Campbell River Project Water Use Plan

Upper Campbell Reservoir Drawdown Zone

Reference: JHTWORKS-3

Revegetation Treatment Report – Year 1

Study Period: January 1 to January 12, 2018

Laich-Kwil-Tach Environmental Assessments Ltd. Partnership and Ecofish Research Ltd.

January 12, 2018

JHTWORKS-3

Upper Campbell Reservoir Drawdown Zone Revegetation Treatment Report – Year 1




Prepared for:

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EXECUTIVE SUMMARY

As the Campbell River Water Use Planning (WUP) process reached completion in 2012, several concerns remained with respect to the effects of BC Hydro operations on the substrates and vegetation within the reservoir drawdown zone. Among these was the erosion and destabilization of shoreline vegetation of the Upper Campbell Reservoir, caused by operational changes in water level and accompanying wind and wave action (BC Hydro 2016). Between 1996 and 2004, the Upper Campbell Reservoir operated under a higher than normal annual water budget; however, since 2004, reservoir operations have returned to lower summer water levels. Operation at higher levels for several years removed substrate and vegetation from a 0.5 m band of shoreline around the reservoir, totalling an estimated 440 hectares. Given the resultant visual impacts, the WUP Consultative Committee identified the need to improve the aesthetic quality of the exposed shoreline in locations visible from high-use recreation areas. Consequently, the Comptroller of Water Rights issued a *Water Act* Order that required a terms of reference be written to "identify, prioritize and revegetate highly visible reservoir perimeter sites within the drawdown zone".

The Upper Campbell Reservoir Drawdown Zone Revegetation Program (JHTWORKS-3) is a 10-year physical works and monitoring program with the primary goal of improving the visual quality and riparian habitat values of high profile reservoir shoreline areas through enhancement of natural recolonization of native vegetation communities in the upper drawdown zone. There are three phases to the project: 1) identification/prioritization of sites for revegetation treatment trials (Year 1); 2) planning, trial implementation, and monitoring of revegetation treatment trials (Years 2-6); and 3) implementation of the final revegetation treatment plan at additional sites around the reservoir (Years 7-10). This Revegetation Treatment Report presents results from Year 1 of JHTWORKS-3, which is being implemented by Laich-Kwil-Tach Environmental Assessments Ltd. Partnership (LKT) with support from Ecofish Research Ltd. (Ecofish).

The specific objectives of Year 1 of JHTWORKS-3 were: 1) identification and prioritization of highly visible reservoir perimeter sites within high recreational use areas that have the highest potential for revegetation and natural recolonization success; 2) design of operational trials based on naturally occurring species composition and vegetated site conditions and characteristics; and 3) development of an effectiveness monitoring program to evaluate success.

Steps to accomplish Year 1 objectives included: 1) collecting and compiling information and data through background review, outreach, and consultation to guide site selection; 2) conducting a reconnaissance visit to confirm site suitability; 3) collecting baseline data on each proposed site to characterize the site and allow evaluation of treatment options; 4) designing the operational trial prescriptions using the results of all approaches as well as feedback from a workshop; and 5) developing an effectiveness monitoring program.

Trial Site and Treatment Type Selection and Characterization

Criteria for selecting and evaluating potential revegetation sites were divided into three categories: revegetation priority, revegetation opportunity, and the likelihood of revegetation success. A number of sites were investigated and, eight sites were selected for operational trials, in consultation with key stakeholders including First Nations. Within these eight sites, 49 specific treatment areas (including controls) were delineated.

Revegetation treatments were designed for four distinct landscapes ('treatment types'): A) low slope (less 5%) or alluvial fan; B) moderate slope drawdown (5-15%); C) steep upper drawdown (over 15%); and D) steep upland forest (over 45%). In each of the eight revegetation sites, two to fourteen treatment areas were established, with each categorized as one of the four treatment types. Each treatment type was represented between seven and 17 times within all sites combined.

Baseline data were collected, analysed, and presented by treatment type and treatment area to characterize the vegetation response, environmental setting, and disturbances typical of each. Permanent monitoring plots were also established to sample vegetation stem densities within each of the treatment areas, and repeatable aerial drone imagery and ground-based photographs were taken.

Treatment Prescriptions

Sixteen revegetation treatments (including controls) were developed, four for each treatment type. Treatment prescriptions were based on site conditions (e.g., existing substrate, elevation, vegetation present) and the key factors that affect the ability of plants to become established and survive. The specific recommendations included prescriptions for site preparation (e.g., slope stabilization, substrate mounding, ground preparation, creation of trenching or terracing, installation of woody debris), plant species and size, planting treatment (e.g., staking, transplanting), and source material (e.g., topsoil or other substrate materials, transplants, woody debris). For each treatment a rationale, as well as risks/challenges, are presented. A schedule and cost estimate is provided for the treatment planning/trials phase, provided that specified assumptions are met. Alternative restoration prescriptions were also suggested for potential future use.

Effectiveness Monitoring Program

The effectiveness monitoring program has the objective of evaluating the effectiveness of the revegetation techniques and adaptively modifying prescriptions based on monitoring results. The program is based on the repeated collection of baseline/monitoring data and is scheduled to begin in Year 2 when the treatment trials will be implemented.

Conclusions and Recommendations

This Revegetation Treatment Report satisfies the requirements of Year 1/ Phase 1 of JHTWORKS-3. It presents the revegetation sites selected for JHTWORKS-3, the revegetation treatment prescriptions developed for operational trials, and the objectives and methods of the effectiveness monitoring program. It also describes the approach adopted to accomplish these objectives. The information presented provides much of the information required to conduct the detailed planning that will be required to implement the recommended treatments. However, this revegetation treatment plan is a living document and the schedule and prescriptions may be amended in consideration of cost, other 'works' projects, effectiveness monitoring results, the outcomes of annual monitoring committee meetings, and/or other factors. Recommendations for future years of the program include collecting baseline data at two sites where this was not accomplished in Year 1, improving the evaluation of human disturbance, assessing progress and identifying problems and improvements on an ongoing basis, continuing outreach, consultation, and research as required as the program progresses, and allowing the effectiveness monitoring program to evolve in accordance with results and observations.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF MAPS

LIST OF APPENDICES

1. INTRODUCTION

Water use planning integrates ecologically, socially, and economically sustainable work practices at BC Hydro. The goal is to provide a balance between competing water values that include fish and wildlife, recreation, and power generation. Water Use Plans (WUPs) were developed for many of BC Hydro's hydroelectric facilities through a consultative process involving local stakeholders, government agencies, and First Nations. The framework for water use planning requires that a WUP be reviewed on a periodic basis to ensure ongoing compliance and continuous improvement; there is expected to be monitoring and works projects embedded in a WUP to address outstanding management questions and concerns in the years following its implementation.

As the Campbell River WUP (BC Hydro 2012) process reached completion, several concerns remained with respect to the effects of BC Hydro operations on the substrates and vegetation within the area between the low and high water marks as the reservoir fills and empties, known as the reservoir drawdown zone. The fluctuating water levels associated with flooding and drawdown activity within reservoirs, along with accompanying wind and wave action, can cause erosion and destabilize shoreline vegetation. Such impacts to the shoreline and vegetation have been a concern for the Upper Campbell Reservoir, which operated under a higher-than-normal annual water budget from 1996 to 2004. During this operational period, the summer maximum water level was raised 0.5 meters, from 220.5 m[1] to 221.0 m, and the summer minimum water level was raised 2 meters, from 217.0 to 219.0 m. However, since 2004, reservoir operations have returned to lower summer water levels, from June 21 to September 10, similar to pre-1996. When the reservoir operated at higher levels, it caused mortality in vegetation not accustomed to submersion, and affected and ultimately removed substrate and vegetation from the 0.5 m band of shoreline around the reservoir, totalling an estimated 440 hectares.

Given the visual impacts of these reservoir operations on the shoreline and vegetation of the Upper Campbell Reservoir, the WUP Consultative Committee prioritized improving the aesthetic quality of the exposed shoreline in locations visible from high-use recreation areas. In addition, the *Water Act* Order issued by the Comptroller of Water Rights on November 21, 2012 (Schedule C, Clause 1c) required that a terms of reference be written to "identify, prioritize and revegetate highly visible reservoir perimeter sites within the drawdown zone" in the Upper Campbell Reservoir.

[1] All elevations references to sea level.

The Upper Campbell Reservoir Drawdown Zone Revegetation Program (JHTWORKS-3) is a 10-year program with the primary goal of improving the visual quality and riparian habitat values of high profile reservoir shoreline areas impacted by fluctuating water levels. Accomplishment of this goal requires that the natural recolonization of native vegetation communities in the upper drawdown zone of the Upper Campbell Reservoir is actively enhanced (BC Hydro 2016). Additional benefits of this Program are improved First Nations resource values, wildlife habitat, and a likely increase in shoreline stability. Year 1 of JHTWORKS-3 is being implemented by Laich-Kwil-Tach (LKT) with support from Ecofish Research Ltd. (Ecofish).

JHTWORKS-3 is divided into three phases that will be implemented over the ten year period: phase 1) identification/prioritization of sites for revegetation treatment trials (Year 1); phase 2) planning, trial implementation, and monitoring of revegetation treatment trials (Years 2-6); and phase 3) implementation of the final Revegetation Treatment Plan at additional sites around the reservoir (Years 7-10).

This Revegetation Treatment Report presents results from Year 1 of JHTWORKS-3 (Phase 1). The specific objectives of Year 1 of JHTWORKS-3 were: 1) identification and prioritization of highly visible reservoir perimeter sites within high recreational use areas that have the highest potential for revegetation and natural recolonization success; 2) design of operational trials (i.e., revegetation treatment trials) based on naturally-occurring species composition and vegetated site conditions and characteristics; and 3) development of an effectiveness monitoring program to evaluate the success of the operational trials. Accomplishment of these objectives involved compiling information from a background review and consultation with key stakeholders to guide site selection; collecting baseline data on each proposed treatment site to characterize the site and allow evaluation of treatment options; designing operational trial restoration prescriptions using the results of the background review, baseline data, and consultation; and developing a monitoring program. The operation trial treatment prescription portion of the report should be considered a living document. The schedule and prescriptions may be modified based on annual effectiveness monitoring results, cost, other 'works' projects, the outcomes of annual monitoring committee meetings, and/or other factors.

2. BACKGROUND: PHYSICAL AND ECOLOGICAL CONTEXT

2.1. Vegetation Ecology and Reservoir Operations

The Upper Campbell Reservoir is the largest and most southern and western component of the Campbell River hydroelectric system. It is comprised of two waterbodies that are impounded by the Strathcona Dam: Upper Campbell Lake to the north and Buttle Lake to the south (Map 1). The Strathcona Dam was constructed between 1955 and 1958, with a second generating unit installed in 1968. The Upper Campbell Reservoir also provides primary flow regulation for the Ladore and John Hart dams, which are located downstream. Land ownership surrounding the Upper Campbell Reservoir is primarily BC Parks, TimberWest Forest Corp., and other fee-simple private ownership.

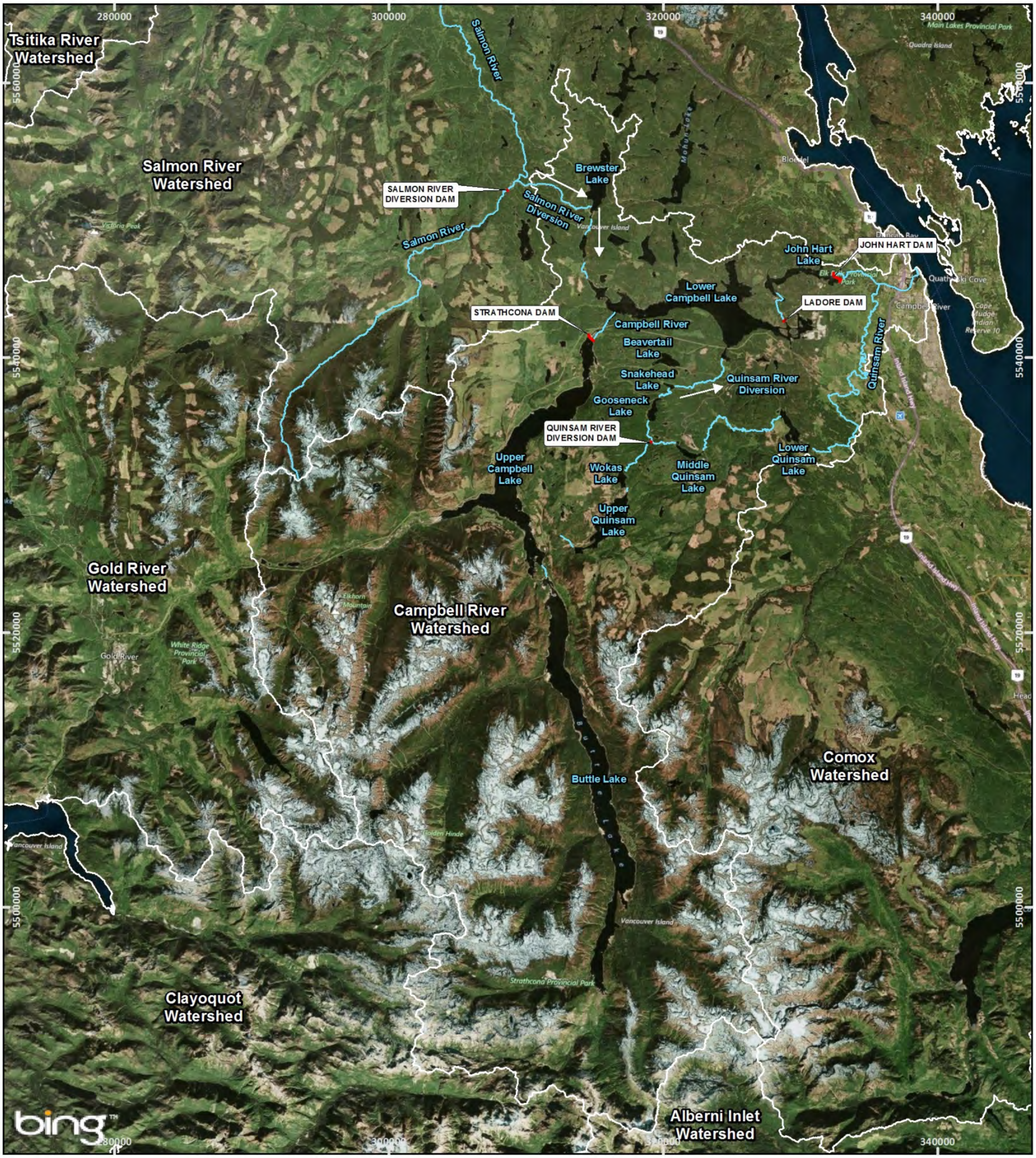
The Upper Campbell Reservoir is located within the western variant of the very dry maritime subzone of the Coastal Western Hemlock biogeoclimatic zone (CWHxm2). It is transitional between the wetter temperate rainforests that characterize the majority of the BC Coast, the sub-Mediterranean "rainshadow" ecosystems of the Coastal Douglas-fir zone to the south, and the cold montane moist maritime ecosystems at higher elevations around its perimeter (MOF 1994). A subsident orographic effect from the Vancouver Island ranges and adjacency with the temperature moderating marine environment contribute to the region's distinct biogeoclimatic characteristics (MOF 1991).

The CWHxm2 occurs at lower – middle elevations (up to 700 m) on the east side of Vancouver Island and is characterised by warm and dry summers, moderately warm springs and falls with moderate rainfall, and moist, mild winters with abundant rainfall and little snowfall (Green and Klinka 1994, Swift and Ran 2012) (Figure 1). Wildfires cause infrequent, stand-initiating events during summer droughts as a part of the natural disturbance regime (NDT2) (Swift and Ran 2012).

The soils surrounding the Upper Campbell Reservoir are reflective of the glacial history of the area. Primary parent materials include bedrock, unconsolidated glacial tills and glaciofluvial deposits of varying thickness. These parent materials are composed of angular and sub-angular gravels, cobbles and sand, with rapid drainage and moderately to poorly developed subsoil and surface soils (A and B horizons). The soil texture and high percentage of coarse fragments generally result in very-poor to poor soil nutrient regimes and very-dry to moderately-dry soil moisture regimes (MOF 1994).

Climate and soil characteristics are major factors influencing vegetation community distribution and ecology, in part, because temperature, nutrient availability and precipitation play a key role in vegetation reproduction, germination, and establishment. Climate data from the Strathcona Dam ranging from 1980 to 2016 indicate that precipitation is lowest in July and August, during the same period when temperatures peak (Figure 1). Climate predictions indicate that this pattern will continue in the future; however, water deficits will become more severe (Wang *et al.* 2016). Hydrologic inputs to the Upper Campbell Reservoir during the growing season are largely from snow melt from the surrounding Vancouver Island Ranges by way of small streams and medium sized rivers including the Thelwood and the Elk rivers. In the future, annual snowfall is predicted to decrease. Hence, as is typical of the region, vegetation growth is constrained by water deficits towards the end of the long growing season. This effect is anticipated to be exacerbated by predicted lower summer precipitation and winter snowfall (Wang *et al.* 2016). These effects will also likely be compounded by the coarse soils typical of the region. In addition, sunlight as well temperature, especially cold temperatures in fall, winter and spring, define and limit the growing season. In general, a similar growing season is expected to persist with the average temperature from fall through spring expected to increase but the total number of frost free days anticipated to decrease (Wang *et al.* 2016).

Project Overview



Legend

- Dam
- Stream

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 2 4 6 8 10 12 14 16 km

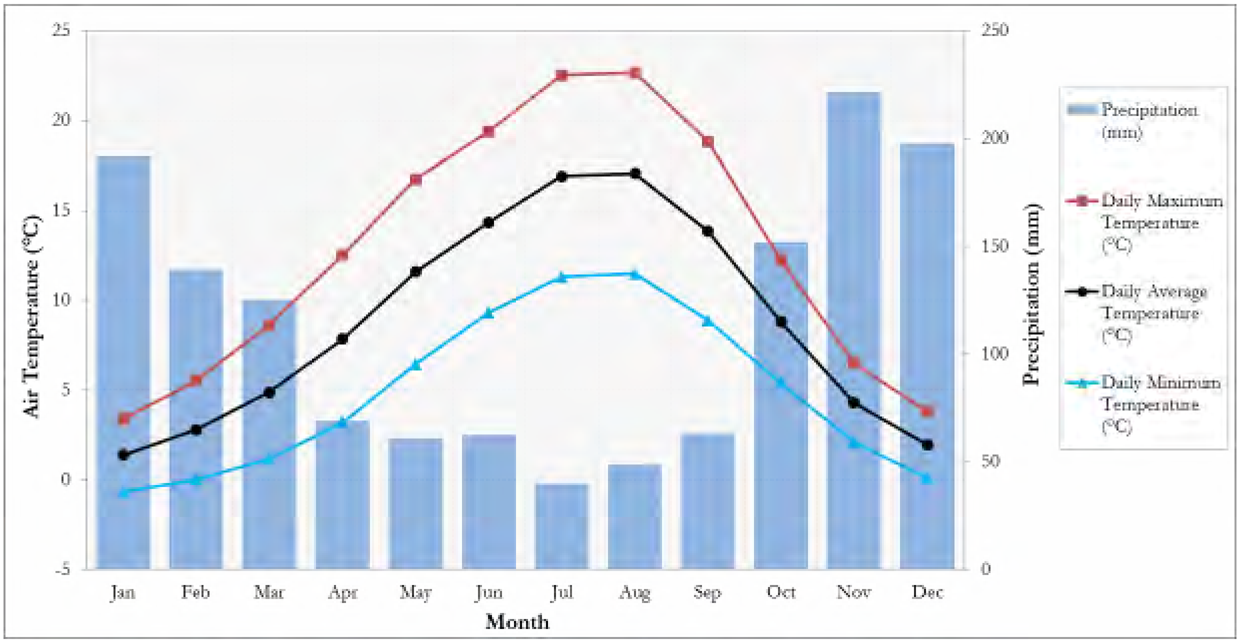
Scale: 1:400,000

NO.	DATE	REVISION	BY
1	29/03/2016	1230_SAM_QUN_Overview_Portrait_2015Jul03	CGA
2			
3			
4			
5			

Date Saved: 29/03/2016
Coordinate System: NAD 1983 UTM Zone 10N

Map 1

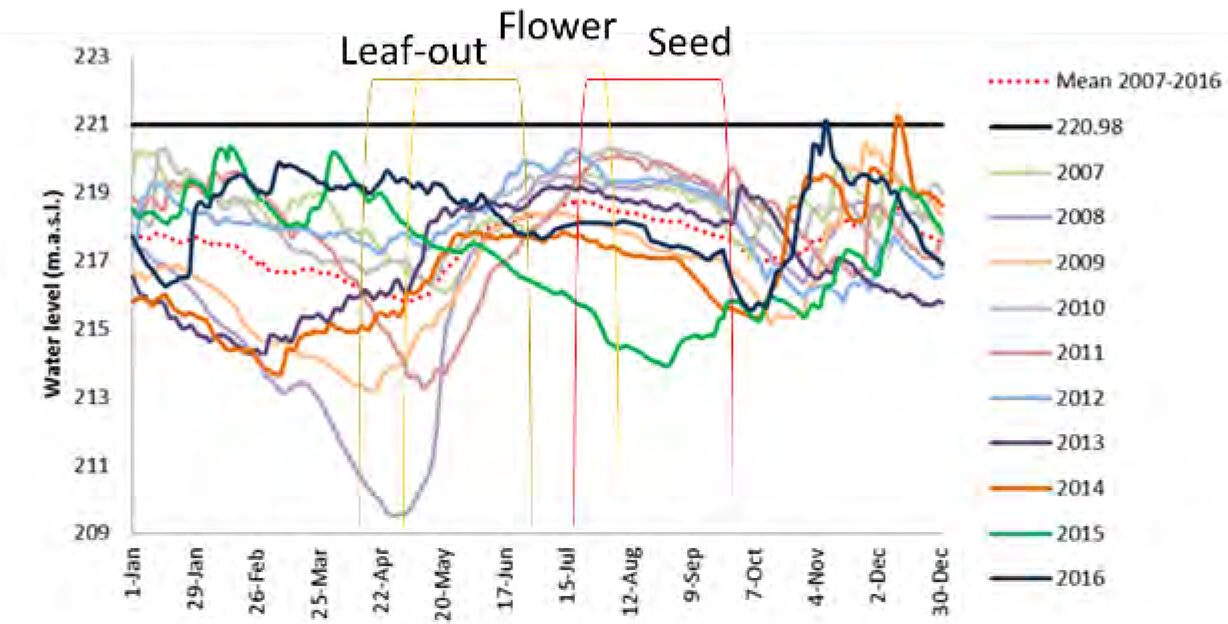
Figure 1. Temperature and precipitation graph for 1980 to 2016 monthly climate normals at Strathcona Dam weather station (BC Hydro 2016).



In reservoir systems, operations have a large effect on vegetation ecology and distribution (Appendix A). In general, vegetation occurring within the drawdown zone of reservoirs is less abundant, less diverse, and consists of more exotic species than similar habitats in natural lakes, and is often devoid of rare shoreline herbs (Wilcox & Meeker 1991, Hill *et al.* 1998, Shafroth *et al.* 2002, Furey *et al.* 2004). This is particularly true of the upper littoral zone, which receives the most fluctuation in water levels. The littoral zones of reservoirs also often have high levels of erosion, and low levels of nutrient accumulations, which can inhibit vegetation establishment.

Similar to other reservoirs (e.g., Nilsson and Keddy 1988, Riis and Hawes 2002, Leira and Cantonati 2008, Xie *et al.* 2014; Appendix A), the operational regime of Upper Campbell Reservoir plays an important role in determining the shoreline ecology and vegetation community composition within the littoral zone of the reservoir. Upper Campbell Reservoir's historic operational water elevation has been between 210.0 m and 221.0 m. The current maximum and minimum operating levels are 212.0-220.5 m respectively (as measured at Strathcona Dam). The preferred operating zone varies throughout the year (as determined based on the WUP targets such as recreation, flood risk, fish and fish habitat). During the summer recreational period, the preferred operating zone ranges from 217.0-220.5 m (BC Hydro 2012). Overall, the operational water levels vary each year but are typically lowest in the spring, high in the summer, low in early fall, high again in late fall and then decreasing until spring (BC Hydro 2012) (Figure 2). These water level fluctuations result in water levels that are low during the beginning of the growing season, when plants are leafing out, and high in the middle of the growing season when plants typically fruit and disperse by seed. Thus, a greater range of the elevations of the littoral zone that support plants and their potential habitats are inundated for more days in the summer months than in the spring. This means that most vegetation in the drawdown zone is inundated before it reproduces, and seeds that may have germinated in the drawdown zone will not have had much time to establish before they are inundated.

Figure 2. Annual water levels in Upper Campbell Reservoir from 2007-2017 in relation to plant life stages typical of the geographic region.



The effects of the operational regime on plant communities in the Upper Campbell Reservoir vary depending on the elevation that they occupy in the littoral zone (Figure 3). The lower elevations of the littoral zone (i.e., 214.0-216.0 m) are inundated much more consistently throughout the growing season and from year to year, while plants occurring in the highest elevations (i.e., 220.0-221.0 m) are typically not inundated throughout the growing season. In contrast, vegetation communities occurring in the intermediate to upper elevations (i.e., 216.0-220.0 m) are subject to the most variable inundation regime, including throughout the growing season and from year to year (Figure 3). Consequently, the plant species currently present within the drawdown zone of Upper Campbell Reservoir occur within distinct vegetation communities in specific elevation bands that are dictated by the interaction between their physiological traits, the inundation regime and other environmental 'filters' such as slope, aspect, substrate, oxygen availability, and fetch (see also Section 4.1 – trial site selection). Riparian vegetation communities in the Upper Campbell Reservoir most commonly occur on floodplains and alluvial fans, where gradients are lower and soils are typically composed of fine fluvial sediments and relic terrestrial soils. Some riparian communities also exist on steeper shorelines around the lakes where soils have been washed away exposing subsurface sand and gravels; however, vegetation is often sparser and less diverse on these sites, and vegetation rarely occurs on slopes over 15% (Ballin *et al.* 2015). Much of the remainder of the shoreline is unvegetated or sparsely vegetated, with a substrate dominated by coarse fragments (e.g., gravel, boulders) or steep rock bluffs.

Figure 3. Percentage of days each meter of elevation of the littoral zone is out of water during the growing season (May to September) 2007-2016.

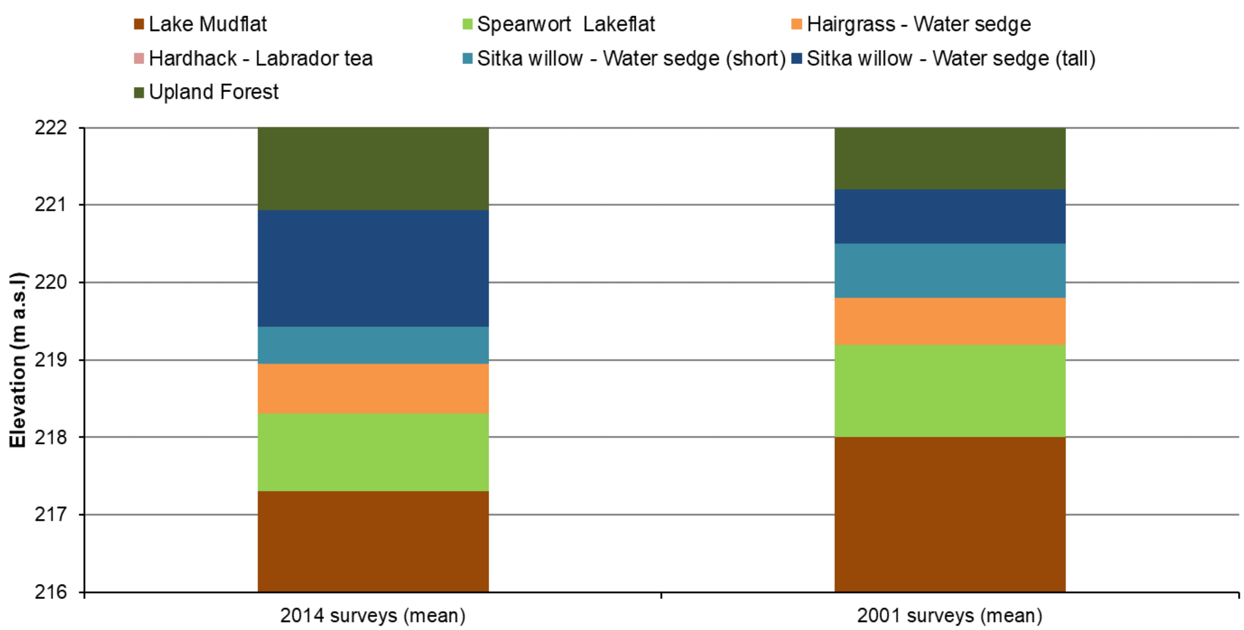
Month	Elevation (m ASL)	Year 2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
May	221	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	220	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	219	100%	100%	100%	100%	100%	100%	100%	100%	100%	32%
	218	100%	100%	100%	100%	100%	77%	42%	100%	87%	0%
	217	100%	100%	100%	52%	100%	0%	32%	55%	0%	0%
	216	0%	81%	84%	0%	100%	0%	0%	13%	0%	0%
June	221	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	220	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	219	100%	93%	100%	63%	100%	50%	100%	100%	100%	100%
	218	37%	50%	47%	3%	100%	0%	0%	100%	100%	37%
	217	0%	0%	10%	0%	60%	0%	0%	0%	50%	0%
	216	0%	0%	0%	0%	23%	0%	0%	0%	0%	0%
July	221	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	220	100%	100%	100%	77%	100%	71%	100%	100%	100%	100%
	219	45%	0%	100%	0%	48%	0%	10%	100%	100%	100%
	218	6%	0%	0%	0%	6%	0%	0%	100%	100%	45%
	217	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%
	216	0%	0%	0%	0%	0%	0%	0%	0%	55%	0%
August	221	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	220	100%	100%	100%	35%	77%	100%	100%	100%	100%	100%
	219	0%	0%	100%	0%	0%	0%	100%	100%	100%	100%
	218	0%	0%	90%	0%	0%	0%	0%	100%	100%	42%
	217	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%
	216	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%
September	221	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	220	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	219	83%	40%	100%	60%	3%	53%	100%	100%	100%	100%
	218	20%	0%	100%	0%	0%	0%	3%	100%	100%	100%
	217	0%	0%	33%	0%	0%	0%	0%	90%	100%	20%
	216	0%	0%	0%	0%	0%	0%	0%	47%	100%	0%

The plant species occurring along Upper Campbell Reservoir were described and classified into six communities based on their elevational distribution, by McLennan and Veenstra (2001) (Figure 4). These communities include: lake mudflat; spearwort lakeflat; hairgrass – water sedge; Sitka willow – water sedge (short); Sitka willow – water sedge (tall); and upland forest. Field observations of the elevation bands in which each of these vegetation communities occurs are shown in Figure 4 for surveys completed in 2001 and for more recent surveys conducted in 2014 (Ballin *et al.* 2015).

The more recent (2014) surveys show a general downward shift in elevation of the vegetation communities since the 2001 surveys based on the change in the operational regime in 2004 (i.e., post WUP), that lowered the maximum reservoir water level.

The vegetation communities characterized by McLennan and Veenstra (2001) and JHTMON-10 (Ballin *et al.* 2015), depicted in Figure 4, occur in similar habitats with similar elevational distribution as to the sites targeted for revegetation in JHTWORKS-3. With the exception of 'lake mudflat', these vegetation communities are described in more detail below.

Figure 4. Measured elevations of vegetation communities in the Upper Campbell Reservoir in 2001 (McLennan and Veenstra 2001) and 2014 (Ballin *et al.* 2015).



2.1.1. Spearwort Lakeflat

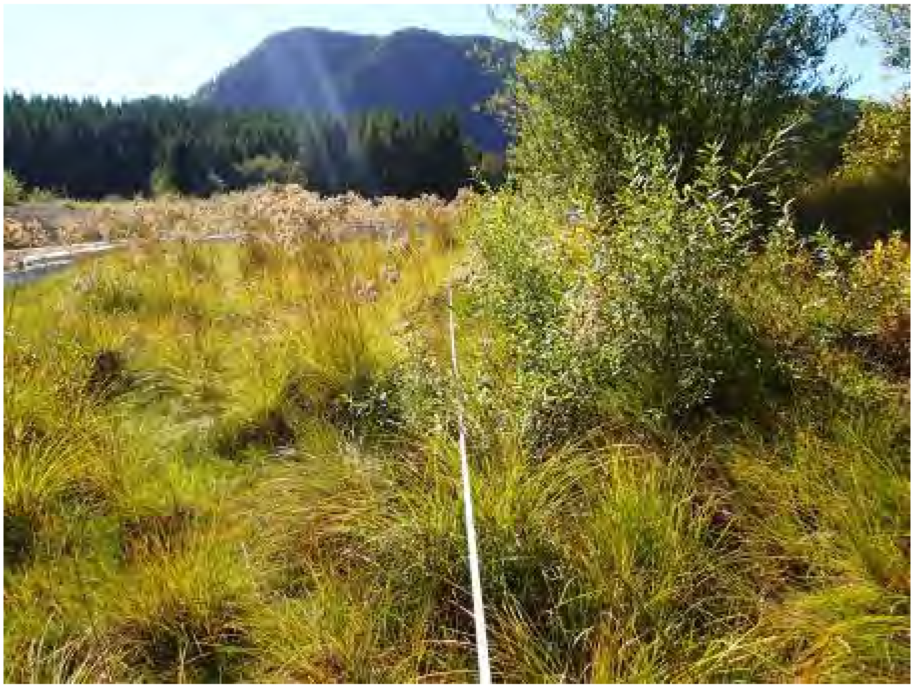
Spearwort lakeflat communities occupy the lowest vegetated elevations in the littoral zone of the reservoir. Extensive occurrences of the community are frequently located on the lower elevations of fluvial lakeflats above mudflats and below the hairgrass – water sedge community. The vegetation community is often more sparsely represented (less than 10% cover) in its respective elevation band where floodplains are less extensive or absent, shoreline substrates coarser and slopes steeper (>5%). Sedges, rushes, grasses, and various other herbs have a clumpy distribution at the upper extent of the community, while the lower extent is often a mosaic of lesser spearwort (*Rannunculus flammula*), sparse other emergent aquatic vegetation, and exposed sandy or mudflat substrate (Ballin *et al.* 2015, McLennan and Veenstra 2001).

Figure 5. Spearwort Lakeflat on the Upper Campbell Reservoir, September 4, 2014.

2.1.2. Hairgrass – Water Sedge

The hairgrass – water sedge community occurs along the shoreline of the Upper Campbell Reservoir in the drawdown zone between the Sitka willow – water sedge community and the spearwort lakeflat community (Figure 6). The vegetation community is most extensive on alluvial fans at the outflow of streams and is rarely present on slopes over 4% gradient. Herbaceous diversity increases at the upper extent of the community. Larger water sedges (*Carex sp.*), slough sedge (*C. opnupta*) and tufted hairgrass (*Deschampsia cepitosa*) are often present in the middle of the elevation band and smaller sedges occupy the lower extent (Ballin *et al.* 2015, McLennan and Veenstra 2001).

Figure 6. Hairgrass - water sedge community along a creek outflow at the north end of Upper Campbell Lake, September 3, 2014.



2.1.3. Sitka Willow – Water Sedge

The Sitka willow – water sedge community occurs along the upper shoreline of the Upper Campbell Reservoir on slopes up to 15% and provides a transition between the hairgrass – water sedge community (if present) and upland forest communities. The community demonstrates two distinctive structural stages: a tall and a short stage. The taller stage consistently occupies a higher elevation band than the shorter stage (Ballin *et al.* 2015, McLennan and Veenstra 2001).

The Sitka willow – water sedge community experiences periodic, seasonal flooding. The short structure of this community experiences inundation more frequently and for more extensive periods of time. Vegetation is typically dominated by Sitka willow with components of other willows such as Pacific willow (*Salix lucida spp. lasiandra*) and hooker's willow (*Salix hookeriana*). Red alder (*Alnus rubra*) and black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) are commonly present at the upper extent of the community, and black cottonwood extends as low as willow in several locations. In some drier sites where gravels dominate the substrate, invasive Scotch broom (*Cytisus scoparius*) composed a significant portion (up to 50%) of the shrub layer (Figure 7). In moister sites, more often found on Buttle Lake, salmonberry (*Rubus spectabilis*) and red elderberry (*Sambucus racemosa*) were present. The understory vegetation at lower elevations was typically composed of sedges and exotic and native grasses. The upper elevations were composed of a variety of herbs that ranged from drought tolerant strawberry (*Fragaria virginiana*), and trailing blackberry (*Rubus ursinus*), as well as invasive St. John's wort (*Hyperacum perforatum*) and oxeye daisy (*Leucanthemum vulgare*), to more moisture dependant grasses and ferns.

Much of the upper extent of the tall Sitka willow – water sedge community is in the early seral stages of transitioning to upland forested communities in response to operational changes which have reduced disturbance return intervals from flooding (Figure 8) (Ballin *et al.* 2015, McLennan and Veenstra 2001). Drier sites are typically being colonized by conifers such as Douglas-fir (*Pseudotsuga menziesii*) and shore pine (*Pinus contorta var. contorta*), while wetter sites are dominated by red alder and black cottonwood. At many sites, portions of the uppermost extent of the drawdown zone exposed since the change in operations, especially drier or nutrient poor sites that are not densely populated with native vegetation, have been colonized with invasive species, such as Scotch broom (e.g., Figure 7).

Figure 7. Tall Sitka willow - Water sedge community with high component of Scotch broom observed at the north end of the Upper Campbell Lake Reservoir, September 2, 2014.

Figure 8. Tall Sitka willow - Water sedge community in transition to conifer forest observed at Ralph River on Buttle Lake, January 15, 2015.

2.1.4. Upland Forest

Upland forest vegetation communities occupying the slopes around the Upper Campbell River Reservoir are typical of the CWHxm2 (Figure 9). Zonal sites are dominated by Douglas-fir, with western hemlock (*Tsuga heterophylla*) and some western redcedar (*Thuja plicata*). Dominant understory species include salal (*Gaultheria shallon*), dull Oregon-grape (*Mahonia nervosa*), red huckleberry (*Vaccinium parvifolium*), step moss (*Hylocomium splendens*) and Oregon beaked moss (*Kindbergia oregana*) (Green and Klinka 1994). Pacific dogwood (*Cornus nuttallii*) is common along edge habitats and shore pine and western white pine (*Pinus monticola*) are abundant in early successional areas. Dry exposed eroding slopes lie just above the drawdown zone in portions of the reservoir. These areas are generally sparsely vegetated with drought tolerant species including kinnikinnick (*Arctostaphylus uva-ursi*), Oregon-grape; trailing blackberry, hemp dogbane (*Apocynum cannabinum*), and Scotch broom. In many instances, larger tree species have slid down the slope from the forest above such as Douglas-fir and Pacific dogwood and maintain a mature root structure that is rooted in the intact soils and forest above.

Figure 9. Upland forest at north end of Upper Campbell Lake, September 3, 2014.

2.2. Prior Restoration Trials

2.2.1. Upper Campbell Reservoir

BC Hydro has actively been investing in revegetation of the Upper Campbell Reservoir since 1993 (Appendix A). This investment has been put towards describing the naturally occurring vegetation communities around the reservoirs (McLennan and Veenstra 2001), research on the relationship between shoreline vegetation communities and the inundation regime (i.e., JHTMON-10) (McLennan and Veenstra 2001, Bruce 2002, Ballin *et al.* 2015), supporting and leading revegetation trials and programs (Mackillop and Dushenko n.d., Mackillop 2003, Redden and Cuthbert 2006, Read 2017, pers. comm., Polster 2017).

Revegetation trials in the Upper Campbell Reservoir have included planting of live deciduous stakes, seedlings and 'ecomats' (transplants of mats of forest floor plant species) at different elevations in several locations along Upper Campbell Reservoir, including the south end of Buttle Lake near the inflow of Thelwood Creek, the floodplain of the Elk River, and on the shore of Upper Campbell Lake near the entrance to Strathcona Park. Although the monitoring programs for these trials only lasted a few years, they have shown that: 1) at the trial sites within the drawdown zone, Sitka willow transplants have the highest survival among the five willow species planted and are also superior to black cottonwood; 2) Sitka willow transplants collected from nearby areas (local provenances) have higher survival than imported provenances of Sitka willow collected from further away (i.e., coastal areas such as the old island highway); and, 3) that ecomats perform well in the upper drawdown zone on slopes less than 20% when transplanted in early spring. Information learned from previous studies that supported development of these trials included the knowledge that: 1) sediment trapping is needed for subsequent establishment of herbaceous communities; and, 2) trees can establish within 1.5 m of maximum reservoir height (full pool); and, 3) the ability of trees to survive summer flooding is correlated with ability of seedlings to produce adventitious roots (roots arising from stem tissue) (Mackillop and Dushenko n.d., Mackillop 2003, Read 2017, pers. comm.).

