Bridge River Project Water Use Plan

Carpenter Reservoir Drawdown Zone Riparian Enhancement Program

Implementation Year 5

Reference: BRGWORKS-1

Annual Report

Period: April 2019 – March 2020

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Executive Summary

This annual report summarizes the physical works conducted in the 6th year of BRGWORKS-1 Carpenter Reservoir Riparian Enhancement Program. Enhancement treatments included machine mounding of the drawdown zone substrate, planting of native vegetation, and mechanical and hand seeding. Maintenance of planting sites was also conducted during the 2019 field season. Treatments were completed in May and June of 2019. Fill planting and hand seeding treatments were implemented into sites previously mounded and planted in 2017. New planting and seeding treatments were carried out across the Low Mud Flat. Kellogg's sedge (*Carex kelloggii*) was the focal native perennial species utilized. Across the Low Mud Flat (639.5m elevation), new patches of sedges were planted in isolation and in areas seeded with fall rye (*Secale cereale*). Test patches of native annual meadow bird's foot trefoil were also seeded. The growing season across much of the treatment area (Low Mud Flat) was relatively short in 2019 due to late project start and inundation timing. In 2019, dust storms generated in the treatment areas were common during the months of April through June and ceased as water levels rose. Commonly, winds blow from west to east which moves any dust away from the populated area of Gold Bridge BC. Dust continues to be generated from relatively low elevation sites directly along the eroding banks of the Bridge River. Recommendations are made based on experiences and observations that will apply to the 2020 BRGWORKS-1 physical works project as well as the BRGMON-2 monitoring program.

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OBJECTIVES, MANAGEMENT QUESTIONS and HYPOTHESES after 2014			
Study Objectives **Numbers relate to MQ.**	**Management Questions**	**Management Hypotheses**	**Year 2017 (Status)**
To design and implement a reservoir planting program for the western end of Carpenter Reservoir focusing on the area between the Gun Creek Fan and Tyaughton Lake Road Junction.	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.	YET TO BE DETERMINED - Initial observations confirm that dust is generated from localized areas of fine sands located along the immediate eroding banks of the Bridge River. The edge of the eroding banks immediately adjacent to the Bridge River are difficult to vegetate and may require other treatment methods to control dust. Vegetation established across the mud flats may sequester dust, reducing possible resuspension after initial deposition.

To focus on the planting of appropriate species of vegetation. This is done using information gained from 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 Carpenter Reservoir?	H2: The planting of vegetation in the drawdown area does not increase the aesthetic quality and recreational opportunities in the western end of Carpenter Reservoir.	Public surveys conducted during 2014-2015 provided baseline inputs of public perception of reservoir aesthetic and recreational use. Recreational use of region varied greatly. More than 50% of responses to aesthetic perception were negative. The survey also included questions regarding wildlife and dust storms. Public feedback showed that the 2016 fall rye treatment was positive aesthetically. Surveys will be repeated in the final year of the BRGWORKS-1 program.

To evaluate the program, to assess the effectiveness of the planting program in establishing natural re-colonization of the area from Tyaughton Lake Road Junction to the Gun Creek Fan (This will be covered under the BRGMON-2 program).	MQ3: Will the planting of vegetation enhance the quality of riparian habitats, increase their potential to support wildlife populations and provide localized improvements in the quality and productivity of aquatic habitats in Carpenter Reservoir?	H3: The planting of vegetation in the drawdown area does not enhance the quality of riparian habitats nor does it increase their potential to support wildlife populations and provide localized improvements in the quality and productivity of aquatic habitats in Carpenter Reservoir.	Wildlife sign and species observations have been recorded at all treatment plots. Observations included presence and use of site by mule deer. Incidental observations during project field work include peregrine falcon (red-listed) at the Gun Creek Fan East site. Other species with confirmed use at target re-vegetation site are beaver, Canada goose, mountain bluebird, river otter, long-toed salamander, western toad, savannah sparrow, spotted sandpiper and horses. A breeding bird survey that was conducted in 2016 and repeated in 2018 indicated no species at the riparian enhancement sites. As expected, the reference sites with diverse vegetation structure and composition (Buffer Mud Flat Shallow Beach) had the most diversity in song birds. Spotted sandpipers nesting on one of the revegetation sites was confirmed in 2019. Juvenile western toads and juvenile western terrestrial garter snakes were also observed in mounded polygon areas.

			With regard to aquatic habitat, It is likely that successful establishment of vegetation in the Carpenter Reservoir drawdown zone will also result in an increase in benthic community productivity with associated benefits in productivity up the reservoir's aquatic food chain.

1. Introduction

2019 was year 6 of the BRGWORKS-1 revegetation project in the Carpenter Reservoir drawdown zone. This represents the 5th Annual Report for the program that had a lag year and no report in 2018. The Terms of Reference (TOR) for the original Water Use Plan (WUP) project (BC Hydro, 2012) were revised over the winter of 2016-2017 with a major revision being the extension of the program from a 5-year to a 7-year program (BC Hydro, 2017). Revisions provided a lag year in 2018 to allow for more time dedicated to observing results before designing the final 2 years of treatments. BRGWORKS-1 has been monitored through the BRGMON-2 program, and recommendations from those findings have been followed annually (Scholz and Gibeau, 2018, 2017, 2016, 2015). Treatments for 2017 and for 2019 shifted emphasis of the program from a revegetation focus to include a variety of riparian enhancement techniques (physical works) to encourage natural colonization of the Carpenter Reservoir drawdown zone (BC Hydro, 2017).

The BRGWORKS-1 program began in 2014 and took an experimental and staged adaptive management approach to treatments. The primary focus was on identifying appropriate species and effective methods for re-vegetation to encourage natural colonization (Scholz, 2015, 2017, 2018). In 2017, treatments were shifted to include physical works and revegetation trials. 2019 treatments followed and built on treatments initiated in 2017 with additional physical works and revegetation efforts. In contrast to 2017, mounded sites were not immediately treated with revegetation actions in 2019; however, these mounded sites will be a focus of revegetation in 2020 after the mounds have settled and the risk of losing the plants is decreased.

There are three management questions associated with BRGWORKS1 program:

1. 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?
2. Will the planting of vegetation in the drawdown area increase the aesthetic quality and recreational opportunities in the western end of the Carpenter Reservoir?

3. Will the planting of vegetation provide localized improvements in the quality and productivity of aquatic habitats in Carpenter Reservoir?

The null hypotheses being tested are:

1. 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.
2. The planting of vegetation in the drawdown area does not increase the aesthetic quality and recreational opportunities in the western end of Carpenter Reservoir.
3. The planting of vegetation in the drawdown area does not enhance the quality of riparian habitats, nor does it increase their potential to support wildlife populations and provide localized improvements in the quality and productivity of aquatic habitats in Carpenter Reservoir.

This report summarizes 2019 treatments and prework requirements, including an archaeology assessment of treated sites. Additionally, the results of 2018-2019 dust storm monitoring and community outreach and input are presented. The BRGWORKS-1 program has continued to follow a staged approach guided by adaptive management based on BRGMON-2 and BRGWORKS-1 observations, experiences and results.

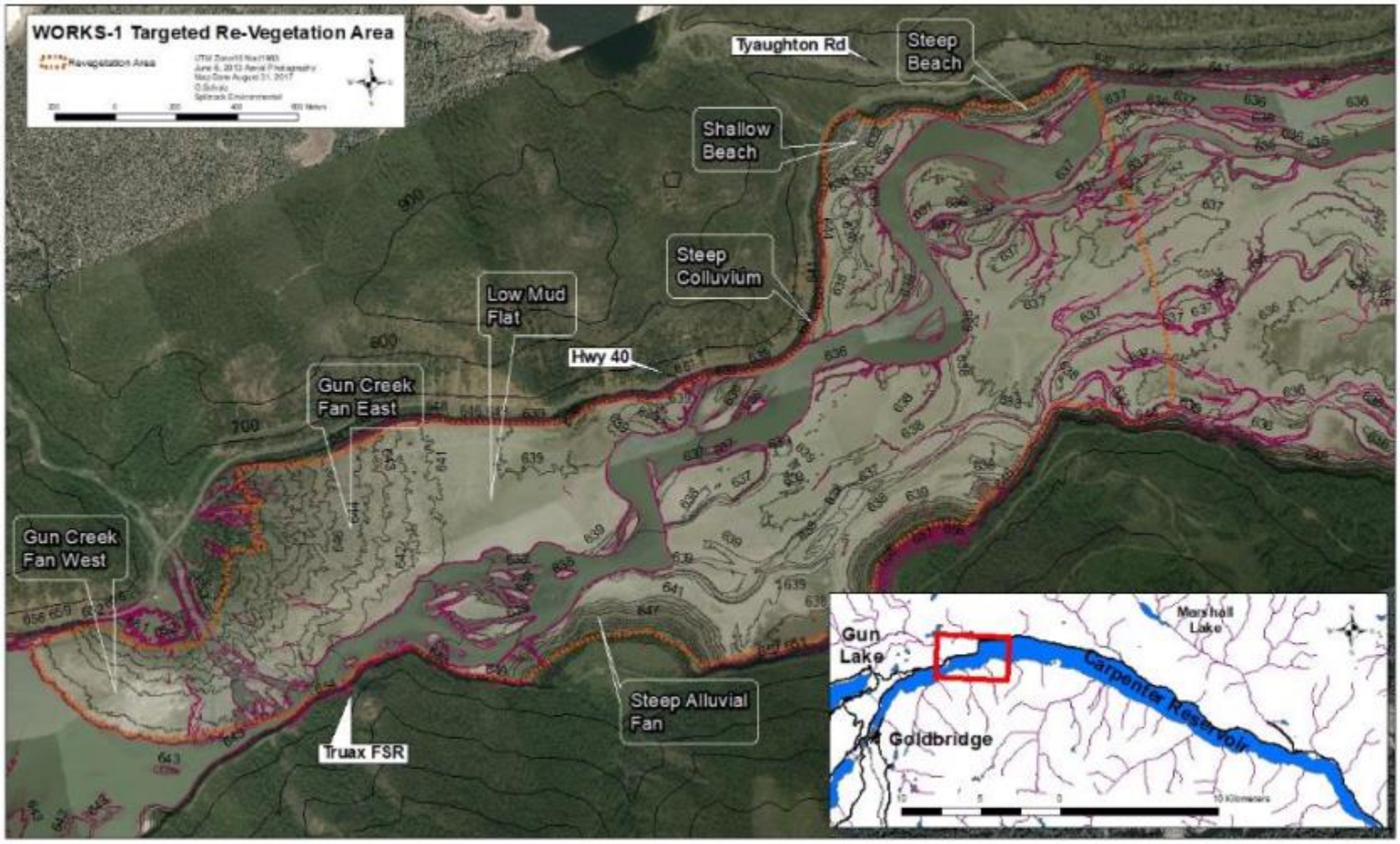


Figure 1. Target revegetation area of the Carpenter Reservoir drawdown zone. 2019 focus on Low Mud Flat and Gun Creek Fan East and West.

1.1 Project Location

The BRGWORKS-1 revegetation project is located approximately 280 km northeast of Vancouver, British Columbia in the Coast Cascade Mountains. The treatment area in the Carpenter Reservoir drawdown zone is approximately 8 km north east of the town of Gold Bridge, BC (Figure 1, and Figure 2). The site is located within St'at'imc traditional territory in the Southern Interior ecoprovince and is within the Interior Transitional Ranges ecoregion. The treatment area is classified as Interior Douglas-fir very dry cold (IDFxc) biogeoclimatic zone (BC Ministry Forests, 2012).

The Gun Creek Fan is central to much of the BRGWORKS-1 project target restoration area. The fan has a BC Hydro operated 13 site, public recreation campground located on the east side. Historically (1934-1950) the mining town of Minto was also located on the east side of the fan, within the Carpenter Reservoir drawdown zone. The Ministry of Transportation and Infrastructure owns a dormant gravel pit on the west side of the Gun Creek Fan. The bulk of the project's treatment sites are accessed on the east side of the Gun Creek Fan. Apart from treatment trials in 2014 and 2015, all treatments have been implemented on the north shore of the Reservoir.

