Columbia River Project Water Use Plan

Kinbasket and Arrow Lakes Reservoir Revegetation Management Plan

Kinbasket Revegetation 1800/1500

Implementation Year 6

Reference: CLBWORKS-1

Kinbasket Revegetation Program: 2014 Post-Planting Report

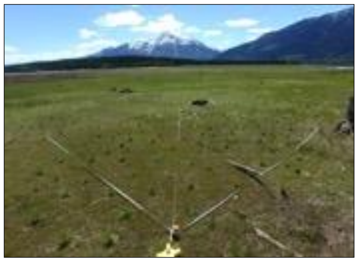
Study Period: 2013 - 2014

LGL Limited environmental research associates
Sidney, BC

February 23, 2015

EA3450

KINBASKET AND ARROW LAKES RESERVOIR REVEGETATION MANAGEMENT PLAN

CLBWORKS-01 Kinbasket Revegetation:

2014 Post-planting Report

Prepared for

BC hydro

Columbia Water License Requirements
Environmental Risk Management
Burnaby BC

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Margo Dennis and Philip Bradshaw of BC Hydro administered this project with technical assistance from Guy Martel (BC Hydro). Sedge planting was carried out by Columbia Extreme Contacting Ltd. (CEC), Parson, BC and orchestrated by Mark Teasdale (CEC) and Doug Adama (LGL Limited). Virgil Hawkes (LGL Limited) provided program management and technical oversight. Jeremy Gatten, Ryan Batten, and Virgil Hawkes assisted with the collection of field data.

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Cover photos

Kinbasket Reservoir from left to right: 1 x 1 m sampling quadrate, 5 x 5 m sampling quadrate, Columbia Extreme planting crew at Km 88 site, Kinbasket reservoir, *Carex lenticularis*© Doug Adama, LGL Limited

EXECUTIVE SUMMARY

The operation of Kinbasket Reservoir for power generation negatively impacts vegetation in the upper elevations of the reservoir. In 2007, a reservoir wide planting program (CLBWORKS-1) was initiated to offset the operational impacts to benefit littoral productivity, wildlife habitat, shoreline erosion, archaeological site protection, and shoreline aesthetics.

In March of 2013, LGL Limited was contracted to (1) identify a site for planting 68,020 sedge (*Carex lenticularis* and *C. aperta*) seedlings, (2) prepare a planting plan, (3) oversee the planting, and (4) undertake pre–treatment and outplanting monitoring. As directed by BC Hydro, the project objective was to plant the seedlings at a site (or sites) where they would have the greatest chance of establishment. In April through early May 2013, a site was identified (KM 88) and a detailed planting plan was developed. Restoration objectives for five treatment units were prescribed with the aim of increasing the density of sedge between 5,000 and 15,000 sedges per hectare and increasing the extent of the KS community within the drawdown zone.

Between May 15th and June 3rd, 2013, 3.3 hectares were planted in three treatment units at KM 88 site at a stocking density of 20,700 seedlings per hectare (sph). Survival one year after planting was between 93 and 100 per cent and mortality was observed to be between 0 and 3.4 per cent. With respect to the project objective, the 2013 planting was successful; however, due to prolonged inundation in 2014, lower survival is anticipated in future years. Continued monitoring will be required to assess both the survival of the seedlings and to assess the restoration objectives of the prescription.

The following recommendations are provided:

- To increase the knowledge gained from previous work under CLBWORKS-01 (2008 to 2011), we recommend that a catalogue of previous revegetation treatments be created describing the restoration objectives, revegetation methods, and current and target stocking densities for each site.
- Although the short-term project objective of establishing the sedge seedlings at a suitable site for high survival was met, several years of monitoring are required to assess both the long-term survival of the seedlings in achieving the restoration objectives of the planting prescription. This monitoring should be incorporated into CLBMON-09.
- To improve future prescriptions and vegetation establishment, we recommend that CLBWORKS-01 adopt an experimental approach. The benefit of such an approach should result in more successful and cost effective treatments prescriptions. In particular, we suggest hypotheses testing on: (i) the size of *Carex* seedling and transplant success, (ii) the timing, duration, and depth of inundation on *Carex spp* and other potential species suitable for restoration planting, and (iii) the effect of substrate and soil on seedling survival.
- In order to will facilitate the collection of necessary site information and to allow for sufficient time to review of the plans to ensure they do not conflict with other values (e.g., archeological) or management objectives (e.g., debris removal), restoration prescriptions and planting plans should be prepared at least one year in advance.

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1.0 INTRODUCTION

The operation of Kinbasket Reservoir for power generation negatively impacts vegetation in the upper elevations of the reservoir (Hawkes et al 2012). The Columbia River Water Use Plan (WUP) was developed to balance environmental, recreational, power generation, cultural, heritage, navigation and flood control values on the Columbia River (BC Hydro 2005). Pursuant to the recommendations of the WUP, a reservoir wide planting program (CLBWORKS-1) was initiated to offset the operational impacts by maximizing vegetation growth in the drawdown zone of Kinbasket Reservoir to benefit littoral productivity, wildlife habitat, shoreline erosion, archaeological site protection, and shoreline aesthetics.

Since 2007, 71.5 hectares (ha) have been treated in Kinbasket Reservoir (Keefer et al 2008, 2010, 2011, and 2012). Due to poor plant survival and establishment, the planting program was postponed in 2012 until a review of the program was completed. At the time, BC hydro was in possession of 122,565 sedge seedlings propagated in 2011 for planting in Kinbasket. The seedlings were held in cold storage as alternate planting sites were sought. Approximately 25,000 seedlings were allocated to the Williston Reservoir, 20,000 seedlings were donated to the Tsay Keh Dene, and 10,000 seedlings were donated to the Ministry of Forests, Lands and Natural Resources for a restoration project in the West Kootenays.

With no other options to recover costs for the remaining sedge stock (n = 68,020; 59,920 Kellogg's Sedge [*Carex lenticularis*] and 8,100 Columbia Sedge [*C. aperta*]), LGL Limited was contacted in March of 2013 to: (1) identify a site for the seedlings, (2) prepare a planting plan, (3) oversee the planting, and (4) undertake pre–treatment and outplanting[1] monitoring. The primary objective was to identify and plant a site for maximum survival and a two-part contract was initiated to undertake the work. The first phase of the work entailed the planning and implementation aspects of the project and the second phase comprised outplanting monitoring and the preparation of a summary report. Phase one of the project was carried out from April through June of 2013 and the second phase was to occur in the fall of 2013. To accommodate the construction of the additional turbines in Mica Dam (Units 5 and 6), reservoir levels were held high until December of 2013 and the outplanting monitoring (Phase Two) could not be completed and was postponed until 2014. This report briefly summarizes the planting activities in 2013 and reports out on results of the post-planting data collected in 2014.

[1] Outplant monitoring is the monitoring of seedling establishment within the same year of planting.

2.0 METHODS

2.1 Study Area

Completed in 1973, Mica Dam impounded the Columbia River creating the Kinbasket Reservoir. Mica Dam currently has four turbines that provide a generating capacity of 1,805 MW. In 2015, the installation of two additional turbines will be completed providing additional 1,000 MW of peak capacity. Under Water Licences No. 27068 and 39432, BC Hydro is authorized to store a maximum of 7 MAF [2]and 5 MAF in Kinbasket Reservoir, respectively. Licence No. 27068 applies to the volume of water stored under the Columbia River Treaty and Licence No. 39432 applies to the volume of water stored under Non-Treaty Storage (NTS). The normal operating range of the reservoir is between elevations 707.0 m ASL (2,319.42 ft.) and 754.4 m ASL (2475.0 ft.); however, application may be made to the Comptroller of Water Rights for additional storage if there exists a high probability of a spill. Under the normal operating regime, Kinbasket Reservoir begins to fill in the spring (April) and is typically full by the mid to late summer. The reservoir is drafted in the fall and winter for power generation as demand for energy increases.

Flanked by the Rocky Mountains to the east and the Selkirk and Monashee Mountain Ranges to the west (Figure 2-1), Kinbasket Reservoir extends 216 km from Donald to Valemount, BC. The shoreline of the reservoir is generally steep and rocky; however, low-lying land occurs on alluvial fans and fluvial or lacustrine terraces. The reservoir consists of seven reaches: Beaver Mouth, Kinbasket Reach, Bush Arm, Sullivan Arm, Mica Cr., Wood Arm, and Canoe Reach; the area of interest for this report is the KM 88 Site in Bush Arm (Figure 2-1).

2.2 Site Selection[3]

A desktop review was conducted in March and April of 2013 to identify sites for planting the 68,020 seedlings. This entailed (1) a review of the growth requirements of *Carex lenticularis* and *C. aperta*, and (2) the selection of suitable planting sites within Kinbasket Reservoir. Relevant BC Hydro reports, published literature, and orthorectified aerial imagery were reviewed to identify potential sites for revegetation. This process was aided with the CLBMON-10 vegetation community mapping to identify Kellogg's Sedge (KS) vegetation community polygons where *C. lenticularis* occurs naturally (Hawkes et al 2007, Hawkes et al 2010). Aerial imagery was also used to identify areas where wood debris accumulates as planting these sites would have little value and conflict with BC Hydro's wood debris removal program.

In late April 2013, a field reconnaissance was conducted of two sites identified from the desktop review. During the reconnaissance, the presence and extent of *C. lenticularis* and the KS community were determined and soil conditions were investigated. Survival of *C. lenticularis* and *C. aperta* at sites planted in 2011 were also visually assessed.

[2] MAF = million acre-feet.

[3] See (Adama 2013; Appendix A) for more on the site selection process and restoration prescription.

Following the desktop review and field reconnaissance, the site at Km 88 in Kinbasket Reservoir was selected based on the following rationale:

- *Carex lenticularis* occurs naturally from 746 to 751 m ASL and *C. aperta* occurs sporadically above 751 m ASL indicating that the site will support these species;
- Although high in clay content, the soil appeared suitable to support both species of sedge;
- The Km 88 site is in the lee of the wind and is less prone to woody debris accumulation; and
- The Km 88 site is a high value site for wildlife and vegetation resources (Hawkes et al. 2007, Hawkes and Tuttle 2013).

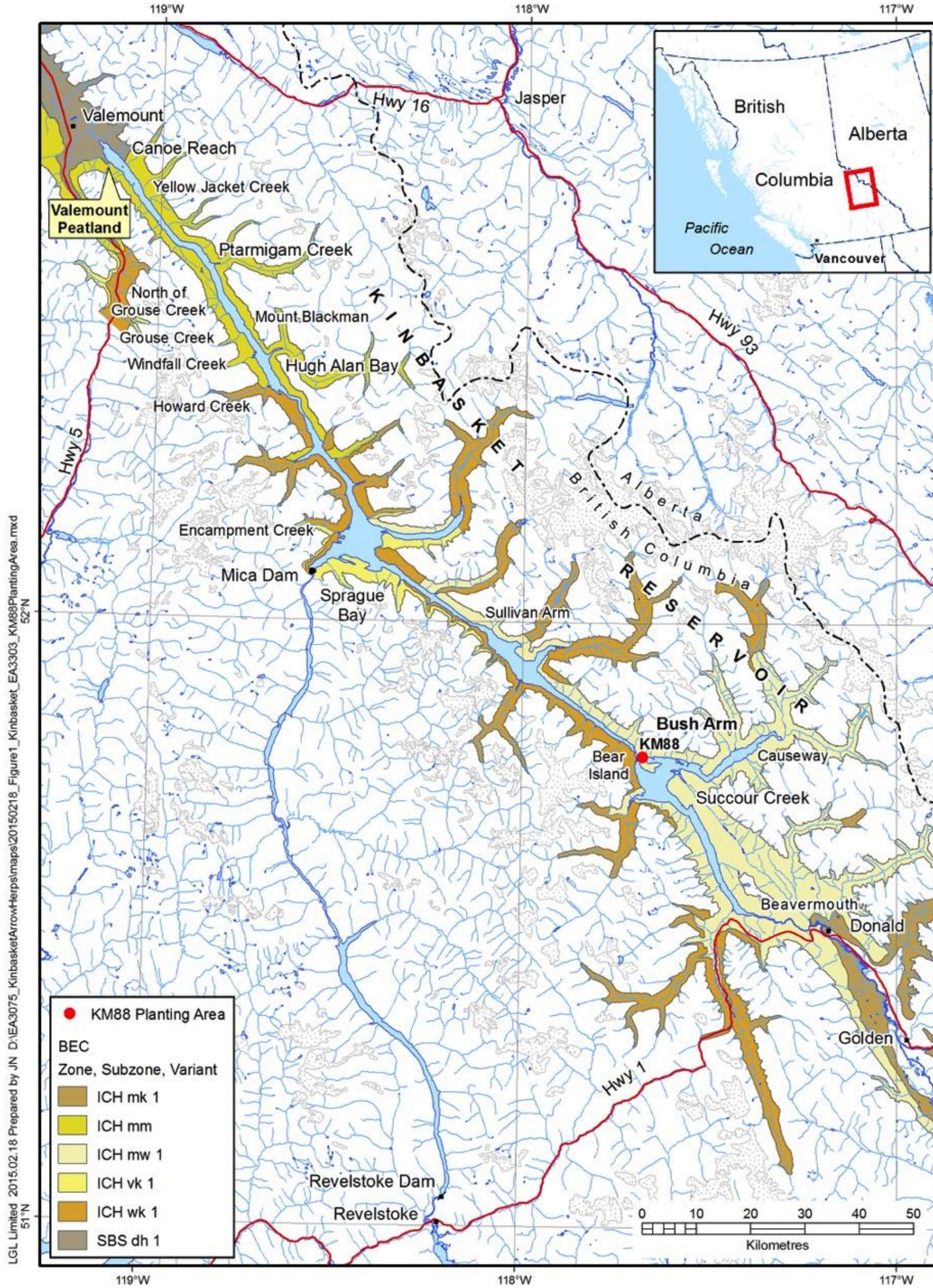

Figure 2-1: Location of the Km 88 planting site (red dot) in Kinbasket Reservoir, 2013.

