterpillar 325B) was transported to site. An on-site meeting was held prior to construction to discuss the general layout of the mounds and total area to be cleared. Work progressed as follows:

1. **Wood debris clearing, piling, and sorting.** The cover of wood debris at the site was extensive and needed to be cleared. Large logs and root wads were sorted and piled for later use in the mound construction. All other materials were removed from the mound construction site and piled for later use (Figure 4-2).

Figure 4-2: Removing wood debris and sorting large logs at the Bush Causeway South site, September 28, 2015.

2. **Excavation and log placement:** To create the base for the mounds the ground was excavated to a depth of approximately 100 cm. A sill log was placed at the face of the mound (facing the reservoir) and larger logs were laced perpendicular to the sill log (Figure 4-3). The sill and base logs were anchored into place by inserting one end of the base logs into the soil and compressing the sill log into the soil with the excavator bucket.

Figure 4-3: Excavating the 'nest' for the sill logs and fill (left) and placing the sill logs and perpendicular base logs at the mound at Bush Arm Causeway South.

3. **Excavation fill (small woody debris and soil):** To fill the nest and cover the base and sill logs, smaller logs, debris and soil were placed into the nest. The layers of wood, debris, and soil were compacted using the excavator bucket (Figure 4-4).

Figure 4-4: Filling the 'nest' with smaller logs, debris and soil.

4. **Mound creation: wood and soil piling.** Mound creation occurred through the addition of woody material and soil until a desired height was achieved. In this case, the target elevation of the top of the mound was 754.68 m ASL or approximately 1.7 m above ground at this location. The completed mound is shown in Figure 4-5.

Figure 4-5: The completed mounds at the Bush Arm Causeway south location showing the matrix of substrate and woody debris with a rough surface.

5. **Site cleanup and live-staking.** Following mound creation, the area cleared of woody debris was treated to remove compaction areas and the soil was loosened and furrowed to promote vegetation regrowth (Figure 4-6). Live stakes were planted throughout the mound (n = 48; Figure 4-6). Stakes were mainly black cottonwood (two were red-osier dogwood). The depth, height above ground, and diameter of each stake was measured to determine if these variables affected regrowth (Figure 4-7). The performance of the live stakes will be assessed in spring 2016.

Figure 4-6: Land following de-compaction and furrowing to promote the re-establishment of vegetation at the Bush Arm Causeway South location (left) and live stakes planted in one of the mounds (right).

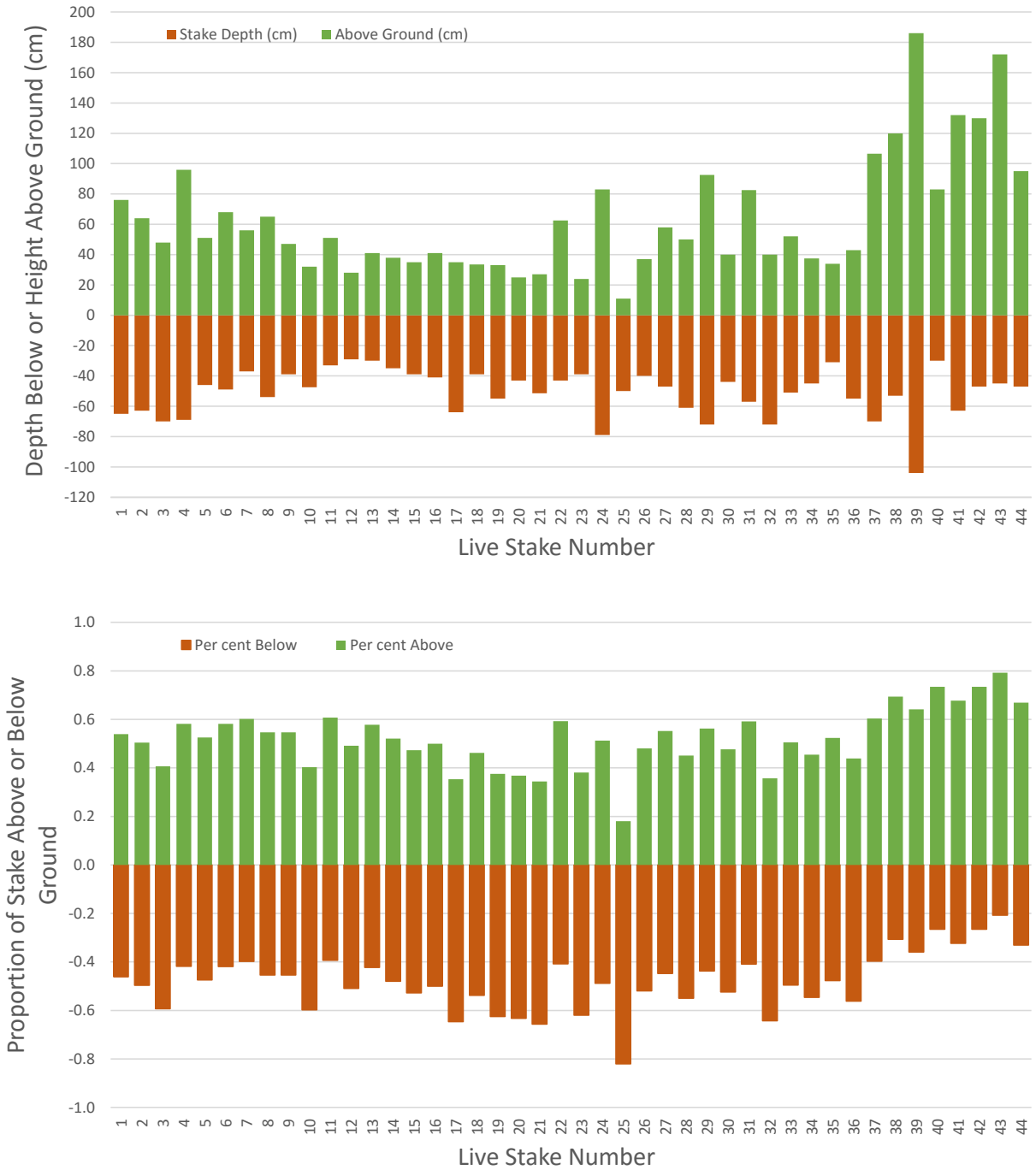

Figure 4-7: Planting depth and height above ground (top) and proportion of stake above and below ground (bottom) for live stakes planted in the larger mound at the Bush Causeway South site. Two additional live stakes were planted at this site (1) depth: 45 cm; height above ground: 1,560 cm, 2) 56 cm deep; 638 cm height above ground). Live stake diameter ranged from 8.0 to 40.0 mm, mean = 23.5 mm.

6. **Archaeological Monitoring:** Throughout the construction process, archaeological monitors were on site to assess cleared and excavated areas for artifacts (Figure 4-8). No artifacts were documented during the construction process.

Figure 4-8: Archaeology monitors visually assess the area cleared of woody debris prior to excavation.

7. **Site Measurement**: All features created at each site were measured in the field using a handheld GPS receiver. A drone was used to capture aerial images of the site prior to construction in July and immediately following construction in October. The GPS data and aerial imagery were loaded into a GIS to delineate the shape and extent of each feature created at each site.
8. **As-Built:** The total area manipulated was 4,119 m^2, resulting in the creation of two mounds; the removal of wood debris from 2,999 m^2 of land; and the incorporation of 572 m^2 of existing habitat (Table 4-1). The two mounds created were 134.6 m^2 and 413.1 m^2. The larger mound was situated between 753.2 m and 754.5 mASL with an average height of 1.5 to 2 m above ground. The smaller mound was similar in height and was built between 753.5 and 754.4 mASL. Aerial imagery of the Bush Arm Causeway site before and after construction is provided in Figure 4-9.

Table 4-1: Details (area and elevation) for each construction type at Bush Causeway South, Kinbasket Reservoir.

		Area (m^2)				Elevation (m ASL)		
Type	**polygons**	**Min**	**Max**	**Mean**	**Total**	**Min**	**Max**	**Mean**
Cleared Habitat	1	2999	2999	2999	2999	751.97	754.54	753.34
Mound	2	135	413	274	548	753.18	754.38	753.79
Uncleared Area	1	572	572	572	572	752.24	753.95	753.20

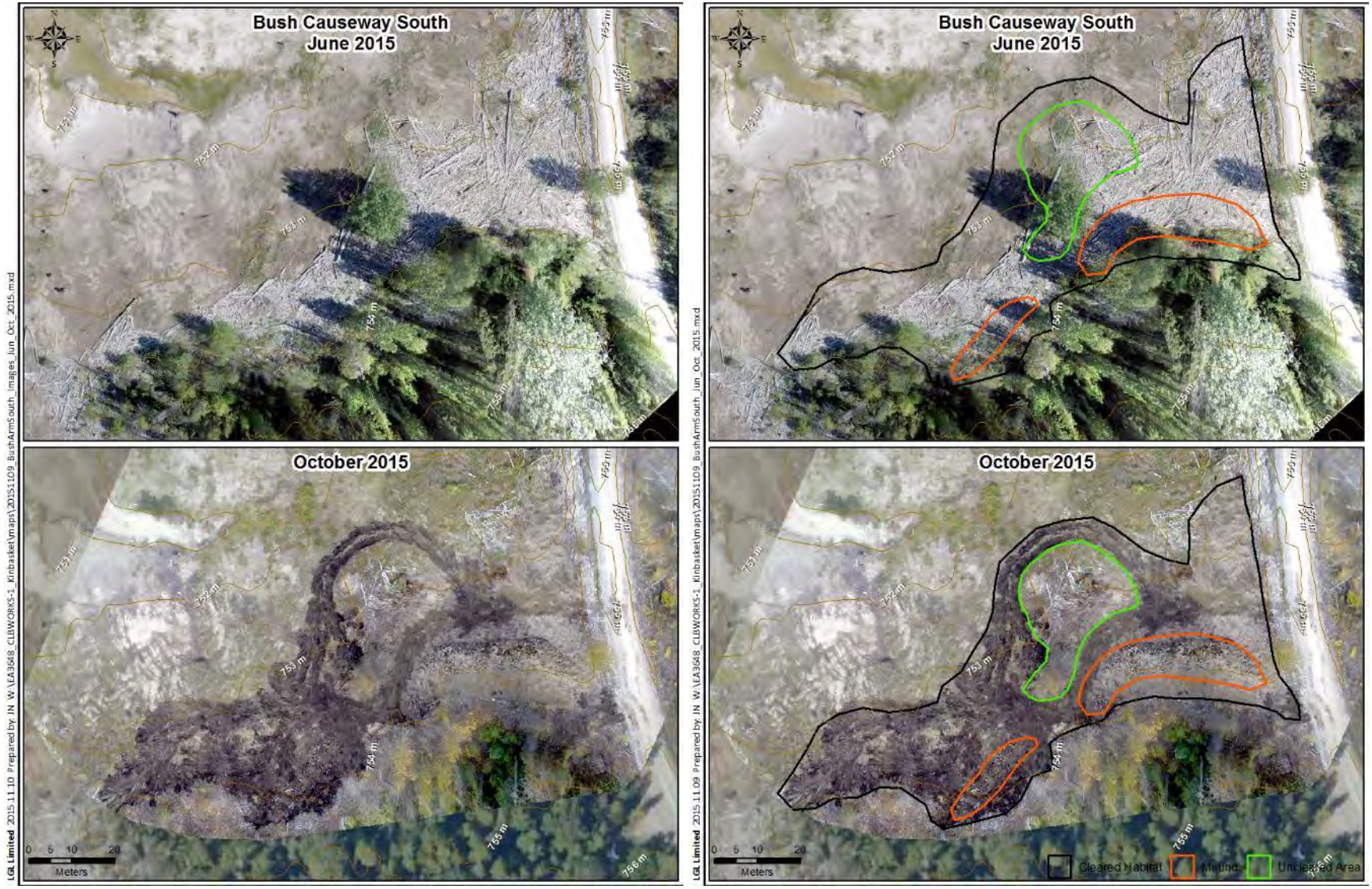

Figure 4-9: The Bush Causeway South site prior to construction (top left) and following clearing and construction of the mounds (bottom left). The addition of polygons delineating the area cleared, the area not cleared, and the two mounds is provided for context (top right, bottom right). Images obtained via drone (operated by Murray Chapple, Sterling Lumber)

4.1.5 Performance Measures

The following performance measures were developed to assess the success of the physical works projects at Bush Arm Causeway South. Bolded text indicates the current status of performance measures.

1. Creation of a mound as described in Hawkes (2015b) that persists during all seasons and following inundation;
   Two mounds were built following the specification in Hawkes (2015). Assessments in 2016 and 2017 are required to determine how well the mounds persist during all seasons and during inundation.
2. Little to no erosion of the mound following inundation and winter. Erosion will be determined using aerial photos obtained from a drone. Photos will be acquired immediately following mound creation and again following inundation or the winter season;
   Assessments of erosion and mound integrity following the winter season will be made in early 2016. Aerial photos were obtained pre- and post-construction and should be acquired again in the spring and fall 2016 to assess post-winter integrity, integrity following a growing season, and if the reservoir exceeds the base elevation of the mounds, photos should be acquired as soon as the water retreats to elevations below the base of the mound.
3. Survival of at least 50 per cent for all planted live stakes for all species;
   This performance measure will not be assessed until spring 2016 (in part).
4. Successful natural establishment of vegetation common to the site at the wood debris removal sites and on the mound;
   Preliminary assessments of vegetation establishment will commence in late spring/early summer 2016. Additional live-staking should be considered for spring 2016 to enable an assessments of differential survivorship or vigor between fall and spring-planted live stakes.
5. Successful protection / retention of currently vegetated areas adjacent to the mound;
   This performance measure will not be assessed until spring 2016 (in part).
6. Provision of wildlife habitat for insects, songbirds, and small mammals;
   This performance measure will not be assessed until spring 2016 (in part).
7. Continued evidence of use of the Bush Arm Causeway South area by wildlife (e.g., mule deer, moose, and black bear).
   This performance measure will not be assessed until spring 2016 (in part).
8. No evidence of pond creation around the base or behind the mound (to avoid fish stranding); and
   This performance measure will not be assessed until spring 2016 (in part).
9. No negative impacts to existing wetland habitat near the proposed construction site.
   This performance measure will not be assessed until spring 2016 (in part).

4.2 Bush Arm Causeway – North

4.2.1 Overview

Three distinct but related treatments were applied at the Bush Arm Causeway North site: 1) wood debris removal; 2) windrow creation; and 3) mound creation. In addition, wood was removed from several ponds to enhance the value of those ponds for pond-breeding

amphibians and birds. Wood debris removal was required to construct the windrows and mounds and vegetation should regrow naturally in the cleared areas. Emphasis was on maintaining the integrity of much of the site, which already possesses high vegetation and wildlife values relative to other areas in the drawdown zone. The prescription developed for this location (Hawkes 2015b) took into consideration existing site conditions that lent themselves to the proposed works.

4.2.2 Site Description

The Bush Arm Causeway North site is located in the northeast corner of Bush Arm at ~63 km along the Bush Forest service Road. Mound and windrow construction occurred adjacent to the causeway and the ponds cleared at the site were also adjacent to the causeway. All physical works locations were located in the drawdown zone of Kinbasket Reservoir. The topography at the site is gently sloping with minor undulations. Elevation at the site ranges from 752 to 754 m ASL. A conservative estimate of the volume (m^3) of wood debris available at the site prior to construction was 4,008 m^3. Additional site-specific information on the Bush Arm Causeway North site can be found in Hawkes (2015). Pre-construction site photos (July and September 2015) are provided below (Figure 4-10).

Figure 4-10: Examples of vegetation cover and wood debris distribution at the Bush Arm Causeway North site prior to construction in summer 2015 (top panel) and during construction in the fall (bottom panel). Summer photos dated July 15, 2015; fall photos dated Sept. 30, 2015.

4.2.3 Construction

Work occurred between September 30 and October 1 2015. Prior to the scheduled start date, the excavator (Caterpillar 325B) was transported to site. An on-site meeting was held prior to construction to discuss the general layout of the mounds and total area to be cleared. Work progressed as follows:

1. **Wood debris clearing, piling, and sorting.** The cover of wood debris at the site was extensive and needed to be cleared. Large logs and root wads were sorted and piled for later use in the mound construction. All other materials were removed from the mound construction site and piled for later use (Figure 4-11).

Figure 4-11: Removing wood debris and clearing the ground at the Bush Causeway North Site, September 29, 2015.

2. **Excavation and log placement:** To create the base for the mounds the ground was excavated to a depth of approximately 100 cm. Large logs were placed at the face of the mound (facing the reservoir) (Figure 4-12). The sill and base logs were anchored into place by inserting one end of the base logs into the soil and compressing the sill log into the soil with the excavator bucket. Large root wads were inserted into the face of the mound to form a protective barrier.

Figure 4-12: Excavating the 'nest' for the sill logs and fill, and placing the sill logs and anchoring the root wads are log logs by back filling the area behind the root wad.

3. **Excavation fill (small woody debris and soil):** The excavation area, root wads, and logs were covered with layers of smaller wood debris and soil (from the excavation). The completed island mound and surrounding drawdown zone habitat are shown in Figure 4-13.

Figure 4-13: Covering the mound with smaller logs and substrate excavated from the site.

4. **Mound creation: wood and soil piling.** Mound creation occurred through the addition of woody material and soil until a desired height was achieved. In this case, the target elevation of the top of the mound was 754.68 mASL or approximately 1.7 m above ground at this location. This is roughly the elevation of the causeway roadbed. An example of the completed physical works at the Bush Arm Causeway North site is shown in Figure 4-14.

Figure 4-14: Some of the completed mounds at the Bush Arm Causeway north location showing the height of the mounds relative to the existing causeway. In this locations mounds were built perpendicular and parallel to the existing roadbed.

5. **Pond cleaning and creation:** In addition to the creation of mounds and wind rows at the Bush Arm Causeway North location, wood debris was removed from several existing ponds. In total, three ponds were cleaned of wood debris, providing an additional 978 m^2 of pond habitat for wildlife in the drawdown zone that was previously unavailable. Examples of the ponds (before and after) clearing are provided in Figure 4-15.

Figure 4-15: Before and after photos of pond clearing and cleanup at the Bush Arm Causeway north location. Note the positioning of a large sill log in the top right. The bottom panels are of the same pond, but from different perspectives to show the wood accumulation (bottom left) and cleaned pond (bottom right) with the retention of peat islands

The utility of transplanting sedges was trialed at one location. In this case we simply moved sedges from one side of the cleaned pond to the other (Figure 4-16).

Figure 4-16: Transplanting sedges (*Carex aquatilis, C. utriculata, and C. lasiocarpa*) at the Bush Arm Causeway North site. Only locally available plants were used

6. **Site cleanup.** Following mound creation and pond cleaning, the area cleared of wood debris was treated to remove compaction areas and the soil was loosened and furrowed to promote vegetation regrowth (Figure 4-17).

Figure 4-17: Completed physical works at Bush Arm Causeway North showing a cleaned pond (left) and land prepared the re-establishment of vegetation (right, foreground)

7. **Archaeological Monitoring:** Throughout the construction process, archaeological monitors were on site to assess cleared and excavated areas for artifacts (see Figure 4-8). No artifacts were documented during the construction process.

8. **Site Measurement**: All features created at each site were measured in the field using a handheld GPS receiver. A drone was used to capture aerial images of the site prior to construction in July and immediately following construction in October. The GPS

data and aerial imagery were loaded into a GIS to delineate the shape and extent of each feature created at each site.

9. **As-Built:** The total area manipulated was 5,848 m^2, resulting in the creation of five mounds covering an area of 721.1 m^2 and cleaning of three ponds (total area: 977.7 m^2). In total, 3,957.8 m^2 of wood was removed and an additional 191.4 m^2 was not cleared in 2015 (Table 4-2). The five mounds created ranged in area from 85.7 m^2 to 256.6 m^2 and the elevation range over which the mounds were built ranged from 752.2 m ASL to 754.2 mASL. Aerial imagery of the Bush Arm Causeway North site before and after construction is provided in Figure 4-18.

Table 4-2: Details (area and elevation) for each construction type at Bush Causeway North, Kinbasket Reservoir.

		Elevation (mASL)		
Type	**Area (m^2)**	**Min**	**Max**	**Mean**
Cleared Habitat	1663.80	752.13	752.89	752.52
Cleared Habitat	129.30	752.23	753.03	752.55
Cleared Habitat	200.54	752.37	753.34	752.64
Cleared Habitat	1964.21	752.13	754.24	752.60
Mound	256.63	752.33	754.18	752.57
Mound	183.84	752.27	752.99	752.68
Mound	86.70	752.29	753.99	752.64
Mound	85.76	752.20	753.28	752.50
Mound	108.25	752.58	752.87	752.73
Pond	124.69	752.15	752.42	752.25
Pond	159.87	752.11	752.32	752.17
Pond	693.16	752.25	752.59	752.42
Uncleared Area	2.33	752.43	752.50	752.46
Uncleared Area	35.98	752.28	752.44	752.35
Uncleared Area	13.64	752.46	752.50	752.49
Uncleared Area	2.91	752.39	752.43	752.41
Uncleared Area	10.96	752.41	752.57	752.48
Uncleared Area	125.60	752.35	752.65	752.47

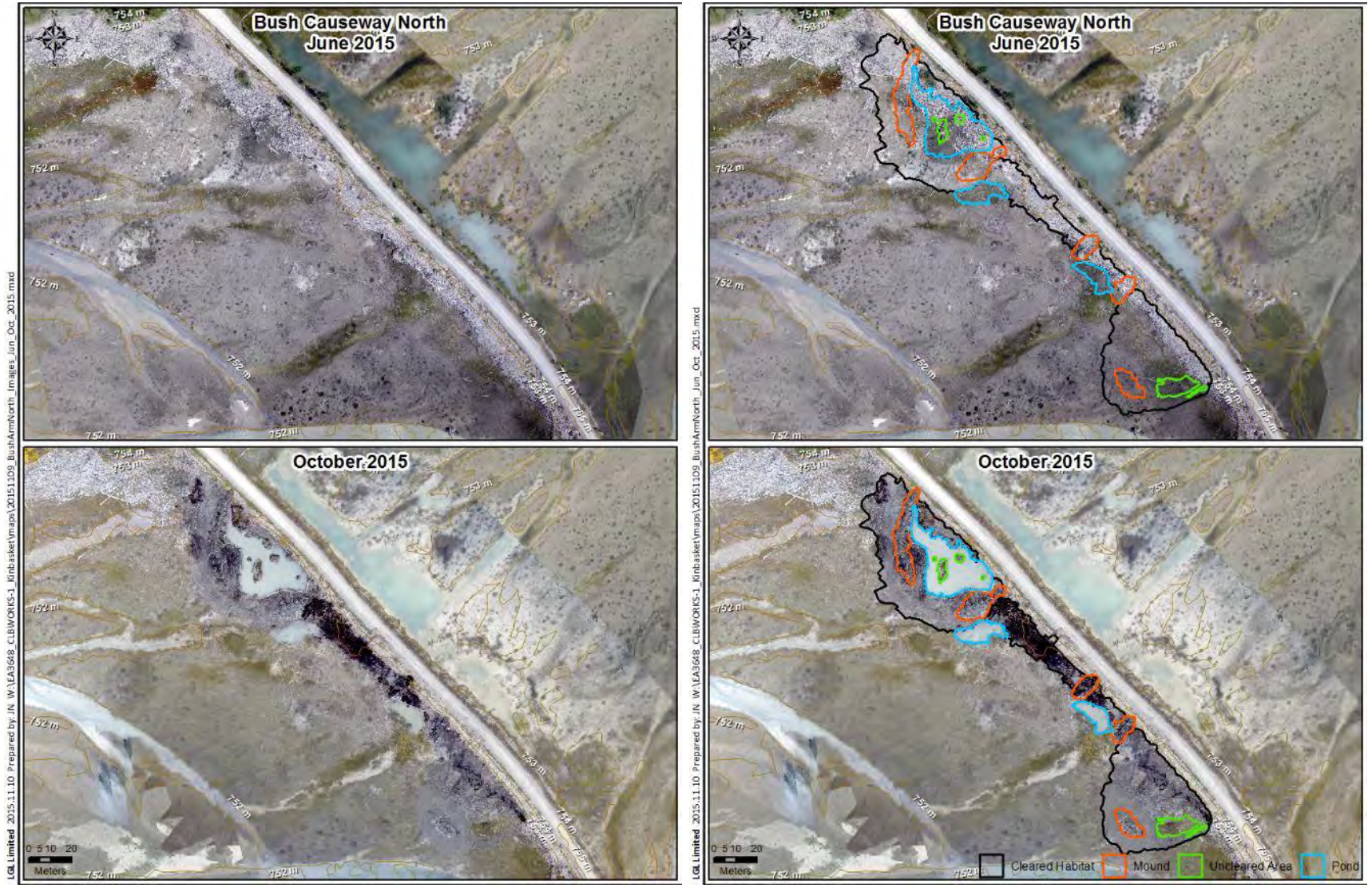

Figure 4-18: The Bush Causeway North site prior to construction (top left) and following clearing and construction of the mounds (bottom left). The addition of polygons delineating the area cleared, the area not cleared, the mounds, and ponds is provided for context (top right, bottom right). Images obtained via drone (operated by Murray Chapple, Sterling Lumber)

4.2.4 Performance Measures

The following performance measures were developed (Hawkes 2015b) to assess the success of the physical works projects at Bush Arm Causeway North. Bolded text indicates the current status of performance measures.

