Bridge River Project Water Use Plan

Carpenter Reservoir Drawdown Zone Re-Vegetation Program

Implementation Year 3

Reference: BRGWORKS-1

BRGWORKS-1 Carpenter Reservoir Drawdown Zone Riparian Enhancemei Program

Study Period: 2016

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Splitrock Environmental
Odin Scholz B.Sc.

March, 05, 2018

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Executive Summary

In 2016 the third year of the WORKS-1 re-vegetation program, treatment trials built upon trials and lessons learned from 2014 and 2015 efforts. Focal species for planting were lakeshore sedge (*Carex lenticularis*), bluejoint reedgrass (*Calamagrostis canadensis*) and foxtail barley (*Hordeum jubatum*). Planting treatments were carried out in polygon areas at the Low Mud Flat, Gun Creek Fan East and Gun Creek Fan west sites. Seeding trials were expanded to cover a 10 ha area on the Low Mud Flat. The majority of the area was seeded with the non-native annual grass fall rye. Fall rye was planted with the intention of creating a fast cover to mitigate dust generation and to alter microsite conditions through the addition of organic matter above and within the substrate and to recruit some short term roughness to the substrate in the form of stubble. Seeding trials also included sowing locally collected lakeshore sedge and Canada wildrye (*Elymus canadensis*) as well as mechanical scarification only.

Container plants of black cottonwood (*Populus balsamifera ssp. trichocarpa*) and trembling aspen (*Populus tremuloides*) were planted into treatment trial polygons on the Gun Creek Fan East and West Sides. A small polygon of Canada wildrye plants was planted at the Gun Creek Fan East . Live stake cuttings of black cottonwood and willow were planted into the upper drawdown and buffer zone elevations on the Gun Creek Fan West side. Cuttings were planted into excavated trenches, watered, backfilled, watered and trimmed. Several trenches included mounds and ditches to create microsites that could encourage colonization and create beneficial conditions such as protecting cuttings from mechanical damage by driftwood. Areas of disturbance created while digging cutting trenches were planted with bluejoint reedgrass plugs.

Water levels for Carpenter Reservoir allowed for the lowest treatment trials to remain above water until the first week of August, longer than the 17-year average inundation schedule. Full pool levels did not reach most of the planted cuttings from 2016.

A breeding songbird survey was conducted in late May 2016 at target re-vegetation areas and nearby control areas with the drawdown zone. Twenty-three species of songbird were recorded during the survey. The site most diverse in vegetation composition and structure on the buffer mud flats had the greatest songbird diversity. The sites low in vegetation cover and structure, the Low Mud Flat and the Gun Creek Fan East, had the lowest songbird diversity.

A weather station equipped with a programable camera was installed in April 2016. The camera was programmed to take images every 5 minutes during daylight hours. 15000 images were collected between April and August and then analysed. Four per cent of the captured images (539) were identified as containing a dust event. Most dust events occurred in May and June. 66% of events were considered small and 9% large. Without prior sampling, it is difficult to say if the fall rye treatment reduced dust storm generation. Dust events were observed to occur through the rye treatment area. Most of the observed dust events were originating along the eroding edges of the Bridge River. Dust events dropped to near nil when reservoir levels covered the Low Mud Flat.

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Table 1 **BRGWORKS-**1 Status 2015

OBJECTIVES, MANAGEMENT QUESTIONS and HYPOTHESES after 2014			
Study Objectives **Numbers relate to MQ.**	**Management Questions**	**Management Hypotheses**	**Year 2016 (Status)**
To design and implement a reservoir planting program for the Western end of Carpenter Lake focusing on the area between Tyaughton Lake Road Junction and the Gun Creek Fan.	MQ1 Will the planting of vegetation in the drawdown area mitigate the effects of dust storms resulting from reservoir drawdown particularly in the western end of the reservoir near the Town of Gold Bridge?	H1 The planting of vegetation in the drawdown area does not mitigate the effects of dust storms resulting from reservoir drawdowns particularly in the western end of the reservoir near the Town of Gold Bridge.	Initial observations indicate dust is generated from areas of fine sands located along the immediate eroding river banks during low pool times of year. Weather station with camera was set up in April 2016 and images are captured on a regular basis. Initial year data set was 15000 images of which 4 % or (539) had dust events. Events most frequent in May and June 2016. Observed dust events were from a total of 93 wind storms. Dust abated by August when reservoir levels were covering low mud flats.
To focus on the planting of appropriate species of vegetation this is done using information gained in the BRGMON-2 program.	MQ2 Will the planting of vegetation in the drawdown area increase the aesthetic quality and recreational opportunities in the western end of the reservoir?	H2 The planting of vegetation in the drawdown area does not increase the aesthetic quality and recreational opportunities in the western end of the reservoir.	Public survey conducted 2014-2015 baseline inputs of public perception of reservoir aesthetic and recreational use. Recreation use of region extreme varied. Aesthetic perception >50% negative. Also included questions regarding wildlife and dust storm. Public feedback that 2016 fall rye treatment was positive aesthetically.

To conduct evaluations of the program to assess the degree to which the planting program helps to establish natural re-colonization of the area from Tyaughton Lake Road Junction to Gun Creek Fan (This will be covered under the BRGMON-2 program).	MQ3a Will the planting of vegetation enhance the quality of riparian habitats to increase their potential to support wildlife populations and provide localized improvements in the quality and productivity of aquatic habitats in the reservoirs?	H3a The planting of vegetation in the drawdown area does not enhance the quality of riparian habitats to increase their potential to support wildlife populations and provide localized improvements in the quality and productivity of aquatic habitats in the reservoirs.	Wildlife sign and species observations recorded at treatment plots. Information on animal presence information. Mule deer use at site. Incidental observations during field work confirm Peregrine falcon (Red listed) of Gun Creek Fan East site. Other species with confirmed use at target re-vegetation site mule deer, beaver, Canada geese, mountain bluebirds, river otter, long-toed salamander, western toad, horse, cow. Breeding bird survey was conducted in 2016 to form a baseline of breeding songbirds in target re-vegetation and control areas 23 species in survey. LMF and GCFE lowest diversity. Most diverse vegetation structure and composition (Buffer mud flat) had most diversity in song birds.
To conduct evaluations of the program in order to assess the degree to which the planting program helps enhance the quality of riparian habitats, increases their potential to support wildlife populations, and provide localized improvements in the quality and productivity of aquatic habitats in the reservoir.	MQ3b Will planting of vegetation provide localized improvements in the quality and productivity of aquatic habitats in the reservoir?	H3b The planting of vegetation in the drawdown area does not enhance the quality and productivity of aquatic habitats in Carpenter Reservoir.	Need to reconnect with BRGMON 4 (Carpenter Reservoir and Middle Bridge River Fish) and BRGMON 10 Carpenter Reservoir Productivity Model, Study programs to include consideration of WORKS 1 Re-vegetation region in their studies.

1. Introduction

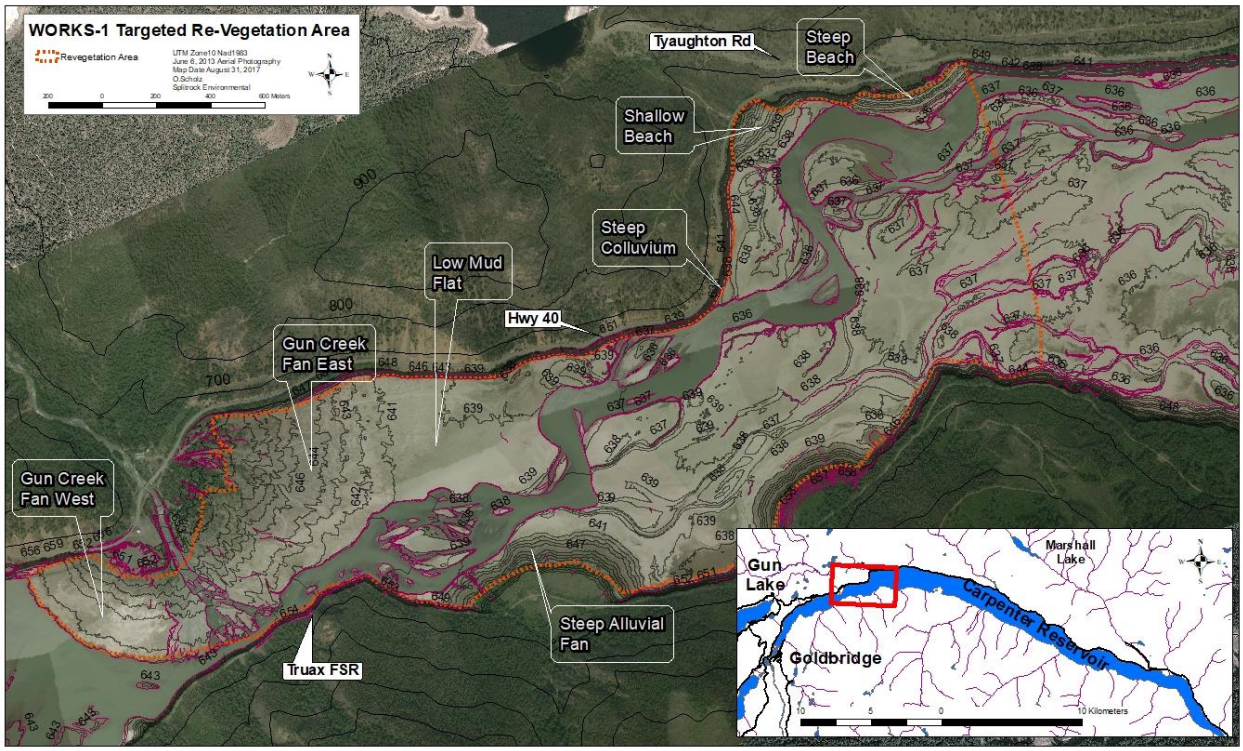
2016 was year three of the BRGWORKS-1 five-year re-vegetation project on Carpenter Reservoir drawdown zone. The objectives of the BRGWORKS-1 project are to identify appropriate species of vegetation and effective methods for re-vegetation and promotion of natural re-colonization in a section of the drawdown zone of Carpenter Reservoir. Trials have focused on 5 terrain classes in the target restoration area: Steep Beach (STB), Shallow Beach (SHB), Gun Creek Fan East (GCFE), Gun Creek Fan West (GCFW), Steep Alluvial Fan (SAF) and Low Mud Flat LMF (MAP 1). The re-vegetation trials have included planting, seeding, live stake cuttings and mechanical treatments. With the exception of fall rye seed all species used in the project are native species of vegetation found to occur naturally in the Carpenter Reservoir Drawdown Zone.

The BRGWORKS-1 program has followed a staged adaptive approach to re-vegetation. 2016 efforts expanded upon the test plots established in the 2014 (Scholz, 2014) and the re-vegetation trials of 2015 (Scholz, 2015). 2014 plots were targeted plantings of nursery grown plugs of lakeshore sedge (*Carex lenticularis*), foxtail barley (*Hordeum jubatum*), blue wildrye (*Elymus glaucus*), bluejoint reedgrass (*Calamagrostis canadensis*), slender wheatgrass (*Elymus trachycalus*), fowl bluegrass (*Poa palustris*) and Baltic rush (*Juncus balticus*). In 2014 seeding trial plots 1mX1m in size were hand sown with locally collected bluejoint reedgrass and Canada wildrye (*Elymus canadensis*) seed. Live stake cutting trials were carried out by hand using planting bars in 2014 at the STB, SHB and SAF. An excavator was used to plant cuttings at the GCFE and GCFW sites.

2015 efforts focused on planting lakeshore sedge and, bluejoint reedgrass into trial polygons at five of the six terrain types. The exception was the Steep Alluvial Fan site that had cutting treatments only in 2015. In 2015 additional native grass polygons planted with foxtail barley, foul bluegrass and Canada wildrye (*Elymus canadensis*) were realized on the Gun Creek Fan West. 2015 seeding trials were expanded into polygons in the Low Mud Flat (642-640m elevation). Fall rye (*Secale cereale*) and lakeshore sedge seed were planted using a tractor and pull-behind seeder in the LMF polygons. Bluejoint reedgrass, foul bluegrass, fall rye and an upper reservoir seed mix were sown in trials with a tractor and seeder at elevations between 644-647m on the GCFE. In 2015 live staking of black cottonwood (*Populus balsamifera ssp. trichocarpa*) and local willow species *(Salix sp.)* were planted by hand in polygons on the STB, SHB, SAF, GCFE and GCFW sites. In addition, an excavator was used to plant larger diameter cuttings at the mouth of Gun Creek on the GCFE and GCFW sites.