3. METHODS

The selection and prioritization of revegetation sites, design of operational trials (also referred to as revegetation treatment trials), and development of a monitoring plan was directed using the combined results of a literature review and outreach, a reconnaissance site visit, an expert workshop, and collection of baseline data. Collectively, these approaches provided an understanding of the revegetation potential given the ecological and biophysical conditions and limitations for the drawdown zone of the Upper Campbell Reservoir.

3.1. Background Literature Review and Outreach

Relevant background information was reviewed and compiled to: 1) support the selection of revegetation sites, 2) describe the vegetation ecology and biophysical environment of the Upper Campbell Reservoir, 3) support identification of the environmental filters that are preventing vegetation establishment and/or that may affect the success of the revegetation program, and 4), to guide development of restoration prescriptions. The information reviewed (Appendix A) included: monitoring and works program reports from related WUP projects (e.g., Arrow, Kinbasket, and Carpenter Reservoir revegetation programs), background studies conducted in the Campbell system, general literature on vegetation response to reservoir operations, and literature and guidance on restoration techniques. Outreach was also conducted to augment results from the literature review and to gather detailed location-specific information. BC Hydro employees familiar with past restoration efforts in the Upper Campbell Reservoir were engaged by telephone or email.

A bibliography summarizing background literature and information collection is provided in Appendix A. The bibliography includes summaries of key documents and lessons to apply to JHTWORKS-3 physical works and effectiveness monitoring components.

3.2. Reconnaissance Visit

A reconnaissance visit was conducted on April 25th, 2017 to field verify the visual quality, revegetation status, and biophysical condition of identified potential high priority revegetation sites prior to the expert workshop (Section 3.3). The visit was conducted by two biologists with expertise in terrestrial ecology and revegetation, and one field technician. The reservoir level was 216.8 m during the visit which allowed a large portion of the drawdown zone to be viewed. Because the onset of spring was delayed in 2017, shrubby vegetation was just starting to leaf out during the field visit.

Figure 10. Willow leafing-out at Buttle Lake Campground during reconnaissance field visit on April 25, 2017.

3.3. Workshop

The expert workshop was hosted by BC Hydro, LKT, and Ecofish on June 19, 2017 at Strathcona Park Lodge to discuss the JHTWORKS-3 revegetation program for the Upper Campbell Reservoir. In addition to workshop hosts, the workshop was attended by representatives of BC Parks, Strathcona Park Lodge, K'ómox First Nation, We Wai Kai Nation, Wei Wai Kum First Nation, and TimberWest. The key objectives of the workshop were to compile and share recreational and biological knowledge to guide and support: 1) the identification of priority sites for operational trials along the reservoir from a visual quality and riparian habitat perspective; and 2) development of site-specific revegetation prescriptions for the revegetation treatment trials. Workshop topics were also extended to include discussion of the future desired condition of the drawdown zone, appropriate measures of revegetation success, and approaches to effectiveness monitoring. Following the workshop, a memorandum was provided to all workshop participants that summarized the key information and direction provided by workshop participants that was to be integrated into the current and future phases of the revegetation program. The workshop agenda, PowerPoint presentation, a list of invitees in attendance and not present, and the summary memorandum are provided in Appendix B.

3.4. Baseline Data Collection

Baseline data collection and analysis methods are presented in detail in the *JHTWORKS-3 Upper Campbell Reservoir Drawdown Zone Revegetation Program – Baseline Data Collection Methods and Effectiveness Monitoring Plan* (Appendix C). Baseline field data were collected within each site. Data collection methods involved recording physical and ecological parameters that describe the current vegetation status (vegetation response), environmental setting, and disturbance factors, as well as collection of drone and ground-based photomonitoring data.

Baseline data were collected at two spatial scales: treatment area and plot. The 'treatment area' scale characterized the entire area where each revegetation treatment trial will be implemented (see Section 2), and provides a description of relatively broad-scale physical and ecological characteristics of the entire treatment area, such as slope, fetch or percent cover of vegetation. A permanent monitoring plot (also referred to as "plot") was established within each treatment area at a location representative of the range of environmental conditions, to capture a sample of the density of vegetation by species.

Baseline data were collected over six days in September, 2017. Treatment area and plot scale environmental data and photopoint monitoring data were collected over five days from September 12-15th, and September 28th, and drone data were collected in one day, on September 21st, 2017.

Environmental data series were compiled and presented to provide information on climatic and hydrological trends including climatic and environmental data, and hydrometric data recorded by BC Hydro from the Strathcona Dam and Upper Campbell gauge located at Buttle narrows respectively (i.e., Figure 1 and Figure 2). Year 1 data analysis for hydrometric data included summary statistics and determining the proportion of each month elevations of the drawdown zone are out of water (Figure 2 and Figure 3).

4. REVEGETATION SITE, TREATMENT TYPE AND TREATMENT AREA SELECTION AND CHARACTERIZATION

A primary objective of Year 1 (Phase 1) was identification of high priority revegetation sites at which revegetation treatment trials will be implemented and monitored beginning in Year 2. Potential sites with high visibility and high recreational use were first identified from the JHTWORKS-3 Terms of Reference (TOR) (BC Hydro 2016). These sites were then field-verified during a reconnaissance visit (Section 3.2), and their suitability discussed at the workshop (Section 3.3). The revegetation sites were then divided into treatment areas and assigned a treatment trial based on treatment type and localized characteristics. Baseline data were collected for each revegetation area (Section 3.4) to characterize the area, including consideration of factors that may limit or promote revegetation and support the development of treatment prescriptions. The baseline data will also support effectiveness monitoring beginning in Year 2 (Section 5.5).

4.1. Selection of Revegetation Sites

4.1.1. Identification of Potential Revegetation Sites

Revegetation sites were selected based on criteria for revegetation priority, revegetation opportunity, and the likelihood of revegetation success based on the environmental setting and disturbance (i.e., environmental filters, introduced in Section 2). The criteria are presented in Table 1.

Table 1. Selection criteria for revegetation treatment trial sites.

Revegetation Opportunity	
Land ownership	Land ownership of site. Includes public, Provincial Park, private managed forest land or private ownership. Certain ownership types may not be conducive to trials as more detailed agreements with landowners would be necessary.
Machine access	Ease of machine access to site and potential solutions for anticipated constraints.
Cost	Expected relative cost to revegetate site in consideration of physical constraints such as steep slopes or access.
Known or potential physical works	Considers whether the site is being evaluated under JHTWORKS-2 (recreation facility upgrades) (BC Hydro 2016c) or has other planned physical works. Presents potential opportunities to collaborate with planned physical improvements or poses a constraint to implementing a trial.
Archeological site	Considers the archeological potential of the site and archeological artifacts found at the site as presented in the LKT Archeological Resource Overview of the Campbell River Watershed (Baseline 2012) and updated by the Archaeological Impact Assessment of Recreation Improvements/ Developments in Campbell & Buttle Lakes (Baseline 2017). Revegetation works should not impact archaeological sites.
Species and ecosystems at risk	Records of plant species and ecological communities at risk (CDC 2017) within treatment area. All upslope terrestrial areas and some wetland areas are expected to have the potential to support ecological communities at risk with restoration efforts but are currently in such a degraded state that they would not be considered as such. No rare plant survey was conducted thus there is potential for rare plants to occur in treatment areas, however none are expected.
Revegetation Priority	
Visibility	Site proximity or adjacency to the Upper Campbell Reservoir high use recreational area(s) or within the viewshed of high use areas (i.e., previously identified high priority sites or frequented by recreational users).
Public satisfaction	Expected public satisfaction in consideration of site elevation and public use survey conducted as part of JHTMON-2 (Morris and Conrad 2015). The survey was conducted at the Buttle Lake and Ralph River campgrounds. The survey identified lower satisfaction with shoreline conditions and a perception of safety issues with lower reservoir elevations (deemed for this project as below 219 m). During lower reservoir levels, barren shoreline and/or stumps are exposed. The presence of stumps is associated with higher perceived safety risk.
Fish and wildlife habitat	Expected or known aquatic/riparian values for fish and wildlife. These include lower gradient sites, sites near a stream or other high value habitat, and sites that link adjacent high value habitats.
Revegetation Success	
Elevation (m)	The elevation of sites and their water elevations throughout the year, especially during the growing season, influences the vegetation species and communities that may successfully grow, as vegetation is limited by both inundation (flooding) and drought. For the purpose of this project, the target vegetation elevations will be between 217.5 and 223 m elevation to reflect elevations that are most likely to support successful revegetation trials. Potential vegetation communities (and species) are based on measured and modelled vegetation minimum community boundary elevations from JHTMON-10. Sites above 217.6 (or higher) will support hairgrass-water sedge vegetation communities. Sites above 217.8 m (or higher) will support Sitka willow-water sedge (short) vegetation communities. Sites above 218.2 m (or higher) will support Sitka willow-water sedge (tall) vegetation. Sites above 219.2 m (or higher) will support upland forest. Elevation is also relevant to aesthetics and user satisfaction.
Slope (%)	Slope is relevant to a site's ability to trap and retain fine sediments, to be exposed to erosion forces and wave exposure. Riparian vegetation mapping for JHTMON-10 indicated that the maximum slope that supports natural vegetation within the drawdown zone is 15%, which is the slope that was assumed in the TOR. However, different communities and treatments are tolerant of different slope. In addition, many of the areas with an aesthetic concern have slopes over 15%. Some of these areas may be suitable for vegetation treatment trials, especially in the elevation bands that support willow and upland forest.
Substrate	Dominant substrate at site. Indicates ability of site to retain fines and conveys current growing medium. Large coarse substrates (e.g., cobble) stabilize the site while fine substrates(e.g., sand) are more prone to erosion and deposition; however, many species require fine substrates to grow. Coarse substrates also indicate chronic erosion of fines.
Natural recruitment	Evidence of natural recruitment of vegetation suggests that site conditions are suitable for revegetation trials. This may include sites with sparse vegetation that could be augmented with planting, partially vegetated sites that could be protected from human or wildlife disturbances, or sites dominated by invasive species that could be replaced with native species tolerant of similar site conditions.
Aspect	Site aspect is relevant to insolation and reservoir fetch. Increased insolation decreases soil moisture availability. Increased fetch increases erosive forces and debris deposition. In general, south-east facing sites are most exposed to reservoir fetch and hence erosion/deposition.
Water availability	Presence of subsurface or surface water/soil moisture availability (i.e., favourable hydrology) during appropriate time period.
Human disturbance	Evidence of ATV/vehicle use, fires or heavy foot traffic at the site that may restrict revegetation success.
Wildlife disturbance	Evidence of browsing or damage from mammals (e.g., ungulates, beavers, other rodents), birds (e.g., Canada Geese), or other wildlife that may restrict revegetation success.
Invasive species	Presence of invasive species that may restrict revegetation success.

4.1.2. Final Revegetation Site Selection

The final sites selected for operational trials are described in Table 2, and presented in Map 2. A brief description of each site, as well as a description of how each revegetation site meets the site-selection criteria is also included in the site profile sheets in Appendix D.

Although considered in site selection, the criteria of 'Cost' and 'Archaeological Site' are not presented in the site profile sheets. This is because cost was more relevant to the treatment area size than the treatment location (i.e., the cost of planting an area is a greater factor affecting cost than machine access), and because BC Hydro is commissioning an archaeological assessment of the sites. One site, the Strathcona Portal (JHT-RV01), included islets visible from the park entry point that were considered during the workshop but later discarded due to challenges associated with access.

Table 2. Sites selected for revegetation trials.

Site Name	Revegetation Site
JHT-RV02	Old Buttle Lake Boat Launch
JHT-RV03	Buttle Lake Campground
JHT-RV04	Rainbow Island Marine Campsite
JHT-RV05	Driftwood Bay Group Site
JHT-RV06	Buttle Lake Boat Launch
JHT-RV07	Buttle Lake Campground Fan
JHT-RV08	Karst Creek Boat Launch
JHT-RV09	Ralph River Campground

4.2. Treatment Type Selection

Four distinct types of landscape were identified that would benefit from revegetation work, hereafter referred to as 'treatment types'. These are: A) low slope or alluvial fan (Figure 11 and Figure 12); B) moderate slope drawdown (Figure 13); C) steep upper drawdown (Figure 14); and D) steep upland forest (Figure 15). Each type is distinguished by elevation relative to reservoir operations, by slope and other environmental filters (Table 4).

Table 3. Physical and ecological description of the four treatment types.

Label	Treatment Type	Description
A	Low slope or alluvial fan	These areas have slopes under 5% and occupy alluvial fans or shallow bays. They are typically well vegetated with herbaceous species at lower elevations (i.e., below 219 m), and with taller shrubs and trees at progressively higher elevations. The primary objective for revegetation of these areas is increasing visibility of lower elevation shallow areas and stumps to reduce the hazard for boaters. This treatment type supports all of the vegetation communities listed in Section 2.1; however, the target area for revegetation is occupied by the lowest two communities - 'spearwort lakeflat' and 'hairgrass - water sedge', as well as the mudflats that occupy lower elevations than these two communities.
B	Moderate slope drawdown	These areas have slopes under 15%. They are typically sparsely vegetated with patches of herbs and patches of deciduous shrubs. This treatment type occupies elevations suitable for the 'tall and short Sitka willow - water sedge' deciduous shrub communities (i.e., 217.8+ m) (Section 2.1.3) as well as the upper extent of the drawdown zone that may be capable of succeeding into terrestrial vegetation communities. The primary objective for revegetation is increasing the shrub cover to improve visual quality and riparian habitat, and support vegetation succession, where possible.
C	Steep upper drawdown	These areas have slopes over 15%. They are typically not vegetated to very sparsely vegetated with deciduous shrubs. This treatment type occupies elevations suitable for the 'tall and short Sitka willow - water sedge' deciduous shrub communities (i.e., 217.8+ m) (Section 2.1.3) as well as the upper extent of the drawdown zone that may be capable of succeeding into terrestrial vegetation communities. The primary objective for revegetation is increasing the shrub cover to improve visual quality and riparian habitat, and support vegetation succession, where possible.
D	Steep upland forest	These areas have slopes over 45% and are in a perpetual state of erosion. They are typically not vegetated to sparsely vegetated with herbs, low lying shrubs or the odd large Douglas-fir or Pacific dogwood tree that has slid down the slope and remains rooted above. This treatment type occupies elevations above the current and past 'full pool' of the reservoir (i.e., above 221.0 m) and thus are not, nor have ever been inundated by reservoir operations. These elevations are suitable for establishment of 'upland forest' communities (Section 2.1.4). The primary objective for revegetation of these areas is increasing vegetative cover to stabilize the slope, which will help enable vegetation to establish and grow to improve visual quality.

Figure 11. Treatment type A at Buttle Fan, JHT-RV07, at a reservoir elevation of 217.7 m, on September 13, 2017.

Figure 12. Treatment type A at Ralph River, JHT-RV09, at a reservoir elevation of 217.6 m, on September 15, 2017.

Figure 13. Treatment type B at Buttle Boat Launch, JHT-RV06, at a reservoir elevation of 217.7 m, on September 14, 2017.

Figure 14. Treatment type C at Buttle Campground, JHT-RV03 at a reservoir elevation of 217.8 m (left), on September 12, 2017, and at Buttle Boat Launch, JHT-RV06, at a reservoir elevation of 216.5 m (right), on September 28, 2017.

Figure 15. Treatment type D at Rainbow Island, JHT-RV04, at a reservoir elevation of 217.6 m, on September 13, 2017.

4.3. Characterization of Treatment Types and Treatment Areas

The eight sites selected for operational trials were divided into 49 treatment areas, including controls, of which baseline data were collected for 47 (Table 4). Each of the 47 treatment areas for which baseline data were collected, had a minimum of one permanent monitoring plot per treatment area. Each site had two to fourteen treatment areas, which were categorized into one of the four treatment types (Table 3 and Table 4). Data have been analysed and presented by treatment type to characterize the vegetation response, environmental setting, and disturbances typical of each type. Data for each treatment area and permanent monitoring plot are presented in Appendix E and Appendix F. Maps of each treatment area and monitoring plot are provided in the site profile sheets (Appendix D).

Table 4. Number of treatment areas and permanent monitoring plots in which baseline data were collected, by treatment type.

Treatment Type	No. of Treatment Areas	No. of Treatment Areas with Baseline Data Collection	No. of Permanent Monitoring Plots
A	11	11	11
B	7	7	7
C	19	18	20
D	12	11	11
Total	*49*	*47*	*49*

4.3.1. Ecological and Physical Parameters of Treatment Types and Treatment Areas

4.3.1.1. Vegetation Response

Vegetation can be described by many parameters including structural stage, the percent cover of each vegetation layer or species, as well as the distribution and vigour of each species in an area. Structural stage is used to describe the appearance of a vegetation community based on physical and biotic characteristics. Structural stage can depict the stage of development along the successional trajectory characteristic of the community or characterize the lifeform of a vegetation community (MOF 2010). Figure 16 presents the frequency of structural stages across treatment types. Treatment type A was typically in a forb (herbaceous flowering plant) dominated structural stage (Figure 11, Figure 12), while treatment area B was dominated by short shrubs (less than 2 m tall), followed by graminoids (e.g., grasses and sedges) and tall shrubs (2-10 m tall) (Figure 13). Treatment area C was most often sparsely vegetated (<10% cover), followed by short shrub dominated (Figure 14), while treatment area D was typically sparsely vegetated, except for some sites where large trees had slid down the bank lending itself to be classified as young forest (Figure 15). Structural stage data for each site are provided in Appendix E.

Changes in community structure and succession can be detected through shifts in the percent cover of each vegetation layer present on a site (MOF 2010). Figure 17 presents the distribution of the vegetative cover of vegetation layers across treatment areas. Herbs (forbs and graminoids) represent the dominant cover in treatment types A, B, and C, followed by short shrubs in B and C, and trees and short shrubs are most dominant in treatment type D. The estimated cover of each vegetation layer for each treatment area is presented in Appendix E.

Vegetation communities can also be described by species composition. The percent cover of dominant species was documented within each treatment area. Figure 18 presents the average cover of dominant species in each treatment type. Lesser Spearwort was the most common species observed in both treatment type A and B and was the third most common species observed in treatment type C. Sitka willow was the second most common species in treatment types B and C. Black cottonwood and Douglas-fir had the highest percent cover in treatment types C and D, respectively. Note that all species of mosses were combined and thus may be overrepresented in each treatment type. Changes in vegetation community composition will be monitored throughout the trial program and used to inform the assessment of revegetation success.

Figure 16. Frequency of the dominant structural stage by treatment type.

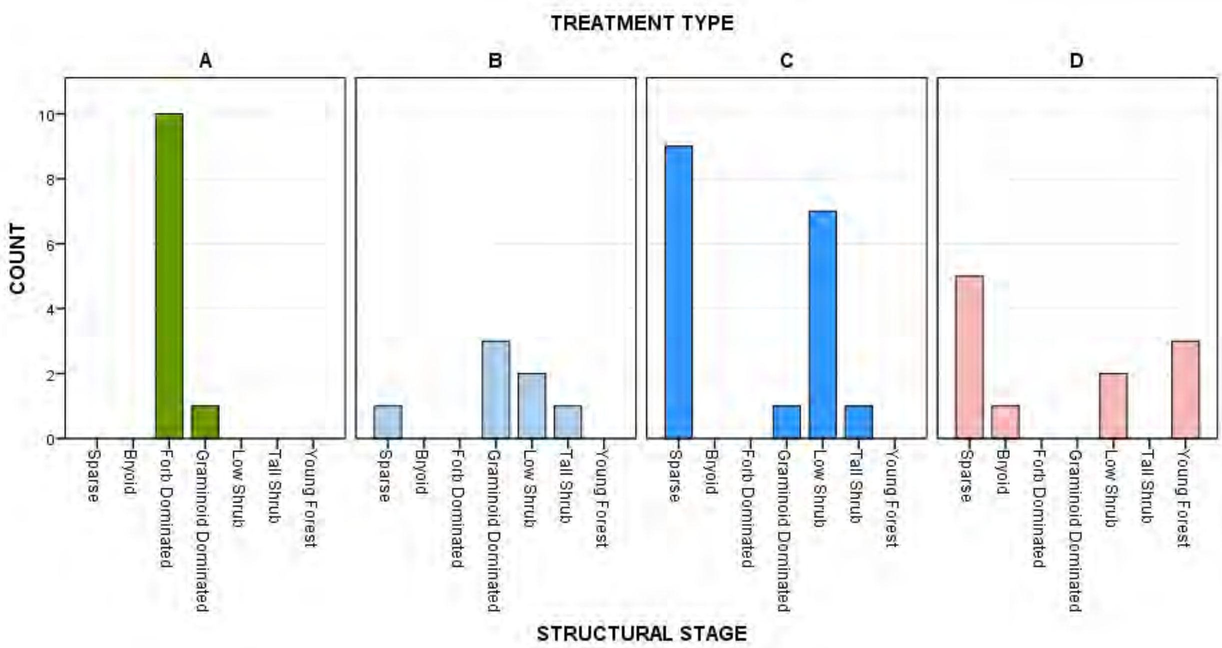


Figure 17. Average percent cover of each vegetation layer by treatment type

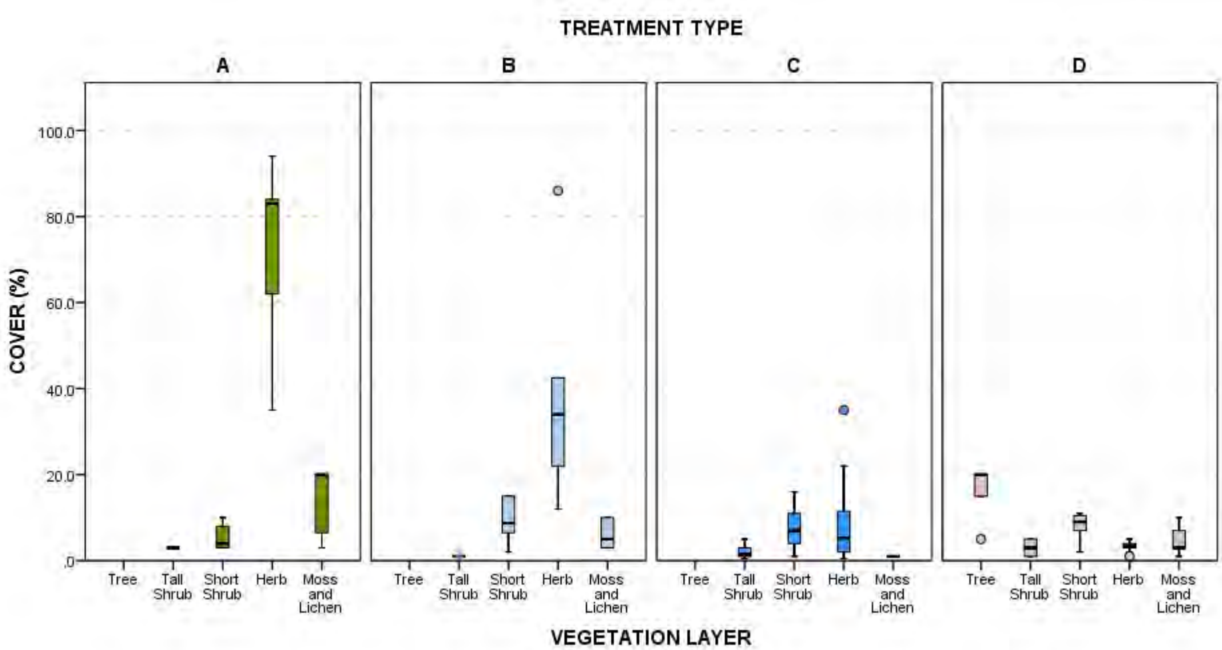
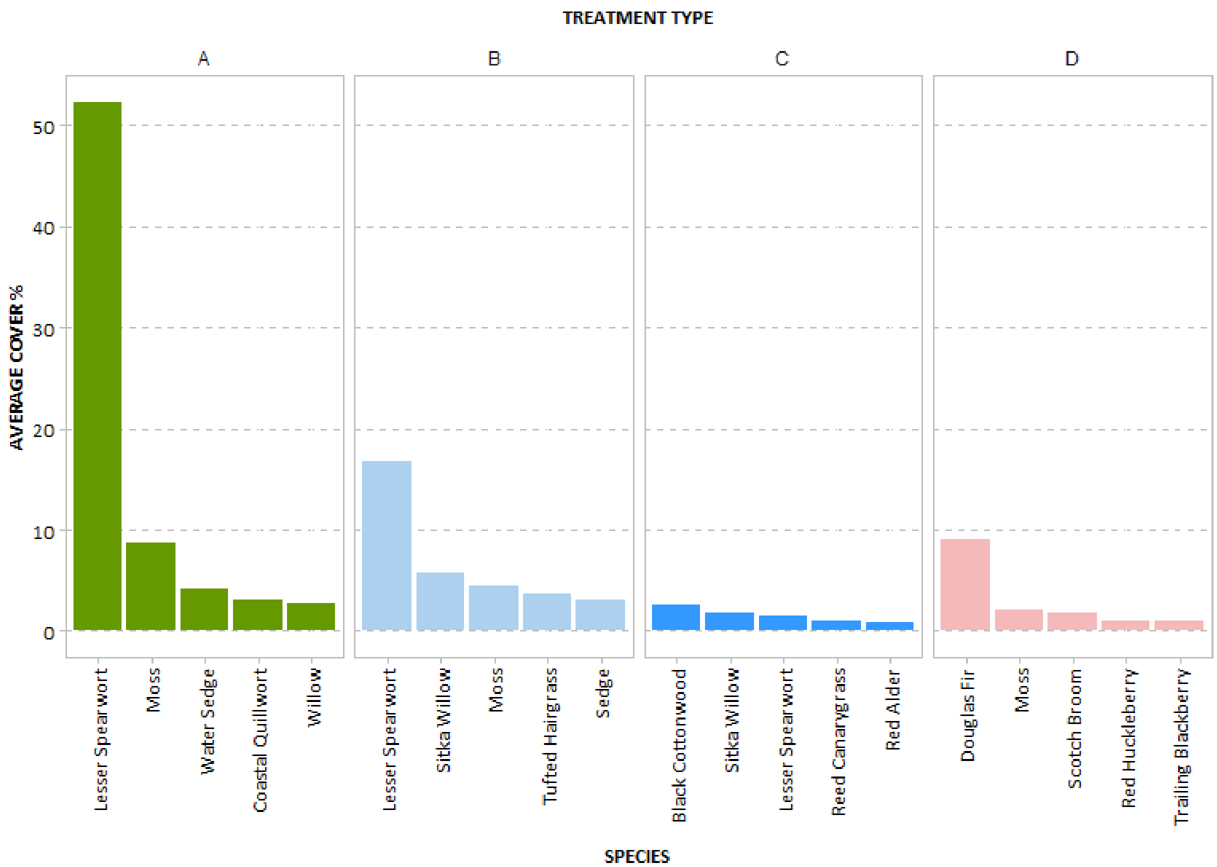


Figure 18. Dominant cover of plant species in each treatment type.



4.3.1.2. Environmental Setting

Many environmental filters influence the presence and distribution of vegetation species and communities. Naturally occurring vegetation community types in the Upper Campbell Reservoir can largely be predicted by elevation, as it relates to reservoir operations, because individual plant species have different tolerances to inundation (Mackillop 2003), as described in Section 2. Thus, the likelihood of success of specific treatment prescriptions for treatment types is dependent on treatment area elevation. Permanent monitoring plots were established at representative locations within treatment areas by locating them at approximately the median elevation of each treatment area and the top and bottom elevation of each site was surveyed. The median elevations of treatment types A, B and C occur at progressively higher elevations between 218 m to 219 m, while the median elevation of treatment type D occurs at a higher elevation of 222.7 m (Figure 19, Table 5). All treatment areas in treatment type A are entirely within the current drawdown zone, whereas treatment types B and C are mostly located within the drawdown zone with some areas spanning above current water levels. Treatment areas in treatment type D are entirely above the current drawdown zone except for one site (JHT-PRM48) that reaches 219.0 m at its lower end

(Table 5). The elevation of each permanent monitoring plot and elevation range of each treatment area are presented in Appendix E.

Vegetation communities within the Upper Campbell Reservoir are also strongly predicted by the site slope on which they occur. Vegetation communities typically naturally establish and persist on slopes of 15% or less, with the most vigorous occurrences of most communities occurring on slopes of 5% or less (Section 2, Ballin *et al.* 2015). Treatment types A to D are also distinguished by the slopes on which they occur (Figure 20). Treatment type A occurs on the shallowest slope (<5%), while treatment types B, C and D occur on increasing site slopes of approximately 10%, 26% and 53%, respectively. Appendix E presents the vertical slope of each site.

Several additional environmental parameters contribute to vegetation success and were collected for each treatment area as described in the baseline data collection (Section 3.4) and site selection (Section 4.1.1) methods. This environmental setting data for each site is presented in Appendix E.

Figure 19. Distribution of the elevations of permanent monitoring plots present by treatment type.

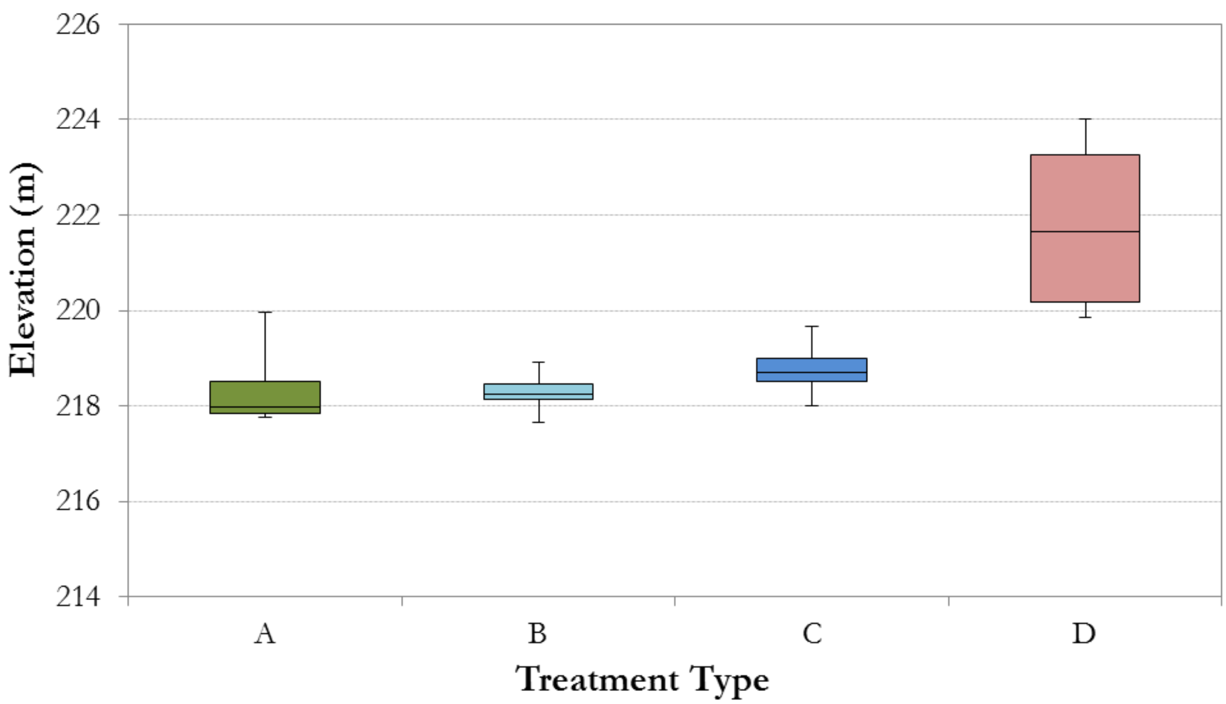
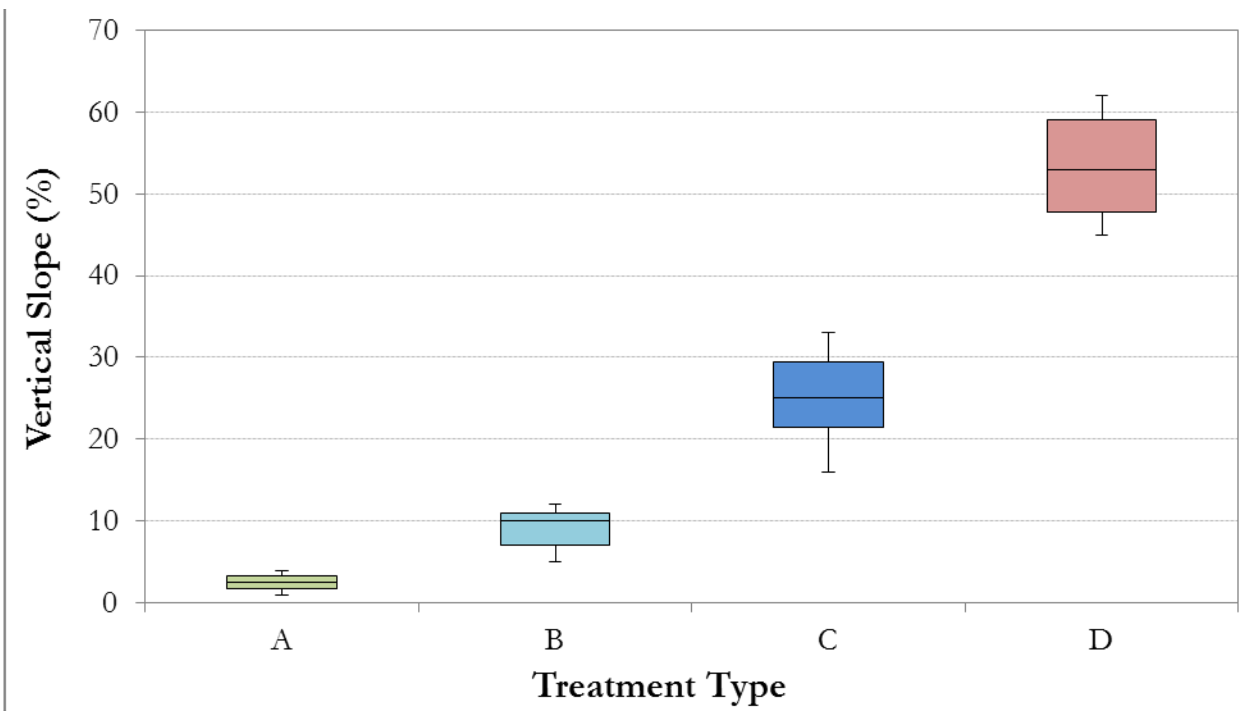


Table 5. Elevation range of treatment areas by treatment type.

Treatment Type	Average Permanent Monitoring Plot	Range of Treatment Area Elevations (m)
A	218.18	216.5 - 220.3
B	218.29	217.6 - 220.7
C	218.73	217.6 - 221.6
D	222.65	219.0 - 229.0

Figure 20. Distribution of site slope at each treatment type.



4.3.1.3. Disturbance factors

All sites either support or have the potential to support invasive species. Low slope and alluvial fans (A) had the lowest occurrence of invasive species, whereas the upper drawdown had the highest occurrence (B, C) (Table 6). Frequently occurring invasive species included (by treatment type): Scotch broom (B, C), Canada thistle (*Cirsium arvense*) (A, C), St. John's Wort (B, C), oxeye daisy (B, C), dock (*Rumex sp.*) (A, B, C), and Himalayan blackberry (B) (only a few sites). Reed canary grass (*Phalaris arundinacea*) was also observed in all but the hottest (most exposed) sites; however, it is unknown if this is the native or introduced species. Many of the listed invasive species also occurred below or above treatment type D where substrates were more stable. For the upper drawdown and upland sites (B-D), stabilizing the substrate will increase the potential for invasive species to colonize.

On most sites, vegetation was observed to have some amount of wildlife, disease or insect damage, with the exception of a few sites with little to no vegetation (Table 6). No wildlife, disease or insect damage was observed at a few sites with little to no vegetation. Wildlife damage included grazing from geese, deer/ungulates, and rodents. Grazing by ungulates is expected to be particularly high on alluvial fans that are densely vegetated with deciduous shrubs at higher elevations and thus are already a good source of forage and cover (e.g., JHT-RV07 and JHT-RV09).

All sites had some amount of human disturbance (Table 6). Generally, sparsely to non-vegetated portions of the upper drawdown at the selected high-visibility and high recreational use sites (treatment types B and C) are also used for walking, swimming, fires and general recreation. A walking trail transects the steeper sloped area just above the summer high water mark at several sites and tire tracks were observed adjacent to the boat launches where the shoreline was accessible (e.g., JHT-RV06). Steep upland areas (D) often had a small amount of trampling. Trampling increased on shorter slopes with opportunities to walk above them (e.g., in the vicinity of plots JHT-RV04 [JHT-PRM15 and JHT-PRM16]). Evidence of human disturbance was lowest in low slope or alluvial fan areas (A) that were not exposed during the summer of 2017.

Table 6. Summary of the number of sites of each disturbance rating within each treatment type.

Treatment	Rating	Disturbance Type[1]		
		Wildlife, Disease or Insect Damage	Human Disturbances	Invasive Species
A	low	2	11	9
	moderate	9		2
B	low	5	4	2
	moderate	2	3	5
C	none	2		
	low	11	15	7
	moderate	5	3	11
D	none	2		
	low	8	10	7
	moderate	1	1	4

[1]The number indicates the number of sites in each disturbance category in each disturbance type.

4.3.2. Vegetation Characteristics of Permanent Monitoring Plots

Permanent monitoring plots were used to sample the density of woody vegetation (i.e., trees and shrubs). Most plots had a low total number of stems of trees or shrubs. The estimated vegetation density across all plots and treatment types was 5,469.4 (± 2,458.1) stems per hectare (Table 7). The estimated vegetation density was highest on low slope and alluvial fans (A), followed by moderately sloped upper drawdown sites (B), then steep upland slopes (D), and lastly, steep upper drawdown sites (C). Shrub species accounted for the majority of woody vegetation across treatment types (5,469.4 ± 2,458.1 stems per hectare). Treatment area B had a higher proportion of trees than other types due to high densities of shrub height cottonwood.

Most woody vegetation (90%) counted in plots was alive (Appendix F). The majority of the dead stems observed in plots was either small willows/ cottonwood in treatment type A or dead stems of low lying shrubs (e.g., trailing blackberry, kinnikinnick) in treatment type D.

The high density of shrubs in low lying flats and alluvial fans (A) can be almost entirely attributed to small willow/ cottonwood scattered throughout the flats (Figure 21), whereas most of the trees observed in moderate and steep sloped upper drawdown sites (B and C) were black cottonwood.

Two low lying shrubs were included in stems counts because of their year-round contribution to providing visual ground cover, even though they are considered in the herbaceous layer – kinnikinnick and trailing blackberry. These drought tolerant and branchy shrubs, as well as tall Oregon grape were responsible for high stem counts at steep upland forest sites (D).

Detailed results on the number of stems of each tree and shrub species in each plot, the number of alive and dead woody stems in each plot, and the estimated density of vegetation in each plot are presented in Appendix F.

Table 7. Mean densities of living trees and shrubs in survey plots by treatment type.

Treatment Type	Trees		Shrubs		Mean Stems per Plot (trees & shrubs)	Estimated Vegetation Density (stems/ ha)
	stems/ plot	stems/ ha	stems/ plot	stems/ ha		
A	0.2	36.4	62.9	12,581.8	74.5	12,618.2
B	6.4	1,285.7	32.0	6,400.0	17.4	7,685.7
C	2.3	450.0	10.9	2,180.0	11.0	2,630.0
D	2.0	400.0	18.7	3,745.5	22.4	4,145.5
Mean	**2.3**	**465.3**	**27.3**	**5,469.4**	**0.0**	**5,934.7**
Confidence interval (±stems/ha)		*346.9*		*2,458.1*		*2,439.0*

Figure 21. Small willow/cottonwood responsible for high density of alive and dead vegetation in low lying flats and alluvial fans (treatment area A) at Ralph River Campground (JHT-RV09), on September 15, 2017.

5. TREATMENT PRESCRIPTIONS

The objective of the revegetation treatments is to mimic the characteristics of naturally-occurring vegetation communities in and above the drawdown zone of the reservoir within or near to the elevation of the treatment area. Treatments were designed to provide the site conditions or supplying the plant species that support natural succession. Revegetation treatment trials were informed and guided by the workshop participants, including BC Hydro and BC Hydro's consulted experts.