1. Creation of a windrow and mound as described in Hawkes (2015) that persists during all seasons and following inundation;
   Five mounds were constructed, one of which is a stand-alone island. The islands and mounds are armored using local materials. Assessment of mound and island integrity are required to determine how well the mounds persist during all seasons and during inundation
2. Little to no erosion of the windrow and mound following inundation and winter. Erosion will be determined using aerial photos obtained from a drone. Photos will be acquired immediately following mound creation and again following inundation or the winter season;
   Assessments of erosion and mound integrity following the winter season will be made in early 2016. Aerial photos were obtained pre- and post-construction and should be acquired again in the spring and fall 2016 to assess post-winter integrity, integrity following a growing season, and if the reservoir exceeds the base elevation of the mounds, photos should be acquired as soon as the water retreats to elevations below the base of the mound.
3. Survival of at least 50 per cent for all trans-planted sedges;
   This performance measure will not be assessed until spring 2016 (in part).
4. Successful natural establishment of vegetation common to the site at the wood debris removal sites and on the mound;
   Preliminary assessments of vegetation establishment will commence in late spring/early summer 2016.
5. Successful protection / retention of currently vegetated areas adjacent to the mound;
   This performance measure will not be assessed until spring 2016 (in part).
6. Provision of wildlife habitat for amphibians, insects, songbirds, and small mammals;
   This performance measure will not be assessed until spring 2016 (in part).
7. Continued evidence of use of the area by wildlife (e.g., mule deer, moose, elk, black, and grizzly bear);
   This performance measure will not be assessed until spring 2016 (in part).
8. Reduction of wood debris in the wetlands and ponds such that the cover of native aquatic macrophytes increases by at least 10 percent; and
   This performance measure will not be assessed until spring 2016 (in part). A full assessment of this performance measure will not be possible until after at least one growing season.
9. Evidence of amphibian breeding in ponds with a reduced volume of wood debris (amphibians do not currently breed here, but they do breed across the causeway in existing ponds that are largely devoid of wood debris).
   This performance measure will not be assessed until spring 2016 (in part).

5 Conclusions and Recommendations

The objective of the 2015 physical works pilot project was to create habitat features in the drawdown zone of Kinbasket Reservoir using existing materials (wood debris and soil) that would increase topographic heterogeneity in an otherwise homogenous environment. Doing so should lead to increased vegetation establishment and improvements to wildlife habitat suitability over time. The use of mounding to increase topographic heterogeneity (e.g., Larkin et al. 2006) has been used to reclaim brackish marshes (Armitage et al. 2011), freshwater wetlands (Bruland and Richardson (2005), and grasslands (Hough-Snee et al. 2011). While the success of the methods used to create the mounds appears to vary, the application of mound creation to the drawdown zone of a hydroelectric reservoir presented a novel approach to habitat reclamation that required testing.

The 2015 pilot project to construct mounds and wind rows and clean ponds of wood debris in the drawdown zone of Kinbasket Reservoir resulted in the construction of seven mounds in two locations, the cleaning of three previously wood-choked ponds in one location, and the removal of 6,957 m^2 of wood from all areas. An additional 763.3 m^2 of uncleared land was incorporated into the physical works features created at the Bush Arm Causeway. In terms of the construction process and creation of physical works, the pilot project can be viewed as successful. However, the longer-term viability of the mounds and wind rows will not be known until there is another high water year in Kinbasket Reservoir. Similarly, the efficacy of the mounds and wind rows in functioning as receptors for vegetation cannot be assessed until at least one growing season has passed. The survivorship of live stakes and transplanted sedges will be assessed during the 2016 growing season during field work for other monitoring programs (e.g., CLBMON-10 or CLBMON-11A). Whether the cleaned ponds get used by amphibians, water-associated birds, or other wildlife will need to be assessed over time. It is likely that amphibians and birds will use the ponds in 2016 and assessments will be made during field work for CLBMON-11A and CLBMON-37. Following inundation, areas around the mounds and wind rows should also be assessed for slumping, which could increase the potential for fish stranding.

Although Hawkes (2015) provided prescriptions for up to five locations in Bush Arm, the area treated in 2015 was likely the maximum that could have been treated with available resources (in terms of time and heavy equipment). There was a learning curve associated with the creation of the mounds and the subsequent site-preparation to reduce soil compaction. If future physical works projects involving the removal and mounding of wood debris are considered by BC Hydro, additional resources (in terms of heavy equipment) will be required.

The methods employed for mound construction appeared efficient. Anecdotal information suggests that the cost of building mounds using on-site materials is similar to the costs associated with wood debris removal, piling and burning, supporting the notion that using wood debris in this manner is a cost-effective alternative to piling and burning.

Of the nine objectives, four were met (numbers 1 to 4) and five are pending (numbers 5 to 9) (see Section 1.2). Logistical constraints contributed to the implementation of physical works at two of the five sites identified and reservoir operations in 2015 precluded assessments of reservoir impacts on the mounds or a determination of whether mounds can exclude wood debris from the parts of the drawdown zone shoreward of the

constructed islands and windrows. Limited planting occurred in 2015, so the efficacy of various planting methods cannot be assessed at this time.

The following recommendations are made for future consideration:

1. The removal of wood from ponds should provide highly suitable wetland habitat in the drawdown zone of Kinbasket Reservoir. However, there is a high probability that wood could cover the wetlands again if the ponds are not adequately protected. The installation of a log boom around the Bush Arm Causeway North site is recommended to ensure the protection of the ponds, mounds, and islands built in this location. Alternatively, additional mounds could be built to keep wood out of the wetlands. If additional mounds are built, wood debris will likely need to be transported from other areas of the drawdown zone and existing ecological values (e.g., high plant diversity), and other monitoring programs (e.g., CLBMON-61) will need to be considered.
2. For future iterations of CLBWORKS-1, the use of at least two excavators is recommended. This will reduce the amount of time required to construct the physical works at each location and create efficiencies in terms of wood debris movement and mounding. Multiple excavators are recommended whenever mounds are being constructed in specific locations to protect shoreward values. Using additional machinery will reduce the overall impact to the ground and ensure materials are delivered and piled in specific locations.
3. Sites not treated in 2015 (Chatter Creek, Hope Creek, Goodfellow Creek) should be considered for future iterations of CLBWORKS-1. However, it is recommended that these works be postponed until the ability of existing mounds to withstand high reservoir levels can be assessed.
4. The prescriptions developed in 2015 focused solely on Bush Arm. Additional opportunities exist in other parts of Kinbasket Reservoir (e.g., Valemount Peatland) and site-specific prescriptions for future consideration could be prepared for those locations.
5. An assessment of live stakes and sedge transplants is recommended in 2016 to assess the utility of either or both of these methods to jump start the revegetation process on the mounds and in the drawdown zone surrounding the mounds (i.e., in the areas cleared of wood debris).
6. In addition to assessments of live stakes planted in the fall of 2015, additional live stakes and sedges could be planted in the spring of 2016 to assess whether there is a difference in growth and survivorship of fall vs. spring planted live stakes.
7. The use of a drone to acquire site specific and timely aerial photography of the mounds was very useful and additional photos of the mounds should be acquired in the spring of 2016. Those photos could be compared to the photos taken immediately following mound construction and pond clearing to assess whether there was any erosion or other changes associated with the features created or enhanced.
8. The productivity of the cleaned ponds should be determined. This could be accomplished during work associated with CLBMON-61. At a minimum, temperature, conductivity, and dissolved oxygen data loggers should be installed in at least one of the cleaned ponds to determine if the physicochemical properties of the cleaned pond are similar to other ponds in the drawdown zone.

9. Certain aspects of CLBWORKS-1 were not implemented completely in 2015. For example, testing various methods of vegetation establishment on the mounds was not possible in 2015 and should be considered for future iterations of CLBWORKS-1.

6 References

Adama, D. 2015. CLBWORKS-1 Kinbasket Reservoir Revegetation Program, 2014 Post-planting Report. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generations, Water License Requirements, Burnaby, BC. 20 pp + Appendices.

Armitage, A.R. C-K. Ho, E.N. Madrid, M.T. Bell, and A. Quigg. 2013. The influence of habitat construction technique on the ecological characteristics of a restored brackish marsh. Ecological Engineering 62: 33–42.

BC Hydro. 2007. Columbia River Project Water Use Plan. BC Hydro Generation, Burnaby B.C. 41 pp.

BC Hydro. 2015. Columbia River Project Water Use Plan. Kinbasket and Arrow Reservoirs revegetation management plan. Physical works terms of reference. CLBWORKS-1 Kinbasket Revegetation Physical Works Addendum 4. 11 pp.

Bruland, G.L. and C.J. Richardson. 2005. Hydrologic, edaphic, and vegetative responses to microtopographic reestablishment in a restored wetland. Restoration Ecology 13(3): 515–523.

Ewing, K., 2002. Mounding as a technique for restoration of prairie on a capped landfill in the Puget Sound lowlands. Restoration Ecology 10(2): 289–296.

Fenneman, J.D., and V.C. Hawkes. 2012. CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis. Annual Report – 2011. LGL Report EA3271. Unpublished report by LGL Limited, Sidney, B.C., for BC Hydro Generation, Water Licence Requirements, Castlegar, B.C. 78 pp. + Appendices.

Hawkes, V.C and P. Gibeau. 2015. CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources. Annual Report – 2014. LGL Report EA3532. Unpublished report by LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generations, Water License Requirements, Burnaby, B.C. 74 pp + Appendices.

Hawkes, V.C and P. Gibeau. 2015. CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources. Annual Report – 2014. LGL Report EA3532. Unpublished report by LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generations, Water License Requirements, Burnaby, B.C. 74 pp + Appendices.

Hawkes, V.C., 2015a. LGL Limited Contract No. 77816 Release 3: Debris boom installation, Valemount Peatland. Letter report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generations, Water License Requirements, Burnaby, B.C. February 18, 2015.

Hawkes, V.C. 2015b. CLBWORKS-1 Kinbasket Reservoir revegetation program: year 7 – 2015. Debris mound and wind row construction pilot program. Site Prescriptions. Unpublished report by LGL Limited environmental research associates, Sidney, B.C. for BC Hydro Generations, Water License Requirements, Burnaby, B.C., 49 pp.

Hawkes, V.C., C. Houwers, J.D. Fenneman, and J.E. Muir. 2007. Kinbasket and Arrow Lakes reservoir revegetation management plan: Kinbasket Reservoir inventory of vegetation resources. Annual Report – 2007. LGL Report EA1986. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generations, Water Licence Requirements, Burnaby, BC. 82 pp.

Hawkes, V.C., M.T. Miller, J.E. Muir, and P. Gibeau. 2013. CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis. Annual Report – 2013. LGL Report EA3453. Unpublished report by LGL Limited, Sidney, BC, for BC Hydro Generation, Water Licence Requirements, Castlegar, BC. 70 pp. + Appendices.

Hill, N.M., P.A. Keddy, and I.C. Wisheu. 1998. A hydrological model for predicting the effects of dams on the shoreline vegetation of lakes and reservoirs. Environmental Management, 22(5): 723–736

Hough-Snee, N., L.A. Long, L. Jeroue, and K. Ewing. 2011. Mounding alters environmental filters that drive plant community development in a novel grassland. Ecological Engineering 37(11): 1932–1936.

Keefer, M.E., R. Moody, K. Dixon, and A. Kennedy. 2011. Kinbasket Reservoir Revegetation Program Physical Works Report (2010). Report prepared by Keefer Ecological Services for BC Hydro. 41 pp. + Appendices.

Keefer, M.E., R. Moody, T.J. Ross, A. Chapman, and J. Meuleman. 2010. Kinbasket Reservoir Revegetation Program Physical Works Report (2009). Report prepared by Keefer Ecological Services for BC Hydro. 39 pp. + Appendices.

Keefer, M.E., T.J. Ross, and K. Kettenring. 2007. Kinbasket Reservoir Revegetation Program Physical Works (Phase 1) Site Verification and Seed Collection. Report prepared by Keefer Ecological Services for BC Hydro. 21 pp. + Appendices.

Keefer, M.E., T.J. Ross, T. Ehlers, and J. Meuleman. 2008. CLBWORKS-1 Kinbasket Reservoir Revegetation Program Physical Works Report (2008). Report prepared by Keefer Ecological Services for BC Hydro. 53 pp. + Appendices.

Larkin, D., G. Vivian-Smith, and J.B. Zedler. 2006. Chapter 7: Topographic heterogeneity theory and ecological restoration. Pages 142 – 164 *In*: D.A. Falk, M.A. Palmer, and J.B. Zedler (eds.). Foundations of Restoration Ecology. Society for Ecological Restoration International. Island Press. 364 pp.

Luken, J.O. and T.N. Bezold. 2000. Plant communities associated with different shoreline elements at Cave Run Lake, Kentucky. Wetlands, 20: 479–486.

Nilsson; C. A. Ekblad, M. Gardfjell and B. Carlberg. 1991. Long-Term effects of river regulation on river margin vegetation. The Journal of Applied Ecology, 28: 963–987.

Poff, N.L. and J.K.H. Zimmerman. 2010. Ecological responses to altered flow regimes: a literature review to inform the science and management of regulated rivers. Freshwater Biology 55: 194–205.

Van Geest, G.J., H. Coops, R.M.M. Roijackers, A.D. Buijse, and M. Scheffer. 2005. Succession of aquatic vegetation driven by reduced water-level fluctuations in floodplain lakes. Journal of Applied Ecology, 42: 251 – 260.

Werner, K.J. and J.B. Zedler. 2002. How sedge meadow soils, microtopograhy, and vegetation respond to sedimentation. Wetlands 22(3): 441–466.

Yazvenko, S.B. 2009. CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis. Sampling Design. Prepared for BC Hydro by LGL Limited, Sidney, B.C. 19 pp. + Appendices.

Yazvenko, S.B., V.C. Hawkes, and P. Gibeau. 2010. CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis. Annual Report – 2009. LGL Report EA3073. Unpublished report by LGL Limited, Sidney, B.C., for BC Hydro Generation, Water Licence Requirements, Castlegar, B.C. 83 pp. + Appendices.

Ye, C., K. Zhang, Q. Deng, and Q. Zhang. 2012. Plant communities in relation to flooding and soil characteristics in the water level fluctuation zone of the Three Gorges Reservoir, China. Environmental Science and Pollution Research. DOI: 10.1007/s11356-012-1148-x.

7 Appendix

KINBASKET AND ARROW LAKES RESERVOIRS REVEGETATION MANAGEMENT PLAN

CLBWORKS-1 Kinbasket Reservoir Revegetation Program

Year 7 – 2015
Debris Mounds and Wind Row Construction Pilot Program

Site Prescriptions

Prepared for

BC hydro

British Columbia Hydro and Power Authority

Vancouver, B.C.

Prepared by

Virgil C. Hawkes, M.Sc., R.P.Bio.
LGL Limited environmental research associates
9768 Second Street
Sidney, British Columbia, V8L 3Y8

September 2, 2015

LGL LIMITED
environmental research associates

Cover photos

From left to right: Debris in the drawdown zone of Kinbasket Reservoir at Hope Creek, Chatter Creek, and in Bush Arm. Photos © Virgil C. Hawkes.

TABLE OF CONTENTS

LIST OF FIGURES

1 INTRODUCTION

1.1 Summary

This document describes the physical works prescriptions for a pilot project in Bush Arm of Kinbasket Reservoir, The project will assess the efficacy of wood debris removal, debris mound construction, and windrow for establishing self-sustaining riparian vegetation communities (BC Hydro 2015). If successful, these physical works could function to increase vegetation cover and in turn help improve aesthetics, control dust, contribute to the protection of known cultural heritage sites from erosion and human access, enhance littoral productivity and create wildlife habitat. The enhancements align with BC Hydro's Water Use Plan Consultative Committee's (WUP CC) support of a reservoir-wide planting and enhancement program in lieu of operational changes (BC Hydro 2005). The work considered for 2015 builds on the restoration efforts that occurred between 2007 and 2014.

1.2 Background

The drawdown zone of a hydroelectric reservoir is a challenging environment for plants and animals, particularly when the annual change in reservoir elevation can be as much as 39 m. Flooding and flow alteration resulting from varied reservoir operations create complex disturbances that can modify entire ecosystems, with effects extending upstream and downstream of the dam (Nilsson *et al.* 1991; Hill *et al.* 1998; Luken and Bezold 2000; Van Geest *et al.* 2005, Poff and Zimmerman 2010, Ye *et al.* 2012). Currently, little is known about the influence of dam operations on the structural and functional components of the terrestrial and semi-terrestrial plant communities that establish on reservoir shorelines within the zone of water level fluctuation (i.e. the drawdown zone). In 2007 BC Hydro initiated a monitoring program (CLBMON-10) to assess the distribution and spatial extent of existing vegetation communities in the drawdown zone of Kinbasket Reservoir. The results of that study indicate that substantial portions of the drawdown zone are vegetated to some degree with habitats higher in elevation associated with a higher cover of vegetation and increased species richness and diversity (Hawkes and Gibeau 2015). Despite this, vast areas of the drawdown remain sparsely vegetation or completely devoid of vegetation. Several factors contribute to this lack of vegetation including the timing, duration, and frequency of inundation, substrate type, soil moisture and nutrient regimes, erosion and sedimentation associated with wave action and reservoir flows, and wood debris accumulation and scouring.

To mitigate for the varied effects of reservoir operations on vegetation establishment and development in the drawdown zone of Kinbasket Reservoir, BC Hydro implemented CLBWORKS-1, a 10-yr, reservoir-wide restoration program to enhance sustainable vegetation growth in the drawdown zone of Kinbasket Reservoir for ecological and social benefits (BC Hydro 2008). Between 2008 and 2011, a total of 69.15 ha in 19 treatments areas in the drawdown zone of Kinbasket Reservoir was planted by Keefer Ecological Services (Keefer et al. 2007, 2008, 2010, 2011). Plug seedling treatments, particularly those involving Kellogg's sedge (*Carex lenticularis*) alone or mixed with other species, dominated the planting regime. Eight different revegetation prescriptions were applied during this time (Hawkes et al. 2013). CLBMON-9, an effectiveness monitoring study of the revegetation efforts, occurred between 2008 and 2013 (Yazvenko 2008; Yazvenko et al. 2009; Fenneman and Hawkes 2012, Hawkes et al. 2013). The results of CLBMON-9 indicate that the revegetation program was unsuccessful and did not contribute to enhancing sustainable vegetation growth in the upper elevations of the reservoir.

More recent efforts to enhance the vegetation in the upper elevations of Kinbasket Reservoir appear to have achieved greater short-term success. For example, larger sedge plugs planted at an ecologically suitable site in Bush Arm in 2013 (Adama 2015) and a log boom installed around a wetland in the Valemount Peatland following the clearing of wood debris in 2014 (Hawkes 2015) have both contributed to the establishment of vegetation in drawdown zone.

1.3 Rationale for Pilot Project

The construction of mounds to increase the heterogeneity of otherwise homogeneous habitats has contributed to the success of ecological restoration projects in a variety of ecosystems (Ewing et al. 2002; Bruland and Richardson, 2005; Werner and Zedler 2007; Hough-Snee et al. 2011). With respect to the drawdown zone of hydroelectric reservoirs, the use of debris mounds to increase topographic heterogeneity[1] was discussed during the Revegetation Technical Review in December 2014, a workshop to review the status of the revegetation and associated effectiveness monitoring programs in Kinbasket and Arrow Lakes Reservoir that occurred between 2007 and 2014. The application of these methods (mound creation) in a semi-aquatic (reservoir) ecosystem to increase topographic heterogeneity and promote the establishment and development of vegetation communities requires testing, which is the premise of this pilot study.

1.4 Goals, Objectives, and Scope

The goal of this pilot project is to assess the efficacy of constructed debris mounds and windrows for establishing self-sustaining riparian vegetation communities. It is hypothesized that planted mounds and windrows will promote the natural establishment of vegetation in the upper elevations of the drawdown zone (i.e., 750 to 754 m ASL) and that vegetation will naturally establish at wood debris removal sites. Further, it is hypothesized that terrestrial or wetland habitat behind the mounds and windrows will be protected from erosion via wind and wave action and from scouring and compaction associated with wood debris. Post-construction monitoring is required as the efficacy of constructed debris mounds and windrows to enhance vegetation establishment and development in the drawdown zone of a hydroelectric reservoir is untested. Further, the extent to which 'natural filters' (e.g., presence of woody debris, erosion, wave action, wind, substrate compaction, and human activity) impact the effectiveness of the mounds and windrows to enhance sustainable vegetation growth needs to be better understood:

To assess the potential impacts of these parameters on the integrity of the mounds and windrows, the following objectives for CLBWORKS-1 in 2015 were drafted:

1. Identify potential sites for assessing the application of windrows and mounds for enhancing vegetation and wildlife habitat in Kinbasket Reservoir;
2. Prepare site-specific construction specifications and restoration prescriptions for each pilot area;
3. Implement the restoration prescriptions at each site as per the site-specific construction specifications;

[1] Topographic heterogeneity is the pattern of elevation over a specific area and the contribution of various process (e.g., geological, hydrological, biological) that contribute to the development of a complex three-dimensional landscape that influences the composition and function of ecological processes (Larkin et al. 2006)

4. Specify pre- and post-treatment monitoring requirements (to be carried out under CLBMON-9 and CLBMON-11A) that will assess the efficacy of constructed debris mounds and windrows for establishing self-sustaining riparian vegetation communities. This will include an assessment of the:
    a. structural integrity of constructed wood debris and soil mounds and windrows in full reservoir pool conditions with the active natural processes on the reservoir (e.g., wave erosion); and
    b. the methods to establish vegetation on constructed wood debris and soil mounds/ windrows;
5. inform BC Hydro on how reservoir operations affect the structural integrity of wood debris and soil mounds/ windrows and determine if mitigation strategies can be developed to reduce these impacts;
6. Test methods to establish vegetation on constructed wood debris and soil mounds/ windrows;
7. Inform BC Hydro on to what extent constructed wood debris and soil mounds/ windrows exclude floating woody debris from the parts of the drawdown zone shoreward of the constructed islands and windrows;
8. Establish vegetation on the constructed mounds/ windrows and integration with the Kinbasket Debris Removal Program (CLBWORKS-1); and
9. Assess the effectiveness of the CLBWORKS-1 program including the effects of treatment methods and site-specific attributes using a cataloguing approach.