In 2016 efforts concentrated larger area planting of lakeshore sedge polygons in the LMF zone, targeting between 640-644m elevations. Planting of native grass plugs was carried out on Gun Creek Fan East and West. Seeding trials were focused on large areas on the LMF at and below 640m elevation where fall rye was seeded into two large treatment trial polygons with additional seeding trials of Canada wildrye and lakeshore sedge. Cuttings trials were carried out by hand on the STB, SHB and GCFE and GCFW. An excavator was employed for additional cuttings treatments on the GCFW side. A water truck was hired to assist in watering the cuttings planted by excavator.

Dust storm frequency was monitored through images captured from the nearby weather station installation.

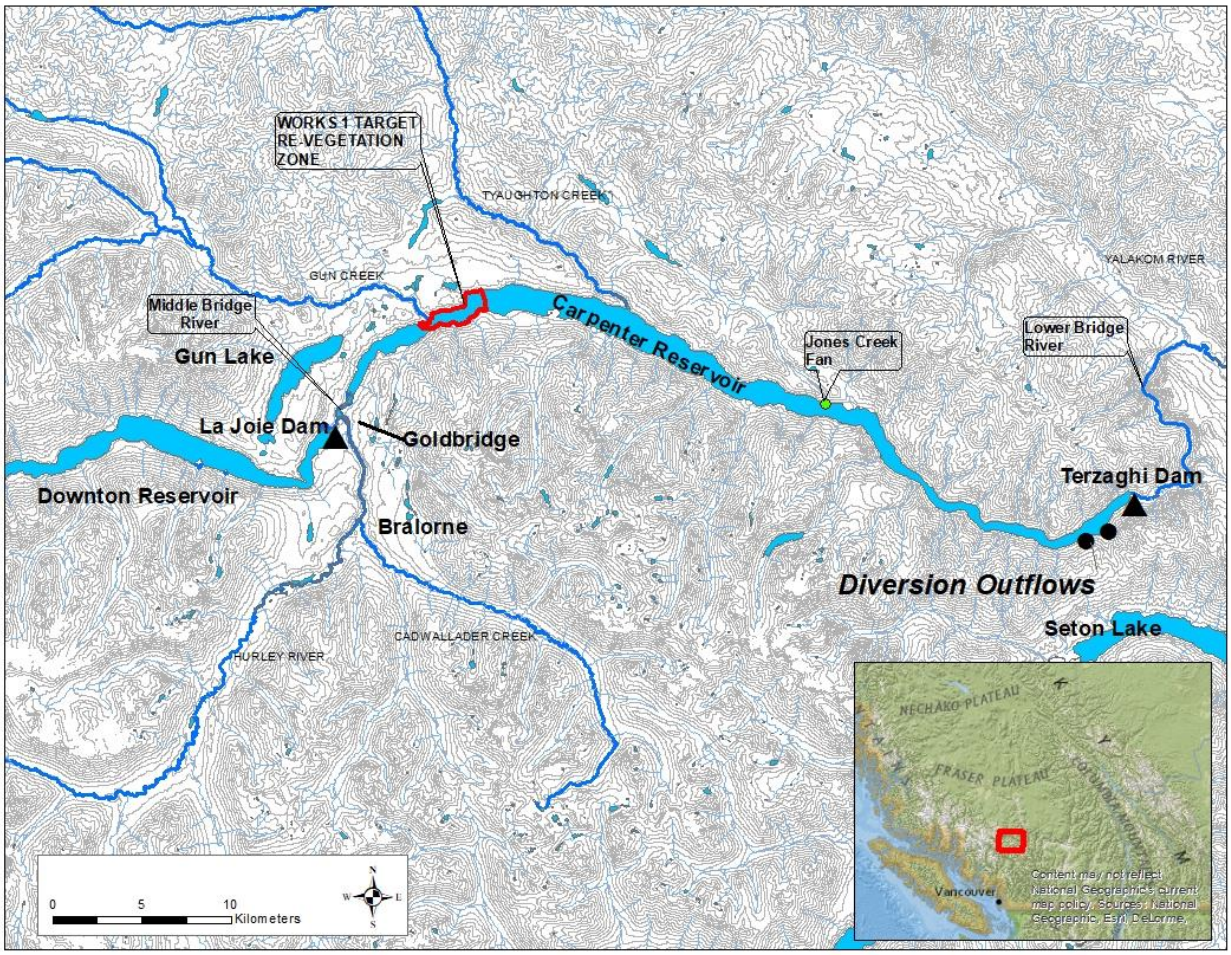


MAP 1. Target re-vegetation area of the Carpenter Reservoir drawdown zone. Terrain type areas referenced in text of the report are identified.

1.1 Project Location

The WORKS-1 re-vegetation project is focused on an area of the Carpenter Reservoir drawdown zone just east of the town of Goldbridge BC (MAP 2). The site is approximately 280km north-east of Vancouver British Columbia in the Coast-Cascade mountains. The area is located on St'at'imc traditional territory. The project area is within the Southern Interior ecoprovince and is within the Interior transitional ranges ecoregion. The project area is within the Interior Douglas-fir very dry cold biogeoclimatic zone.

The target re-vegetation area includes the site that was once the historic town site of Minto BC. The town site is now within the reservoir drawdown zone. The Gun Creek fan that is central to much of the WORKS-1 efforts area has a free BC Hydro public recreation campground on the east side of the fan and a Ministry of Transportation and Infrastructure gravel pit on the west side.



MAP 2 Carpenter Reservoir Region and geographic location in the province. 292 ha targeted re-vegetation region of the Carpenter Reservoir WORKS-1 Re-vegetation Project

2. Methods

2.1 Re-Vegetation

During 2016 re-vegetation efforts on Carpenter Reservoir were carried out at four terrain treatment sites within the target re-vegetation zone; Shallow Beach, Low Mud Flat, Gun Creek Fan East and Gun Creek Fan West. Re-vegetation techniques in 2016 included planting potted plants up to 1gallon in size, plugs and live stake cuttings, and expanded area seeding trials using fall rye, lakeshore sedge and Canada wildrye. The three main treatment techniques are described on a site by site basis.

2.1.1 Potted Plants

Seed used to grow nursery stock of lakeshore sedge, bluejoint reedgrass, foxtail barley and foul bluegrass was collected within 5 km of the treatment sites. Canada wildrye, black cottonwood was collected within 100km of the site. Trembling aspen (*Populus tremuloides*) was purchased from a regional nursery. As in 2015, seed was propagated and grown locally at Splitrock Native Plant Nursery in Lillooet. Seeds were started soon after harvest and held over winter. Plants

were grown in a temperature controlled greenhouse to extend the growing season. Most plants were grown as plugs in styro blocks. Black cottonwood and trembling aspen were planted out in 1gallon containers. A small batch of Canada wildrye grass was also planted out into 1 gallon containers.

Lakeshore sedge seedlots were two different ages (sown at two times) - late summer 2015 (Older stock) and again in February 2015 (Younger)- in a heated greenhouse. Native grasses were sown in the fall and overwintered at the nursery. Cottonwoods and aspen plants were at least a year and a half old.

Plants were transported to the site in treeplanting style boxes and stored in a Fiberglass Insulated Seedling Transport (F.I.S.T^{tm}) canopy equipped truck to regulate temperature and moisture. On site silva cool tarps were used to shade and control plant temperatures prior to them being planted. Crew technicians transported plants in planting bags lined with silvacool inserts to maintain optimum temperatures for plants. Planting was carried out using standard tree planting shovels. Planting sites and plants were watered after planting.

2.1.2 Live Stake Cuttings

Black cottonwood (*Populus balsamifera*) and willow species (*Salix sp*.) were harvested from the local region. Willow was harvested within 5 km of the planting site, and cottonwoods were transported from within 60 km of treatment site. Cottonwoods were harvested from a gravel pit on the Jones Creek alluvial fan on Carpenter Reservoir (MAP 2). Cuttings were harvested, stripped of side branches and transported to the planting sites. Cuttings were soaked for at least 24-hours prior to planting and stored in the shade prior to planting (Figure 1). Cottonwood and willow cuttings ranged in diameter from 2 to 5cm at the narrow end. Cuttings were planted into trenches excavated to 1-1.5m in depth. Cuttings were hand planted in the base of the trenches (Figure 2). Trenches were dug by and excavator on the Gun Creek Fan West (Figure 3). Trenches were watered prior to backfilling and watered a second time after backfilling (Figure 4, Figure 5). Cuttings were trimmed back using loppers after planting. Between 10 and 30cm of the cutting was maintained above ground. In 2016 cuttings planting was focused on the Gun Creek Fan West side and planted at elevations above 647m placing most of them within the buffer zone and above usualy flooding and the disturbances associated with it.

Hand planting of cutting using steel bars was carried out at the Steep Beach site. Bars were utilized to make holes up to 1.5m deep and cuttings were then inserted into the holes, watered and tamped down to ensure a firm contact of cutting with the substrate. Cuttings were watered a second time after planting. All efforts were made to plant the cuttings over a metre deep. Allowing for variable and coarse rocky substrates hand planted cutting depths ranged from 0.5 to 1.5m.

Figure 1 live stake cutting staged on the GCFW just prior to planting. 13 May 2016

Figure 2 Planting cuttings in the bottom of trenches 20 April 2016.

Figure 3 Gun Creek Fan West side, excavator digging trenched for live stake cutting planting. 18 May 2016.

Figure 4 Watering cuttings trenches on the Gun Creek Fan West, prior to backfilling with excavator.20 April 2016

Figure 5 Watering cuttings after they were backfilled by excavator.20 April 2016.

2.1.3 Seeding Trials

In 2016 seeding trials were expanded from 2015 trials out across the 640m elevation on the Low Mud Flat accessed from the Gun Creek Fan East side (MAP 1). Seeding was carried out using a tractor with a pull-behind seeder (Figure 6). The seeder was equipped with a seed hopper, plough discs, a chain grid harrow and compactor.

Lower Mud Flat trial seeding plots were laid out to test three seeding treatments and a control:

1. Fall rye
2. Lakeshore sedge
3. Canada wildrye
4. Mechanical scarification with no seeding

Seeding treatments were applied along a 10.5ha area paralleling the Middle Bridge River on the lower mud flat. Straight fall rye sown areas were divided by the three polygons of native species and mechanical scarification treatments.

Figure 6 Tractor with seeder sowing fall rye on Low Mud Flat 13 April 2016.

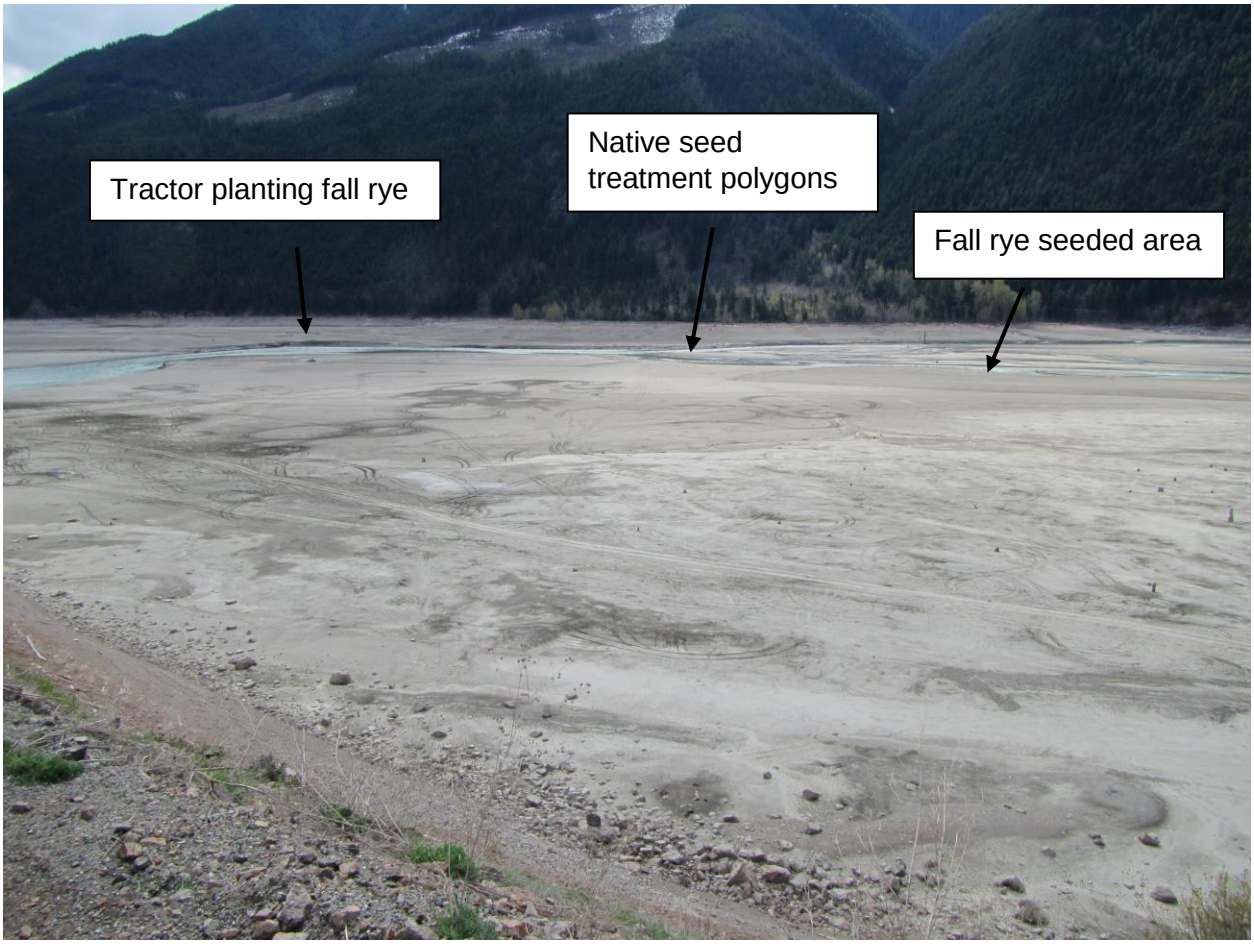


Figure 7 Photo taken of tractor seeding in progress. Photo taken from side of Hwy 40 overlooking LMF 13 April 2017.