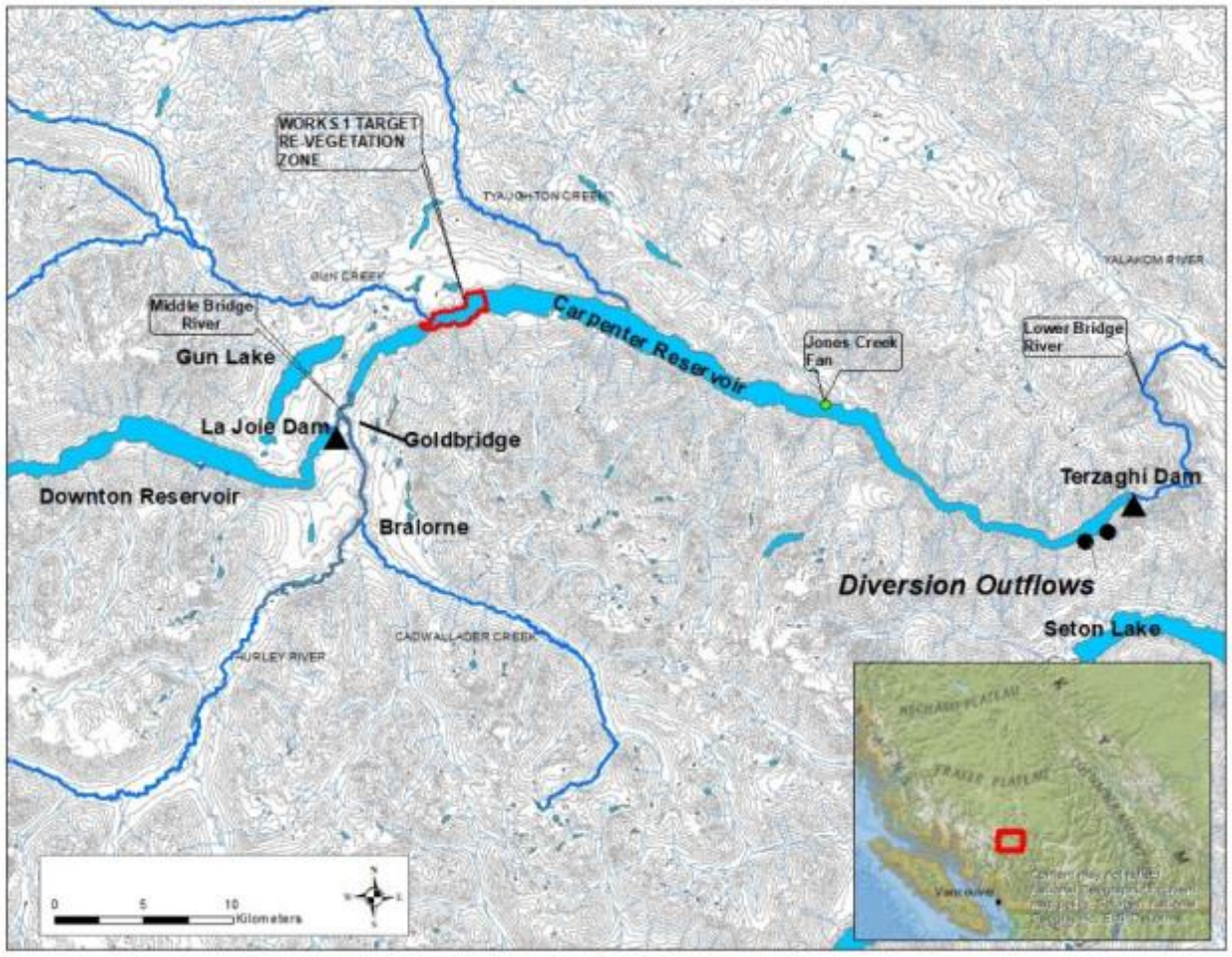


Figure 2. Region and geographic location of Carpenter Reservoir in British Columbia. 292 ha targeted revegetation region of the Carpenter Reservoir BRGWORKS-1 Revegetation Program

2. Methods

2.1.1 Permitting

A Section 11 BC *Water Sustainability Act* permit obtained dated April 26, 2017, was extended to cover work conducted in 2019. All work areas were above water levels at the time of treatment. The permit application was submitted by BC Hydro, with assistance and documentation from Splitrock Environmental Sekw'el'was (Splitrock) (Permit # R3-3005963).

Similar to 2017 survey carried out by Amec Foster Wheeler and St'at'imc Government Services, an archaeology impact assessment was conducted across all proposed treatment sites prior to treatment application in 2019 by Wood and Associates and St'at'imc Government Services. Maps of proposed treatment sites were provided to archaeologists, and the assessment was conducted between May14 and May 19, 2019. Field crews used standard assessment techniques and analysed the areas within the identified treatment polygons.

Historically, Gun Creek Fan East was the location of the mining town Minto. The town was founded in 1934 and inhabited until 1941. In 1942, the site was repurposed as an internment camp in 1942 for Japanese immigrants during World War II. The site was recently recognized with a heritage sign in 2017 as one of the regional internment camps occupied between 1942-1949. The town site of Minto was largely abandoned in 1940 and was flooded by high flows from Gun Creek in 1950. Currently, the entire town site is within the drawdown zone of Carpenter Reservoir (http://www.lillooetbc.ca/Recreation-Activities/Golden-Miles-of-History/Japanese-Canadians-in-Lillooet/The-Minto-Japanese-Canadian-World-War-II-Interment.aspx). While not considered a heritage site, Minto Mine is a provincially recognized historic area on the Heritage BC website, a result of the Japanese Canadian Historic Places Recognition Project.

2.1 Riparian Enhancements

Riparian enhancements were concentrated on the Low Mud Flat and on the Gun Creek Fan East side in 2019 (Figure 4, Table 2). Machine treatments were implemented on the Low Mud Flat area and on Gun Creek Fan East at the transition zone between alluvial and lacustrine deposition. Tractor tilling and seeding was performed on the Low Mud Flat, and planting and hand seeding was implemented on the Low Mud Flat as well as in sites treated with mounding in 2017. The bulk of the planted native species were Kellogg's sedge with lesser amounts of bluejoint reedgrass and trees and shrubs at upper elevations.

2.1.2 Machine treatments

The Bridge River Band was contracted to provide a machine operator and a 200 series Hitachi excavator to complete works in 2019. Riparian enhancements were planned and flagged out on in the spring of 2019. The goal was to roughen the relatively smooth microtopography of the drawdown zone, similar to rough and loose treatments used by Polster (2009). Treatment sites were targeted for the alluvial fan-lacustrine mud flat transition zone on the Gun Creek Fan East side as recommended in the 2018 BRGMON-2 report (Scholz and Gibeau, 2019). Treatment areas were placed outside of the historic Minto lot sites (Figure 4). Any sign of historical use or artifacts from theold town site were noted and avoided. Upper elevation polygons on the Gun Creek Fan West side were also delineated. Treatment areas were physically marked out with flagging for both archaeology assessment and machine operators. Proposed treatment polygons were adjusted in the field based on observations and professional judgement. Project field supervisor successfully completed BC Hydro Heritage and Archaeology Awareness training and two field crew successfully completed the Resources Information Standards Committee British Columbia Archaeological Inventory and CMT Training for Crew Members course. Machine operators were oriented on archaeology and historic find procedures, safety and environmental protection before the work was commenced. A second contractor was retained to assist with treatments after Bridge River Contracting encountered equipment and operator problems. Treatments were conducted between mid-June and the first week of July. As a precaution and to respect Heritage concerns, field planning for machine and tractor treatments were conducted to avoid any visible signs and property bounderies connected with the historic Minto town site. Mounding treatment polygons were kept outside of the historic Minto town lot sites.

2.1.5 Seeding Trials

Treatments were implemented across the Low Mud Flat (approximately 639.5 mASL elevation) using a tractor equipped with a plotmaster© seeder. Treatment polygons were flagged and designated as both individual and combined treatments (Table 2). Three types of seed were employed in trials in 2019. Fall rye (Secale *cereale*) was selected for seeding trials due to its rapid growth of robust plants that provide cover, and biomass above and below soil. Biomass was deemed important in increasing terrestrial and aquatic habitat (Perrin et al, 2001). Fall rye seeding trials in 2016, and monitored in 2017 indicated beneficial effects on seedling recruitment and Kellogg's sedge plug establishment. Fall rye seed was planted mechanically using the plotmaster© seeder pulled by a tractor, at an area density of approximately 50 kg/ha. Locally harvested native annual meadow birds-foot trefoil (Lotus denticulatus) was hand-seeded and the ground hand-raked (Figure 3). The trefoil was seeded at approximately 25kg/ha, and one plot was hand-seeded with Kellogg's sedge at an area density of approximately 15kg/ha. Polygons were hand-seeded and raked on the Low Mud Flat and in mounded sites (2017) at Low, Mid and Upper elevations of Gun Creek Fan East.

In addition to seeding, mechanical treatment (Tilled) was conducted across only two polygons (T1908, T1904, Figure 3). Plough tines and discs were employed for mechanical treatment, and no harrowing or compaction was used.

Table 2 Summary of 2019 treatments by polygon.

Polygon Id	Treatment	Area m²
T1904, T1908	tractor tilled	7806
T1903, T1907, T1909	tractor seeded with fall rye (*S. cereale*)	19773
T1905, T1914	seed fall rye, plant patches of sedges (*C. kelloggii*)	12910
T1901, T1902, T1906	planted patches of sedge (*Kellogg's sedge*)	19854
T1911, T1913, T1918	hand seed/rake *(Meadow bird's foot trefoil*)	2278
T1910, T1912, T1915	fill plant (*C. kelloggii)*	2348
T1916, T1917	fill plant (*C. canadensis)*	1311
T1919,T1918	fill plant (*P. balsamifera, P. Ponderosa, A.incana, A. viridis, Salix sp.)*	1622

Figure 3 Seeding in 2019. Tractor and plotmaster seeder carrying out mechanical treatment only (tilling) (left) and hand seeding and raking (right).

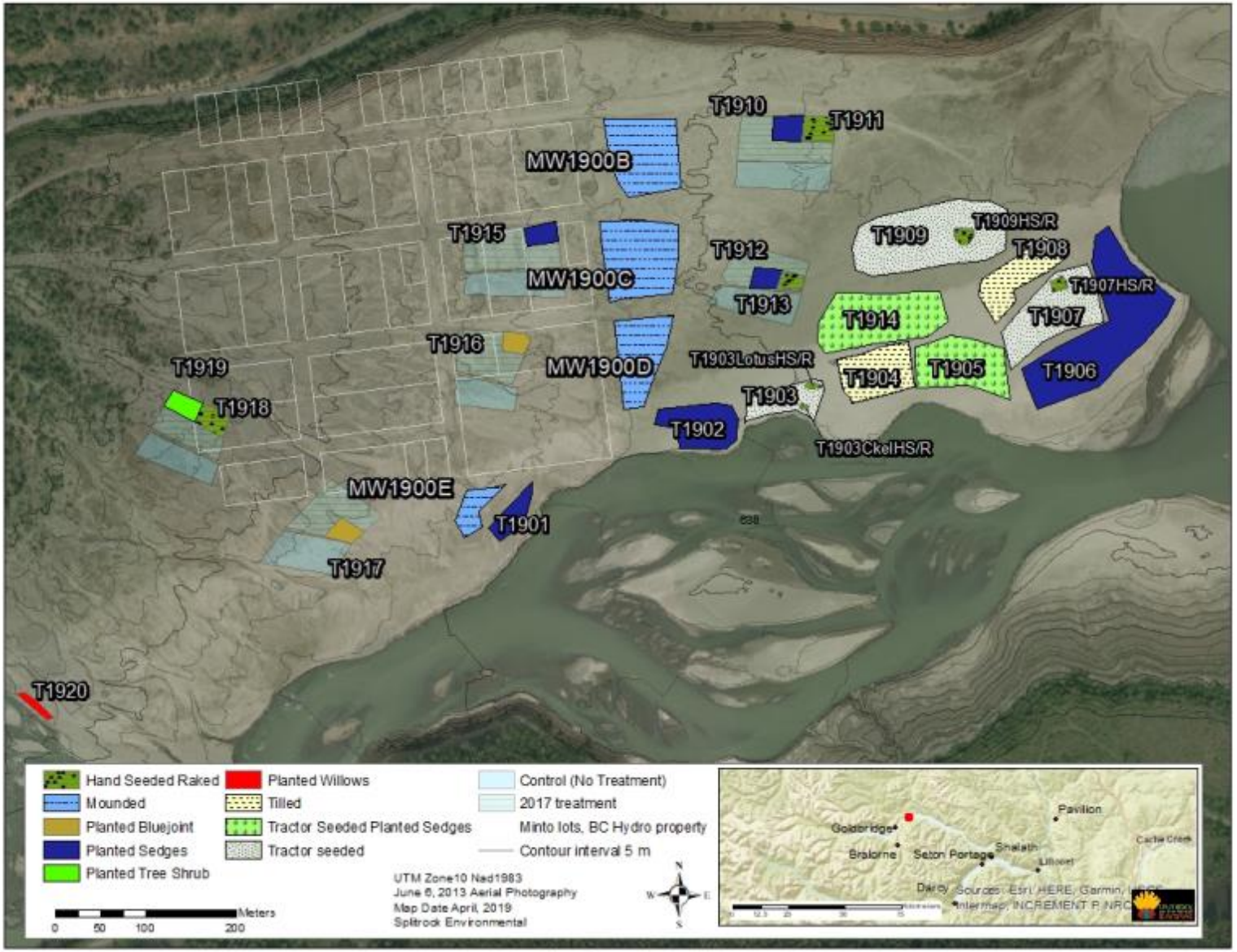


Figure 4. BRGWORKS-1 2019 treatment polygons.