The scope of the pilot project is limited by the duration of the scope of series and duration of the contract (currently June 2015 to March 2016). During this time, wood debris mounds and windrows will be constructed at as many as 5 locations in 2015 (see below). This one year pilot project will strive to meet the aforementioned objectives; however, vegetation planting will need to occur in subsequent years. Further, post-restoration monitoring of the pilot treatments (under CLBMON-9 and CLBMON-11A) will not be possible until mid to late 2016, as such some of the objectives will not assessed under the current iteration of CLBWORKS-1. Moreover, an assessment of the effects of wave action or water-related impacts on the mounds and windrows and protection of vegetation from wood debris is not possible until the elevation of Kinbasket Reservoir exceeds 751 m ASL, which cannot be forecast with any degree of certainty. As such any spring-based assessments will need to be made during spring 2016 (likely in late April or early May depending on site access and environmental conditions). Conditions permitting, it may be possible to assess the effects of freezing and thawing and snow melt on the integrity of the mounds and windrows, which could also occur in spring 2016.

2 STUDY AREA

The approximately 216 km long Kinbasket Reservoir is located in southeastern B.C., and is surrounded by the Rocky and Monashee Mountain ranges (Figure 2-1). The Mica hydroelectric dam, located 135 km north of Revelstoke, B.C., spans the Columbia River and impounds Kinbasket Reservoir. The Mica powerhouse, completed in 1973, has a generating capacity of 1,805 MW, and Kinbasket Reservoir has a licensed storage volume of 12 million acre feet (MAF; BC Hydro 2007). The normal operating range of the reservoir is between 707.41 m and 754.38 m elevation, but can be operated to 754.68 m ASL with approval from the

Comptroller of Water Rights. A hydrograph of Kinbasket Reservoir between 2008 and 2014 is shown in Figure 2-2.

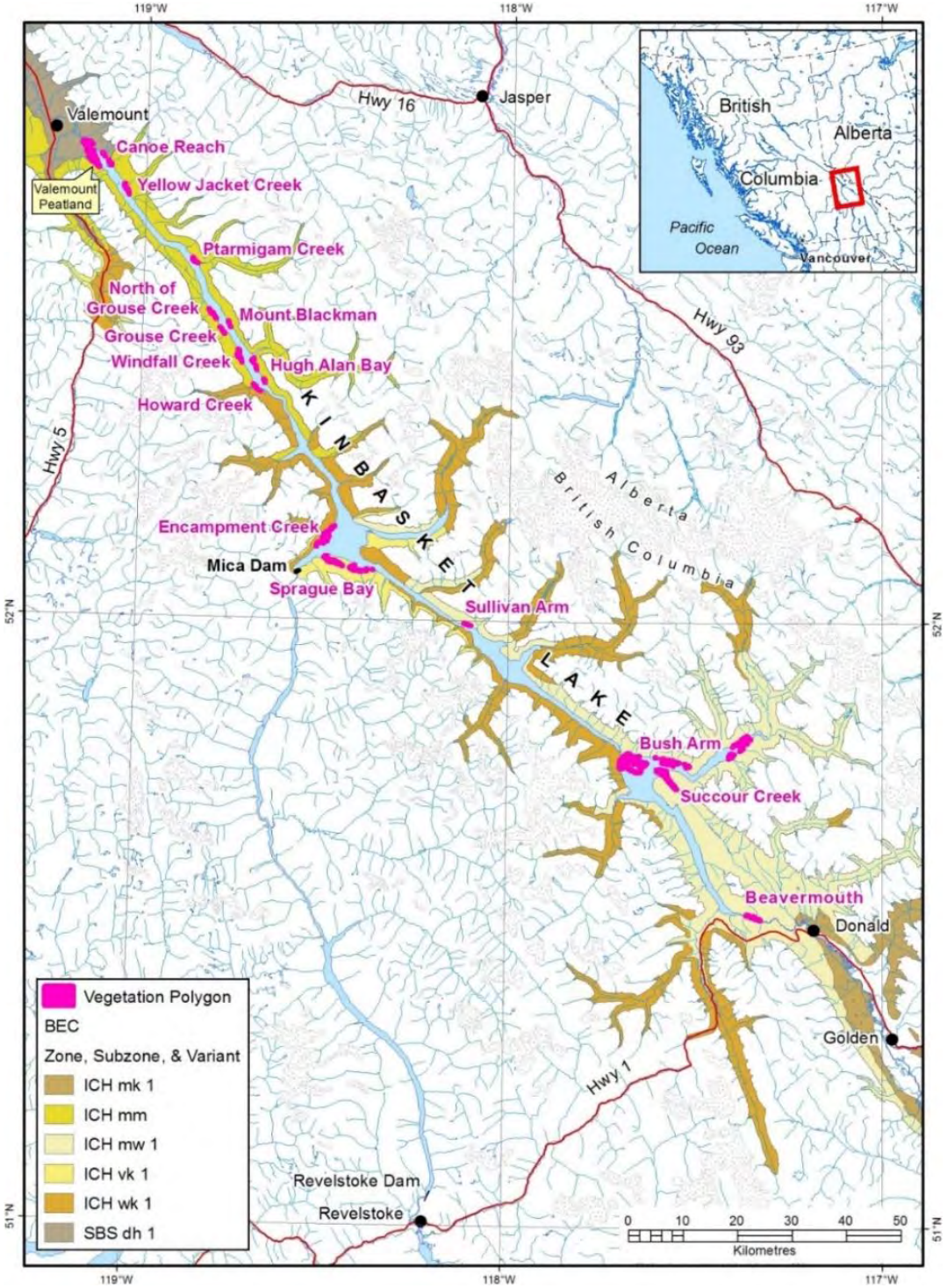

Figure 2-1: **Location of Kinbasket Reservoir in British Columbia. Previous vegetation sampling locations (pink areas) shown for reference to other Columbia Monitoring programs. Landscape unit names (e.g., Beavermouth, Encampment Creek) were assigned to each area sampled in 2007. Pink areas also denote the locations of aerial photograph acquisition (last acquisition: 2014)**

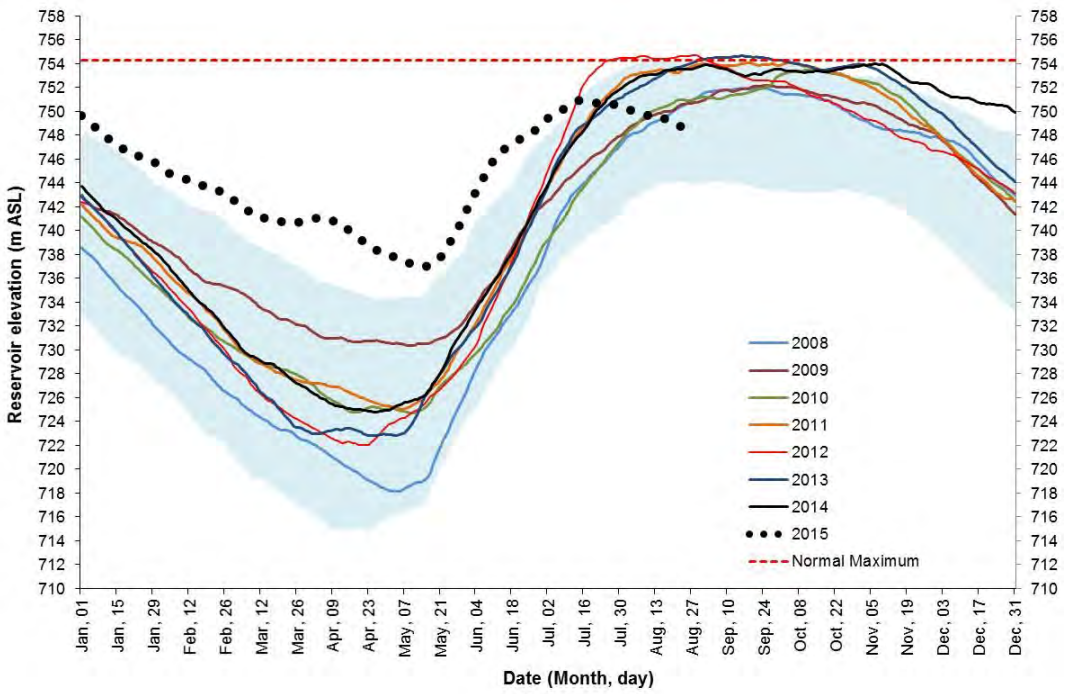

Figure 2-2: Kinbasket Reservoir elevations for 2008 through August 25, 2015. The shaded region delineates the 10th and 90th percentile in reservoir elevation (1977 to August 25, 2015).

For 2015, work associated with the construction of mounds and windrows will be confined to Bush Arm (Figure 2-2; Figure 2-3). The five areas were selected for the CLBWORKS-1 pilot study for the following reasons:

1. They were readily accessible by land and water, meaning it is relatively easy to get equipment and people into each site;
2. Each site has an abundance of wood debris on site that can be used to build the mounds and wind rows;
3. Each site has been treated in the past under CLBWORKS-1 using revegetation applications. These sites were selected for that part of the program because of their position in the drawdown zone (upper 5 m), their topography (relatively flat or gently sloping), and because some of the drawdown zone in those locations was vegetated, suggesting that they would be suitable receptor sites;
4. Each site is adjacent to upland forest. This is important because of the potential for existing seed banks or plants to migrate into the drawdown zone after the mounds and wind rows have been built. If the mounds and wind rows effectively protect portions of the drawdown zone or provide suitable substrates for vegetation establishment and development, then the areas behind the mounds and wind rows could be colonized naturally; and
5. Each site represents a slightly different mix of exposure, slope, aspect, substrate type, and wood debris accumulation potential or history. Each site also has different existing wildlife habitat suitability. Having different sites representing different conditions will help determine which combinations of site characteristics are associated with the highest degree of success.

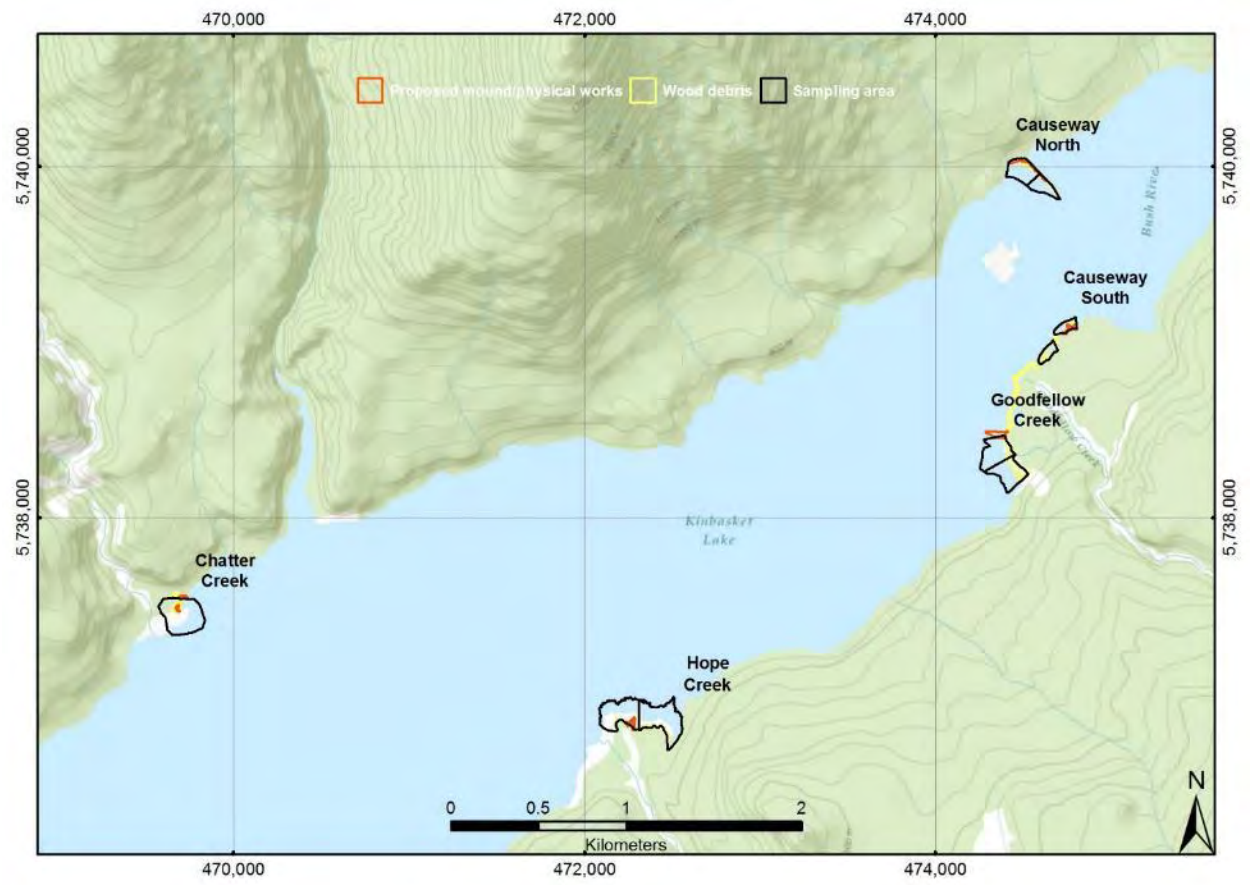

Figure 2-3: Location of proposed physical works locations in Bush Arm, Kinbasket Reservoir

3 GENERAL METHODS

3.1 Rationale and Approach

Vegetation cover and richness is limited in the drawdown zone of Kinbasket Reservoir. The clearing of wood debris, construction of mounds and windrows, and subsequent planting of the mounds and windrows is intended to assist with the establishment of vegetation communities that will potentially contribute to increased wildlife habitat suitability.

The proposed physical works will create mounds built using wood debris and substrates available on site. In all cases the prescriptions are variations of the same construction process of using wood debris and local substrates to create mounds that are elevated above the normal high reservoir elevation. The shape and size of the mounds varies by site. Similarly, live stakes for planting will be obtained on site or nearby, thus only plants adapted to the local environment will be used. The actual size and configuration of the mounds will depend on the volume of wood debris available at each site and on site-specific characteristics and objectives.

3.2 Objectives

In general, the objectives for wood debris clearing and mound construction are the same for each of the five sites selected for this pilot program and include:

1. Use existing on-site resources (wood debris and soil / substrate) to create mounds of various shapes and sizes;
2. Plant the mounds with woody-stemmed live stakes (balsam poplar and willows);
3. Increase species diversity and cover by placing the mounds close to existing vegetation at the higher elevations of the drawdown zone;
4. Over time, improve wildlife habitat suitability for songbirds by providing nesting and perching habitat and for ungulates by providing browse; and
5. Protect sensitive habitat or existing vegetation communities where possible.

Site specific objectives are provided with the site specific prescriptions (Section 5).

3.3 Construction Methods

Construction will consist of excavation and movement of wood debris and substrate using hydraulic excavators. No off-site material is proposed for mound construction. All excavated material will be retained and added to the mound to assist in mound stabilization and to provide a substrate into which live stakes can be planted.

Debris mound construction will require some minor excavation at each site to create a shallow pit that approximates the area of the base of the mound. Additional minor excavations may be required to obtain substrates to include in the mound into which vegetation can be planted. Large logs and root wads will be placed in the excavation created for the base of the mound to form a 'nest' for the remainder of the material. The root wads will be placed with roots facing away from the centre of the mound and large logs will be interlaced throughout the wads. Smaller wood material will be placed in the centre of the nest and overlain with whatever substrate is on site. This pattern will be repeated until the mound achieves the target elevation for the site and to ensure that the top of the mound will stick out of the water even when the reservoir is at full pool. The mound will be comprised primarily of wood with some substrate (approx. 80:20 ratio). Where possible, existing features will be incorporated into the mounds to increase the suitability and size of the mounds.

The elevation of the top of the mounds should be constructed so that the top of the mound is exposed for the entire year, even during surcharge events (which increase the maximum reservoir elevation from a normal of 754.38 to 754.68 m ASL).

Structural loads on the proposed dyke structure will consist primarily of hydrostatic forces and wave and erosive forces. To resist these loads, the sides of the mounds will compacted to a suitable level to minimize future settlement. Additionally, to reduce or prevent erosion the mounds will be constructed at relatively gentle side slopes of 6 (horizontal) to 1 (vertical) or flatter. To resist erosive wave forces, the edge of the mound exposed to the prevailing wind will be armored with larger logs and root wads.

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 and scouring by wood debris will be the primary environmental forces acting on the mound when the reservoir elevation exceeds 753 m ASL.

3.4 Permitting

No specific permits are required for mound construction or monitoring.

3.5 Considerations

3.5.1 Reservoir Operations

The elevation of Kinbasket Reservoir should be ≤ 750 m ASL at the time of construction to facilitate site access and construction. Most mounds will be built at elevations > 752 m ASL, which reduces the total volume of material required to ensure the mound height is greater than the normal maximum reservoir elevation (754.38 m ASL) and to incorporate the mounds into existing vegetation communities that are more prevalent at higher elevations.

3.5.2 Public Safety

Appropriate signage will be erected prior to and during construction. Given that the areas identified for the proposed physical works are 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 at a safe distance during construction activities.

3.5.3 Wildlife

The presence of wildlife at each of the proposed mound construction sites will be assessed prior to construction and during construction. Construction activities will occur outside of the songbird breeding period and if construction occurs near potential amphibian breeding ponds, visual encounter surveys will be conducted at the proposed construction site prior to commencing work. If any amphibians or reptiles are located they will be captured and moved away from the site. Capture and release of amphibians and reptiles is permitted under Wildlife Act Permit MRCB15-168515 issued to LGL Limited environmental research associates (valid through March 31, 2016).

3.5.4 Fisheries

At present the sites selected do not provide fisheries values for most of the year. The quality of fish habitat provided when the site is inundated has not been assessed. There are fish (mainly red-side shiner, *Cyprinella lutrensis*) in several small ponds at one location; however, these ponds will not be impacted by mound construction. The proposed mound construction is not specifically designed to enhance fish habitat, but fish could use the habitat around the edge of the mound when reservoir elevations are high enough. Given that the construction process required excavation, efforts will be made to ensure that depressions capable of entraining fish are not created. The design of the mounds and windrows will also preclude the collection of water behind the mounds, which could result in fish entrainment.

3.5.5 Archaeology

The proposed physical works will involve some ground disturbance activities. Ground disturbance depth is not unknown, but could be in the 50 to 100 cm range. An archaeological assessment was not completed as part of the development of the prescription and archaeological monitories will be onsite during excavation.

3.5.6 Recreation

The sites proposed for mound creation are associated with a low level of recreational use with limited access from the land or water. The proposed mound construction is not likely to impact current or future recreational use at the selected sites.

3.6 Performance Measures

Performance measures will vary by site, but general performance measures will include

- The persistence of the debris mounds and windrows constructed at each site following reservoir inundation;
- Survival of live stakes approximating 50% one year following planting;
- Measureable increase in vegetation cover at wood debris removal locations of at least 25%
- Limited ingrowth of non-native species

3.7 Monitoring

3.7.1 During Construction

Monitoring activities during construction will include on-site environmental monitoring of construction activities and archaeological monitoring of excavation sites. The purpose of this monitoring will be to ensure that the appropriate environmental protection measures, including flow diversions and sediment control, are in place (as required) and to ensure any archaeological artifacts are documented and appropriate mitigation implemented (e.g., stop excavation and assess further).

3.7.2 Post Construction

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

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

Effectiveness monitoring will occur as part of CLBMON-11A and CLBMON-9 will include the monitoring of ground-nesting birds, insects (beetles and spiders) and vegetation. Monitoring protocols from CLBMON-37 may also be implemented or adapted to assess whether the objectives and performance measures have been met.

To assess how the mounds overwinter, a drone will be used to obtain aerial photography of each constructed mound immediately following construction. The mounds will be re-photographed after the winter to assess whether erosion or changes to the mounds has occurred.

4 SCHEDULE

Construction is scheduled for late September / early October 2015. Pre-construction monitoring occurred during spring and summer 2015 as part of CLBMON-9 and CLBMON-11A. The timing of construction coincides with suitable reservoir elevation (i.e., < 750 m ASL) and staff / contractor availability. Post-construction monitoring will occur in spring 2016 as soon as the site is accessible (i.e., snow has melted and road access in possible).

A monthly schedule of activities is as follows:

September: prescription development and pre-construction planning; start construction

October: complete construction; acquire aerial photos (drone); develop monitoring plan (timing); begin reporting

November: submit draft report with draft monitoring schedule (consistent with CLBMON-9 and CLMBON-11A from previous years).

March 2016: Pilot project completion

5 SITE-SPECIFIC PRESCRIPTIONS

The following sections describe the site-specific prescriptions for each site. At each of these locations the considerations listed in Sections 3.5.1 to 3.5.6 apply.

The implementation of the prescriptions at each site may vary from what is provided in this document and it ultimately contingent on several factors including logistical constraints (e.g., site access), financial constraints, and any unforeseen circumstances (e.g., documentation of archaeological artifacts) that could preclude physical works at one or more sites.

The prescriptions provided below are variations on the methods provided in Section 3.3 and are as follows:

Hope Creek: Modified windrow/mound constructed between 753 m and 754 m ASL. Creation of new habitat and protection of existing vegetation communities and portions of the foreshore.

Goodfellow Creek: Modified windrow/mound constructed between 752 m and 754 m ASL. Creation of new habitat and protection of existing vegetation communities and portions of the foreshore.

Bush Arm Causeway - South: Modified mound constructed between 753 m and 754 m ASL. Creation of new habitat, creating connectivity between the treeline and the upper elevations of the drawdown zone, and protection of existing vegetation communities and portions of the foreshore.

Bush Arm Causeway – North: Creation of a windrow adjacent to the Bush Arm Causeway, construction of a stand-along mound islands, and removal or wood debris from existing ponds. Windrow construction will occur at 754 m ASL, mound island at 753 m ASL, and pond cleanup between 753 m and 754 m ASL: (if time and resources permit). Protection of foreshore.

Chatter Creek: Creation of two mound islands, one stand-alone and one that bridges the gap between two vegetated high points of land. Mounds will be constructed between 751 m and 753 m ASL. Protection of existing habitat and foreshore.

Based on existing reservoir conditions and what is known about site access, the focus of windrow and mound construction will be on three sites: Bush Arm Causeway – South, Bush Arm Causeway – North, and Chatter Creek. If time and resources permit, work will occur at Goodfellow Creek. It is unlikely that work will occur at Hope Creek given that it won't be possible to transport equipment to the site via tug and barge (the reservoir will be too low). Accessing the proposed physical works site at Hope Creek by land would require crossing Hope Creek with an excavator, which is not ideal.

5.1 Hope Creek

5.1.1 Overview

Two distinct, but related treatments will be applied at the Hope Creek site: 1) wood debris removal and 2) mound creation. Wood debris removal is required to construct the mound and vegetation should regrow in the cleared areas.

Wood Debris Removal

A conservative estimate of the volume (m^3) of wood debris available at the Hope Creek site is 2,810 m^3. This should be enough material to build a mound as described below. The area (m^2) covered by wood debris that will be cleared is ~ 3,750 m^2. This cleared area should be monitored for plant growth in 2016 to assess the efficacy of wood debris removal to promote the establishment and development of vegetation communities at high elevations of the drawdown zone (i.e., between 753 and 754 m ASL).

Mound Construction

The proposed mounding at Hope Creek will create a v-shaped mound that extends from the treeline (i.e., 754 m ASL) into the drawdown zone. The mound will cover an area of ~ 1,280 m^2 and extend from ~754 to 753 m ASL and extend ~ 65 to 70 m in the drawdown zone (straight line distance from the tree line). The mound will be created by moving existing on-site materials (wood debris and substrate) to the mound location. The mound will vary from 6 to 20 m in width and have a height of 1.5 to 2 m. For years with normal operating elevations, the mound will be exposed for the entire growing season (April 1 to September 30). Under historical conditions, elevations ≥ 753 m ASL were exposed (not inundated) for ~157 days per year (min. = 119; Max = 183; mean = 157 days) based on historical data (1997 to 2014). This represents ~ 86% of the growing season. Because the mound will be built at a height of 1.5 m to 3.0 m above current elevations, the elevation of the leading edge of the mound will increase from 753 to a minimum of 754.5 m ASL, which will ensure that it is only inundated during periods of surcharge. The elevation of the mound will increase towards the treeline with a minimum elevation range of 754.5 to 755.5 m ASL. The realized gain in elevation will be a function of the volume of wood debris available on site. The base of the mound will be 2.5 to 3 times wider than the top, which will be flattened to accommodate planting of balsam poplar or willow stakes.