2.2 Dust Storms

One of the objectives of the WORKS 1 program is to reduce the frequency of dust storms occurring in the drawdown zone. In order to monitor if re-vegetation efforts have an effect on dust storms it was decided to monitor dust storm events from a weather station equipped with a camera. A provincial government permit of occupation was required for constructing the weather station. Approval for installing the weather station on crown land was received in the spring of 2016. The WORKS 1 weather station was erected on 5 Mile Ridge to the north-east of the target re-vegetation area in April 2016. The station was equipped to monitor solar radiation, wind speed and direction, temperature and precipitation. The station runs on solar power and is equipped with a CC5MPX 5 megapixel camera and data logger. The camera is programmed to capture a still image every 5 minutes during daylight. Camera and weather station data requires monthly visits to the site for data downloading. Collected data was analysed for the number of images observed with evidence of dust events. Images with dust storms were identified and storms were tallied by month.

Figure 8 Weather station being installed 13 April 2017.

Figure 9 Example of photo capture from weather station camera, this image was from 8 April 2017.

2.3 Aesthetics and Recreational Use

A public survey was designed and has been solicited to locals in the Goldbridge Area. The survey was compiled in 2014 and serves as a baseline for monitoring public perception of the reservoir area. Questions were developed regarding perception, use, observations of wildlife and dust storms. It also served as a basis for engaging members of the local population. For results of the initial survey see Scholz, 2015 BRGWORKS-1 year 2 final report.

2.4 Wildlife Use

Wildlife presence and use of the area is being monitored via recording wildlife and wildlife sign as a component of the data collected under the BRGMON 2 monitoring program. Incidental observations of wildlife and wildlife sign are also recorded during WORKS-1 field operations and BRGMON 2 data collection. Recording wildlife observations was also a component of the public survey conducted in 2014-2015 and results were reported on in Scholz, 2015. A breeding songbird survey was carried out in 2016 (Heinrich, 2016) to establish avian species breeding and utilizing both re-vegetation treatment sites and reference sites around the reservoir.

2.5 Water Levels and Drawdown Zone Elevations

BC Hydro makes efforts to maintain a 3m elevation buffer zone around Carpenter Reservoir by having a target maximum elevation of 648.00masl. Hydro manages Carpenter reservoir for power generation, fish habitat, and to minimize spills from Terzaghi Dam into the Lower Bridge River (BC Hydro, 2011). BC Hydro states that reservoir incursions above 648.0 m are expected as a result of meeting other constraints with higher priorities such as safety. Over the past 17 years the average full pool level for Carpenter Reservoir has been approximately 646masl or 2 vertical meters below the lower limit of the riparian buffer zone (Figure 10).

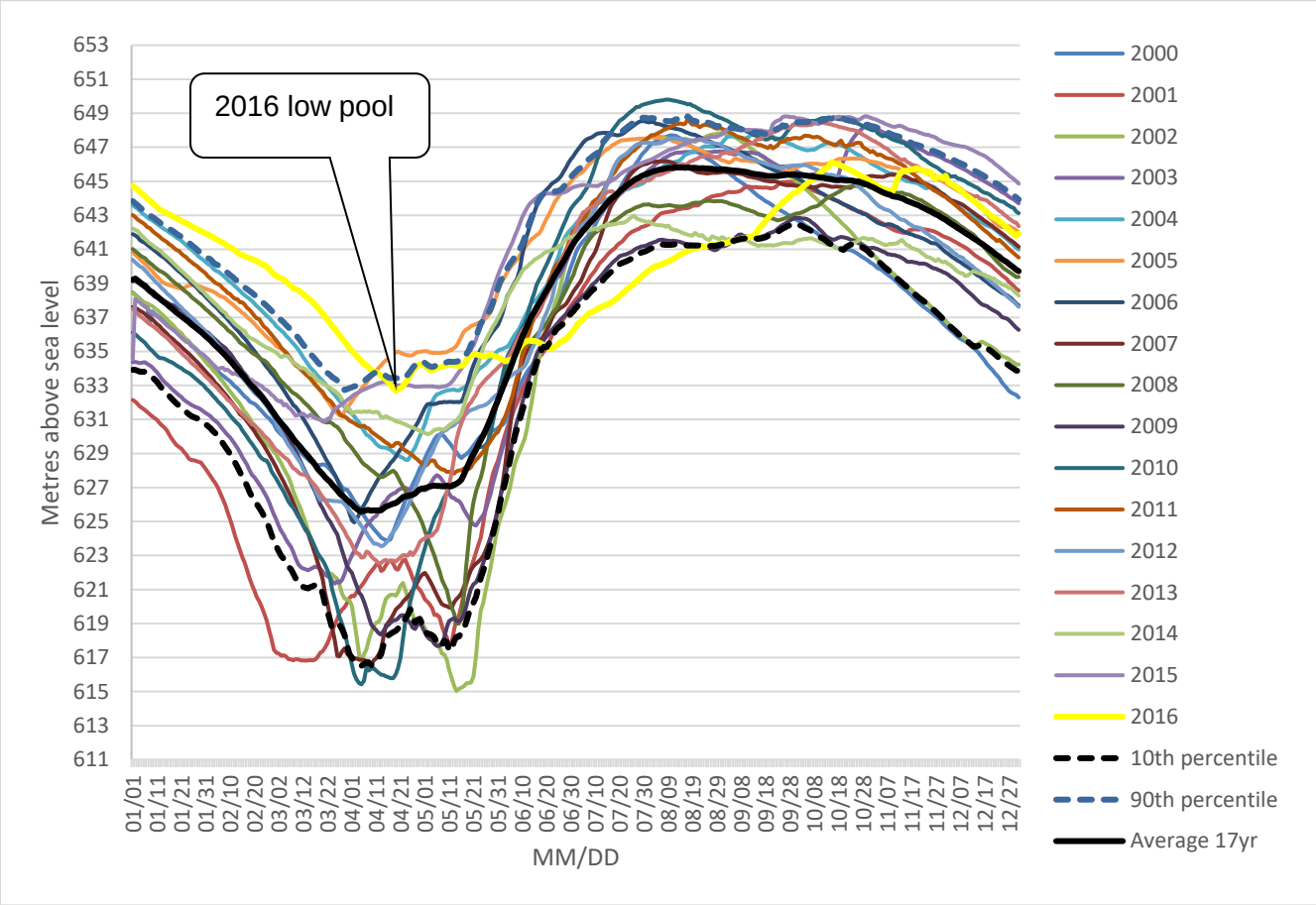


Figure 10 Carpenter Reservoir annual water levels from 2000-2016, low pool for 2016 is labeled.

3. Results

Results section is divided into five sections to address re-vegetation, dust storm frequency, aesthetic and recreation use, wildlife use and water level results.

3.1 Re-Vegetation

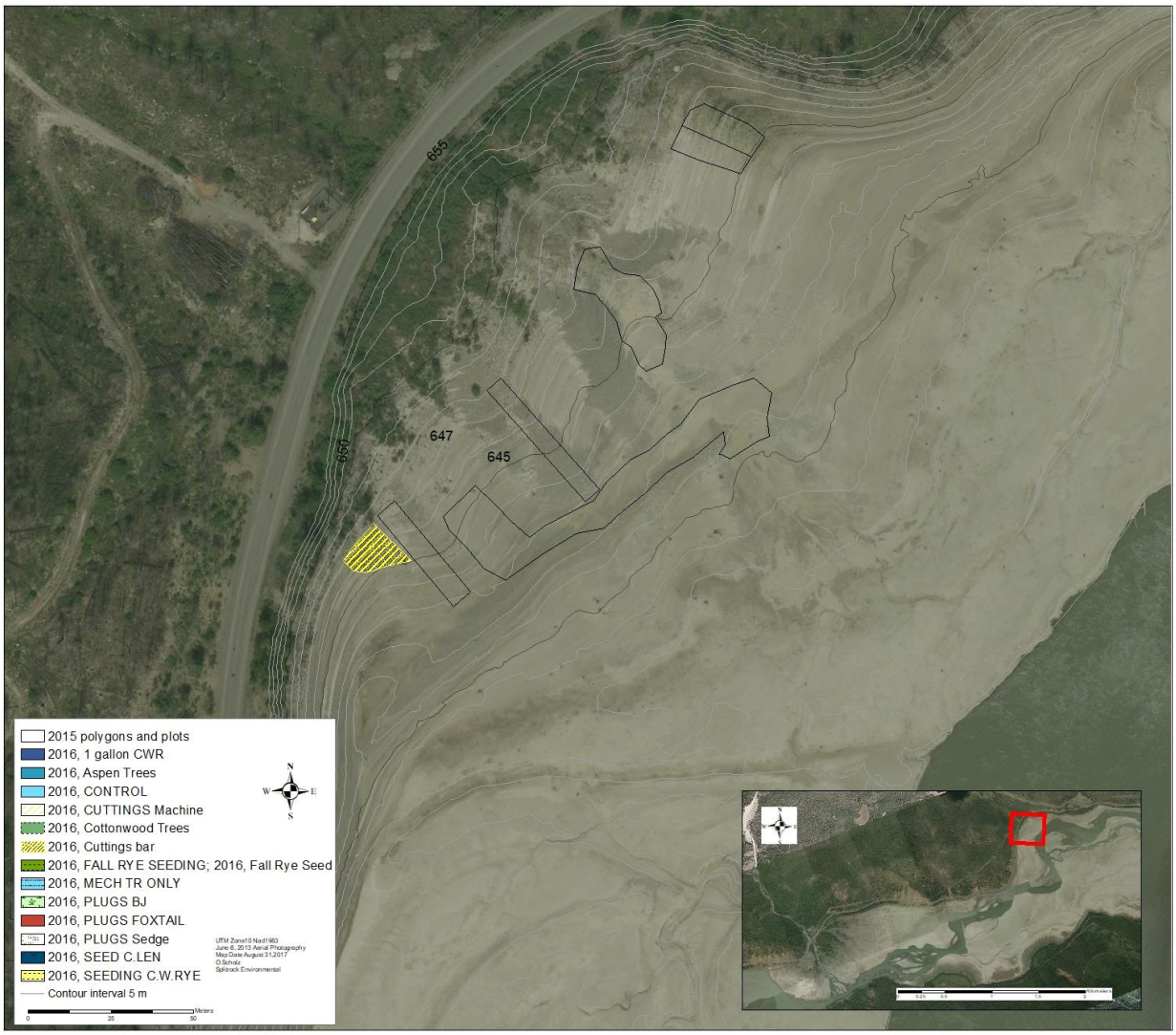
For logistical reasons and due to the previous degree of effort already exerted at each site the 2016 WORKS-1 re-vegetation efforts were carried out on four of the six terrain types within the target re-vegetation area. The results of the 2016 WORKS-1 efforts are presented in four sections by each of the treated Terrain treatment type sites. See 2014 BRGWORKS 1 final report (Scholz, 2014) for a detailed description of the Terrain Types. The 2016 treatments are summarized in Table 2 .