Some of the treatment areas assessed are large enough for multiple trial types and may be further divided depending on current and future trial requirements.

5.1. Revegetation Treatment Trials by Treatment Type

Sixteen treatment prescriptions, including controls, are recommended, four for each treatment type. The individual prescriptions were based on site conditions and the key factors that affect the ability of plants to become established and survive. Table 8 to Table 11 describes the revegetation treatment locations, restoration details, rationale and risks and challenges per treatment type.

Table 8. Proposed revegetation treatment trials by for treatment type A.

Treatment #	Treatment Location	Treatment	Existing Substrate	Restoration Treatment Details			Rationale	Risks/Challenges
				Site Preparation and Planting Treatment	Plant Species and Size	Source of Material		
A-1	Low slope shoreline or former alluvial fan (0-10%), 216.5-219.7 m elevation	Fill and plant stump cavities.	Fines/Gravel	Select stumps with appropriate cavities and a surveyed top elevation above 217.8 m. Fill with growing medium and gravel. Plant stumps with tops below 219.8 m with deciduous stakes. Armour with large gravel or cobble. Plant stumps with tops above 219.8 m with flood tolerant forest species (where available). If there are inadequate stump cavitites to plant with terrestrial species, pockets can be drilled out and planted. Plant available planting pockets up to a minimum spacing of 20 cm between plants.	Deciduous stakes: Sitka willow (*Salix sitchensis*), black cottonwood (*Populus trichocarpa*) and red-osier dogwood (*Cornus stolonifera*), 1 meter in length. Forest species may include: western hemlock (*Tsuga heterophylla*), shore pine (*Pinus contorta ssp. contorta*), western white pine (*Pinus monticola*) and grand fir (*Abies grandis*) depending on availability, up to size of 1 gallon pot.	Topsoil imported and gravel/cobble imported or collected. Dormant deciduous stakes harvested by project crew from pre-identified donor sites in the days preceding planting. Forest species will be transplanted from pre-identified and approved location. This may include salvage from WORKS-2 or other maintenance or upgrade projects.	Introduce species and growing medium into suitable elevations that would not otherwise be easily colonized with the aim to improve the aesthetics of mudflats and herb-dominated areas, and increase visibility of stumps for boaters to improve safety. Moreover, planting trees in stumps may accelerate the rate of decay making the stumps more habitable for several species.	Locating a sufficient number of stakes of a sufficient size at donor sites. Securing materials and retaining planting medium and stakes when subjected to wave action and reservoir operations. Live root transplants have lower chance of success than pots/plugs. Decay of stumps is stunted by inundation which may limit the nutrient availability and growing space as trees grow, especially as roots may not be able to extend into ground similar to the terrestrial environment due to inundation regime and respective tolerance of species to flooding.
A-2i	Low slope shoreline or former alluvial fan (0-10%), 217.2-219.7 elevation	Mound and complex and/or stabilize substrate.	Fines/Gravel	Mound substrate with machine to above 217.8 m elevation as guided by surveyor. Armour the mound with woody debris and boulders. Avoid existing vegetation to extent possible. Create approximately 60 mounds per hectare that are approximately 2 x 2 m. Use stumps for support as available.	None	Woody debris will be from shoreline or imported from pre-identified and approved cutblock or ROW clearing.	Raise substrate to an elevation that can support taller vegetation to improve the aesthetics and vegetative cover of mudflats and herb-dominated areas, and increase visibility of stumps for boaters to improve safety.	Securing materials and creating stable mounds that do not erode when subjected to wave action and reservoir operations. Disturbing existing vegetation. Risk that mounds will not be colonized or will be colonized by less desirable species.
A-2ii	Low slope shoreline or former alluvial fan (0-10%), 217.2-219.7 elevation	Mound and complex and/or stabilize substrate. Machine plant deciduous stakes.	Fines/Gravel	Mound substrate with machine to above 217.8 m elevation as guided by surveyor. Armour the mound with woody debris and boulders. Avoid existing vegetation to extent possible. Create approximately 60 mounds per hectare that are approximately 1 x 1 m or 2 x 2 m. Use stumps for support as available. Divide the treatment polygon into three strips perpendicular to the shoreline and plant one species per strip. Stakes will be 2/3 buried and may be inserted at various angles above 217.8 m elevation. Ten stakes will be planted per mound	Deciduous stakes: Sitka willow, black cottonwood and red-osier dogwood, minimum 1 m in length.	Woody debris will be from shoreline or imported from pre-identified and approved cutblock or ROW clearing. Dormant deciduous stakes will be harvested by project crew from pre-identified donor sites in the days preceding planting.	Raise substrate to an elevation that can support taller vegetation to improve the aesthetics and vegetative cover of mudflats and herb-dominated areas, and increase visibility of stumps for boaters to improve safety. Plant substrate with tall desirable species to provide higher chance of survival as they will not be entirely submerged. Hence, the plants will be able to grow throughout more of growing season. Example, red-osier may survive well on mudflats at appropriate elevations.	Securing materials and creating stable mounds that do not erode when submerged or when subjected to wave action. Avoiding disruption of existing vegetation. Locating donor sites and deciduous stakes of sufficient size. Red-osier dogwood is frequently browsed. Uncertain what the minimum elevation is in which red-osier dogwood will persist. Willow and cottonwood may prefer coarser substrates than what are available on the lower elevations of the mudflats, as they have mostly been observed on coarser substrates around the reservoir.
A-3	Low slope shoreline or former alluvial fan (0-10%), 216.5-219.7 m elevation	Control	Fines/Gravel	n/a			The control sites will assist in monitoring the effectiveness of the treatment implemented.	

Table 9. Proposed revegetation treatment trials by for treatment type B.

Treatment #	Treatment Location	Treatment	Existing Substrate	Restoration Treatment Details			Rationale	Risks/Challenges
				Site Preparation and Planting Treatment	Plant Species and Size	Source of Material		
B-1i	Moderate slope (5-15%) upper drawdown zone, 217.6-221.0 m elevation	Rough and loose. No planting.	Gravel/Sand/ Cobble	Create rough and loose topography (Polster 2012) and provide erosion protection/ stabilization with addition of woody debris and boulders/cobble. Embed woody debris as possible. Add leaf litter/mulch as practical. Do not disturb well vegetated portions of site.	None	Woody debris will be from shoreline or imported from pre-identified and approved cutblock or ROW clearing. Cobble will be from disturbed unvegetated areas surrounding the reservoir.	Rough and loosen substrate to create suitable microsites for plant growth and to enable seeds to establish before reservoir levels rise. Woody debris and cobble may help to stabilize the substrate and create microhabitats of finer sediments and protected areas where plants can establish and survive. Additions of leaf litter contribute biota and nutrients.	Securing materials. Machine access and timing for appropriate reservoir elevation. Currently embedded stumps and wood are surrounded by less vegetation than would be expected. Seeds disperse in the fall and winter and do not readily distribute in the spring when these areas are exposed, and thus the seed source available to populate the rough and loose topography may be scarce. Rough and loose topography is likely to be eroded when water levels rise. Appropriate plants such as sedges may need to be planted to secure substrates.
B-1ii	Moderate slope (5-15%) upper drawdown zone, 217.6-221.0 m elevation	Rough and loose with deciduous stakes planted by machine in trenches. Plant stakes by hand in areas that are not machine accessible or where injury to existing vegetation is a risk.	Gravel/Sand/ Cobble	Create rough and loose topography with trenches/terraces for willow and cottonwood stakes, and provide erosion protection with addition of woody debris and cobble. Embed woody debris as possible. Do not disturb well vegetated portions of site. Stake deciduous species by machine as guided by surveyed elevations (217.8-221.0 m). Hand stake areas with decent herbaceous cover or sparse shrub cover as to not disturb existing vegetation. Plant stakes with 50 cm spacing in rows 2 m apart. Add leaf litter/mulch as practical.	Deciduous stakes: Sitka willow and black cottonwood and red-osier dogwood. Machine planted stakes will be 1-2 m in length, hand planted stakes will be 0.3-0.7 m in length.	Woody debris will be from shoreline or imported from pre-identified and approved cutblock or ROW clearing. Cobble will be from disturbed unvegetated areas surrounding the reservoir. Dormant stakes will be harvested by project crew from donor sites in the days preceding planting.	Staking provides deciduous vegetation an opportunity to establish in an environment that is challenging to establish by seeds. Revegetation can be accelerated by planting species with rhizomatous root structures.	Roughening and loosening substrate below reservoir full pool may make it more prone to erosion of remnant terrestrial soils and substrate. Securing woody debris and cobble. Locating enough willow and cottonwood stems of sufficient size. Machine access and timing for appropriate reservoir elevation.
B-2	Moderate slope (5-15%) upper drawdown zone, 217.6-221.0 m elevation	No site preparation. Stake deciduous species by hand.	Gravel/Sand/ Cobble	No site preparation. Stake deciduous species by hand. Plant stakes with 50 cm spacing in rows 2 m apart.	Sitka willow, black cottonwood and red-osier dogwood. Hand planted stakes will be 0.3-0.7 m in length.	Dormant stakes will be harvested by project crew from donor sites in the days preceding planting.	Staking provides deciduous vegetation an opportunity to establish in an environment that is challenging to establish by seeds. Revegetation can be accelerated by planting species with rhizomatous root structures.	Collection and staging of transplants and leaf litter. Securing transplants and substrate from erosion
B-3	Moderate slope (5-15%) upper drawdown zone, 217.6-221.0 m elevation	Control	Gravel/Sand/C obble	n/a			The control sites will assist in monitoring the effectiveness of the treatment implemented.	

Table 10. Proposed revegetation treatment trials by for treatment type C.

Treatment #	Treatment Location	Treatment	Existing Substrate	Restoration Treatment Details			Rationale	Risks/Challenges
				Site Preparation and Planting Treatment	Plant Species and Size	Source of Material		
C-1i	Steep (>15%) upper drawdown zone, 217.6-221.0 m elevation	Complex substrate with additions of coarse wood. No planting.	Gravel/Cobble /Sand	Create slightly rough and loose topography and provide erosion protection with addition of woody debris and boulders/cobble. Add leaf litter/mulch as practical.		Woody debris will be from shoreline or imported from pre-identified and approved cutblock or ROW clearing. Cobble will be from disturbed unvegetated areas surrounding the reservoir.	Woody debris and cobble placement will help to retain sediment and stabilize substrate. This treatment has only been prescribed in protected bays with low wave energy and exposure to fetch.	Machine access and timing for appropriate reservoir elevation. Securing woody debris and cobble. Possibility of substrates eroding due to steep slopes and erosive forces on less consolidated substrates.
C-1ii	Steep (>15%) upper drawdown zone, 217.6-221.0 m elevation	Willow and cottonwood stakes planted by machine in trenches	Gravel/Cobble /Sand	Create slightly rough and loose topography by creating trenches/ terraces for willow and cottonwood stakes, and provide erosion protection with addition of woody debris and boulders/cobble. Stakes will be 1-2 m in length. Plant stakes with 30 cm spacing in rows 2 m apart. Add leaf litter/mulch as practical.	Sitka willow, black cottonwood and red-osier dogwood. Machine planted stakes will be 1-2 m in length, hand planted stakes will be 0.3-0.7 m in length. Hand planted stakes will be 0.3-0.7 m in length.	Woody debris will be from shoreline or imported from pre-identified and approved cutblock or ROW clearing. Cobble will be from disturbed unvegetated areas surrounding the reservoir. Dormant stakes will be harvested by project crew from donor sites in the days preceding planting.	Steep and exposed areas should not be disturbed without providing vegetation and erosion protection. Rows of trenched stakes will disperse wave energy and settle out sediment, whereas, woody debris and cobble placement will help to retain sediment and stabilize substrate. Trenches enable larger stakes to be planted and stakes to be planted deep so their roots can stay moist during drier seasons. Furthermore, taller stakes have a higher above ground height and thus can remain out of water for longer periods of time allowing a longer growing season.	Machine access and timing for appropriate reservoir elevation. Securing woody debris and cobble. Locating willow donor sites and trees of sufficient size. Possibility of terraces and stakes eroding due to steep slopes.
C-2	Steep (>15%) upper drawdown zone, 217.6-221.0 m elevation	No site preparation. Stake deciduous species by hand.	Gravel/Cobble /Sand	No site preparation. Stake deciduous species by hand. Plant stakes with 30 cm spacing in rows 2 m apart.	Sitka willow, black cottonwood and red-osier dogwood. Hand planted stakes will be 0.3-0.7 m in length.	Dormant stakes will be harvested by project crew from donor sites in the days preceding planting.	Hand planted stakes will result in less ground disturbance and thus reduce potential substrate erosion from reservoir operations.	Locating willow donor sites and trees of sufficient size. It may be challenging to install stakes due to compact substrates.
C-3	Steep (>15%) upper drawdown zone, 217.6-221.0 m elevation	Control	Gravel/Cobble /Sand	n/a			The control sites will assist in monitoring the effectiveness of the treatment implemented.	

Table 11. Proposed revegetation treatment trials by for treatment type D.

Treatment #	Treatment Location	Treatment	Existing Substrate	Restoration Treatment Details			Rationale	Risks/Challenges
				Site Preparation and Planting Treatment	Plant Species and Size	Source of Material		
D-1	Steep (40%+) eroded upland forest slopes, 220.5 m+ elevation with ~zonal forest soils with LFH and A layer absent	Bioengineer slope with cottonwood modified brush layers installed by hand. Forest species planted on the created terraces.	Sand/Mineral Soil	Stabilize slope with modified brush layers to create small terraces (Polster 2016). Plant terraces with transplanted forest species, if available. Structures will be approximately 2 m long with 2 m spacing between rows horizontally and vertically. Species placement will depend on aspect and expected moisture availability.	Black cottonwood for brush layers. Forest species may include Douglas-fir, shore pine, tall Oregon grape (*Mahonia aquifolium*) and Kinnikinnick (*Arctostaphylus uva-ursi*).	Dormant stakes will be harvested by project crew from donor sites in the days preceding planting. Understory forest species will be harvested by project crew from pre-identified and approved near-by areas. This may include salvage from WORKS-2 or other maintenance or upgrade projects.	Creation of stable terraces in which native vegetation can root. The live stabilization structures created by growing roots will contribute to stabilization, in addition to the original structure. The plant will contribute to a more favorable microhabitat and general site conditions (e.g., nitrogen, biota, shade). Planting forest floor transplants can introduce propagules from other forest understory species as well as enhance soil mycorrhizae, other biota and nutrients from forest soils.	Locating cottonwood donor sites and trees of sufficient size. Collection and staging of transplants. Securing brush layers. Minimizing erosion created during treatment implementation.
D-2	Steep (40%+) eroded upland forest slopes, 220.5 m+ elevation with ~zonal forest soils with LFH and A layer absent	Cottonwood stakes planted by hand	Sand/Mineral Soil	Prepare ground for individual stakes as necessary; stakes will be 0.3-0.7 m in length, spaced every 20 cm.	Black cottonwood	Dormant stakes will be harvested by project crew from donor sites in the days preceding planting.	Stabilize slopes with fast growing, drought tolerant species that are rhizomatous.	Locating cottonwood donor sites. Some sites are very hot and dry which will limit survival of stakes. These slopes are at an angle that is continuing to erode. The stakes may erode away, especially if they do not have enough moisture to properly establish.
D-3	Steep (40%+) eroded upland forest slopes, 220.5 m+ elevation with ~zonal forest soils with LFH and A layer absent	Stabilize bottom of slope with logs and boulders. Plant with individual forest plants and cottonwood stakes.	Sand/Mineral Soil	Move logs tight against base of slope and backfill soil. Place 1 log vertically/ parallel to slope every 2 m. Prepare microsites for planting upslope of the logs. Plant with transplanted forest species, if available. Add leaf litter/mulch as practical. Plant with 70 cm spacing.	Deciduous stakes: black cottonwood. Forest species may include: Pacific dogwood, shore pine, Douglas-fir.	Coarse wood will be collected from nearby shoreline accumulations or associated with forestry operations. Forest species will be harvested by project crew from pre-identified and approved near-by areas. This may include salvage from WORKS-2 or other maintenance or upgrade projects. Dormant stakes will be harvested by project crew from donor sites in the days preceding planting.	Stabilizing substrate will allow plants time to seed and take root. Plant with local transplants to enhance soil mycorrhizae, other biota and nutrients from forest soils as well as provide competition to invasive species that are likely to rapidly colonize the area. Plant stakes to introduce fast growing tall vegetation that will provide shade to other transplants while improving aesthetics of the eroded slopes. Plant nitrogen fixing trees (e.g. Douglas-fir, red alder) to enhance soil, to improve the microhabitat and compete with invasive species.	Obtaining logs. Collection and staging of transplants. Locating cottonwood donor sites and trees of sufficient size. Even with stabilization from logs, some sites may still be too hot and dry to support vegetation and erosion is likely to remain a strong force until the angle of repose is reached.
D-4	Steep (40%+) eroded upland forest slopes, 220.5 m+ elevation with ~zonal forest soils with LFH and A layer absent	Control	Sand/Mineral Soil	n/a			The control sites will assist in monitoring the effectiveness of the treatment implemented.	

Treatment #	Treatment Location	Treatment	Existing Substrate	Restoration Treatment Details			Rationale	Risks/Challenges
				Site Preparation and Planting Treatment	Plant Species and Size	Source of Material		
D-1	Steep (40%+) eroded upland forest slopes, 220.5 m+ elevation with ~zonal forest soils with LFH and A layer absent	Bioengineer slope with cottonwood modified brush layers installed by hand. Forest species planted on the created terraces.	Sand/Mineral Soil	Stabilize slope with modified brush layers to create small terraces (Polster 2016). Plant terraces with transplanted forest species, if available. Structures will be approximately 2 m long with 2 m spacing between rows horizontally and vertically. Species placement will depend on aspect and expected moisture availability.	Black cottonwood for brush layers. Forest species may include Douglas-fir, shore pine, tall Oregon grape (*Mahonia aquifolium*) and Kinnikinnick (*Arctostaphylus uva-ursi*).	Dormant stakes will be harvested by project crew from donor sites in the days preceding planting. Understory forest species will be harvested by project crew from pre-identified and approved near-by areas. This may include salvage from WORKS-2 or other maintenance or upgrade projects.	Creation of stable terraces in which native vegetation can root. The live stabilization structures created by growing roots will contribute to stabilization, in addition to the original structure. The plant will contribute to a more favorable microhabitat and general site conditions (e.g., nitrogen, biota, shade). Planting forest floor transplants can introduce propagules from other forest understory species as well as enhance soil mycorrhizae, other biota and nutrients from forest soils.	Locating cottonwood donor sites and trees of sufficient size. Collection and staging of transplants. Securing brush layers. Minimizing erosion created during treatment implementation.
D-2	Steep (40%+) eroded upland forest slopes, 220.5 m+ elevation with ~zonal forest soils with LFH and A layer absent	Cottonwood stakes planted by hand	Sand/Mineral Soil	Prepare ground for individual stakes as necessary; stakes will be 0.3-0.7 m in length, spaced every 20 cm.	Black cottonwood	Dormant stakes will be harvested by project crew from donor sites in the days preceding planting.	Stabilize slopes with fast growing, drought tolerant species that are rhizomatous.	Locating cottonwood donor sites. Some sites are very hot and dry which will limit survival of stakes. These slopes are at an angle that is continuing to erode. The stakes may erode away, especially if they do not have enough moisture to properly establish.
D-3	Steep (40%+) eroded upland forest slopes, 220.5 m+ elevation with ~zonal forest soils with LFH and A layer absent	Stabilize bottom of slope with logs and boulders. Plant with individual forest plants and cottonwood stakes.	Sand/Mineral Soil	Move logs tight against base of slope and backfill soil. Place 1 log vertically/ parallel to slope every 2 m. Prepare microsites for planting upslope of the logs. Plant with transplanted forest species, if available. Add leaf litter/mulch as practical. Plant with 70 cm spacing.	Deciduous stakes: black cottonwood. Forest species may include: Pacific dogwood, shore pine, Douglas-fir.	Coarse wood will be collected from nearby shoreline accumulations or associated with forestry operations. Forest species will be harvested by project crew from pre-identified and approved near-by areas. This may include salvage from WORKS-2 or other maintenance or upgrade projects. Dormant stakes will be harvested by project crew from donor sites in the days preceding planting.	Stabilizing substrate will allow plants time to seed and take root. Plant with local transplants to enhance soil mycorrhizae, other biota and nutrients from forest soils as well as provide competition to invasive species that are likely to rapidly colonize the area. Plant stakes to introduce fast growing tall vegetation that will provide shade to other transplants while improving aesthetics of the eroded slopes. Plant nitrogen fixing trees (e.g. Douglas-fir, red alder) to enhance soil, to improve the microhabitat and compete with invasive species.	Obtaining logs. Collection and staging of transplants. Locating cottonwood donor sites and trees of sufficient size. Even with stabilization from logs, some sites may still be too hot and dry to support vegetation and erosion is likely to remain a strong force until the angle of repose is reached.
D-4	Steep (40%+) eroded upland forest slopes, 220.5 m+ elevation with ~zonal forest soils with LFH and A layer absent	Control	Sand/Mineral Soil	n/a			The control sites will assist in monitoring the effectiveness of the treatment implemented.	

5.2. Revegetation Treatment Trials by Revegetation Site

Each of the eight revegetation sites (i.e., JHT-RV02, JHT-RV03, etc.) was divided into treatment areas and each treatment area was assigned a revegetation treatment (Table 8, Table 9, Table 10 Table 11). Treatment assignments for each year and maps for each site are presented alongside site information in the site-specific restoration profiles in Appendix D. All treatment type 'A's were assigned as 'alternate' year (i.e., treatment is not currently scheduled), as treatment of the low slope alluvial fan is not being recommended due to the current revegetation trajectory. These areas (i.e., elevations and slopes) are generally well vegetated with herbs, are visible to the public less frequently than the other treatment types, and are expected to be more costly to treat. Nevertheless, baseline data have been collected and revegetation trials have been designed for these areas should they be required. Note that the 'Treatment #' presented in the treatment trial tables (Table 8, Table 9, Table 10, Table 11) correspond with the mapped treatment areas in Appendix D. The permanent monitoring plot label for each treatment area in Appendix D corresponds to the baseline data for each site (Section 4.3, Appendix E, Appendix F).

Although baseline data were collected and operational trials prescribed for each treatment area within the selected revegetation sites, this revegetation treatment plan is a living document and the actual sites and revegetation treatment trials that are implemented may be adjusted based on logistics, costs or other factors.

5.3. Cost

The estimated cost of implementing the proposed revegetation treatment trials at each site is presented in Table 12 to support the planning and trial phase (Years 2 to 6) of the 10 year program.

Cost estimates are for the cost to do the physical works only, and include machinery, materials and labour, but exclude any costs associated with monitoring, reporting or acquiring permits. The cost of revegetating each treatment site and treatment area is closely associated with the area (m^2) of each trial. The estimated total budget allocated to revegetation trials as written in the TOR (BC Hydro 2016) is presented in the table for comparison to the cost estimated to complete the revegetation trials. Treatment type 'A' was not included in the budget at this time.

Table 12. Cost of implementing revegetation trials by site for the treatment planning/trials phase (Years 2 to 6 of the 10-year program).

Revegetation Sites	Treatment	Total Area (m^2)	Year 2	Year 4	Year 2, 3, or 4[1]	Total Cost
RV02	B-1i	714	$ 4,536			$ 4,536
	C-1ii	1,173	$ 15,707			$ 15,707
	C-2	271	$ 1,907			$ 1,907
	C-3 (control)	237	$ -			$ -
			$ 22,150			*$ 22,150*
RV03	C-1ii	247			$ 7,407	$ 7,407
	C-2	288			$ 1,907	$ 1,907
	D-2	140			$ 1,120	$ 1,120
	D-3	316			$ 5,072	$ 5,072
Subtotal					*$ 15,506*	*$ 15,506*
RV04	D-1	403	$ 6,352			$ 6,352
	D-2	213	$ 1,872			$ 1,872
	D-3	188	$ 4,572			$ 4,572
	D-4 (control)	247	$ -			$ -
Subtotal			*$ 12,796*			*$ 12,796*
RV05	B-1ii	899		$ 15,059		$ 15,059
	B-2	472		$ 3,027		$ 3,027
	B-3 (control)	785		$ -		$ -
	C-1ii	608		$ 13,819		$ 13,819
Subtotal				*$ 31,905*		*$ 31,905*
RV06						
Island	C-1ii	2,334			$ 24,571	$ 24,571
	C-2	392			$ 1,907	$ 1,907
	C-3 (control)	1,246			$ -	$ -
	D-1	100			$ 2,992	$ 2,992
	D-2	132			$ 1,120	$ 1,120
	D-4 (control)	102			$ -	$ -
Subtotal					*$ 30,590*	*$ 30,590*
Lake Shoreline	B-3 (control)	1,185	$ -		$ -	$ -
	C-1ii	853	$ 15,059			$ 15,059
	C-2	985	$ 5,267			$ 5,267
	C-3 (control)	741	$ -			$ -
Subtotal			*$ 20,326*			*$ 20,326*
RV08	B-2	2,430	$ 9,579			$ 9,579
	B-3 (control)	2,437	$ -			$ -
Subtotal			*$ 9,579*			*$ 9,579*
Planning & Coordination			*$ 9,728*	*$ 4,786*	*$ 6,914*	*$ 21,428*
TOTAL			***$ 74,579***	***$ 36,691***	***$ 53,010***	***$ 164,280***
TOTAL (with RV06 island only)			$ 54,253	$ 36,691	$ 53,010	$ 143,954
TOTAL (with RV06 Lake Shoreline only)			$ 74,579	$ 36,691	$ 22,420	$ 133,690
Estimated TOR Implementation Budget						*$ 192,856*

[1]Depending on the schedule of JHTWORKS-2

5.3.1. Assumptions - General Assumptions Regarding Work

Key assumptions regarding the proposed treatment areas include the following:

- The work will be serviced out of Campbell River, BC. Travel and mobilization costs have been included in the cost estimate.
- We have assumed site supervision by a Qualified Professional (QP). Supervision would be provided on a part-time basis to direct machine and labourers as necessary.
- We assumed that labour required to implement restoration treatments will be provided by A'Tlegay Fisheries Society Environmental Technicians through LKT.
- We have budgeted 8 hours field days with no overtime.
- Budgets are based on the size of the polygons and effort to complete the prescribed treatment.
- We have assumed boulders are not available on site and will require purchase and delivery. We have assumed large woody debris is also not available on site. However; we assumed that large wood could be sourced free of charge but would require a delivery fee.
- The estimated budget includes project management, safety planning and coordination costs.
- The estimated budget does not include environmental management planning (EMP) or potential costs related to EMP (i.e., bird surveys, amphibian salvage, erosion/sediment control).
- The estimated budget does not include a construction environmental management plan (CEMP) or a document detailed best practices during the trial phase (e.g., monitoring vehicles for invasive plants).
- We assumed that all required archaeology assessments are being managed by BC Hydro and financed under a separate budget.
- The estimated budget does not include costs related to working within BC Parks (i.e., consultation, permits).
- No maintenance costs, such as watering, are assumed or included in the estimated budget.
- No costs to replace vegetation that dies or becomes damaged, or to repair any damaged site preparation, have been included, at this time.
- Costs for interpretive signage or exclusion fencing have not been included in the estimate.
- Costs are considered an estimate. Weather, reservoir operations, availability of materials and machinery, and other unforeseen circumstances may all affect costs.

5.3.2. Donor Sites

Deciduous Stakes

Four willow donor sites were identified in the Upper Campbell Reservoir (JHT-DON01 – Buttle Lake Campground, JHT-DON02 – Buttle Fan, JHT-DON03 – Ralph River and JHT-DON04 – Karst Creek) and one black cottonwood site (JHT-DON01), as shown on the site profiles (Appendix D). The amount of black cottonwood suitable for staking identified at the donor site is unlikely to be sufficient to meet the trial requirements. Additional black cottonwood can be harvested from the right-of-way (RoW) of the Inland Island Highway (Highway 19). Similarly, no red-osier dogwood donor sites were identified. It is expected that red-osier dogwood can be harvested from the perimeter of the diversion lakes (e.g., Brewster Lake) where it is abundant. The best time to harvest deciduous stakes is in the early spring when the plants are still dormant. Collection will target 2-5 year old straight sucker-type branches with lengths of 0.3-2 m (depending on if they are to be hand or machine planted).

Forest Species

Opportunities may exist to salvage appropriate forest species during the anticipated upgrade works associated with JHTWORKS-2, such as the construction of a trail at the Buttle Lake Campground. Other sources of forest species could include salvage from RoW clearing or road development associated with forestry operations. The establishment success and availability of forest species will depend on the seasonality of salvage timing (e.g., spring and fall are preferred to summer or winter) and mechanical site preparation schedules of the prescriptions.

Coarse Woody Debris

Coarse woody debris may be sourced on-site or off-site. Some sites, such as Rainbow Island (Figure 15), have accumulations of wood. Other sources could include logs caught along the intake booms associated with dams on the Campbell hydroelectric system or unmerchantable timber from recent cutblocks. Attempts will be made to procure coarse woody debris in a variety of decay stages and sizes, and of coniferous origin.

Leaf Litter/Mulch

Leaf litter may be sourced on-site from deciduous stands. This is best accomplished in late fall, but may also be successful in early spring prior to leaf-out.

Other

Nursery stock has not been included in any prescriptions, however, there are several local nurseries that are available to collect and propagate appropriate species from the local environment if needed in the future. Similarly, Campbell River has several retail stores that can supply boulders and cobble and other garden supplies at an industrial scale.

5.4. Schedule

Implementation of operational trials will likely be scheduled for early in the spring before leaf out (i.e., February-March) to capture the beginning of the growing season and to allow treatments to stabilize and plants to establish following late fall inundation and storms, and prior to summer inundation and drought. This timing also considers the harvesting window for deciduous stakes. However, the exact timing of trials will depend on the unique seasonal variability of the year. In some cases, it may be practical and acceptable to conduct treatments in treatment type D during the fall, as this timing may be more favorable for forest transplants, and in some instances, for deciduous stakes. Such deviations from the schedule should be assessed on a case by case basis.

5.5. Future Restoration Prescriptions

The treatment trials presented in this report were deemed to integrate the best balance of revegetation success and cost effectiveness so that they can realistically be implemented at a larger scale. However, there are several other methods or trials that could be implemented and can be considered in the future. These include:

- Fertilize and/or add lime to naturally regenerating or planted species to increase nutrient availability;
- Plant nursery transplants grown from local seed;
- Plant herbaceous species such as sedges that are effective at consolidating substrate;
- Implement treatment type 'A' prescriptions;
- Secure substrate and lessen erosion with landscaping fabric made from natural fibres;
- Plant forest transplants in the uppermost portion of the upper drawdown zone; and
- Consider species suitability to climate forecasts in planting prescriptions.

6. EFFECTIVENESS MONITORING PROGRAM

The effectiveness monitoring program is scheduled to begin in Year 2 when the treatment trials will be implemented. The effectiveness monitoring program is based on the repeated collection of baseline/ monitoring data (Section 3.4) over time and the analysis of these data with the objective of evaluating the effectiveness of the revegetation techniques and adaptively modifying prescriptions based on monitoring results. The effectiveness monitoring program is described in more detail alongside the baseline data collection methods and monitoring schedule in Appendix C.

7. CONCLUSION AND RECOMMENDATIONS

This Revegetation Treatment Plan satisfies the requirements of Year 1/ Phase 1 of JHTWORKS-3. The plan presents the revegetation sites selected for JHTWORKS-3, the revegetation treatment prescriptions developed for operational trials, and the objectives and methods of the effectiveness monitoring program. This Year 1 report also describes the approach adopted for the selection of revegetation sites and development of revegetation treatment prescriptions, which involved the collection and compilation of information and data through background review, outreach, consultation, a reconnaissance visit, an expert workshop, and baseline data collection.

The information presented in this report provides much of the information required to conduct the more detailed planning that will be required to implement the recommended treatments (e.g., securing materials and machinery, receiving permissions to work in BC Parks). However, this is a living document, and the prescribed treatment trials may be amended in consideration of cost, other 'works' projects, effectiveness monitoring results, the outcomes of annual monitoring committee meetings, and/or other factors. Nevertheless, the information contained in this document should be considered when planning and implementing any revegetation treatments in the Upper Campbell Reservoir.

As identified and intended by the TOR (BC Hydro 2016a), future years of the program need to consider the following associated with data collection, analysis, and program adaptation in future years:

- Evaluation of treatment progress, identification of potential problems or difficulties, and consideration of potential improvements should be conducted on an ongoing basis. Treatment prescriptions may require modifications for a variety of reasons. Adaptive changes to prescriptions, generally or on a site-specific basis, in accordance with on-site feedback will maximize effectiveness of the program, expediency of restoration, and learning.

- Baseline data (treatment area and plot) should be collected at the two sites where this was not accomplished in 2017 if trials at these sites will be implemented.

- Outreach, consultation, and research should continue to be incorporated into the revegetation program as treatment trials are conducted and results are obtained.

- The differences between the objectives of baseline data collection in Year 1 and those in future years should be kept in mind during planning and field work, as should the importance of providing flexibility for the current monitoring program. The purpose of data analysis in Year 1 was to characterize the baseline condition of the treatment types for use in the development of specific treatment prescriptions. In future years, the primary purpose of data collection and analysis will be to monitor the effectiveness of the revegetation treatments as part of the effectiveness monitoring program. Thus, it will be important to consider many factors that may affect program success, both positive and negative. Although

> the current effectiveness monitoring program provides a framework for the evaluation and interpretation of results, it is important that this program also be allowed to evolve in accordance with results and observations. This will allow it to adapt to changing conditions and/or to explore environmental or other factors that may not have been initially identified.

In addition to the TOR future actions and requirements, we also recommend that human disturbance continue to be assessed when planning and implementing revegetation treatments trials since the level human disturbance is an important factor in the prescription of treatments and may strongly influence the potential for treatment success. During baseline data collection, human disturbance may have been underestimated because field work occurred in the spring and fall and not during the summer high-use period.

REFERENCES

Ballin, L., J. Abell, and D. Lacroix. 2015. JHTMON-10: Upper and Lower Campbell Lake Reservoirs Shoreline Vegetation Model Validation – Year 1 Monitoring Report. Consultant's report prepared for BC Hydro by Laich-Kwil-Tech Environmental Assessment Ltd. Partnership and Ecofish Research Ltd., November 27, 2015.

Baseline. 2012. Archaeological Resource Overview of The Campbell River Watershed for the Laich-Kwil-Tach Treaty Society – DRAFT. Consultant's report prepared for Laich-Kwil-Tach Treaty Society. Courtenay, B.C.

Baseline. 2017. Report for the Archaeological Impact Assessment of Recreation Improvements/ Developments in Campbell & Buttle Lakes. Consultant's report prepared for Laich-Kwil-Tac Environmental Assessments Limited Partnership, K'ómox First Nation, Mowachaht/Muchalaht First Nation, We Wai Kai First Nation, Wei Wai Kum First Nation and the BC Archaeology Branch in partial fulfillment of Heritage Inspection Permit 2017-0068. Courtenay, B.C.

BC Hydro. 2012. Campbell River System Water Use Plan Revised for Acceptance by the Comptroller of Water Rights. November 21, 2012 v6. 46 p.

BC Hydro. 2016a. Campbell River Water Use Plan Monitoring Program Terms of Reference: JHTWORKS-3 Upper Campbell Reservoir Drawdown Zone Revegetation Program. June 28, 2016.

BC Hydro 2016b. Strathcona Dam weather station (SCA, 227 m, 1980-2016). Automated weather stations operated by BC Hydro. Accessed on October 16, 2017.

BC Hydro. 2016c. Campbell River Project Water Use Plan Physical Works Terms of Reference. JHTWORKS-2: Upper Campbell Lake Reservoir and Campbell Lake Reservoir Recreation Facility Upgrade Feasibility. Available online at https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/vancouver-island/campbell-river/jhtworks-2-terms-of-reference-2016-01-01.pdf. Last Accessed: November 7, 2017.

Bruce, J.A. 2002. Model to estimate elevation bands of plant communities in Campbell River watershed reservoirs. Technical Note to the Campbell River WUP Wildlife Technical Sub-committee. BC Hydro, Water Use plans, Burnaby, B.C. February, 2002. File No. WUP-JHT-TN-W04.

CDC (BC Conservation Data Centre). 2017. BC Species and Ecosystems Explorer. BC Ministry of Environment. Available online at: http://a100.gov.bc.ca/pub/eswp/. Accessed June 2017.

Furey, P. C., Nordin, R. N., Mazumder, A. 2004. Water level drawdown affects physical and biogeochemical properties of littoral sediments of a reservoir and a natural lake. Lake and Reservoir Management 20: 280–295.

Green, R.N. and K. Klinka. 1994. A Field Guide to Site Identification and Interpretation for the Vancouver Forest Region: Land Management Handbook 28. BC Ministry of Forests. Victoria, BC.

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

Leira, M., Cantonati, M. 2008. Effects of water-level fluctuations on lakes: an annotated bibliography. Hydrobiologia 613: 171–184.

Mackillop, S. 2003. Investigations of revegetation strategie using woody species for fish habitat enhancement and aesthetic improvement in the drawdown zone at Buttle Lake, British Columbia.

Mackillop, S. and W. Dushenko. N.d. South Buttle Lake (Reservoir) Shoreline Revegetation. Royal Roads University.

McLennan, D and V. Veenstra. 2001. Riparian Ecosystem Mapping Campbell River. Prepared by Oikos Ecological Services Ltd. for BC Hydro, Burnaby B.C. 18 pp + appendices.

MOF (BC Ministry of Forests). 1991. Ecosystems of British Columbia. Res. Br. And For. Sci. Br., BC Min. For., Victoria, B.C. Special Report Series 6.

MOF (BC Ministry of Forests). 1994. A Field Guide for Site Identification and Interpretation for the Vancouver Forest Region. Res. Br., BC Min. For., Victoria, B.C. Land Management Handbook. No. 28.

MOF (BC Ministry of Forests). 2010. Field Manual for Describing Terrestrial Ecosystems 2nd Edition. Land Management Handbook 25. Victoria BC. Available online at: http://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh25/Lmh25_ed2_(2010).pdf.Accessed on September 5, 2017.

Morris, R. and S. Conrad. 2015. JHTMON-2: Upper Campbell, Lower Campbell and John Hart Reservoirs and Elk Canyon Public Use and Perception Survey – Year 1 Reporting. Consultant's report prepared for BC Hydro by Laich-Kwil Tach Environmental Assessment Limited Partnership and EDI Environmental Dynamics Inc., December 21, 2015.

Nilsson, C. Keddy, PA. 1988. Predictability of change in shoreline vegetation in a hydroelectric reservoir, northern Sweden. Canadian Journal of Fisheries and Aquatic Sciences 45: 1896-1904.

Polster, D. 2012. Making Sites Rough and Loose: A Soil Adjustment Technique. Technical note in Boreal Reclamation Program, Boreal Research Institute.

Polster, D. 2016. Natural Processes: Restoration of Drastically Disturbed Sites. Polster Environmental Services, Duncan, B.C.

Polster, D. 2017. Restoration Monitoring Heber Dam Decommissioning. Consultants report prepared by Polster Environmental Services for BC Hydro, August 2017.

Redden. I. and I. Cuthbert. 2006. Elk River 2005 Channel Stabilization Project Part 11: Monitoring Results. Streamline Watershed Management Bulletin 10(1): 15-17.

Riis, T., and I. Hawes 2002. Relationships between water level fluctuations and vegetation diversity in shallow water of New Zealand lakes. Aquatic Botany 74: 133–148.

Shafroth, P.B., J.M. Friedman, G.T. Auble, L.M. Scott, and J.H. Braatne. 2002. Potential Responses of riparian vegetation to dam removal: Dam removal generally causes changes to aspects of the physical environment that influence the establishment and growth of riparian vegetation BioScience 52: 703-712.

Swift, K. and S. Ran. 2012. Successional Responses to Natural Disturbance, Forest Management, and Climate Change in British Columbia's Forests. BC Journal of Ecosystems and Management. 13(1):1–23.

Wilcox, D.A., and J.E. Meeker. 1991. Disturbance effects on aquatic vegetation in regulated and unregulated lakes in northern Minnesota. Canadian Journal of Botany 69: 1542–1551.