2.3 Seedling Propagation and Storage

Seedling propagation is described in Keefer et al (2007 and 2010). Seeds were collected in 2010 and grown at the Tipi Mountain Native Plants and Roserim Nurseries (Keefer et al 2012); however, the locations of the seed collection sites were not specified (Keefer et al 2012). The seedlings were kept in large cell blocks until the autumn of 2012. In the autumn, the seedlings were trimmed to reduce issues with mold during dormancy and to ensure that plants remain at a manageable size for planting. After trimming, the plugs were lifted from the cell blocks and bundled for winter (cold) storage. The bundled sedge were stored at around - 4°C and transferred to High Country Cold Storage in Kamloops BC for cold storage for the 2012/2013 winter (BC Hydro, pers. comm).

2.4 Planting Plan

A planting plan delineating 5 treatment units (TU) was prepared in the spring of 2013 (Adama 2013; Appendix A). The primary objective of the project was to plant the seedlings at a site (or sites) where they would have the greatest chance of establishment (BC Hydro, pers. comm.). Long-term target densities were established for each treatment unit based on site conditions and 50 per cent survival of the planted seedlings (Table 2-1; Adama 2013). The restoration objectives were to increase the abundance (density) of sedge from 10,000 to 15,000 sedges per hectare in TU's 1, 3, and 4 and increase the extent of the KS community in the drawdown zone. Due the presence of *Phalaris arundinacea* (Reed Canary Grass), the target density for TU 5 was lower (between 5,000 and 10,000 ha). Better able to compete with *P. arundinacea* (Christy 2004; Wilson et al 2008), *C. aperta* was earmarked for planting in TU-5. These restoration objectives will increase littoral productivity and wildlife habitat; reduce shoreline erosion and provide archaeological site protection at the Km 88 site.

Table 2-1: Treatment Unit (TU) objectives and current, target, and stocking densities

TU	Comm Type†	Elevation Range (m ASL)	Area (ha)	Current Density (sph**)	Target Density (sph)	Stocking Density (sph)	Treatment Unit Objectives
1	KS/MA	746- 750	2.0	2,700	10,000 - 15,000	20,000 - 30,000	• Increase the abundance of *C. lenticularis* in the TU • Extend the KS community down to 746 m ASL into the adjacent MA community
2	KS/MA	747-748	-	5,900	-	-	• Do not plant. Retain as control.
3	KS/MA	746-748	2.36	400	10,000 - 15,000	20,000 - 30,000	• Increase the abundance of *C. lenticularis* in the TU • Extend the KS community down to 746 m ASL into the adjacent MA community
4	RC/KS	747-749	0.6	1,000	10,000 - 15,000	20,000 - 30,000	• Increase the abundance of *C. lenticularis* in the TU • Extend the KS community down to 747 m ASL into the adjacent MA community
5	RC/KS	748-751	0.6	1,400	5,000 - 10,000	10,000 - 20,000	• Increase the abundance of *C. aperta* in the TU • Establish *C. aperta* among openings in the RC community. • Extend the KS community up to 751 m ASL into the adjacent RC community.

*sph= seedlings per hectare

†Community Type: Reed Canary Grass (RC), Kellogg's Sedge (KS), Marsh Cudweed-Annual Hairgrass (MA)

On May 15, 2013, TU 4 was dropped for planting due to archaeological concerns. This was not a concern as more than enough ground (5 ha) was available for planting in the three remaining TU's. At a stocking density of 20,000 sph (seedling her hectare), we estimated that approximately 3.4 ha would be planted.

Treatment unit boundaries were delineated by the presence of native *Carex* and *P. arundinacea*. The lower boundaries were determined by the lowest extent of *C. lenticularis* while the upper boundaries were determined by a high abundance (greater than 50 per cent cover) of either *Carex* or *P. arundinacea*. The boundaries of the TU boundaries were delineated using pin flags and traversed with a SX Blue II™ GPS.

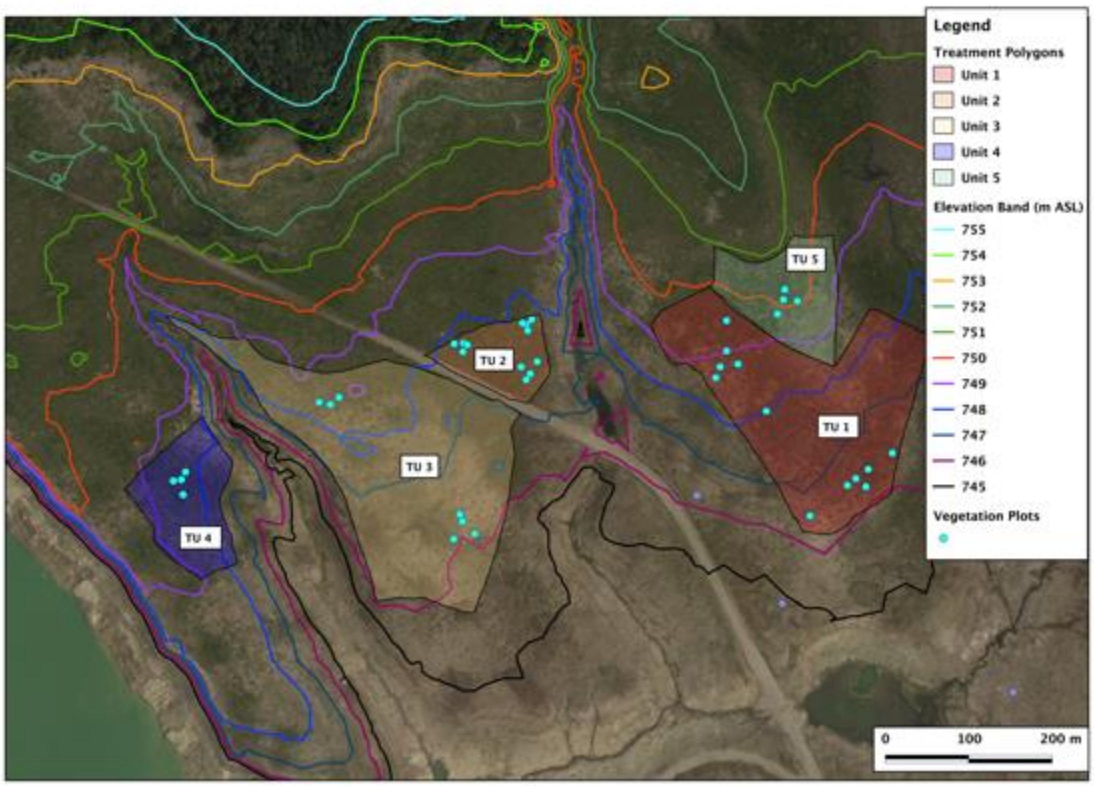

Figure 2-2: Km 88 treatment units (TU) boundaries and pin locations of 5 x 5 m quadrate

2.5 Outplanting

The planting stock consisted of 59,920 *C. lenticularis* and 8,100 *C. aperta* (Table 2-2). A thaw order was placed on May 3rd, 2014 to at High Country Cold Storage Ltd. for a May 15th delivery at Bush Harbour. Planting was to commence on May 16th; however, the plugs arrived frozen and required thawing. This delayed the planting and required additional handling and stock management. The plugs were gradually thawed in the reefer at Bush Harbour for the next several days. They were inspected and sorted daily from May 15 to May 19th and planting commenced on May 20, 2013.

Table 2-2: Carex planting stock.

Species	Plug Size	Plug Volume (ml)	Quantity of Plugs
C. aperta	412B	95	8,100
C. lenticularis	412A	125	8,100
C. lenticularis	412B	95	720
C. lenticularis	512A	220	51,100

Columbia Extreme planted the seedlings between May 20th and June 3rd, 2014. Access to the site was through private land (Coleman property) along old skid trails and the historic Big Bend Highway[4]. Planting was carried out by a crew of 6 professional tree planters following standard tree planting methods (Figure 2-3). *Carex lenticularis* and *C. aperta* were planted at 50 cm spacing and were spaced 50 cm from established *Carex Phalaris*, and established vegetation (e.g., *Scripus microcarpus).* The plantings were confined to the KS, RC, and MA communities as per prescription (Adama 2013). In total, 3.3 hectares were planted in three treatment units (TU 1, 3, and 5; Figure 2-4). The overall planting density was 20,700 seedlings per hectare (sph); however, the overall density estimate from the 1 x 1 m quadrate sampling in 2013 was 23,738 (Table 2-3).

Figure 2-3: Sedge planting at Km 88 by Columbia Extreme.

[4] The landowner provided written permission allowing LGL Limited and Columbia Extreme to access the site.

Table 2-3: Density of planted sedge seedlings in 2013 with 90 per cent confidence intervals

TU*	Polygon Area (ha)	Area Planted (ha)	2013 Seedling Density (sph)
1	1.95	1.95	25,454 ± 4,345
2	0.36	0	-
3	2.36	0.82	25,000 ± 4,234
4	0.6	0	-
5	0.6	0.5	20,714 ± 7,300
Total	**5.9**	**3.3**	**23,738 ± 1952**

* TU = Treatment Unit

** sph = seedling plug per hectare

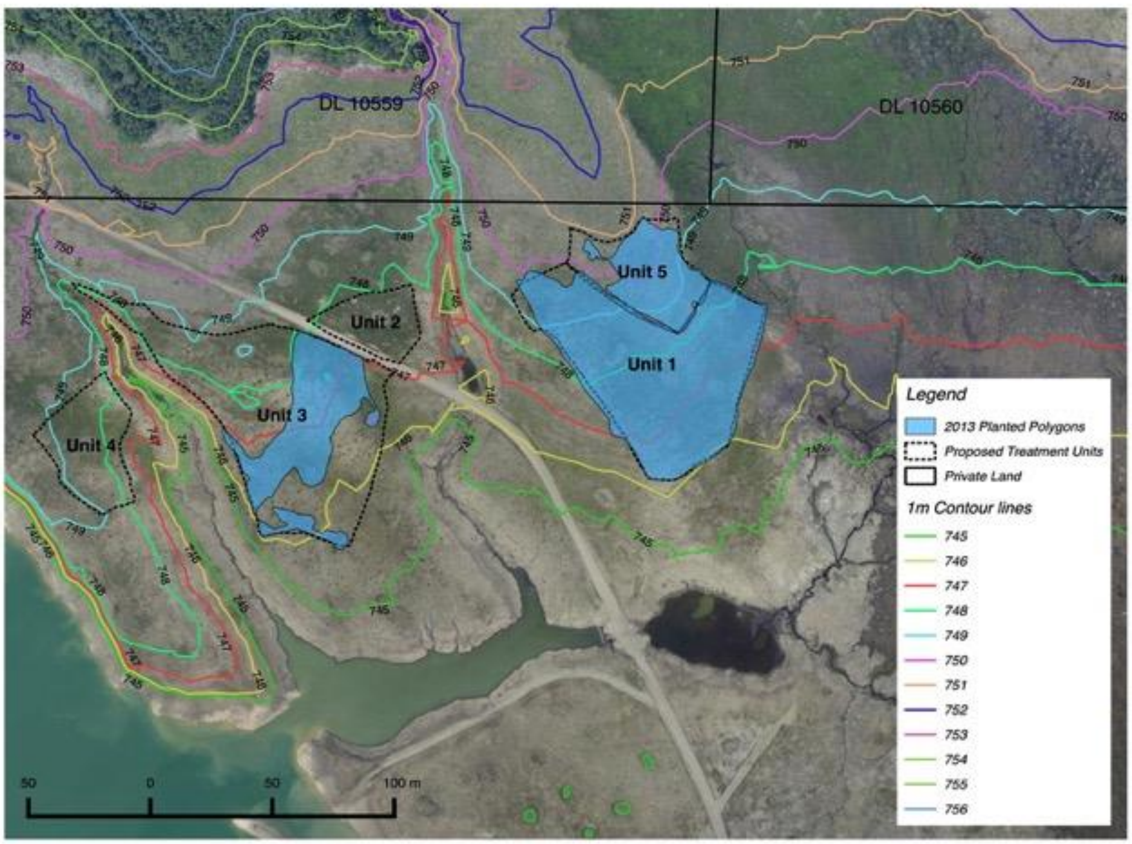

Figure 2-4: Proposed TU boundaries and areas planted in 2013, Kinbasket Reservoir

2.6 Sampling Methods

Pretreatment site conditions were determined in 2013 from 5 x 5 m plots (Figure 2-5) established in the 5 TU's in May 2013 (Appendix A; Adama 2013). Vegetation and site data were collected following the procedures established under CLBMON-09 (Hawkes 2010). On June 4th 2013, outplanting densities were estimated using temporary 1 x 1 m quadrats randomly located throughout the planted portions of the treatment units[5]. The quadrats were positioned by tossing the 1 x 1 m sampling frames (Figure 2-6) in a random distance and direction while walking through the planted polygons. The number of planted plugs and native sedge plants were counted in each 1 x 1 m quadrat.