Table 2 Summary table of re-vegetation treatments carried out in 2016.

		CONTAINER PLANTS						CUTTINGS		SEEDING			
CODE	**TERRAIN TYPE**	**Sedge Plugs**	**BJ Plugs**	**Foxtail Plugs**	**CWR**	**Cottonwood trees**	**Trembling aspen**	**Number Cuttings Willow**	**Number Cuttings Cottonwood**	**Area Seeded Fall Rye m²**	**Area Seeded Carex Lenticularis m²**	**Area Mechanical treatment only m²**	**Area seeded Canada Wildrye**
STB	Steep Beach	***No Treatment***											
SHB	Shallow Beach							132	73				
LMF	Low Mud Flat	10312								9.6ha (480kg)	.4ha (.95kg)	.32ha	.3ha (1.4kg)
GCFE	Gun Creek Alluvial Fan East		2360	2960	30	75							
GCFW	Gun Creek Alluvial Fan West		9225			25	25	360	629				
SAF	Steep Alluvial Fan	***No Treatment***											
SC	Steep Colluvium	***No Treatment***											
	TOTAL	10312	11585	2960	30	100	25	492	702				

3.1.1 Shallow Beach

One treatment was carried out at the SHB site in 2016. A polygon of live stake cuttings of willow and cottonwoods were planted by hand at the west end of the shallow beach (MAP 3). In total 205 cuttings were planted into a 157m² polygon on April 18, 2016 (132 willow and 73 cottonwood). Cuttings were trimmed to between 20-30 cm of height and watered in during and post planting.



MAP 3 Shallow beach area with 2016 live stake cuttings polygon highlighted. Black silhouette polygons 2015 treatments.

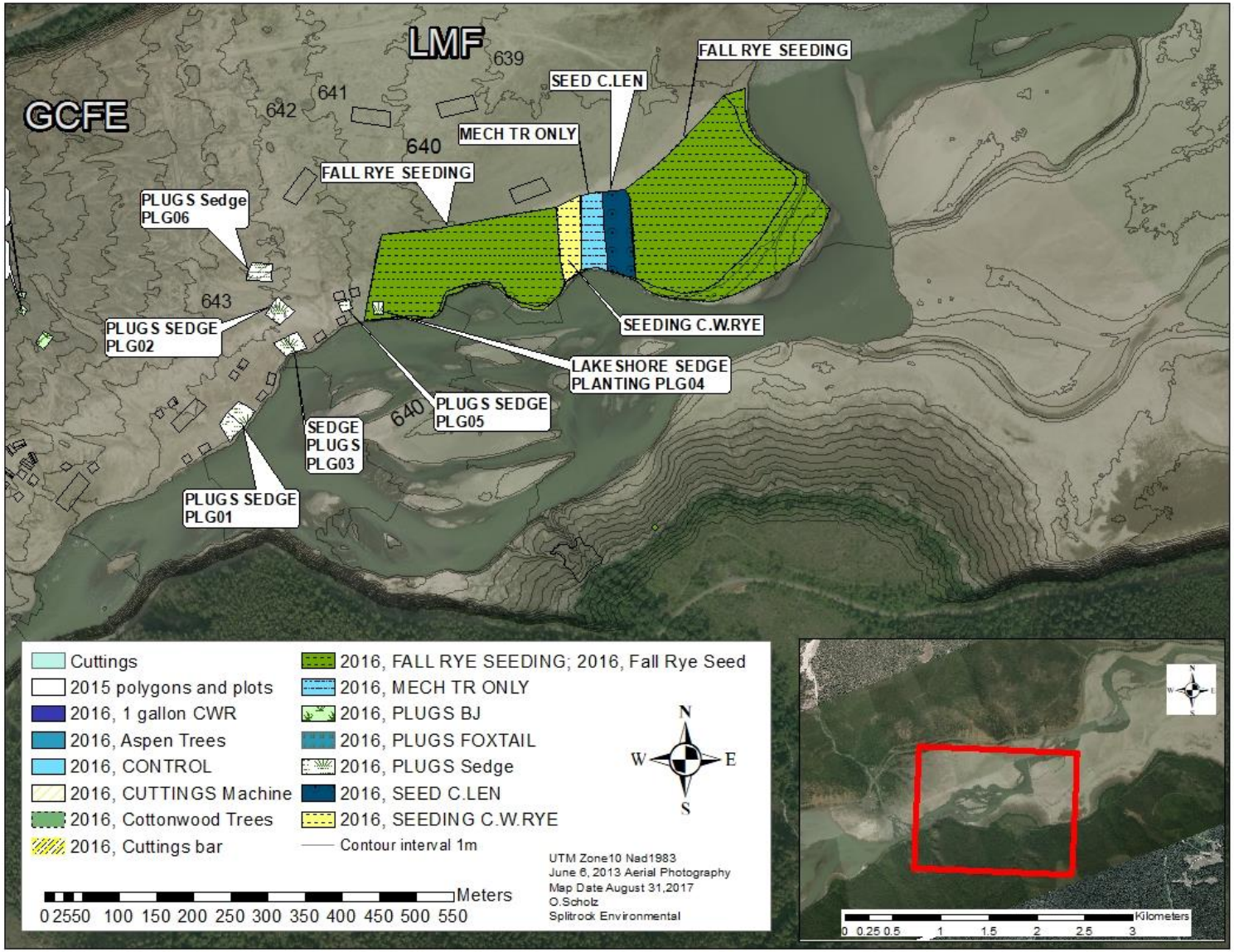
Figure 11 SHB west end polygon of live stake cuttings photographed 13May 2016 a month after planting , green shoots are noted sprouting from the stakes.

3.1.3 Low Mud Flat

Seeding and planting treatments were carried out across the Low Mud Flat in 2016. Trials expanded on seeding and planting test plots from 2015. Six polygons totalling .4 ha in area were laid out and planted with lakeshore sedge plugs (MAP 4). Planting polygons were situated along the banks of the Bridge River on the level mud flat. Polygons were located at elevations between 640m and 643m. Polygons ranged in size from 202m² to 1270m². Planting densities ranged from just over 1 plant per square metre to over 4 plants per square metre (Table 3). Polygons PLG01, PLG04,05-06 were planted to an even dense spacing (Figure 12). Polygons PLG02 and PLG03 were planted in dense strips with similar spacing to PLG01, however in PLG02 strips approximately 2m wide were spaced apart with unplanted gaps of a similar width to the planted strip (Figure 13). The gaps were left between strips with the intention to monitor if the strips could have an influence in the neighbouring non-planted ground with increased vegetation recruitment potential. Gaps would also allow more ground to be treated by fewer plants, potentially stretching limited resources. When planting the two different aged batches of lakeshore sedge, plants were tracked separately to allow future assessment to see if there was any benefit to planting slightly older vs younger plants. Early season observations of 2015 planting trials on the LMF pointed to older planting stock attaining significantly larger growth than younger planted stock. This increased production in older vs younger planting stock was reportedly observed in other studies on the Upper Arrows by Anne Moodie (personal communication). Plants were all watered in after planting (Figure 14).

Table 3 Lakeshore sedge polygons planted on LMF in 2016.

ID	Plant Age	Number Planted	Area m²	Plants per m²	Treatment details
PLG01	1.5yr	2830	647	4.37	East side of polygon dense planting
PLG01	.5yr	1940	622	3.12	West side of polygon dense planting
PLG02	1.5yr	1073	757	2.03	Planted 2m wide strips with 2m wide gap between strips.
PLG02	.5yr	466			
PLG3	.5yr	846	373	2.27	Planted dense planting
PLG3	1.5yr	475	417	1.14	Planted bands with 1-2m gap between strips
PLG04	1.5yr	502	245	2.05	Plugs planted within Fall Rye seeded area
PLG05	1.5yr	703	202	3.48	Plugs dense planting
PLG06	1.5yr	1477	732	2.02	Plugs even planting
Total		10312	3995		
Average				2.56	



MAP 4 2016 Low Mud Flat re-vegetation treatment polygons, large polygons are seeding treatment trials smaller are lakeshore sedge planting sites. Black silhouette polygons are the locations of treatment polygons established in 2015.

Figure 12 Planters planting lakeshore sedge in polygon PLG01, 25 April 2016.

Figure 13 PLG02 with gaps left between planted strips. Photo taken one day after planting, 29 April 2016.

Figure 14 PLG02 watering one day post planting. 29 April 2016. Water pumped from a 2 inch water pump and fire hose.

Seeding trials initiated in 2015 were carried out in narrow 50m strips. The water level rose relatively early in 2015, flooding the trials soon after they were planted. This limited fall rye growth in treatment trials to 20cm long blades prior to flooding. Armed with the high probability that the 640m elevation would be flooded before fall rye plants could form viable seed, planting trials were carried out across a 10ha area paralleling the Bridge River (MAP 4). This area was chosen for treatment as it had been observed on the ground that the dust storms seemed to generate in this area and having a fast growing annual establish may help reduce wind speed at ground level and reduce the amount of dust arising from this area. The dust was observed to be originating from fine sands eroding along the very steep cut banks of the river. Fines blow up from the eroding river banks and depending on the wind are deposited across the flat silt surface of the mud flat. The flat silts of the mud flat are themselves relatively wind resistant if undisturbed. The fines scattered across the surface of the mud flat provide a source for dust when subsequent winds blow. It was hypothesized that the fall rye may trap dust. In addition to dust storm control it was hypothesized that having organics and residual stubble post high water may serve to trap seed and provide microsite conditions that may encourage natural colonization by native vegetation. A third reason for trialing fall rye treatment was to determine if the action of planting the rye seed would also serve to bury (plant) naturally occurring sedge seed promoting a recruitment of sedges and possibly other native species.

Two large polygons were seeded with fall rye at about 50kg per hectare (Figure 15). Three smaller polygons were treated to compare responses to;

1. Lakeshore sedge seed being sown and then tilled in,
2. Canada wildrye being first sown and then tilled in, and
3. An area was tilled only (mechanical treatment only) no seeding (Figure 16).

These areas will be monitored in future to compare and assess for effects on vegetation composition and cover. The tractor and seeder treatment was limited to the flat areas of the mud flat. The ground immediately paralleling the river bank was inaccessible to the tractor and seeder due to safety reasons and to the contoured terrain. This area measured 1.3 ha and the polygon was treated using a walk behind seeder and sown with fall rye seed only with no mechanical scarification.

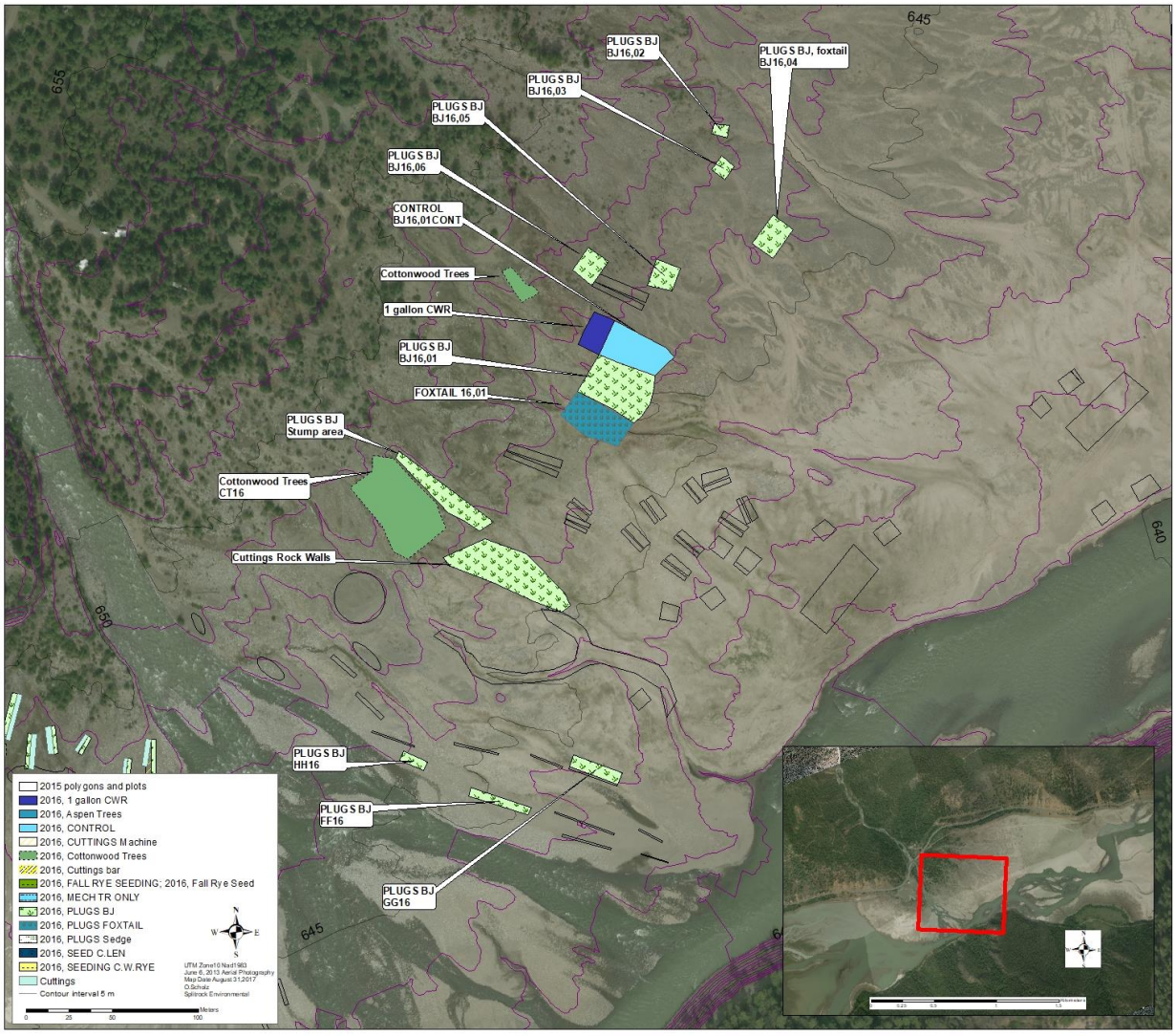
Figure 15 Tractor seeding LMF with fall rye. 14 April 2016.