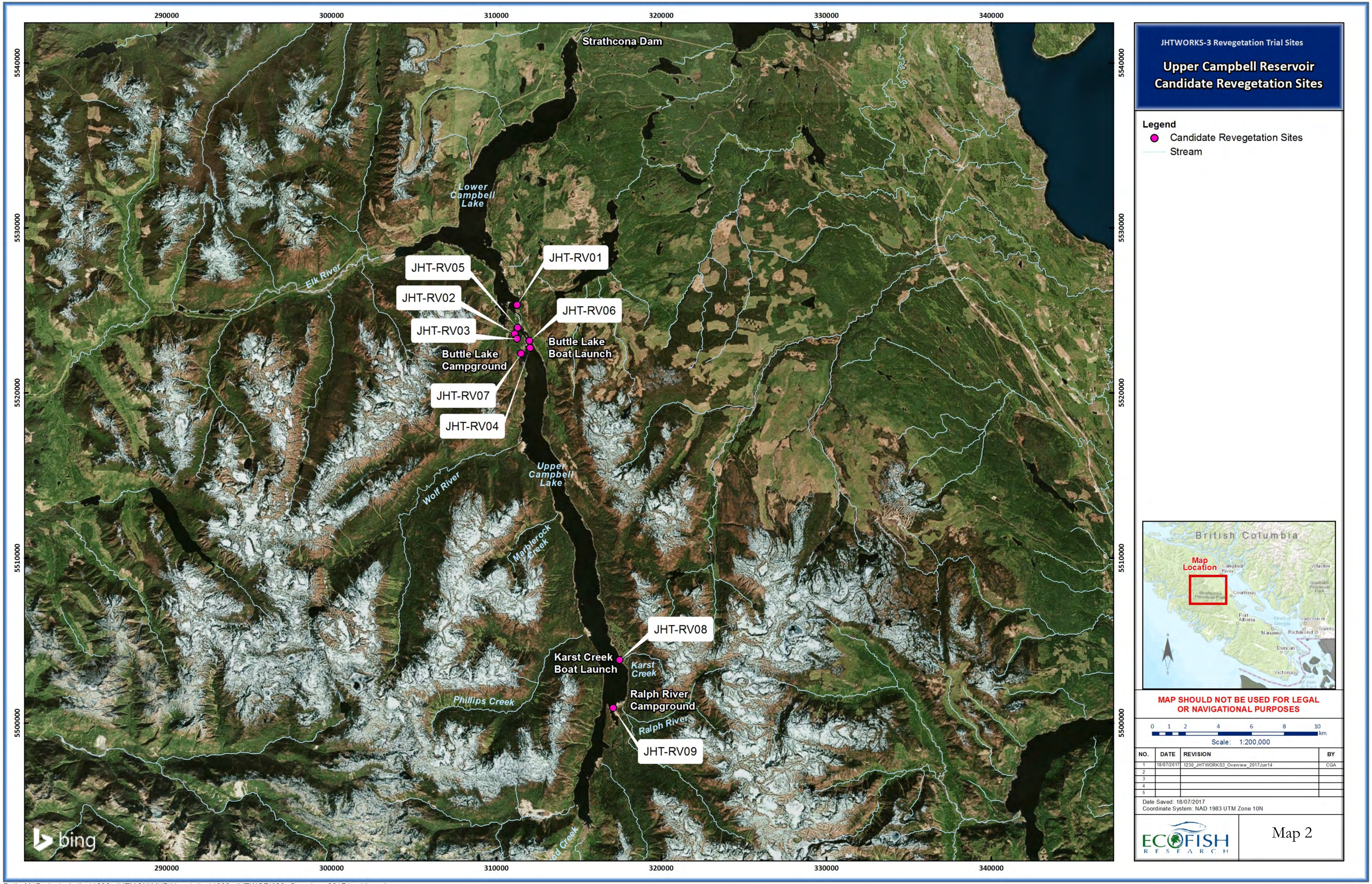
Wang, T., A. Hamann, D. Spittlehouse, and C. Carroll. 2016. Locally Downscaled and Spatially Customizable Climate Data for Historical and Future Periods for North America. PLoS ONE 11(6): e0156720. Available online at: http://www.climatewna.com/ClimateBC_Map.aspx. Accessed on December 21, 2017.

Xie Y.-h., T. Yue T, C. Xin-sheng, L. Feng and D. Zheng-miao. 2014. The impact of Three Gorges Dam on the downstream eco-hydrological environment and vegetation distribution of East Dongting Lake, Ecohydrology, DOI: 10.1002/eco.1543

Personal Communications

Read, R. 2017. Transmission Vegetation and Access Manager, BC Hydro. Telephone conversation with Leah Ballin, Ecofish Research Ltd. on June 13, 2017.

PROJECT MAPS



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APPENDICES

Appendix A. Bibliography - Background Review

LIST OF TABLES

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 1 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
BRGWORKS-1-yr1	2015	Carpenter Reservoir Drawdown Zone Re-Vegetation Program	Scholz, O. 2015.BRGWORKS-1 Bridge River Power Development Water Use Plan Carpenter Reservoir Drawdown Zone Re-Vegetation Program Implementation Year 1. Unpublished report by Splitrock Environmental Sekw'el'was, Lillooet, BC. 61 pp + Appendices.	Revegetation of Carpenter Reservoir drawdown zone	Phase 1 of the BRGWORKS-1 five year re-vegetation project on Carpenter Reservoir drawdown zone. Four terrain types and 5 elevation bands were planted with 1X1m test plots with one of 7 native forb species. Plots were monitored for survival 3 months post planting. Based on the predicted water pool levels for Carpenter Reservoir in 2014 planting locations were chosen to test species, microsites, and elevations on four types of terrain which were categorized as having the highest potential for successful revegetation within the targeted re-vegetation zone. Key issue of concern for revegetation objective: dust storms, aesthetics and recreation; key issues for planting success: wave action - plants planted into fine loose soils will be highly disturbed or dislodged, whereas cobble areas though more difficult to plant, may stabilize plants
Bruce	2002	Model to estimate elevation bands of plant communities in Campbell River watershed reservoirs - Water Use Plan Technical Note	Bruce, J.A. 2002. Model to estimate elevation bands of plant communities in Campbell River watershed reservoirs. Technical Note to the Campbell River WUP Wildlife Technical Sub-committee. BC Hydro, Water Use plans, Burnaby, B.C. February, 2002. File No. WUP-JHT-TN-W04.	Terrestrial vegetation/water level relationships/ Campbell Reservoir Ecology	predictive model of six riparian vegetation community types relative to elevation and supposed duration of inundation (based on historical data 1984-2000). The purpose of the model is to track potential long-term impacts of reservoir operation changes and to track the potential impact of various operating regimes.

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 2 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
CLBMON-10-yr 5	2014	Kinbasket Inventory of Vegetation Resources	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.	Monitoring of revegetation efforts in Kinbasket Reservoir	The fifth year of a 10 year program to monitor the effectiveness of revegetation treatments in the drawdown zone of Kinbasket Reservoir (associated with CLBWORKS-1). Through a combination of field data collection, aerial photograph interpretation, and statistical analyses, 19 vegetation communities were delineated for the drawdown zone of the reservoir. Analysis included documentation of changes of the distribution and extent of these communities since 2012. Improvements associated with the acquisition of aerial photos between 2010 and 2014 resulted in a much-improved set of vegetation polygons, and resulted in the refinement of mapping produced in 2007 and an overall greater extent of mapping in 2012. The program has concluded that it is difficult, without direct experimentation, to separate out the relative importance of wet stress and growing degree days (GDDs) in modulating patterns of plant distribution and abundance on the landscape. GDD's may prove to be an important factor that ultimately limits the capability of certain vegetation communities to expand in spatial extent, or of new communities to become established.
CLBMON-12-yr 4	2013	Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis Implementation Year 4	Enns, K., and J. Overholt. 2013. CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis: 2013 Draft Report. Unpublished report by Delphinium Holdings Inc. for BC Hydro Generation, Water Licence Requirements, Castlegar, BC. 65 pages	Monitoring of revegetation efforts in Arrow Lakes Reservoir	The present study, CLBMON-12, addressed site-level changes in vegetation in response to various influences, including revegetation treatments. This is the seventh report in a series of studies on the effects of reservoir operations on revegetated and non-revegetated areas in the drawdown zone of the Arrow Lakes Reservoir. Monitoring of CLBWORKS-2 was initiated in 2008 as an evaluation of pre-treatment baseline conditions. Post-treatment measurements at the site level were taken in 2009, 2011 and 2013. Records for fertilization treatments were incomplete, therefore no evaluation of the efficacy of fertilization was possible. ON THE DIFFERENCE BETWEEN CLBMON-12 and CLBMON-33: The present study, CLBMON-12, addressed site-level changes in vegetation in response to various influences, including revegetation treatments. CLBMON-33 addressed landscape-level changes in vegetation and used aerial photography and field measurements to evaluate effects of reservoir operations on existing vegetation communities. Both studies have used field measurements to assess effects. CLBMON-12 attempted to distinguish between the influence of reservoir operations on both native and managed vegetation, as well as accounting for how 'background" influences, including climate, topography and parent materials influence vegetation

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 3 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
CLBMON-12-yr 5	2016	Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis Implementation Year 5	Miller, M.T., P. Gibeau, and V.C. Hawkes. 2016. CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis. Annual Report – 2015. LGL Report EA3545. Unpublished report by Okanagan Nation Alliance, Westbank, BC, and LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generations, Water License Requirements, Castlegar, BC. 55 pp + Appendices.	Monitoring of revegetation efforts in Arrow Lakes Reservoir	Project initiated in 2008 to assess the effectiveness of revegetation treatments applied to the reservoir drawdown zone between 2009 and 2011 under the CLBWORKS-2 program. Primary objectives: (1) to assess the short-term effectiveness of the revegetation program at expanding the quality (as measured by diversity, distribution and vigour) and quantity (as measured by cover, abundance and biomass) of vegetation in the drawdown zone within the 434 to 440 m ASL elevation band; and (2) to assess whether revegetation establishment is facilitated by the implementation of the soft constraints operating regime. Results of the CLBMON-12 program will help determine whether changes to the reservoir's soft constraints operating regime (or, in lieu of operational changes, additional physical works) may be required to maintain or enhance planted shoreline vegetation and the ecosystems it supports. Revegetation efforts to date have achieved mixed success. A portion of the stock (primarily Kellogg's sedge and black cottonwood) planted between 2008 and 2011 has survived and taken root and, in limited areas, is growing vigorously. In other areas, survival of plantings has been minimal to non-existent. Establishment failures can probably be ascribed to a combination of environmental factors including prolonged inundation, infertile or unstable substrates, wave action and erosion/deposition, and soil moisture deficits. In areas where revegetated plants have taken hold, an apparent lack of new recruits suggests that revegetated populations may not be self-sustaining over the long term and may require repeated planting interventions to persist. Regression tree analyses identified substrate, microtopography, water energy, aspect, and soil moisture as potentially important predictors of long-term planting survival. Although low-elevation vegetation communities are somewhat negatively influenced by prolonged inundation in the midsummer to fall period, many of the plant species in the drought-tolerant vegetation community types at higher elevation benefit from brief inundation if they are not impacted by wave scour. The number of days of inundation and the depth of inundation (which affect GDD's), and the relative proportion of sand, silt and gravel in the substrate accounted for most of the variation in plant cover. Duration of inundation exceeding 100 days negatively influenced plant height in both treated and control plots (Enns et al 2013).

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 4 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
CLBMON-33-yr 5	2015	Arrow Lakes Reservoir Inventory of Vegetation Resources	Miller, M.T., J.E. Muir, P. Gibeau, and V.C. Hawkes. 2015. CLBMON-33 Arrow Lakes Reservoir Inventory of Vegetation Resources. Year 8 Annual Report – 2014. LGL Report EA3545. Unpublished report by Okanagan Nation Alliance, Westbank, BC, and LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generations, Water License Requirements, Castlegar, BC. 55 pp + Appendices.	Monitoring of revegetation efforts in Arrow Lakes Reservoir	The Arrow Lakes Reservoir Inventory of Vegetation Resources study (CLBMON-33) is a Water License Requirement project initiated in 2007 to assess the impacts of the current reservoir operating regime on existing vegetation in the drawdown zone of the Arrow Lakes Reservoir. The primary objective of this 10-year study is to monitor landscape level changes in the spatial extent, structure, and composition of vegetation communities within the 434-440 m ASL elevation band of the drawdown zone, and to assess if any observed changes are attributable to "soft constraints." As in previous years, the current study design employed aerial imagery of 43 discrete study areas of the Arrow Lakes Reservoir drawdown zone acquired prior to summer inundation to compare vegetation conditions between time periods (in this case between 2007 and 2014, the maximum available time span). The ALR drawdown zone is a moderately dynamic system at the local scale but relatively stable at the landscape level. Changes may take long periods of time to become apparent; there is currently no compelling evidence that the soft constraints operating regime is failing to maintain vegetation spatial limits, structure, and composition of existing vegetation communities in the drawdown zone. However, recommendations include the analysis of GDD's as a potential management tool for fine-tuning soft constraints operating regimes to maximize desired vegetation values in the Arrow Lakes drawdown zone.

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 5 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
CLBMON-35-TOR	2016	CLBMON-35 Plant Response to Timing and Duration of Inundation	Columbia River Project Water Use Plan Monitoring Program Terms of Reference. CLBMON-35 Kinbasket and Arrow Reservoirs revegetation management plan Monitoring Program Terms of Reference.CLBMON-35 Plant Response to Timing and Duration of Inundation. January 7, 2016.	Evaluation of inundation and other factors that affect plant survival in Arrow Lakes and Kinbasket Reservoirs	In 2014, BC Hydro conducted a technical review of its Revegetation Programs and associated monitoring studies within the ALR and the Kinbasket Reservoir (KIN). A number of recommendations came out of the Revegetation Technical Review (RTR), including the need to catalogue and analyze data collected to date. The purpose of the catalogue exercise would be to ascertain what variables (biotic and abiotic) contributed to the successes or failures of each type of vegetation treatment at a given site. The goal of cataloguing and analyzing these data is to help elucidate the extent to which 'reservoir filters' impact plant species survival within the drawdown zone. Filters or constraints are variables which prevent vegetation from becoming established (e.g., presence of woody debris, erosion and deposition, wave and wind action, substrate compaction, human activity, soil anoxia). In addition, CLBMON program results, which analyze existing vegetation in the drawdown zone, will be summarized and compared to CLBWORKS to further ascertain which variables in the drawdown zone promote the survival of plant species and plant communities. Under this revised Terms of Reference for CLBMON-35, data to date from the CLBWORKS programs revegetation treatments and results from the four vegetation monitoring programs (CLBMON-9, 10, 12, and 33) will be assimilated into two catalogue-style databases (one for each reservoir ALR and KIN) which will developed to answer key management questions. Only the TOR appears to be available at this time.
CLBMON-9-yr 4	2013	Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis	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.	Monitoring of revegetation efforts in Kinbasket Reservoir	The fourth year of a 10 year program to monitor the effectiveness of revegetation treatments in the drawdown zone of Kinbasket Reservoir (associated with CLBWORKS-1). Involved resampling of revegetation treatments stratified by geographic region, elevation, vegetation community type in the north, central, and south regions of Kinbasket Reservoir. Results from this study were consistent with previous (2011) findings: transplants have fared poorly overall in the drawdown zone, with survivorship of sedge seedling plugs declining to < 50 per cent on average after two years, and to < 10 per cent on average three or more years after planting. Virtually no deciduous stakes have survived. 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. There was also a general decrease in both total cover and species richness in treatment plots since 2011.

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 6 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
CLBWORKS-1-yr6	2015	Kinbasket Revegetation Program: 2014 Post-Planting Report	Adama, D. 2015. CLBWORKS-01 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.	Revegetation in Kinbasket Reservoir	Due to poor plant survival and establishment in previous years (2007 to 2012), the planting program postponed until a review of the program could be completed. However, sedge seedling stock remained unplanted. This program was initiated to select sites for these seedlings, plant them, and undertake pre-treatment and outplanting monitoring (monitoring of seedling survival within the planting year). Site selection involved review of growth requirements, review of suitable planting sites including vegetation community mapping, consideration of locations where species grows naturally. Seedling survival was high.
CLBWORKS-2_p3	2011	Arrow Lakes Reservoir Revegetation Program Physical Works (Phase 3)	Keefer Ecological Services Ltd. 2011. CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works. Phase 2 Report – 2011 Unpublished report by Keefer Ecological Services Ltd., Cranbrook, BC, for BC Hydro Generation, Water Licence Requirements, Castlegar, BC. 38 pp. + Apps.	Revegetation in Arrow Lakes Reservoir	Fourth year of large scale implementation of revegetation of key sites within the drawdown zone

Laich-Kwil-Tach ENVIRONMENTAL ASSESSMENTS L P

ECOFISH RESEARCH

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 7 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
Fraser *et al.*	2015	A call for applying trophic structure in ecological restoration	Fraser, L H., W.L. Harrower, H.W. Garris, S. Davidson, P.D.N. Hebert, R. Howie, A. Moody, D. Polster, O.J. Schmitz, A.R.E. Sinclair, B.M. Starzomski, T.P. Sullivan, R. Turkington, D. Wilson. 2015. A call for applying trophic structure in ecological restoration. Restoration Ecology Vol. 23, No. 5, pp. 503–507.	Ecological restoration	Abstract: Ecological restoration projects have traditionally focused on vegetation as both a means (seeding, planting, and substrate amendments) and ends (success based upon primary productivity and vegetation diversity). This vegetation-centric approach to ecological restoration stems from an historic emphasis on esthetics and cost but provides a limited measure of total ecosystem functioning and overlooks alternative ways to achieve current and future restoration targets. We advocate a shift to planning beyond the plant community and toward the physical and biological components necessary to initiate autogenic recovery, then guiding this process through the timely introduction of top predators and environmental modifications such as soil amendments and physical structures for animal nesting and refugia. Growing scientific understanding that feedbacks from animals can cause top-down control that determines the abundance and diversity of plants as well the rate at which nutrients are cycled through ecosystems. If the ultimate goal of restoration is recovery of self-sustainable, stable, and resilient communities, the re-establishment of top-down and bottom-up controls, and ecological networks must be planned. We argue that this approach requires more explicit emphasis on targeting the species compositions of food webs comprising ecosystems and their interactions.
Furey *et al.*	2004	Water level drawdown affects physical and biogeochemical properties of littoral sediments of a reservoir and a natural lake	Furey, P. C., Nordin, R. N., Mazumder, A. 2004. Water level drawdown affects physical and biogeochemical properties of littoral sediments of a reservoir and a natural lake. Lake and Reservoir Management 20: 280–295.	Aquatic macrophyte/water level relationships. Sediment physicochemistry.	Compared the seasonal littoral benthic dynamics of a reservoir (Sooke Reservoir, BC) with those of a nearby natural lake (Shawnigan Lake). The reservoir experienced seasonal drawdown of c. 6 m, whereas the lake experienced natural drawdown of < 0.5 m and thus provided a control to specifically examine the effects of drawdown. Despite both waterbodies being relatively deep, thermal stratification was much weaker in the reservoir, e.g. temperature differences between the surface and the bottom never exceeded 2°C in the reservoir whereas differences were up to 11.5°C in the lake. Unlike the reservoir, the lake experienced concomitant declines in dissolved oxygen concentrations in the thermocline. Macrophyte density was much lower in the reservoir and growth there was restricted to higher in the littoral zone. Macrophytes that became exposed in the upper littoral zone by the end of the summer and fall did not, however, die back. The authors contrast this result with that which would be expected in reservoirs situated further north where freezing would be expected to cause die back and increase exposure of the sediments. The lower extent of macrophyte coverage was also shown to shift downwards in response to drawdown in the reservoir, thus increasing the size of the effective littoral area. Sediment sampling indicated that bed sediments were finer–textured in the littoral zone of the lake, indicating that sediment erosion and focusing was more dominant in the littoral zone of the reservoir. The upper region of the littoral zone that was sampled in the reservoir was determined to be an erosional zone, whereas all of the littoral area that was sampled in the lake was determined to be an accumulation zone. Nutrient and organic matter concentrations were lower in the littoral zone of the reservoir, while stable isotope analysis indicated that a greater relative proportion of organic matter was derived from allochotonous sources in the reservoir compared with the lake.

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 8 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
Hill *et al.*	1998	A hydrological model for predicting the effects of dams on the shoreline vegetation of lakes and reservoirs	Hill, N. M., Keddy, P. A., Wisheu, I. C. 1998. A hydrological model for predicting the effects of dams on the shoreline vegetation of lakes and reservoirs. Environmental Management 22: 723–736.	Terrestrial vegetation/water level relationships	a) The authors compare the hydrological regimes and vegetation of 13 regulated and 37 unregulated lakes in Nova Scotia b) Vegetation was surveyed at six sites per lake from 1 m below the water line to 1 m above the shrub line c) Shoreline vegetation of regulated systems was less diverse, contained more exotic species, and devoid of rare shoreline herbs d) Restoring the natural hydrological regime can restore shoreline vegetation communities. e) A general model is proposed which is designed to be applied to temperate reservoirs. It identifies a 'sweet spot' where moderate within and among year variation lead to maximum species abundance.
Jansson *et al.*	2000	Effects of river regulation on river-margin vegetation: a comparison of eight boreal rivers	Jansson, R., Nilsson, C., Dynesius, M., Andersson, E. 2000. Effects of river regulation on river-margin vegetation: a comparison of eight boreal rivers. Ecological Applications 10: 203–224.	Terrestrial vegetation/water level relationships	a) The authors compared the flora in 200 m wide margins along the length of eight rivers in Sweden, four which were free-flowing and four which were regulated b) The number of species and cover per site were higher along the free flowing rivers than along storage reservoirs, with large fluctuations between low water levels in spring and high levels in late summer and fall c) Regulated systems had a higher proportion of wind-dispersed species than free-flowing rivers.

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 9 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
JHTMON-10- Year 1	2016	Upper and Lower Campbell Lake Reservoirs Shoreline Vegetation Model Validation (JHTMON-10) (year 1 monitoring)	Ballin, L., J. Abell, and D. Lacroix. 2015. JHTMON-10: Upper and Lower Campbell Lake Reservoirs Shoreline Vegetation Model Validation - Year 1 Monitoring Report. Consultant's report prepared for BC Hydro by Laich-Kwil-Tech Environmental Assessment Ltd. Partnership and Ecofish Research Ltd., November 27, 2015.	Terrestrial vegetation / water level relationships / Campbell Reservoir Ecology / Monitoring	a) Verification of a shoreline vegetation model (Bruce 2002) that defines the elevational boundary between different plant communities as defined by McLennan and Veenstra (2001). The shoreline vegetation model was developed in order to predict the response of riparian and emergent vegetation (extent and distribution) to operational changes proposed during WUP development, and describes vegetation community elevation bands. For this project the model was reconstructed and hydrology data through 2013 was included, and the plant community elevational boundaries predicted by Bruce were adjusted. (see Table 9) b) the shoreline vegetation model was found to describe plant community boundaries with reasonable accuracy when all results were pooled, but when the elevation boundary between communities was analyzed separately there were statistically significant differences between model predictions and field measurements for three of the five boundary types. This error may be reduced as vegetation communities continue to adjust to the change in reservoir conditions (see Figure 28) c) Key observations were made of a downward elevational shift in plant community boundaries in response to the change in maximum reservoir levels starting in 2004 d) there were significant differences in boundary elevations between transects and not all transects had all the predicted vegetation communities (Figures 7 and 28) e) mapping the extent and type of riparian vegetation communities from air photo (2014) interpretation reveals the location of low gradient shorelines most affected by water level fluctuations. This mapping may be another method to monitor and measure change to the vegetation community after WUP implementation. f) A DEM was generated to investigate a hypothesis regarding whether 15% slope is a threshold for riparian vegetation establishment/presence and this was true for the Upper Campbell Reservoir. f) this report is year 1 of a 10 year program
JHTMON-2 Year 1	2015	Upper Campbell, Lower Campbell and John Hart Reservoirs and Elk Canyon Public Use and Perception Survey	Morris, R. and S. Conrad. 2015. JHTMON-2: Upper Campbell, Lower Campbell and John Hart Reservoirs and Elk Canyon Public Use and Perception Survey – Year 1 Reporting. Consultant's report prepared for BC Hydro by Laich-Kwil Tach Environmental Assessment Limited Partnership and EDI Environmental Dynamics Inc., December 21, 2015.	Recreation / aesthetics	Plans for a 10-year study to evaluate public use and perception of 8 sites (reservoir, river and elk falls) which are affected by BC Hydro operations. Questionnaires were developed to measure public response to the operation of the System and additional works constructed within the area influence by the System. Data was to have been collected in 2015 and 2016.

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 10 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
JHTWORKS-2 TOR	2016	Upper Campbell Lake Reservoir and Campbell Lake Reservoir Recreation Facility Upgrade Feasibility	Campbell River Project Water Use Plan Physical Works Terms of Reference. JHTWORKS-2: Upper Campbell Lake Reservoir and Campbell Lake Reservoir Recreation Facility Upgrade Feasibility. January 2016.	Recreation	Identification, feasibility and preliminary design of recreation upgrades to address access (boating and swimming) at priority sites affected by the lowering of the water levels during the recreation peak use time of year. Current facilities were designed prior to implementation of the new WUP regime in 2012.
Leira & Cantonati	2008	Effects of water-level fluctuations on lakes: an annotated bibliography	Leira, M., Cantonati, M. 2008. Effects of water-level fluctuations on lakes: an annotated bibliography. Hydrobiologia 613: 171–184.	Aquatic biology/water level relationships	A review of the literature on the effects of water-level fluctuations on lakes, 1991-2008. It is telling that the section on effects on biota includes only a very small section on terrestrial vegetation which notes that "much less attention has been paid to terrestrial plant communities, although terrestrial species are very sensitive to water-level changes". Only two papers (one is an Australian study and one from the tropics) are included in this section. Elsewhere, it notes that the duration of flooding has been shown to be more important in lacustrine wetlands than the depth. Note that the saved document consists of a special issue of Hydrobiologia which contains other papers of some relevance.
Mackillop, S.	2003	Investigations of revegetation strategie using woody species for fish habitat enhancement and aesthetic improvement in the drawdown zone at Buttle Lake, British Columbia.	Mackillop, S. 2003. Investigations of revegetation strategie using woody species for fish habitat enhancement and aesthetic improvement in the drawdown zone at Buttle Lake, British Columbia.	Revegetation on Buttle Lake	Tested six seedling species (Western red cedar, western hemlock, black twinberry, red-osier dogwood and Sitka willow) in 2 elevation bands at south end of Buttle Lake. No flooding that year. Drought effects observed. Recommend multiyear research program. Reviews mechanism of environmental stressors in the drawdown zone. Ability of trees to survive summer flooding was correlated with ability of seedling to produce adventitious roots. Walters *et al.* (1980) classified species as very tolerant, tolerant or intermediately tolerant to flooding for 2 or more growing seasons. The five very tolerant species are red alder, Sitka alder, pacific dogwood, red-osier dogwood, Salix sp.. Tolerant species included amabilis fir, Douglas maple, black hawthorn, Sitka spruce, black cottonwood, western red cedar and western hemlock (p 18). Many of the willows survived down to 4 m below full pool.• s. sitchensis and s. hookeriana the two willow spp native to Strathcona park. Another identified as S. lasiandra. S. sitchensis the most abundant and adaptive. The stress it must be adapted to includes not only flooding but adjustment to re-exposure to oxygen and also drought. It is assumed that s. sitchensis has a higher tolerance than the other spp which are less abundant and grow in fewer microhabitats. • Former BC Hydro projects: Upper Campbell lake planting near park entrance in 1993: successful planting of 5 spp of Salix plus cottonwood. Green jute netting incorporated as immediate visual improvement as well as protection from wave action. Established within 1.5 m of full pool. Sediment trapping effect essential for subsequent development of herbaceous communities.

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 11 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
Mackillop, S. and W. Dushenko		South Buttle Lake (Reservoir) Shoreline Revegetation	Mackillop, S. and W. Dushenko. N.d. South Buttle Lake (Reservoir) Shoreline Revegetation. Royal Roads University	Revegetation on Buttle Lake	Present methods and results of planting trials in Buttle Lake.
McLennan and Veenstra	2001	Riparian Ecosystem Mapping Campbell River	McLennan, D and V. Veenstra. 2001. Riparian Ecosystem Mapping Campbell River. Prepared by Oikos Ecological Services Ltd. for BC Hydro, Burnaby B.C. 18 pp + appendices.	Campbell Reservoir Ecology / terrestrial vegetation / water level relationships	Baseline mapping, transect and community data used for JHTMON10. Describes ecosystems that exist within the drawdown and adjacent riparian habitat of Upper Campbell and the smaller reservoirs, as well as the relationship between communities and water levels, describes communities at risk (may be out of date). TEM-based map of project area
Nilsson	1981	Dynamics of the shore vegetation of a north Swedish hydro-electric reservoir during a 5-year period.	Nilsson, C. 1981. Dynamics of the shore vegetation of a north Swedish hydro-electric reservoir during a 5-year period. Acta Phytogeographica Suecica 69. Doctoral Thesis. Uppsala University, Sweden.	Terrestrial vegetation/water level relationships	This thesis provides additional material relating to the Nilsson and Keddy (1988) study that is described above.

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 12 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
Nilsson & Keddy	1988	Predictability of change in shoreline vegetation in a hydroelectric reservoir, northern Sweden	Nilsson, C. Keddy, PA. 1988. Predictability of change in shoreline vegetation in a hydroelectric reservoir, northern Sweden. Canadian Journal of Fisheries and Aquatic Sciences 45: 1896-1904.	Terrestrial vegetation/water level relationships	a) A study of relationships between shoreline vegetation and water levels using 10 years of data for a reservoir in Sweden. b) The flora comprised sparse vegetation, and there was a strong positive relationship between abundance and richness, indicative of disturbed habitats. c) Vegetation was most stable when there was 40-60 days of flooding. d) At best, water level changes could only explain ~40% of the variability in species abundance and richness. The simple system was not readily predictable. e) Of the hydrological variables, the duration of flooding in the previous year was the best explanatory variable.
Northcote & Atagi	1997	Ecological interactions in the flooded littoral zone of reservoirs: the importance and role of submerged terrestrial vegetation with special reference to fish, fish habitat and fisheries in the Nechako Reservoir of British Columbia, Canada	Northcote, T. G., Atagi, G. Y. 1997. Ecological interactions in the flooded littoral zone of reservoirs: the importance and role of submerged terrestrial vegetation with special reference to fish, fish habitat and fisheries in the Nechako Reservoir of British Columbia, Canada. Report prepared for the Ministry of Environment, Lands and Parks, Skeena Region. Skeena Fisheries Report SK-111. 71 p.	Ecological effects of flooding following reservoir construction	A review of the ecological interactions in the littoral zone of recently flooded reservoirs. Focusses on trophic upsurge due to mobilization of nutrients from recently flooded soils. Notes that "Macrophyte growth in reservoirs subject to much fluctuation in water level usually is restricted to the lowermost drawdown point or below, as was evident in Buttle Reservoir (Vancouver Island, B.C.) in October 1996 (TGN personal observations)". Includes a summary of the history of inundation to Buttle Lake and Upper Campbell Reservoir, including aerial photographs.

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 13 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
Polster, D.	2017	Restoration Monitoring - Heber Dam Decommissioning	Polster, D. 2017. Restoration Monitoring Heber Dam Decommissioning. Consultants report prepared by Polster Environmental Services for BC Hydro, August 2017.	Restoration techniques and success of Heber Dam	Revegetation methods applied to restoration of Heber Dam and results of five year monitoring program.
Polster, D.	n.d.	Segment Live Silt Fencing - new	Polster, D. n.d. Segment Live Silt Fencing presentation.	Live staking	Presentation on how the use of live staking in ditches can slow velocities.
Ray Read	2017	Transmission Vegetation and Access Manager, personal communication with Leah Ballin on June 13, 2017	Read, R. 2017. Personal Communication. Telephone conversation between Ray Read, Transmission Vegetation and Access Manager, BC Hydro, with Leah Ballin, Ecofish on June 13, 2017.		Revegetation trials in Buttle Lake in 1990's. Ecopads and willow staking. Both treatments successful. Ecopads are 2-3m2 x 1-2 ft deep pads of upland terrestrial vegetation (trees, shrubs, moss, fungi etc.; up to 30 m upslope) that are transplanted at the upper elevations of the drawdown zone. The transplants were applied to slopes of ~<20% within the upper elevations of the inundation zone within bays where they would have a higher chance of survival. There was no anchoring done, as vegetation was given sufficient time to naturally root down before summer inundation. Some species died, especially during periods of prolonged flooding, but for the most part they did well and expanded over time. You could probably do this on terraces as well, however, doing any kind of willow wattling is expensive. Could probably accomplish ~200 m of shoreline in a day. Willow staking. These did well (note species lists and amounts in Mackillop 2003). They were planted both in the river bed and along the adjacent shoreline and did well, but did better the closer to the site that they were from. For example the cuttings from the old island highway and most coastal areas didn't survive as well (too bad because we were thinking the inland island highway could be a good source). You could plant them horizontally to help catch sediment. Ray recommends that that the best option for steep slopes in the middle draw down zone is likely locally sourced good quality willow staking. He agrees it is good to capture sediment as would be done with willow fencing but thinks the time it takes to do this is likely not worth it.

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 14 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
Redden. I. and Cuthbert. I.	2006	Elk River 2005 Channel Stabilization Project Part 11: Monitoring Results	Redden. I. and Cuthbert. I. .2006. Elk River 2005 Channel Stabilization Project Part 11: Monitoring Results. Streamline Watershed Management Bulletin 10(1): 15-17	Elk River Revegetation	Methods and results of live staking in the Elk River to stabilize substrates.
Richardson and Mallik	2005	Shoreline vegetation change in upstream and downstream reaches of three temperate streams dammed for hydroelectric generation in British Columbia.	Mallik, A.U. and J.S. Richardson. 2005. Shoreline vegetation change in upstream and downstream reaches of three temperate streams dammed for hydroelectric generation in British Columbia. Report to BC Hydro.	Terrestrial vegetation/water level relationships	a) Vegetation transects were completed at three flow controlled rivers to detect differences in vegetation cover. b) Differences in vegetation communities amongst sites were larger for the flow controlled portion of the river as compared to upstream and downstream sections. c) Significantly fewer alder and redcedar were located downstream of reservoirs potentially due to reductions in extremes in flow variation.
Riis & Hawes	2002	Relationships between water level fluctuations and vegetation diversity in shallow water of New Zealand lakes	Riis, T., Hawes, I. 2002. Relationships between water level fluctuations and vegetation diversity in shallow water of New Zealand lakes. Aquatic Botany 74: 133–148.	Aquatic macrophyte/water level relationships	a) A study to examine which aspects of the hydrological regime influence the 'low mixed community' of aquatic macrophytes in 21 New Zealand lakes. b) Vegetation in each lake was surveyed once and water level data for the previous 10 years was used to summarize historic water level fluctuations. c) Surveys were undertaken using SCUBA with 6 to 50 transects per lake. The upper and lower depth limit of each species was recorded along the transect. d) Diversity was quantified using: species richness, Shannon-Weiner Diversity Index and evenness. e) Regarding WL: "It is not a trivial task to parameterize water level fluctuations in lakes in a way that integrates both the spatial and temporal dimensions on an ecologically relevant scale. We approached the problem by calculating three groups of statistics, which a priori we considered likely to affect the habitat for LMC plants. Firstly, we used the quartile range (25–75%) instead of actual range to buffer for extremes, to describe the general conditions in the lakes during the 10 years prior to the vegetation survey, rather than the extreme events. Extreme events may be ecologically significant but also are the timing of the extreme events. If a long dry period had occurred several years prior to the vegetation survey it would not have had the same effect as if it had happened the last year prior to the survey. This confounding effect of timing led us to exclude extreme events for each lake. Secondly, to give an indication of the potential magnitude of desiccation events, we calculated the frequency and mean duration of events when the level fell below the median. Thirdly, to help define the hydrological requirements of the LMC, we determined the level on the shore where the mean dry period duration was 10, 30, 60, 120 and 180 days." f) Species richness was much higher in lakes with high intra-annual variability (e.g. UCR) rather than high inter-annual variability.

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 15 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
Shackelford *et al*.	2013	Primed for Change: Developing Ecological Restoration for the 21st Century	Shackelford, N., R.J. Hobbs, J.M. Burgar, T.E. Erickson, J.B. Fontaine, E. Laliberte, C.E. Ramalho, M.P. Perring, and R.J. Standish. 2013. Primed for Change: Developing Ecological Restoration for the 21st Century. Restoration Ecology Vol. 21, No. 3, pp. 297–304 297.	Ecological restoration principles	Abstract: Restoration is a young and swiftly developing field. It has been almost a decade since the inception of one of the field's foundational documents—the (Primer). Through a series of organized discussions, we assessed the Primer for its currency and relevance in the modern field of ecological restoration. We focused our assessment on the section entitled "The Nine Attributes of a Restored Ecosystem" and grouped each of the attributes into one of four categories: species composition, ecosystem function, ecosystem stability, and landscape context. We found that in the decade since the document's inception, the concepts, methods, goals, and thinking of ecological restoration have shifted significantly. We discuss each of the four categories in this light with the aim of offering comments and suggestions on options for updating the Primer. We also include a fifth category that we believe is increasingly acknowledged in ecological restoration: the human element. The Primer is an important document guiding the practice of restoration. We hope that this critical assessment contributes to its ongoing development and relevance and more generally to the development of restoration ecology, particularly in our current era of rapid environmental change. Nine attributes of the primer for the restored ecosystem with new additions:/updates contains a characteristic assemblage of the species that occur in the reference ecosystem and that provide appropriate community structure; consists of indigenous species (with some exceptions); all functional groups necessary for the continued development and/or stability of the restored ecosystem are represented or, if they are not, the missing groups have the potential to colonize by natural means; the physical environment is capable of sustaining reproducing populations of the species necessary for its continued stability or development along the desired trajectory (includes functional redundancy and response diversity to quantify resistance and resilience); functions normally for its ecological stage of development; is suitably integrated into a larger ecological matrix or landscape (includes attribute about ecosystem spatial configuration, importantly size); threats to the health and integrity of the restored ecosystem from the surrounding landscape have been eliminated or reduced as much as possible (incorporate both minimization/removal of those threats as well as the incorporation of their reality into restoration planning); is sufficiently resilient to endure the normal periodic stress events in the local environment; is self-sustaining to the same degree as its reference ecosystem, and has the potential to persist indefinitely under existing environmental conditions; include the human element (social/cultural values).

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 16 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
Shafroth *et al.*	2002	Potential responses of riparian vegetation to dam removal	Shafroth, P. B., Friedman, J. M., Auble, G. T., Scott, L. M., Braatne, J. H. 2002. Potential Responses of riparian vegetation to dam removal: Dam removal generally causes changes to aspects of the physical environment that influence the establishment and growth of riparian vegetation BioScience 52: 703-712	Terrestrial vegetation/water level relationships	a) Focusses on the effects of dam removal so of limited relevance to JHTMON10. b) Highlights potential for areas of high disturbance to favour invasive plant growth. c) Provides information on plant succession in response to altered hydroperiod, although the emphasis is on landscapes in the interior USA.
Turner *et al.*	2005	Divergent impacts of experimental lake-level drawdown on planktonic and benthic plant communities in a boreal forest lake	Turner, M. A., Huebert, D. B., Findlay, D. L., Hendzel, L. L., Jansen, W. A., Bodaly, R. A., Armstrong, L. M., Kasian, S. E. M. 2005. Divergent impacts of experimental lake-level drawdown on planktonic and benthic plant communities in a boreal forest lake. Canadian Journal of Fisheries and Aquatic Sciences 62: 991–1003	Aquatic macrophyte and phytoplankton/water level relationships.	An experimental study of a small oligotrophic lake in Ontario which was subject to water level manipulations by lowering surface water level by 2–3 m during winter and subsequently raising it in summer. The manipulations were specifically designed to mimic the effects of hydropower operations and the study focused on effects to both littoral and pelagic primary productivity. Contrary to expectations, nutrient release following summer water level increases were muted and, consequently, changes to pelagic primary productivity were minor. Macrophyte biomass decreased, particularly in the case of isoetids (slow growing perennials). Epilithon exhibited a minor response, reflecting short turnover times which permitted benthic algae to adapt to the changes and colonize new habitat. The authors concluded that "the trophic impacts of declining lake levels, whether due to hydroelectric reservoir manipulations or climate change, are likely to be much greater in the littoral zone than in the pelagic zone if major nutrients are unaltered".