In 2014, seedling survivorship was sampled using 1 x 1 m quadrats, as described above. The number of live and dead seedlings and native sedge plants were counted in quadrats to estimate post-treatment survival and mortality. Seedling vigour was also assessed using a qualitative scale of good, moderate, poor, and dead following procedures established for CLBMON-09 (Figure 2-7). A plant with good vigour had an outward appearance of good health (no brown leaves, healthy looking). A plant with moderate vigour was mostly healthy with some yellowing or wilting; while a plant with poor vigour exhibited obvious signs of poor health. It was often difficult to clearly distinguish between plants of good and moderate vigour. Dead plants were classified as plants with no identifiable living tissue. As the seedlings had only been in the ground for one year, they were immediately distinguishable from native sedge (Figure 2-7). In addition to assessing seedling vigour, plant height (mm) was measured from the ground to the tip of the longest leaf blade. Where herbivory was observed, plant height was measured but these data were excluded from analysis.

2.7 Data Analysis

The number of days that the seedlings were inundated in 2013 and 2014 were estimated for each 1 m elevation band planted (745 to 751 m ASL) by summing the number of days that the reservoir exceeded the elevation band from April 1 to March 31. The 2013 and 2014 inundation data was compared to the 30-year average (1977 to 2006) by comparing the number of days each elevation band was inundated to the 30-year average.

For each treatment unit, seedling survival was estimated by comparing the 2013 and 2014 densities using a t-test (Zar 2010). Seedling height was compared across treatment units using an ANOVA (Zar 2010) and seedling vigour was compared using a chi-square goodness of fit test (Zar 2010). As it was often difficult to distinguish between plant and good and moderate vigour, the good and moderate vigour classes were pooled into a single class. All statistical tests were performed using JMP (2014). All test were performed with $\alpha = 0.10$.

[5] As TU's 3 and 5 were not planted entirely (Figure 2-4), survivorship sampling was confined to the planting polygons with the treatment units.

Figure 2-5: Permanent 5 x 5 m CLBMON-09 sampling quadrat. Tape measure used to divide the quadrate into two sections to aid the tallying of seedlings.

Figure 2-6: 1 x 1 m quadrate frame with four planted *Carex* seedlings (circles) within the quadrate

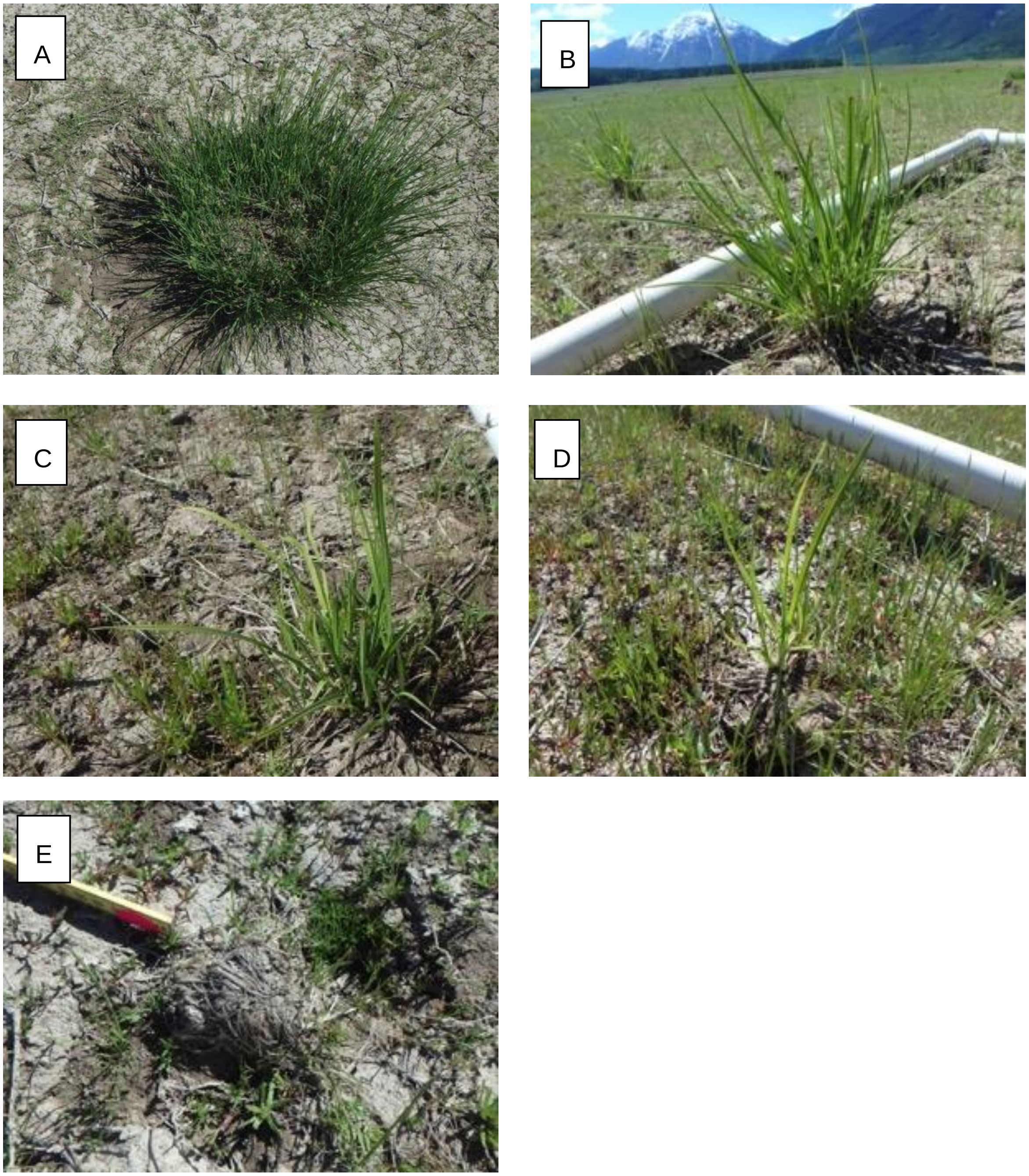

Figure 2-7: Native sedge plant and seedling vigour categories. A) Native sedge, B) Good vigor, C) Moderate vigor, D) Poor vigor, E) Dead seedling

3.0 RESULTS

3.1 Reservoir Levels

In 2013 and 2014, the elevation of the Kinbasket Reservoir was 5.0 m and 4.3 m higher than normal (i.e., 30-year baseline; Figure 3-1). In 2013, Kinbasket Reservoir was surcharged to an elevation of 754.63 m ASL and in 2014 the reservoir reached an elevation of 753.92 m ASL inundating the seedlings from between 3.6 to 8.6 m in 2013 and 2.9 and 7.9 m in 2014. In 2013, the areas planted were inundated from 119 and 175 days, which was between 47 and 66 days longer than the 30-year baseline (Figure 3-1). In 2014, the planted sedge were inundated 143 and 213 days, which was between 53 and 128 days longer than the 30-year baseline.

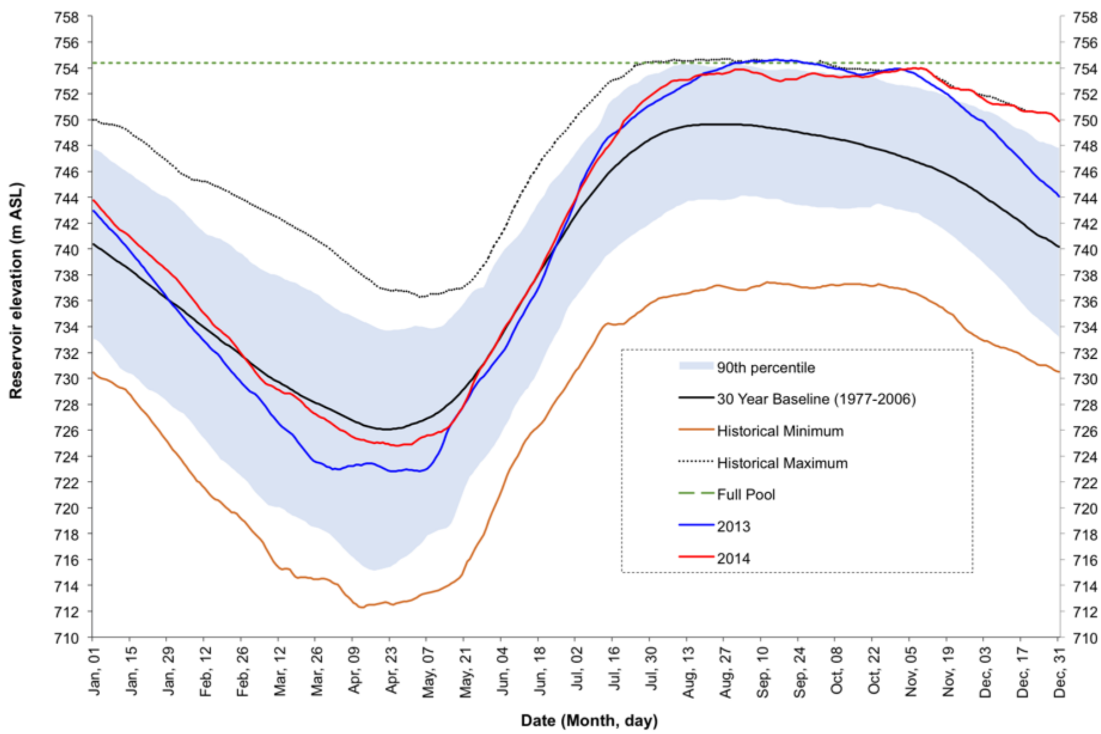

Figure 3-1: Daily Kinbasket Reservoir levels for 2013 and 2014. Historical mean (30-year baseline), minimum, maximum and full pool elevations are also shown.

Table 3-1: The number of days seedlings were inundated by elevation band in 2013 and 2014. Difference between days inundated in 2013 and 2014 to the 30-year baseline (1977 to 2006) provided in brackets

Elevation (m ASL)	2013	2014	30-year Baseline
745	175 (47)	213 (85)	128
746	167 (50)	204 (87)	117
747	161 (56)	189 (84)	105
748	153 (64)	180 (91)	89
749	143 (68)	171 (96)	75
750	131 (66)	163 (98)	65
751	119 (66)	143 (90)	53
Mean	150 (60)	180 (90)	90

3.2 Post-planting Vigour and Survival

Monitoring in 2014 (one year after planting) indicated a high level of survival (93 to 100 per cent) across the three treatment units (Table 3-2). Seedling mortality was estimated at between 0 and 3.4 per cent (Table 3-3). However, as plugs can be lost through erosion, expelled from the soil via frost heaving and dead seedlings can be difficult to locate, mortality is likely underestimated. Nevertheless, the values of mortality and the density of the seedlings in 2014 were relatively consistent.