Given that Kinbasket Reservoir will not be filled to maximum capacity in 2015, the potential effects of wave action and inundation on the mound will need to be assessed at a later date. However, future consideration of a windrow or log boom at this site is recommended.

5.1.2 Rationale

Vegetation cover in the drawdown zone at Hope Creek is limited by substrate type, soil moisture, and soil nutrients. Wood debris accumulation precludes or limits vegetation growth in the upper elevations of the drawdown zone. Using existing wood debris and substrates to build a mound should create a suitable receiving environment for live stakes. Because the top of the mound will not be inundated for much of the year the total cover of woody-stemmed vegetation should increase, and over time, will contribute to improvements in wildlife habitat suitability. Areas cleared of wood debris should recover naturally as has been observed elsewhere in the drawdown zone (e.g., areas of Canoe Reach). Depending on the rate of wood debris accumulation at the site, cleared areas should show signs of recovery the year following removal. The location of the mound is related to existing topography and areas that are relatively devoid

of naturally occurring vegetation. Building the mound close to the normal high water mark and existing vegetation will increase the probability of colonization by plants in addition to those planted in the mound.

5.1.3 Site Description

The Hope Creek site is located on the south side of Bush Arm in Kinbasket Reservoir and is accessed at ~57 km along the Bush Forest Service Road. The mound site is located on an alluvial fan ~72 ha in area with elevations ranging from 741 m ASL to 755 m ASL. The site selected for mounding is centred at 472272 E 5736844 N and is relatively flat with undulating topography with a north to northwest aspect. Elevation at the mound construction site ranges from 751 m ASL to 755 m ASL. The location of the proposed physical works at Hope Creek is shown in Figure 5-6 and the location of Hope Creek relative to Bush Arm and Kinbasket Reservoir is shown in Figure 2-3.

5.1.4 Land Ownership

The proposed project occurs within the drawdown zone of Kinbasket Reservoir, which is managed by BC Hydro under a Water Licence.

5.1.5 Current Site Conditions

5.1.5.1 Existing Vegetation

Current vegetation mapping of the drawdown zone (Hawkes and Gibeau 2015) indicates that ~ 16.5 ha of the Hope Creek fan are vegetated with vegetation occurring between ~746 and 754 m ASL (). Elevations >754.38 (the normal maximum elevation) are dominated by upland coniferous forest (FO). The vegetation mapping indicates that in addition to a vast area of barren gravel and sand, three communities are present: the Clover-Oxeye daisy (CO), Common Horsetail (CH), and Cottonwood-Trifolium (CT) communities. Hawkes and Gibeau (2015) suggested that under normal operating conditions (i.e., when Kinbasket Reservoir is filled to the normal maximum of 754.38 m ASL) the CH community represents a pioneering community in the context of drawdown zone vegetation community dynamics, the CO a mid to late seral stage and the CT and later seral stage. However, the distribution and occurrence of these communities, along with their successional stage change relative to reservoir operations (e.g., prolonged periods of inundation, surcharge). The site selected for mound construction is in area with little to no existing vegetation.

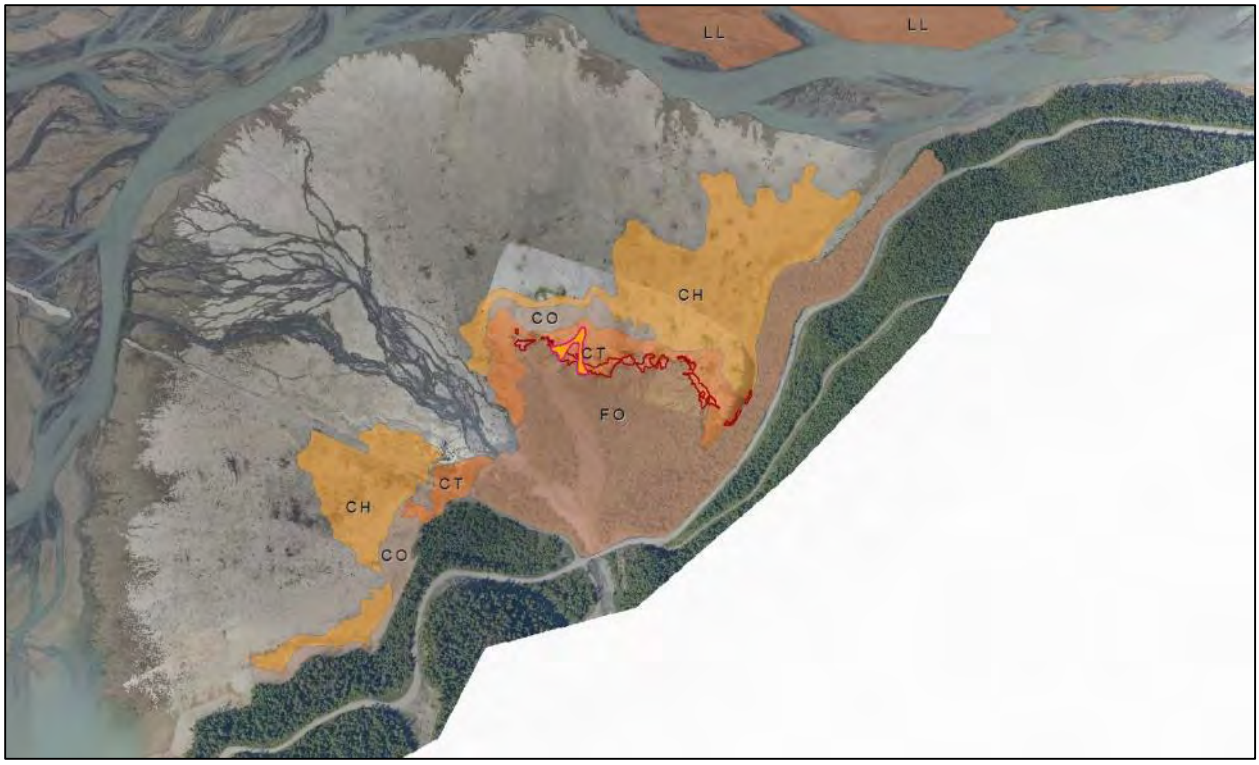

Figure 5-1: Distribution of existing vegetation at Hope Creek (from Hawkes and Gibeau 2015). CO = Clover-Oxeye daisy; CH = Common Horsetail; CT = Cottonwood-Trifolium; FO = Forest.

In 2015, vegetation data were collected from the proposed physical works sites. The number of vascular plant species documented from the Hope Creek area was 38, most of which were forbs (n = 17), grasses (n=7), and shrubs)n=7). One tree species, *Populus trichocarpa*, was documented growing in the drawdown zone

Current site photos (April and July 2015) are provided below (Figure 5-2).

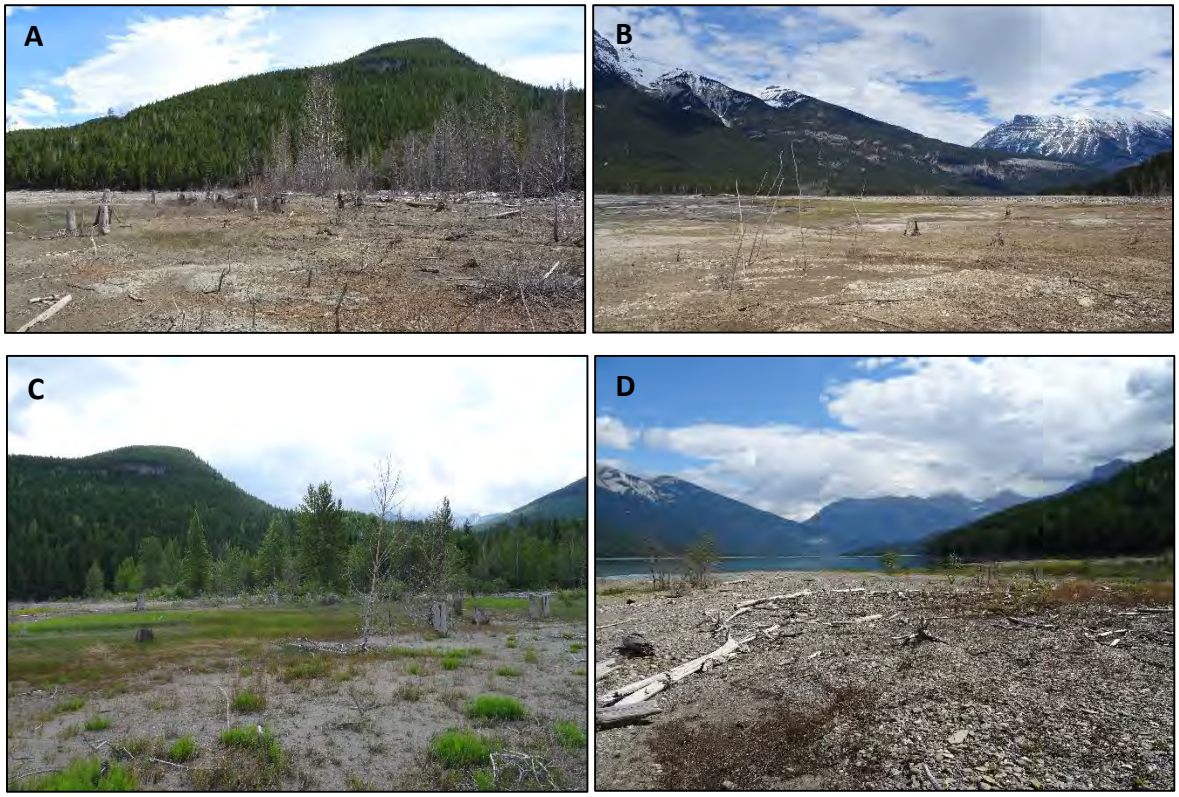

Figure 5-2: Examples of vegetation cover at the Hope Creek location in April (April 28, 2015; A, B) and July (July 15, 2015; C, D). Plate D is of the area proposed for mound construction.

5.1.5.2 Revegetation Efforts

Between 2008 and 2011 several revegetation prescriptions were applied under previous iterations of CLBWORKS-1. A total of ~ 16.4 ha were treated (Figure 5-3) with sedge plugs and seedlings of various species including water sedge, lenticular sedge, woolgrass, black cottonwood, mountain alder, willow spp., and bluejoint reedgrass planted. As per Hawkes et al (2013), the majority of the vegetation treatments applied in the drawdown of Kinbasket Reservoir failed and most transplanted plants were unable to cope with the combination of inundation timing, frequency, duration and depth, or with the by-products of these factors such as erosion, woody debris scouring, and drought conditions

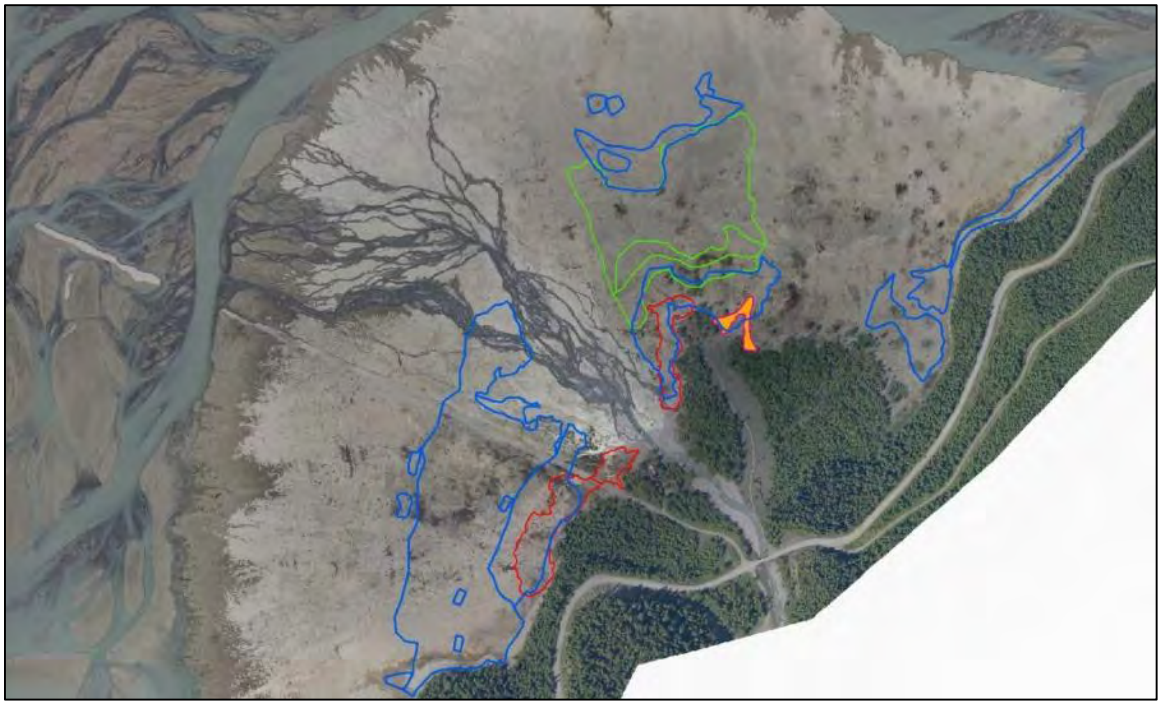

Figure 5-3: Distribution of revegetation prescriptions applied in the drawdown zone of Kinbasket Reservoir at Hope Creek in 2008 (red polygons), 2010 (blue polygons), and 2011 (green polygons) relative to the proposed location of the debris mound (orange filled polygon).

5.1.5.3 Wildlife

Hawkes et al. (2007) described the wildlife suitability of Bush Arm as high. However, the wildlife suitability rating was ascribed due to unique and valuable habitats associated with Bear Island, swamp horsetail habitat on the north side of Bush Arm (at km 79) and in higher elevation habitats near the Bush Arm Causeway. In general, current wildlife use of the Hope Creek area is lower than in other regions of Bush Arm. There are no areas of standing water that could be used by pond-breeding amphibians, shorebirds, or waterfowl and wildlife use of the area appears to be limited to ungulates (mule deer and moose), black bear, and various songbirds.

5.1.5.4 Soils

Soil profiles have not been produced for Hope Creek, but cursory assessments of the substrate in the area were made during field work for CLBMON-9 in 2015. The majority of substrates were classified as sand, gravel, and organics (Figure 5-4). These categories classify the surface substrates; the composition of the underlying substrates is not known. A limited analysis of Soil Organic Carbon (SOC) was conducted on data collected in 2013. The amount of SOC depends on soil texture, climate, vegetation, and historical and current land use and management. Soil texture affects SOC because of the stabilizing properties that clay has on organic matter and in general, soils with higher clay content are likely to have higher SOC. As indicated in Figure 5-4, the clay content of the soils at Hope Creek is low, which is related to the relatively low SOC values of 1.5 to 2.5 per cent. The content of SOC in soil ranges from < 1 per cent in sandy soils to almost 100 per cent in wetland soils. Because SOC is an important determinant of soil function, influencing the physical structure of the soil, the ability of the soil to hold water, and the soils ability to supply nutrients to plants, SOC values can be used to determine how functional the soil is. In the case of Hope

Creek, SOC values of 1.5 to 2.5 per cent suggest soil with relatively low function, limited water holding capacity, and therefore limited ability for the soils to supply nutrients.

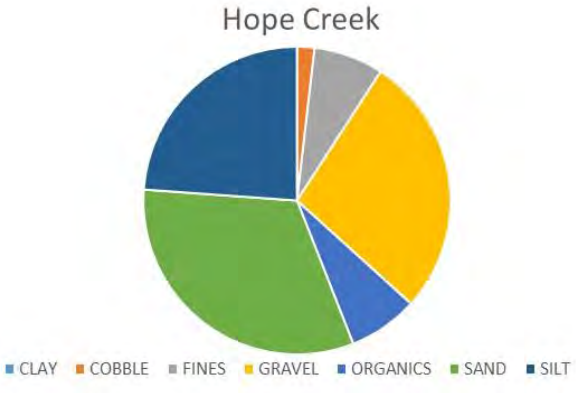

Figure 5-4: Distribution of dominant surface substrates at Hope Creek. Visual assessments of substrates were made during field work for CLBMON-9 (June and July 2015).

5.1.5.5 Hydrology

Hope Creek is a 3rd order stream approximately 11.4 km in length that drains into Bush Arm after flowing through an alluvial fan (which is bisected by Hope Creek). Aside from the mildly braided channel of Hope Creek, there are no other hydrological features at the site. However, because the Hope Creek fan occurs in the drawdown zone of Kinbasket Reservoir, the hydrology of the site must be discussed relative to reservoir operations. As discussed above, certain elevations of the drawdown zone are exposed for as much as 86% of the growing season; however, the proportion of time that the drawdown zone is exposed is a function of elevation and reservoir levels. As expected, areas lower in the drawdown zone are exposed for shorter periods than those at upper elevations. The hydrograph of Kinbasket Reservoir follows a predictable yet variable pattern with low water in early spring and maximal water levels in late summer / early fall (Figure 2-2). The elevations of the proposed mound location are exposed for most of the year, providing suitable growing conditions for certain species of plants, including some woody-stemmed species like willow and balsam poplar. Constructing the mound so the top elevation exceeds 754.38 will ensure that at least some portions of the mound are exposed year-round, which should reduce wet stress and increase the probability of survival.

5.1.6 Objectives

The objectives for wood debris removal and mound construction at Hope Creek include the objectives listed in Section 3.2 and the following:

1. Place and construct the mound in such a way to protect existing vegetation communities (Figure 5-5); and
2. Assess the efficacy of weed debris removal at this location to promote the establishment and development of vegetation.

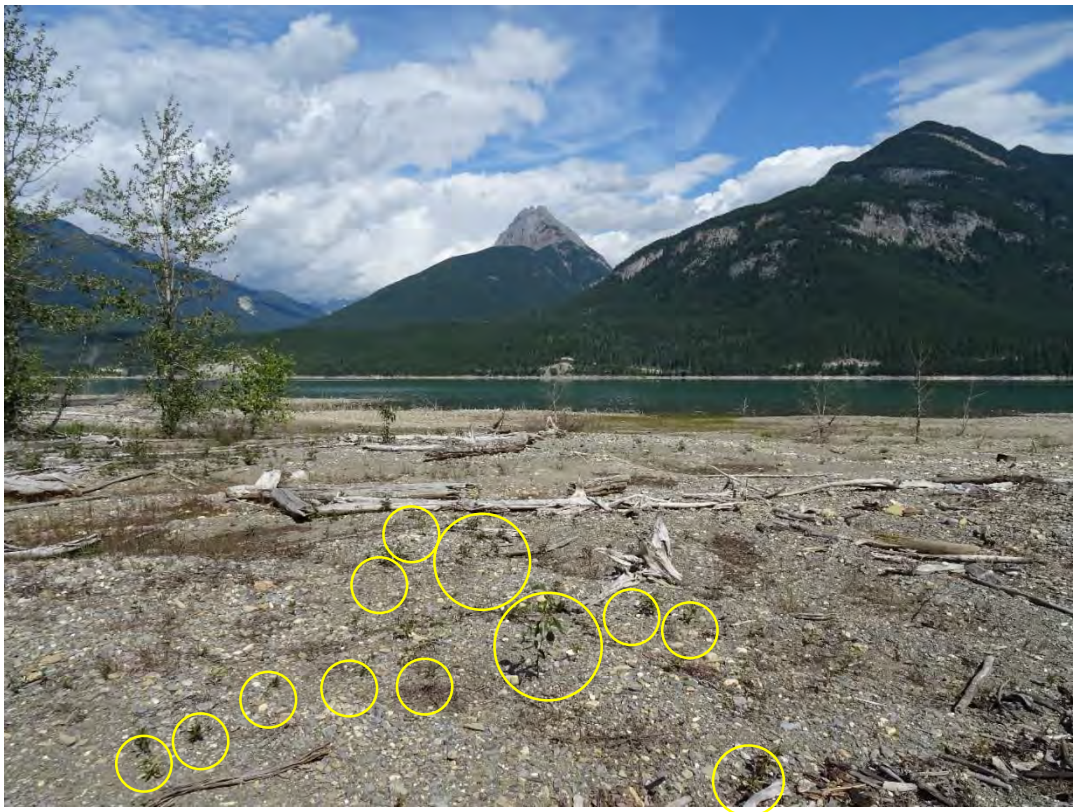

Figure 5-5: Example existing vegetation at Hope Creek. In this case cottonwood seedlings (inside yellow circles) are regenerating naturally. Building a mound that provides for the protection of sites like this will increase the probability of successful revegetation through site-specific manipulation and the natural regeneration. Photo Date: July 15, 2015. Reservoir Elevation: 750.95 m ASL.

5.1.7 Target Site Conditions

The target site conditions of the proposed mound construction include the creation of an elevated mound with a total area of ~1,280 m^2 ranging in width from 6 to 20 m at the base and 2 to 6 m at the top. The mound will extend from 754.38 m ASL (the normal high water mark of Kinbasket Reservoir) to ~753 m ASL. Total berm length will be ~ 65 to 70 m. The elevation of the top of the mound will vary from a minimum of 754.5 to 755.5 m ASL. The mound will be comprised of wood debris and local substrates and live stakes (cottonwood and willow) will be planted into the substrate along the top and sides of the mound[2]. The mound will be situated so that it ties in with existing vegetation at the upper elevation to promote natural ingrowth from existing vegetation communities. The addition of sedge plugs may be considered at a later date (i.e., following an assessment of mound persistence following the next full or high water event).

5.1.8 Performance Measures

The following performance measures are suggested to assess the success of the mound construction at Hope Creek:

1. Creation of a mound as described above that persists during all seasons and following inundation;

[2] Live-staking is not proposed as part of the pilot program

2. Little to no erosion of the mound following inundation and winter. Erosion will be determined using aerial photos obtained from a drone. Photos will be acquired immediately following mound creation and again following inundation or the winter season;
3. Survival of at least 50 per cent for all planted live stakes for all species;
4. Successful natural establishment of vegetation common to the site at the wood debris removal sites and on the mound;
5. Successful protection / retention of currently vegetated areas adjacent to the mound;
6. Provision of wildlife habitat for insects, songbirds, and small mammals; and
7. Continued evidence of use of the Hope Creek area by wildlife (e.g., mule deer, moose, and black bear).

5.1.9 Construction Schematics

The Hope Creek wood debris removal and mound construction areas are illustrated in Figure 5-6 and a mound construction schematic is provided in Figure 5-7.