2.1.3 Potted Plants

Nursery stock planted in 2019 was comprised of locally sourced native species. The principal species used were Kellogg's sedge (*Carex kelloggii*), bluejoint reedgrass (*Calamagrostis canadensis*), black cottonwood (*Populus balsamifera ssp. trichocarpa*), Ponderosa pine (*Pinus ponderosa*), mountain alder (*Alnus incana*) and green alder (*Alnus viridis*). Rooted coyote willow (*Salix exigua*) cuttings were planted near Gun Creek. A small number (50) common horsetail (*Equisetum arvense*) were planted on the Low Mud Flat. Potted plants were propagated from local sources including Kellogg's sedge and bluejoint reedgrass harvested within Carpenter reservoir drawdown area and grown at the Splitrock native plant nursery in Lillooet B.C.

During planting treatments, plants were kept cool under reflective Silvicool tarps in a shaded location. Crew technicians transported plants in planting bags lined with Silvicool inserts to maintain optimum temperatures for plants. Planting was carried out using standard tree planting shovels. Plants were spaced at different distances depending on the treatment site. Sedge plugs were planted in patches spaced between 10 and 30m apart while individual plants in a patch were spaced 30cm to 60cm apart. Polygons mounded in 2017 were fill planted using sedge, bluejoint, tree and shrub plugs with a spacing of at least 60 cm in between individuals (surviving and newly planted). Plants were watered on site after planting, and trees and shrubs at upper elevations (unlikely to be flooded) were mulched with partially composted bark mulch.

2.1.4 Live Stake Cuttings

A small patch of rooted willow (*Salix exigua*) and black cottonwood cuttings were planted in 2019. At polygon T1920 along the east side of Gun Creek on Gun Creek fan, rooted cuttings were planted into holes prepared with an excavator's assistance. The planting site was selected close to Gun Creek at an elevation where live stake trials from 2015 have had good survival (646 mASL) (Scholz and Gibeau, 2019). Cuttings were rooted in a greenhouse environment in deep containers (50cm) (Figure 5). Cuttings were planted by hand at the base of the machine-excavated hole, and were partially backfilled by hand. The rest of the holes were filled by machine. The cuttings were irrigated two weeks later.

Figure 5. Planting rooted cuttings in T1920 machine-dug trench June 24, 2019.

2.2 Dust Storms

Data was captured throughout the 2019 growing season at the 5 Mile Ridge Weather Station. Images were captured during daylight hours at 5-minute intervals. Images were analyzed by viewing each image and assessing the photo for evidence of dust suspension. Observed events were subjectively classified as small, medium or large. The origin (location) of dust events was noted, and any notes regarding the image were recorded by the observer. After all dust events were identified, events were tallied to indicate the number of events. If events occurred in sequence within a 30-minute span, all events were considered part of the same storm event. Individual images were ranked for size of event, therefore individual storms spanning multiple images could contain a range of different sized events including small, medium and large. Images were also analysed for sites that are primary sources of dust generation.

Figure 6. Map showing location of the dust storm monitoring weather station with cameras orientation relative to project area. Example of station photo inset.

2.3 Wildlife Use

Wildlife presence and use in the study area is being monitored by recording wildlife and wildlife sign as a component of the BRGMON-2 monitoring program. Incidental observations of wildlife presence and wildlife sign were also recorded during BRGWORKS-1 field operations and BRGMON-2 data collection. Locals provided wildlife observations in the study area as a component of the public survey conducted in 2014-2015, and the results were reported in Scholz, 2015. A breeding songbird survey was carried out in 2016 (Heinrich, 2016) to establish avian species composition at both revegetation treatment sites and reference sites around the reservoir. The breeding bird survey was repeated in 2018. An amphibian survey was also completed in 2018. The wildlife monitoring was subcontracted to Wildtech (R. Heinrich), and the 2018 report is included in the appendix of this report.

2.4 Water Levels and Drawdown Zone Elevations

BC Hydro manages Carpenter Reservoir water levels to maintain a 3 vertical meter buffer zone by having a target maximum pool elevation of 648.00 meters above sea level (mASL). BC Hydro manages Carpenter Reservoir for power generation, fish habitat, and to minimize spillage from Terzaghi Dam into the Lower Bridge River (BC Hydro, 2011). In the water use plan it states that reservoir incursions above 648.0 m are expected as a result of meeting other constraints with higher priorities, such as safety. The water levels for 2019 and the preceding BRGWORKS-1 treatment year's (2014-2019) hydrographs are presented in context of the 20-year WUP period from 2000-2019.

3. Results

The results section is divided into six sub-sections to address water levels, weather, riparian enhancements, dust monitoring, aesthetic and recreation and wildlife summaries for 2019.

3.1 Water Levels

Annually, Carpenter Reservoir water levels rise during much of the annual growing season (May-August). The rate and timing of filling determines the length of the growing season for plants in riparian enhancement treatment areas. Over the past 20 years, the average full pool level for Carpenter Reservoir has been approximately 646 mASL or 2 vertical meters below the lower elevation of the riparian buffer zone (Figure 7). During the period of BRGWORKS-1 treatments (2014-2019, WUP on Figure 7) the timing of water levels reaching the riparian enhancements (639.5-640 mASL) has been later by 2 weeks than the 20-year average. This time amounts to a minimum of 200 additional growing degree days. During 2019, water levels were drawn down to low levels (approximately 10th percentile). Rising water levels reached the lowest elevation of BRGWORKS-1 treatment zones (639.5-640 mASL) in early July. Full pool peaked around 645 mASL in 2019, leaving the upper drawdown treatment zones, particularly the polygons mounded in 2017 unaffected by inundation (Figure 8). Water levels dropped back below treatment areas in late December of 2019.

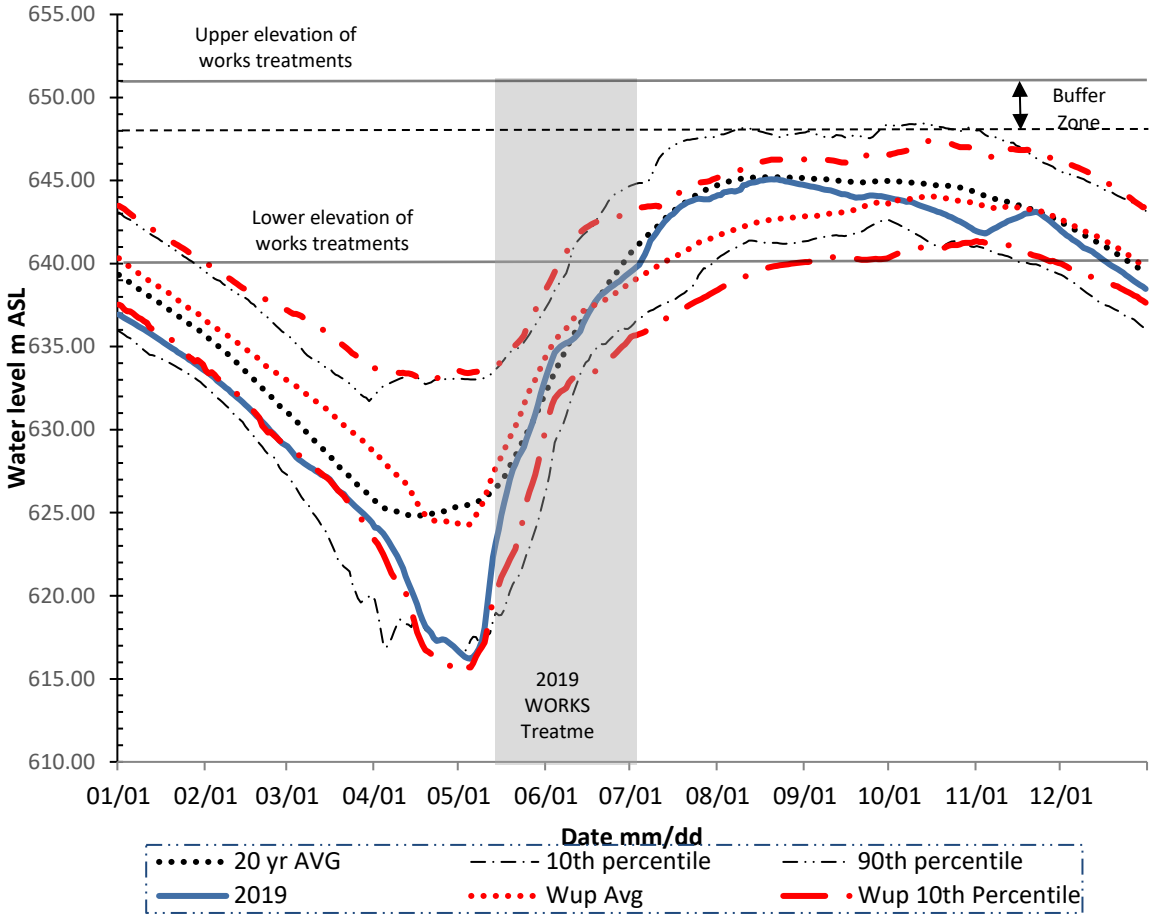


Figure 7. Carpenter Reservoir hydrograph for 2019 with annual daily average, 20-year and BRGWORSK-1 WUP period averages (2014-2019). Elevation zone of WORKS treatments is for all treatment years.