Table 3-2: Density of planted sedge seedlings in 2013 and 2014 with 90 % confidence intervals

TU*	2013 Planting Density per hectare	2014 Seedling per hectare	Estimated Per Cent Survival
1	25,454 ± 4,345	23,750 ± 3,834	93 %
3	25,000 ± 4,234	24,286 ± 4,696	97 %
5	20,714 ± 7,300	21,000 ± 8,834	100 %

* TU = Treatment Unit

** sph = seedling plug per hectare

Table 3-3: Seedling height and vigour with 90 % confidence intervals

TU*	Height	% Dead	% Poor	% Moderate	% Good	% Good & Moderate
1	11.8 ± 0.7	1.6	32.8	42.2	23.4	66.6
3	11.8 ± 0.9	3.4	28.8	50.8	16.9	70.4
5	13.5 ± 1.0	0	13.5	62.2	24.3	86.5
Average	12.2 ± 0.5	1.9 ± 1.9	26.9 ± 5.7	50.0 ± 6.4	21.2 ± 5.3	71.2 ± 5.7

* TU = Treatment Unit

Seedlings in TU-5 appeared to be growing better than in TU-1 and 3. Seedlings in TU 5 were taller ($p = 0.07$, $\alpha = 0.10$; Table 3-4) and appeared in better condition (86.5 per cent versus 66.7 and 70.2 per cent in good and moderate condition; $\chi^2 = 0.07$, $\alpha = 0.10$) than seedlings in TU-1 and 3 (Table 3-3, Table 3-5).

Table 3-4: One-Way Analysis of Variance table of seeding height by treatment unit

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Treatment Unit	2	74.0899	37.0450	2.7086	0.0697
Error	157	2147.2538	13.6768		
C. Total	159	2221.3438			

Table 3-5: Contingency Table and Chi Square test results comparing vigour by across treatment units, α = 0.10

Treatment Unit	Poor	Good	Total
1			
Count	21	42	63
Expected	17.25	45.75	
%	33.33	66.66	
3			
Count	17	40	57
Expected	15.61	41.39	
%	29.82	70.18	
5			
Count	5	32	37
Expected	10.13	26.87	
%	13.51	86.49	
Total	43	114	157
N	**DF**	**-LogLike**	**RSquare (U)**
157	2	2.68	0.029
	Test	**ChiSquare**	**Prob>ChiSq**
	Likelihood Ratio χ^2	5.36	0.068
	Pearson's χ^2	4.87	0.088

4.0 DISCUSSION

The goal of CLBWORKS-01 is to improve littoral productivity, wildlife habitat, shoreline erosion, archaeological site protection, and shoreline aesthetics by maximizing vegetation growth in the drawdown zone. The objective for 2013 was to plant the remaining seedling stock from 2012 at a site with a high likelihood for establishment. The long-term ecological objectives are to increase the extent of the Kellogg's Sedge (KS) community in the drawdown zone and the overall abundance of *C. lenticularis* and *C. aperta* in this community (Adama 2013).

4.1 Meeting Project Objectives

Based on high seedlings survival (93 to 100 per cent), we conclude that the short-term project objectives (of planting and establishing the seedlings) were met unequivocally. However, in light of high reservoir levels and prolonged inundation in 2013 immediately following planting, this result was unexpected. On July 3rd, 2013 (only one month after the completion of planting), the reservoir began inundating the seedlings; by July 29th, 2013, all the seedlings were inundated. Depending on their elevation in the reservoir, seedlings were inundated to depths of 3.6 to 8.6 m from 119 to 175 days. Consequently, we anticipated considerably lower seedling survival than was observed. Despite the high reservoir levels and prolonged inundation, survival rates were higher than those reported for sedge plantations in Kinbasket from planted in previous years. Hawkes et al (2012) report an average year one survivorship of 53.5 per cent in plantings carried out over 2008 and 2011.

Several factors may help explain the high survival rates observed at Km 88. First, as the objective of the project was to plant at a site with a high likelihood of establishment, this guided the site selection process and planting prescription. Logically, we used the occurrence of native *C. lenticularis* and *C. aperta* and the CLBMON-12 vegetation community mapping (Hawkes et al 2007; Hawkes et al 2010) to identify suitable planting sites. We then applied additional criteria to avoid conflict with other BC Hydro WLR programs such as debris removal. Field visits were then conducted to refine site selection and acquire site information. After the requisite field data were gathered and the objectives of the planting prescriptions developed, treatment unit boundaries were established based on the presence/absence of the two sedge species and other vegetation (e.g., Reed Canary Grass). Thus, we specifically aimed to achieve a high rate of establishment by planting at an ecologically suitable site as identified by the best available information.

A second factor that may have contributed to high survival was seedling size. In previous years, one-year old seedling were cultivated in 211, 412A or 412 B plugs (40, 125, and 95 ml). With the revegetation program on hold in 2012, the seedlings were held for additional year at the nurseries resulting in larger seedlings, most requiring 512 plugs (220 mml; Table 2-2). Although we were unable to find information specific to *C. lenticularis* and *C. aperta*, the influence of seedling size on outplanting survival on other vegetation is well established (Ministry of Forests 1998; Steed and Dewald 2003; Landis et al 2010; Hough-Snee 2010). Larger seedlings have a higher probability of survival as they have greater leaf area, higher root and shoot biomass, and greater root growth potential. Under stress (such as prolonged inundation), the larger seedlings have more energy reserve to draw on resulting in higher survival (Hough-Snee 2010; Steed and Dewald 2003). In addition, the larger plug media may have also provided a benefit to seedlings in the clay rich soils by buffering against drought during the summer months and anoxia during inundation.

Admittedly, these explanations are speculative; however, the revegetation program (CLBWORKS-01) was not designed for hypotheses testing (BC Hydro 2007) and there was insufficient time to incorporate a rigorous experimental approach into the planting plan/prescriptions. Nevertheless, our findings highlight the importance of incorporating an experimental approach into the revegetation program, which would lead to the development of better planting plans, restoration prescriptions, and revegetation success. For example, while factors such as seedling size may confer a survival advantage, there are increased costs associated with the propagation and outplanting of larger plugs as they require an additional year in the nursery, an additional year of cold storage, and cost significantly more to plant. Thus it may be more cost effective to plant smaller seedlings at higher densities to offset higher rates of mortality. However, without an experimental approach it will not be possible to identify the most cost effective approach in establishing vegetation in the reservoir.

4.2 Achieving Long-Term Success

Although the short-term project objective was met, additional monitoring will be required to assess long-term survival of the seedlings. In previous years, Hawkes et al (2012) reported that seedling survival dropped from 53.5 per cent in year one to 38.9 per cent in year two, and as suggested above, we anticipate increased mortality in 2015 due to the prolonger inundation of seedling in fall and winter of 2014. Thus monitoring in 2015 will be essential. Given the prolonged period of inundation in 2014 (at least 143 and 213 days), we anticipate reduced survival in 2015, particularly at lower elevations in TU's 1 and 3. Flooding creates anoxic soil conditions that inhibits root growth and rapidly kills mycorrhizae (which are highly aerobic), inducing a cascade of physiological dysfunction in plants (Kozlowski 2012). While *C. lenticularis* and *C. aperta* appear to withstand extended periods of inundation, there are physiological limits, which partially explains the distribution of the naturally occurring plants across the elevation gradient at Km 88. If the growing season is insufficient to counter the annual energy requirements or if biochemical changes inhibit sufficient nutrient uptake, plant growth will cease and mortality will increase. In addition, the cumulative impact from successive years of prolonged inundation on these species is not known. With the recent change in the operating regime for Kinbasket Reservoir (Adama et al 2013), it will be important to determine the inundation limits of these species to ensure high levels of survival and establishment success over time.

While establishing *C. lenticularis* and *C. aperta* in the TU's is an important step in expanding the KS community in the drawdown zone, the KS community is composed of additional species including Wool-grass (*Scirpus atrocinctus*), Yellow Sedge (*Carex flava*) and Toad Rush (*Juncus bufonius*), clover (*Trifolium spp.*), and Narrow-leaved Collomia (*Collomia linearis*) (Hawkes et al 2008). It is anticipated it will take several years for the KS community to become fully establish, particularly at lower elevations, and the planting of additional species should be considered provided the 2013 seedlings demonstrate reasonable survivorship (25 to 50 per cent) over the next 5 years. However, as it appears that the operating regime of the reservoir has changed dramatically since 2010 (BC Hydro elevation data), monitoring under CLBMON-09 must continue to determine whether further planting is required and to assess whether the 2013 planting is sufficiently successful.

5.0 RECOMMENDATIONS

We present the following recommendations:

- To increase the knowledge gained from previous work under CLBWORKS-01 (2008 to 2011), we recommend that a catalogue of previous revegetation treatments be created describing the restoration objectives, revegetation methods, and current and target stocking densities for each site.
- Although the short-term project objective of establishing the sedge seedlings at a suitable site for high survival was met, several years of monitoring are required to assess both the long-term survival of the seedlings in achieving the restoration objectives of the planting prescription. This monitoring should be incorporated into CLBMON-09.
- To improve future prescriptions and vegetation establishment, we recommend that CLBWORKS-01 adopt an experimental approach. The benefit of such an approach should result in more successful and cost effective treatments prescriptions. In particular, we suggest hypotheses testing on: (i) the size of *Carex* seedling and transplant success, (ii) the timing, duration, and depth of inundation on *Carex spp* and other potential species suitable for restoration planting, and (iii) the effect of substrate and soil on seedling survival.
- In order to will facilitate the collection of necessary site information and to allow for sufficient time to review of the plans to ensure they do not conflict with other values (e.g., archeological) or management objectives (e.g., debris removal), restoration prescriptions and planting plans should be prepared at least one year in advance.

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7.0 APPENDIX: PLANTING PLAN

EA3484

KINBASKET AND ARROW LAKES RESERVOIRS
Monitoring Program No. CLBWORKS-01
Kinbasket Reservoir Revegetation




CLBWORKS-01
Phase 4a
Planting Plan

Prepared for

BC Hydro Generation
Water Licence Requirements
Burnaby, BC

BC Hydro Reference CO. 68636

EA3484

Prepared by

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May 15, 2013

LGL LIMITED
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Cover photos

From left to right: Common Horsetail Community in Bush Arm; woody debris accumulation on the Common Horsetail community at Beavermouth; Willow-Sedge community in the Valemount Peatlands; and Reed Canarygrass in Beavermouth. All photos © Virgil C. Hawkes, LGL Limited.

Table of Contents

1.0 INTRODUCTION

1.1 Background

During the Columbia River Water Use (WUP) planning process, a Consultative Committee (CC) recognized the value of vegetation for improving aesthetic quality, controlling dust, protecting cultural heritage sites from erosion and human access, and enhancing littoral productivity and wildlife habitat on BC Hydro reservoirs. The CC further recognized that the most significant opportunity for accomplishing these objectives lay in restoring and expanding riparian and wetland vegetation in the reservoir drawdown zone, because the drawdown zone is substantially affected by changes in BC Hydro's operation of the reservoir.

After considering several operating alternatives, the CC supported a reservoir-wide planting and shoreline enhancement program in lieu of operational changes during the growing season to maximize vegetation growth in the drawdown zone and to facilitate the development of long-term self-sustaining vegetation communities. This program targets the upper elevations of the drawdown zone between elevations 747 m and 754 m, and investigations will be undertaken to examine the feasibility of extending vegetation into lower portions of the drawdown zone, to a lower limit of 741m.

The revegetation program has been underway since 2007 (Keefer et al 2008, 2010, 2011, and 2012). In March 2013, LGL Limited was contacted by BC Hydro to (1) identify a site or sites for planting 59,920 Kellogg's Sedge (*Carex lenticularis*) and 8,100 Columbia Sedge (*C. aperta*) sedge plugs, (2) prepare a planting plan, (3) undertake the pre and post treatment monitoring, and (4) oversee the planting. This document presents a planting plan that describes the rationale for the site selection of the proposed planting site and provides planting prescriptions for four treatments units at the km88 site to be planted in 2013. A report will incorporate data that summarizes both the results of the planting and monitoring.

1.1 Project Goals

The overarching mandate of the Kinbasket Revegetation program is to enhance vegetation resources in the upper elevations of Kinbasket Reservoir. The program targets the upper elevations of the drawdown zone between elevations 747 m and 754.4 m for planting. The key objectives of the revegetation program are to:

i. maximize vegetation growth in the drawdown zones; and,
ii. provide benefits to littoral productivity, wildlife habitat, shoreline erosion and, archaeological site protection

The goal of the revegetation program in 2013 is to plant 68,020 sedge plugs (59,920 *C. lenticularis* and 8,100 *C. aperta*) at a site or site(s) in Kinbasket Reservoir. The direction provided by BC Hydro was to identify potential planting sites that have the greatest likelihood of success for establishment. The restorartion objective of this 2013 planting is to increase the extent of the Kellogg's Sedge (KS) community and the overall abundance of *C. lenticularis* and *C. aperta* in the proposed planting areas.

2.0 STUDY AREA

2.1 Physiography

At 216 km in length, Kinbasket Reservoir extends from Donald to Valemount, BC and is flanked by the Rocky Mountains to the east and the Selkirk and Monashee Mountain Ranges to the west (Figure 2-1). The shoreline of the reservoir is generally steep and rocky; however, low-lying land occurs on alluvial fans, glacial terraces, and lacustrine benches. The reservoir consists of seven reaches including Columbia Reach (Beaver Mouth), Kinbasket Reach, Bush Arm, Sullivan Arm, Mica Arm, Wood Arm, and Canoe Reach. The work proposed for 2013 will take place at the confluence of Bush Arm and Kinbasket Reach, near Bear Island.