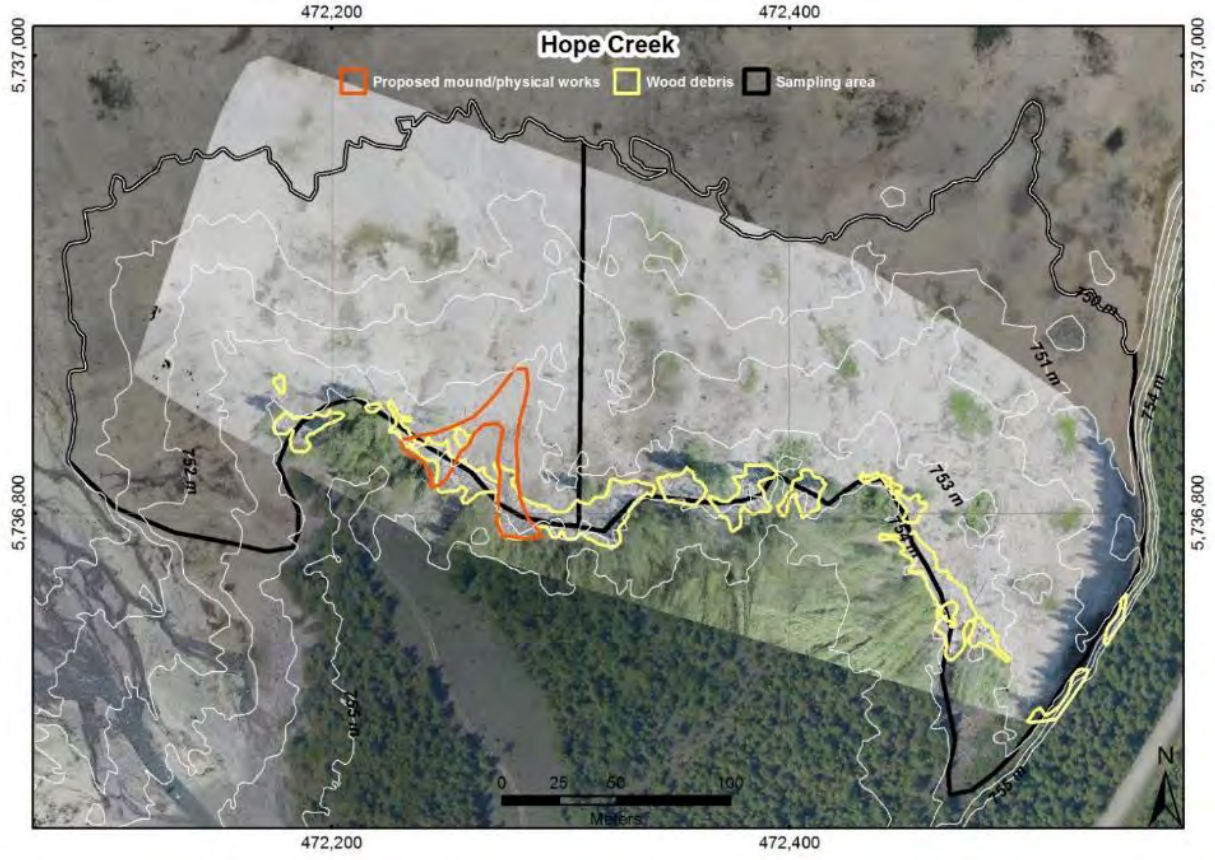

Figure 5-6: Schematic of proposed mound location (orange polygon) at Hope Creek. The distribution of wood debris relative to the mound construction site is shown (yellow polygon). The location and shape of the mound is approximate.

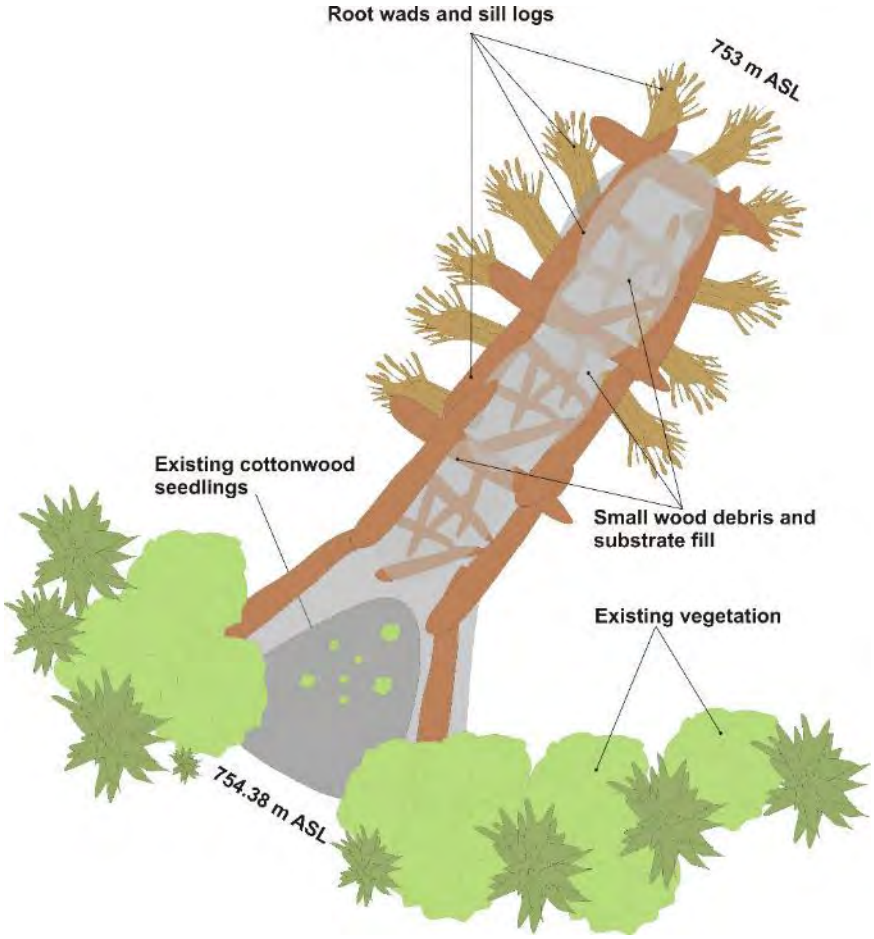

Figure 5-7: Schematic of proposed mound/windrow construction (top view) at Hope Creek showing the distribution of root wads, sill logs, small wood debris and substrates relative to the existing tree line and cottonwood seedlings. Although not drawn to scale, the mound would be between 6 and 20 m wide and 65 to 70 m long with a height of 2.5 to 3.5 m. The top of the mound would be 2 to 6 m wide with a flat top to facilitate planting of live stakes. An existing patch of cottonwood seedlings will be protected behind the mound.

5.2 Goodfellow Creek

5.2.1 Overview

Two distinct, but related treatments will be applied at the Goodfellow Creek site: 1) wood debris removal and 2) mound creation. Wood debris removal is required to construct the mound and vegetation should regrow in the cleared areas.

Wood Debris Removal

A conservative estimate of the volume (m^3) of wood debris available at the Goodfellow Creek site is 11,244 m^3. This should be enough material to build a mound as described below. The area (m^2) covered by wood debris is ~ 14,992 m^2. Not all of this area will be cleared, but the cleared area should be monitored for plant growth in 2016 to assess the efficacy of wood debris removal to promote the establishment and development of vegetation communities at high elevations of the drawdown zone (i.e., between 752 and 754 m ASL).

Mound Construction

The proposed mounding at Goodfellow Creek will create a linear windrow/mound that extends from the treeline (i.e., 754 m ASL) into the drawdown zone. The mound will cover an area of ~ 2,000 m^2 and extend from ~754 to 752 m ASL and extend ~ 65 to 70 m in the drawdown zone (straight line distance from the tree line). The mound will be created by moving existing on-site materials (wood debris and substrate) to the mound location. The mound will be ~ 10 to 12 m in width and have a height of 2.5 to 3 m. For years with normal operating elevations, the mound will be exposed for the entire growing season (April 1 to September 30). Under historical conditions, elevations ≥ 752 m ASL were exposed (not inundated) for ~145 days per year (min. = 104; Max = 183; mean = 145 days) based on historical data (1997 to 2014). This represents ~ 79% of the growing season. Because the mound will be built at a height of 1.5 m to 3.0 m above current elevations, the elevation of the leading edge of the mound will increase from 753 to a minimum of 754.5 m ASL, which will ensure that it is only inundated during periods of surcharge. The elevation of the mound will increase towards the treeline with a minimum elevation range of 754.5 to 757.5 m ASL. The realized gain in elevation will be a function of the volume of wood debris available on site. The base of the mound will be 2.5 to 3 times wider than the top, which will be flattened to accommodate planting of balsam poplar or willow stakes.

Given that Kinbasket Reservoir will not be filled to maximum capacity in 2015, the potential effects of wave action and inundation on the mound/windrow will need to be assessed at a later date. However, future consideration of a windrow or log boom at this site is recommended.

5.2.2 Rationale

Vegetation cover in the drawdown zone in the vicinity of Goodfellow Creek is limited by substrate type, soil moisture, and soil nutrients. Wood debris accumulation precludes or limits vegetation growth in the upper elevations of the drawdown zone. Using existing wood debris and substrates to build a mound/windrow should create a suitable receiving environment for live stakes and limit the accumulation of wood debris in portions of the drawdown zone. Because the top of the mound will not be inundated for much of the year the total cover of woody-stemmed vegetation should increase, and over time, will contribute to improvements in wildlife habitat suitability. Areas cleared of wood debris should recover naturally as has been observed elsewhere in the drawdown zone (e.g., areas of Canoe Reach). Depending on the rate of wood debris accumulation at the site, cleared areas should show signs of recovery the year following removal. The location of the mound is related to existing topography and areas that are relatively devoid of naturally occurring vegetation. Building the mound close to the normal high water mark and existing vegetation will increase the probability of colonization by plants in addition to those planted in the mound.

5.2.3 Site Description

The Goodfellow Creek site is located on the south side of Bush Arm in Kinbasket Reservoir and is accessed at ~59 km along the Bush Forest Service Road. The mound site is located on in floodplain habitat between Goodfellow Creek and Bush River. Elevation at the site range from 748 to 754 m ASL. The site selected for mounding is centred at 474362 E 5738471 N and is relatively flat with undulating topography with a westerly aspect. Elevation at the mound construction site ranges from 752 m ASL to 755 m ASL. The location of the proposed physical works at Goodfellow Creek is shown in Figure 5-6 and the location of Goodfellow Creek relative to Bush Arm and Kinbasket Reservoir is shown in Figure 2-3.

5.2.4 Land Ownership

The proposed project occurs within the drawdown zone of Kinbasket Reservoir, which is managed by BC Hydro under a Water Licence.

5.2.5 Current Site Conditions

5.2.5.1 Existing Vegetation

Current vegetation mapping of the drawdown zone (Hawkes and Gibeau 2015) indicates that most of the drawdown zone around the project site is vegetated to some degree with vegetation communities spanning the elevations of 748 to 755 m ASL The vegetation mapping indicates that seven communities are present: Swamp Horsetails (SH), Kellogg's Sedge (KS), Lady's Thumb-Lamb's quarter (LL), Driftwood (DR), Clover-Oxeye daisy (CO), Common Horsetail (CH), and Cottonwood-Trifolium (CT) communities. Hawkes and Gibeau (2015) suggested that under normal operating conditions (i.e., when Kinbasket Reservoir is filled to the normal maximum of 754.38 m ASL) the LL and CH communities represents a pioneering community in the context of drawdown zone vegetation community dynamics, the KS and CO a an early-mid to mid-late seral stage and the CT and SH communities a later seral stage. However, the distribution and occurrence of these communities, along with their successional stage change relative to reservoir operations (e.g., prolonged periods of inundation, surcharge). The site selected for mound construction is in area with limited existing vegetation cover.

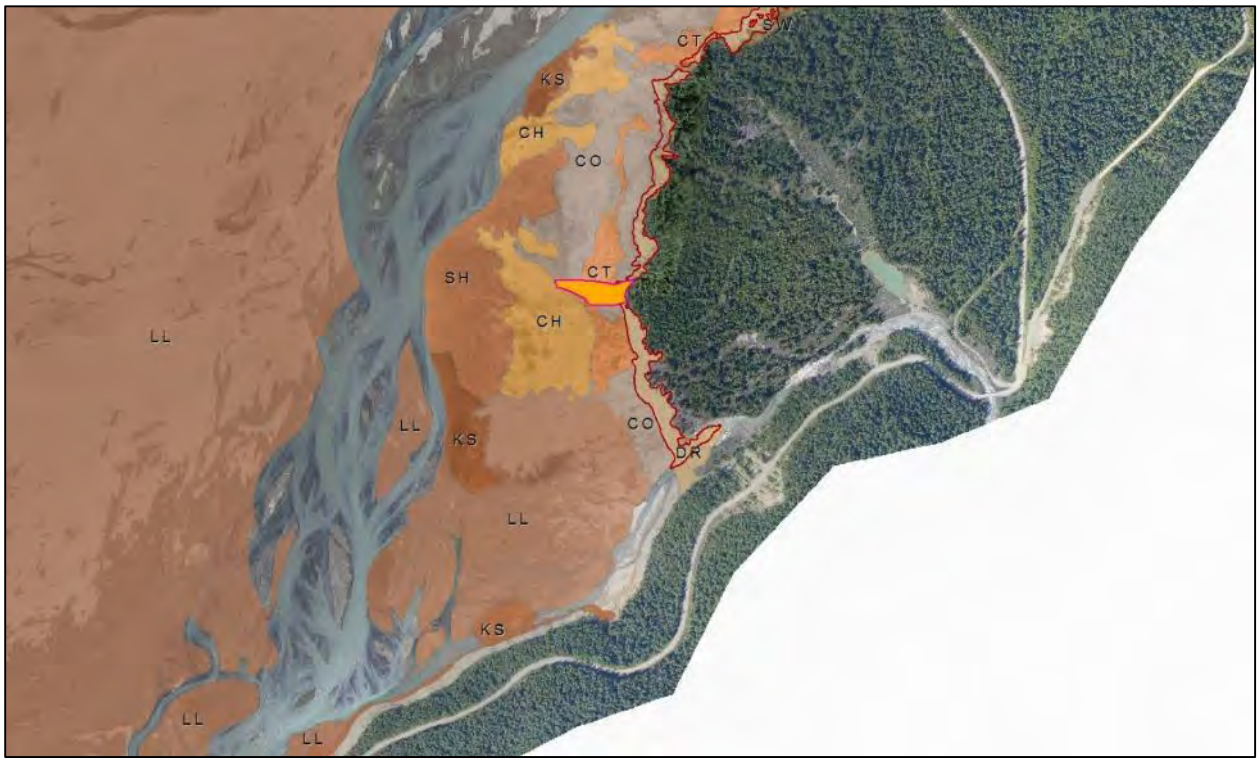

Figure 5-8: Distribution of existing vegetation communities at Goodfellow Creek (from Hawkes and Gibeau 2015). CO = Clover-Oxeye daisy; CH = Common Horsetail; CT = Cottonwood-Trifolium; DR = Driftwood; SH = Swamp Horsetails; KS = Kellogg's Sedge; LL = Lady's Thumb-Lamb's Quarter.

In 2015, vegetation data were collected from the proposed physical works sites. The number of vascular plant species documented from the Goodfellow Creek area was 28 (the lowest of the five sites sampled),

most of which were forbs (n = 13) and grasses/sedges (n=7). Three tree species*, Betula occidentalis, B. papyrifera*, and *Populus trichocarpa*, were documented growing in the drawdown zone

Current site photos (April and July 2015) are provided below (Figure 5-9).

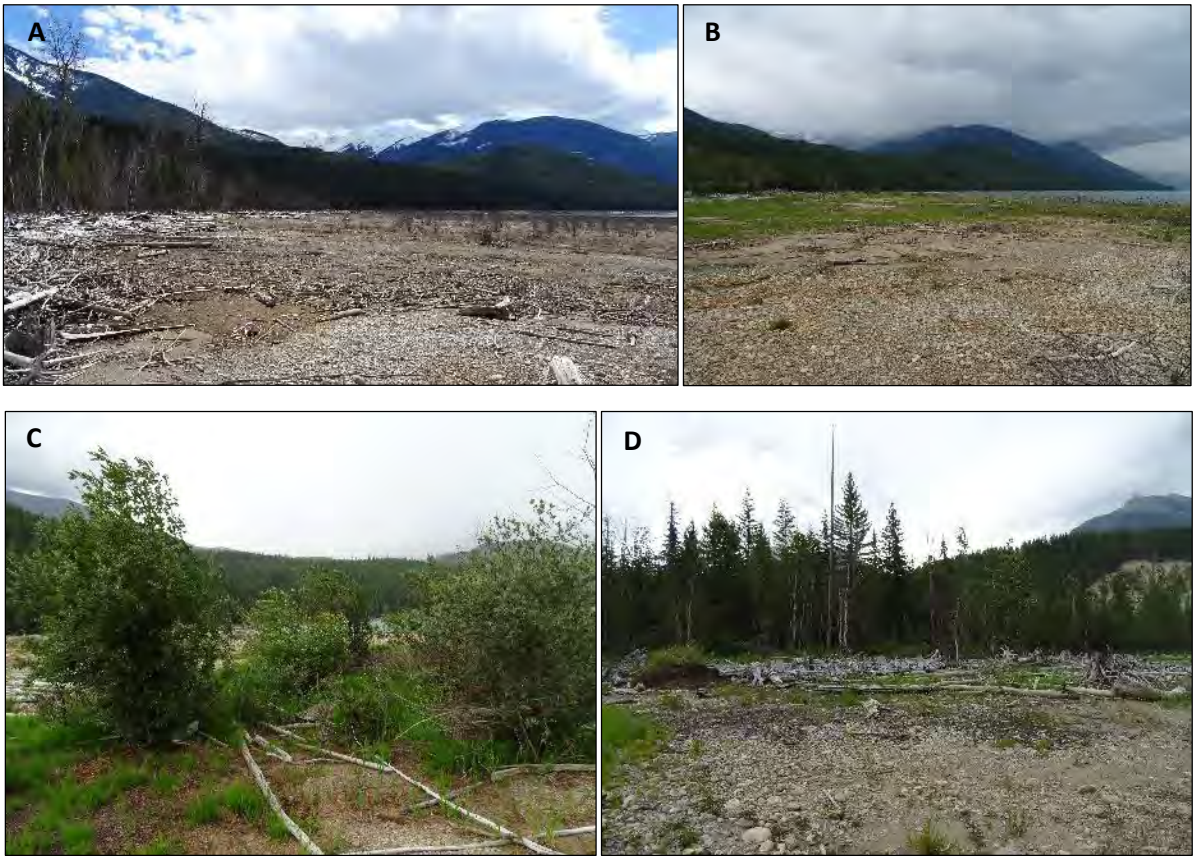

Figure 5-9: Examples of vegetation cover at the Goodfellow Creek location in April (April 28, 2015; A) and July (July 15, 2015; B, C, D). Plate D is the area proposed for mound construction.

5.2.5.2 Revegetation Efforts

Between 2008 and 2011 several revegetation prescriptions were applied under previous iterations of CLBWORKS-1. A total of ~ 5.3 ha were treated (Figure 5-3) with plug seedlings of black cottonwood and mountain alder and live staking, mainly willow staking. Some of these willow stakes were planted in an area where wood debris was piled, burned, and buried in 2007. As per Hawkes et al (2013), the majority of the vegetation treatments applied in the drawdown of Kinbasket Reservoir failed and most transplanted plants were unable to cope with the combination of inundation timing, frequency, duration and depth, or with the by-products of these factors such as erosion, woody debris scouring, and drought conditions.

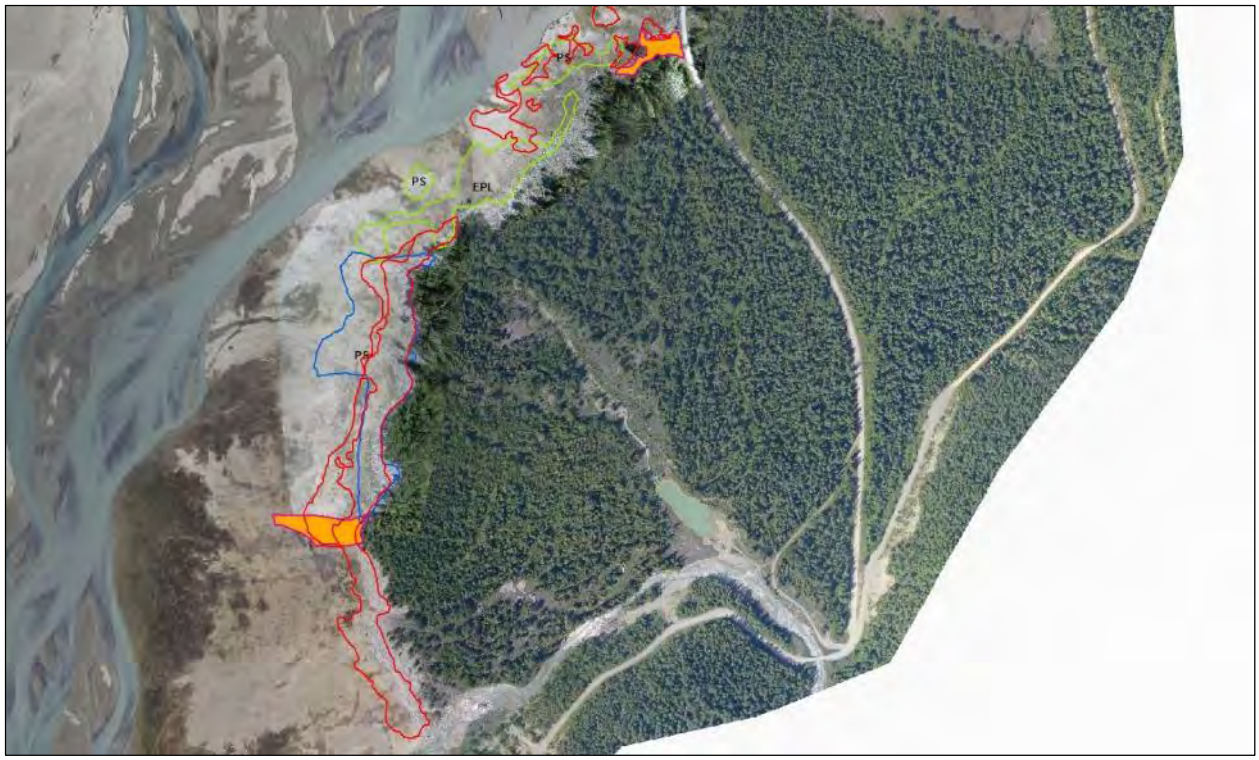

Figure 5-10: Distribution of revegetation prescriptions applied in the drawdown zone of Kinbasket Reservoir at Goodfellow Creek in 2008 (red polygons), 2010 (blue polygons), and 2011 (green polygons) relative to the proposed location of the debris mound (southern-most orange filled polygon).

5.2.5.3 Wildlife

Hawkes et al. (2007) described the wildlife suitability of Bush Arm as high. However, the wildlife suitability rating was ascribed due to unique and valuable habitats associated with Bear Island, swamp horsetail habitat on the north side of Bush Arm (at km 79) and in higher elevation habitats near the Bush Arm Causeway. In general, current wildlife use of the Goodfellow Creek area is lower than in other regions of Bush Arm. There are no areas of standing water in the drawdown zone that could be used by pond-breeding amphibians, shorebirds, or waterfowl and wildlife use of the area appears to be limited to ungulates (mule deer and moose), black bear, grizzly bear, and various songbirds. Raptor use of large cottonwoods and conifers in the adjacent upland forest has been observed.

5.2.5.4 Soils

Soil profiles have not been produced for Goodfellow Creek, but cursory assessments of the substrate in the area were made during field work for CLBMON-9 in 2015. The majority of substrates were classified as sand, gravel, and organics (Figure 5-11). These categories classify the surface substrates; the composition of the underlying substrates is not known.

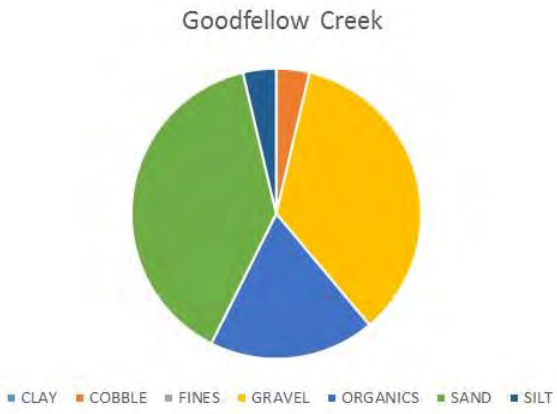

Figure 5-11: Distribution of dominant surface substrates at Goodfellow Creek. Visual assessments of substrates were made during field work for CLBMON-9 (June and July 2015).