Figure 16 Weighing out lakeshore sedge and Canada wildrye seed prior to planting.

Figure 17 Walk behind seeder poised along the inaccessible edge between tractor seeding and Lower Bridge River. 14 April 2016.

3.1.4 Gun Creek Fan East

In 2016 re-vegetation treatments on the Gun Creek Fan East focused on planting native grasses primarily bluejoint reedgrass *(Calamagrostis canadensis),* and foxtail barley *(Hordeum jubatum).* Both bluejoint and foxtail barley have proven effective in surviving in trials in the drawdown zone as well as having prominence among the suite of native species that naturally colonize the upper drawdown zone. GCFE treatment polygons were situated between 644m and 649m elevation (MAP 5). The bulk of the treatment polygons were in the upper drawdown and buffer zone elevations (646-649m).



MAP 5 Re-vegetation polygons on the Gun Creek Fan East treated in 2016.

Polygons were laid out taking the landscape microtopography into consideration. Planting areas were selected based on the availability of plantable substrates. Much of the upper Gun Creek Fan is extremely coarse and rocky making planting and the likelihood of plant survival low. Micro swales and areas with finer soils were targeted as having higher potential of sustaining planted plants. Three polygons close to Gun Creek were planted parallel to strips of cottonwood cuttings planted in 2015. These sites close to Gun Creek had been observed as

sources of dust generation with few other species growing (Figure 18). Scattered natural stands of bluejoint reedgrass were observed thriving in the area close to Gun Creek indicating a high likelihood of establishment success. Having stands of bluejoint reedgrass colonize this area would provide dust control, ground level wind breaks and both aquatic and terrestrial habitat complexity.

Figure 18 Polygon HH with surface cover of fine sands that are easily elevated by winds. The area surrounding the 2015 cuttings trench was planted with bluejoint reedgrass plugs in 2016.

Rooted cottonwood trees were planted into two polygon areas on the Gun Creek Fan East side. Up to this point in the WORKS program rooted cottonwoods had not been used. It has been noted that it is a struggle to get live stakes of cottonwoods to survive planting in the upper drawdown zone (Scholz and Gibeau, 2015). The low survival of cottonwood stakes was in part motivation to try rooted stock. Cottonwoods were targeted for planting in the upper drawdown and lower buffer zone where prolonged flooding and the associated flood damages are reduced. Black cottonwoods are observed growing naturally down to these elevations though in low numbers. One polygon CT16 was chosen for planting due to the fairly regular distribution of old stumps across the site (Figure 19). Cottonwood trees were planted on the north side of each of 50 stumps in the polygon. The intention being to place the cottonwood seedlings into a pre-existing beneficial microsite. Stumps would provide seedlings with shade from sun and wind, and also provide organic matter subsurface from decomposing roots. Decomposing roots hold more moisture than the surrounding substrate providing unique subsurface conditions. The

stump will also capture and funnel precipitation toward the planting site. Stumps have been observed as regular perches and pluck sites for numerous birds including peregrine falcon (*Falco peregrinus ssp. anatum*), bald eagle (*Haliaeetus leucocephalus*), crows (*Corvus brachyrhynchos* , ravens (*Corvus corax*)), that brings nutrients to the site in the form of feces, bones and feathers.

Cottonwood trees were planted into a second patch at a higher elevation on the Gun Creek Fan East. This second site was chosen due to the existence of fine loamy sand soils that provide better conditions for rooted plant establishment than the dominant surrounding rocky substrate. Working to establish cottonwood trees at these upper elevations of the drawdown zone is intended to speed up succession and expand the riparian forest bringing the structural and functional complexity that comes with a deciduous forest. Once established cottonwoods will spread via rhizomes, therefore each established cottonwood, either by live stake or rooted cutting, has the potential to impact a broader local area. This includes spreading naturally down into the drawdown zone where it is more difficult to get trees established from either plants or cuttings.

Table 4 Container plant polygons and treatments for GCGE 2016.

Polygon	Treatment type	No_Planted	Area m²
BJ16,01	PLUGS BJ	1350	1038
BJ16,02	PLUGS BJ	70	63
BJ16,02	PLUGS Foxtail	140	
BJ16,03	PLUGS BJ	100	91
	PLUGS foxtail	250	
BJ16,04	PLUGS BJ	225	300
BJ16,05	PLUGS BJ	350	223
BJ16,06	PLUGS BJ	200	231
FF16	PLUGS BJ	530	178
GG16	PLUGS BJ	540	215
HH16	PLUGS BJ	290	89
II16	PLUGS BJ	190	569
JJ16	PLUGS FOXTAIL	220	704
RW16	PLUGS BJ	380	1343
BJ16,01CONT	CONTROL	0	760
1 Gallon CWR	1 gallon pots	30	291
Cottonwood trees	1 gallon pots	25	177
CT16	1 gallon plants	50	1740

Figure 19 Site of natural stumps targeted for microsite conditions imposed by the stumps structure and decomposition function.

A polygon of Canada wildrye 1-gallon plants was planted on the Gun Creek Fan East. Canada wildrye has been used successfully in other riparian restoration situations by Splitrock Environmental and wildrye has shown a propensity for surviving both dry and flood conditions.

3.1.5 Gun Creek Fan West

Gun Creek Fan West side was the target of planting and live stake cutting treatment trials in 2016. Twenty-four trenches were excavated and cuttings planted into them as described in the methods. Based on observations from previous trials from 2014 and 2015 and the damage sustained to the cuttings it was decided to retreat to the higher elevation of the drawdown zone, including the buffer zone, to escape the brunt of damage caused by flooding and freezing. Cutting trenches spanned elevations from 647-649.5m (MAP 6). In total 492 willow and 702 cottonwood cuttings were planted into the trenches on the GCFW. The majority of the trenches ran with the slope of the fan, with three trenches running across the slope (O, F and G MAP 6). Polygons O, F and G were constructed with small mounds running across the slope directly below the planted cuttings. The berms were a mound of mixed soil and rock with ditches on either side. The microsites created by the mounds and ditches was constructed to offer protective microsites for the cuttings and to potentially support better growth of planted grasses and promote colonization by native species (Figure 20, Figure 21).

The West side of the fan has more mineral soil and fines in the substrate than are typically found on the east side. Digging trenches and back filling to plant cuttings created surface disturbance around the trenches with exposed mineral soil (Figure 22), it was decided to plant the disturbed areas around the planted cutting with native grasses. Bluejoint reedgrass was the target species used on the Gun Creek Fan West side. Bluejoint occurs naturally in sporadic clumps West side of the fan (Figure 23). Additional polygons were planted with bluejoint reedgrass lower down into the drawdown zone, going as low as 643.5m elevation.

Table 5 Gun Creek Fan West live stake cuttings polygon tallies. Type column indicated stakes planted in trench vs extra cutting planted by hand filling in gaps in the trenches after they were back filled.

ID	Type	Willow	Cottonwood
A	Trench	11	49
B	Trench	11	27
C	Trench	0	32
D	Trench	0	43
E	Trench	0	38
F	Trench	0	35
G	Trench	45	2
H	Trench	71	4
I	Trench	10	26
J	Trench	8	35
K	Trench	26	25
L	Trench	16	37
l	BAR	4	16
M	Trench	0	44
N	Trench	19	19
N	BAR	10	9
O	Trench	17	12
O	BAR	10	5
P	Trench	5	22
Q	Trench	3	40
R	Trench	25	31
S	Trench	27	10
T	Trench	19	8
U	Trench	10	7
V	Trench	10	8
W	Trench	3	26
X	Trench	0	19
	TOTAL	492	702

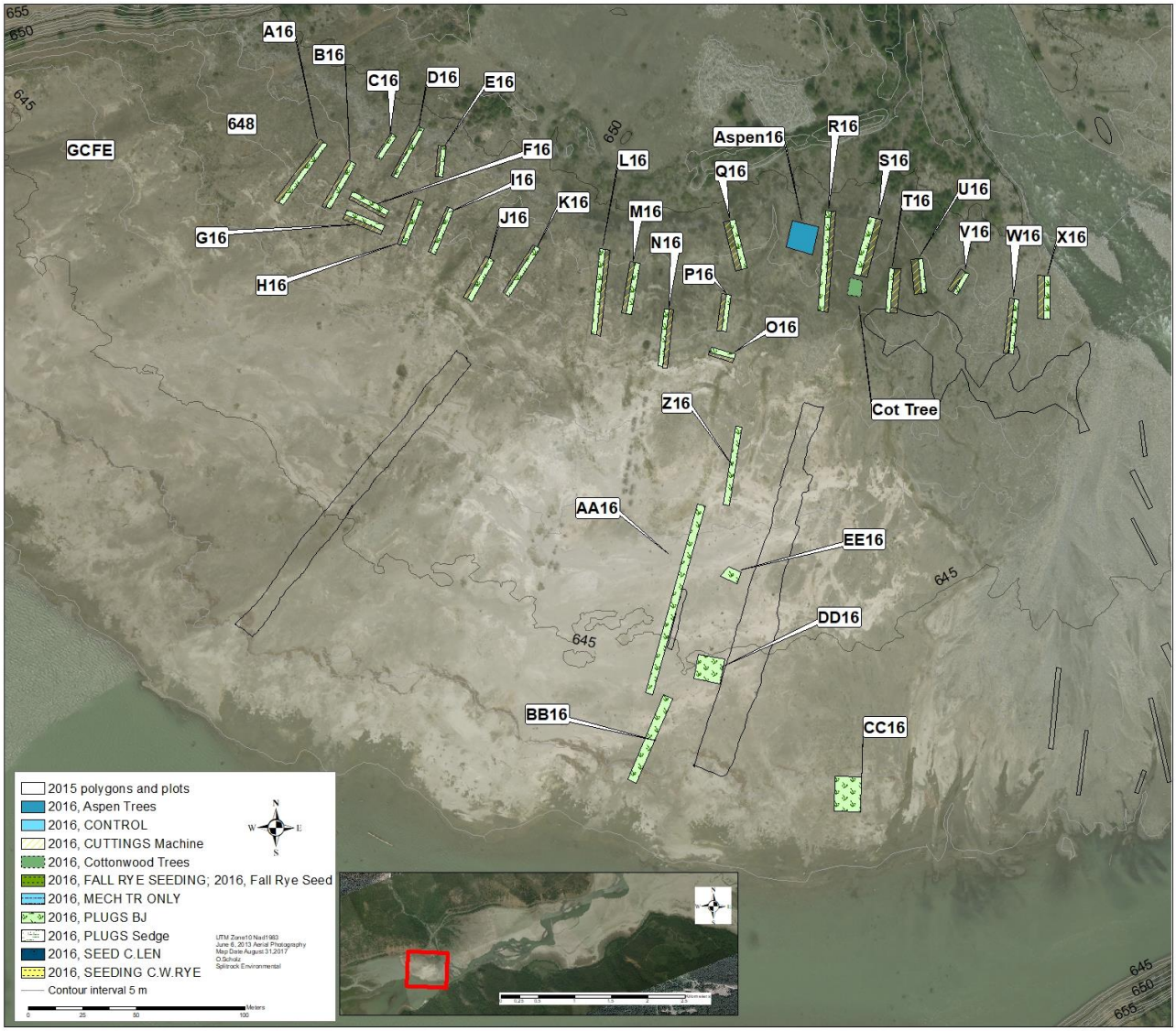
Table 6 Bluejoint reedgrass polygons planted alongside cuttings trenches on the GCFW.