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 17 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
Van Eck *et al.*	2004	Is tolerance to summer flooding correlated with distribution patterns in river floodplains? A comparative study of 20 terrestrial grassland species	Van Eck, W. H. J. M., Van De Steeg, H. M., Blom, C. W. P. M., de Kroon, H. 2004. Is tolerance to summer flooding correlated with distribution patterns in river floodplains? A comparative study of 20 terrestrial grassland species. Oikos 107: 393-405.	Terrestrial vegetation/water level relationships	a) The authors undertook experimental studies of the tolerance of 20 grass species to inundation. Results were compared with data collected from 123 vegetation surveys in the Rhine River basin. b) The elevations of plants that were surveyed were not normally-distributed thus median and other percentile values were used to characterize distributions. c) Experiments involved submerging species for 2 months and measuring survival and biomass recovery. d) Most species had a limited range of distribution along the elevation gradient. Survival was reduced for most species when inundation > 1 week. Flood tolerant species occurred at lower levels. Flood tolerant species were able to recover after flooding, and the success of this recovery was generally not affected by flood duration. e) The introduction provides a good summary of the physiological effects of inundation on plant growth. Oxygen deficiency is the major physiological constraint encountered by plans during inundation. Adaptions include aerenchyma formation or anaerobic respiration (energetically expensive). Post-anoxic injury can occur as metabolites formed during submergence are metabolized following re-emergence.
Van Eck *et al.*	2006	Seasonal dependent effects of flooding on plant species survival and zonation: a comparative study of 10 terrestrial grassland species	Van Eck, W. H. J. M., Lenssen, J. P. M., Van De Steeg, H. M., Blom, C. W. P. M., de Kroon, H. 2006. Seasonal dependent effects of flooding on plant species survival and zonation: a comparative study of 10 terrestrial grassland species Hydrobiologia 565: 59-69.	Terrestrial vegetation/water level relationships	a) The authors conducted an experimental study of how variation in the seasonal variability of flooding affected the distribution of 10 grasses. b) All species survived longer under winter floods than under summer floods. The elevation of species was strongly related to their tolerance to summer (not winter) flooding. c) "zonation patterns as created by occasional summer floods may be maintained for a long time, probably due to the limited ability of species to re-colonise lower positions in the floodplain".
Wilcox & Meeker	1991	Disturbance effects on aquatic vegetation in regulated and unregulated lakes in northern Minnesota	Wilcox, D. A., Meeker, J. E. 1991. Disturbance effects on aquatic vegetation in regulated and unregulated lakes in northern Minnesota. Canadian Journal of Botany 69: 1542–1551.	Aquatic macrophyte/water level relationships	a) Water level regulation can reduce macrophyte diversity in the littoral zone due to both too–little and too–much hydrological disturbance that is associated with water level stabilization and increased fluctuation respectively. The authors compared macrophyte communities in two lakes for which water level management was imposed, with a local unregulated lake. Their results showed that the unregulated lake, which had a moderate degree of natural variability in water level, had a much more structurally–diverse macrophyte community than the regulated lakes which had either artificially–imposed low or high levels of variability in water levels. b) Although the study did not explicitly consider productivity or biomass, the depauperate communities in the regulated lakes typically comprised less–extensive coverage than the communities in the unregulated lake. In particular, the macrophyte community in the lake that underwent large drawdown in early winter suffered from freezing damage in the upper region of the littoral zone. c) This lake was characterized by a general dominance of stress–tolerant species with thin stemmed, mat or low rosette architectures, with a lack of macrophytes in the upper water column.

Table 1. Literature reviewed and persons interviewed for the JTHWORKS-3 study (part 18 of 18).

Author(s)	Date	Title	Citation	Topic	Summary/ Key Elements
Xie *et al.*	2014	The impact of Three Gorges Dam on the downstream eco-hydrological environment and vegetation distribution of East Dongting Lake	Xie Y.-h., Yue T., Xin-sheng C., Feng L. and Zheng-miao D. 2014. The impact of Three Gorges Dam on the downstream eco-hydrological environment and vegetation distribution of East Dongting Lake, Ecohydrology, DOI: 10.1002/eco.1543	Terrestrial vegetation/water level relationships	a) A study of the effects of water level fluctuations associated with the Three Gorges Dam in China on the elevation of vegetation in a very large downstream lake (Lake Dongting, 2625 km2). The WL in the lake fluctuates by 12-14 m with a maximum in August and a minimum in January/February. b) Satellite remote sensing images (Landsat) were obtained for 6 dates between 1995 and 2011 when the water level was approximately the same (21 m). Land cover was classified as either vegetation (forest, reeds, grass), mud flat or water body. Land cover data were combined with a digital elevation model. c) Change in submergence duration is shown to drive the elevation of vegetation cover.
Zohary & Ostrovsky	2011	Ecological impacts of excessive water level fluctuations in stratified freshwater lakes	Zohary, T., Ostrovsky, I. 2011. Ecological impacts of excessive water level fluctuations in stratified freshwater lakes. Inland Waters. 1: 47–59.	Aquatic biology/water level relationships	A general review of the ecological impacts of water level fluctuations. Highlights the potential for water level fluctuations to cause a shift in primary productivity from the littoral (macrophytes) to the pelagic (phytoplankton).

Laich-Kwil-Tach ENVIRONMENTAL ASSESSMENTS L P

ECOFISH RESEARCH

Appendix B. Expert Workshop

TABLE OF CONTENTS

1. AGENDA

AGENDA

BCH JHTWORKS-3: Upper Campbell Reservoir Drawdown Zone Revegetation Program

Physical Works Component – Phase 1: Site Identification/Prioritization

DATE: June 19, 2017

TIME: 10:00-16:00

LOCATION: STRATHCONA PARK LODGE - 41040 GOLD RIVER HIGHWAY (MAP)

ATTENDEES

	Confirmed:	Representing
1	Jim Meldrum	We Wai Kai / Wei Wai Kum
2	Tina McLean	K'omoks First Nation
3	David Polster	Consultant (BCH)
4	Jamie Boulding	Strathcona Park Lodge
5	Bill Grutzmacher	TimberWest
6	Andy Smith	BC Parks
7	Graham Cameron	Rec Sites and Trails BC
8	Erica McClaren	BC Parks
9	Jeff Walker	BCH
10	Eva Wichmann	BCH
11	Phil Bradshaw	BCH
12	Susan Pinkus	BCH
13	Deb Lacroix	Ecofish
14	Leah Ballin	Ecofish

Meeting Facilitator: Ecofish Research Ltd.

MATERIALS:

- Supporting materials will be provided at the meeting.

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1. MEETING OBJECTIVES

The key objectives of the workshop are to gather and share recreational and biological knowledge to guide and support: (1) the identification of priority revegetation trial sites along the reservoir from a visual quality and riparian habitat perspective, and (2) to identify site-specific revegetation prescriptions as part of the operational treatment. We will examine the site selection criteria, evaluate potential trial revegetation sites, and discuss alternatives. We will also evaluate proposed revegetation treatments for potential trial sites and consider alternatives based on local experience and expert knowledge.

2. SCHEDULE

AGENDA TOPIC	Lead (s)	Time
1. Welcome & Introductions • Safety Orientation • Review Meeting Objectives	Ecofish & BC Hydro	10:00-10:15
2. Project Overview & Revegetation Site Selection Context: • Overview of JHTWORKS-3 TOR – Phase 1 • Present selection criteria and corresponding methodological approach	Ecofish	10:15 – 10:45
STRETCH AND REFRESHMENTS		10:45 – 11:00
3. Breakout session 1: • Evaluate revegetation site selection criteria & methodological approach and propose alternatives; and, • Evaluate potential trial revegetation sites and propose alternatives.	All	11:00 – 12:00
LUNCH (BAG LUNCH AND WALK AROUND THE BUTTLE NARROWS)		12:00 – 13:30
4. Proposed Revegetation Techniques: • Present proposed revegetation techniques, including planting species for trial sites.	Ecofish	13:30 – 14:00
5. Breakout session 2: • Evaluate revegetation techniques and species selection for trial sites and propose alternatives	All	14:00 – 15:30
6. Wrap up • Summary of key recommendations • Next steps	Ecofish & BC Hydro	15:30 – 16:00

2. LIST OF ATTENDEES

Response	Attendee	Affiliation
Confirmed/ attended	Jim Meldrum	We Wai Kai / Wei Wai Kum
	Tina McLean	K'omoks First Nation
	Cory Frank	K'omoks First Nation
	David Polster	Consultant (BCH)
	Jamie Boulding	Strathcona Park Lodge
	Bill Grutzmacher	TimberWest
	Erica McClaren	BC Parks
	Jeff Walker	BCH
	Eva Wichmann	BCH
	Phil Bradshaw	BCH
	Susan Pinkus	BCH
	Deb Lacroix	Ecofish
	Leah Ballin	Ecofish
Confirmed/ no attendance	Andy Smith	BC Parks
	Graham Cameron	Rec Sites and Trails BC
Invited but not confirmed	Allister McLean	BCH
	Stephen Watson	BCH
	Shannon Anderson	DFO
	Stacey Larsen	DFO
	Aniko Nelson	SRD

3. WORKSHOP PRESENTATION

JHTWORKS - 3:UPPER CAMPBELL RESERVOIR DRAWDOWN ZONE REVEGETATION PROGRAM PHYSICAL WORKS COMPONENT – PHASE 1: IDENTIFICATION/PRIORITIZATION

June 19th, 2017

Laich-Kwil-Tach
ENVIRONMENTAL ASSESSMENTS L P
BC Hydro
Power smart
ECOFISH
RESEARCH

WELCOME, SAFETY, AND INTRODUCTIONS

- Washrooms
- Exits
- Introductions

AGENDA

AGENDA TOPIC	Lead (s)	Time
Project Overview & Revegetation Site Selection Context	Ecofish	10:15 – 10:45
Stretch and Refreshments		10:45 – 11:00
Breakout session 1– site selection criteria, candidate sites, and alternatives	All	11:00 – 12:00
Lunch (Bag lunch and walk around the Buttle Narrows)		12:00 – 13:30
Proposed revegetation techniques and species selection	Ecofish	13:30 – 14:00
Breakout group 2 – revegetation techniques, species selection, and alternatives	All	14:00 – 15:30
Wrap up and adjourn	Ecofish	15:30 – 16:00

PROJECT **BACKGROUND** & GOALS

- 440 ha of drawdown zone exposed in summer
  - High reservoir levels (1996-2004)
  - Lower operating level (pre 1996, 2004-present)

- Goal: *Improve the visual quality and habitat values of high profile reservoir shoreline areas previously impacted by fluctuating reservoir levels*

SCOPE OF JHTWORKS-3

- <u>Objective</u>:

Assist natural recolonization of native vegetation communities in the drawdown zone to improve visual quality and riparian habitat value

10 Year program - 3 Phases

Phase 1 – Identification/ Prioritization	Phase 2 – Planning/ Trial Phase	Phase 3 – Implementation
Year 1	Years 2-6	Years 7-10

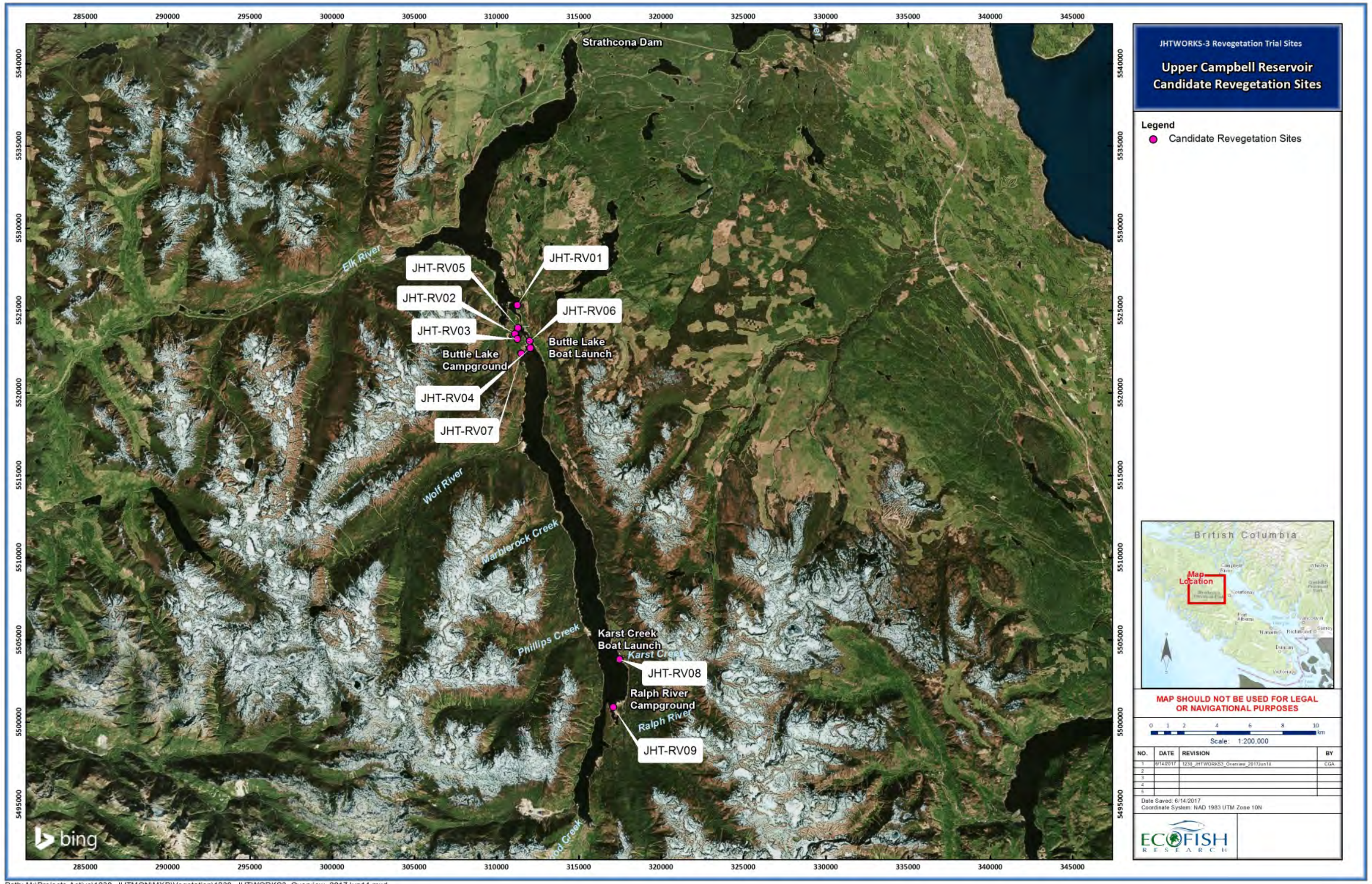


WORKSHOP OBJECTIVES

1. Identify priority revegetation trial sites along the reservoir from a visual quality and riparian habitat perspective
2. Identify site specific revegetation prescriptions for the trial sites.

VIRTUAL TOUR OF THE RESERVOIR

Laich-Kwil-Tach ENVIRONMENTAL ASSESSMENTS L P



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ENVIRONMENTAL ASSESSMENTS L P

PHOTOGRAPHS - VISUAL PERSPECTIVE

Viewsheds

Upper Campbell Marine Site

Towards Rainbow Island from Trail (high reservoir)

Towards Rainbow Island from Trail (low reservoir)

ECOFISH RESEARCH

BC Hydro Power smart

PHOTOGRAPHS - VISUAL PERSPECTIVE

Viewsheds

Towards Rainbow Island

South from Rainbow Island trail (low reservoir)

South from Rainbow Island trail (high reservoir)

PHOTOGRAPHS - VISUAL PERSPECTIVE

Laich-Kwil-Tach
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Viewsheds

From Buttle Lake Boat Launch

To Driftwood Group Site beach

View south from bridge over Narrows

PHOTOGRAPHS - VISUAL PERSPECTIVE

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Lower reservoir flats (216 – 218 m)

Buttle Lake Campground

Northeast shore of reservoir (Campbell Lake)

Southern end of Buttle Lake

PHOTOGRAPHS - VISUAL PERSPECTIVE

Lower reservoir flats (216 – 218 m)

Ralph River Campground

Northeast shore of reservoir (Campbell Lake)

Old Buttle Lake Boat Launch

PHOTOGRAPHS - VISUAL PERSPECTIVE

Middle drawdown (218-220 m)

East Buttle Lake Campground

Middle Buttle Lake Campground

Ralph River Campground

PHOTOGRAPHS - VISUAL PERSPECTIVE

Middle to upper drawdown and upland (218-221 m)

From Rainbow Island

Old Buttle Boat Launch

Buttle Boat Launch

FACTORS THAT MAY CONSTRAIN SUCCESSFUL REVEGETATION

Inundation and drought

PHOTOGRAPHS - CONSTRAINTS

Surface erosion



PHOTOGRAPHS - CONSTRAINTS

Exposure to fetch – erosion & deposition

Rainbow Island (south aspect)

Rainbow Island (north aspect)

Driftwood Group Site (south aspect)

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ENVIRONMENTAL ASSESSMENTS L P

PHOTOGRAPHS - CONSTRAINTS

Steep slopes - erosion

Old Buttle Boat Launch

Driftwood Group Site

From Rainbow Island

PHOTOGRAPHS - CONSTRAINTS

Human and wildlife disturbance

APPROACH - SITE SELECTION

- Site selection criteria:
  - Revegetation opportunity
  - Revegetation priority
  - Revegetation success

SITE SELECTION CRITERIA

Revegetation opportunity

- Land ownership
- Machine access
- Cost
- Known or potential physical works

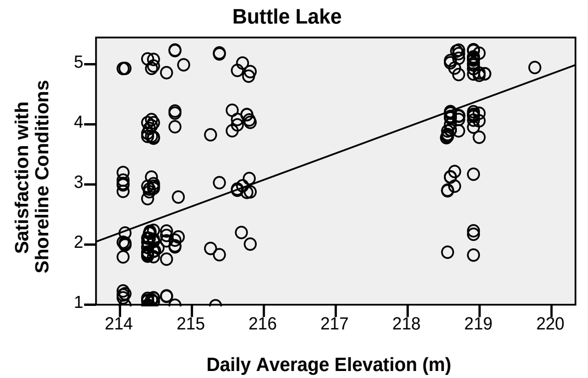
SITE SELECTION CRITERIA

Revegetation priority

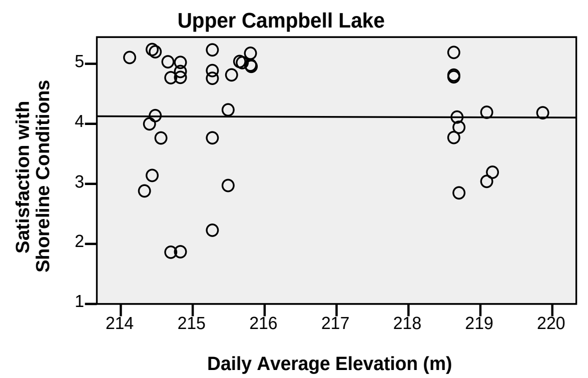
- Visibility
- Public satisfaction
- Fish and wildlife habitat

PUBLIC PERCEPTION SURVEYS

- Satisfaction with shoreline condition
- Perception of safety



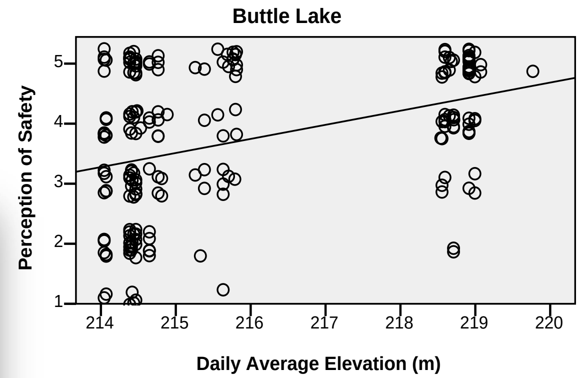
Satisfaction with shoreline condition (1=Very dissatisfied, 2=Somewhat dissatisfied, 3=Neither, 4=Somewhat satisfied, 5=Very satisfied)



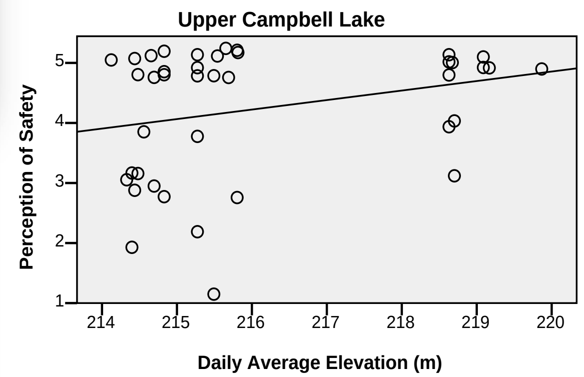
Satisfaction with shoreline condition (1=Very dissatisfied, 2=Somewhat dissatisfied, 3=Neither, 4=Somewhat satisfied, 5=Very satisfied)

Ralph River Campground

Buttle Lake Campground



Perception of safety (1=Very unsafe, 2=Somewhat unsafe, 3=Neither, 4=Somewhat safe, 5=Very safe)



Perception of safety (1=Very unsafe, 2=Somewhat unsafe, 3=Neither, 4=Somewhat safe, 5=Very safe)

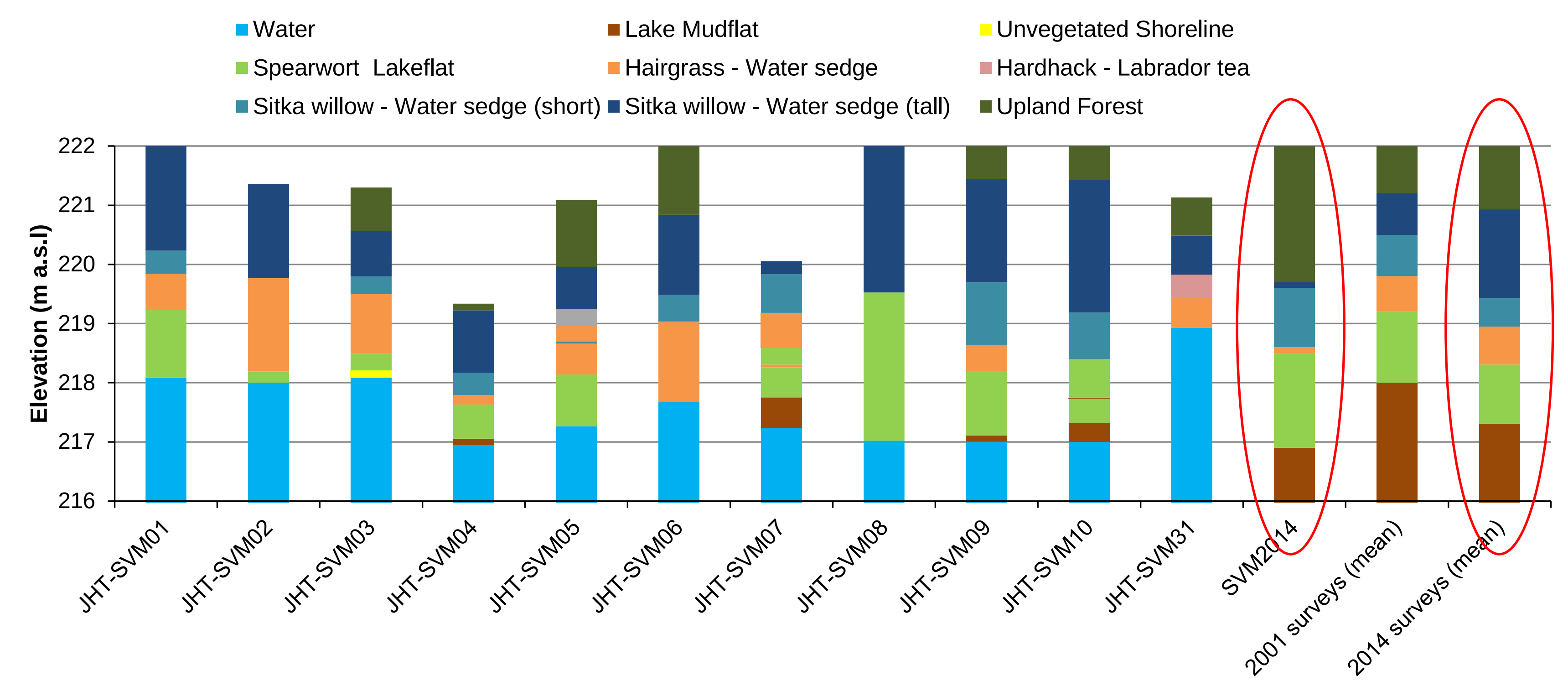
JHTMON-2 (EDI 2016)

SITE SELECTION CRITERIA

Revegetation success

- Elevation (m)
- Slope (%)
- Substrate
- Natural recruitment
- Aspect (fetch and insolation)
- Water availability
- Human disturbance
- Wildlife disturbance

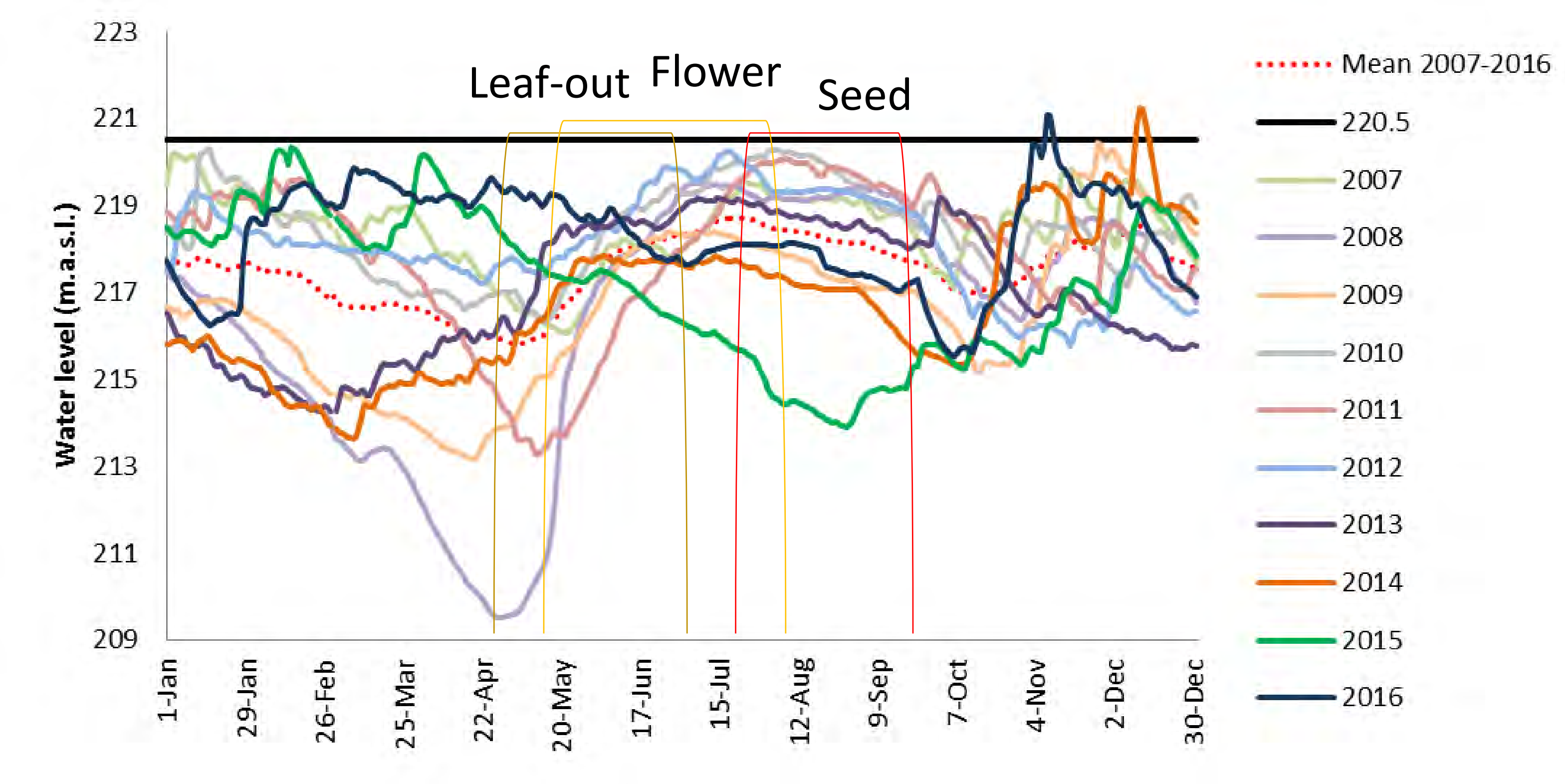
ELEVATION & VEGETATION COMMUNITIES



JHTMON-10 (Ecofish 2014)

ELEVATION, INNUNDATION & THE GROWING SEASON

- Daily water level in the Upper Campbell Lake Reservoir 2007-2016.

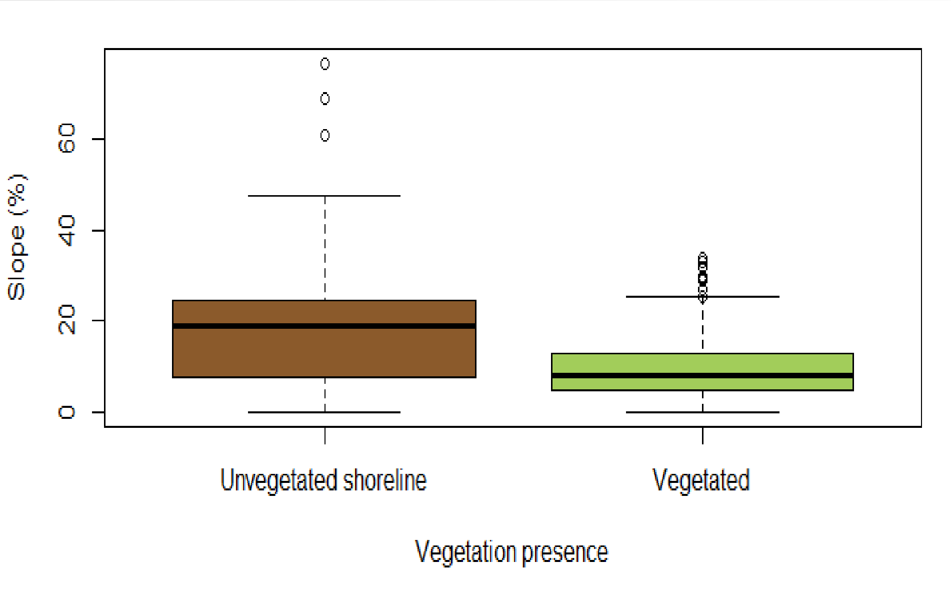


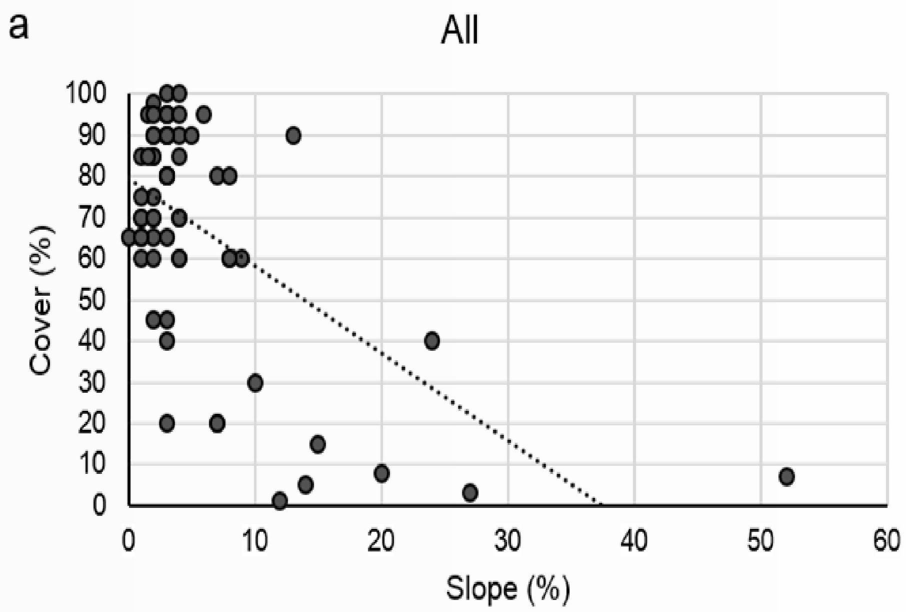
JHTMON-10 (Ecofish 2014)

PROPORTION OF DAYS PER YEAR THAT EACH ELEVATION BAND IS EXPOSED

Month	Elevation (m ASL)	Year 2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
May	221	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	220	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	219	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.32
	218	1.00	1.00	1.00	1.00	1.00	0.77	0.42	1.00	0.87	0.00
	217	1.00	1.00	1.00	0.52	1.00	0.00	0.32	0.55	0.00	0.00
	216	0.00	0.81	0.84	0.00	1.00	0.00	0.00	0.13	0.00	0.00
June	221	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	220	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	219	1.00	0.93	1.00	0.63	1.00	0.50	1.00	1.00	1.00	1.00
	218	0.37	0.50	0.47	0.03	1.00	0.00	0.00	1.00	1.00	0.37
	217	0.00	0.00	0.10	0.00	0.60	0.00	0.00	0.00	0.50	0.00
	216	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
July	221	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	220	1.00	1.00	1.00	0.77	1.00	0.71	1.00	1.00	1.00	1.00
	219	0.45	0.00	1.00	0.00	0.48	0.00	0.10	1.00	1.00	1.00
	218	0.06	0.00	0.00	0.00	0.06	0.00	0.00	1.00	1.00	0.45
	217	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
	216	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00
August	221	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	220	1.00	1.00	1.00	0.35	0.77	1.00	1.00	1.00	1.00	1.00
	219	0.00	0.00	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
	218	0.00	0.00	0.90	0.00	0.00	0.00	0.00	1.00	1.00	0.42
	217	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
	216	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
September	221	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	220	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	219	0.83	0.40	1.00	0.60	0.03	0.53	1.00	1.00	1.00	1.00
	218	0.20	0.00	1.00	0.00	0.00	0.00	0.03	1.00	1.00	1.00
	217	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.90	1.00	0.20
	216	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	1.00	0.00

SLOPE & VEGETATION COVER





JHTMON-10 (Ecofish 2014)

BREAKOUT GROUP 1 - SITE SELECTION

- Evaluate revegetation site selection criteria & methodological approach, and propose alternatives.
- Evaluate potential trial revegetation sites and propose alternatives.

LUNCH (12:00 – 13:30)

REVEGETATION TREATMENT APPROACH

- Cost effective
- Simple
- High likelihood of achieving *future desired condition*
- Native species, locally sourced

Planting sedges in the K'ómox estuary

POTENTIAL **REVEGETATION** APROACHES FOR THE UPPER CAMPBELL RESERVOIR

- **Treatment areas**
  - Low slope and alluvial fans
  - Moderate slopes within the drawdown
  - Steep slopes within the drawdown
  - Steep upland slopes

Laich-Kwil-Tach ENVIRONMENTAL ASSESSMENTS L P

LOW SLOPE AND ALLUVIAL FAN SITES

- Plant sedges (217.6 – 221.0 m)
  - Plugs, pots and/or locally sourced transplant mats
  - Trial species – *C. sitchensis, C. obnupta, C. lenticularis*
- Plant willows (217.8 – 221 m)
  - Machine or hand plant
  - Locally sourced
  - Trial species – *S. sitchensis, H. hookeriana*
- Erosion protection and elevation gains
  - Substrate complexing
- Ecomats in upper drawdown (219+)

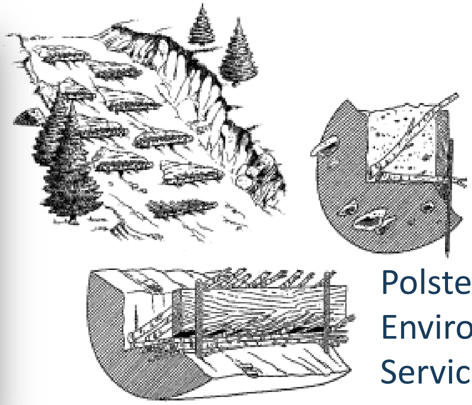
MODERATE **SLOPES WITHIN** THE DRAWDOWN

- Plant sedges (217.6 – 221.0 m)
  - Plugs, pots and/or locally sourced transplant mats
  - Pocket planting
  - Trial species – *C. sitchensis, C. obnupta, C. lenticularis*
- Plant willows (217.8 – 221 m)
  - Machine or hand plant
  - Locally sourced
  - Trial species – *S. sitchensis, H. hookeriana*
- Bioengineering and erosion protection
  - Substrate complexing
  - Brush layers
- Ecomats in upper drawdown (219+)

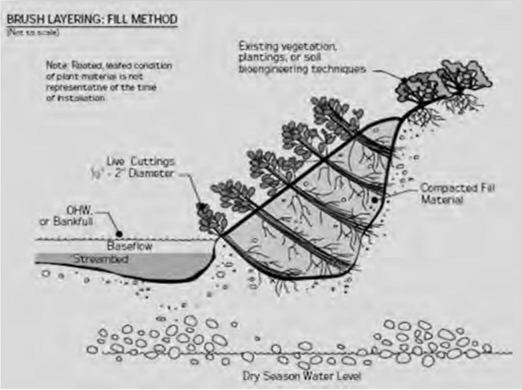
Laich-Kwil-Tach
ENVIRONMENTAL ASSESSMENTS L P

STEEP SLOPES WITHIN THE DRAWDOWN

- Plant willows (217.8 – 221 m)
  - Hand plant
  - Locally sourced
  - Trial species – *S. sitchensis, H. hookeriana*
- Bioengineering and erosion protection
  - Willow modified brush layers
- Ecomats in upper drawdown (219+)
  - Staked down with willow



Polster Environmental Services

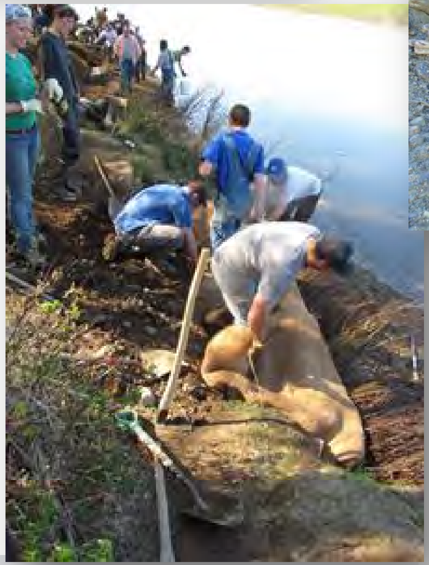


Indiana General Assembly

Alaska sustainable salmon fund

STEEP UPLAND SLOPES

- Plant willows (217.8 – 221 m)
  - Hand plant
  - Trial species – *S. sitchensis, H. hookeriana*
- Bioengineering and erosion protection
  - Willow modified brush layers
  - Vertical pole drains
- Ecomats in upper drawdown (219+)



Alaska sustainable salmon fund

ALTERNATE APPROACHES

- Plant nursery stock
- Hydroseed mixtures
- Build stump islands and plant them
- Plant on top of stumps
- Willow wattle fencing
- Rock armouring/pocket planting
- Windrows

Polster Environmental Services

Miller Creek

BREAKOUT GROUP 2 – REVEGETATION TECHNIQUES, SPECIES COMPOSITION AND ALTERNATIVES

Laich-Kwil-Tach ENVIRONMENTAL ASSESSMENTS L P

WRAP UP - NEXT STEPS

THANK YOU!

4. SUMMARY MEMORANDUM

Laich-Kwil-Tach Environmenal Assessments LP
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Campbell River, B.C. V9W 2E4
Phone: 250-287-8868

Ecofish Research Ltd.
Suite 202 – 250 Dogwood Street
Campbell River, B.C. V9W 2X9
Phone: 778-346-3933
info@ecofishresearch.com
www.ecofishresearch.com

MEMORANDUM

TO:	**Phil Bradshaw and Jeff Walker, BC Hydro**
FROM:	**Deborah Lacroix and Leah Ballin, Ecofish Research Ltd.**
DATE:	**July 12, 2017**
FILE:	**1230-21.02**

RE: JHTWORKS-3 Upper Campbell Reservoir Drawdown Zone Revegetation Program – Summary of June 2017 Expert Workshop on Operational Trial Site & Treatment Identification / Prioritization

On June 19, 2017, BC Hydro, Laich-Kwil-Tach Environmental Assessment Ltd. Partnership (LKT), and Ecofish Research Ltd. (Ecofish) hosted an expert workshop at Strathcona Park Lodge to discuss the JHTWORKS-03 revegetation program for the Upper Campbell Reservoir. The workshop was attended by BC Parks, BC Hydro and their external technical expert, Strathcona Park Lodge, K'ómox First Nation, We Wai Kai Nation, Wei Wai Kum First Nation, TimberWest and Ecofish. The key objectives of the workshop were to gather and share recreational and biological knowledge to guide and support: (1) the identification of priority sites for operational trials along the reservoir from a visual quality and riparian habitat perspective, and (2) site-specific revegetation prescriptions for the operational treatments. Workshop topics were also extended to include future desired condition, measures of success, and effectiveness monitoring. The purpose of this memorandum is to summarize the key information and direction provided by workshop participants. This information will be integrated into future phases of the revegetation program.