5.2.5.5 Hydrology

Goodfellow Creek is a 4th order stream approximately 15.6 km in length that drains into Bush Arm after flowing through floodplain habitat adjacent Bush River and Goodfellow Creek. Both Goodfellow Creek and Bush River are prone to channel realignments due to the rock and cobble composition of the majority of the floodplain. Aside from the proximity of Goodfellow Creek to Bush River, there are no other hydrological features at the site. However, because the proposed construction site at Goodfellow Creek occurs in the drawdown zone of Kinbasket Reservoir, the hydrology of the site must be discussed relative to reservoir operations. As discussed above, certain elevations of the drawdown zone are exposed for as much as 86% of the growing season; however, the proportion of time that the drawdown zone is exposed is a function of elevation and reservoir levels. As expected, areas lower in the drawdown zone are exposed for shorter periods than those at upper elevations. The hydrograph of Kinbasket Reservoir follows a predictable yet variable pattern with low water in early spring and maximal water levels in late summer / early fall (Figure 2-2). The elevations of the proposed mound location are exposed for most of the year, providing suitable growing conditions for certain species of plants, including some woody-stemmed species like willow and balsam poplar. Constructing the mound so the top elevation exceeds 754.38 will ensure that at least some portions of the mound are exposed year-round, which should reduce wet stress and increase the probability of survival.

5.2.6 Objectives

The objectives for wood debris removal and mound construction at Goodfellow Creek include the objectives listed in Section 3.2 and the following:

1. Place and construct the mound in such a way to protect existing vegetation communities;
2. Assess whether a wood debris mound/windrow can preclude future wood debris accumulation in this part of the drawdown zone; and
3. Assess the efficacy of wood debris removal at this location to promote the establishment and development of vegetation.

5.2.7 Target Site Conditions

The target site conditions of the proposed mound construction include the creation of an elevated mound with a total area of ~2,000 m^2 ranging in width from 10 to 12 m at the base and 2 to 4 m at the top. The

mound will extend from 754.38 m ASL (the normal high water mark of Kinbasket Reservoir) to ~752 m ASL. Total berm length will be ~ 65 to 70 m. The elevation of the top of the mound will vary from a minimum of 754.5 to 757.5 m ASL. The mound will be comprised of wood debris and local substrates and live stakes (cottonwood and willow) will be planted into the substrate along the top and sides of the mound[3]. The mound will be situated so that it ties in with existing vegetation at the upper elevation to promote natural ingrowth from existing vegetation communities. The addition of sedge plugs may be considered at a later date (i.e., following an assessment of mound persistence following the next full or high water event).

5.2.8 Performance Measures

The following performance measures are suggested to assess the success of the mound construction at Goodfellow Creek:

1. Creation of a mound as described above that persists during all seasons and following inundation;
2. Little to no erosion of the mound following inundation and winter. Erosion will be determined using aerial photos obtained from a drone. Photos will be acquired immediately following mound creation and again following inundation or the winter season;
3. Survival of at least 50 per cent for all planted live stakes for all species;
4. Successful natural establishment of vegetation common to the site at the wood debris removal sites and on the mound;
5. Successful protection / retention of currently vegetated areas adjacent to the mound;
6. Provision of wildlife habitat for insects, songbirds, and small mammals; and
7. Continued evidence of use of the Goodfellow Creek area by wildlife (e.g., mule deer, moose, and black bear).

5.2.9 Construction Schematics

The Goodfellow Creek wood debris removal and mound construction areas are illustrated in Figure 5-12 and a mound construction schematic is provided in Figure 5-13.

[3] Live-staking is not proposed as part of the pilot program

Figure 5-12: **Schematic of proposed mound location (orange polygon) at Goodfellow Creek. The distribution of wood debris relative to the mound construction site is shown.** The location and shape of the mound is approximate.

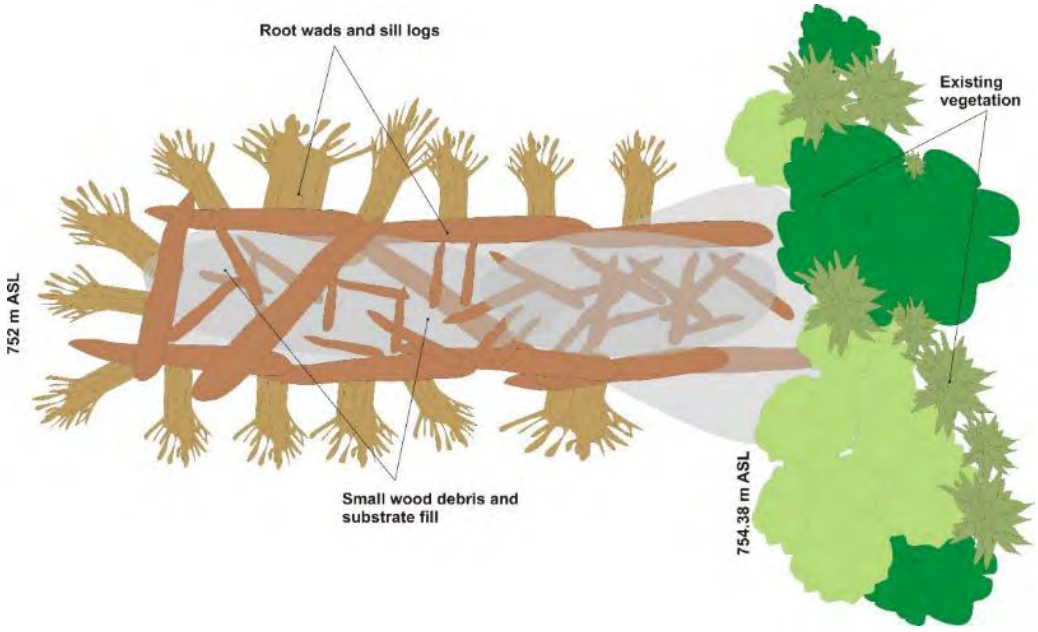

Figure 5-13: **Schematic of proposed mound construction (top view) showing distribution of root wads, sill logs, small wood debris and substrates relative to the existing tree line and cottonwood seedlings.** Although not drawn to scale, the mound would be 10 to 12 m wide and 65 to 70 m long with a height of 2.5 to 3.5 m. The top of the mound would be 2 to 3 m wide with a flat top to facilitate planting of live stakes.

5.3 Bush Arm Causeway - South

5.3.1 Overview

Two distinct, but related treatments will be applied at the Bush Arm Causeway South site: 1) wood debris removal and 2) mound creation. Wood debris removal is required to construct the mound and vegetation should regrow in the cleared areas.

Wood Debris Removal

A conservative estimate of the volume (m^3) of wood debris available at the Bush Arm Causeway South site is 7,157 m^3. This should be enough material to build a mound as described below. Not all of the wood accumulated in this will be cleared, but the cleared area should be monitored for plant growth in 2016 to assess the efficacy of wood debris removal to promote the establishment and development of vegetation communities at high elevations of the drawdown zone (i.e., at elevations > 753 m ASL).

Mound Creation

The mound proposed for the Bush Arm Causeway South site will connect existing high points in the drawdown zone to create a large, broad mound extending from 753 m to 755 m ASL. Having a total area of ~ 1,600 m, the mound will vary in height from 2.5 to 3.5 or 4 m. The mound will parallel the existing treeline for ~ 80 m and extend into the drawdown zone between 6 and 25 m. The mound will be created by moving existing on-site materials (wood debris and substrate) to the mound location. For years with normal operating elevations, the mound will be exposed for the entire growing season (April 1 to September 30). Under historical conditions, elevations ≥ 753 m ASL were exposed (not inundated) for ~157 days per year (min. = 119; Max = 183; mean = 157 days) based on historical data (1997 to 2014). This represents ~ 86% of the growing season. Because the mound will be built at the highest elevations in the drawdown zone (~ 753 to 754 m ASL) and to a height of 2.5 m to 4.0 m above current elevations, the elevation of the leading edge of the mound will increase from 753 to a minimum of ~755.5 m ASL, which will ensure that it is only inundated during periods of surcharge. The base of the mound will be 3 to 4 times wider than the top, which will be flattened to accommodate planting of cottonwood or willow stakes

5.3.2 Rationale

The expansion of vegetation in the drawdown zone is hindered by the accumulation of wood debris. Altering the cover of wood debris into a substrate suitable for planting live stakes will contribute to the expansion of woody-stemmed species in the drawdown zone. Removing wood debris from portions of the drawdown zone will contribute to the natural establishment of vegetation. Overtime, extending the cover of trees and other vegetation in the drawdown zone will enhance the suitability of the drawdown zone for wildlife.

5.3.3 Site Description

The Bush Arm Causeway South site is located in the northeast corner of Bush Arm at ~63 km along the Bush Forest service Road. The mound construction location is located adjacent to the causeway in the southwest corner. The topography at the site is undulating with some naturally occurring high points that provide habitat for trees (cottonwood). Elevation at the site ranges from 751 to 755 m ASL. The site selected for mound construction is centred at 474580 E and 5739922 N and the windrow is centred at 474766 E and 5739076 N. The location of the proposed physical works at Bush Arm Causeway South is

shown in Figure 5-14 and the location of Bush Arm Causeway North relative to Bush Arm and Kinbasket Reservoir is shown Figure 2-3.

5.3.4 Land Ownership

The proposed project occurs within the drawdown zone of Kinbasket Reservoir, which is managed by BC Hydro under a Water Licence.

5.3.5 Current Site Conditions

5.3.5.1 Existing Vegetation

Current vegetation mapping of the drawdown zone (Hawkes and Gibeau 2015) indicates that most of the drawdown zone around the project site is vegetated to some degree with vegetation communities spanning the elevations of 751 to 755 m ASL. The vegetation mapping indicates that six communities are present covering ~ 14.7 ha (Figure 5-14): Driftwood (DR; 3.24 ha), Clover-Oxeye daisy (CO; 7.72 ha), Cottonwood-Trifolium (CT; 1.0 ha), Shrub-Willow (SW; 0.52 ha), Swamp horsetail (SH; 0.63 ha), and Common Horsetail (CH; 1.57 ha). Hawkes and Gibeau (2015) suggested that under normal operating conditions (i.e., when Kinbasket Reservoir is filled to the normal maximum of 754.38 m ASL) the CH community represents a pioneering seral stage in the context of drawdown zone vegetation community dynamics, the CO community represents a mid-late seral stage in the context and the SH, SW, and CT a later seral stage. The DR community is not considered in the context of vegetation community dynamics. The distribution and occurrence of these communities, along with their successional stage change relative to reservoir operations (e.g., prolonged periods of inundation, surcharge). The site selected for mound construction is in area with limited existing vegetation cover and occurs in the DR community.

Figure 5-14: Distribution of existing vegetation communities at Bush Arm Causeway South (from Hawkes and Gibeau 2015). CO = Clover-Oxeye daisy; CT = Cottonwood-Trifolium; DR = Driftwood; SH = Swamp

horsetail; CH = Common horsetail; SW = Shrub-Willow. The proposed physical works location is shown (orange-filled polygons).

In 2015, vegetation data were collected from the proposed physical works sites. The number of vascular plant species documented from the Bush Arm Causeway South Site was 38, most of which were forbs (n = 18); grasses/sedges (n=9), and shrubs (n=7). One tree species was documented growing in the drawdown zone (black cottonwood).

Current site photos (April and July 2015) are provided below (Figure 5-15).

Figure 5-15: Examples of vegetation cover and wood debris distribution at the Bush Arm Causeway South site. A: distribution of wood debris at the proposed physical works site and B: existing vegetation adjacent to the wood debris area. All photos July 15, 2015.

5.3.5.2 Revegetation Efforts

Between 2008 and 2011 several revegetation prescriptions were applied under previous iterations of CLBWORKS-1. A total of ~ 2.0 ha were treated (Figure 5-16) with willow seedling (0.41 ha), live staking (by hand; 0.6 ha) and live staking using a machine (1.1 ha). Most live stakes were cottonwood. As per Hawkes et al (2013), the majority of the vegetation treatments applied in the drawdown of Kinbasket Reservoir failed and most transplanted plants were unable to cope with the combination of inundation timing, frequency, duration and depth, or with the by-products of these factors such as erosion, woody debris scouring, and drought conditions.

Figure 5-16: Distribution of revegetation prescriptions applied in the drawdown zone of Kinbasket Reservoir at the Bush Arm Causeway South location in 2008 (red polygons) and 2011 (green polygons) relative to the proposed location of the debris mound (orange filled polygon).

5.3.5.3 Wildlife

Hawkes et al. (2007) described the wildlife suitability of Bush Arm as high, which describes the current suitability of the Bush Arm Causeway South site. Several species of amphibians and reptiles have been documented from this location along with species of ground-nesting bird such as Killdeer and Spotted Sandpiper, numerous songbirds, elk, moose, deer and grizzly bear have all been observed at this location. An existing pond close to the proposed physical works site is used regularly by pond-breeding amphibians (Western toad, Long-toed salamanders).

5.3.5.4 Soils

Soil profiles have not been produced for the Bush Arm Causeway South site, but cursory assessments of the substrate in the area were made during field work for CLBMON-9 in 2015. The majority of substrates were classified as fines, clay, and organics (Figure 5-22). These categories classify the surface substrates; the composition of the underlying substrates is not known. These soils were also assessed in areas not currently covered with wood debris. As discussed in Section 5.1.5.4, soils with higher clay content are likely to have higher SOC and therefore greater potential for the soils to supply nutrients to vegetation. The relatively high vegetation species richness at the Bush Arm Causeway South site is due in part to the composition of the soil and elevation of the site in the drawdown zone.

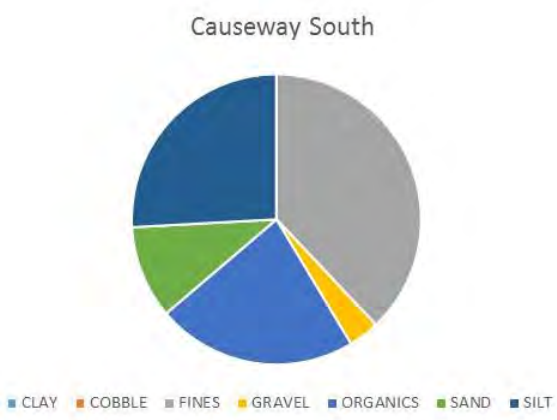

Figure 5-17: Distribution of dominant surface substrates at Bush Arm Causeway South. Visual assessments of substrates were made during field work for CLBMON-9 (June and July 2015).

5.3.5.5 Hydrology

The Bush Arm Causeway South side is situated adjacent to the south bank of the Bush River. There is an ephemeral mud-bottom pond near the proposed construction site that is used on a near annual basis by pond-breeding amphibians (Western Toad and Long-toed Salamander). There are no other hydrological features on site.

5.3.6 Objectives

The objectives for wood debris removal, windrow, and mound construction at Bush Arm Causeway South include the objectives listed in Section 3.2 and the following:

1. Create a wood debris mound extending from the high water mark (tree edge) that extends in to the drawdown zone that links current high points; and
2. Assess the efficacy of wood debris removal at this location to promote the establishment and development of vegetation.

5.3.7 Target Site Conditions

The target site conditions of the proposed mound construction include the creation of mound that ties into the existing tree line and connect several high points of land. The mound would be constructed between the 753 and 755 m ASL elevation bands and have a total area of ~ 1,600 m^2. The mound would have a top elevation of 755 to 756 m ASL and be constructed such that water could not overtop the mound (even during surcharge) and preclude ponding on either side or behind the mound (to avoid fish entrainment).

5.3.8 Performance Measures

The following performance measures are suggested to assess the success of the mound construction at Bush Arm Causeway South:

1. Creation of a mound as described above that persists during all seasons and following inundation;
2. Little to no erosion of the mound following inundation and winter. Erosion will be determined using aerial photos obtained from a drone. Photos will be acquired immediately following mound creation and again following inundation or the winter season;
3. Survival of at least 50 per cent for all planted live stakes for all species;

4. Successful natural establishment of vegetation common to the site at the wood debris removal sites and on the mound;
5. Successful protection / retention of currently vegetated areas adjacent to the mound;
6. Provision of wildlife habitat for insects, songbirds, and small mammals; and
7. Continued evidence of use of the Bush Arm Causeway South area by wildlife (e.g., mule deer, moose, and black bear).
8. No evidence of pond creation around the base or behind the mound;
9. No negative impacts to existing pond habitat near the proposed construction site.

5.3.9 Construction Schematics

The Bush Arm Causeway South mound construction area is illustrated in Figure 5-18 and a mound construction schematic is provided in Figure 5-19.

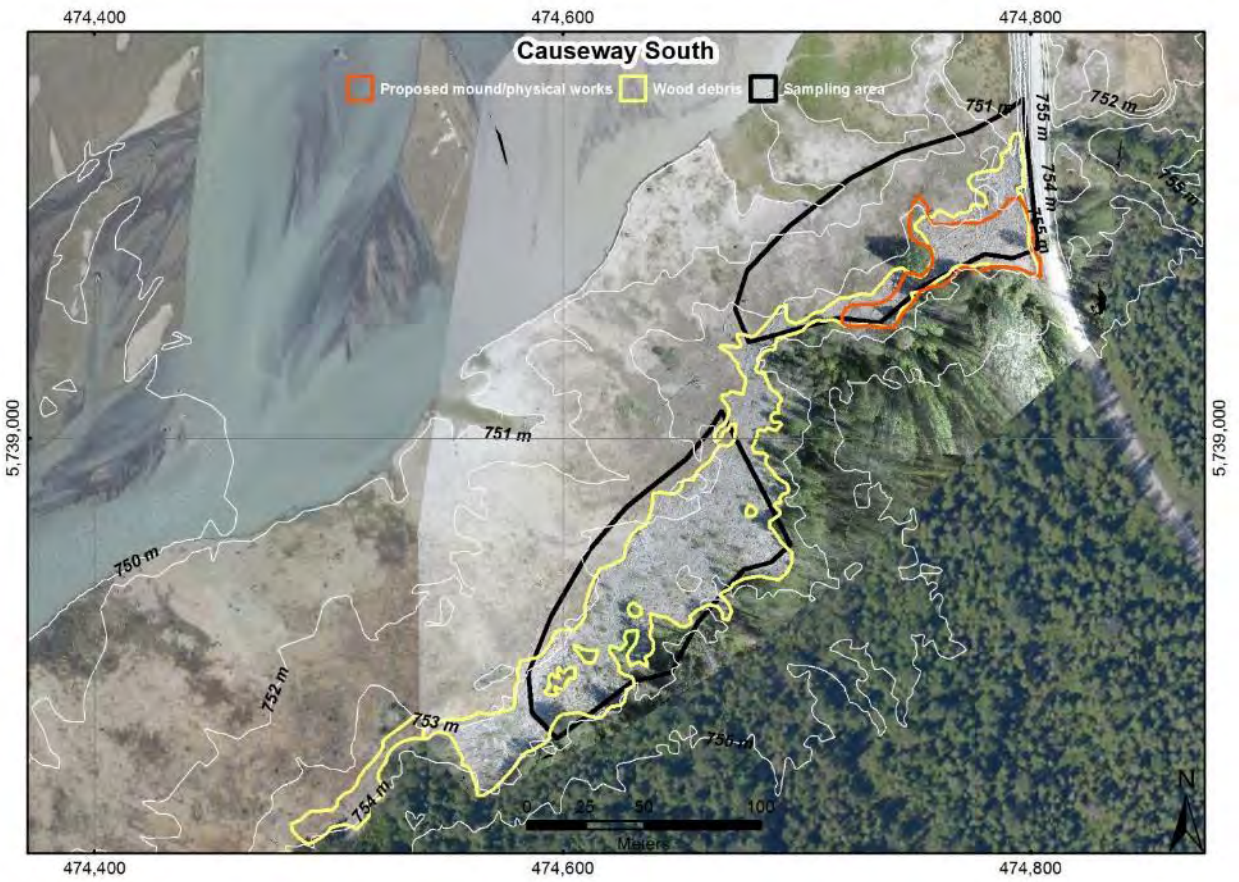

Figure 5-18: Schematic of proposed mound location (orange polygon) at Bush Arm Causeway South. The distribution of wood debris relative to the mound construction site is shown. The location and shape of the mound is approximate.

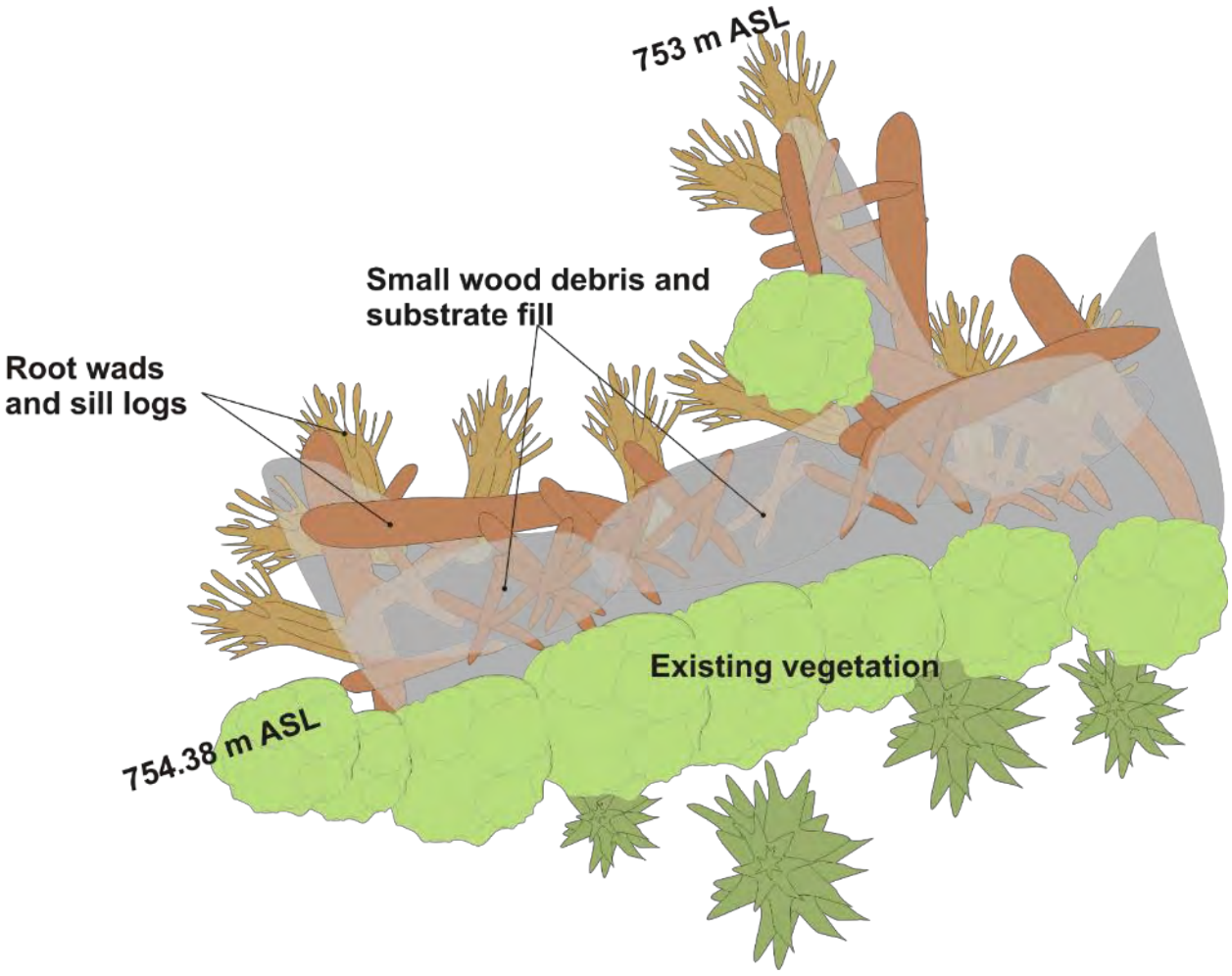

Figure 5-19: Schematic of proposed mound construction (top view) at Bush Arm Causeway South showing distribution of root wads, sill logs, small wood debris and substrates relative to the existing tree line. Although not drawn to scale, the windrow will be 5 to 25 m wide and ~ 80 m long.

5.4 Bush Arm Causeway – North

5.4.1 Overview

Three distinct, but related treatments will be applied at the Bush Arm Causeway North site: 1) wood debris removal; 2) windrow creation, and 2) mound creation. Wood debris removal is required to construct the windrow and mound and vegetation should regrow in the cleared areas. Wood removal from the existing ponds is also recommended and may be pursued if time permits.