NAME	Number of Plants	Area m²
A16	430	73
B16	400	59
C16	120	26
D16	170	57
E16	140	32
F16	280	46
G16	280	46
H16	180	56
I16	200	54
J16	150	58
K16	250	60
l16	260	96
M16	230	60
N16	330	58
O16	140	27
P16	200	36
Q16	250	61
R16	290	124
S16	300	85
T16	170	48
U16	115	36
V16	150	27
W16	170	56
X16	160	54
Total	5365	1335

Figure 20 Trench G with mound and trench below planted cuttings.

Figure 21 Trench O on the GCFW with mound and ditches on the downslope side of the cuttings.

Figure 22 Disturbed soils alongside planted cuttings trench, site was planted with bluejoint plugs.



MAP 6 2016 re-vegetation polygons on the GCFW. Black outlined polygons are the sites of 2015 treatments.

Figure 23 Photo looking the GCFW with sparse natural clumps of bluejoint reedgrass. Note patch of low growing grass in foreground is the exotic quack grass (*Elytrigia repens*).

For the first time in the WORKS 1 project trembling aspen (*Populus tremuloides*) was planted. Plants were in the form of 1 gallon pots. Aspen were planted into one polygon in the upper buffer zone at 649.5m elevation. The polygon was 160m² in area. Aspen were observed established in patches at the upper edge of the drawdown zone. Aspen have a great propensity for suckering and spreading vegetatively. This characteristic was observed on the Shallow Beach site where clonal suckers were observed advancing down into the drawdown zone from well established 'parent' plants situated above the drawdown full pool. Young suckers quickly colonize into the upper drawdown zone providing modifications to the site ecology by adding vegetation structure and organic matter to a largely mineral and rock environment. Advancing aspen have been observed to be killed back by high reservoir levels and subsequently suckers have been observed as vigorous re-sprouts (Figure 24). The ability of the roots to survive and re-sprout is no doubt not without limit. However, the management approach to Carpenter Reservoir water levels is to limit the time that the buffer zone is flooded. This could place both trembling aspen and black cottonwood as ideal species to work towards establishment in the 3m vertical buffer zone that surrounds Carpenter Reservoir. This tenacious characteristic of Aspen may lend well to providing advanced vegetation structure on the otherwise barren and sparsely vegetated western fan. If these plants establish it may be desirable to establish

patches of aspens and cottonwoods around the more barren reaches of Carpenter Reservoir starting with the target re-vegetation area. A patch of 25 container grown cottonwood seedling was also planted into the Gun Creek Fan West site.

Figure 24 Trembling aspen suckers sprouting from buried roots. Visible are dead stems of aspen sprouts killed back by the previous year's full pool. Sprouts have at least two months of growth prior to flooding with some years flood levels will not reach this high.

3.2 Dust Storms

The weather station equipped with solar panel and camera was installed on 5-Mile Ridge in mid April 2016. A chain link fence was constructed around the station installation. The fence was topped with barbed wire as a security precaution (Figure 25). The station required monthly visits to the site to download camera imagery data. The camera was programmed to take an image of the site every 5 minutes during daylight hours. Camera images were analysed and the number of images with positive observation of dust events was recorded.

Figure 25 Completed weather station and camera on five mile ridge 17 April 2016.

In 2016, 14991 images were collected by the camera and analysed for dust events. Five hundred and thirty-six images or 4%, were observed to capture a dust event. Dust events were considered part of the same storm if they occurred within a half hour of each other. When time frames were analysed it was assessed that 93 individual storm events were recorded throughout the sampling period[1]. The greatest number of events were recorded in June. June was also the month with the highest number of sampling days. The month of May had a higher percentage of dust events relative to the number

[1] Some technical issues were encountered during some of the data download sessions which lead to some stretches of time when the camera data card was full and not recording images. Therefore, the data is a sub set of the total dust season of 2016.

of samples 6%. Sampling was halted in August as the reservoir was at full pool and dust events were near nil.

Table 7

Month	Total Sampled	Images with Dust events	% of images with dust events	Indv. Total Storms
April	3003	55	2%	11
May	3505	196	6%	22
June	6320	270	4%	50
July	726	14	2%	9
August	1437	1	0%	1
	14991	536	4%	93

Figure 26 9% of dust events were classified as large - example from 8 May 2016 6am.

Figure 27 last dust event captured in 2016 on 1 August. Localized event may be result of a vehicle on the site. Note inundation of green fall rye treatment area.

3.3 Aesthetic and Recreational Use

No additional surveys were conducted in 2016. Off road vehicle driving was observed to be one of the most common recreation activities engaged in within the target revegetation area (Figure 28). For details refer to the 2015 WORKS 1 report for overview of recreation use at the site as compiled from the public survey. The author received numerous comments from locals that the fall rye treatment was visually appealing.

Figure 28 LMF with numerous tracks from off road vehicle use of the site 5 June 2016.

3.4 Wildlife Use

In an attempt to gather more wildlife data at the target re-vegetation sites a breeding songbird survey was carried out in May 2016. 8 Point count stations were established and monitored at both treatment and control or reference sites near the target re-vegetation area. Twenty-three species of songbird were recorded during the survey. The buffer mud flat area near Goldbridge is a well-developed shrub herb ecosystem located above 648m elevation. For locations and full description of buffer mud flat and mid mud flat vegetation communities see 2013 BRGMON 2 final report by Scholz and Gibeau, (2014). This site had the highest songbird diversity at 13 species. The Low Mud Flat and the GCFE had the lowest diversity at 2 species detections. See Appendix 1 ‘Songbird Point Count Summary Carpenter Reservoir 2016 Report’ (Heinrich R.).

3.5 Water Levels

Water levels in 2016 were fairly unique for Carpenter Reservoir taking into account the period since 2000. The range in water levels between full and low pools was small at 12m difference. The 2016 low pool elevation was above the 90th percentile of levels since the year 2000. Reservoir levels were above normal from January through the first week of June. Levels stayed below average until the middle of September 2016, when they rose to just above average levels and remained there for the rest of the year.

2016 works were affected by the somewhat anomalous levels by having a longer than usual growing season at low elevations. The 640m elevation marked the lowest elevation of 2016 treatments. Reservoir levels did not rise back to cover 640m until the end of the first week of August in 2016. It is possible that extended low water levels could have resulted in the fall rye seeding treatment on the Low Mud Flat producing viable seed. The site was observed just prior to inundation where flowering heads were noted but where seed was not developed, thereby making it highly unlikely that any viable seed resulted from this seeding trial. Fall rye plants grew to a good size adding organic matter to the site and soils, and it is likely that stubble will persist into 2017, post inundation. The longer growing season means that the rye will have grown larger than under average flood year conditions. The longer growing season of 2016 meant that planted sedges and grasses had a longer establishment period before inundation which may help with long term growth and survival i.e. Plants were able to grow larger root reserves to aid survival through inundation period. It is possible the late high water may have had a negative impact on the live stake cuttings which require more moisture than planted plants and although heavily watered when planted do depend on reservoir inundation for moisture.

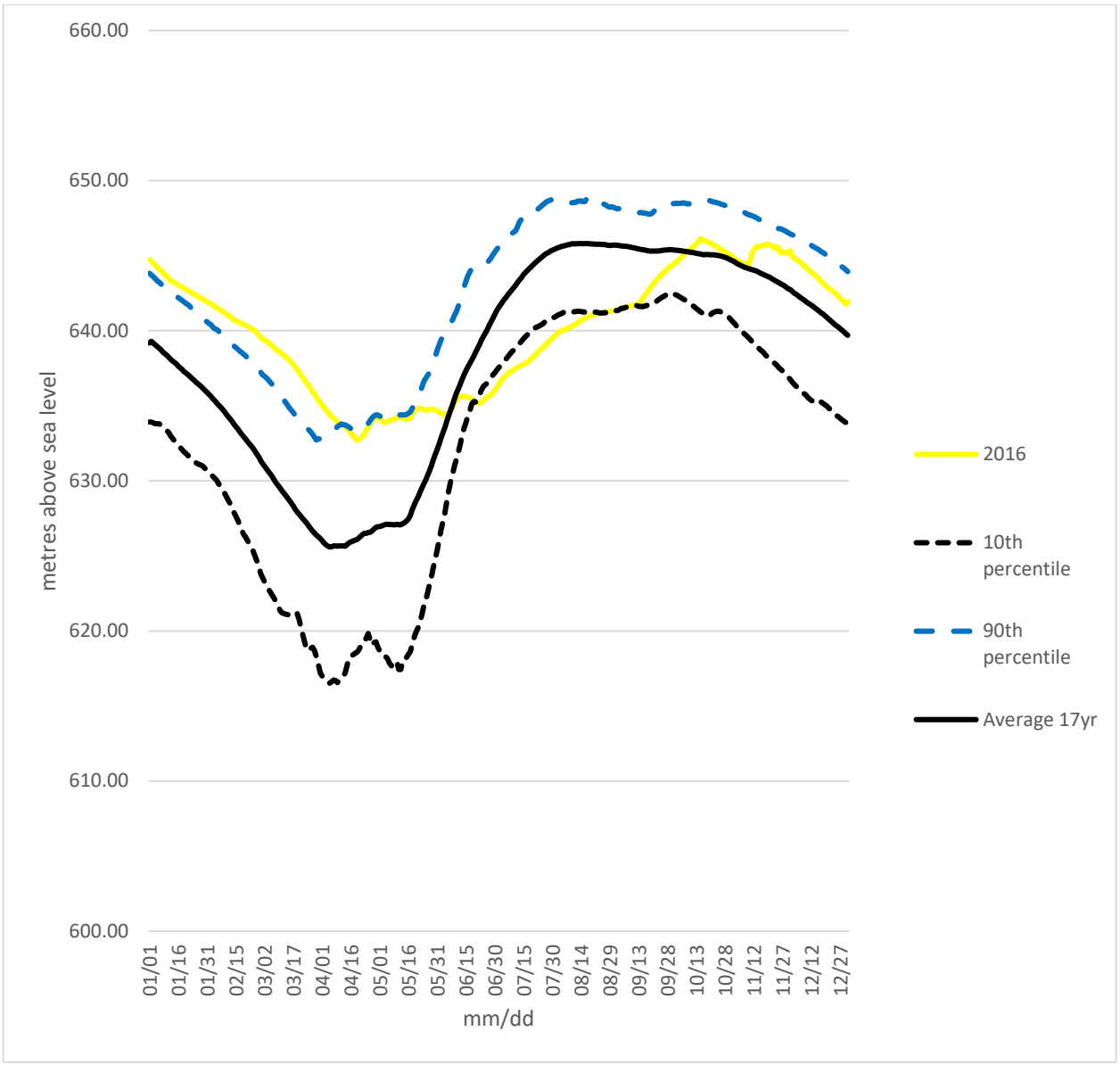


Figure 29 The 2016 hydrograph for Carpenter Reservoir placed with the 10th and 90th percentiles and the average levels since 2000.

4. Summary

2016 WORKS-1 re-vegetation treatment trials expanded from 2014 and 2015 experiences. Larger polygon areas were treated using seeding techniques. Larger polygon areas were also planted with sedge and grass plugs. The 2016 year was an expansion of treatments and response to observations from small plots and polygon strip treatments from 2014 and 2015. Observations of species response to re-vegetation treatments indicated that lakeshore sedge, bluejoint reedgrass and foxtail barley continued to be good candidates for surviving the harsh drawdown zone conditions. In addition, Canada wildrye seeding trials indicated it was able to germinate and grow in the drawdown zone, therefore seeding trials and planting with mature wildrye plants was carried out in 2016.

Due to logistical considerations, efficiency and previous years efforts 2016 treatments were focused on four of the terrain types in the target re-vegetation zone; the SH, LMF, GCFE and GCFW. The bulk of the 2016 treatment trials were on the LMF, GCFE and GCFW.