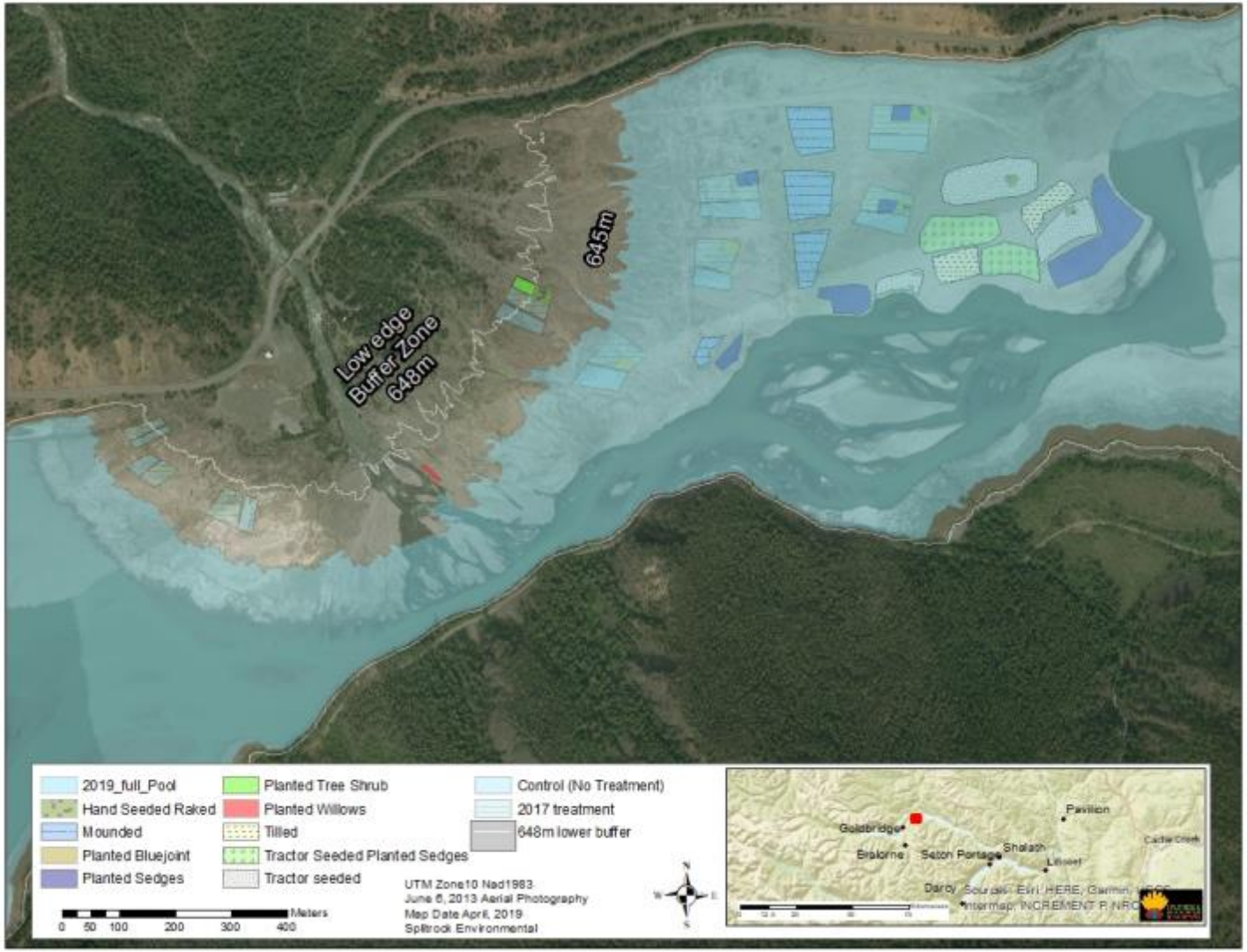


Figure 8 Treatment area around Gun Creek Fan depicting water levels reaching full pool August 22, 2019.

3.2 Weather

During the 2019 growing season, a total of 281 mm of precipitation fell across the BRGWORKS-1 treatment area. Much of the rain fell in June and July. Plants planted and seeds sown in 2019 received approximately 65 mm of rain during their establishment period prior to inundation of the Low Mud Flat treatment sites.

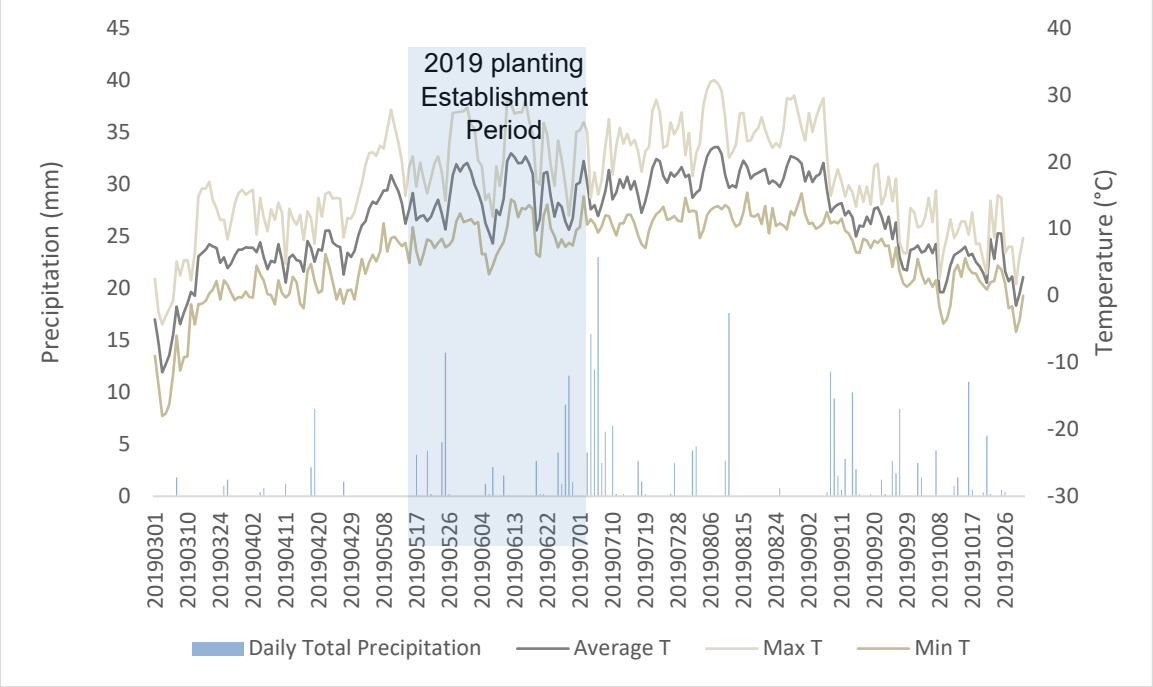
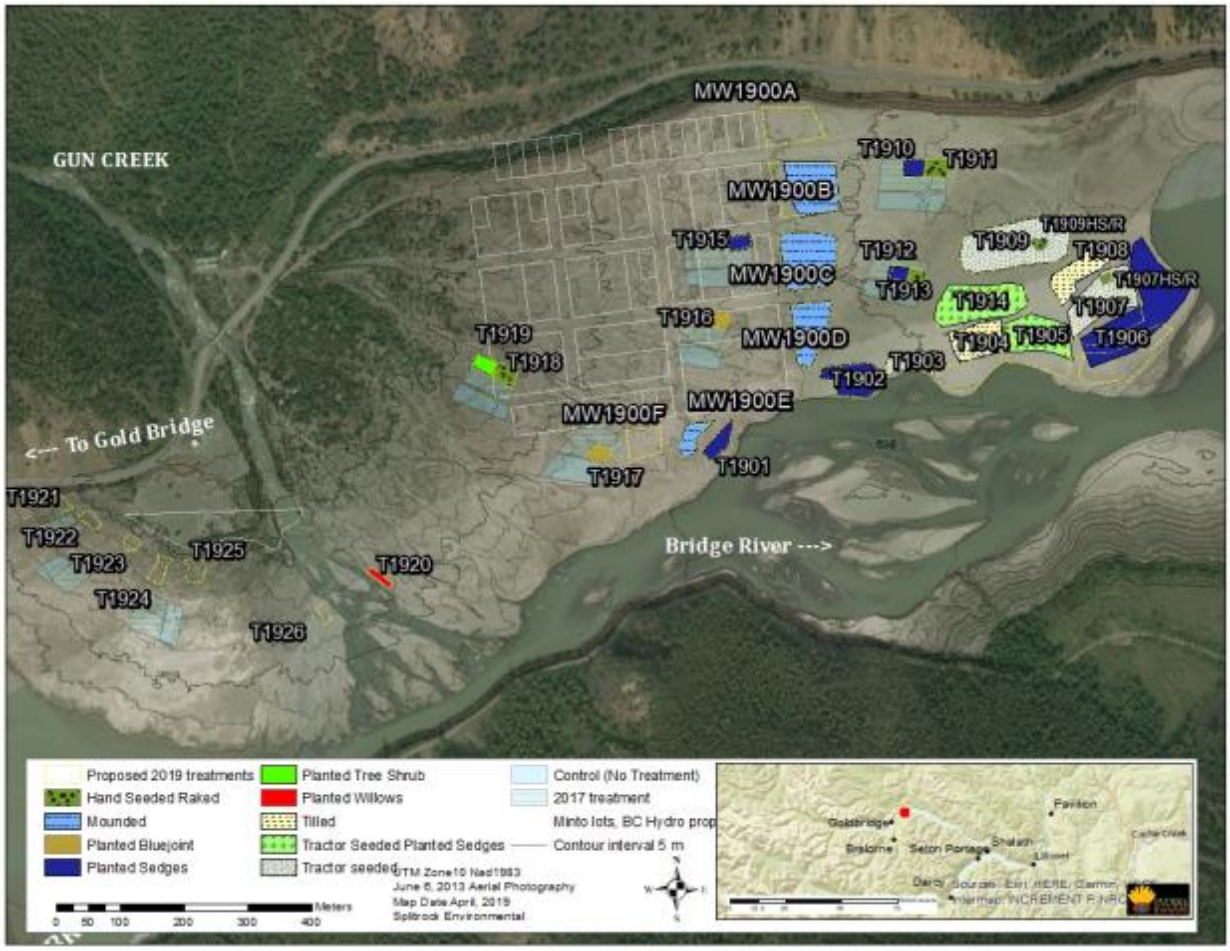


Figure 9 Precipitation during 2019 growing season. Period from planting and seeding to inundation of Low Mud Flat (639.5m) is shaded in grey.

3.3 Riparian Enhancements

Most of the areas proposed for treatment in 2019 were treated. Some of the machine work polygons were not treated due to contractors running out of time. MW1900A, MW1900F, T1921, T1922, T1923, T1924, T1925, T1926 were not treated in 2019 (Map 1). The proposed boundaries for T1904, T1905 and T1906 were adjusted in the field prior to accomodate both the archaeology assessment information and restoration treatment conditions. The boundaries were moved to avoid disturbing areas where a high number of naturally-recruiting desirable plants (sedges) were observed. During treatment, effort was made to avoid disturbing naturally establishing sedges. All naturally established plants were Kellogg's sedge (C. kelloggii).



Map 1 Map of proposed and treated polygons 2019

3.3.1 Permitting

An archaeology impact assessment carried out by Wood and Associates between May 14, 2019 and May 18, 2019 did not indicate any archaeological concern in the proposed treatment areas. All proposed treatment polygons, including those modified on site from initial boundaries, were assessed. The impact assessment included proposed polygons on Gun Creek Fan West that were not treated in 2019. Splitrock was given clearance via email to initiate restoration treatments. Sites identified in 2017 on the Gun Creek Fan West were considered and avoided in all project planning.

3.3.2 Machine Treatments

Mounding treatments were carried out in June and early July of 2019. Mechanical problems delayed the contractor start date, and progress was sporadic and slow, while water levels steadily rose. A second contractor was retained to ensure the bulk of the treatment areas would be completed before inundation of the treatment area occurred. Approximately 19,000m² of area was mounded within 4 polygons (MW1900B, MW1900C, MW1900D, MW1900E) (Table 3). T1920 was also mechanically treated to assist planting cuttings. Polygons MW1900A and MW1900F on the Gun Creek Fan East side and T1921 through T1926 on the Gun Creek Fan West side were not treated in 2019. These polygons will also be completed in 2020.

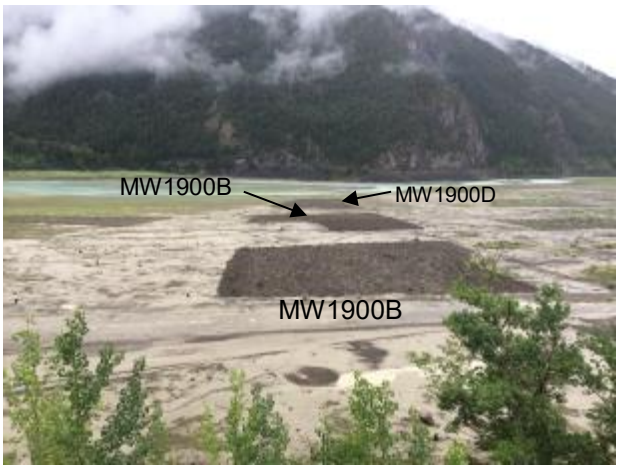


Figure 10 Mounding polygons on the Gun Creek Fan East, MW1900B, MW1900C and MW1900D near complete July 2019.