Wood Debris Removal

A conservative estimate of the volume (m^3) of wood debris available at the Bush Arm Causeway North site is 4,008 m^3. This should be enough material to build a mound as described below. The area (m^2) covered by wood debris that will be cleared is ~ 5,344m^2. Not all of this area will be cleared, but the cleared area should be monitored for plant growth in 2016 to assess the efficacy of wood debris removal to promote the establishment and development of vegetation communities at high elevations of the drawdown zone (i.e., between 752 and 754 m ASL).

Windrow Construction

The proposed mounding at Bush Arm Causeway North Creek will create a linear windrow that parallels the causeway and extends into the drawdown zone. The windrow will cover an area of ~ 2,800 m^2 and extend from the causeway to ~ 20 m into the drawdown zone. Like mound construction, the windrow will be created by moving existing on-site materials (wood debris and substrate) to the mound location. The mound will be up to 20 m in width and have a height of 2.5 to 3 m. For years with normal operating elevations, the mound will be exposed for the entire growing season (April 1 to September 30). Under historical conditions, elevations ≥ 753 m ASL were exposed (not inundated) for ~157 days per year (min. = 119; Max = 183; mean = 157 days) based on historical data (1997 to 2014). This represents ~ 86% of the growing season. Because the windrow will be built at the highest elevation in the drawdown zone (~ 754 m ASL) and to a height of 1.5 m to 3.0 m above current elevations, the elevation of the leading edge of the mound will increase from 754 to a minimum of ~756.5 m ASL, which will ensure that it is only inundated during periods of surcharge. The base of the mound will be 3 to 4 times wider than the top, which will be flattened to accommodate planting of balsam poplar or willow stakes.

Given that Kinbasket Reservoir will not be filled to maximum capacity in 2015, the potential effects of wave action and inundation on the mound/windrow will need to be assessed at a later date. However, future consideration of a windrow or log boom at this site is recommended.

Mound (Island) Construction

In addition to the construction of the windrow against the Bush Arm Causeway a second feature – a wood debris mound or island – will be built in the drawdown zone at this location. The wood debris mound will be situated near the southeast end of the windrow and have a diameter of approximate 20 to 30 m at the base. The island will be built using similar construction methods to other mounds and windrows to create a flat-topped tetrahedron-like shape that will have an elevation > 754.38 m ASL. The target elevation will be around 756 m ASL, or similar to that of the windrow.

5.4.2 Rationale

Overall, the works proposed at this site are intended to enhance vegetation growth and cover in the existing wood debris accumulation site, remove wood from several small ponds, clear wood debris from portions of the drawdown zone and use that material to build a mound island while maintaining the integrity of much of the site, which already has high vegetation and wildlife values relative to other areas in the drawdown zone. The prescription developed for this location takes into consideration existing site conditions that lend themselves to the proposed works. Site access is easy, the site is relatively flat, wood debris is currently piled adjacent to the causeway, providing a partially developed wood debris mound that could be augmented with additional work, and there are already tree and shrub species growing in the existing wood debris. Constructing a mound island in this location will be relatively easy and provides a location for easy post-construction monitoring. Given that the entire area is vegetated, the mound should be constructed in an area of lower vegetation cover. The prescription for this site also considered the monitoring needs of other BC Hydro monitoring programs, particularly CLBMON-61. There are long-term monitoring plots established at this location and the prescription has been developed to avoid these locations.

5.4.3 Site Description

The Bush Arm Causeway North site is located in the northeast corner of Bush Arm at ~63 km along the Bush Forest service Road. The windrow is located adjacent to the causeway and the mound is located in the drawdown zone north of the bridge over the Bush River and at the south end of the windrow. The topography at the site is gently sloping with minor undulations. A channel of the Bush Rive defined the southern edge of the site and there are several small ponds and wetlands in the upper elevations (currently covered by wood debris). Elevation at the site ranges from 752 to 754 m ASL. The site selected for mound construction is centred at 474580 E and 5739922 N and the windrow is centred at 474513 E and 5740028 N. The location of the proposed physical works at Bush Arm Causeway North is shown in FIGURE and the location of Bush Arm Causeway North relative to Bush Arm and Kinbasket Reservoir is shown Figure 2-3.

5.4.4 Land Ownership

The proposed project occurs within the drawdown zone of Kinbasket Reservoir, which is managed by BC Hydro under a Water Licence.

5.4.5 Current Site Conditions

5.4.5.1 Existing Vegetation

Current vegetation mapping of the drawdown zone (Hawkes and Gibeau 2015) indicates that most of the drawdown zone around the project site is vegetated to some degree with vegetation communities spanning the elevations of 751 to 755 m ASL. The vegetation mapping indicates that three communities are present (Figure 5-20) and cover an areas of ~ 4.6 ha: Driftwood (DR; 0.8 ha), Clover-Oxeye daisy (CO; 3.3 ha), and Cottonwood-Trifolium (CT; 0.5 ha) communities. Hawkes and Gibeau (2015) suggested that under normal operating conditions (i.e., when Kinbasket Reservoir is filled to the normal maximum of 754.38 m ASL) the CO community represents a mid-late seral stage in the context of drawdown zone vegetation community dynamics and the CT a later seral stage. The DR community is not considered in the context of vegetation community dynamics. The distribution and occurrence of these communities, along with their successional stage change relative to reservoir operations (e.g., prolonged periods of inundation, surcharge). The site selected for mound construction is in area with limited existing vegetation cover.

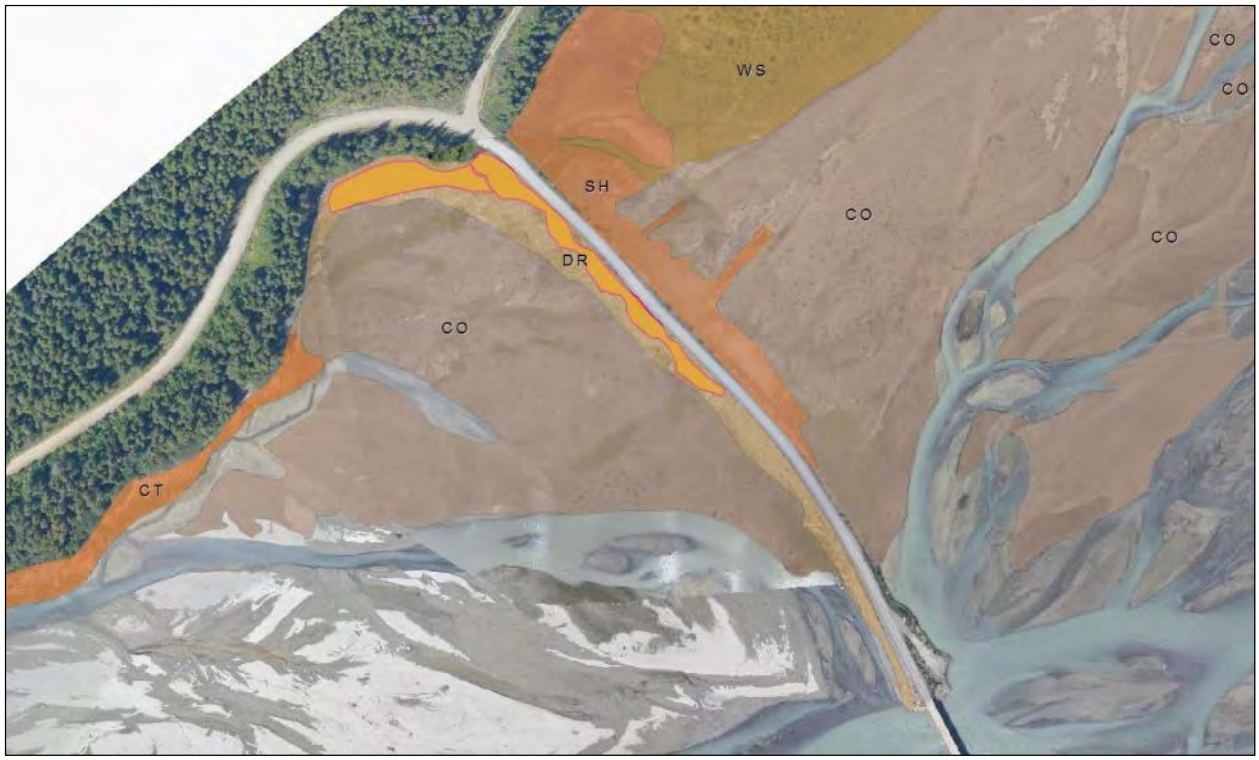

Figure 5-20: Distribution of existing vegetation communities **at Bush Arm Causeway North (from Hawkes and Gibeau 2015). CO = Clover-Oxeye daisy; CT = Cottonwood-Trifolium; DR = Driftwood. The proposed physical works location is shown (orange-filled polygons).**

In 2015, vegetation data were collected from the proposed physical works sites. The number of vascular plant species documented from the Bush Arm Causeway North Site was 54 (the highest of the five sites sampled), most of which were forbs (n = 31); grasses/sedges (n=11), and shrubs (n=7). No tree species were documented growing in the drawdown zone although there are a few small patches of trees growing just at the higher water mark (trembling aspen and cottonwood). There are also several mounds of peat at the high water mark with various shrub species including juniper.

Current site photos (April and July 2015) are provided below (Figure 5-21).

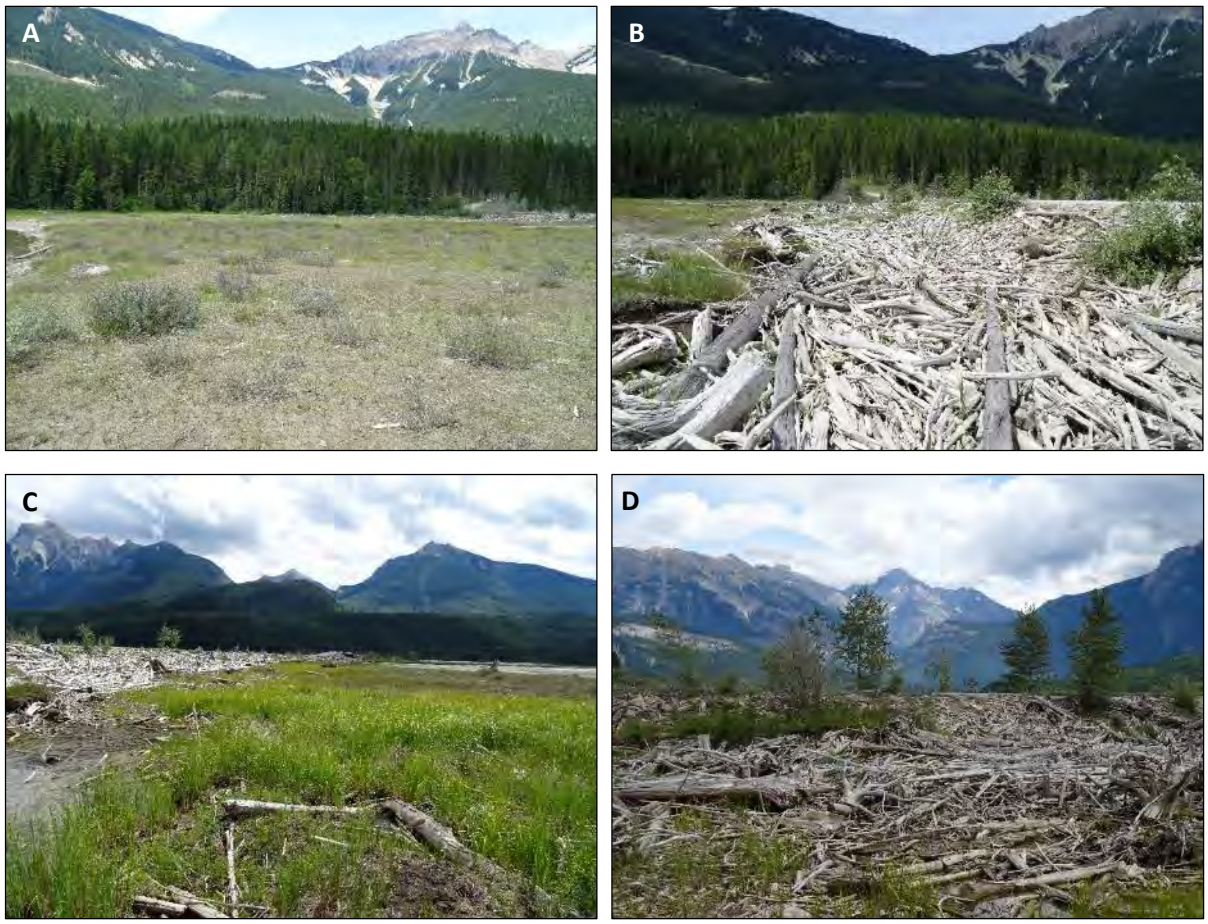

Figure 5-21: Examples of vegetation cover and wood debris distribution at the Bush Arm Causeway North site. A: shrub/grass habitat in the CO community; B: wood debris and shrubs adjacent to the causeway; C: sedge/grass cover at toe pf wood debris accumulation, and D: cottonwood and willow growing among the wood debris. All photos July 15, 2015.

5.4.5.2 Revegetation Efforts

Revegetation treatments have not been attempted at this location.

5.4.5.3 Wildlife

Hawkes et al. (2007) described the wildlife suitability of Bush Arm as high, which describes the current suitability of the Bush Arm Causeway North site. Several species of amphibians and reptiles have been documented from this location along with species off ground-nesting bird such as Killdeer and Spotted Sandpiper, numerous songbirds, elk, moose, deer and grizzly bear have all been observed at this location. The exiting ponds at the site are occupied by red-side shiners and perhaps one or two other species (a formal fish assessment has not been completed). The ponds have characteristics of more-stable wetlands including the presence of several rushes and floating attic vegetation (Figure 5-22).

Figure 5-22: Examples of aquatic vegetation and ponds in the drawdown zone at Bush Arm Causeway North.

5.4.5.4 Soils

Soil profiles have not been produced for the Bush Arm Causeway North site, but cursory assessments of the substrate in the area were made during field work for CLBMON-9 in 2015. The majority of substrates were classified as clay and organics (Figure 5-23). These categories classify the surface substrates; the composition of the underlying substrates is not known. As discussed in Section 5.1.5.4, soils with higher clay content are likely to have higher SOC and therefore greater potential for the soils to supply nutrients to vegetation. The relatively high vegetation species richness at the Bush Arm Causeway North site is due in part to the composition of the soil and elevation of the site in the drawdown zone.

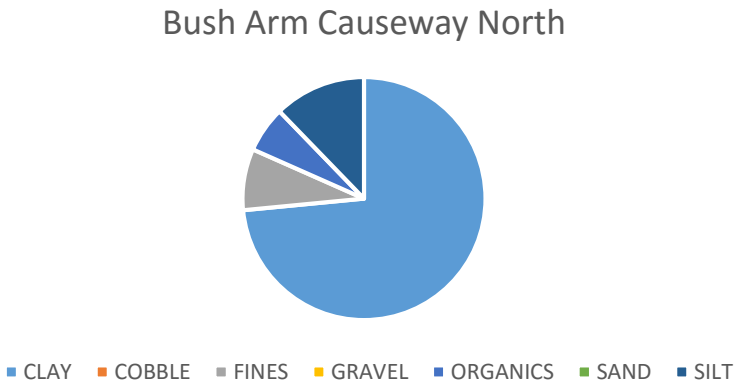

Figure 5-23: Distribution of dominant surface substrates at Bush Arm Causeway North. Visual assessments of substrates were made during field work for CLBMON-9 (June and July 2015).

5.4.5.5 Hydrology

Several small wetlands and ponds occur on the site, mainly in the upper elevations (753 to 754 m ASL). Water drains from west to east into a channel of the Bush River, which defines the southern edge of the site. There are no creeks or rivers flowing through the site.

5.4.6 Objectives

The objectives for wood debris removal, windrow, and mound construction at Bush Arm Causeway North include the objectives listed in Section 3.2 and the following:

1. Create a windrow adjacent to the causeway that results in the removal of wood from existing wetlands and creates a suitable habitat for live staking;
2. Construct a mound island in the drawdown zone as a proof-of-concept; and
3. Assess the efficacy of wood debris removal at this location to promote the establishment and development of vegetation.

An ancillary objective is the removal of wood debris from the small wetlands and ponds to improve habitat suitability for pond-breeding amphibians.

5.4.7 Target Site Conditions

The target site conditions of the proposed windrow construction include the creation of a windrow adjacent to the causeway with an elevation ranging from 754 to 755 m ASL with a total area of ~2,800 m^2. The windrow will be long and linear and range in width from 3 to 10 m at the base (~ 50 percent of the current distribution of wood debris at the site) and 1 to 5 m at the top.

The mound island will have a base diameter of ~ 50m^2 and a top elevation of at least 754.5 m ASL with the actual elevation depending on the availability of wood debris. Total berm length will be ~ 150 m (less than the current distribution of wood debris on site).

The windrow and mound will be comprised of wood debris and local substrates and live stakes (cottonwood and willow) will be planted into the substrate along the top and sides of the mound[4]. The addition of sedge plugs may be considered at a later date (i.e., following an assessment of mound persistence following the next full or high water event).The mound will be situated near the southern end of the windrow, but will be constructed as a stand-alone trial. If possible the mound will be situated in front of an existing wetland to determine whether mound placement can preclude wood debris accumulation in wetland habitats.

5.4.8 Performance Measures

The following performance measures are suggested to assess the success of the windrow and mound construction at Bush Arm Causeway North:

1. Creation of a windrow and mound as described above that persists during all seasons and following inundation;
2. Little to no erosion of the windrow and mound following inundation and winter. Erosion will be determined using aerial photos obtained from a drone. Photos will be acquired immediately following mound creation and again following inundation or the winter season;
3. Survival of at least 50 per cent for all planted live stakes for all species;
4. Successful natural establishment of vegetation common to the site at the wood debris removal sites and on the mound;
5. Successful protection / retention of currently vegetated areas adjacent to the mound;
6. Provision of wildlife habitat for amphibians, insects, songbirds, and small mammals;
7. Continued evidence of use of the area by wildlife (e.g., mule deer, moose, elk, black, and grizzly bear);
8. Reduction of wood debris in the wetlands and ponds such that the cover of native aquatic macrophytes increases by at least 10 percent; and

[4] Live-staking is not proposed as part of the pilot program

9. Evidence of amphibian breeding in ponds with a reduced volume of wood debris (amphibians do not currently breed here, but they do breed across the causeway in existing ponds that are largely devoid of wood debris).

5.4.9 Construction Schematics

The Bush Arm Causeway North wood debris removal, windrow, and mound construction areas are illustrated in Figure 5-24 and a mound construction schematic is provided in Figure 5-25.

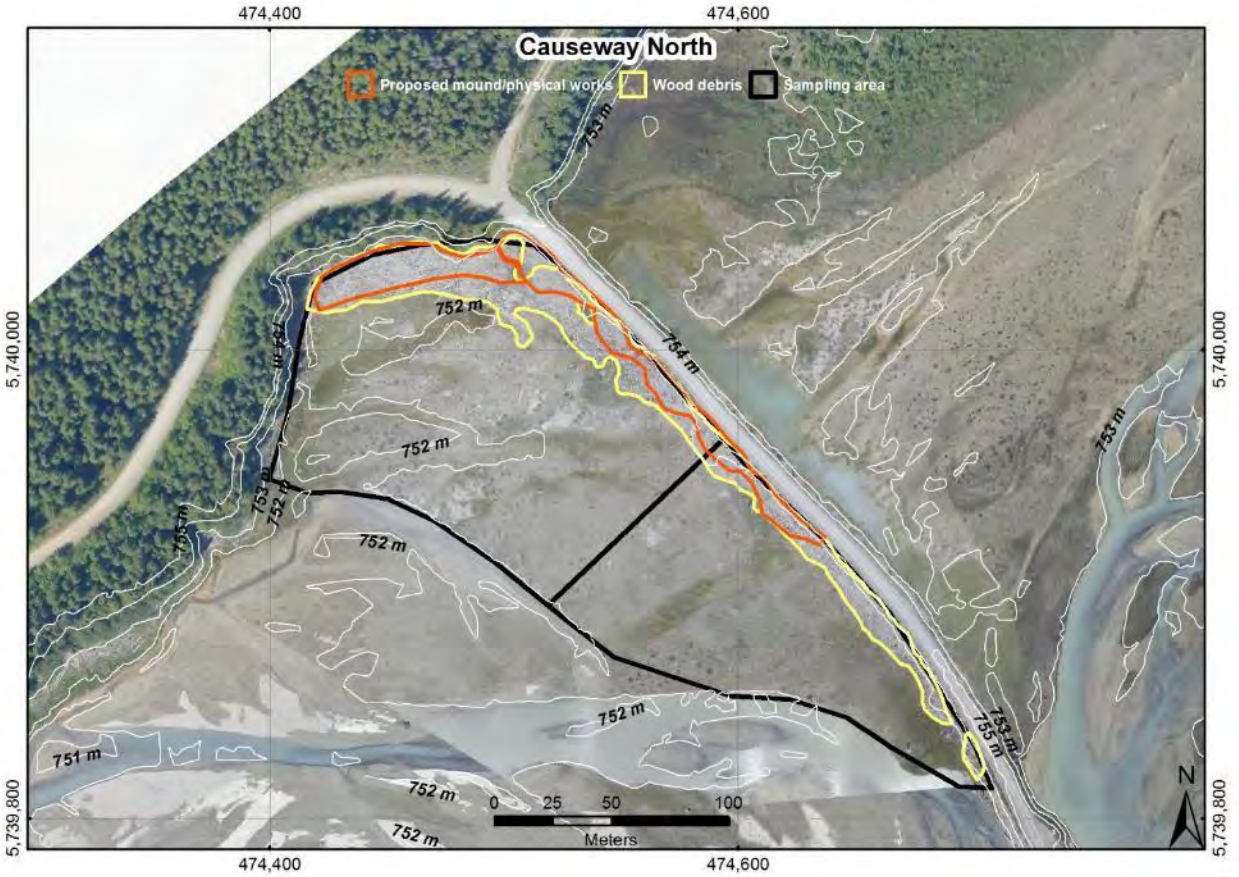

Figure 5-24: Schematic of proposed mound location (orange polygon) at Bush Arm Causeway North. The distribution of wood debris relative to the mound construction site is shown. The location and shape of the mound is approximate.