1. SITE SELECTION

The site selection discussion covered the criteria utilized to select potential revegetation sites for operational trials, general feedback and considerations for the sites selected/proposed, and input on operational trial locations within revegetation sites.

1.1. Criteria for Selecting Revegetation Sites

We presented the 15 site selection criteria adopted to guide selection of potential revegetation sites. These criteria were organized in a hierarchal manner. The three key categories are: (1) revegetation opportunity, (2) revegetation priority, and (3) revegetation success (i.e., likelihood of revegetation success).

In general, all participants agreed with the criteria developed for site selection. The participants did advise that revegetation sites should avoid archaeological sites and rare ecosystems and/or plants. Based on this feedback, we have added two additional categories to the revegetation opportunity selection criteria: (1) archaeological site, and (2) risk to environmental resources.

1.2. Identified Revegetation Sites

A total of nine revegetation sites were presented/proposed for consideration (Map 1). In general, participants agreed with the selected sites. The participants did identify two islands within the selected sites as good priority for operational trials. The first island is located within the Strathcona Portal (JHT-RV01) site and the other is located within the Buttle Lake Boat Launch (JHT-RV06).

Participants also identified additional potential future revegetation sites. These included the boat launch five kilometres northeast of the Narrows on Upper Campbell Lake, Auger Point, and the lower alluvial fans with stumps at Wolf and Phillips creeks.

1.3. Operational Trial Sites

Specific areas within the revegetation sites that provide good opportunities for operational trials were discussed. Participants provided the following priorities:

- Steep slopes on the island visible from the Strathcona Portal when looking westward (within JHT-RV01) and its surrounding shoal that currently poses a navigation risk;
- Steep slopes on the island north of the Buttle Lake Boat Launch (within JHT-RV06), as well as the shoals as they pose a navigation risk;
- Steeper slopes at JHT-RV02 (Old Buttle Boat Launch). However, prior to investing in restoration at this site, the long-term goals for the boat launch area need to be confirmed;
- The eroding steep upland slopes at JHT-RV04 within the bay adjacent to Rainbow Island Marine Campground, upslope of JHT-RV07 (the adjacent alluvial fan), and the small islet adjacent to Rainbow Island Marine Campground to the northwest; and,
- The shallow areas and vehicle damaged shoreline of JHT-RV06 (Buttle Lake Boat Launch).

2. SITE-SPECIFIC REVEGETATION PRESCRIPTIONS

The workshop also focused on examining different potential revegetation treatments for the operational trial sites. The discussion covered both the general approach to revegetation and specific treatment types proposed for sites with similar aesthetics and environmental filters (constraints).

2.1. General Guidance to Revegetation

The participants provided the following general guidance with regards to revegetation:

- Focus revegetation trials on 'riskier' or 'difficult' sites by implementing one or two treatment types (e.g., one or two treatment types on steep upland slopes);
- Concentrate treatment effort and expense earlier in the implementation phase rather than equally throughout (as allocated in the Terms of Reference TOR) to provide adequate time to monitor success and to support more efficient use of resources;
- Transplanting willows and 'ecomats' within BC Parks would likely be acceptable. Prior approval is nevertheless required;
- Implement the treatment type over the entire operational trial site rather than leaving a portion as a control;
- Rely on a natural succession approach rather than planting (i.e., build the physical habitat and allow natural regeneration) to increase chance of plant success and gain budgetary efficiencies. For example, fines will settle into appropriately positioned larger substrates which can then facilitate the establishment of plant species; vegetation communities can develop on modified brush layers built on eroding slopes; and seeds can establish on suitable stumps placed within appropriate microsite conditions;
- Facilitate natural revegetation with the use of microbes by adding local leaf litter;
- Avoid non-natural materials when implementing revegetation treatments (e.g. rebar, etc.). Use natural materials wherever possible;
- Avoid building habitat sinks (i.e., habitat that attracts wildlife species but contributes to more mortality than recruitment; for example shrubby shoreline habitat that provides suitable nesting habitat during the nest initiation phase but then is later inundated resulting in flooded nests and nestlings); and,
- Consider educating recreational users by adding signs at or near operational trial sites.

2.2. Revegetation Treatments

Four different treatment areas were proposed at the workshop to facilitate discussions based on environmental filters. These were: (1) steep upland forest, (2) steep upper drawdown, (3) moderate slopes within the drawdown, and (4) low slope or alluvial fan.

Participants indicated that the priority areas should be the steep upland forest, steep upper drawdown, and areas of lower slope and alluvial fans which pose a boating hazard. Revegetation prescriptions for the three priority areas were discussed and informed by previous revegetation projects in the Upper Campbell Reservoir, local observations of natural revegetation and ecological processes, and experience with revegetation efforts in other BCH reservoirs.

The revegetation treatments discussed are:

2.2.1. Steep upland forest

- Modified brush layers with black cottonwood;
- Stabilize bottom of slope to facilitate growth of a vegetative screen similar to what is naturally occurring behind some logs at JHT-RV04/JHT-RV07; and
- Consider toping or spiralling crown of trees on top of slopes to delay slope failure and unravelling (mixed opinions on this recommendation).

2.2.2. Steep upper drawdown

- Improve substrate by roughing and loosening.

2.2.3. Low slope and alluvial fans

- Mound and complex substrate;
- Install boulders to block erosive forces. The boulders will also collect sediment and seeds; and,
- Plant on top of and around stumps. This method will likely need machinery to manipulate stumps and relocate them to a higher elevation.

3. FUTURE DESIRED CONDITION, MEASURES OF SUCCESS AND EFFECTIVENESS MONITORING

During the workshop, participants also discussed the future desired condition of treatment sites, measures of success, and the statistical approach to effectiveness monitoring.

For future desired condition, participants agreed that the sites should resemble pre-disturbance condition; however, they also recognized that the public currently recreates within certain unvegetated areas (e.g., beaches) which would be prevented if revegetated. Participants also noted that planting flowering shrubs could aid in creating aesthetically appealing viewscapes; however, employing natural successional processes is more important. The discussion on future desired condition also guided revegetation treatment prescriptions (see Section 2).

Participants agreed that defining treatment success can be challenging. This is further complicated by a short monitoring period and a preference for natural regeneration. Success may have to largely rely on qualitative measures, summary statistics, analysis of trends and trajectories. However, the TOR emphasizes the need for a robust statistical approach to effectiveness monitoring. Nevertheless, given the TOR budget allocated to this project, participants recommended that more effort be allocated to revegetation trials and treatments rather than statistically robust monitoring. We will consult with Ecofish's data analysis team to propose a reduced statistical approach to monitor treatment effectiveness. Nonetheless, effectiveness monitoring will include collection of numerous qualitative and quantitative parameters to measure and assess site and vegetation characteristics that are suitable for the specific revegetation prescriptions.

4. CONCLUSION AND NEXT STEPS

The expert workshop was successful in meeting the objectives of identifying priority sites for operational trials and determining candidate revegetation treatment prescriptions. The group provided valuable insight and direction that will guide the future phases of the project. In the short-term, information gathered at the workshop will contribute to site-specific revegetation treatment prescriptions for the first year of the operational trials, as well as the conceptual plan for the entire five year treatment planning/trial treatment period.

Yours truly,

Ecofish Research Ltd.

Prepared by:	Reviewed by:
Signed	*Signed*
Leah Ballin, M.S.F.M., R.P.Bio., R.P.F.	Deborah Lacroix, M.Sc., R.P.Bio.
Wildlife Biologist/Task Manager	Senior Ecologist/Vice President

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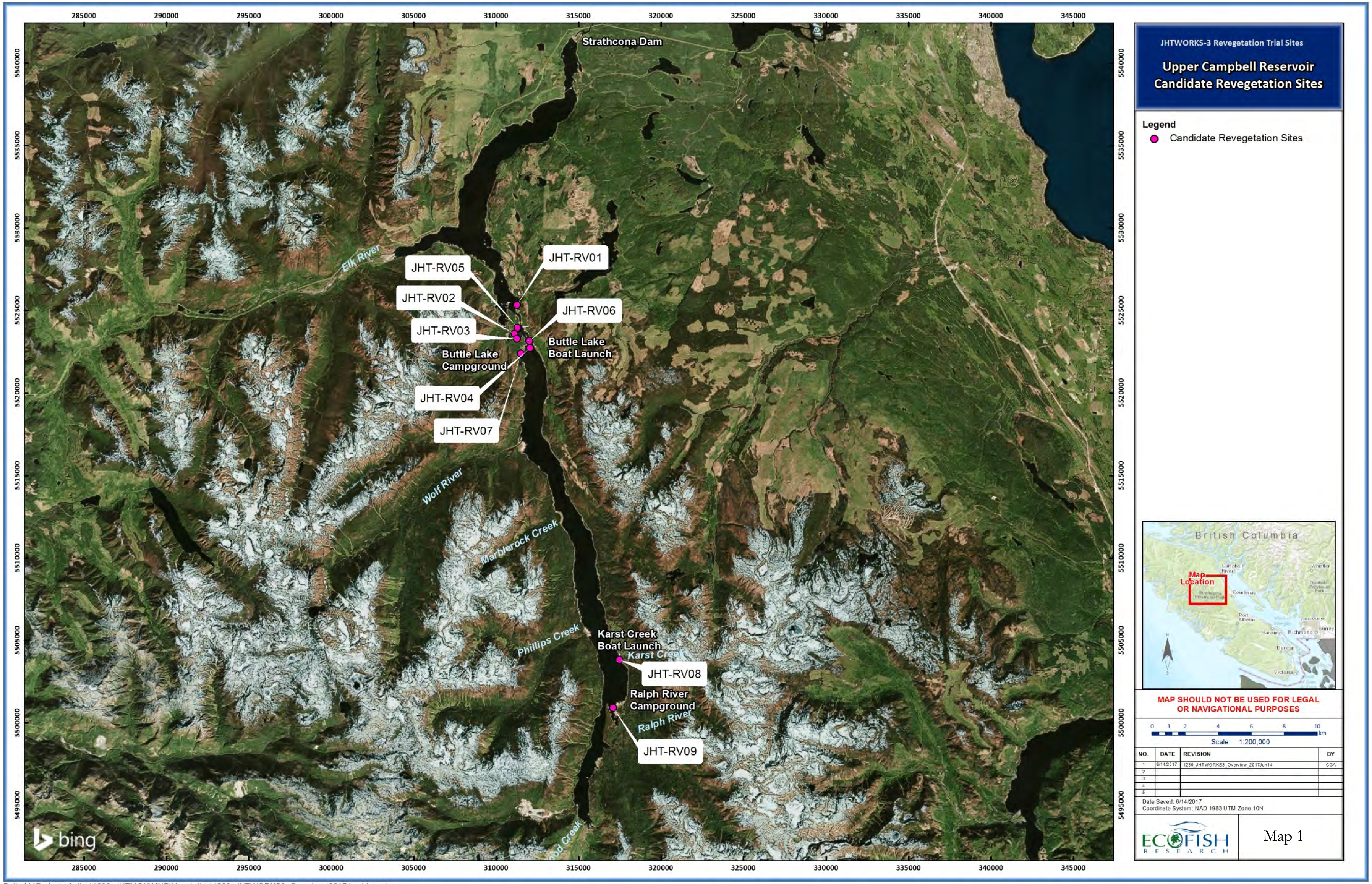

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Appendix C. Baseline Data Collection and Effectiveness Monitoring Plan

Laich-Kwil-Tach Environmenal Assessments LP
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MEMORANDUM

TO: **Phil Bradshaw and Jeff Walker, BC Hydro**

FROM: **Leah Ballin, MSFM, R.F.P., R.P.Bio., Deborah Lacroix, M.Sc., R.P.Bio., Matthew Bayly, M.Sc., Mark Sloan, M.Sc., R.F.P., R.P.Bio., Ecofish Research**

DATE: **January 12, 2018**

FILE: **1230-21**

RE: **JHTWORKS-3 Upper Campbell Reservoir Drawdown Zone Revegetation Program – Proposed Baseline Data Collection Methods and Effectiveness Monitoring Plan**

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1. INTRODUCTION

The Identification/Prioritization Phase (Phase 1) of the Upper Campbell Reservoir Drawdown Zone Revegetation Program (JHTWORKS-3) includes three primary goals: (1) the collection of baseline data at proposed revegetation trial sites and surrounding areas to assess the existing conditions, (2) to plan and finalize revegetation trial types, and (3) to assemble the foundational data to monitor the effectiveness of revegetation treatments during the Planning/Trials Phase (Phase 2) of the program. The revegetation treatment areas, including reference sites, were presented, discussed, and selected during the Expert Workshop held on June 19, 2017, and later summarized in the follow-up memorandum (Lacroix and Ballin 2017). During Phase 1 of the program, baseline data is collected in order to understand the environmental condition and setting of each treatment area, including ecological and physical filters, and to identify potential donor sites.

The objective of this memorandum is to present the general approach to baseline data collection, and to describe the detailed data collection approach and data analysis. In future years, the same data collection methods and analytical techniques will be applied to monitor the effectiveness of revegetation treatments, hence allowing a direct comparison of vegetative succession over time in treatment vs. reference areas and an understanding of the effectiveness of treatment prescriptions.

2. GENERAL APPROACH

Data will be collected at two spatial scales: (1) treatment area and (2) plot (e.g., Figure 1). Baseline data will be collected for each treatment area (including reference sites) to provide a description of physical and ecological characteristics representative of the entire area, such as species composition, percent cover of vegetation and aspect. Treatment area data will include photomonitoring from ground-based points and a drone. Plot data will be collected at selected locations within each treatment area to describe the ecological characteristics that are more specific to a localized area. Plots will be strategically distributed within each treatment area to represent the range of environmental conditions and to capture specific revegetation treatment types, such as planted stump islands or modified brush layers. On sensitive sites, plot data will not be collected to avoid the potential physical harm and/or damage that may be incurred by accessing the plot, for example on steep dry sites. In these cases, only treatment area data will be collected and relied upon, such as photo monitoring.

Baseline data will be collected with the same methods as effectiveness monitoring. Data will be collected during the spring and the fall to capture the beginning and end of the growing season, the effects of the harsher winter and summer climatic conditions, and changing water levels (Table 1). All data parameters will be collected in the fall and standard photopoint monitoring will be collected twice annually, in the spring and fall.

Due to the small size of treatment areas and the diversity of treatment types\ monitoring the success of revegetation treatments at all trial sites will primarily rely on summary statistics and trends/relationships between vegetation density, structure, vigour and composition, environmental characteristics, and visible disturbances.

Figure 1. **Example of treatment area-level and plot-level layout within a revegetation trial area.**

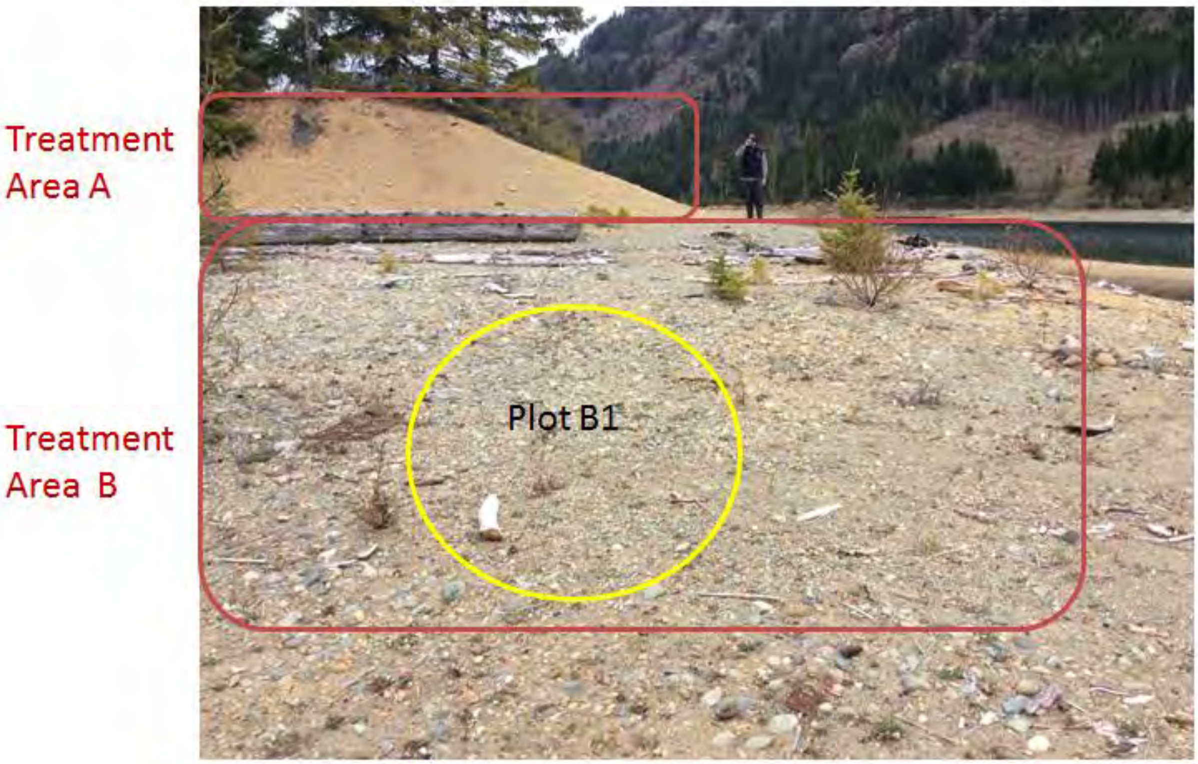

Table 1. **JHTWORKS-3 baseline data collection and effectiveness monitoring schedule during the Identification/Prioritization Phase (Year 1) and Planning/Trial Phase of the program (Years 2 to 6).**

Data type	Monitoring Schedule										
	Identification Phase	Trial Phase									
	Yr 1 (2017)	Yr 2 (2018)		Yr 3 (2019)		Yr 4 (2020)		Yr 5 (2021)		Yr 6 (2022)	
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Photo monitoring - photopoint	x	x	x	x	x	x	x	x	x	x	x
Photo monitoring - drone	x		x		x		x		x		x
Ecological and Physical Data Collection (Treatment area & Plot)	x		x		x		x		x		x
Environmental data series	x		x		x		x		x		x

3. DATA COLLECTION METHODS

3.1. Treatment Area

Field data collection for each treatment area will include photo monitoring (from drone and ground) and the recording of ecological and physical data. Environmental data such as climate and hydrometric data will also be compiled to support the assessment of revegetation success. The same climate and hydrometric datasets will apply to the entire reservoir and thus all treatment areas.

3.1.1. Photo Monitoring

Georeferenced ground-based photo monitoring points and drone imagery will be established and used to provide a repeatable means of qualitatively assessing change in vegetation success and impacts to visual quality.

3.1.1.1. Photopoint

A photo monitoring point will be established at each revegetation trial site that provides an overview of the entire treatment area from the ground. Photographs will be taken at 1.3 m height at a fixed bearing. The azimuth of the photograph from the photo monitoring point towards the treatment area will be recorded as well as the coordinates of the photo monitoring point. Two reference benchmarks will also be established in the field to assist with relocating the photo point and repeating the photographs. The distance and azimuth to these two benchmarks will be recorded. In subsequent years of monitoring, previous years photographs will be taken into the field to ensure repeatability. Once photograph locations are determined, each monitoring site/treatment area will be marked with a caped rebar installed to ensure public safety.

3.1.1.2. Drone imagery

Drone imagery will be collected each year to support qualitative assessment of the vegetative success of each treatment area (e.g. through change in percent cover) and evaluate visual quality. Imagery will be georeferenced and collection methods will be repeated each year to allow for future potential quantitative assessments of vegetation cover, species composition and diversity, and substrate changes.

The drone will be flown at a height of 30 m, which is low enough to allow vegetation to be identified to species. The internal GPS in the drone will be used to georeference the imagery. In addition, distinct natural features will be used to ensure that each year's photographs are georeferenced to exactly the same location and orientation (i.e., correct for geospatial errors, true north consistent).

A colour bar (RGB and BW) will be included in each flight in case image colour calibration is required for future analysis. The elevation of the site will be marked in meter increments on the ground. Elevations will be calculated from the known water surface elevation with a survey station.

All flight registration and safety protocols required by BC Hydro, BC Parks and Transport Canada will be completed and followed.

3.1.2. Ecological and Physical Parameters

Table 2 summarizes the ecological and physical parameters, representing vegetation response, environmental setting and disturbance factors, which will be recorded and collected in the field to assess and evaluate current and future vegetation success and to identify current and future filters. Data collection parameters and methods are based on standard provincial ecosystem description parameters and methodologies (Green and Klinka 1994, RIC 2001, MOF 2010).

3.1.3. Environmental Data Series

Environmental variables such as moisture availability can have a large impact on the effectiveness of treatment prescriptions. Environmental data series will assist in assessing and monitoring trends or anomalies in revegetation success. Climate data will be compiled from Environment Canada representing all treatment areas including but not limited to precipitation and temperature data. In addition, hydrometric data, specifically water level data from the Upper Campbell gauge located at Buttle narrows, will be compiled.

Table 2. Field data collection of ecological and physical parameters for each treatment area.

Data type	Parameter	Field/ Method	Variable or categories	Measure (M) or Estimate (E)	Data class	Equipment
Vegetation response	Total vegetation	Estimate foliar cover per layer	Percent (%) foliar cover per layer (i.e., A, B1, B2, etc.,)[1]	E	Continuous - quantitative	-
	Total cover of each species per layer	Estimate foliar cover of each species by layer	Percent (%) foliar cover of each species by layer (i.e., A, B1, B2, etc.,); classify by cover class[1]	E	Categorical - quantitative	-
	Vigour of each	Estimate vigour of each species	Vigour class 0 - 4, dead to excellent[1], comment on vigour	E	Categorical - qualitative	-
	Distribution of each species by layer	Estimate distribution of each species	Distribution categories 1 - 9, rare individual to dense continuous coverage[1]	E	Categorical - qualitative	-
Environmental setting	Elevation	Survey site elevation, record elevation range of site	Meters (m)	M	Continuous - quantitative	Survey station
	Aspect	Measure aspect	Degrees (°)	M	Continuous - quantitative	Compass
	Slope	Measure slope	Percent (%)	M	Continuous - quantitative	Clinometer
	Exposure	Classify exposure	Full sun, partial sun, full shade	E	Categorical - qualitative	-
	Surface substrate	Estimate substrate composition by type	Percent cover (%) per substrate type or size class (bedrock, boulder, cobble, large gravel, small gravel, sand, mud, wood, organic, water)[3]	E	Categorical - quantitative	-
	Microtopography	Document microtopography	Channelled, gullied, mounded, smooth, tussocked, undulating[1]	E	Categorical - qualitative	-
	Surface shape	Document surface shape	Concave, convex, straight[1]	E	Categorical - qualitative	-
	Soil moisture	Classify soil moisture	Very xeric, xeric, subxeric, submesic, mesic, subhygric, hygric, subhydric, hydric[1]	E	Categorical - qualitative	-
	Water source	Document water source if present	Describe, e.g., seep, stream sub-irrigation or flood	E	Categorical - qualitative	-
	Fetch	Assess fetch	None, low, moderate, high	E	Categorical - qualitative	-
	Erosion	Assess amount of erosion	None, low, moderate, high; describe	E	Categorical - qualitative	-
	Deposition	Assess amount of deposition	None, low, moderate, high; describe	E	Categorical - qualitative	-
	Wood debris	Assess coverage of wood debris	None, low, moderate, high; describe	E	Categorical - qualitative	-
Disturbance	Wildlife, disease or	Assess wildlife damage	None, low, moderate, high; describe	E	Categorical - qualitative	-
	Disease or insect	Assess disease or insect	None, low, moderate, high; describe	E	Categorical - qualitative	-
	Other site disturbance	Document disturbance	None, low, moderate, high; describe	E	Categorical - qualitative	-

[1] MOF 2010

[2] Green and Klinka 1994

[3] RIC 2001

3.2. Plot data

Vegetation success including establishment and survival (starting in Year 2) will be collected from plot data. Plots will be strategically located at representative locations within revegetation treatment areas. Plot size will be 3.99 m in diameter which corresponds to 50 m^2 (FRBC 2001). The number of plots per treatment area will be proportional to the total treatment area. Plots will aim to cover 5-10% of the treatment area. For small treatment areas, a total census of stems will be conducted, when feasible (no plots).

Data collected at the plot or census level will consist of stem counts collected by species (Table 3). Species vigour and health will be noted. Repeatable photographs of each plot or census area will be taken through the plot centre from 3 m south of the plot centre. Plot centers will be marked with a caped rebar installed to ensure public safety.

Table 3. Field data collection of the ecological parameters for each plot

Data type	Parameter	Field/ Method	Variable or categories	Measure (M) or Estimate (E)	Data class	Equipment
Vegetation response	Stem density	Count stems in 3.99 m fixed area plot	Number of stems of each species per plot	M	Continuous - quantitative	Plot cord

4. DATA ANALYSIS

4.1. Treatment Area

4.1.1. Photo Monitoring

Processed drone imagery will be qualitatively assessed each year for changes in vegetation cover, species composition, growth, survival and health, as well as changes to the environmental setting and any disturbances. Images will be compared to previous years and similar treatment areas and treatment types.

A variety of analytical methods are available to quantify change in vegetation communities using UAV aerial imagery. Future data analysis methods may include measurements of vegetation cover using image classification tools that use spectral signatures such as those in ArcGIS or QGIS.

4.1.2. Ecological and Physical Parameters

Year 1 data analysis will focus on summary statistics of the vegetation response and environmental setting parameters (Table 1), including averages, data ranges, graphs and/or box plots.

In future years, if feasible, principal component analysis (PCA) will be conducted to indicate the principal drivers of vegetation success (e.g., treatment type, aspect, substrate, exposure) and explain trends. Future years data analysis will compare data summaries of treatments, years and locations.

Shannon Wiener Index of diversity could also be calculated in future years to measure the diversity and describe the succession of treatments.

4.1.3. Environmental Data Series

Environmental data series will be summarized and presented in graphs showing annual and multiannual trends. This will include: precipitation, temperature and the inundation regime, and how they relate to growing degree units.

4.2. Plot data

Summary statistics of stem counts from plot data will be compiled to demonstrate density, species composition and survival.

5. REPORTING

Baseline data will be compiled and presented in the annual revegetation treatment plan report.

Yours truly,

Ecofish Research Ltd.

Prepared by:	Reviewed by:
Signed	*Signed*
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Terrestrial Ecologist/ Task Manager	Senior Ecologist/Vice President

REFERENCES

FRBC (Forest Renewal BC). 2001. Juvenile Quality Spacing Quality Inspection. Available at: http://www.for.gov.bc.ca/isb/forms/lib/fs251.pdf. Last accessed September 5, 2017.

Green, R.N. and K. Klinka. 1994. A Field Guide to Site Identification and Interpretation for the Vancouver Forest Region: Land Management Handbook 28. BC Ministry of Forests. Victoria, BC.

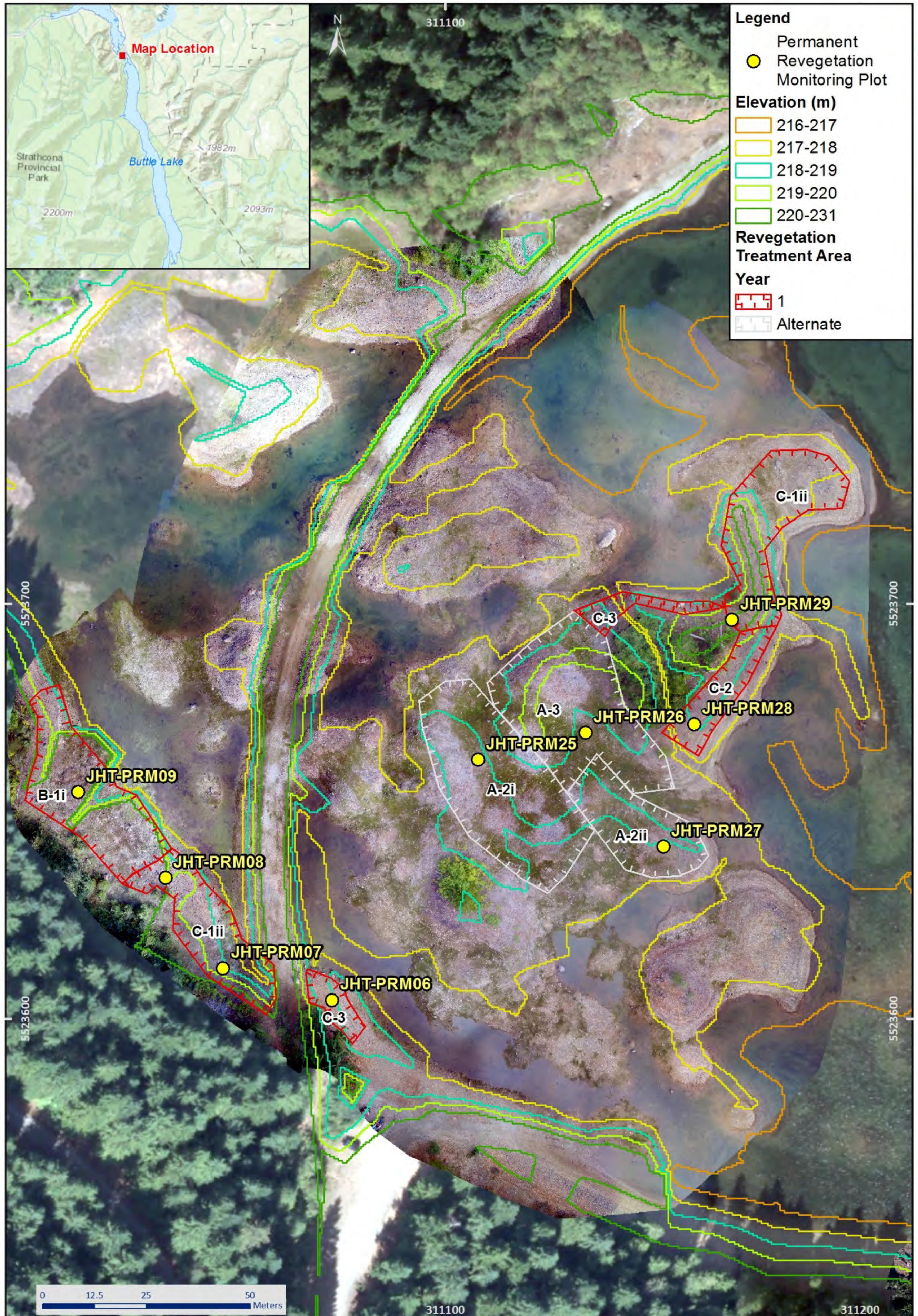
Lacroix, D. and L. Ballin. 2017. JHTWORKS-3 Upper Campbell Reservoir Drawdown Zone Revegetation Program – Summary of June 2017 Expert Workshop on Operational Trial Site & Treatment Identification / Prioritization. Consultant's memorandum prepared for BC Hydro by Ecofish Research Ltd. and Laich-Kwil-Tach Environmental Assessments LP., July 12, 2017.

MOF (BC Ministry of Forests). 2010. Field Manual for Describing Terrestrial Ecosystems 2nd Edition. Land Management Handbook 25. Victoria BC. Available online at: http://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh25/Lmh25_ed2_(2010).pdf Accessed on September 5, 2017.

RIC (Resources Inventory Committee). 2001. Reconnaissance (1:20 000) Fish and Fish Habitat Inventory Standards and Procedures. Prepared by BC Fisheries Information Services Branch for the Resources Inventory Committee. Available online at: w.gov.bc.ca/hfd/library/documents/bib90253.pdf. Accessed on September 5, 2017.

Appendix D. Site-specific Restoration Profiles

LIST OF MAPS



Site Description

Old boat launch within a bay with vegetated islets varying in elevation, topography, slope, and exposure. Part of Buttle Lake Campground.

Revegetation Site Attributes

Revegetation Opportunity	
Land ownership:	Crown Land (drawdown zone) - BC Parks
Machine access:	Good - from old boat launch at low water
Known or potential physical works:	JHTWORKS-2 trail and swimming dock installation
Plant species and ecological communities at risk:	None expected
Revegetation Priority	
Visibility:	Highly visible from Driftwood Bay group site (JHT-RV05) and partially visible from Buttle Lake Campground (JHT-RV03) and Westmin Rd.
Public satisfaction:	Abundant area below 219 m; no stumps
Fish and wildlife habitat:	Moderate
Environmental Setting and Disturbance	
Elevation (m):	217-221+
Slope (%):	Majority of highly visible areas 10-33% with flatter areas at elevations 217-218 m
Substrate:	Mix of angular dark and round light gravel and cobble size. Mineral soil on flats.
Natural recruitment:	Natural recruitment occurring (including trees) but constrained by erosion and browsing. North aspect shows better recruitment.
Aspect:	All aspects. East-southeast most visible.
Fetch:	Low - mostly protected in bay
Water availability:	Low on islets, moderate adjacent to upslope forest
Human disturbance:	Moderate adjacent to old boat launch, low on islets
Wildlife disturbance:	Moderate - High (evidence of beaver & geese grazing)
Invasive species:	Moderate

JHTWORKS-3 Revegetation Sites

Old Buttle Boat Launch JHT-RV02

Revegetation Treatment Trials

A - Low Slope or Alluvial Fan

PRESCRIPTION

A-2. Complex and/or stabilize substrate. Mound to above 217.8 m elevation, as guided by surveyed elevations. Use woody debris and boulders to stabilize, as needed.

i. No planting

ii. Stake deciduous species by machine as guided by surveyed elevations (217.8-221.0 m).

A-3. Control

B - Moderate Slope Drawdown

PRESCRIPTION

B-1. Complex and/or stabilize substrate (roughen and loosen, terraces). Use woody debris and boulders/cobble to stabilize as needed. Add leaf litter/mulch as practical.

i. No planting

C - Steep Upper Drawdown

PRESCRIPTION

C-1. Substrate complexing and/or stabilization (roughen/loosen and terracing), as directed by a QP. Strategically use woody debris and boulders/cobble to stabilize as needed. Add leaf litter/mulch as practical.

ii. Stake deciduous species by machine as guided by surveyed elevations (217.8-221.0 m).

C-2. No site preparation. Stake willow, cottonwood and red-osier dogwood by hand as guided by surveyed elevations (217.8-221.0 m).

C-3. Control

VEGETATION SPECIES

Sitka willow (*Salix sitchensis*)

Black cottonwood (*Populus balsamifera*)

Red-osier dogwood (*Cornus stolonifera*)

ECOFISH RESEARCH

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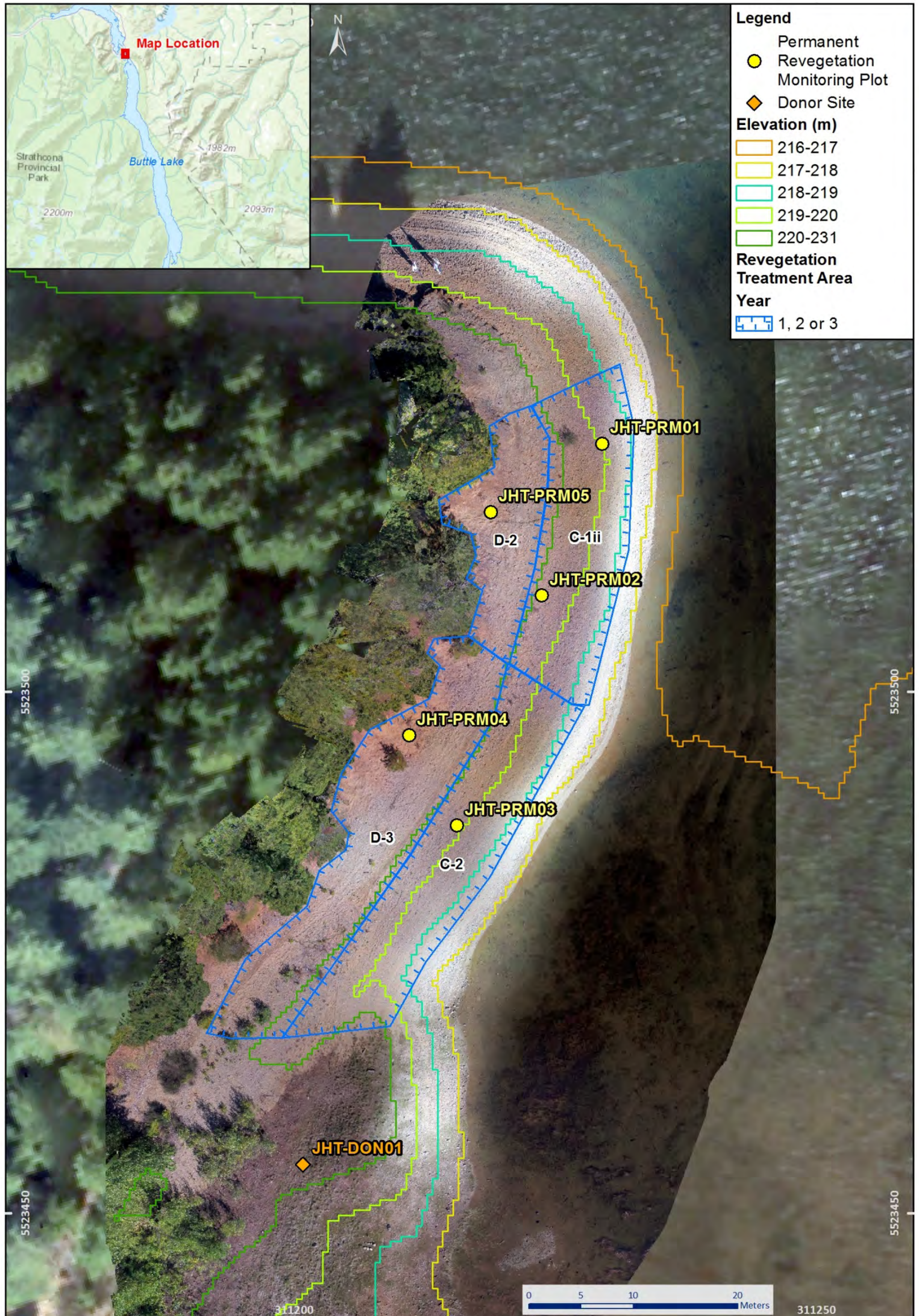
JHTWORKS-3 Revegetation Sites

Buttle Lake Campground JHT-RV03



Site Description

Part of high-use Buttle Lake Campground and linked to beach built from imported sand. Potential revegetation area is adjacent steeper shoreline.

Revegetation Site Attributes

Revegetation Opportunity

Land ownership:	Crown Land (drawdown zone) - BC Parks
Machine access:	Good - from old boat launch or campground at low water
Known or potential physical works:	JHTWORKS-2 trail and swimming dock installation
Plant species and ecological communities at risk:	None expected

Revegetation Priority

Visibility:	Highly visible for visitors to Buttle Lake Campground, Buttle Lake boat launch users (JHT-RV06) and boaters in the Narrows. Proposed trail will draw the public to this area for swimming.
Public satisfaction:	Abundant area below 219 m; no stumps
Fish and wildlife habitat:	Moderate - High

Environmental Setting and Disturbance

Elevation (m):	217-221+
Slope (%):	28-47%
Substrate:	Fines and gravel on flat and lower slopes, with gravel and cobble on steep slopes.
Natural recruitment:	Lower shoreline variably vegetated. Steep slopes adjacent to the beach not vegetated. Recruitment of willow and other trees within southeastern section of bay.
Aspect:	East
Fetch:	Low
Water availability:	Low - Unknown
Human disturbance:	Moderate - walking, boat docking on beach
Wildlife disturbance:	Moderate (evidence of geese & deer grazing)
Invasive species:	Moderate

Revegetation Treatment Trials

C - Steep Upper Drawdown

PRESCRIPTION

C-1. Substrate complexing and/or stabilization (roughen/loosen and terracing), as directed by a QP. Strategically use woody debris and boulders/cobble to stabilize as needed. Add leaf litter/mulch as practical.

ii. Stake deciduous species by machine as guided by surveyed elevations (217.8-221.0 m).

C-2. No site preparation. Stake deciduous species by hand as guided by surveyed elevations (217.8-221.0 m).

D - Steep Upland Forest

PRESCRIPTION

D-2. Stake cottonwood by hand

D-3. Stabilize bottom of slope with logs and boulders. Add leaf litter/mulch as practical. Stake with cottonwood. Transplant forest plants from new trail to Buttle Lake Campground (JHTWORKS-2) if available.