Table 3 Polygons mounded in 2019.

All	Area (m²)	Treatment
MW1900B	6121	Mounded
MW1900C	6868	Mounded
MW1900D	4521	Mounded
MW1900E	1407	Mounded
Total	18917	

3.3.3 Seeding

Seeding treatments in 2019 included mechanical sowing and hand-seeding and raking. Annual fall rye was mechanically seeded into polygons T1903, T1905, T1907, T1909 and T1914 covering 32924m² (Table 4). Rye was sown at an area density of approximately 50 kg/ha. Meadow bird's foot trefoil (*Lotus denticulatus*) seed was hand-sown and raked into 5 polygons totalling 2130m². Kellogg's *sedge* seed was sown into 5 polygons totalling 2082m². Accumulated growing degree days (AGDD) for seeding treatments ranged between 556 to 794 from the time of seeding to inundation (Table 5). Biomass sampling conducted on June 20th of 2019 indicated an average of 180 kg/ha of biomass was grown in polygons T1907 and T1903. Meadow bird's foot trefoil that was sown into polygons located within areas treated in 2017 had longer growing seasons. These sites had 794 AGDD. Polygon T1918 was not affected by inundation and experienced a full growing season. A natural patch of meadow bird's foot trefoil was observed growing on the Low Mud Flat. Plants were flowering and were producing green seed on June 23, 2019. These naturally established plants were flowering, fully grown and developing seed after 1120 AGDD (Figure 11).

Table 4 Approach to seeding in 2019.

NAME	Seed Lotus (Kg)	Seed C. kelloggii (Kg)	Fall Rye (KG)	area m²	Treatment
T1903			35	2558	Mechanical seeding
T1903CkelHS/R		0.09		(56)	Mechanical seeding-Hand seeding/raking
T1903LotusHS/R	0.25			(100)	Mechanical seeding-Hand seeding/raking
T1905			45	5419	Mechanical seeding
T1907			31	6421	Mechanical seeding
T1907HS/R	0.28	0.36		(244)	Mechanical seeding-Hand seeding/raking
T1909			45	11035	Mechanical seeding
T1909HS/R		1		(346)	Mechanical tilled-Hand seeding/raking
T1911	0.2	0.2		944	Hand seeding/raking
T1913		0.2		492	Hand seeding/raking
T1914			38	7491	Mechanical seeding/ planting
T1918	0.5			842	Hand seeding/raking
Total	1.23	1.85	194		

Table 5 Polygon seeding details 2019 treatment and growing season.

Polygon	Date seeded	Approx Innundation Date	Seed	2019 Growing Degree days before flooding
T1911, T1913,	May 15	July 5	*meadow bird's-foot trefoil, Kellogg's sedge*	794
T1918	May 17	None	*meadow bird's-foot trefoil*	2375
T1903, T1905, T1907,T1903CkelHS/R, T1903Lotus, T1907HS/R	May 23	July 01	*fall rye, meadow bird's-foot trefoil , Kellogg's sedge*	627
T1914	May 24	July 01	*fall rye*	613
T1909,	May 28	July 01	*fall rye*	556
T1909HS/R	May 28	July 01	*meadow bird's-foot trefoil,*	556

Figure 11 Left: example of fall rye growth after 565 AGDD. Right: natural patch of meadow bird's foot trefoil with estimated 1120 AGDD.

3.3.4 Planting

The majority of the plants planted through the BRGWORKS-1 project in 2019 consisted of *Carex kelloggii* plugs. Patches of *C. kelloggii* were planted in the Low Mud Flat polygons. Patches consisted of between 100 and 200 plugs spaced approximately 30-60cm apart (Bluejoint reedgrass plugs were added to mid-elevation polygons (T1916, T1917). Trees and shrubs were planted into upper-elevation polygon MW1706 (T1918,T1919). The extremely coarse substrate of MW1706 provided little area for planting, therefore planting was extended to include T1918. Trees and shrubs planted in T1918 and T1919 were mulched and irrigated following planting (Table 6).

Table 6. 2019 planting summary table. [1] 25 each of *P. ponderosa, A.incana, A.viridis, P.balsamifera*. [2] 10 *S.exigua*, 6 *P. balsamifera*.

Name	Type of planting	*Kellogg's sedge*	*Bluejoint*	*Horsetail*	tree shrub	rooted cuttings	area	Treatment
T1901	Patches	695					1291	Planting 3X200, 1X95
T1902	Patches	1500					3611	Planting 10X150
T1905	Patches	900					5419	Tractor seeding/ planting 9 X 100
T1906	Patches	2100		50			12604	Planting 10X200, 1X100
T1910	Fill	300					900	Planting
T1912	Fill	300					675	Planting
T1914	Patches	1500					7491	Tractor seeding/ planting 10X150
T1915	Fill	300					773	Planting
T1916	Fill		300				626	Planting
T1917	Fill		150				685	Planting
T1919	Fill				1100		780	Planting
T1920	Area					216	390	Cuttings
Total		7595	450	50	100	16	35245	

Planted patches of sedges included areas that were already seeded with fall rye (T1905, T1914). Polygons T1901 and T1906 were planted with patches of sedges. Sedge plugs were added to sections of mounded polygons treated in 2017 (T1910, T1912, T1915,). Bluejoint reedgrass plugs were added to mid-elevation polygons (T1916, T1917). Trees and shrubs were planted into upper-elevation polygon MW1706 (T1918,T1919). The extremely coarse substrate of MW1706 provided little area for planting, therefore planting was extended to include T1918. Trees and shrubs planted in T1918 and T1919 were mulched and irrigated following planting.


d
Left; polygon T1905 seeded with fall rye and visible circular patches of planted sedges. Right; planting Poly T1906.

3.3.5 Live Stake Cuttings

With machine assistance, rooted cuttings were planted on the east side of Gun Creek. Ten rooted coyote willow (*S. exigua)* and 6 black cottonwood (*P. balsamifera)* were planted approximately 1m deep at polygon T1920. Cuttings planted on the west side of Gun Creek Fan in 2017 were irrigated and mulched in 2019. Upper elevation polygons were irrigated at least twice during the growing season. Dense patches of noxious and exotic invasive plant species were observed colonizing live stake cutting polygons. The most notable of these polygons was the area of Gun Creek Fan West that was mounded in 2017. Spotted knapweed (*Centaurea stoebe*) and Dalmatian toadflax (*Linaria genistifolia*) are both provincially-listed noxious weed species and were common in these polygons. Other exotic species commonly observed across these sites were oxeye daisy (*Leucanthemum vulgare*) and great mullein (*Verbascum thapsus*). Maintenance included mechanical removal of exotics, as time allowed.

.

Figure 12 Mulch added to MW1909, both cuttings and planted *P.balsamifera* and Salix species.

3.4 Dust Storms

Images were analysed for 2019 from January through October. During the year, a total of 149 dust storms were observed. The vast majority of the storms (93%) were observed in April, May and June (Figure 14, Table 7). Much of the site was under ice through the end of March 2019. The majority of dust generation, as noted in previous years, arises from the river banks and fluvial bars along and within the main flow channel of the Bridge River (Figure 16). These sites are characterized by loose, fine silts and sands that are disturbed through combined water and wind erosion. The majority of these larger river bank, dust-generating sites are covered in water when the reservoir water levels are at 635.5 m in elevation (Figure 17). Carpenter Reservoir water levels reached 635.5 m in elevation on June 11, 2019. Dust is repeatedly observed being suspended from vehicle traffic. Vehicle-suspended dust is localized and short lasting. A slight amount of dust suspension was observed being generated during tractor seeding under BRGWORKS-1 project.

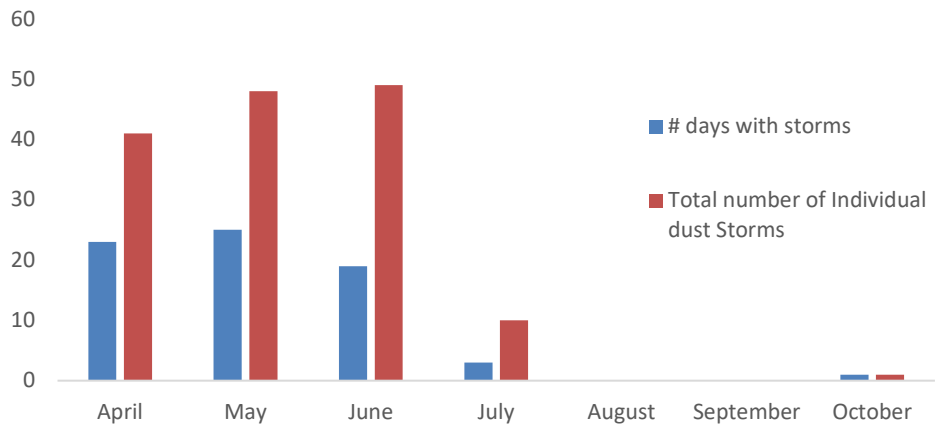


Figure 13 The total number of dust storms and individual days with dust storms during 2019.

Figure 14 Typical dust storms, arrows indicating frequent points where dust is generated along the banks of the Bridge River.

Figure 15 Reservoir levels on June 11, 2019 (635.5m).

Table 7. Summary of Dust Storm Events captured on images April-October 2019.

Month	Total Sampled	Total Positive Recordings of Storms	Total Small	Total Medium	Total Large	Indv. Total Storms	% of sample	# days 2019
April	4909	758	239	250	266	41	0.154	23
May	5668	637	282	179	180	48	0.112	25
June	5789	290	189	48	53	49	0.050	19
July	5792	12	4	3	5	10	0.002	3
August	5316	0	0	0	0	0	0.000	0
September	4461	0	0	0	0	0	0.000	0
October	3891	2	1	1	0	1	0.001	1
Total	31365	1699	715	481	504	149		71

3.5 Aesthetic and Recreational Use

The east side of the Gun Creek fan is a BC hydro recreation campground. Anecdotally the campground is often in use by a few campers through summer weekdays and busier on weekends. Crews observed 4X4, ATV and motorcycle traffic on the Gun Creek Fan. Walkers and anglers at the river were also fairly commonly observed, particularly at the confluence of Gun Creek and the Bridge River. A small jetboat was observed being launched and operated in the Bridge River. Shotgun shell casings and clay pigeon remnants were observed on the low mud flats suggesting skeet shooting is practiced on the mud flat.

3.6 Wildlife Use

While on site, crews recorded anecdotal observations of wildlife presence and use in the area. Of note, juvenile western toads (*Anaxyrus boreas*) were observed in MW1702 (T1911) (Figure 18). These toads were observed during seeding of the site in May. Care was taken to avoid contact with any toads that may have been there during treatment. Based on typical breeding timing it is unlikely that the toads were bred on site in pools that remained at the base of some of the mounds. Adult toads would have been seeking reproduction sites at this time of year and 2020's toadlets would not be expected to emerge from pools until late June at the earliest (Heinrich, 2020). During planting and seeding during May 26-28th of 2019, numerous juvenile toads were observed directly along the fringe and banks of the Bridge River where it flows through

the Low Mud Flats. Other incidental observations included multiple juvenile western terrestrial garter snakes (*Thamnophis elegans vagrans*) found in the polygons mounded in 2017 during BRGMON-2 monitoring in June of 2019 (Scholz and Gibeau, 2020). Occasionally, Mule deer tracks were observed across the site. A deer leg was found lying on the Low Mud Flat (Figure 19). A spotted sandpiper nest and spotted sandpiper egg shells were observed in one of the treatment areas. The site in question was planted with *Kellogg's sedge* plugs in 2016.

Figure 16 Left; example of a western toad found in T1911 May 15, 2019. Right; T1911 June 21, 2019 with pools in base of mounds. (please note time stamp on camera was one month off)

Figure 17 Left; mule deer leg observed on low mud flat June 5, 2019. Right; spotted sandpiper nesting site with egg shell. June 12, 2019.