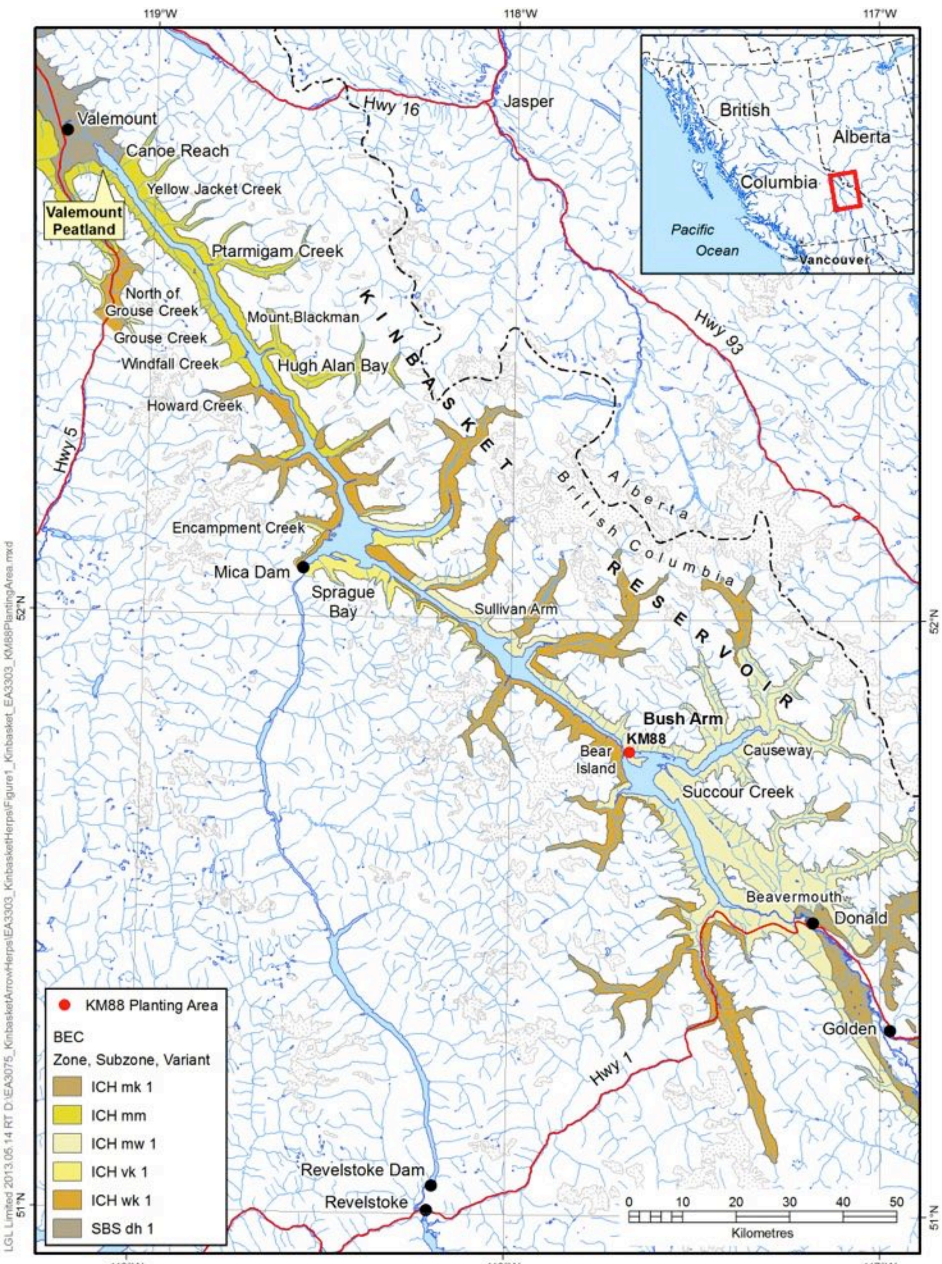

Figure 2-1: Kinbasket Reservoir

2.2 Climate

Easterly movements of damp air from the Pacific Ocean dominate the climate. The climate near Valemount is continental, and is characterized by seasonal extremes of temperature; severe, snowy winters; relatively warm, moist, and short summers; and moderate annual precipitation (440–900 mm). The climate at Bush Arm is typified by cool, wet winters and warm dry winters. The distribution of precipitation is affected by the north-south trend of the mountain systems. Mean annual precipitation ranges from 500 to 1400 mm of which 25 to 50 per cent falls as snow.

In winter, polar air masses moving south into Alberta often spill through passes into the Rocky Mountain Trench resulting in cooler and drier conditions than what is observed to the west in the Columbia Mountains. The snow pack accumulates above 2,000 m elevation through the month of May and continues to contribute runoff long after the snow pack has melted at lower elevations. Summer snowmelt is reinforced by rain from frontal storm systems and local convective storms. Runoff begins to increase in April or May and usually peaks in June to early July, when approximately 45 per cent of the runoff occurs. Mean annual temperatures range from 4.7 to 5.2°C (Environment Canada 2013).

2.3 Reservoir Operations

Kinbasket Reservoir was created in 1975 with the construction of Mica Dam 135 km north of Revelstoke. The first two turbines were commissioned in 1974 and two more were installed in 1977 bringing the total capacity of the powerhouse to 1,805 MW. Another two 500 MW generators are scheduled to be added in 2014/2015 for a total generating capacity of 2,805 MW.

BC Hydro is authorized by Conditional Water Licences No. 27068 and 39432 to store a maximum of 7 MAF [1]and 5 MAF, respectively. Licence No. 27068 applies to the volume of water stored under the Columbia River Treaty and Licence No. 39432 applies to the volume of water stored under Non-Treaty Storage (NTS). The normal operating range of the reservoir is between elevations 707.0 m ASL (2319.42 ft) and 754.4 m ASL (2475.0 ft) (Figure 2-2); however, applications may be made to the Comptroller of Water Rights for additional storage for environmental or other purposes if there exists a high probability of spill.

[1] MAF = million acre-feet.

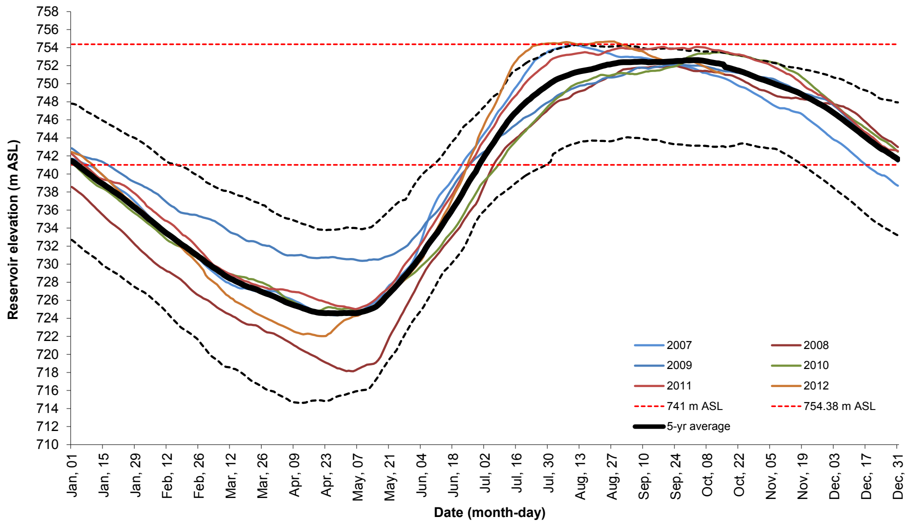

Figure 2-2: Kinbasket Reservoir elevations for 2008 through 2012 (partial). The dashed lines represent the 10th and 90th percentile. The 5-yr average is shown (thick black line) as well as the elevation range of interest (dashed red lines)

3.0 METHODS

3.1 Desktop Review

A desktop review was conducted to identify a site (or sites) with a high likelihood of success for establishing the sedge plugs. This entailed (1) consideration of the growth requirements of *C. lenticularis* and *C. aperta*, and (2) the selection of suitable habitat within Kinbasket Reservoir. Relevant BC Hydro WLR reports from previous years were reviewed including: CLBWORKS-01 Kinbasket Reservoir Revegetation Physical Works (Keefer et 2007, 2008, 2010a, 2010b, 2012); CLBMON-09 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis (Yazvenko 2008, Yazvenko et al 2009, Fenneman and Hawkes 2012); and CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources (Hawkes et al 2007, Hawkes and Muir 2008, Hawkes et al 20120, and Fenneman and Hawkes 2012). Additional information was also obtained from Wilson et al (2008) and from Internet sources including: http://www.plants.usda.gov; http://www.anpc.ab.ca/; http://www.efloras.org/; http://linnet.geog.ubc.ca/.

Orthorectified aerial imagery of Bush Arm, Mica Arm, and Canoe Reach were reviewed to identify potential sites for revegetation that fit within the overarching goals of CLBWORKS-01. This process was aided with the CLBMON-10 vegetation community mapping to identify Kellogg's Sedge (KS) polygons were *C. lenticularis* occurs naturally. Aerial imagery was also used to identify areas where wood debris accumulates as planting these sites would have little value and create conflict with BC Hydro's wood debris removal program.

3.2 Site Visit and Data Collection

On April 25th 2013, a field reconnaissance was conducted of two sites identified from the desktop review in the km88 area (Figure 3-1). During the reconnaissance, the presence and extent of *C. lenticularis* and the KS community was noted and soil conditions were investigated. Survival of *C. lenticularis* and *C. aperta* at sites planted in 2011 were also noted.

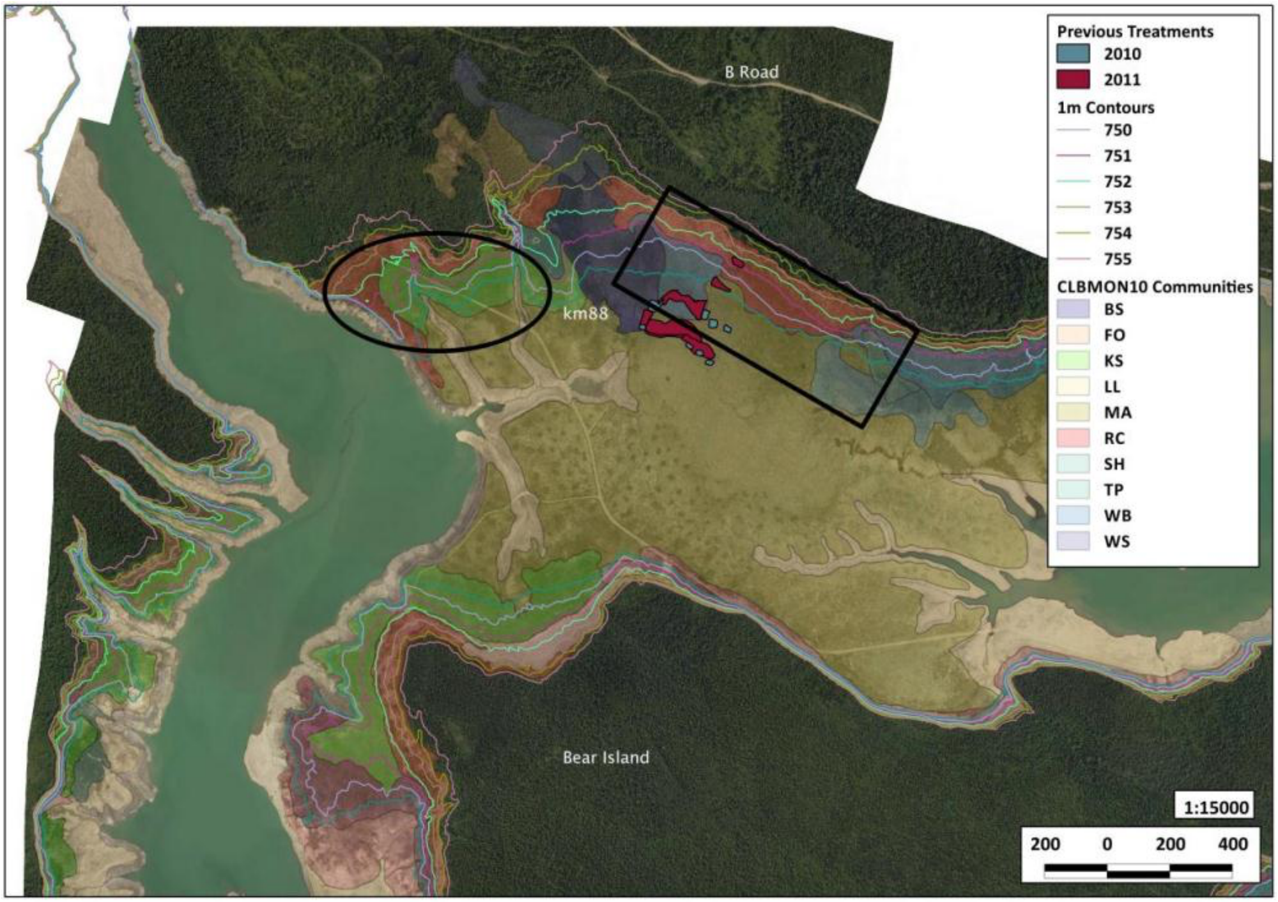

Figure 3-1: Potential planting sites in the km88 area reviewed during a site visit on April 25th, 2013. A Kellogg's Sedge (*C. lenticularis*) community is identified by green shading in the "West Site" (ellipse). The "East Site" (rectangle) was planted previously in 2010 and 2011.