VEGETATION SPECIES

Black cottonwood (*Populus balsamifera*)
Sitka willow (*Salix sitchensis*)
Forest species may include:
Shore pine (*Pinus contorta ssp. contorta*)
Western white pine (*Pinus monticola*)
Douglas-fir (*Psuedotsuga menziesii*)
Pacific dogwood (*Cornus nuttali*)
Tall Oregon grape (*Mahonia aquifolium*)
Kinnikinnick (*Arctostaphylus uva-ursi*)

ECOFISH RESEARCH

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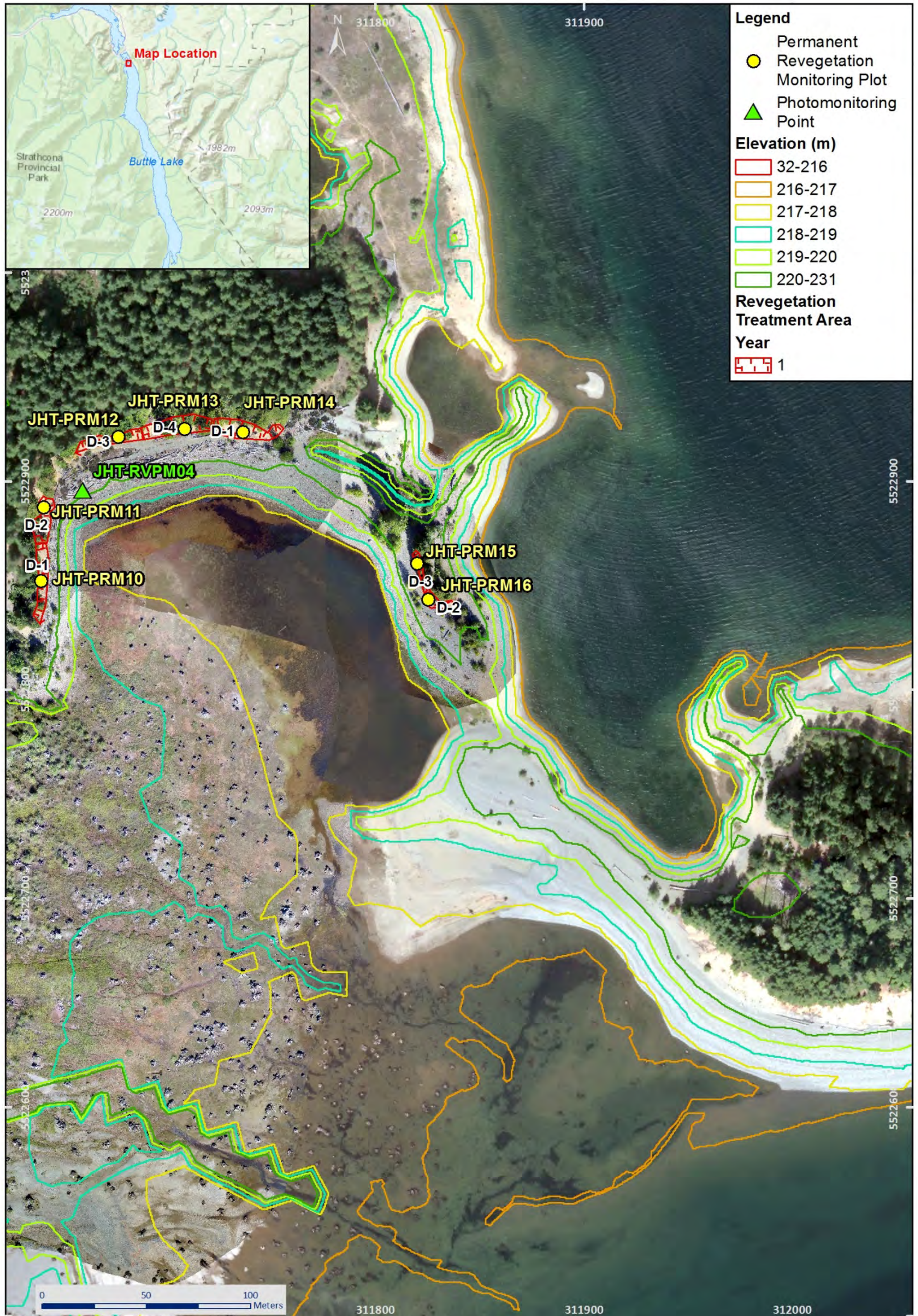
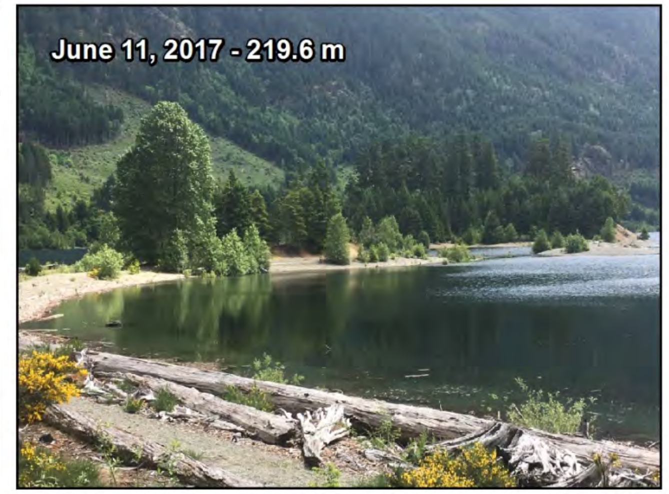
JHTWORKS-3 Revegetation Sites

Rainbow Island Marine Site JHT-RV04





Site Description

High-use site, walk-in campground at Rainbow Island, that provides views up the narrows and to JHT-RV07. The area is comprised of flat areas that are variably vegetated and extensive unvegetated steep slopes including drawdown area and upland eroding forest soils.

Revegetation Site Attributes

Revegetation Opportunity	
Land ownership:	Crown Land (drawdown zone) - BC Parks
Machine access:	Fair - a barge may be required if the existing walking trail is too narrow
Known or potential physical works:	Unknown
Plant species and ecological communities at risk:	None expected
Revegetation Priority	
Visibility:	Highly visible for recreational users walking the beach trail, camping on the island, using the Buttle Lake boat launch (JHT-RV06) and boating in the Narrows
Public satisfaction:	The shoreline slopes to below 219 m. Some areas associated with steep unvegetated shoreline
Fish and wildlife habitat:	Moderate
Environmental Setting and Disturbance	
Elevation (m):	217-221+
Slope (%):	Steep upland slopes 47-60%
Substrate:	Gravel and sand in drawdown zone, eroded forest soils upslope.
Natural recruitment:	Recruitment impeded by erosion/deposition and high solar exposure/water deficits. Conifers growing at top of upper drawdown on east aspects. Higher recruitment observed with lower slope.
Aspect:	Variable with a large portion of the site's unvegetated area facing southeast and exposed to a long fetch.
Fetch:	None for upslope areas. High in drawdown.
Water availability:	Low for upslope forest
Human disturbance:	Flat areas heavily used, low on steep upland slopes.
Wildlife disturbance:	Low
Invasive species:	Moderate (high on suitable sites)

Revegetation Treatment Trials

D - Steep Upland Forest

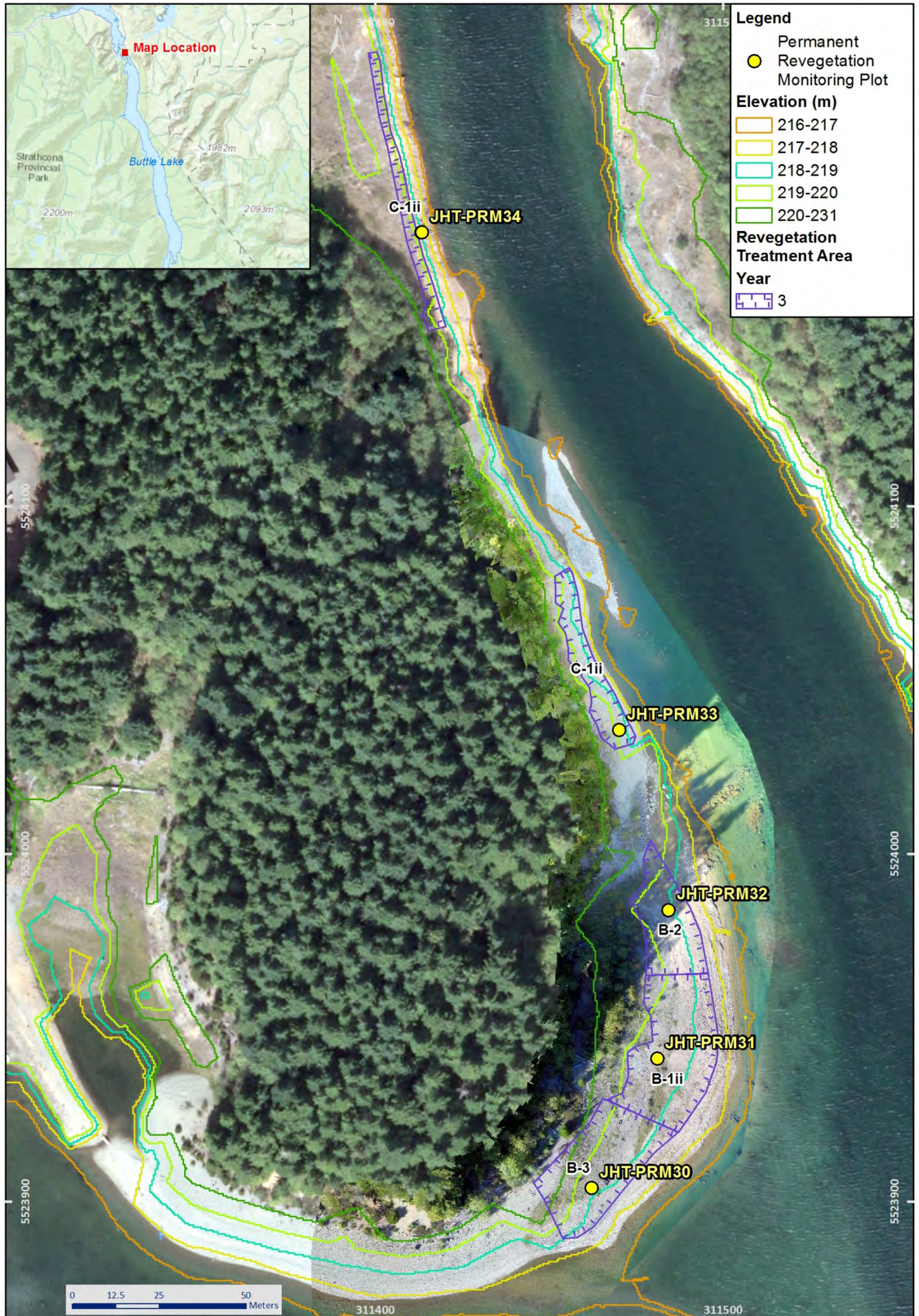
PRESCRIPTION

D-1. Bioengineer slope with cottonwood modified brush layers installed by hand. Transplant forest plants from new trail to Buttle Lake Campground (JHTWORKS-2) or other source if available, on the created terraces.
D-2. Stake cottonwood by hand
D-3. Stabilize bottom of slope with logs and boulders. Add leaf litter/mulch as practical. Stake with cottonwood. Transplant forest plants from new trail to Buttle Lake Campground (JHTWORKS-2) if available.
D-4. Control

VEGETATION SPECIES

Black cottonwood (*Populus balsamifera*)
Forest species may include:
Douglas-fir (*Psuedotsuga menziesii*)
Pacific dogwood (*Cornus nuttali*)
Tall Oregon grape (*Mahonia aquifolium*)
Kinnikinnick (*Arctostaphylus uva-ursi*)

ECOFISH RESEARCH



Site Description

Group campsite with a small lower-gradient beach and swimming area. Adjacent beaches are steeper. Site wraps around towards the HWY 287 bridge and steep section of the Narrows.

Revegetation Site Attributes

Revegetation Opportunity

Land ownership:	Crown Land (drawdown zone) - BC Parks
Machine access:	Good - adjacent to beach access, old route connects site with JHT-RV02 at low water
Known or potential physical works:	Unknown
Plant species and ecological communities at risk:	None expected

Revegetation Priority

Visibility:	Moderately to highly visible for visitors to the group site and Buttle Lake Campground (JHT-RV02 and JHT-RV03). Partially visible from Westmin Rd. and the bridge over the Narrows.
Public satisfaction:	The shoreline slopes to below 219 m; no stumps
Fish and wildlife habitat:	Moderate

Environmental Setting and Disturbance

Elevation (m):	217-221+
Slope (%):	Beach 7-12% with adjacent steeper shores 33-26%
Substrate:	Gravel and cobble, with sand on gentler slopes. Woody debris embeded and washed ashore.
Natural recruitment:	Recruitment of deciduous trees above 220.0 m. Some coniferous transplants above 220.0 m in Narrows. A slim band of small willow at ~217.8 m elevation on some slopes >15%, patches of herbs below 12% slope.
Aspect:	East-South
Fetch:	Moderate - High, woody debris accumulations near campsite and highly eroded in narrows
Water availability:	Low - Moderate
Human disturbance:	Low for much of site
Wildlife disturbance:	Low - Moderate
Invasive species:	Moderate

JHTWORKS-3 Revegetation Sites

Driftwood Group Campsite JHT-RV05

Revegetation Treatment Trials

B - Moderate Slope Drawdown

PRESCRIPTION

B-1. Complex and/or stabilize substrate (roughen and loosen, terraces). Use woody debris and boulders/cobble to stabilize as needed. Add leaf litter/mulch as practical.
ii. Stake deciduous species by machine as guided by surveyed elevations (217.8-221 m). Hand stake areas with decent herbaceous cover or sparse shrub cover as to not disturb existing vegetation.
B-2. No site preparation. Stake deciduous species dogwood by hand as guided by surveyed elevations (217.8-221 m).
B-3. Control

C - Steep Upper Drawdown

PRESCRIPTION

C-1. Substrate complexing and/or stabilization (roughen/loosen and terracing), as directed by a QP. Strategically use woody debris and boulders/cobble to stabilize as needed. Add leaf litter/mulch as practical.
ii. Stake deciduous species by machine as guided by surveyed elevations (217.8-221.0 m).

VEGETATION SPECIES

Black cottonwood (*Populus balsamifera*)
Sitka willow (*Salix sitchensis*)
Red-osier dogwood (*Cornus stolonifera*) (type B only)

ECOFISH RESEARCH

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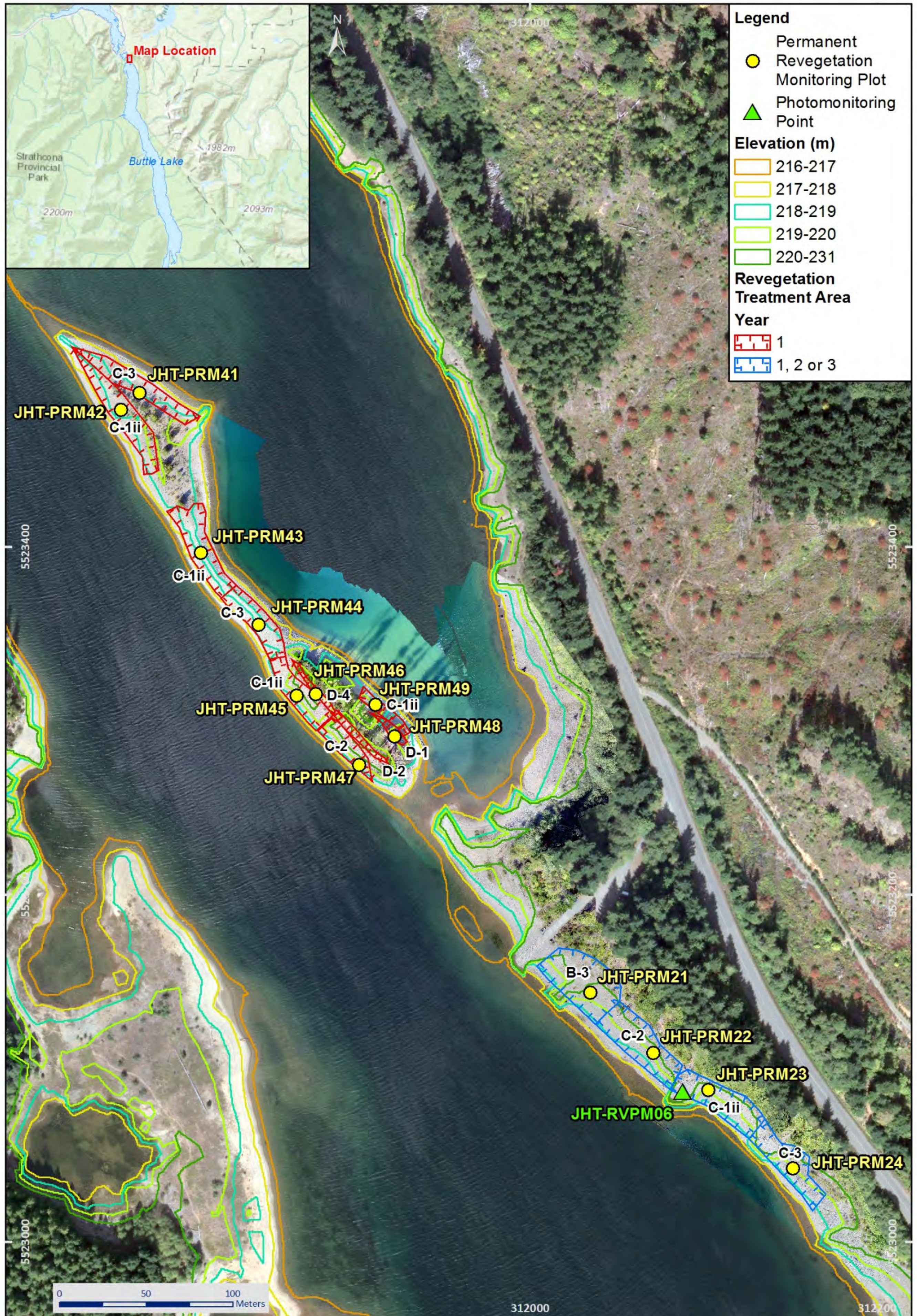

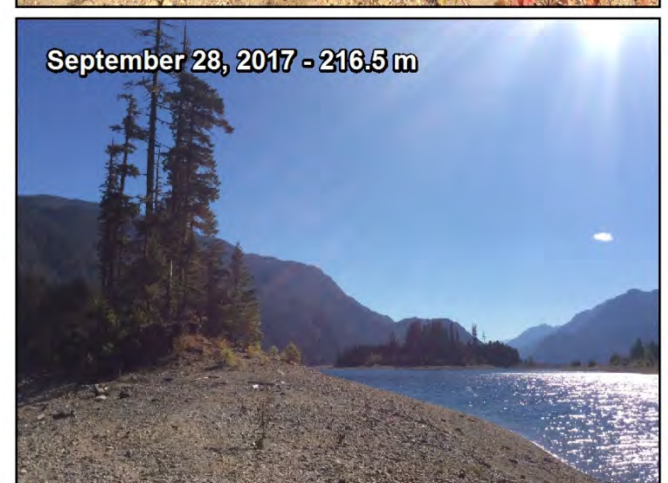

Site Description

Paved boat launch with views across the Narrows to JHT-RV04 and other sites. Gravel beaches adjacent to boat launch and island with variable revegetation.

Revegetation Site Attributes

Revegetation Opportunity

Land ownership:	Crown Land (drawdown zone) - BC Parks
Machine access:	Excellent - adjacent to boat launch, good to island when water level is below 216.4 m
Known or potential physical works:	JHTWORKS-2 boat launch upgrade
Plant species and ecological communities at risk:	None expected

Revegetation Priority

Visibility:	Moderately to highly visible from Rainbow Island Marine campsite (JHT-RV04), users of the boat launch and Buttle Lake Campground (JHT-RV03), as well as boaters in the Narrows.
Public satisfaction:	The shoreline slopes to below 219 m; no stumps.
Fish and wildlife habitat:	Low - Moderate

Environmental Setting and Disturbance

Elevation (m):	217-221+
Slope (%):	11-32% in upper drawdown, 45-50% in upslope areas on island
Substrate:	Large gravel in drawdown zone, mineral soil upslope.
Natural recruitment:	Some evidence of recruitment including patches of grasses, sedges, and willows.
Aspect:	All aspects (island), beach (west)
Fetch:	Moderate - high, areas between islet and main island, islet and west shore, and bays have high fetch and wave exposure
Water availability:	Low - Moderate
Human disturbance:	High - adjacent to boat launch, vehicle tracks, trampling, low on island
Wildlife disturbance:	Low
Invasive species:	Low - Moderate

JHTWORKS-3 Revegetation Sites

Buttle Lake Boat Launch JHT-RV06

Revegetation Treatment Trials

B - Moderate Slope Drawdown

PRESCRIPTION

B-3. Control

C - Steep Upper Drawdown

PRESCRIPTION

C-1. Substrate complexing and/or stabilization (roughen/loosen and terracing), as directed by a QP. Strategically use woody debris and boulders/cobble to stabilize as needed. Add leaf litter/mulch as practical.

ii. Stake deciduous species by machine as guided by surveyed elevations (217.8-221.0 m).

C-2. No site preparation. Stake decicuous species by hand as guided by surveyed elevations (217.8-221.0 m).

C-3. Control

D - Steep Upland Forest

PRESCRIPTION

D-1. Bioengineer slope with cottonwood modified brush layers installed by hand. Transplant forest plants from new trail to Buttle Lake Campground (JHTWORKS-2) or other source if available, on the created terraces.

D-2. Stake cottonwood by hand

D-4. Control

VEGETATION SPECIES

Black cottonwood (*Populus balsamifera*)
Sitka willow (*Salix sitchensis*)
Red-osier dogwood (*Cornus stolonifera*)
Forest species may include:
Western white pine (*Pinus monticola*)
Douglas-fir (*Psuedotsuga menziesii*)
Shore pine (*Pinus contorta ssp. contorta*)
Salal (*Gaultheria shallon*)
Tall Oregon grape (*Mahonia aquifolium*)
Salal (*Gaultheria shallon*)
Tall Oregon grape (*Mahonia aquifolium*)

ECOFISH RESEARCH

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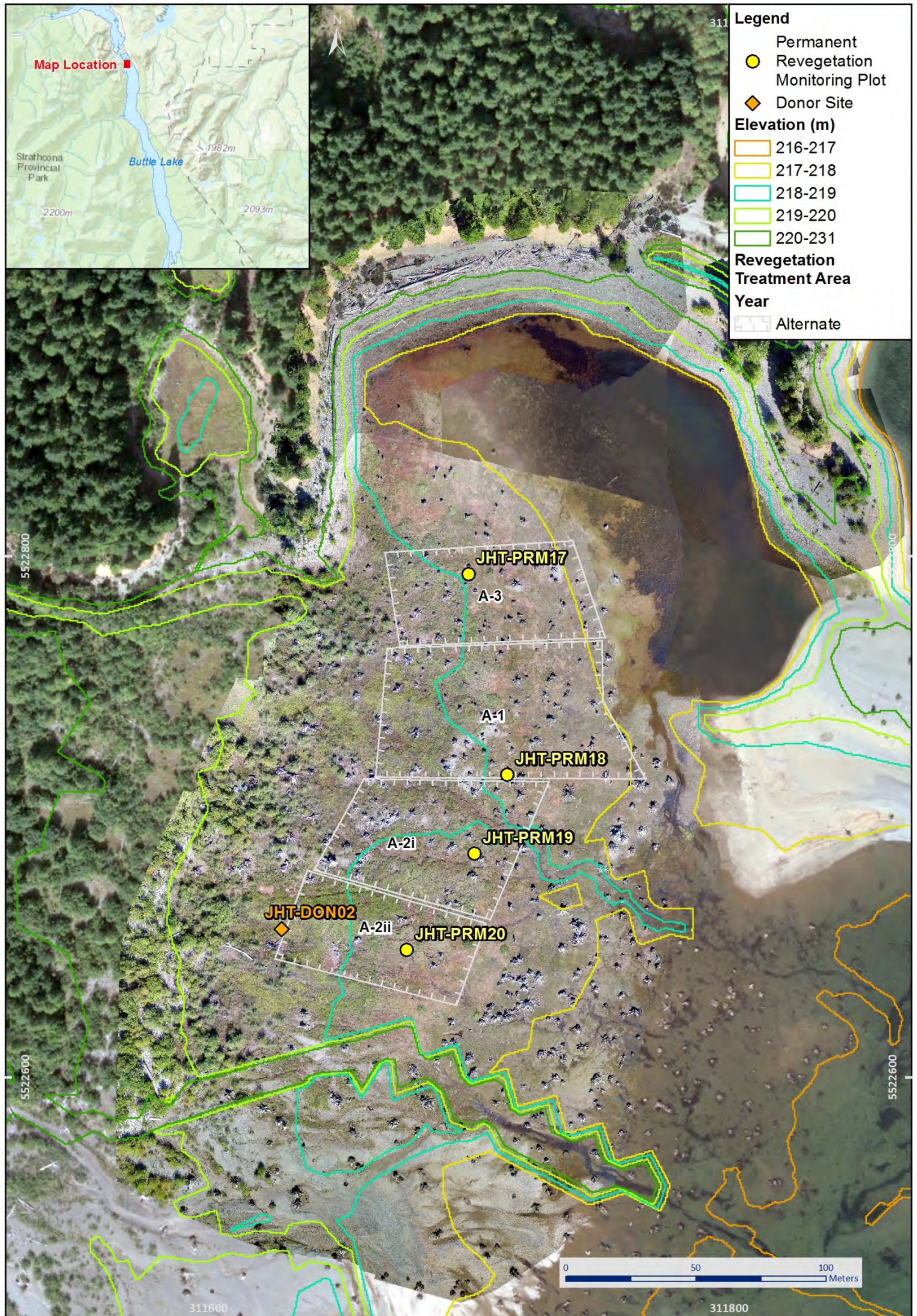

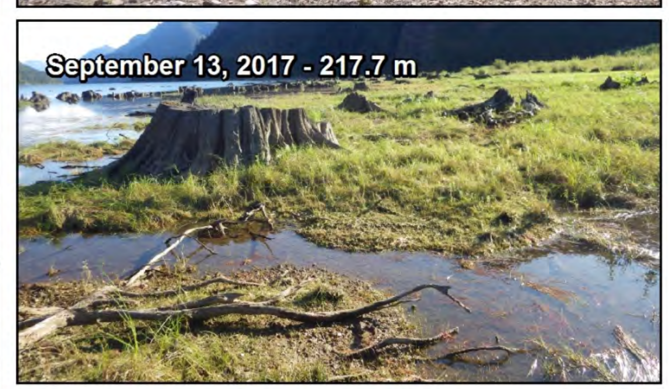

Site Description

Alluvial fan with stumps west of Rainbow Island. Generally very well vegetated above 217.6 m.

Revegetation Site Attributes

Revegetation Opportunity	
Land ownership:	Crown Land (drawdown zone) - BC Parks
Machine access:	Fair - a barge may be required if the existing walking trail is too narrow
Known or potential physical works:	None
Plant species and ecological communities at risk:	None expected
Revegetation Priority	
Visibility:	Visible from Rainbow Island (JHT-RV04) and boaters on Buttle Lake.
Public satisfaction:	Extensive low gradient area below 219 m; many stumps present
Fish and wildlife habitat:	High
Environmental Setting and Disturbance	
Elevation (m):	217-219+
Slope (%):	1%
Substrate:	Mineral soil, some stumps
Natural recruitment:	High recruitment of vegetation communities typical of the elevation band.
Aspect:	East
Fetch:	Low - disipated by slope
Water availability:	Good - upslope stream and forest and reservoir
Human disturbance:	Low - Nil
Wildlife disturbance:	Moderate
Invasive species:	Low

JHTWORKS-3 Revegetation Sites

Buttle Lake Fan
JHT-RV07

Revegetation Treatment Trials

A - Low Slope or Alluvial Fan

PRESCRIPTION

A-1. Select stumps with a top height over 217.8 m, as guided by surveyed elevations, and fill with soil and plant. Plant stumps with tops below 219.8 m with deciduous stakes. Plant stumps with tops above 219.8 m with flood tolerant forest species (where available). Armour with large gravel or cobble.

A-2. Complex and/or stabilize substrate. Mound to above 217.8 m elevation, as guided by surveyed elevations. Use woody debris and boulders to stabilize, as needed.

i. No planting

ii. Stake deciduous species by machine as guided by surveyed elevations (217.8-221.0 m).

A-3. Control

VEGETATION SPECIES

Black cottonwood (*Populus balsamifera*)
Sitka willow (*Salix sitchensis*)
Red-osier dogwood (*Cornus stolonifera*)
Forest species may include:
Western hemlock (*Tsuga heterophylla*)
Western redcedar (*Thuja plicata*)
Shore pine (*Pinus contorta ssp. contorta*)
Salal (*Gaultheria shallon*)

ECOFISH RESEARCH

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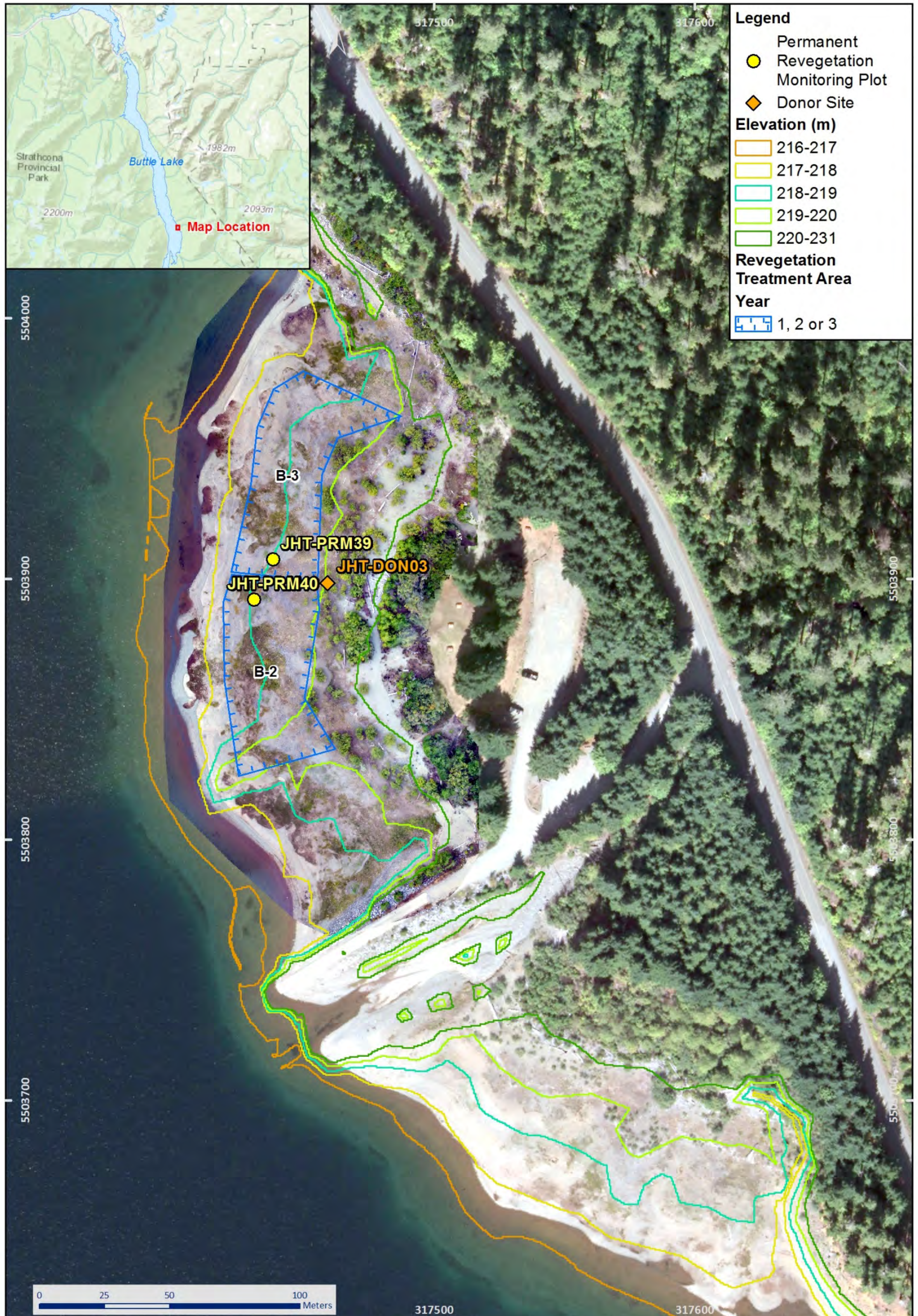

JHTWORKS-3 Revegetation Sites

Karst Creek Boat Launch JHT-RV08

Site Description

Concrete boat launch with variably vegetated areas on either side. Day use area.

Revegetation Site Attributes

Revegetation Opportunity	
Land ownership:	Crown Land (drawdown zone) - BC Parks
Machine access:	Excellent - boat launch
Known or potential physical works:	JHTWORKS-2 boat launch upgrade
Plant species and ecological communities at risk:	None expected
Revegetation Priority	
Visibility:	Highly visible for boat launch users and boaters on Buttle Lake.
Public satisfaction:	Extensive area below 219 m; stumps have been mostly removed
Fish and wildlife habitat:	Moderate
Environmental Setting and Disturbance	
Elevation (m):	217-221+
Slope (%):	Majority <6%
Substrate:	Gravel with pockets of mineral soil.
Natural recruitment:	North beach adjacent to creek better vegetated than south.
Aspect:	West (northwest to southwest)
Fetch:	High
Water availability:	Unknown, some subsurface flow from Karst Creek
Human disturbance:	Moderate (to high) - vehicle tracks, trampling, campfires
Wildlife disturbance:	Low
Invasive species:	Low

Revegetation Treatment Trials

B - Moderate Slope Drawdown

PRESCRIPTION

B-2. No site preparation. Stake deciduous species by hand as guided by surveyed elevations (217.8-221 m).

B-3. Control

VEGETATION SPECIES

Black cottonwood (*Populus balsamifera*)
Sitka willow (*Salix sitchensis*)
Red-osier dogwood (*Cornus stolonifera*)

ECOFISH RESEARCH

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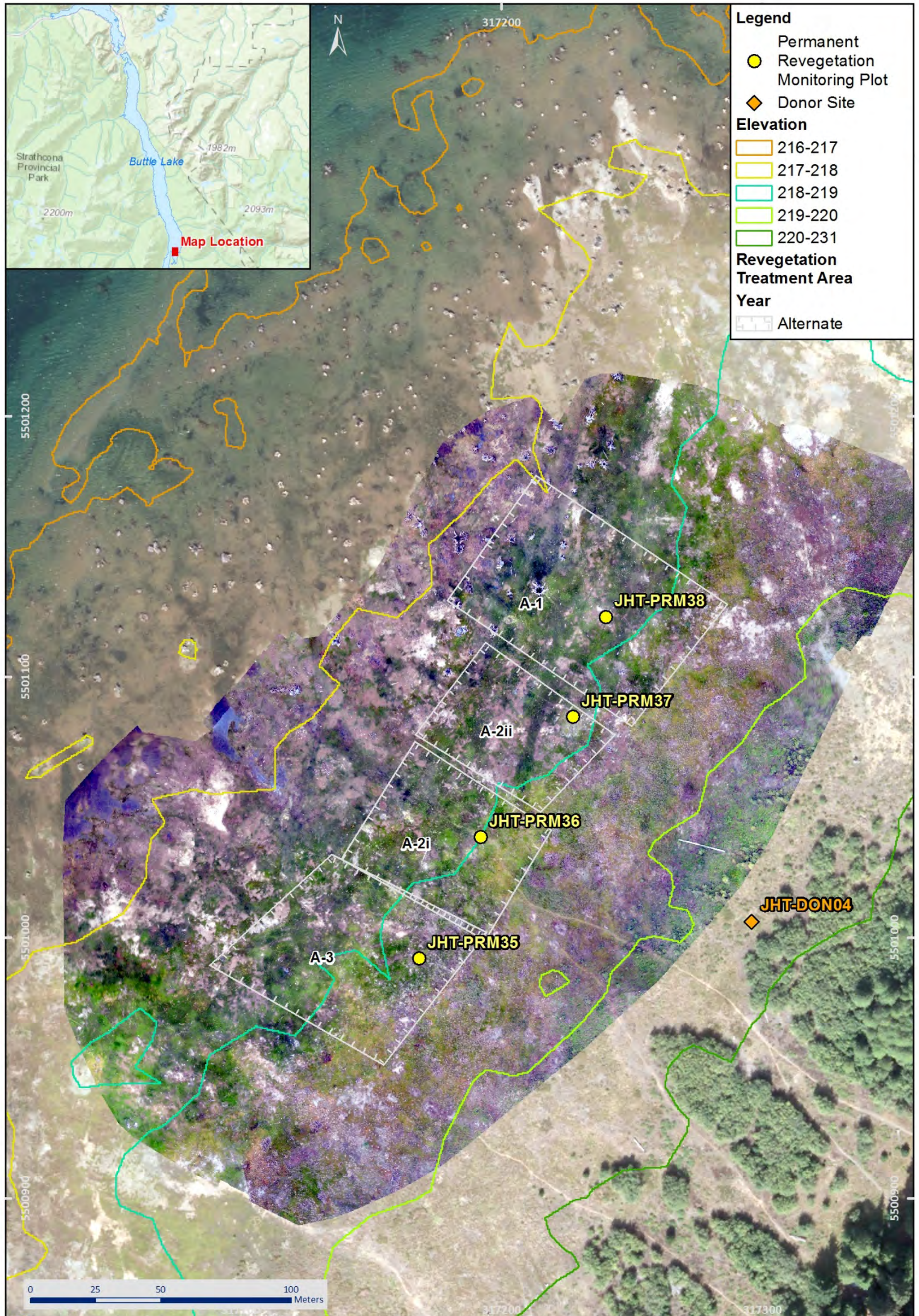
JHTWORKS-3 Revegetation Sites

Ralph River Campground
JHT-RV09



Site Description

Well vegetated expansive alluvial fan adjacent to the Ralph River Campground.

Revegetation Site Attributes

Revegetation Opportunity

Land ownership:	Crown Land (drawdown zone) - BC Parks
Machine access:	Good - may require temporary road to access lower elevations
Known or potential physical works:	JHTWORKS-2 trail to swimming area
Plant species and ecological communities at risk:	None expected

Revegetation Priority

Visibility:	Highly visible for visitors to Ralph River Campground
Public satisfaction:	Extensive area below 219 m; some stumps have been removed while those remaining are at lower elevations
Fish and wildlife habitat:	Moderate - High

Environmental Setting and Disturbance

Elevation (m):	217-221+
Slope (%):	<2%
Substrate:	Mineral soil
Natural recruitment:	High recruitment of vegetation communities typical of elevation bands.
Aspect:	West (northwest to southwest)
Fetch:	High but effect dispersed by slope
Water availability:	Good; higher at north end by Ralph River
Human disturbance:	Low (to moderate) - trampling, campground
Wildlife disturbance:	Moderate - High (evidence of deer, elk, geese grazing)
Invasive species:	Low - Moderate

Revegetation Treatment Trials

A - Low Slope or Alluvial Fan

PRESCRIPTION

A-1. Select stumps with a top height over 217.8 m, as guided by surveyed elevations, and fill with soil and plant. Plant stumps with tops below 219.8 m with deciduous stakes. Plant stumps with tops above 219.8 m with flood tolerant forest species (where available). Armour with large gravel or cobble.

A-2. Complex and/or stabilize substrate. Mound to above 217.8 m elevation, as guided by surveyed elevations. Use woody debris and boulders to stabilize, as needed.

i. No planting

ii. Stake deciduous species by machine as guided by surveyed elevations (217.8-221.0 m).

A-3. Control

VEGETATION SPECIES

Black cottonwood (*Populus balsamifera*)
Sitka willow (*Salix sitchensis*)
Red-osier dogwood (*Cornus stolonifera*)
Forest species may include:
Western hemlock (*Tsuga heterophylla*)
Western redcedar (*Thuja plicata*)
Douglas-fir (*Psuedotsuga menziesii*)

ECOFISH RESEARCH

Path: M:\Projects-Active\1230_JHTMON\MXD\Vegetation\Site Profile Sheets\JHTWORKS3_SiteProfileSheet_RalfRiver09_2017Nov01.mxd

Appendix E. Treatment Area Data

TABLE OF CONTENTS

LIST OF TABLES

Table 1. Revegetation Treatment Area and Permanent Monitoring Plot locations, elevations, and dates surveyed (1 of 2).