Seeding trials were expanded to treating over 10ha of the LMF with fall rye, lakeshore sedge, Canada wildrye and mechanical scarification. Over 10,000 lakeshore sedge plugs were planted across .4ha area of the LMF. Over 15,000 native grass plants were planted into polygons on both the GCFE and GCFW.

One small patch of live stakes was planted out at the SHB site, while the rest of the cutting trials for 2016 were carried out at the GCFW. Cuttings were planted above 647m elevation in response to the observed damage caused at lower elevations by flooding, including girdling damage from floating driftwood and debris, and mechanical damage from ice. Cuttings were cut low after planting in 2016, as a result of observations of the 2015 cutting trails where many of the surviving cuttings had been cut by beaver. Originally the 2015 cuttings had been left long with the idea that longer cuttings would protrude above reservoir water levels for longer periods of time allowing them a better chance of survival than low cuttings. Cuttings were watered in heavily as it has been observed in the many trenches dug that prior to inundation there is little sub surface moisture in the coarse rocky soils of the Gun Creek fan.

2016 was the first year that rooted plants of black cottonwood and trembling aspen trees were planted in treatment trials. Two polygons of cottonwoods were planted on the Gun Creek Fan East and one on the Gun Creek Fan West. A small patch of trembling aspen was planted out on the GCFW. Poplar plantings were kept largely to the buffer zone above 648m elevation on both the east and west fan areas.

Dust event frequency was monitored from a camera established at a weather station located to the east of the revegetation treatment area. Just under 15000 images were captured and analysed for dust events between April and August 2016. 4% of the total images (539) captured some dust event. Dust events were most frequent in May and June. Some technical glitches with data transfer meant that some sampling days were missed, however the sampling does provide a baseline for future comparison of dust event frequency and scale. Most (66%) of the dust events were categorized as small, 16% med and 9 % large events. When considering the time of each observed dust

event it was determined that there were 93 separate dust storms captured between April and August 2016.

Results of the public survey conducted in 2014-2015 and reported in 2015 stands as a baseline for monitoring public perception of aesthetics and recreation use at the target re-vegetation area.

A breeding songbird study was carried out to establish a baseline of species utilizing both the re-vegetation areas and similar reference sites to the west of the revegetation area. Unsurprisingly the LMF and the GCFE had the lowest detections at 2 species, while the highest number of detections was at the most structurally complex site at the Buffer Mud Flats near the town of Goldbridge, where 13 species were detected.

All works efforts will be monitored under the BRGMON 2 program. Recommendations for future WORKS-1 program efforts will be based on treatment response results from the BRGMON 2 monitoring program. 2016 treatments will be monitored in 2017 and appear as part of the 2017 BRGMON 2 final report.

5. References

B.C. Hydro. 2011. Bridge River Power Development Water Use Plan. Revised for Acceptance for the Comptroller of Water Rights March 17, 2011.

B.C. Hydro 2014. Bridge-Seton Water Use Plan Monitoring Program Terms of Reference. BRGWORKS-1 Carpenter Reservoir Drawdown Zone Re-Vegetation Program. March 10, 2014

Heinrich Ralph 2016. Songbird Point Count Summary Carpenter Reservoir 2016 Report. Report for Splitrock Environmental

Scholz, Odin. 2014. BRGWORKS-1 Carpenter Reservoir Drawdown Zone Re-Vegetation Program. Implementation Year. Report to B.C. Hydro

Scholz, Odin. 2015 BRGWORKS-1 Carpenter Reservoir Drawdown Zone Re-Vegetation Program. Year 2. 2015. Report to B.C. Hydro.

Scholz, O and P. Gibeau, 2014. BRGMON 2 Bridge Seton Water Use Plan Carpenter Reservoir Riparian Vegetation Monitoring Project. Implementation Year 1. 2013. Report for BC Hydro.

Acknowledgements

Thank you to the awesome hard work of the Spiltrock crews who worked with care under sometimes harsh weather conditions to bring the spark of life into a barren expanse. Thanks to the wonderful Splitrock nursery staff who raised healthy plants for the project. Thanks to Reg Dubeck for the exceptional machine work and to the determination of Bruce Vaughan the Xwisten water truck operator to bring water to the cuttings.

Thank you also to St'a'timc Eco-Resources for supporting Splitrock in carrying out this challenging project. This is an important project for the St'at'imc, where some of what has been lost may be restored

APPENDIX 1

Songbird Point Count Summary
Carpenter Reservoir
2016 Report

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November 2016

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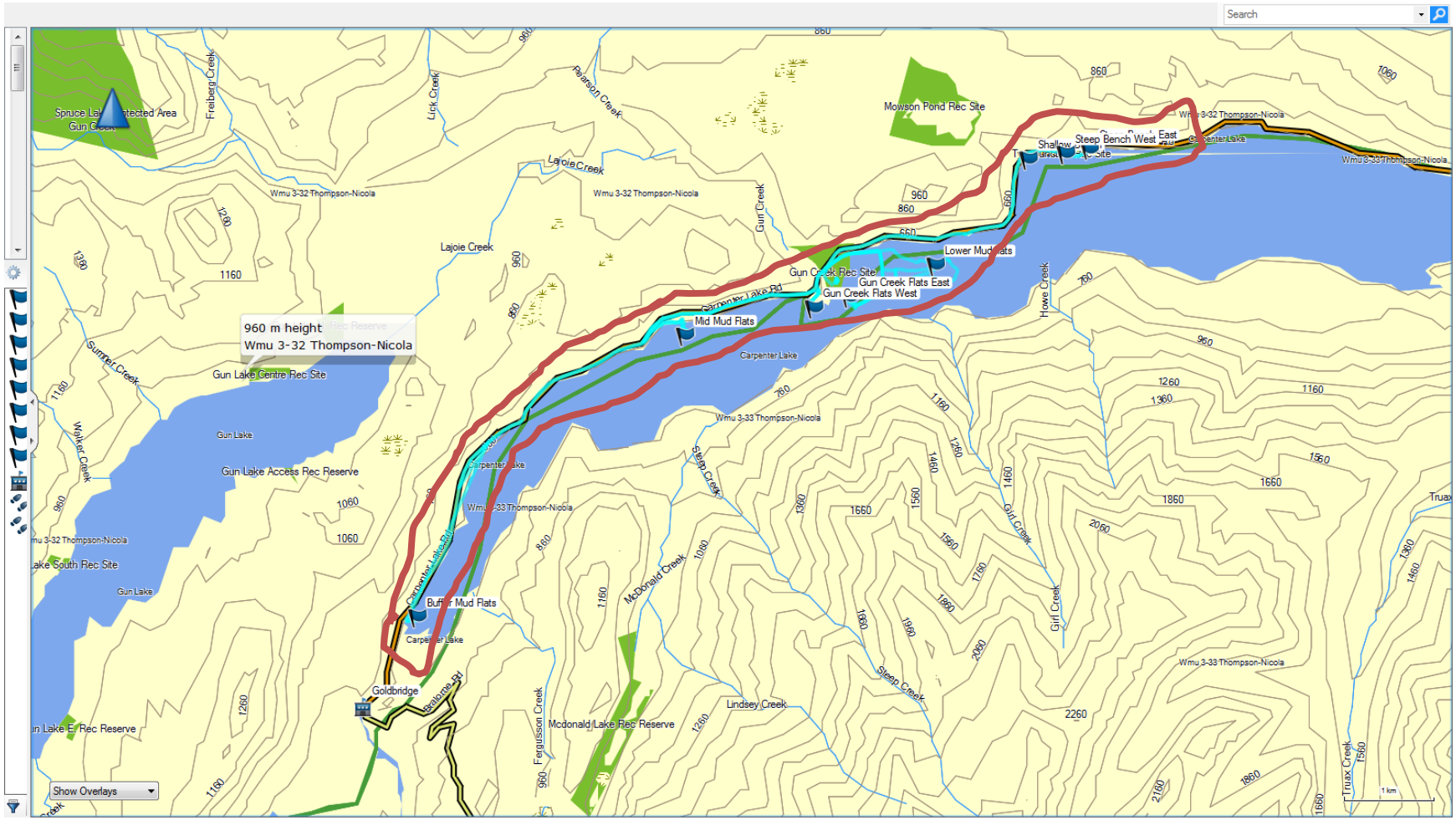
1.0 INTRODUCTION

Wildtech Biological Services was contracted to conduct breeding bird surveys along restoration sites at Carpenter Lake. The purpose of the songbird surveys was to provide a baseline data set for restoration monitoring being conducted under BRGWORKS 1 as part of the Bridge Seton Water Use Plan.

2.0 STUDY AREA

The study area is part of the BRGMON 2 Carpenter Reservoir Vegetation Monitoring and extends from the inlet of the middle Bridge River (Near Goldbridge, BC) to approximately 11 kilometers east along Carpenter Lake (Figure 1).

Figure 30 Study Area (boundary outlined in red)



3.0 METHODS

Songbird point count surveys were conducted at eight locations along Carpenter Reservoir in 2016. Point counts focused on assessing the songbird community at five restoration sites and two control sites (Table 1). Surveys were conducted using an unlimited radius, distance-based point count technique consistent with the standards laid out in BC Resource Inventory Committee's *Inventory Methods for Forest and Grassland Songbirds* (Province of British Columbia, 1999), and in *Monitoring Bird Populations by Point Counts* (Ralph et al., 1995).

Table 8 Point count survey location and descriptions

Site Name	Point count Station	UTM Coordinates			Primary Habitat
		UTM Zone	Easting	Northing	
Control Sites					
Buffer Mud Flats (BMF)	PC01	10U	511348	5634308	Dense Willow/Alder Shrub Complex
Mid Mud Flats (MMF)	PC02	10U	514409	5637443	Sedge meadow complex
Restoration Sites					
Gun Creek Flats West (GCFW)	PC03	10U	515784	5637729	Alluvial Fan/Mud Flats
Gun Creek Flats East (GCFE)	PC04	10U	516184	5637848	Alluvial Fan/Mud Flats
Lower Mud Flats (LMF)	PC05	10U	517146	5638204	Annually flooded mud flats
Shallow Beach (SHB)	PC06	10U	518182	5639377	Reservoir shoreline
Steep Beach West (STBW)	PC07	10U	518600	5639441	Reservoir shoreline
Steep Beach East (STBE)	PC08	10U	518866	5639491	Reservoir shoreline

One round of songbird point count surveys was conducted on May 27th 2016 at a total of eight point count stations. Surveys were conducted during appropriate weather conditions.
Beginning at dawn and continuing for approximately 4 hours surveys were conducted at each site. Noise and other disturbance was minimized while accessing the sites, and a minimum of 2 minutes of silent listening was conducted before the start of the survey to allow for the return of normal bird activity. During this time, air temperature and weather conditions were recorded. Wind levels were assessed using the Beaufort Scale (Table 3), and measured with a Kestrel 4500 pocket weather tracker. Beaufort forces greater than 2 (6 to 12 km/hr) were generally considered unacceptable for songbird surveys.

Table 9. Beaufort wind scale table

Force	Wind Speed (km/hr)	Conditions for songbird surveys
0	< 2	Acceptable
1	2-5	Acceptable
2	6-12	Marginal
3	12-19	Unacceptable
4	20-29	Unacceptable
5	30-39	Unacceptable

Source: Province of BC (1999)

A standardized survey interval of 10 minutes was used, during which time both visual and auditory observations of species, age, and sex (where possible) were recorded. Distance from each bird to the observer was also estimated. Observations were classified as songs, calls, visual, or drumming, and other activity was recorded in a separate column. Incidental habitat and bird observations (i.e., outside of the survey period or location) were recorded but not included in the analysis.

4.0 RESULTS

A total of 66 detections of 23 species were made during the May 27th point count surveys (Figure 2 and Table 3). The most frequently detected species were Canada Goose (*Branta Canadensis)* with 11 detections (16%) followed by Western Tanager (*Piranga ludoviciana*) 8 detections (12%), and Spotted Sandpiper (*Actitis macularius*) with 7 detections (11%).