On May 5th and 6th 2013, five potential planting areas were delineated at the km88 site and soil and vegetation data were collected. Treatment area boundaries were established based on the occurrence of *C. lenticularis* with the rationale that *C. lenticularis* will have a greater likelihood of success in establishing where it occurs naturally. The lower boundaries were determined by the lowest extent of *C. lenticularis* while the upper boundaries were determined by either a high abundance of *C. lenticularis* or *Phalaris arundinacea*. As these species are perennial, the extent of these species and of the KS and RC communities were easily identified.

The potential treatment area boundaries were delineated using pin flags and traversed with a SX Blue II™ GPS. The following data were collected in each treatment area: slope, aspect, area (ha), substrate/soil type, soil texture, soil moisture, surface cover (e.g., wood, rock), vegetation community type, species composition and per cent cover. Vegetation data were collected following the methods used in CLBMON-09 (**Appendix 7.2**). In addition, *C. lenticularis* plants were tallied in 5 x 5 meter sq. plots. Site data were collected on FS1333 Site Inspection Forms (BC Government 2010) and CLBMON-09 datasheets (Hawkes 2010).

4.0 RESULTS AND DISCUSSION

4.1 Information Review

Information on the growth requirements of *C. lenticularis* and *C. aperta* was sparse. Fennenman and Hawkes (2012), the USGS plant database (www.plants.usda.gov), and Wilson et al (2008) provided the best sources of information, which are summarized in in Appendix 7.3. Ultimately the proposed planting sites were identified based on the distribution of the KS community in the reservoir with considering consideration given to constraints such as access and the accumulation of wood debris. Nevertheless, information on the growth requirements of the two sedge species was helpful in developing site-specific planting prescriptions.

4.2 Site Selection

The Km88 area was identified as a potential planting site based on the following:

1. The presence of the CLBMON-10 KS (Kellogg's sedge) community suggests that *C. lenticularis* (Kellogg's sedge) should establish (Figure 4-1).
2. Soils are mineral as opposed to organic, gravel or rocky. Previous plantings on rocky or organic soils has resulted in poor survival. Survival is anticipated to be higher on mineral soils based on the life history requirements of the two *Carex* species.
3. Km88 is a high value site for wildlife and vegetation resources (Hawkes et al. 2007, Hawkes et al. 2012)
4. Km88 is located on a south facing aspect and the prevailing winds come from the north. Consequently, the site is in the lee of the wind and is less prone to woody debris accumulation. This is an important consideration as many previously planted sites have been blanketed with large amounts of wood debris, reducing the efficacy of the revegetation effort and creating conflict with the debris program.

Figure 4-1: The presence of *C. lenticularis* in the CLBMON-10 KS (Kellogg's Sedge) community at km88, Kinbasket Reservoir (June 2010).

On April 25 2013, two sites identified at km88 were assessed as planting opportunities (Figure 3-1). Of the two sites visited, the west site appeared to be the preferred site for planting due to the presence of the KS vegetation community with *C. lenticularis* occurring naturally on site. Poor survival of *C. lenticularis* and *C. aperta* planted in east site in 2010 and 2011 as well as the presence of organic soils and the lack of any live vegetation indicated that survival of *C. lenticularis* and *C. aperta* at this site will likely be low.

4.3 Site Description

The proposed area for planting is located along the east side of Kinbasket Reservoir 7.5 km northwest of Bush Harbour and 1.0 km north of Bear Island (N 51.778357, W -117.676642). The site is downslope of the "B-road" Forest Service Road (FSR) between the km88 and km89 road markers and is located below full pool (754.38 m ASL[2]). The old Big Bend highway bisects the site (Figure 4-2).

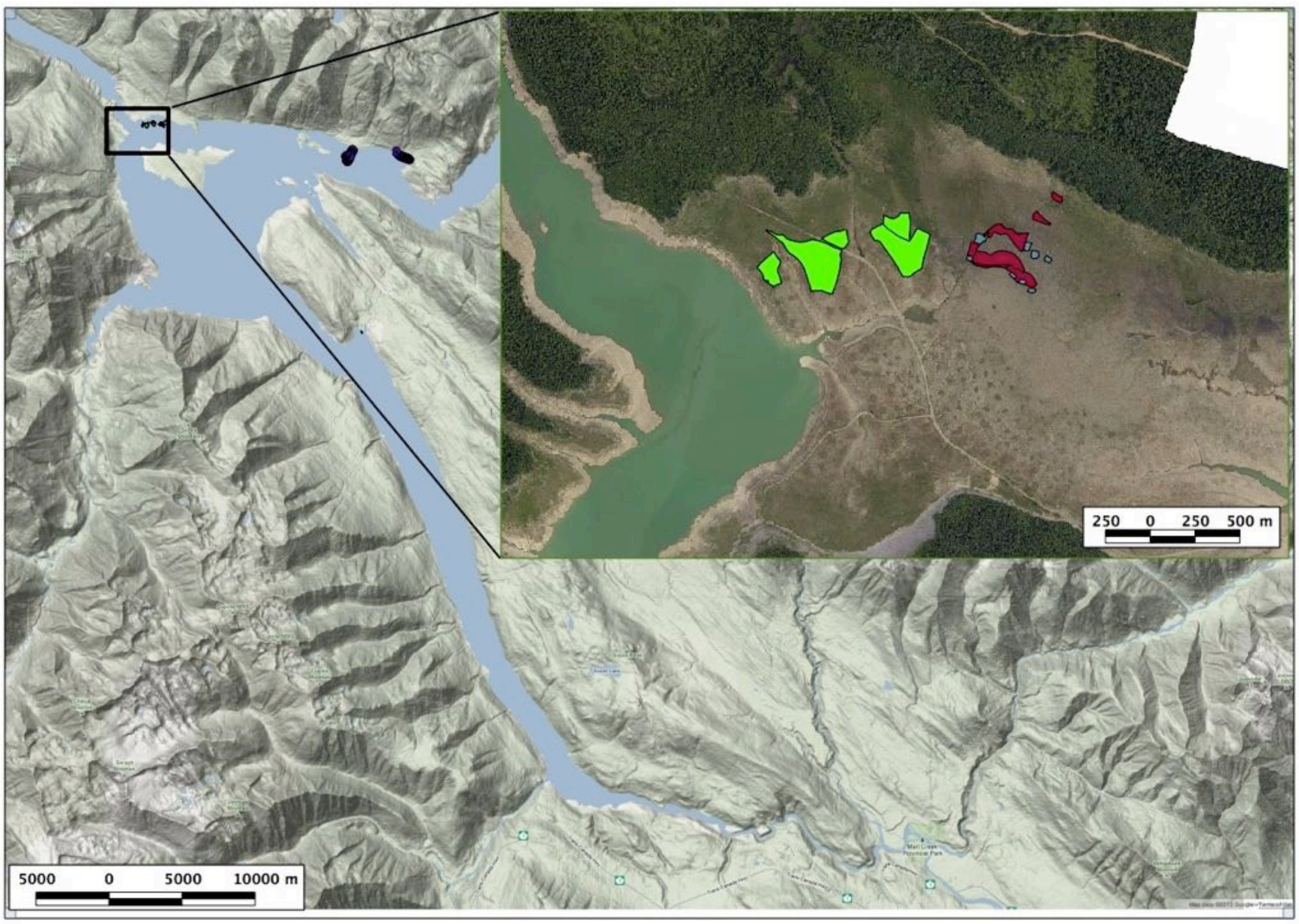

Figure 4-2: Location of the proposed planting site across from Bear Island, Kinbasket Reservoir. The green polygons in the inset image are the proposed planting areas for 2013. Areas planted in previous years are shaded red (2011) and blue (2010).

[2] Meters above sea level

The km88 site lies within the Interior Cedar – Hemlock mw1 Biogeoclimatic subzonevariant (Braumandl et al 2002). The site has a warm south aspect (165°) and has a slope angle of 5 per cent. The site is positioned on a bench of glacial lacustrine fines (slit and clay). Very little woody debris occurs on the site.

As evidenced by remnant stumps, the km88 site likely supported a forest dominated by cedar, hemlock, and spruce prior to inundation. Since the construction of the reservoir, the site is typically inundated annually, which has greatly modified the ecological characteristics of the site. Consequently, classifying the site using the provincial BEC classification is problematic (Hawkes et al 2007). A recent classification of vegetation associations within Kinbasket Reservoir (Hawkes et al 2007 and Hawkes et al 2010) indicated the presence of four vegetation communities at the site: Kellogg's Sedge (KS), Reed Canary Grass (RC), Marsh Cudweed–Annual Hairgrass (MA), and Wool-grass–Pennsylvania Buttercup (WB). Detailed descriptions of these communities are provided in Appendix 7.1.

Five potential treatment units (TU) were mapped as potential planting areas; however, as one is already well stocked with native *C. lenticularis* it will not be planted (see below). The five polygons occur between 746 and 751 m ASL.

4.4 Site Conditions

Investigation of the west site indicated that the Reed Canary Grass (RC) community extends from 753 m ASL to between 749 and 750 m ASL, depending on aspect and topography. The RC community is dominated by dense stands of Reed Canary Grass (*Phalaris arundinacea*) and has low species diversity (Hawkes et al 2008). Between 749 and 750 m ASL, the RC community transitions to the Kellogg's Sedge (KS) community and *P. arundinacea* cover declines creating openings for other vegetation. The KS community occurs between the 749 to 747 m ASL and is dominated by *C. lenticularis* at the higher elevations along the RC–KS boundary. Below 748 m ASL, *C. lenticularis* occurs sporadically down to 746 m ASL, where the community transitions to the Marsh Cudweed–Annual Hairgrass (MA) community. The Wool-grass–Pennsylvania Buttercup (WB) community occurs along the eastern edge of the site.

The sequence of vegetation communities described above was observed in all the treatment units except Treatment Unit (TU) 2. In TU 2, *C. lenticularis* occurred in relatively high densities down to 747 m ASL. This is likely related to the concave topography of the site, which likey results in greater water accumulation and moisture retention in the soil. Due to the high prevalence of *C. lenticularis* at this site, no planting is proposed in this treatment unit.

Treatment Units 1, 3, and 4 span the KS and MA communities and extend down in elevation to the lower extent of *C. lenticularis*. Treatment Unit 1 also extends partially into the WS community along the eastern boundary. Treatment Unit 5 extends up into a RC community where it is only moderately populated by *P. arundinacea*. Considerable planting opportunity exists for planting in these four units (TU 1, 3, 4, and 5).

Site and soil data are summarized in Table 4-1. Soils were exclusively fine textured silty clay loams with little to no sand or rock. LFH layers were thin (< 1 cm) except immediately under *P. arundinacea* or *C. lenticularis*. The A layers were poorly developed at the lower elevations (< 2 cm) but were much more established in the RC community (12 cm). The B-horizons were gleyed likely as a result of frequent and prolonged inundation by the reservoir. Rooting depths were restricted to the upper 15 cm. Wood debris accumulation was minimal (< 2 per cent cover) although a number of remnant burn piles occur through out the area.