A breeding bird and amphibian survey was conducted in 2018 (see full report in Appendix). Surveys were conducted at restoration and reference sites. Amphibians identified during the survey included Pacific chorus frog (*Pseudacris regilla*) and western toad (*Anaxyrus boreas*). Both species were observed in the Mid Mud Flat located upstream of the Gun Creek Fan.

4. Discussion

The BRGWORKS-1 treatments discussed here are then followed by specific discussion relating to each of the 3 management questions. Treatments carried out under the BRGWORKS-1 program in 2019 built on 5 years of treatments and were guided by recommendations made in the 2018 BRGMON-2 Mid Term Comprehensive Report (Scholz and Gibeau, 2019). That report recommended expansion of machine mounding and mechanical seeding treatments across the Low Mud Flat area as well as planting and combined planting and seeding treatments. The sites targeted for mounding were concentrated along the transition zone of substrate composition from the coarse rock of the alluvial fan and the fine silts of the Low Mud Flat.

Implementation of some 2019 treatments was delayed until recommendations from archaeological impact assessment was received. Fall rye was selected for widespread seeding due largely to the grasses large seed, rapid germination and growth and high production of biomass. The fast growing grass was chosen to provide a living cover that could trap wind blown sediment, stabilize the soil surface and provide cover and habitat in a short period of time. The organic matter fromm the grass would build soils. Fall rye has been successfully seeded on other drawdown zones in British Columbia including the Arrow Lakes Reservoir. Fall rye seeding resulted in increased establishment of perennial vegetation including Kellogg's sedge (personal communication A. Moodie). Studies in the Arrow lakies system showed establishment of vegetation (fall rye) in the drawdown zone greatly increases the capacity of the site to host diverse and abundant benthic communities when inundated (Perrin et al, 2001Seeding treatments took place in mid-May and resulted in a limited growing season, with inundation submerging the polygons (640m ASL) by early July. Accumulated growing degree days were approximately 600 days for seeded fall rye. Biomass produced over this time was fairly low (Scholz and Gibeau, 2020). Biomass volume in seeded fall rye polygons was in the same range of biomass produced on the Low Mud Flat control areas. With no additional biomass produced in fall rye plots vs control areas, it is unlikely there were any additional benefits to seeding treatments in 2019. In 2016, fall rye was seeded in mid-April and inundation was four weeks later (July 29, 2016) allowing for 1500 AGDD in fall rye polygons. Although biomass was not sampled in 2016, rye plants were observed to have grown much larger than 2019 plants, and were nearing maturity (flowering)in 2016 reaching between 0.5m and 1m in height compared with 10-20 cm (tiller stage) achieved in 2019. We may speculate that in 2016, seeded fall rye grew to exceed control area biomass by double and likely more. It is estimated that to achieve significant growth of biomass from spring seeded fall rye, the AGDD need to be a minimum of 1000 days (base 0 °C). While 2019 fall rye treatments provided some value in low stage of growth, the effectiveness of seeding would be much greater if seeded earlier (mid-April).

It is unclear how root production in fall rye may affect biomass production and recruitment on the site. Species found in control sites tend to have slender taproots where fall rye has a robust fibrous root structure that forms 30% of total biomass (Patel et al., 2015). Further investigation would be required to compare root biomass production in control vs seeded polygons and to describe the influx of subsurface biomass into the land base from seeding fall rye compared with control areas.

Mounding treatments were completed just ahead of inundation of those sites. Areas mounded in 2019 will have additional treatments completed during the 2020 field season. Polygons MW1900A, MW1900F were not treated in 2019, and it is unclear if MW1900C was completed prior to flooding. An early assessment of the 2019 treatment areas will need to be conducted to determine the full extent of areas still in need of mounding treatment in 2020. All of the areas mounded in 2019 were fully inundated and will likely be well-settled for the 2020 seeding and planting treatments. Polygons that were pre-surveyed and flagged for treatment, but not completed in 2019, will be treated in 2020. Mounding polygons treated in 2019 will have additional planting and seeding treatments in 2020 post inundation as was recommended in BRGMON-2 mid-term comprehensive report (Scholz and Gibeau, 2019).

The Kellogg's sedge plugs planted in 2019 had over a month to establish before inundation. It is likely that plants were able to root into surrounding substrate, anchoring plants against floatation under inundation. Kellogg's sedge plugs planted in patches across the Low Mud Flat in both seeded and non seeded areas will be assessed for survival in 2020. Fill planting conducted in polygons mounded in 2017 (sedges T1910, T1912, T1915 and bluejoint T1916, T1917) will be assessed for survival under BRGMON-2 program in 2020.

Upper elevation treatments did not experience flooding and were more susceptible to the stressors of drought conditions due to coarse dry soils and limited precipitation. The lack of flooding is beneficial to maintaining mulch in place around plants. If the WUP Modified Operations water level pattern continues, maintenance treatments for upper elevation treatment sites, including mulching and irrigation, should continue for the duration of the BRGWORKS-1 program. It would be advisable to add weedy/invasive species treatment to maintenance for the 2020 field season.

Through camera image monitoring from the 5 Mile Ridge, site insights have been gathered regarding management question 1: "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?".

Dust storm mitigation is a main objective of the BRGWORKS-1 program. The prevailing winds continue to be from west to east, driving any dust away from Gold Bridge. Few residences are know to the east in the direction of the prevailing dust movement. The closest known to the east and north are over 5 km from the Gun Creek Fan. It is apparent from observing dust storm patterns that the vast majority of the dust that is generated from the BRGWORKS-1 target treatment area is coming from sites directly along the Bridge River. As discussed in earlier reports, these sites are difficult to vegetate due to the low elevation (<635 mASL) as well as the continuous water erosion from the flowing river (Scholz 2019). Increasing both annual and perennial vegetation cover on the Low Mud Flat may trap fines lowering the potential for resuspension of eroded materials.

Management Question 2: "Will the planting of vegetation in the drawdown area increase the aesthetic quality and recreational opportunities in the western end of the Carpenter Reservoir?".

Identifying impacts of the program on aesthetics and recreation is difficult to measure. A survey of locals and users of the area will be solicited at the end of the treatment program as a way to guage public perception. With the slow rate of establishment and spread of native species the most obvious change is the physical creation of the mounded treatment polygons.. It is unlikely that any obvious significant visual shift in long term cover of vegetation will be notable for a number of years. Although the mounds may appear to have a part in increasing native species diversity, they are not yet having a significant impact on vegetation cover, and the physical texture change will likely continue to be the dominant perception over increases in vegetation cover. Recreational use of the area is appararent with off-road vehicle use being one of the main users.

Management Question 3 “Will the planting of vegetation enhance the quality of riparian habitats and increase their potential to support wildlife populations and provide localized improvements in the quality and productivity of aquatic habitats in Carpenter Reservoir?”

The question considers the effects on the quality and productivity of habitat for both riparian wildlife and aquatic habitat: “

IIncidental observations have shown that mounding treatments have resulted in increased incidental sighting of amphibian and reptile species, though this was not part of a rigorous study. Although breeding bird surveys did not detect any species on the Low Mud Flat treatment area, direct evidence of a spotted sandpiper breeding successfully on a restoration treatment area of the Low Mud Flat was observed. The reference site at the Mid Mud Flat (MMF) is the most comparable habitat to what can be expected as long-term successful results from habitat recruitment for the Low Mud Flat. Given observations at that site, ground nesting species (such as spotted sandpiper) would be the most likely recruits to the restoration treatment areas. In time, upper elevation sites may support more diversity of species as vegetation structure develops.

Currently, based on observations and breeding bird surveys, sign and use of target restoration sites by wildlife species is low. The high exposure from lack of cover minimizes available habitat for most wildlife species. The area may solely function as a direct area of travel both along the river, and across the valley. The Gun Creek Fan is the narrowest distance between north and south shorelines of Carpenter Reservoir. We may speculate that this short crossing distance may encourage wildlife to cross the valley in this area. Incidentally we have observedy, mule deer crossing the river from south to north in this area. Bear (Arctos sp.) tracks leading from the low mud flats, north to south, into the river have also been observed in a similar location.

Observations of toads, snakes and water fowl using the Bridge River and its riverbanks suggests that revegetation efforts building out from the edges of the river aids in increasing habitat connectivity. Creating patches of vegetation such as sedges, and seeding fall rye up to the river bank will create cover, at least temporarily, to allow ground dwelling species such as snakes and toads to move between the river and the mudflats with greater ease. It may be informative to monitor the mounds for pools that may support western toad spawning in the mounding sites. Of particular interest would be the assessment of the longevity of the pools that form at the base of the mounds with respect to their potential as reproduction sites for amphibians or even as potential wildlife

sinks (Pulliam, 1988). Also, to determine if mounding sites are fragmented from other viable habitat such as the Bridge River. Promoting patchy perennial vegetation and contiguous annual vegetation cover, between mounding sites and the river, may enhance wildlife habitat values across the mud flats and within the mounded polygons.

With regard to the effect on aquatic habitat quality and productivity, the findings of Perrin et al., 2002 showed that an increase in vegetation cover increases aquatic productivity. Where native perennial vegetation becomes established and thrives, it can be expected that aquatic habitats to improve in quality and productivity. The question is whether the changes created by BRGWORKS-1 treatments are on a large enough scale to have meaningful long-term impacts on aquatic habitats. It may be worth investigating further if there are any concerns around the mounds and pits serving as stranding sites for fish. The drafting time across these elevations is during winter when a thick ice surface exists, but suckers and shiners are prolific around the Gun Creek Fan, and it may be worth investigating if there are risks to fish.

5. Recommendations

Implementing the final year of the BRGWORKS-1 treatments as early as possible in the spring is the key recommendation from previous years of treatments. This is with particular reference to seeding and planting treatments. Other recommendations are included in the BRGMON-2 2019 final report. Recommendations also include;

- Seeding by mid-April after ice has melted and ground has dried enough to make the soil workable;
- Planting should follow seeding in late April and early May;
- All planting will benefit from irrigation at the time of planting, and subsequent irrigation should be applied throughout the growing season, particularly for upper-elevation coarse substrate sites. Timing and number of maintenance visits required will depend on the seasons weather conditions and reservoir water levels.
- All tree and shrub plantings above 646 mASL elevation should be mulched. Clean compost (free of weeds) is preferred for this purpose;
- Maintenance be expanded to include noxious weed and exotic species control measures on the Gun Creek Fan West side mounded polygons;
- Low-elevation mounded sites should be monitored for possible function as wildlife sinks particularly for western toads;
- Connectivity should be maintained and promoted between mounded sites and the River;
- Biomass sampling for fall rye should be carried out again in 2020 under the BRGMON-2 program to assess biomass produced under a longer growing season than was experienced in 2019. Consider sub-sampling below ground biomass as well (i.e. excavate or pull plants rather than clip) to assess below ground effects of seeding;
- A public survey, similar to the one created in 2014, should be developed and distributed to solicit feedback from the public regarding aesthetic and recreation impacts for the site;

- Make public education a component of the 2020 field season to inform public perception and maintain a dialogue regarding the BRGWORKS-1 project. A public field tour similar to the one conducted in 2017 may be beneficial to carry out;
- Continue monitoring dust generation.

6. Conclusion

Treatments implemented in 2019 built upon 5 years of treatments and on the monitoring results under the BRGMON-2 program. Mounding treatments were a key component of the works, and mounded areas were expanded. The location of mounding treatments was placed based on geomorphological factors and public concerns. Sites were located outside of the main historic town site of Minto BC, and were concentrated on areas where vegetation growth was scarce, and fine soils were shallow at the alluvial fan/lacustrine mud flat transition zone. In addition to mounding, combined treatments of planting and seeding were carried out across the drawdown zone mud flats. Seeding treatments of annuals such as fall rye and meadow bird's foot trefoil had a relatively limited number of growing degree days between seeding and inundation, resulting in small amounts of biomass being produced. Treatments, particularly seeding, will be more productive and ecologically impactful if implemented in early spring. Dust is reduced as vegetation cover increases; however, dominant sites of dust suspension are difficult to target for restoration due to elevation and continuous water erosion. Revegetation across the mud flats does have the potential to trap sediment deposits and to keep them from being remobilized. Aesthetics and recreation effects have not been quantified yet. Both terrestrial and aquatic habitat is improved in quality as vegetation establishes in treatment areas; however, the size of the revegetated area is currently low, though perhaps not insignificant.