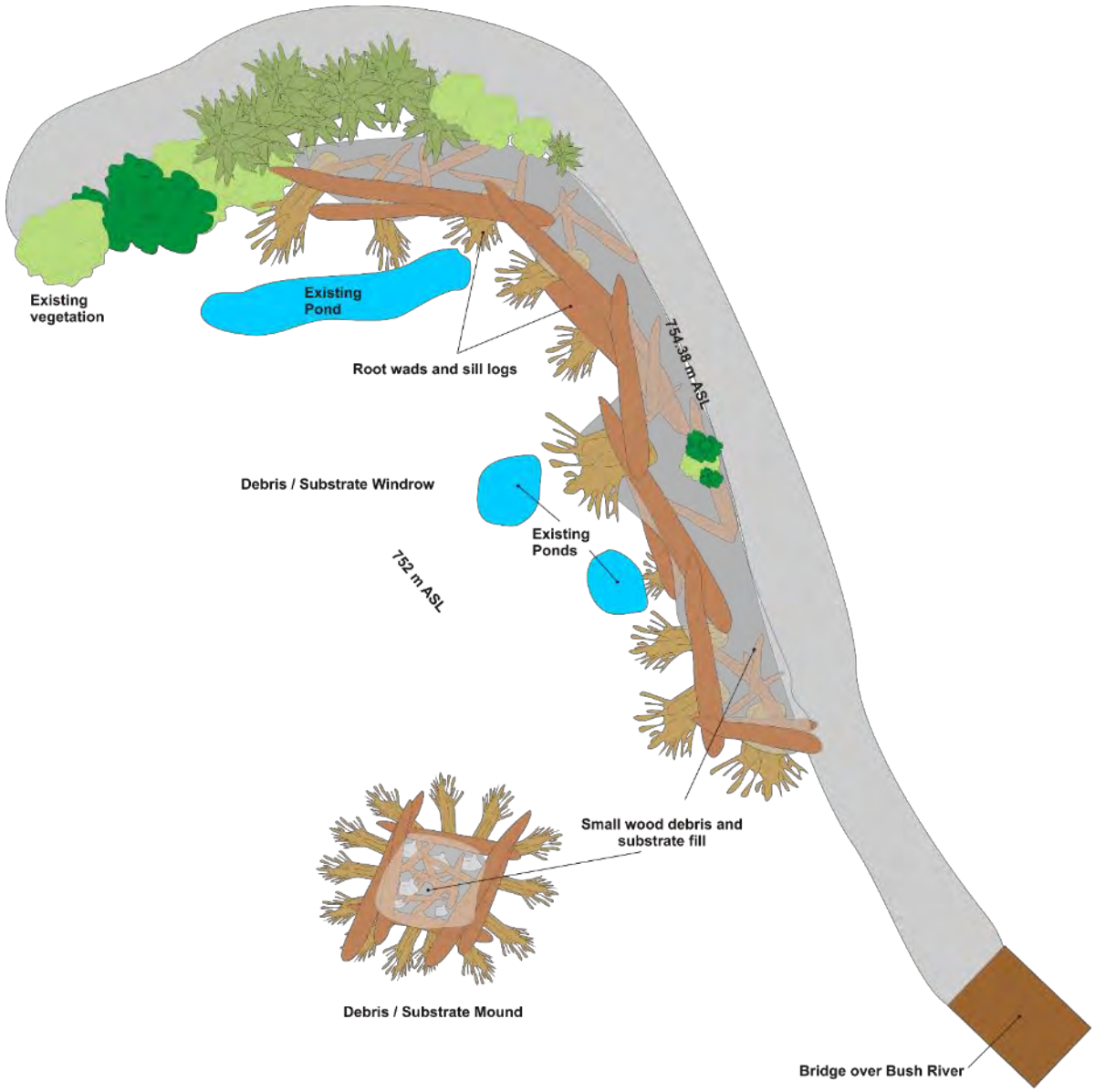

Figure 5-25: Schematic of proposed windrow and mound construction (top view) at Bush Arm Causeway North showing distribution of root wads, sill logs, small wood debris and substrates relative to the existing tree line and cottonwood seedlings. Although not drawn to scale, the windrow will be 3 to 10 m wide and ~ 150 m long. The base diameter of the base will be ~ 50m^2 m and have a height of 3 to 4 m. The top of the mound would be 15 to 20 m wide with a flat top to facilitate planting of live stakes.

5.5 Chatter Creek

5.5.1 Overview

As with the other sites, two distinct, but related treatments will be applied at Chatter Creek: wood debris removal and mound construction. Wood debris removal will occur in two locations, as will mound construction. One mound will be built as a standalone wood debris island while the other will be constructed between two existing high points of land to form a bridge between them. The debris islands

will be built using similar construction methods to other mounds and windrows to create a flat-topped tetrahedron-like shape that will have a top elevation > 754.38 m ASL. The target elevation will be around 756 m ASL.

A conservative estimate of the volume (m^3) of wood debris available at the Hope Creek site is 1,598 m^3. This should be enough material to build the mounds as described below. One mound island will cover an area of ~675 m^2 and the other will be ~500m^2. The wood debris removal areas should be monitored for plant growth in 2016 to assess the efficacy of wood debris removal to promote the establishment and development of vegetation communities at high elevations of the drawdown zone (i.e., between 751 and 754 m ASL).

The proposed construction sites at Chatter Creek are slightly lower in elevation compared to all other locations, with elevations ranging from 751 m to 753 m ASL. This requires that the mounds be somewhat taller than other mounds to ensure the top of the mounds are out of the water when reservoir elevation are at or exceed 754.38 m ASL. Under historical conditions, elevations ≥ 751 m ASL were exposed (not inundated) for ~135 days per year (min. = 102; Max = 183; mean = 135 days) based on historical data (1997 to 2014). This represents ~ 74% of the growing season. To ensure the mounds are exposed for the duration of the growing season, the mounds will need be between 3.5 and 4.5 m tall.

5.5.2 Rationale

The previous revegetation treatments attempted at Chatter Creek were a failure and the duration and frequency of inundation is suspected to be the primary cause. In addition to the soils becoming anoxic, soil conditions at the site are currently poor and do not support a diverse vegetation community. Providing habitat that persists outside of the normal reservoir maximum should afford plants the opportunity to establish. Positioning the mounds to either bridge existing high points or protect existing vegetative growth should increase the overall cover of vegetation at Chatter Creek and increase wildlife habitat suitability over time.

5.5.3 Site Description

The Chatter Creek site is situated just west of Chatter Creek and at the site of the old seasonal road crossing across Bush Arm. The site ranges in elevation from ~745 to 755 m ASL. A position of the Chatter Creek site (~6,500 m2) is treed (mainly aspen and cottonwood with a willow edge) and the remainder of the site is relatively sparsely vegetated. Several mounds, likely old spoils from road construction occur on the site and these are either covered with silt or coarse sand. Several large deposits of cobble occur at Chatter Creek. The treed portion of the site appears to receive some recreational use.

5.5.4 Land Ownership

The proposed project occurs within the drawdown zone of Kinbasket Reservoir, which is managed by BC Hydro under a Water Licence.

5.5.5 Current Site Conditions

5.5.5.1 Existing Vegetation

Vegetation communities in the vicinity of the proposed treatments have not been mapped under CLBMON-10. The closest communities are the Common Horsetail (CH) and Lady's Thumb-Lamb's Quarters (LL) Communities (see Figure 5-27), both of which are pioneering communities. Much of the lower elevations proposed for mound construction are dominated by common horsetail (Figure 5-26).

Vegetation assessments were conducted at the Chatter Creek site in 2015 as part of CLBMON-9 and although the data have not been yet been analysed, the vegetation species richness at the proposed sites was relatively (n=30 species). Forbs were the most frequently encountered life form (n=13 species) followed by grasses and sedges (n=9 species), shrubs (n=4 species) and 2 species of tree were growing on site (black cottonwood and trembling aspen). A depression at the toes of the road cut supports naturally regenerating cottonwood, rose, and willow. Current site photos (July 2015) are provided below (Figure 5-26).

Figure 5-26: Examples of vegetation cover and wood debris distribution at the Chatter Creek site. A: wood debris and one of the proposed mound location; B: wood debris; C: existing cottonwood and rose at toe of slope, and D: Common Horsetail growing in the drawdown zone at ~ 750m ASL. All photos July 15, 2015.

5.5.5.2 Revegetation Efforts

A single treatment was applied at the Chatter Creek site in 2008 (Figure 5-27), which consisted of willow live staking. As with other revegetation treatments applied in the drawdown zone of Kinbasket Reservoir, this treatment was a failure.

Figure 5-27: Distribution of revegetation prescriptions applied in the drawdown zone of Kinbasket Reservoir at the Chatter Creek location in 2008 (red polygons) relative to the proposed location of the debris mounds (orange filled polygons).

5.5.5.3 Wildlife

Hawkes et al. (2007) described the wildlife suitability of Bush Arm as high. However, the wildlife suitability rating was ascribed due to unique and valuable habitats associated with Bear Island, swamp horsetail habitat on the north side of Bush Arm (at km 79) and in higher elevation habitats near the Bush Arm Causeway. In general, current wildlife use of the Chatter Creek area is lower than in other regions of Bush Arm. There are no areas of standing water that could be used by pond-breeding amphibians, shorebirds, or waterfowl and wildlife use of the area appears to be limited to ungulates (mule deer and moose), black bear, and various songbirds.

5.5.5.4 Soils

Soil profiles have not been produced for Chatter Creek, but cursory assessments of the substrate in the area were made during field work for CLBMON-9 in 2015. The majority of substrates were classified as silt, sand, and fines (Figure 5-28). These categories classify the surface substrates; the composition of the underlying substrates is not known. It appears that current soil conditions at the site wold limit the growth of vegetation.

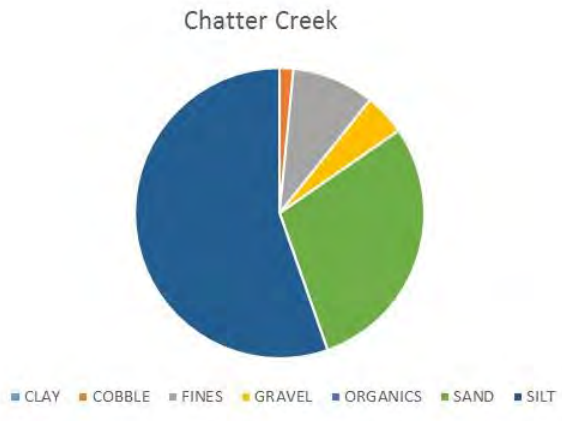

Figure 5-28: Distribution of dominant surface substrates at Chatter Creek. Visual assessments of substrates were made during field work for CLBMON-9 (June and July 2015).

5.5.5.5 Hydrology

Aside from Chatter Creek, which drains into Bush River at the south edge of the physical works location, no other hydrological features are present.

5.5.6 Objectives

The objectives for wood debris removal, windrow, and mound construction at Chatter Creek include the objectives listed in Section 3.2 and the following:

1. Create two mound islands – one as a standalone island and another forms a bridge between two current high points; and
2. Assess the efficacy of wood debris removal at this location to promote the establishment and development of vegetation.

5.5.7 Target Site Conditions

The mound islands built at Chatter Creek will be similar to the one built at Bush Arm Causeway North with the main difference being the elevation at which they are built (between 751m and 753 m ASL). The mound islands will have a base diameter of ~ 50m^2 and a top elevation of at least 754.5 m ASL with the actual elevation depending on the availability of wood debris.

The mounds will be comprised of wood debris and local substrates and live stakes (cottonwood and willow) will be planted into the substrate along the top and sides of the mound[5]. The addition of sedge plugs may be considered at a later date (i.e., following an assessment of mound persistence following the next full or high water event). The northern-most mound will protect an existing patch of cottonwood, willow, and other shrubs at the toe of the slope and the southern-most mound will bridge the gap between two treed high points of land.

5.5.8 Performance Measures

The following performance measures are suggested to assess the success of the mound construction at Chatter Creek:

[5] Live-staking is not proposed as part of the pilot program

1. Creation of two mound islands described above that persist during all seasons and following inundation;
2. Little to no erosion of the mound following inundation and winter. Erosion will be determined using aerial photos obtained from a drone. Photos will be acquired immediately following mound creation and again following inundation or the winter season;
3. Survival of at least 50 per cent for all planted live stakes for all species;
4. Successful natural establishment of vegetation common to the site at the wood debris removal sites and on the mound;
5. Successful protection / retention of currently vegetated areas adjacent to the northern-most mound;
6. Provision of wildlife habitat for insects, songbirds, and small mammals; and
7. Continued evidence of use of the Chatter Creek area by wildlife (e.g., mule deer, moose, and black bear).

5.5.9 Construction Schematics

The Chatter Creek mound locations and wood debris removal sites are illustrated in Figure 5-29 and a mound construction schematic is provided in Figure 5-30.

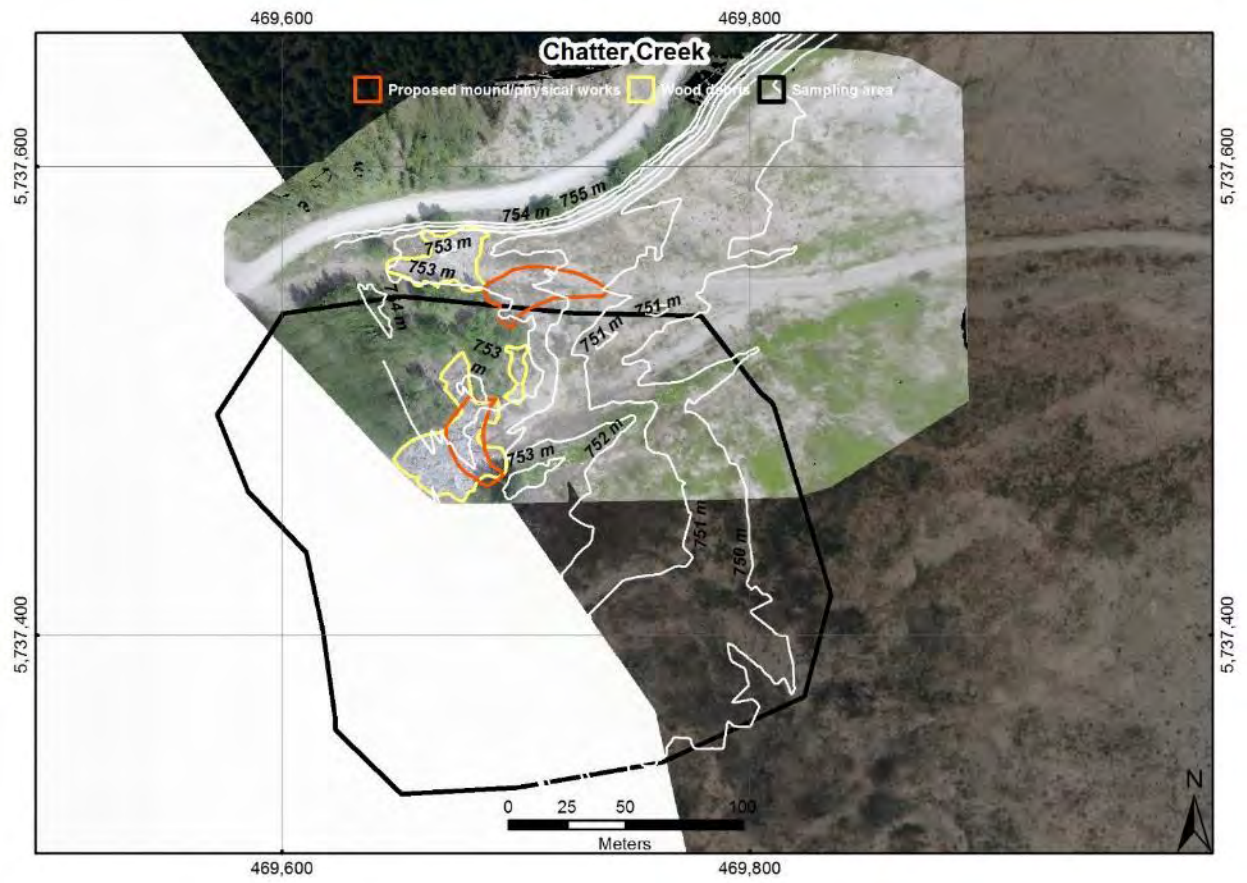

Figure 5-29: Schematic of proposed mound location (orange polygon) at Chatter Creek. The distribution of wood debris relative to the mound construction site is shown. The location and shape of the mounds is approximate.

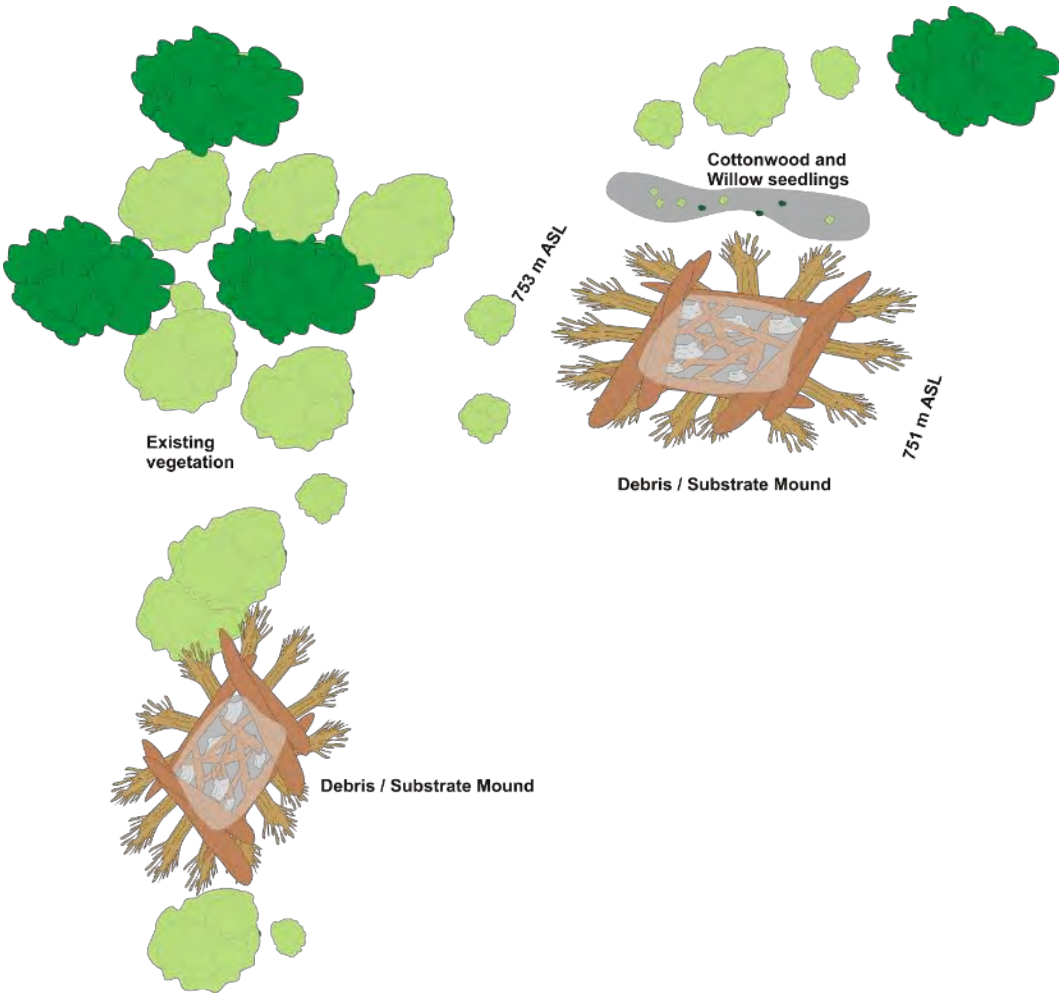

Figure 5-30: Schematic of proposed mound construction (top view) at Chatter Creek showing the two mounds and the distribution of root wads, sill logs, small wood debris and substrates relative to the existing tree line and cottonwood seedlings.

6 References

Adama, D. 2015. CLBWORKS-1 Kinbasket Reservoir Revegetation Program, 2014 Post-planting Report. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generations, Water License Requirements, Burnaby, BC. 20 pp + Appendices.

BC Hydro. 2007. Columbia River Project Water Use Plan. BC Hydro Generation, Burnaby B.C. 41 pp.

BC Hydro. 2015. Columbia River Project Water Use Plan. Kinbasket and Arrow Reservoirs revegetation management plan. Physical works terms of reference. CLBWORKS-1 Kinbasket Revegetation Physical Works Addendum 4. 11 pp.

Bruland, G.L. and C.J. Richardson. 2005. Hydrologic, edaphic, and vegetative responses to microtopographic reestablishment in a restored wetland. Restoration Ecology 13(3): 515–523.

Ewing, K., 2002. Mounding as a technique for restoration of prairie on a capped landfill in the Puget Sound lowlands. Restoration Ecology 10(2): 289–296.

Fenneman, J.D., and V.C. Hawkes. 2012. CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis. Annual Report – 2011. LGL Report EA3271. Unpublished report by LGL Limited, Sidney, B.C., for BC Hydro Generation, Water Licence Requirements, Castlegar, B.C. 78 pp. + Appendices.

Hawkes, V.C and P. Gibeau. 2015. CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources. Annual Report – 2014. LGL Report EA3532. Unpublished report by LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generations, Water License Requirements, Burnaby, B.C. 74 pp + Appendices.

Hawkes, V.C., 2015. LGL Limited Contract No. 77816 Release 3: Debris boom installation, Valemount Peatland. Letter report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generations, Water License Requirements, Burnaby, B.C. February 18, 2015.

Hawkes, V.C., C. Houwers, J.D. Fenneman, and J.E. Muir. 2007. Kinbasket and Arrow Lakes reservoir revegetation management plan: Kinbasket Reservoir inventory of vegetation resources. Annual Report – 2007. LGL Report EA1986. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generations, Water Licence Requirements, Burnaby, BC. 82 pp.

Hawkes, V.C., M.T. Miller, J.E. Muir, and P. Gibeau. 2013. CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis. Annual Report – 2013. LGL Report EA3453. Unpublished report by LGL Limited, Sidney, BC, for BC Hydro Generation, Water Licence Requirements, Castlegar, BC. 70 pp. + Appendices.

Hill, N.M., P.A. Keddy, and I.C. Wisheu. 1998. A hydrological model for predicting the effects of dams on the shoreline vegetation of lakes and reservoirs. Environmental Management, 22(5): 723–736

Hough-Snee, N., L.A. Long, L. Jeroue, and K. Ewing. 2011. Mounding alters environmental filters that drive plant community development in a novel grassland. Ecological Engineering 37(11): 1932–1936.

Keefer, M.E., R. Moody, K. Dixon, and A. Kennedy. 2011. Kinbasket Reservoir Revegetation Program Physical Works Report (2010). Report prepared by Keefer Ecological Services for BC Hydro. 41 pp. + Appendices.

Keefer, M.E., R. Moody, T.J. Ross, A. Chapman, and J. Meuleman. 2010. Kinbasket Reservoir Revegetation Program Physical Works Report (2009). Report prepared by Keefer Ecological Services for BC Hydro. 39 pp. + Appendices.

Keefer, M.E., T.J. Ross, and K. Kettenring. 2007. Kinbasket Reservoir Revegetation Program Physical Works (Phase 1) Site Verification and Seed Collection. Report prepared by Keefer Ecological Services for BC Hydro. 21 pp. + Appendices.

Keefer, M.E., T.J. Ross, T. Ehlers, and J. Meuleman. 2008. CLBWORKS-1 Kinbasket Reservoir Revegetation Program Physical Works Report (2008). Report prepared by Keefer Ecological Services for BC Hydro. 53 pp. + Appendices.

Larkin, D., G. Vivian-Smith, and J.B. Zedler. 2006. Chapter 7: Topographic heterogeneity theory and ecological restoration. Pages 142 – 164 *In*: D.A. Falk, M.A. Palmer, and J.B. Zedler (eds.). Foundations of Restoration Ecology. Society for Ecological Restoration International. Island Press. 364 pp.

Luken, J.O. and T.N. Bezold. 2000. Plant communities associated with different shoreline elements at Cave Run Lake, Kentucky. Wetlands, 20: 479–486.

Nilsson; C. A. Ekblad, M. Gardfjell and B. Carlberg. 1991. Long-Term effects of river regulation on river margin vegetation. The Journal of Applied Ecology, 28: 963–987.

Poff, N.L. and J.K.H. Zimmerman. 2010. Ecological responses to altered flow regimes: a literature review to inform the science and management of regulated rivers. Freshwater Biology 55: 194–205.

Van Geest, G.J., H. Coops, R.M.M. Roijackers, A.D. Buijse, and M. Scheffer. 2005. Succession of aquatic vegetation driven by reduced water-level fluctuations in floodplain lakes. Journal of Applied Ecology, 42: 251 – 260.

Werner, K.J. and J.B. Zedler. 2002. How sedge meadow soils, microtopograhy, and vegetation respond to sedimentation. Wetlands 22(3): 441–466.

Yazvenko, S.B. 2009. CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis. Sampling Design. Prepared for BC Hydro by LGL Limited, Sidney, B.C. 19 pp. + Appendices.

Yazvenko, S.B., V.C. Hawkes, and P. Gibeau. 2010. CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis. Annual Report – 2009. LGL Report EA3073. Unpublished report by LGL Limited, Sidney, B.C., for BC Hydro Generation, Water Licence Requirements, Castlegar, B.C. 83 pp. + Appendices.

Ye, C., K. Zhang, Q. Deng, and Q. Zhang. 2012. Plant communities in relation to flooding and soil characteristics in the water level fluctuation zone of the Three Gorges Reservoir, China. Environmental Science and Pollution Research. DOI: 10.1007/s11356-012-1148-x