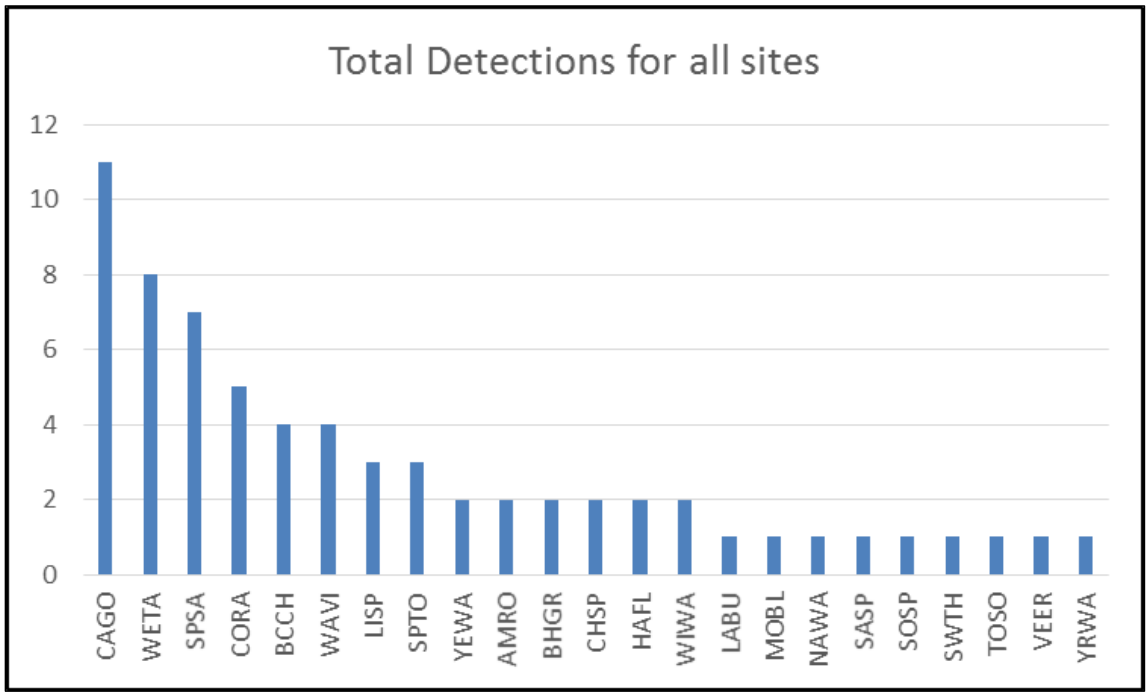


Figure 31 Total detections across all sites.

Control Sites

The Buffer Mud Flats (BMF) control site (Figure 3) had the highest number of total detections (40% of all detections) and the highest number of species (56%). The Mid Mud Flats (MMF) had a lower number of detections (7 (11%)) and only four species (17%).

Restoration Sites

The restoration sites were much more variable in terms of both number of species and number of individuals detected. Total number of detections ranged from a high of nine individuals at the Shallow Bench (SHB) to just two individuals at the Lower Mud Flats (LMF) and Gun Creek Flats East (GFCE).

Table 10 Species list and number of detections by site

Site Name	Species	Number of Detections
BMF	Canada Goose	5
	Black Capped Chickadee	4
	Warbling Vireo	3
	Common Raven	3
	Western Tanager	2
	Black-headed Grosbeak	2
	Yellow-rumped Warbler	1
	Yellow Warbler	1
	Wilson's Warbler	1
	Veery	1
	Swainson's Thrush	1
	Nashville Warbler	1
	American Robin	1
MMF	Spotted Sandpiper	4
	Song Sparrow	1
	Western Tanager	1
	Savannah Sparrow	1
LMF	Canada Goose	1
	Western Tanager	1
GFCW	Canada Goose	3
	Western Tanager	2
	Chipping Sparrow	1
	Spotted Sandpiper	1
GCFE	Canada Goose	1
	Spotted Sandpiper	1
SHB	Lincoln's Sparrow	1
	Spotted Towhee	1
	Common Raven	1
	Warbling Vireo	1
	Hammond's Flycatcher	1
	Yellow Warbler	1
	Lincoln's Sparrow	1
	American Robin	1
	Mountain Bluebird	1
STBW	Western Tanager	1
	Lazuli Bunting	1
	Canada Goose	1
	Townsend's Solitaire	1
	Hammond's Flycatcher	1
	Spotted Towhee	1

Site Name	Species	Number of Detections
STBE	Common Raven	1
	Western Tanager	1
	Spotted Towhee	1
	Wilson's Warbler	1
	Lincoln's Sparrow	1
	Chipping Sparrow	1
	Spotted Sandpiper	1

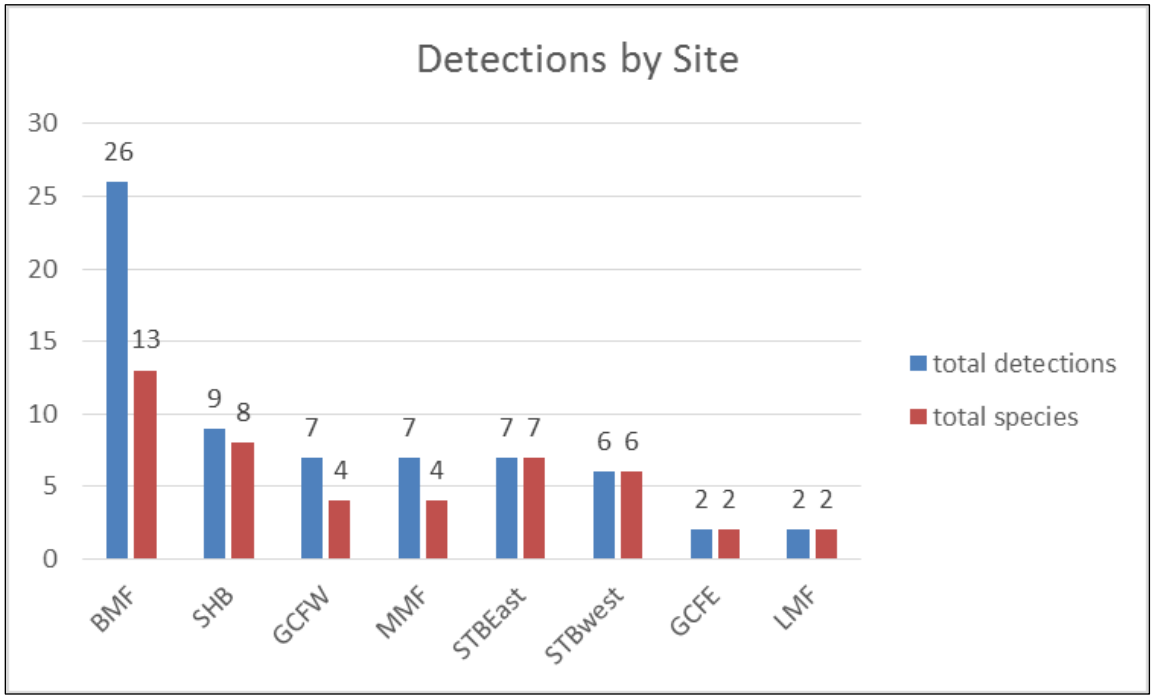


Figure 32 Detections and total numbers of species at each site.

Species richness and species diversity were also calculated. Total species richness was determined as the total number of species detected (23 species). A slight difference in species richness was detected between control (16) and restoration sites (15).

Species diversity was calculated using the Simpson Index (D):

$D = \sum (n/N)^2$

Where n = the total number of individuals detected of each species
N = the total number of individuals detected of all species

Simpson's Index of Diversity = 1 – D

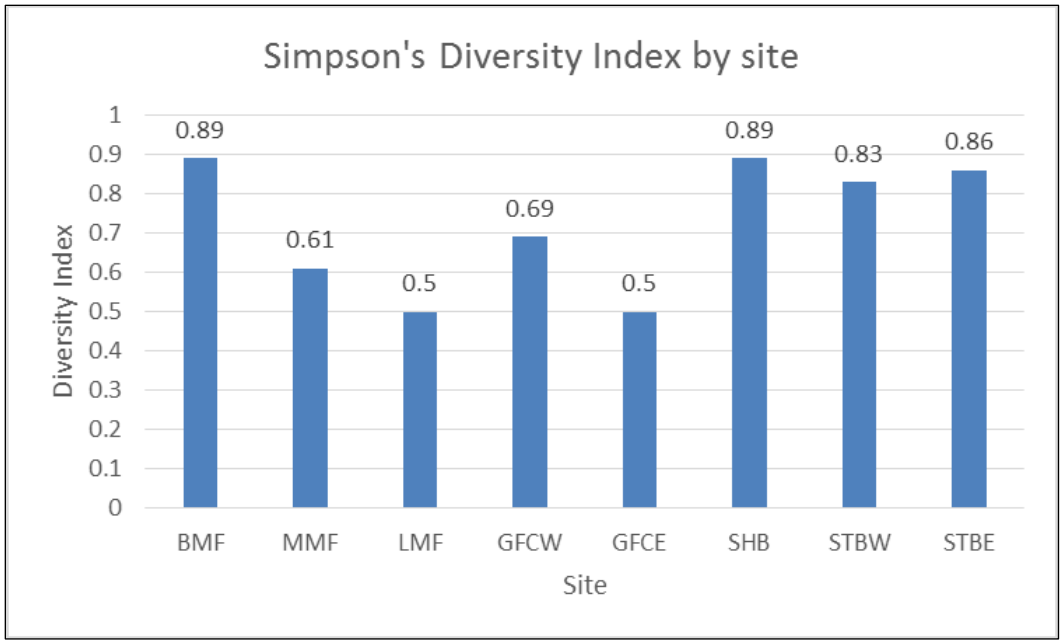


Figure 33 Simpson's Diversity Index by site

Canada Goose was the most common species throughout both control and restoration sites. While Black Capped Chickadees were the most common species in the control and Western Tanager were more common in the restoration sites. Spotted Sandpipers were more abundant in the restoration sites than in the control sites.

Table 11. Comparison of bird detections by habitat type

Site	***# Point Counts***	***# Detections***	***# Species Detected***	***Most Detected Species***	***Simpson's Index of Diversity***
BMF	1	26	13	Canada Goose/Black Capped Chickadee	0.89
MMF	1	7	4	Spotted Sandpiper	0.61
LMF	1	2	2	Canada Goose/Spotted Sandpiper	0.50
GCFW	1	7	4	Canada Goose	0.69
GCFE	1	2	2	Canada Goose	0.50
SHB	1	9	9		0.89
STBW	1	6	6	Western Tanager	0.83
STBE	1	7	7	Western Tanager	0.86
Total	**8**	**66**	**23**		**0.92**

Breeding-related behaviour was observed in 18 of the 23 species encountered during point count surveys. This included singing in males of all species, as well as drumming in woodpeckers and grouse. Both of these behaviours are typical territorial and/or mating behaviour during the breeding season. No visual observations were made of mating, protecting young, or carrying nest material during point count surveys. The majority of breeding individuals were Western Tanager and Warbling Vireo.

Table 12 Number of singing males of each species detected during point count surveys

Species Code	***# Singing Males*** (Includes drumming male woodpeckers and grouse)
AMRO	2
BHGR	1
CHSP	1
HAFL	2
LABU	1
LISP	3
NAWA	1
SASP	1
SOSP	1
SPTO	2
SWTH	1
TOSO	1
VEER	1
WAVI	4
WETA	8
WIWA	2
YEWA	2
YRWA	1

6.0 SUMMARY

Overall, the Buffer Mud Flats control site had the highest species richness and diversity. This is likely directly related to this site having the most vegetation cover and the highest diversity in nesting habitat. Conversely, the Lower Mud Flats and Gun Creek Flats had the lowest vegetation cover and diversity and subsequently the lowest species richness and diversity. The Shallow Beach and the Steep Beach both had relatively high species richness and diversity but this is likely being influenced by the proximity of adjacent upland habitat.

8.0 REFERENCES

Meidinger D. and J. Pojar 1991. Ecosystems of British Columbia. Special Report Series No. 6. BC Ministry of Forests Research Branch, Victoria, BC. 342pp.

Province of British Columbia. 1999. Inventory Methods for Forest and Grassland Songbirds. Version 2.0. Standards for Components of British Columbia's Biodiversity No. 15. Resources Inventory Committee.

Pyle, P., and D. DeSante. 2012. List of North American birds and alpha codes according to American Ornithologists' Union taxonomy through the 53rd AOU Supplement [Downloaded January 23, 2014]. Available from http://www.birdpop.org/alphacodes.htm.

Ralph, C.J; J.R. Sauer, and S. Droege, technical editors. 1995. Monitoring Bird Populations by Point Counts. Gen. Tech. Rep. PSW-GTR-149. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 187p

Reynolds, R.T., J.M. Scott, and R.A. Nussbaum. 1980. A variable circular-plot method for estimating bird numbers. Condor 82: 309-313.