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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

Carpenter Reservoir Amphibian and Songbird 2018 Summary Report

Splitrock Environmental Sekw'el'was LP.

Prepared by:

Ralph Heinrich
Wildtech Biological Services

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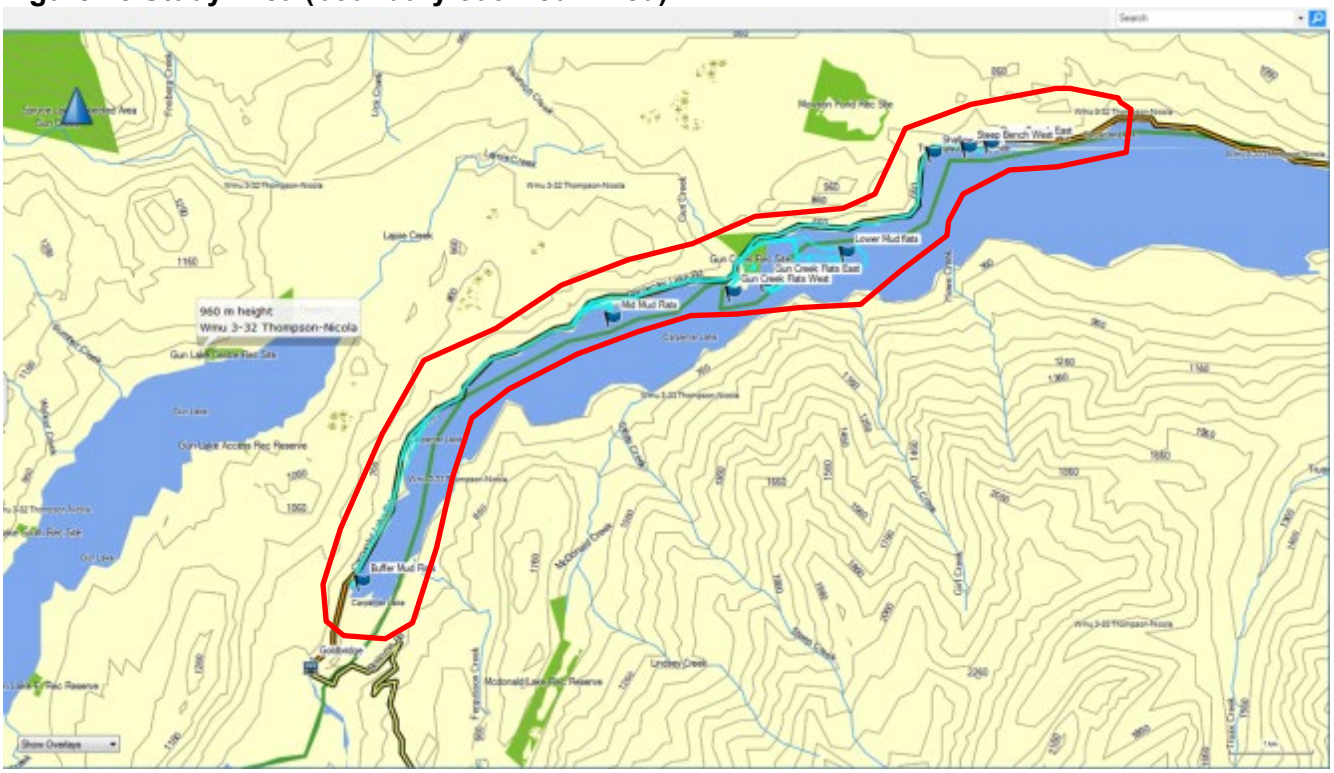
Introduction

Wildtech Biological Services was contracted by Splitrock Environmental Sekw'el'was LP to conduct amphibian auditory surveys and breeding bird point counts at restoration sites on Carpenter Reservoir. The purpose of the surveys was to provide a second season of baseline wildlife data for restoration monitoring being conducted under BRGWORKS 1 Carpenter Reservoir Riparian Enhancement Project, as part of the Bridge Seton Water Use Plan.

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 Gold Bridge, BC) to approximately 11 kilometers east (downstream) along Carpenter Lake (Figure 1).

Figure 18 Study Area (boundary outlined in red)



Methods

Both the amphibian and breeding bird point count surveys were conducted at eight restoration monitoring locations along Carpenter Reservoir in 2018. Amphibians were added as a monitoring component in 2018, whereas the songbird point counts were repeat monitoring from 2016. These surveys focused on assessing the amphibian and songbird communities at six restoration sites and two control sites (Table 1).

Amphibians

Amphibian surveys were conducted using auditory survey techniques outlined in Inventory Methods for Pond Breeding Amphibians and Painted Turtle (RIC 1998) and Graeter et al (2013). A combination of auditory surveys and opportunistic visual encounter transects were used to inventory amphibians. Survey site locations were the same as the songbird point count locations used in 2016 and 2018 (Table 1). Auditory surveys were conducted from dusk until approximately midnight. Two evenings of auditory surveys were conducted approximately three weeks apart to cover a range of environmental conditions and possible breeding events. A five-minute survey duration was used at each station to maximize detections. Auditory surveys were only used to inventory calling species of amphibians.

Songbirds

Songbird point count surveys were conducted at each site (Table 1) 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 (RIC, 1999), and in Monitoring Bird Populations by Point Counts (Ralph et al., 1995).

In order to determine species richness, diversity and potential breeding within habitats associated with each specific site, only detections within 100m radius were used for analysis.

Table 8 Survey locations 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 Fan West (GCFW)	PC03	10U	515784	5637729	Alluvial Fan/Mud Flats
Gun Creek Fan 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

Surveys were conducted at each site during appropriate weather conditions, beginning at dawn and continuing for approximately 4 hours. Noise and other disturbances were 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	Acceptable
3	12-19	Marginal
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.

Incidental Wildlife

All incidental wildlife observations were also recorded. Data collected included where possible: species, age, sex, number of individuals, location (GPS) and photos.

Results

Amphibians

Auditory surveys for amphibians were conducted over two evenings on May 17th and June 9th, 2018. Auditory survey results are presented in Table 3.

Table 10 Auditory Survey Results

Site Name	Species	*Latin Name*	Number of Auditory detections	Number of visual detections
BMF	pacific chorus frog	*Pseudacris regilla*	1	1
MMF	pacific chorus frog	*Pseudacris regilla*	3	Nil
	western Toad	*Anaxyrus boreas*	Nil	1 (adult)
LMF			Nil	Nil
GCFW			Nil	Nil
GCFE			Nil	Nil
SHB			Nil	Nil
STBW			Nil	Nil
STBE			Nil	Nil

Birds

Total Detections

Three rounds of songbird point count surveys were conducted on May 17th June 9th and June 29th, 2018 for a total of eight point count stations (Table 4). A total of 348 detections of 38 species were made during the three rounds of point count surveys (Figure 2 and Table 4). The most frequently detected species were Canada Goose (*Branta Canadensis*) with 115 detections (33%) followed by Mallards (*Anas platyrhynchos*) 70 detections (20%). Mallards and Canada Geese moved frequently between sites and flocked in large numbers and were therefore analyzed separately. For the remaining 36 species a total of 161 detections were made with the most frequently detected species being Western Tanager (*Piranga ludoviciana*) 24 detections (15%), American Robin (*Turdus migratorius*) 22 detections (14%) and Spotted Sandpiper (*Actitis macularius*) with 12 detections (8%).

The point count radius was limited to detections within a 100m radius to better reflect the birds using the habitat within the control and restoration sites. Within the 100m radius limit a total of 233 detections were made. Not including Mallards and Canada geese, the same three species had the most detections (Figure 3, Table 4).

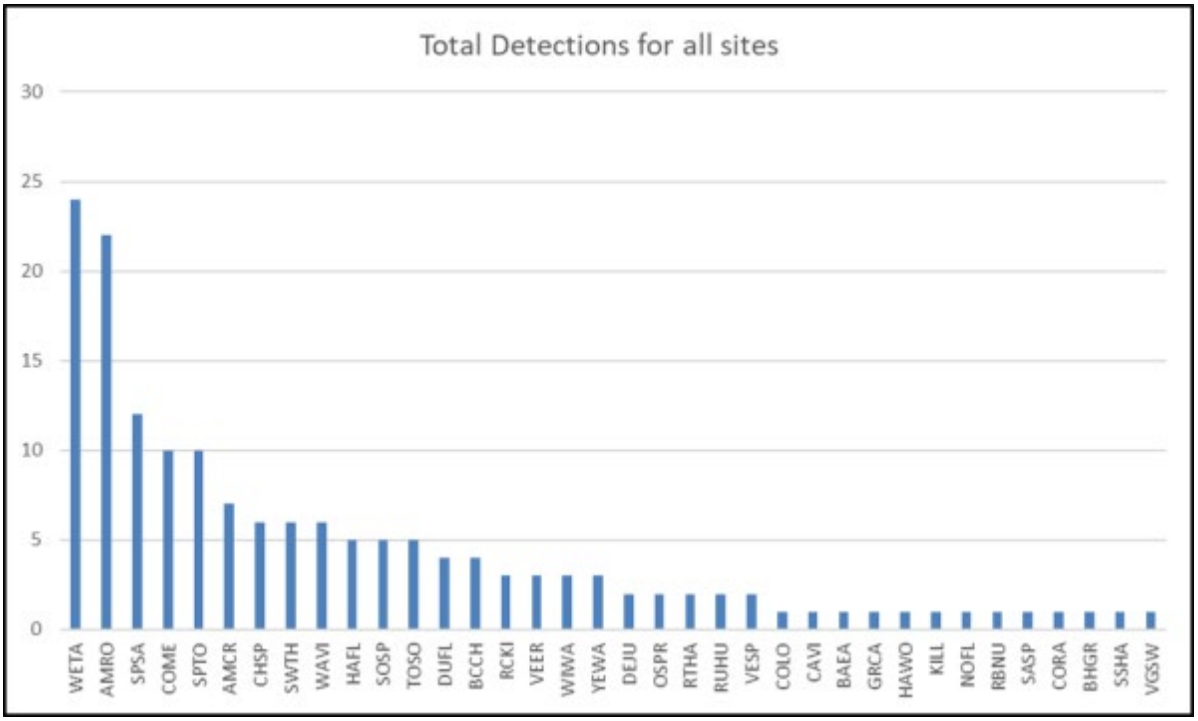


Figure 19 Total detections across all sites (unlimited radius). Canada Goose (115 detections) and Mallards (70 detections) were not included in the graph for visual purposes.