Site	Treatment Area	Permanent Monitoring Plot	UTM's (Zone 10U)		Plot Elevation (m)	Elevation Range (m)	Survey Date
			Easting	Northing			
JHT-RV02	A-2i	JHT-PRM25	311108	5523663	219.96	217.2-218.5	2017-09-14
	A-2ii	JHT-PRM27	311153	5523641	218.70	217.2-218.5	2017-09-14
	A-3	JHT-PRM26	311134	5523669	217.85	217.2-218.5	2017-09-14
	B-1i	JHT-PRM09	311011	5523655	218.05	217.6-219.9	2017-09-12
	C-1ii	JHT-PRM29	311169	5523696	219.12	217.6-221.0	2017-09-14
	C-1ii(a)	JHT-PRM07	311046	5523612	218.18	217.6-219.9	2017-09-12
	C-2	JHT-PRM28	311160	5523671	218.70	217.6-220.0	2017-09-14
	C-3	JHT-PRM06	311073	5523605	218.28	217.6-219.7	2017-09-12
JHT-RV03	C-1ii	JHT-PRM01	311229	5523524	218.00	217.6-220.0	2017-09-12
	C-2	JHT-PRM03	311216	5523487	219.00	217.6-220.0	2017-09-12
	D-2	JHT-PRM05	311219	5523517	223.00	220.5-224.0	2017-09-12
	D-3	JHT-PRM04	311211	5523496	223.00	220.5-224.0	2017-09-12
JHT-RV04	D-1	JHT-PRM10	311640	5522852	223.00	221.5-225.0	2017-09-13
	D-1	JHT-PRM14	311736	5522924	223.00	222.0-226.0	2017-09-13
	D-2	JHT-PRM11	311641	5522888	224.00	222.0-228.0	2017-09-12
	D-2	JHT-PRM16	311825	5522843	223.00	222.0-225.0	2017-09-13
	D-3	JHT-PRM12	311677	5522921	224.00	222.0-229.0	2017-09-13
	D-3	JHT-PRM15	311820	5522861	223.00	222.0-224.0	2017-09-13
	D-4	JHT-PRM13	311708	5522925	223.00	222.0-226.0	2017-09-13
JHT-RV05	B-1ii	JHT-PRM31	311481	5523941	218.34	217.6-220.2	2017-09-14
	B-2	JHT-PRM32	311484	5523984	218.60	217.6-220.2	2017-09-15
	B-3	JHT-PRM30	311462	5523904	217.65	217.6-220.3	2017-09-14
	C-1ii	JHT-PRM33	311470	5524036	218.99	217.6-220.3	2017-09-15
	C-1ii	JHT-PRM34	311416	5524180	219.00	217.6-219.1	2017-09-15
JHT-RV06	B-3	JHT-PRM21	312034	5523143	218.92	217.6-219.3	2017-09-14
	C-1ii	JHT-PRM23	312103	5523088	219.41	217.6-219.4	2017-09-14
	C-1ii	JHT-PRM42	311764	5523479	218.63	217.6-220.6	2017-09-28
	C-1ii	JHT-PRM43	311810	5523397	218.69	217.6-218.7	2017-09-28
	C-1ii	JHT-PRM45	311866	5523315	218.96	217.6-220.1	2017-09-28
	C-1ii	JHT-PRM49	311911	5523309	218.00	217.6-219.5	2017-09-28
	C-2	JHT-PRM22	312071	5523109	218.53	217.6-219.2	2017-09-13
	C-2	JHT-PRM47	311901	5523275	219.66	217.6-221.6	2017-09-28
	C-3	JHT-PRM24	312151	5523042	218.43	217.6-219.1	2017-09-14
	C-3	JHT-PRM41	311775	5523489	218.66	217.6-220.7	2017-09-28
	C-3	JHT-PRM44	311844	5523355	218.94	217.6-219.0	2017-09-28
	D-1	JHT-PRM48	311922	5523291	219.84	219.0-223.5	2017-09-28
	D-4	JHT-PRM46	311876	5523316	220.28	220.0-222.8	2017-09-28

Table 1. Revegetation Treatment Area and Permanent Monitoring Plot locations, elevations, and dates surveyed (2 of 2).

Site	Treatment Area	Permanent Monitoring Plot	UTM's (Zone 10U)		Plot Elevation (m)	Elevation Range (m)	Survey Date
			Easting	Northing			
JHT-RV07	A-1	JHT-PRM18	311715	5522716	217.75	216.5-218.6	2017-09-13
	A-2i	JHT-PRM19	311702	5522686	217.75	217.2-218.6	2017-09-13
	A-2ii	JHT-PRM20	311676	5522649	217.75	217.2-218.6	2017-09-13
	A-3	JHT-PRM17	311700	5522793	218.00	216.5-218.6	2017-09-13
JHT-RV08	B-2	JHT-PRM40	317431	5503892	218.21	217.6-219.7	2017-09-15
	B-3	JHT-PRM39	317438	5503908	218.25	217.6-220.0	2017-09-15
JHT-RV09	A-1	JHT-PRM38	317240	5501123	217.82	216.5-219.7	2017-09-15
	A-2i	JHT-PRM36	317192	5501039	217.87	217.2-219.7	2017-09-15
	A-2ii	JHT-PRM37	317227	5501085	217.98	217.2-220.3	2017-09-15
	A-3	JHT-PRM35	317168	5500992	218.50	217.2-219.7	2017-09-15

Table 2. Revegetation Treament Area vegetation response - structural stage and percent vegetation cover per layer (1 of 2).

Site	Treatment Area	Permanent Monitoring Plot	Structural Stage[1]	Total vegetation cover per layer (%)				
				A	B1	B2	C	D
JHT-RV02	A-2i	JHT-PRM25	2a	0%	0%	1-5%	25-50	1-5%
	A-2ii	JHT-PRM27	2a	0%	0%	1-5%	25-50	1-5%
	A-3	JHT-PRM26	2a	0%	0%	1-5%	25-50	1-5%
	B-1i	JHT-PRM09	2b	0%	0%	1-5%	50-75%	1-5%
	C-1ii	JHT-PRM29	3a	0%	1-5%	5-25%	5-25%	1-5%
	C-1ii(a)	JHT-PRM07	2b	0%	1-5%	1-5%	25-50	0%
	C-2	JHT-PRM28	3a	0%	1-5%	5-25%	5-25%	0%
	C-3	JHT-PRM06	1a	0%	0%	<1%	<1%	<1%
JHT-RV03	C-1ii	JHT-PRM01	1a	0%	0%	1-5%	1-5%	0%
	C-2	JHT-PRM03	1a	0%	0%	1-5%	1-5%	0%
	D-2	JHT-PRM05	1a	0%	0%	1-5%	0%	1-5%
	D-3	JHT-PRM04	3a	0%	1-5%	5-25%	1-5%	1-5%
JHT-RV04	D-1	JHT-PRM10	1	1-5%	1-5%	1-5%	0	0
	D-1	JHT-PRM14	1	1-5%	1-5%	0	1-5%	0
	D-2	JHT-PRM11	5	5-25%	1-5%	1-5%	1-5%	5-25%
	D-2	JHT-PRM16	1a	0%	1-5%	1-5%	1-5%	1-5%
	D-3	JHT-PRM12	5	5-25%	1-5%	5-25%	1-5%	1-5%
	D-3	JHT-PRM15	1b	0%	0%	0	0	5-25%
	D-4	JHT-PRM13	5	5-25%	0%	1-5%	1-5%	1-5%
JHT-RV05	B-1ii	JHT-PRM31	2b	0%	1-5%	1-5%	25-50	1-5%
	B-2	JHT-PRM32	3b	0%	1-5%	5-25%	5-25%	1-5%
	B-3	JHT-PRM30	2b	0%	0%	1-5%	25-50	1-5%
	C-1ii	JHT-PRM33	3a	0%	1-5%	1-5%	1-5%	0%
	C-1ii	JHT-PRM34	1a	0%	0%	1-5%	1-5%	1-5%
JHT-RV06	B-3	JHT-PRM21	1a	0%	1-5%	1-5%	5-25%	0%
	C-1ii	JHT-PRM23	1a	0%	0%	1-5%	1-5%	0%
	C-1ii	JHT-PRM42	3a	0%	1-5%	5-25%	1-5%	0
	C-1ii	JHT-PRM43	1a	0%	0%	1-5%	1-5%	0%
	C-1ii	JHT-PRM45	1a	0%	<1%	1-5%	1-5%	0%
	C-1ii	JHT-PRM49	1a	0%	1-5%	1-5%	1-5%	0%
	C-2	JHT-PRM22	3a	0%	1-5%	5-25%	1-5%	0%
	C-2	JHT-PRM47	3a	0%	1-5%	5-25%	1-5%	0%
	C-3	JHT-PRM24	3b	0%	1-5%	5-25%	5-25%	1-5%
	C-3	JHT-PRM41	3a	0%	1-5%	5-25%	1-5%	0%
	C-3	JHT-PRM44	1a	0%	0%	1-5%	1-5%	0%
	D-1	JHT-PRM48	1a	0%	0%	5-25%	1-5%	1-5%
	D-4	JHT-PRM46	3a	0%	1-5%	5-25%	1-5%	0%

[1] Structural Stage Categories: 1a = sparse, 1b = bryoid, 2a = forb dominated, 2b = graminoid dominated, 3a = low shrub, 3b = tall shrub, 4 = pole sapling.

Table 2. Revegetation Treament Area vegetation response – structural stage and percent vegetation cover per layer (2 of 2).

Site	Treatment Area	Permanent Monitoring Plot	Structural Stage[1]	Total vegetation cover per layer (%)				
				A	B1	B2	C	D
JHT-RV07	A-1	JHT-PRM18	2a	0%	0%	1-5%	>75%	5-25%
	A-2i	JHT-PRM19	2a	0%	0%	1-5%	>75%	0%
	A-2ii	JHT-PRM20	2b	0%	0%	1-5%	>75%	5-25%
	A-3	JHT-PRM17	2a	0%	0%	5-25%	>75%	5-25%
JHT-RV08	B-2	JHT-PRM40	3a	0%	1-5%	5-25%	25-50	0%
	B-3	JHT-PRM39	3a	0%	1-5%	5-25%	25-50	5-25%
JHT-RV09	A-1	JHT-PRM38	2a	0%	0%	1-5%	>75%	5-25%
	A-2i	JHT-PRM36	2a	0%	0%	1-5%	>75%	5-25%
	A-2ii	JHT-PRM37	2a	0%	0%	1-5%	>75%	5-25%
	A-3	JHT-PRM35	2a	0%	0%	1-5%	>75%	25-50%

[1] Structural Stage Categories: 1a = sparse, 1b = bryoid, 2a = forb dominated, 2b = graminoid dominated, 3a = low shrub, 3b = tall shrub, 4 = pole sapling.

Table 3. Revegetation Treament Area environmental setting - aspect, slope, exposure, and substrate (1 of 2).

Site	Treatment Area	Permanent Monitoring Plot	Aspect (°)	Slope (%)	Exposure	Surface Substrate[1]								
						Bedrock	Cobble	Large Gravel	Small Gravel	Fines	Mud	Mineral Soil	Wood	Organic
JHT-RV02	A-2i	JHT-PRM25	354	4	full sun		D	SD				SD		SD
	A-2ii	JHT-PRM27	285	4	full sun				SD			SD		SD
	A-3	JHT-PRM26	285	4	full sun		SD		D			SD		SD
	B-1i	JHT-PRM09	60	10	partial sun				D			SD		SD
	C-1ii	JHT-PRM29	16	26	partial sun		D		SD			SD		SD
	C-1ii(a)	JHT-PRM07	59	22	partial sun		SD	SD	D			SD		SD
	C-2	JHT-PRM28	116	22	partial sun		SD	D	D			SD	T	SD
	C-3	JHT-PRM06	45	33	partial sun		T	D		SD		SD		SD
JHT-RV03	C-1ii	JHT-PRM01	100	29	full sun			D		SD				
	C-2	JHT-PRM03	120	28	full sun			D		SD				
	D-2	JHT-PRM05	100	47	full sun			SD		SD		D		D
	D-3	JHT-PRM04	120	47	full sun			SD		SD		D		D
JHT-RV04	D-1	JHT-PRM10	90	60	partial sun			SD		SD		D	T	D
	D-1	JHT-PRM14	178	56	full sun							D	SD	D
	D-2	JHT-PRM11	100	60	partial sun			SD				D	T	D
	D-2	JHT-PRM16	237	47	full sun					D		SD	T	SD
	D-3	JHT-PRM12	170	60	full sun			T		SD		D	T	D
	D-3	JHT-PRM15	239	50	partial sun			T		SD		D	SD	D
	D-4	JHT-PRM13	172	62	partial sun			SD				D	SD	D
JHT-RV05	B-1ii	JHT-PRM31	133	7	full sun	T	SD		D		T			
	B-2	JHT-PRM32	76	10	partial sun		SD		D	SD				
	B-3	JHT-PRM30	116	12	full sun		D		SD				T	
	C-1ii	JHT-PRM33	62	33	partial sun		D		SD	T		SD	T	SD
	C-1ii	JHT-PRM34	63	26	partial sun		D		SD	SD		T	T	T

[1] D = dominant, SD = subdominant, T = trace, N = none.

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Table 3. Revegetation Treament Area environmental setting - aspect, slope, exposure, and substrate (2 of 2).

Site	Treatment Area	Permanent Monitoring Plot	Aspect (°)	Slope (%)	Exposure	Surface Substrate[1]								
						Bedrock	Cobble	Large Gravel	Small Gravel	Fines	Mud	Mineral Soil	Wood	Organic
JHT-RV06	B-3	JHT-PRM21	212	11	full sun				D					
	C-1ii	JHT-PRM23	219	20	full sun		SD	D	SD					
	C-1ii	JHT-PRM42	225	20	full sun			D	SD	SD			T	
	C-1ii	JHT-PRM43	70	24	full sun		SD	D	SD	SD			SD	
	C-1ii	JHT-PRM45	227	32	full sun	T	SD	SD	SD	D			T	
	C-1ii	JHT-PRM49	27	33	partial sun	T	D	SD	SD	SD			T	
	C-2	JHT-PRM22	223	17	full sun		D		SD					
	C-2	JHT-PRM47	210	31	full sun		D	SD	SD	SD				
	C-3	JHT-PRM24	36	17	full sun	SD	D		SD	SD		SD		SD
	C-3	JHT-PRM41	28	16	full sun			D	SD	SD			T	
	C-3	JHT-PRM44	250	23	full sun		SD	D	SD	SD				
	D-1	JHT-PRM48	300	50	partial sun		D	SD	SD	SD		SD		SD
	D-4	JHT-PRM46	227	45	full sun			SD	SD	D		SD		SD
JHT-RV07	A-1	JHT-PRM18	90	1	full sun				SD			D		D
	A-2i	JHT-PRM19	95	1	full sun							D	SD	D
	A-2ii	JHT-PRM20	100	1	full sun						SD	D	SD	D
	A-3	JHT-PRM17	80	1	full shade							D		D
JHT-RV08	B-2	JHT-PRM40	270	5	full sun				D			SD	T	SD
	B-3	JHT-PRM39	283	5	full sun				D			SD	T	SD
JHT-RV09	A-1	JHT-PRM38	310	1	full sun							D	T	D
	A-2i	JHT-PRM36	300	1	full sun							D	T	D
	A-2ii	JHT-PRM37	300	1	full sun							D	T	D
	A-3	JHT-PRM35	320	1	full sun							D	T	D

[1] D = dominant, SD = subdominant, T = trace, N = none.

Table 4. Revegetation Treament Area environmental setting - microtopography, surface shape, soil moisture, water source (1 of 2).

Site	Treatment Area	Permanent Monitoring Plot	Microtopography	Surface shape	Soil Moisture	Water source
JHT-RV02	A-2i	JHT-PRM25	mounded, undulating	concave, convex	subhygric	reservoir, precipitation
	A-2ii	JHT-PRM27	mounded, undulating	concave, convex	hygric	precipitation, reservoir
	A-3	JHT-PRM26	mounded, undulating	concave, convex	hygric	reservoir, precipitation
	B-1i	JHT-PRM09	undulating	concave, convex, straight	subhygric	precipitation, reservoir
	C-1ii	JHT-PRM29	smooth	concave	submesic	precipitation, reservoir
	C-1ii(a)	JHT-PRM07	smooth	straight	mesic	reservoir, precipitation
	C-2	JHT-PRM28	smooth	straight	subxeric	precipitation, reservoir
	C-3	JHT-PRM06	smooth	concave	xeric	reservoir, precipitation
JHT-RV03	C-1ii	JHT-PRM01	smooth	straight	xeric	reservoir, precipitation
	C-2	JHT-PRM03	smooth	straight	xeric	reservoir, precipitation
	D-2	JHT-PRM05	smooth	straight	xeric	precipitation
	D-3	JHT-PRM04	smooth	straight	xeric	precipitation,small up slope catchment
JHT-RV04	D-1	JHT-PRM10	smooth	straight	xeric	precipitation, upslope
	D-1	JHT-PRM14	smooth	straight	very xeric	precipitation
	D-2	JHT-PRM11	smooth	straight	xeric	precipitation, upslope
	D-2	JHT-PRM16	smooth	straight	very xeric	precipitation
	D-3	JHT-PRM12	smooth	straight	very xeric, xeric	precipitation, upslope
	D-3	JHT-PRM15	smooth	straight	xeric	precipitation
	D-4	JHT-PRM13	smooth	straight	very xeric, xeric	precipitation
JHT-RV05	B-1ii	JHT-PRM31	undulating	concave, convex, straight	submesic	reservoir, precipitation
	B-2	JHT-PRM32	smooth	straight	submesic	reservoir, precipitation
	B-3	JHT-PRM30	smooth, undulating	straight	submesic	precipitation, reservoir
	C-1ii	JHT-PRM33	smooth	straight	submesic	reservoir, precipitation, upslope
	C-1ii	JHT-PRM34	mounded, smooth	straight	subxeric	precipitation, reservoir, upslope

Table 4. Revegetation Treament Area environmental setting - microtopography, surface shape, soil moisture, water source (2 of 2).

Site	Treatment Area	Permanent Monitoring Plot	Microtopography	Surface shape	Soil Moisture	Water source
JHT-RV06	B-3	JHT-PRM21	smooth	straight	xeric, subxeric	precipitation, low slope position, reservoir
	C-1ii	JHT-PRM23	smooth	concave, straight	xeric, subxeric	upslope, precipitation, reservoir
	C-1ii	JHT-PRM42	smooth	straight	xeric	precipitation, reservoir
	C-1ii	JHT-PRM43	smooth	convex, straight	very xeric	reservoir, precipitation
	C-1ii	JHT-PRM45	smooth	straight	xeric	precipitation, upslope, reservoir
	C-1ii	JHT-PRM49	smooth	straight	subxeric	precipitation, reservoir
	C-2	JHT-PRM22	smooth, undulating	straight	xeric, subxeric	precipitation, reservoir, slope position
	C-2	JHT-PRM47	mounded, smooth	straight	xeric	precipitation
	C-3	JHT-PRM24	smooth, undulating	straight	subxeric	precipitation, slope position
	C-3	JHT-PRM41	smooth	straight	xeric	precipitation, reservoir
	C-3	JHT-PRM44	smooth	concave, straight	very xeric	precipitation, reservoir
	D-1	JHT-PRM48	smooth	straight	xeric	precipitation
	D-4	JHT-PRM46	smooth	straight	xeric	precipitation, upslope
JHT-RV07	A-1	JHT-PRM18	undulating	straight	subhygric	reservoir, precipitation
	A-2i	JHT-PRM19	smooth, undulating	straight	subhygric	precipitation, reservoir
	A-2ii	JHT-PRM20	channelled, smooth, undulating	straight	subhygric	reservoir
	A-3	JHT-PRM17	undulating	straight	subhygric	reservoir, precipitation
JHT-RV08	B-2	JHT-PRM40	undulating	straight	hygric	precipitation, upslope, reservoir
	B-3	JHT-PRM39	undulating	straight	hygric	upslope, precipitation, reservoir
JHT-RV09	A-1	JHT-PRM38	smooth, undulating	straight	subhygric	upslope, river, reservoir, precipitation
	A-2i	JHT-PRM36	smooth, undulating	straight	subhygric	upslope, river, reservoir, precipitation
	A-2ii	JHT-PRM37	smooth, undulating	straight	subhygric	upslope, river, reservoir, precipitation
	A-3	JHT-PRM35	smooth, undulating	straight	subhygric	subsurface from river

Table 5. Revegetation Treament Area environmental setting and disturbance factors (1 of 2).

Site	Treatment Area	Permanent Monitoring Plot	Fetch[1]	Erosion[1]	Deposition[1]	Wood debris[1]	Wildlife, Disease or Insect Damage[1]	Human Disturbance[1]	Invasive Species[1]
JHT-RV02	A-2i	JHT-PRM25	L	L	L	L	L	L	L
	A-2ii	JHT-PRM27	L	L	L	L	M	L	L
	A-3	JHT-PRM26	L	L	L	L	M	L	L
	B-1i	JHT-PRM09	L	L	N	L	M	L	M
	C-1ii	JHT-PRM29	L	L	L	L	M	L	M
	C-1ii(a)	JHT-PRM07	L	L	L	N	M	L	M
	C-2	JHT-PRM28	L	M	L	L	M	L	M
	C-3	JHT-PRM06	L	L	L	N	L	M	M
JHT-RV03	C-1ii	JHT-PRM01	L	M	L	N	N	L	M
	C-2	JHT-PRM03	L	M	L	L	N	L	M
	D-2	JHT-PRM05	N	M	L	N	N	L	L
	D-3	JHT-PRM04	N	M	L	N	L	L	L
JHT-RV04	D-1	JHT-PRM10	N	M	M	N	L	L	M
	D-1	JHT-PRM14	N	H	H	L	N	L	L
	D-2	JHT-PRM11	N	H	M	L	L	L	M
	D-2	JHT-PRM16	N	H	H	N	L	M	L
	D-3	JHT-PRM12	N	M	M, H	L	L	L	M
	D-3	JHT-PRM15	N	M	H	L	L	L	L
	D-4	JHT-PRM13	N	H	M	L	L	L	M
JHT-RV05	B-1ii	JHT-PRM31	M	M	M	M	L	L	M
	B-2	JHT-PRM32	H	H	H	M	M	L	M
	B-3	JHT-PRM30	M	M	M	M	L	L	M
	C-1ii	JHT-PRM33	M	H	M	M	M	L	M
	C-1ii	JHT-PRM34	M	H	M	M	M	L	M

[1] H = high, M = moderate, L = low, N = none.

Table 5. Revegetation Treament Area environmental setting and disturbance factors (2 of 2).

Site	Treatment Area	Permanent Monitoring Plot	Fetch[1]	Erosion[1]	Deposition[1]	Wood debris[1]	Wildlife, Disease or Insect Damage[1]	Human Disturbance[1]	Invasive Species[1]
JHT-RV06	B-3	JHT-PRM21	M	M	L	L, M	L	M	M
	C-1ii	JHT-PRM23	M	M	M	L	L	M	L
	C-1ii	JHT-PRM42	M	M	M	L	L	L	L
	C-1ii	JHT-PRM43	M	M	M	N	L	L	M
	C-1ii	JHT-PRM45	M	M	M	L	L	L	L
	C-1ii	JHT-PRM49	L	M	M	L	L	L	L
	C-2	JHT-PRM22	M	M	M	L	L	M	M
	C-2	JHT-PRM47	L	H	M	L	L	L	L
	C-3	JHT-PRM24	M	M	M	L	L	L	M
	C-3	JHT-PRM41	L	M	L	L	L	L	L
	C-3	JHT-PRM44	M	M	M	N	L	L	L
	D-1	JHT-PRM48	L	H	H	L	L	L	L
	D-4	JHT-PRM46	N	H	M	L	M	L	L
JHT-RV07	A-1	JHT-PRM18	L	L	L	L	M	L	L
	A-2i	JHT-PRM19	L	L	L	L	M	L	L
	A-2ii	JHT-PRM20	L	L	L	M	L	L	L
	A-3	JHT-PRM17	L	L	L	L	M	L	L
JHT-RV08	B-2	JHT-PRM40	H	M	H	H	L	M	L
	B-3	JHT-PRM39	H	M	H	H	L	M	L
JHT-RV09	A-1	JHT-PRM38	H	L	L	N	M	L	L
	A-2i	JHT-PRM36	M	L	L	L	M	L	M
	A-2ii	JHT-PRM37	H	L	L	N	M	L	L
	A-3	JHT-PRM35	H	L	N	L	M	L	M

[1] H = high, M = moderate, L = low, N = none.

Appendix F. Permanent Revegetation Monitoring Plot Data

TABLE OF CONTENTS

LIST OF TABLES

Table 1. Measured abundance of tree species in permanent revegetation monitoring plots (1 of 2).

Location	Treatment Type	Site	Douglas-fir (*Pseudotsuga menziesii*)	lodgepole pine (*Pinus contorta* var. *latifolia*)	red alder (*Alnus rubra*)	western hemlock (*Tsuga heterophylla*)	western redcedar (*Thuja plicata*)	western white pine (*Pinus monticola*)	black cottonwood (*Populus balsamifera* ssp. *trichocarpa*)	*All tree species*
Old Buttle Boat Launch (JHT-RV02)	C	JHT-PRM06	0	0	0	0	0	0	0	0
	C	JHT-PRM07	0	0	0	0	0	0	0	0
	C	JHT-PRM08	0	0	0	0	0	0	0	0
	B	JHT-PRM09	0	0	0	0	0	0	0	0
	A	JHT-PRM25	0	0	0	0	0	0	0	0
	A	JHT-PRM26	0	0	0	0	0	0	0	0
	A	JHT-PRM27	0	0	0	0	0	0	0	0
	C	JHT-PRM28	0	2	0	0	0	0	0	2
	C	JHT-PRM29	0	0	0	0	0	0	45	45
Buttle Lake Campground (JHT-RV03)	C	JHT-PRM01	0	0	0	0	0	0	0	0
	C	JHT-PRM02	0	0	0	0	0	0	0	0
	C	JHT-PRM03	0	0	0	0	0	0	0	0
	D	JHT-PRM04	2	1	0	0	0	0	0	3
	D	JHT-PRM05	0	0	0	0	0	0	0	0
Rainbow Island (JHT-RV04)	D	JHT-PRM10	3	0	0	0	0	3	0	6
	C	JHT-PRM11	0	0	0	0	0	0	0	0
	D	JHT-PRM12	1	0	0	0	0	0	0	1
	D	JHT-PRM13	0	0	0	0	0	0	0	0
	D	JHT-PRM14	1	0	0	0	0	0	0	1
	D	JHT-PRM15	0	0	0	0	0	0	0	0
	D	JHT-PRM16	1	0	0	0	1	0	0	2
Driftwood (JHT-RV05)	B	JHT-PRM30	0	0	0	0	0	0	0	0
	B	JHT-PRM31	0	0	0	0	0	0	0	0
	B	JHT-PRM32	0	0	0	0	0	0	0	0
	C	JHT-PRM33	0	0	1	0	2	0	7	10
	C	JHT-PRM34	0	0	2	0	0	0	0	2

Table 1. Measured abundance of tree species in permanent revegetation monitoring plots (2 of 2).

Location	Treatment Type	Site	Douglas-fir (*Pseudotsuga menziesii*)	lodgepole pine (*Pinus contorta* var. *latifolia*)	red alder (*Alnus rubra*)	western hemlock (*Tsuga heterophylla*)	western redcedar (*Thuja plicata*)	western white pine (*Pinus monticola*)	black cottonwood (*Populus balsamifera* ssp. *trichocarpa*)	*All tree species*
Buttle Boat Launch (JHT-RV06 - shoreline)	B	JHT-PRM21	0	0	0	0	0	0	0	0
	C	JHT-PRM22	0	0	0	0	0	0	0	0
	C	JHT-PRM23	0	0	0	0	0	0	0	0
	C	JHT-PRM24	0	0	0	0	0	0	0	0
Buttle Boat Launch (JHT-RV06 - island)	C	JHT-PRM41	0	0	0	0	0	0	19	19
	C	JHT-PRM42	0	0	0	0	0	0	14	14
	C	JHT-PRM43	0	0	0	0	0	0	0	0
	C	JHT-PRM44	0	0	0	0	0	0	0	0
	C	JHT-PRM45	0	0	0	0	0	0	0	0
	D	JHT-PRM46	4	0	0	0	0	1	0	5
	C	JHT-PRM47	0	0	0	0	0	0	0	0
	D	JHT-PRM48	2	0	0	2	0	0	0	4
	C	JHT-PRM49	0	0	0	0	0	0	0	0
Buttle alluvial fan (JHT-RV07)	A	JHT-PRM17	0	0	0	0	0	0	0	0
	A	JHT-PRM18	0	0	0	0	0	0	0	0
	A	JHT-PRM19	0	0	0	0	0	0	0	0
	A	JHT-PRM20	0	0	0	0	0	0	0	0
Karst Creek (JHT-RV08)	B	JHT-PRM39	0	0	0	0	0	0	0	0
	B	JHT-PRM40	0	0	0	0	0	0	0	0
Ralph River (JHT-RV09)	A	JHT-PRM35	0	0	0	0	0	0	0	0
	A	JHT-PRM36	0	0	0	0	0	0	0	0
	A	JHT-PRM37	0	0	0	0	0	0	0	0
	A	JHT-PRM38	0	0	0	0	0	0	0	0
Mean (stems/plot)			0.29	0.06	0.06	0.04	0.06	0.08	1.73	2.33
Standard Deviation			0.82	0.32	0.32	0.29	0.32	0.45	7.19	7.24
Standard error of the mean			0.12	0.05	0.05	0.04	0.05	0.06	1.03	1.03
t-value (90%)			1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677
Confidence Interval (+/- stems/plot)			0.20	0.08	0.08	0.07	0.08	0.11	1.72	1.73
Expected Density			**57**	**12**	**12**	**8**	**12**	**16**	**347**	**465**
Confidence Interval (+/- stems/ha)			*39.12*	*15.18*	*15.18*	*13.69*	*15.18*	*21.51*	*344.65*	*346.95*

Table 2. Measured abundance of shrub species in permanent revegetation monitoring plots (1 of 3).

Location	Treatment Type	Site	kinnikinnick (*Uva arctystaphalos*)	highbush huckleberry (*Vaccinium corymbosum*)	red alder (*Alnus rubra*)	red huckleberry (*Vaccinium*	red-flowering currant (*Ribes sanguineum*)	red-osier dogwood (*Cornus stolonifera*)	salal (*Gaultheria shallon*)	saskatoon (*Amelanchier*	Scotch broom (*Cytisus scoparius*)	Sitka willow (*Salix sitchensis*)	willow (unknown species) (*Salix* sp.)	tall Oregon-grape (*Mahonia aquifolium*)	thimbleberry (*Rubus parviflorus*)	trailing blackberry (*Rubus ursinus*)	*All shrub species*
Old Buttle Boat Launch (JHT-RV02)	C	JHT-PRM06	0	0	0	0	0	7	0	0	0	1	0	0	0	7	15
	C	JHT-PRM07	0	0	3	0	0	1	0	0	0	0	13	0	0	0	17
	C	JHT-PRM08	0	0	0	0	0	0	0	0	0	4	0	0	0	0	4
	B	JHT-PRM09	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3
	A	JHT-PRM25	0	0	0	0	0	0	0	0	0	0	4	0	0	0	4
	A	JHT-PRM26	0	0	0	0	0	0	0	0	0	0	4	0	0	0	4
	A	JHT-PRM27	0	0	0	0	0	0	0	0	0	0	61	0	0	0	61
	C	JHT-PRM28	0	0	0	0	0	1	0	0	0	1	0	0	0	0	2
	C	JHT-PRM29	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
Buttle Lake Campground (JHT-RV03)	C	JHT-PRM01	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
	C	JHT-PRM02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	JHT-PRM03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	JHT-PRM04	0	0	0	0	0	0	0	0	0	0	0	80	0	0	80
	D	JHT-PRM05	0	0	0	0	0	0	0	0	0	0	0	0	0	15	15
Rainbow Island (JHT-RV04)	D	JHT-PRM10	0	0	0	2	0	0	0	0	0	0	0	0	0	7	9
	C	JHT-PRM11	0	0	0	3	0	0	0	0	1	0	0	0	0	0	4
	D	JHT-PRM12	0	0	0	3	0	0	0	0	1	0	0	0	0	0	4
	D	JHT-PRM13	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
	D	JHT-PRM14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	JHT-PRM15	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	D	JHT-PRM16	0	6	0	0	0	0	1	0	0	0	0	0	0	0	7
Driftwood (JHT-RV05)	B	JHT-PRM30	0	0	0	0	0	0	0	0	0	0	6	0	0	0	6
	B	JHT-PRM31	0	0	0	0	0	0	0	0	0	8	0	0	0	0	8
	B	JHT-PRM32	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
	C	JHT-PRM33	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
	C	JHT-PRM34	0	0	0	0	0	0	0	0	0	0	7	0	0	0	7

Table 2. Measured abundance of shrub species in permanent revegetation monitoring plots (2 of 3).

Location	Treatment Type	Site	kinnikinnick (*Uva arctystaphalos*)	highbush huckleberry (*Vaccinium corymbosum*)	red alder (*Alnus rubra*)	red huckleberry (*Vaccinium*	red-flowering currant (*Ribes sanguineum*)	red-osier dogwood (*Cornus stolonifera*)	salal (*Gaultheria shallon*)	saskatoon (*Amelanchier*	Scotch broom (*Cytisus scoparius*)	Sitka willow (*Salix sitchensis*)	willow (unknown species) (*Salix* sp.)	tall Oregon-grape (*Mahonia aquifolium*)	thimbleberry (*Rubus parviflorus*)	trailing blackberry (*Rubus ursinus*)	*All shrub species*
Buttle Boat Launch (JHT-RV06 - shoreline)	B	JHT-PRM21	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3
	C	JHT-PRM22	0	0	0	0	0	0	0	0	0	0	18	0	0	0	18
	C	JHT-PRM23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	JHT-PRM24	0	0	0	0	0	0	0	0	0	0	19	0	0	0	19
Buttle Boat Launch (JHT-RV06 - island)	C	JHT-PRM41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	JHT-PRM42	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
	C	JHT-PRM43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	JHT-PRM44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	JHT-PRM45	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	D	JHT-PRM46	22	0	0	10	4	2	20	2	0	0	0	0	13	5	78
	C	JHT-PRM47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	JHT-PRM48	0	0	0	2	0	2	0	0	0	0	0	0	0	2	6
	C	JHT-PRM49	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Buttle alluvial fan (JHT-RV07)	A	JHT-PRM17	0	0	0	0	0	0	0	0	0	0	264	0	0	0	264
	A	JHT-PRM18	0	0	0	0	0	0	0	0	0	0	156	0	0	0	156
	A	JHT-PRM19	0	0	0	0	0	0	0	0	0	0	61	0	0	0	61
	A	JHT-PRM20	0	0	0	0	0	0	0	0	0	0	6	0	0	0	6

Table 2. Measured abundance of shrub species in permanent revegetation monitoring plots (3 of 3).

Location	Treatment Type	Site	kinnikinnick (*Uva arctystaphalos*)	highbush huckleberry (*Vaccinium corymbosum*)	red alder (*Alnus rubra*)	red huckleberry (*Vaccinium*	red-flowering currant (*Ribes sanguineum*)	red-osier dogwood (*Cornus stolonifera*)	salal (*Gaultheria shallon*)	saskatoon (*Amelanchier*	Scotch broom (*Cytisus scoparius*)	Sitka willow (*Salix sitchensis*)	willow (unknown species) (*Salix* sp.)	tall Oregon-grape (*Mahonia aquifolium*)	thimbleberry (*Rubus parviflorus*)	trailing blackberry (*Rubus ursinus*)	*All shrub species*
Karst Creek (JHT-RV08)	B	JHT-PRM39	0	0	0	0	0	0	0	0	0	0	132	0	0	0	132
	B	JHT-PRM40	0	0	0	0	0	0	0	0	0	0	70	0	0	0	70
Ralph River (JHT-RV09)	A	JHT-PRM35	0	0	0	0	0	0	0	0	0	0	135	0	0	0	135
	A	JHT-PRM36	0	0	0	0	0	0	0	0	0	0	18	0	0	0	18
	A	JHT-PRM37	0	0	0	0	0	0	0	0	0	0	62	0	0	0	62
	A	JHT-PRM38	0	0	0	0	0	0	0	0	0	0	49	0	0	0	49
Mean (stems/plot)			0.47	0.12	0.06	0.41	0.08	0.27	0.43	0.04	0.08	0.49	22.20	1.63	0.27	0.80	27.35
Standard Deviation			3.14	0.86	0.43	1.57	0.57	1.08	2.86	0.29	0.34	1.37	51.12	11.43	1.86	2.61	51.30
Standard error of the mean			0.45	0.12	0.06	0.22	0.08	0.15	0.41	0.04	0.05	0.20	7.30	1.63	0.27	0.37	7.33
t-value (90%)			1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677
Confidence Interval (+/- stems/plot)			0.75	0.21	0.10	0.38	0.14	0.26	0.68	0.07	0.08	0.33	12.25	2.74	0.44	0.62	12.29
Expected Density			**94**	**24**	**12**	**82**	**16**	**53**	**86**	**8**	**16**	**98**	**4441**	**327**	**53**	**159**	**5,469**
Confidence Interval (+/- stems/ha)			*150.60*	*41.07*	*20.53*	*75.07*	*27.38*	*51.55*	*136.93*	*13.69*	*16.47*	*65.70*	*2,449.51*	*547.59*	*88.98*	*124.86*	*2,458.08*

Table 3. Measured abundance of stems per plot and estimated vegetation density per treatment area (1 of 2).

Location	Treatment type	Plot	No. Stems/ plot		Estimated Vegetation Density (alive stems/ha)
			Alive	Dead	
Old Buttle Boat Launch (JHT-RV02)	C	JHT-PRM06	15	0	3,000
	C	JHT-PRM07	17	4	3,400
	C	JHT-PRM08	4	1	800
	B	JHT-PRM09	3	0	600
	A	JHT-PRM25	4	2	800
	A	JHT-PRM26	4	0	800
	A	JHT-PRM27	61	2	12,200
	C	JHT-PRM28	4	1	800
	C	JHT-PRM29	47	0	9,400
Buttle Lake Campground (JHT-RV03)	C	JHT-PRM01	1	0	200
	C	JHT-PRM02	0	0	0
	C	JHT-PRM03	0	0	0
	D	JHT-PRM04	83	44	16,600
	D	JHT-PRM05	15	13	3,000
Rainbow Island (JHT-RV04)	D	JHT-PRM10	15	0	3,000
	C	JHT-PRM11	4	0	800
	D	JHT-PRM12	5	0	1,000
	D	JHT-PRM13	2	0	400
	D	JHT-PRM14	1	0	200
	D	JHT-PRM15	1	0	200
	D	JHT-PRM16	9	5	1,800

Table 3. Measured abundance of stems per plot and estimated vegetation density per treatment area (2 of 2).

Location	Treatment type	Plot	No. Stems/ plot		Estimated Vegetation Density (alive stems/ha)
			Alive	Dead	
Driftwood (JHT-RV05)	B	JHT-PRM30	6	2	1,200
	B	JHT-PRM31	8	0	1,600
	B	JHT-PRM32	1	0	200
	C	JHT-PRM33	12	0	2,400
	C	JHT-PRM34	9	0	1,800
Buttle Boat Launch (JHT-RV06 - shoreline)	B	JHT-PRM21	3	0	600
	C	JHT-PRM22	18	0	3,600
	C	JHT-PRM23	0	0	0
	C	JHT-PRM24	19	2	3,800
Buttle Boat Launch (JHT-RV06 - island)	C	JHT-PRM41	19	0	3,800
	C	JHT-PRM42	16	0	3,200
	C	JHT-PRM43	0	0	0
	C	JHT-PRM44	0	0	0
	C	JHT-PRM45	1	0	200
	D	JHT-PRM46	83	1	16,600
	C	JHT-PRM47	0	0	0
	D	JHT-PRM48	10	0	2,000
	C	JHT-PRM49	1	0	200
Buttle alluvial fan (JHT-RV07)	A	JHT-PRM17	264	26	52,800
	A	JHT-PRM18	156	26	31,200
	A	JHT-PRM19	61	2	12,200
	A	JHT-PRM20	6	0	1,200
Karst Creek (JHT-RV08)	B	JHT-PRM39	132	5	26,400
	B	JHT-PRM40	70	2	14,000
Ralph River (JHT-RV09)	A	JHT-PRM35	135	6	27,000
	A	JHT-PRM36	18	0	3,600
	A	JHT-PRM37	62	1	12,400
	A	JHT-PRM38	49	1	9,800