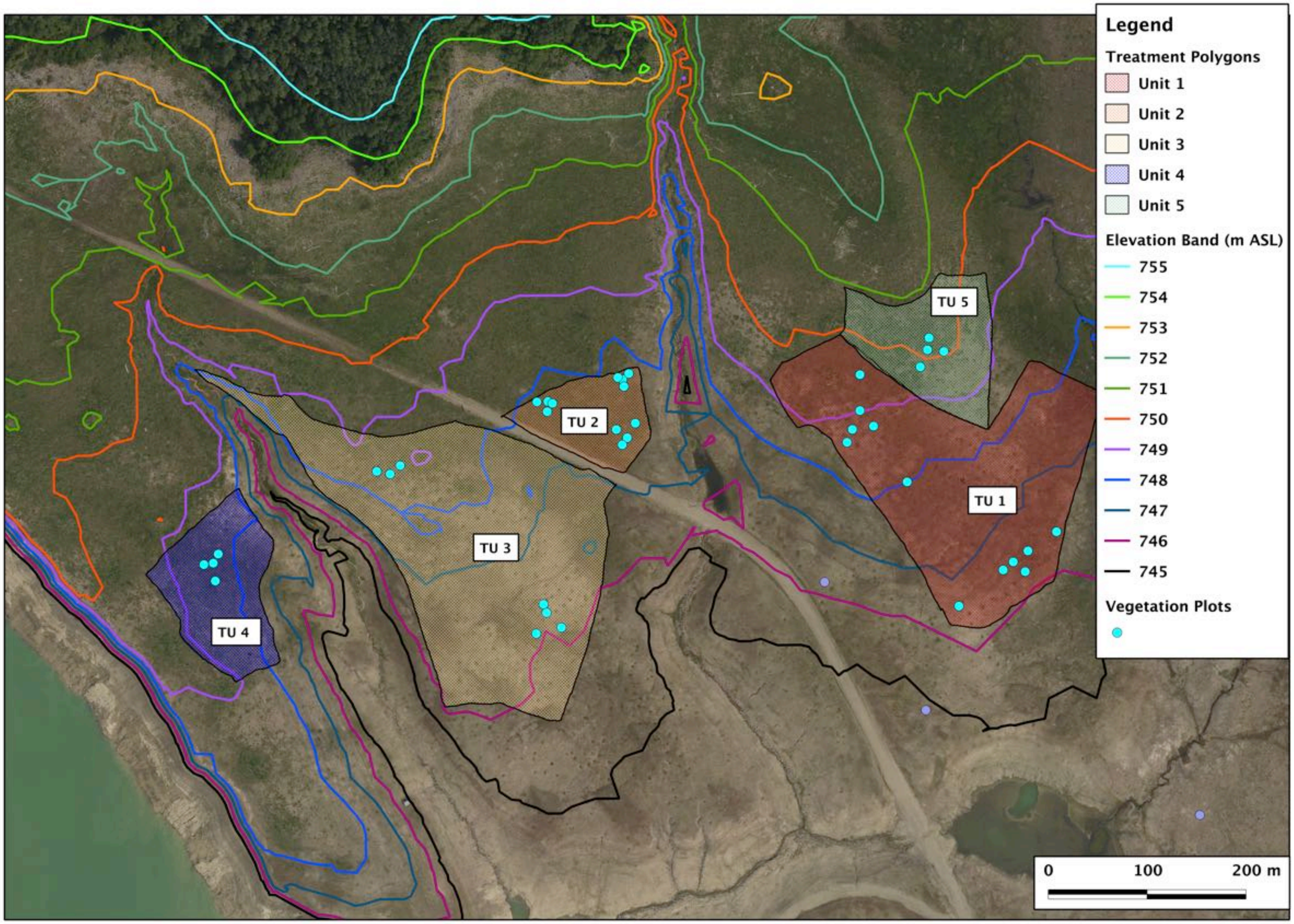

Figure 4-3: **Treatment area boundaries of five polygons established in May 2013. Planting is proposed for Units 1, 3, 4, and 5. Blue dots indicate the location of vegetation plots established May 5th and 6th, 2013.**

Table 4-1: General characteristics of potential treatment polygons.

TU*	Area (ha)	ELEV. (m ASL)	Slope	Aspect	Soil Texture	Soil Classification	Vegetation Communities	Exposed Soil %	Litter Cover %	Plant Cover %	Moss Cover %	Wood Debris Cover %
1	1.93	746–749	4%	160°	SiCL	Gleysol	MA/KS/WB	32.9	55.7	3.7	0.0	1.7
2	0.36	747	2%	155°	SiCL	Gleysol	KS	31.6	54.5	5.5	8.0	0.9
3	2.36	746–749	2%	150°	SiCL	Gleysol	MA/KS	43.4	47.8	6.3	0.1	1.3
4	0.6	747–750	7%	110°	SiCL	Gleysol	RC/KS/MA	12.1	83.2	4.5	0.4	0.0
5	0.6	748–750	5%	166°	SiCL	Gleysol	RC/KS	46.6	47.2	5.8	0.0	0.4

* Treatment Unit

** Veg Community: Kellogg's Sedge (KS), Reed Canary Grass (RC), Marsh Cudweed–Annual Hairgrass (MA), and Wool-grass–Pennsylvania Buttercup (WB).

Vegetation data (per cent cover and frequency) are summarized in Appendix 7.4. As the vegetation data were collected early in the season, only a handful of plants could be identified. Consequently, the vegetation data were of little value in developing the prescriptions.

4.5 Restoration Prescriptions

The overriding revegetation goal is to plant the sedge plugs at a site that has the greatest chance of establishment. The objectives for each site are to increase the abundance (density) of sedge to between 10,000 and 15,000 seedlings per hectare at TU 1, 3, and 4 and to extend the KS boundary into the adjacent MA or RC communities (Table 4-2). The target density for TU 5 is lower (between 5,000 and 10,000 ha) due the presence of *P. arundinacea* (Appendix 7.4) These densities compare with values observed in Treatment Unit 2 and as report by USDA (2013; Appendix 7.3.2).

Table 4-2: Revegetation Objectives and Current and Target Sedge Densities

TU*	Area (ha)	Current Density (sph)	Target Density (sph)*	Stocking Density (sph)	Revegetation Objectives
1	1.93	2,700	10,000 – 15,000	10,000 – 15,000	• Increase the abundance of *C. lenticularis* in the TU • Extend the KS community down to 746 m ASL into the adjacent MA community
2	-	5,900	-	-	• Do not plant. Retain as potential control
3	2.36	400	10,000 – 15,000	10,000 – 15,000	• Increase the abundance of *C. lenticularis* in the TU • Extend the KS community down to 746 m ASL into the adjacent MA community
4	0.6	1,000	10,000 – 15,000	10,000 – 15,000	• Increase the abundance of *C. lenticularis* in the TU • Extend the KS community down to 747 m ASL into the adjacent MA community
5	0.6	1,400	5,000- 10,000	5,000- 10,000	• Increase the abundance of *C. aperta* in the TU • Establish *C. aperta* among openings in the RC community. • Extend the KS community up to 751 m ASL into the adjacent RC community.

sph= seedlings per hectare

* A range of target densities are provided as the availability of planting sites will vary due to microsite conditions and the presence of existing vegetation.

5.0 Planting Plan

5.1 Sedge Plug Planting

LGL Limited will oversee the shovel planting of 68,020 sedge plugs (59,920 *Carex lenticularis* and 8,100 *C. aperta*) in four treatment polygons. The total area laid out for planting is 5.5 ha; however, the final planting area will depend on the stocking density, the density of existing vegetation, and site conditions. Planting will be carried out under subcontract by Columbia Extreme Contracting Limited.

Sedge plugs will be planted to the following specifications:

1. *Carex lenticularis* and *C. aperta* will be planted at 50 cm spacing and will be spaced 50 cm from established *Carex* plants.
2. *C. lenticularis* will be stocked at a density of 10,000 to 15,000 plugs per ha and *C. aperta* will be stocked at a density of 5,000 to 10,000 plugs per ha; however, these will vary due to the presence of existing vegetation and microsite conditions. Keefer et al 2010 reported planting densities of approximately 14,000 stems/ha due to "spacing away from naturals and unplantable substrates".
3. Planting will not occur below the lowest elevation of where *C. lenticularis* occur naturally.
4. Treatment Unit 5 (TU) will be planted with *C. aperta*, which is better able to compete with *P. arundinacea* (Wilson et al 2008).
5. Treatment Unit 2 will be retained as a control as it is already well stocked (approximately 5,900 seedlings per hectare).
6. As we have likely delineated more ground than can be planted, the lower portions of TU 3 (below 747 m ASL) will only be planted after TU 1, 4, and 5 and the upper portion of TU 3 have been planted. This will ensure preference is given to planting higher elevations over the lower elevations.
7. If all the sedge plugs are not planted after planting the proposed areas, TU 4 will be extended down to 747 m ASL to accommodate the overage.

5.2 Monitoring

5.2.1 Planting

Inspections of plantings will be conducted regularly to ensure: 1) planting occurs on acceptable microsites; 2) plugs are properly planted and not damaged in the process; and 3) plugs are planted at the specified spacing. FS704D planting inspection forms will be completed to QA the sedge planting (Appendix 7.5). Planted areas and monitoring plots will be georeferenced using precision GPS (submetre SX Blue) and will be provided in Arc compatible format (ESRI Shapefiles).

5.2.2 Post Treatment Monitoring

Pretreatment monitoring plots were established following the CLBMON-09 methodology (Fenneman and Hawkes 2011). Post treatment monitoring will be coordinated with CLBMON-09 and will occur in June and July 2013. A follow up survey will be conducted in the fall of 2013 to assess survival following inundation of the planted plugs.

5.2.3 Impacts and Benefits

The primary revegetation objective is to achieve a high level of establishment. For this project, a high level of establishment is defined as > 50 per cent survival over three years, a moderate level of establishment as 10 to 50 per cent survival over three years, and a poor level of establishment at < 10 per cent survival over three years.

5.2.4 Environmental Impacts

Negative environmental impacts are not anticipated as result of the sedge planting. While the likelihood of encountering a nest (bird) during the planting window (May 15 to May 31) is extremely low, a wildlife biologist will be on site to survey the treatment areas immediately prior to planting. If an active nest is found, the planting boundaries will be adjusted to provide a 20 m buffer around the nest.

Potential positive potential environmental benefits include:

- An increase in shoreline productivity (arthropod abundance) prior to inundation
- An increase in littoral productivity when inundated
- an increase in habitat for ground foraging and ground nesting birds (e.g., Savannah Sparrow) by increasing ground cover.
- An increase in foraging habitat for common garter snakes (*Thamnophis sirtalis).*

5.2.5 Archaeological Resources

- The planting of sedge plugs by hand will have no impact on archaeological resources.
- Access to the site will follow existing travel routes (roads and skid trails) and will not result in ground disturbance.
- The planting of sedge plugs will offer little to no protection to archaeological resources from erosion resulting from reservoir fluctuations.

5.2.6 Erosion

- The planting of sedge plugs will offer little to no protection against erosion. Further, protection against erosion is not required for sedge establishment.

5.3 Schedule

All work will be completed in 2013. A tentative schedule is provided below; however, the dates of each task are flexible and depend on environmental conditions, site access and reservoir operations.

Task	Schedule*
Planting of seedlings	May 15 to 31, 2013
Post treatment monitoring	June – July 2013
Post inundation monitoring	September or October 2013
Draft Report	31-Oct-13
Final Report	15-Dec-13

*Schedule may vary relative to environmental conditions, access, and reservoir operations

5.4 Coordination with other WLR Studies

Planting at the proposed sites will not conflict with other WLR studies or physical works:

- The project managers for CLBMON-09, CLBMON-10, CLBMON-11A, CLBMON-37, CLBMON-58, and CLBMON-61 have review the proposed planting treatment and no concerns have been brought forward regarding potential conflict. Follow up monitoring of the planted sites will be coordinated CLBMON-09.
- There is no conflict with previous work conducted under CLBWORKS-01 as the proposed planting areas have not been planted previously.
- As described previously there should be no conflict with the Kinbasket debris removal program (CLBWORKS-41).

6.0 References

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7.0 Appendices

7.1 CLBMON-09 Sampling Methodology (Hawkes et al 2011)

7.1.1 Survivorship

The survivorship of plants used in the revegetation program was assessed in 2011 through the use of two or three (depending on the size of the revegetation polygon) 5 x 5 m plots that were established in each combination of revegetation type, elevation strata, vegetation community code and geographic area. Only revegetated areas were assessed for survivorship. The 5 x 5 m plots were positioned to represent the overall condition of the plants in each plot. Within these plots the total number of seedlings or stakes that were observable was recorded, as well as the number of these individuals that were dead and the number that were alive. This enabled a direct assessment of the survivorship of the planting treatments by comparing the number of plants that had survived since planting and the number that had died. In addition, the overall vigour of the plants in the plot was assessed, with each plot being assigned a vigour value of good, moderate or poor, based on professional judgement.

7.1.2 Field Sampling

Once on the ground, a researcher stood at the predetermined plot centre and threw the 0.71 m x 0.71 m (0.5 m^2) quadrat three times around the point within the plot to be sampled. This is a standard technique of describing non-forest vegetation (Mueller-Dombois and Ellenberg 1974, Bonham 1989). The location of the centre of the plot was marked with a rebar stake driven into the ground to the height of ~10 cm to 15 cm. The top of each piece of rebar was capped with a bright orange construction safety cap to (a) facilitate plot relocation in subsequent sampling years and (b) lessen the hazard of hitting it. The location of each 0.5 m^2 quadrat was georeferenced using a precision (submetre) SX-Blue GPS unit. Every quadrat was oriented north–south.

7.1.3 Vegetation Data

Vegetation within each quadrat was identified to species, or in some cases, to genus, and the percentage cover was visually estimated following Mueller-Dombois and Ellenberg (1974). Plant nomenclature followed Douglas et al. (1998*a*, 1998*b*, 1999*a*, 1999*b*, 2000, 2001*a*, 2001*b*, 2002) with current amendments. Vegetation data were collected based on a modification of the FS882 (3) Vegetation Form (Luttmerding et al. 1998). Vegetation was listed by layer:

- A1: Dominant trees
- A2: Main canopy trees
- A3: Sub-canopy trees
- B1: Tall Shrubs (woody plants 2 m to 10 m tall)
- B2: Low Shrubs (woody plants less than 2 m high)
- C: Herbs (forbs and graminoids)
- D: Moss, lichen, seedlings and substrate surface

Estimates of species cover as a proxy for species abundance were conducted in the field visually and separately for each species. Species cover was estimated in each quadrat, and a mean per cent cover per quadrat was computed in office. Percentage cover was visually estimated and rounded using percentage binning developed by Domin and Krajina (Krajina 1969):

- <0.01% - traces
- <0.1% - rare and solitary species
- <1% - scattered small plants
- 1-10% - rounded to nearest 1 per cent
- 11-30% - rounded to nearest 5%
- 31-100% - rounded to nearest 10%.

Vegetation vigour was assessed using a qualitative scale of good, moderate, and poor. Good was defined as the majority of plant (> 75 per cent) surviving and having an outward appearance of good health (no brown leaves, healthy looking plants). Moderate was defined as most plants (between 5-0 and 75 per cent) surviving and mostly healthy (some yellowing or wilting) and low was defined as poor survivorship (> 50 per cent) and obvious signs of poor health (brown levels, more than 50 per cent of each plant was wilted or yellowed, dead or dying plants). Vigour was assessed with plant survivorship.

7.2 Growth Requirements of *Carex lenticualris and C. aperta*

7.2.1 *Carex lenticularis* (Fenneman et al 2012).

Kellogg's Sedge (*Carex lenticularis* var. *lipocarpa*) is found in areas where water levels fluctuate, such as lakeshores, riverside pools and the margins of reservoirs (Wilson et al. 2008). This species has medium anaerobic capacity and low drought tolerance, and is adapted to medium- and coarse-textured soils but not finer substrates (USDA-NRCS 2011). It is a common, naturally-occurring species in the drawdown zone of Kinbasket Reservoir, and its capacity to tolerate fluctuating water levels made it a logical choice for revegetation. Kellogg's sedge is known to establish on disturbed sites (Wilson et al. 2008), which lends further credence to its use for revegetation. Furthermore, once established, this species has the potential to form a dominant cover if the tussocks are densely packed enough to exclude competition and the substrate remains appropriately saturated (Wilson et al. 2008). Field observations of revegetated areas have indicated that the success of individual plantings in the reservoir is highly variable, with some being highly successful in establishing from seedling plugs while others fail completely. This is likely related to ∂the hydrology and substrate at each site as these factors are integral to the success of revegetation.

Kellogg's Sedge is said to have a low seed spread rate, low seedling vigour and slow vegetative spread (USDA-NRCS 2011). A contrasting account claims this species has the ability to produce a large number of seeds that readily sprout on soils exposed along receding water lines (Wilson et al. 2008). This latter reference agrees with field observations around Kinbasket Lake, where seedlings of this species are common on areas of bare substrate that are exposed as the reservoir's water level drops. The fate of these seedlings is not known, but presumably prolonged periods of inundation or sediment deposition results in extremely low survivorship.

Kellogg's Sedge has been less intensively studied than Water Sedge (*C. aquatulis)*, but it likely shares many adaptations and physiological responses. It should be noted, however, that Kellogg's Sedge is considered to be a facultative wetland species and it has short, ascending rhizomes that form individual large tussocks, whereas water sedge is considered to be an obligate wetland plant and it has long, rapidly spreading rhizomes originating from a genet leading to a series of ramets. Regardless of their differences in growth form, it is expected that Kellogg's sedge undergoes similar responses to that of Water Sedge—translocation of resources from aboveground biomass to the roots, formation of aerenchyma, and a decrease in leaf gas exchange—when it experiences prolonged anoxic or hypoxic conditions. Direct observations and indirect evidence pertaining to other *Carex* species with similar hydrologic requirements seem to add weight to this suggestion (e.g., Visser et al. 2000, Steed et al. 2002, Wilson et al 2008).

7.2.2 Growth requirements of *C. aperta* and *C. lenticularis* (www.plants.usda.gov).

Growth Requirements	*C. aperta*	*C. lenticularis*
Duration	Perennial	Perennial
Growth Habit	Graminoid	Graminoid
Adapted to Fine Textured Soils	No	Yes
Adapted to Medium Textured Soils	Yes	Yes
Anaerobic Tolerance	Medium	None
Drought Tolerance	Low	None
Fertility Requirement	Medium	Low
Fire Tolerance	High	High
Frost Free Days, Minimum	85	60
Moisture Use	Medium	High
pH, Minimum	4.9	5.5
pH, Maximum	6.7	7
Planting Density per Acre, Minimum	2700	2700
Planting Density per Acre, Maximum	4800	11000
Precipitation, Minimum	32	24
Precipitation, Maximum	55	60
Root Depth, Minimum (inches)	12	14
Shade Tolerance	Tolerant	Intolerant

7.3 Vegetation Data

Table 7-1: Per cent cover of vegetation observed in 0.5 sq meter quadrats.

Treatment Unit	N	CARELEN	PHALARU	DESCDAN	EQUIVAR	ERYSCHE	PLAGSCO	POLYAVI	POLYPER	DICOT SEEDLING	GRASS SEEDLING
1	6	3.5	3.0	2.0	0.1	0.1	0.3	0.3	0.1	0.1	0.1
2	9	1.8	1.1			0.1	3.6		0.3	0.8	0.9
3	6	0.1	0.1		0.6		0.4	0.1	0.4	3.6	1.1
4	3	4.0	6.0				0.1	3.6	0.1	3.6	0.1
5	3		6.0		0.1	2.4		0.1	0.1	0.1	0.1

Table 7-2: Frequency of plants species detected in 0.5 sq meter quadrats.

Treatment Unit	N	CARELEN	PHALAR	DESCDAN	EQUIVAR	ERYSCHE	PLAGSCO	POLYAVI	POLYPER	DICOT SEEDLING	GRASS SEEDLING
1	6	0.3	0.0	0.2	0.3	0.3	0.8	0.7	0.8	1.0	0.3
2	9	0.9	0.4	0.0	0.0	0.1	0.2	0.0	1.0	0.8	0.9
3	6	0.2	0.2	0.0	0.3	0.0	1.0	0.3	0.5	1.0	1.0
4	3	0.7	0.7	0.0	0.0	0.0	0.3	0.7	0.7	0.7	1.0
5	3	0.0	0.7	0.0	0.7	1.0	0.0	0.3	0.3	0.7	0.3

CARELEN	*Carex lenticularis*	Kellogg's Sedge
PHALAR	*Phalaris arundinacea*	Reed Canary grass
DESCDAN	*Deschampsia danthonioides*	Annual Hairgrass
EQUIVAR	*Equisetum arvense*	Common Horsetail
ERYSCHE	*Erysimum cheiranthoides*	Wormseed Mustard
PLAGSCO	*Plagiobothrys scouleri*	Scouler's popcornflower
POLYAVI	*Polygonum aviculare*	Common Knotweed
POLYPER	*Polygonum persicaria*	Lady's-thumb
DICOT SEEDLING		
GRASS SEEDLING		

7.4 Plot Photos

7.4.1 Treatment Unit 1

7.4.2 Treatment Unit 2

No Images

7.4.3 Treatment Unit 3

7.4.4 Treatment Unit 4

7.4.5 Treatment Unit 5

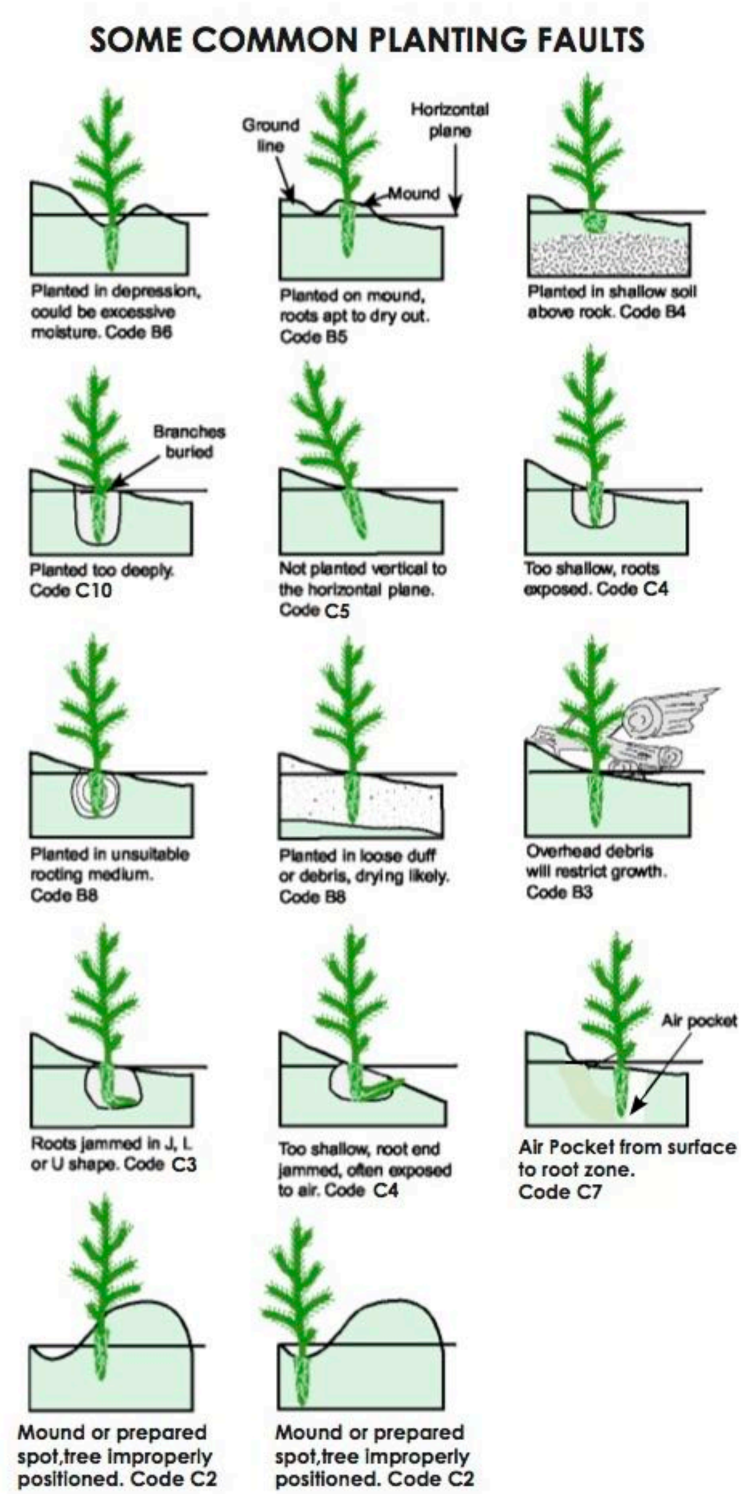
7.5 Planting Quality

C. Planting Quality

Planting quality must be discussed at the pre-work conference and planting quality faults clarified.

1. Inadequate planting spot preparation as defined in the contract
2. Tree improperly positioned on a prepared spot or mound
3. Improper root or plug placement – J or U roots
4. Exposed roots or plug
5. Tree not straight
6. Improper shading as defined in the contract
7. Air pocket (Any air channel from the surface to the root zone that may potentially cause the plug to dry out. Air pocket faults must be clearly defined at the pre-work and they should only be assessed through proper root excavation.)
8. Too loose
9. Too shallow
10. Too deep
11. Unacceptable backfill (backfilling planting hole with litter layer, or snow)

Further explanation of planting faults and normally accepted standards may be found in the planting chapter of the *Silviculture Manual.*


SOME COMMON PLANTING FAULTS
Ground line
Horizontal plane
Mound
Planted in depression, could be excessive moisture. Code B6
Planted on mound, roots apt to dry out. Code B5
Planted in shallow soil above rock. Code B4
Branches buried
Planted too deeply. Code C10
Not planted vertical to the horizontal plane. Code C5
Too shallow, roots exposed. Code C4
Planted in unsuitable rooting medium. Code B8
Planted in loose duff or debris, drying likely. Code B8
Overhead debris will restrict growth. Code B3
Air pocket
Roots jammed in J, L or U shape. Code C3
Too shallow, root end jammed, often exposed to air. Code C4
Air Pocket from surface to root zone. Code C7
Mound or prepared spot, tree improperly positioned. Code C2
Mound or prepared spot, tree improperly positioned. Code C2