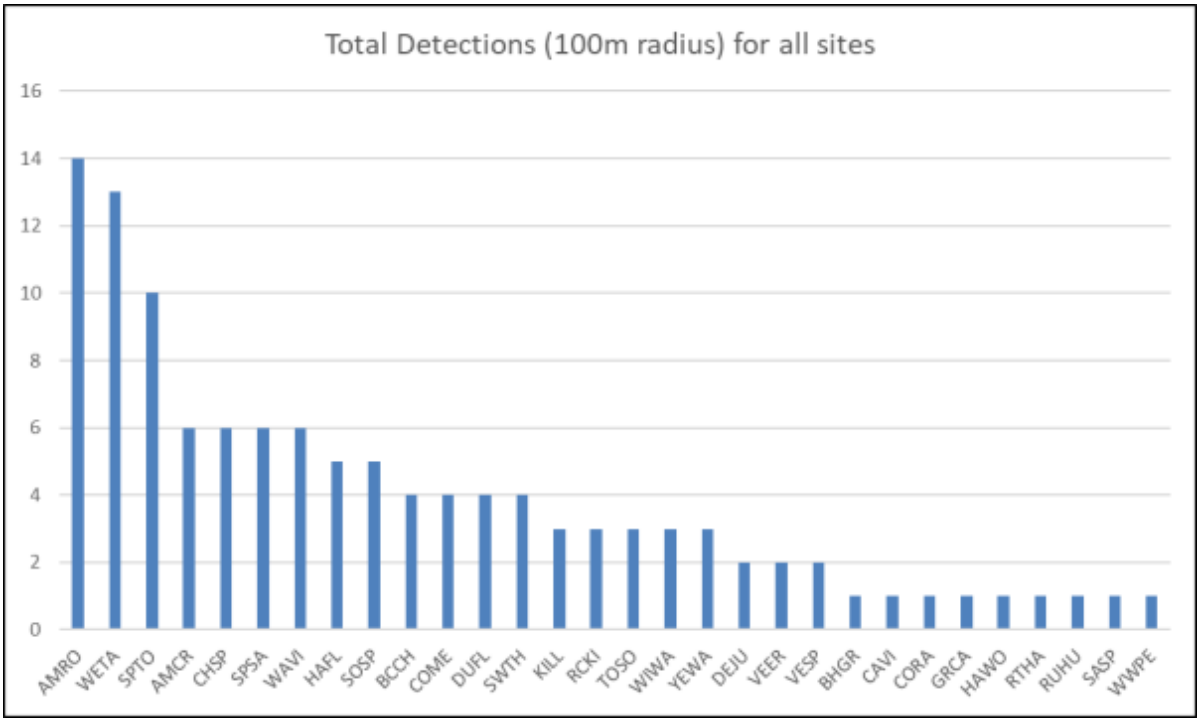


Figure 20 Total detections across all sites (within 100m radius). **Canada Goose (33 detections) and Mallards (61 detections) were not included in the graph for visual purposes.**

Control Sites

The Buffer Mud Flats (BMF) control site (Figure 3 and Table 4) had the highest number of total detections (40% of all detections) and the highest number of species (23) (61%). 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 (Table 4). Total number of detections ranged from a high of nine individuals at the Shallow Beach (SHB) to just two individuals at the Lower Mud Flats (LMF) and Gun Creek Fan East (GFCE).

Table 11 Species list and number of detections by site (three rounds combined)

Site Name	Species	Number of Detections	
		Unlimited Radius	100m Radius
BMF	American Robin	6	4
	Warbling Vireo	5	5
	Canada Goose	4	0
	Black-capped Chickadee	4	4
	Western Tanager	4	2
	Dusky Flycatcher	3	2
	Yellow Warbler	3	3
	Wilson's Warbler	3	3
	Veery	3	2
	Swainson's Thrush	3	2
	Song Sparrow	2	1
	Rufous Hummingbird	2	1
	Western Wood Peewee	1	0
	Hairy Woodpecker	1	1
	Chipping Sparrow	1	1
	Mallard	1	0
	Ruby Crowned Kinglet	1	0
	Gray Catbird	1	1
	Red-breasted Nuthatch	1	0
	American Crow	1	0
	Black-headed Grosbeak	1	1
	Northern Flicker	1	0
	23	52	37
MMF	Canada Goose	19	19
	Common Merganser	6	0
	Spotted Sandpiper	5	3
	Mallard	5	0

Site Name	Species	Number of Detections	
	Western Tanager	4	1
	Song Sparrow	3	2
	American Robin	2	0
	Swainson's Thrush	1	0
	Vesper Sparrow	1	1
	Red-tailed hawk	1	0
	Savannah Sparrow	1	1
	12	49	30
LMF	Canada Goose	2	0
	Western Tanager	2	0
	Common Loon	1	0
	Bald Eagle	1	0
	Swainson's Thrush	1	0
	Townsend;s Solitaire	1	0
	Spotted Sandpiper	1	0
	7	9	0
GCFW	Canada Goose	41	3
	Spotted Sandpiper	5	2
	Common Merganser	4	4
	American Crow	4	4
	Mallard	3	0
	Western Tanager	2	0
	Killdeer	1	1
	American Robin	1	0
	Vesper Sparrow	1	1
	Swainson's Thrush	1	0
	10	63	15
GCFE	Canada Goose	6	0
	Osprey	2	0
	Spotted Sandpiper	1	1
	3	9	1
SHB	American Robin	6	4
	Spotted Towhee	5	5
	Western Tanager	5	4
	Ruby-crowned Kinglet	2	2
	American Crow	2	2
	Canada Goose	2	0
	Chipping Sparrow	2	2
	Hammond's Flycatcher	2	2
	Townsend's Solitaire	2	2
	Red-tailed Hawk	1	1

Site Name	Species	Number of Detections	
	Warbling Vireo	1	1
	Dusky Flycatcher	1	1
	Common Raven	1	1
	Violet-green Swallow	1	0
	14	33	27
STBW	Canada Goose	16	11
	American Robin	5	4
	Western Tanager	4	3
	Spotted Towhee	4	4
	Chipping Sparrow	3	3
	Hammond's Flycatcher	2	2
	Mallard	1	1
	Dark-eyed Junco	1	1
	Townsend's Solitaire	1	1
	Western Wood peewee	1	1
	10	38	31
STBE	Mallard	60	60
	Canada Goose	25*	0
	Western Tanager	3	3
	American Robin	2	2
	Spotted Towhee	1	1
	Sharp-shinned Hawk	1	0
	Cassin's Vireo	1	1
	Hammond's Flycatcher	1	1
	Dark-eyed Junco	1	1
	9	95	69

*Double counted from STBW

Species Richness

Species richness and species diversity were also calculated. Total species richness (Figure 4) was determined as the total number of species detected (38 species using the unlimited radius and 30 species using the 100m radius). Only a slight difference in species richness was detected between control (20) and restoration sites (19).

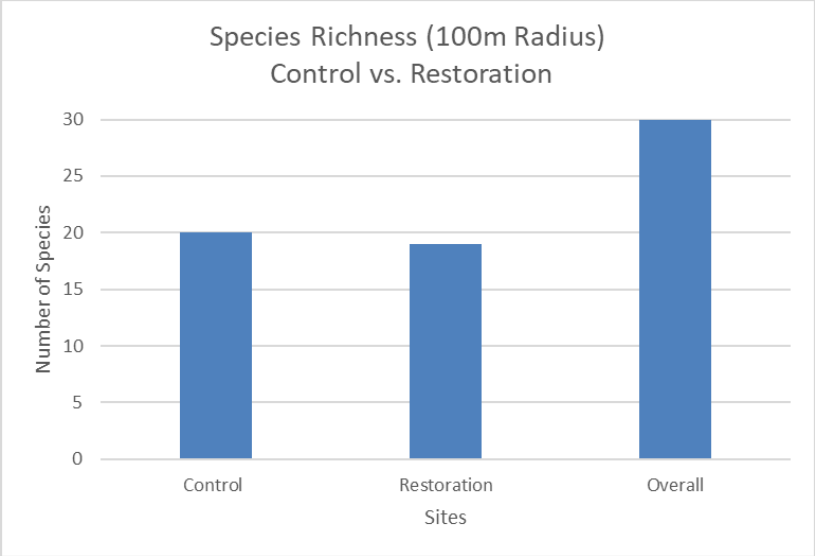


Figure 21 Species richness (100m Radius)

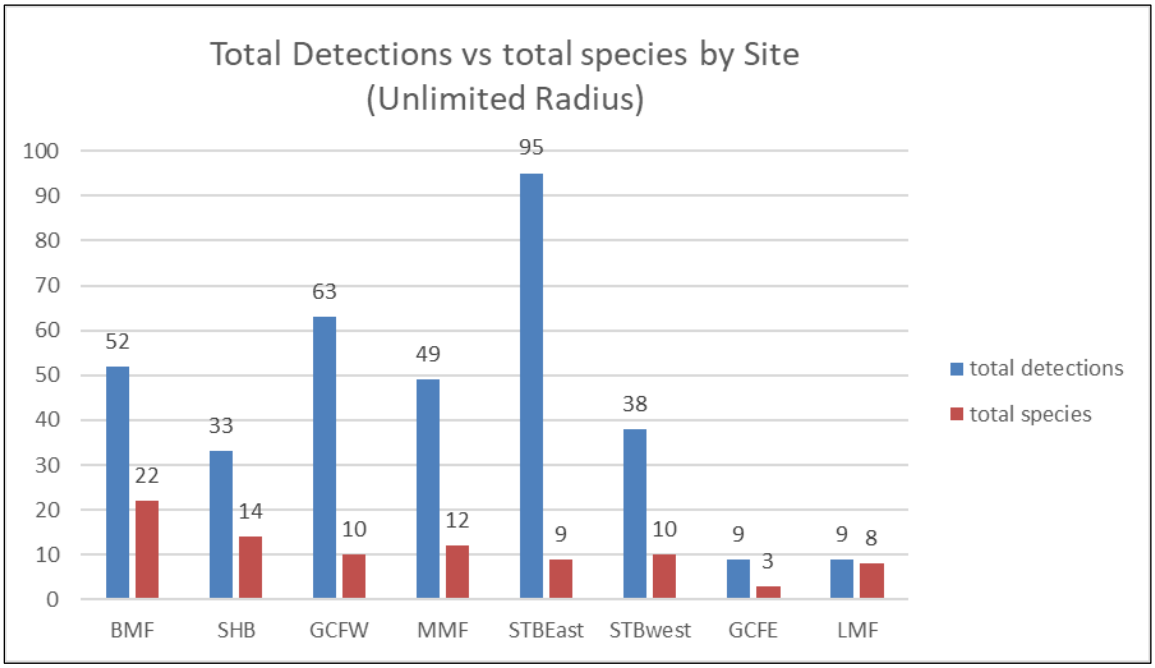


Figure 22 Detections and total numbers of species at each site (unlimited radius).

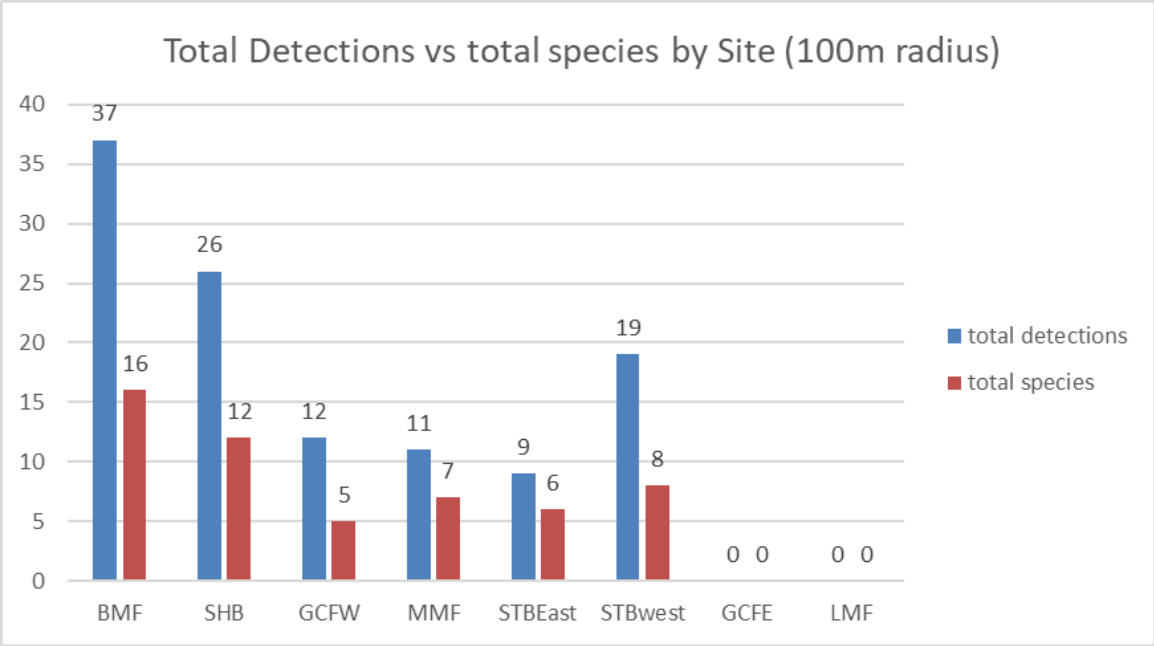


Figure 23 Detections and total number of species at each site (100m radius)

Species Diversity

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

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

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 Therefore the greater the value, the greater the diversity of the site. Diversity was greatest at the Steep Beach West (STBW) and Shallow Beach (SHB) sites (Figure 7). Overall, the control sites had greater diversity than restoration sites (Figure 8).

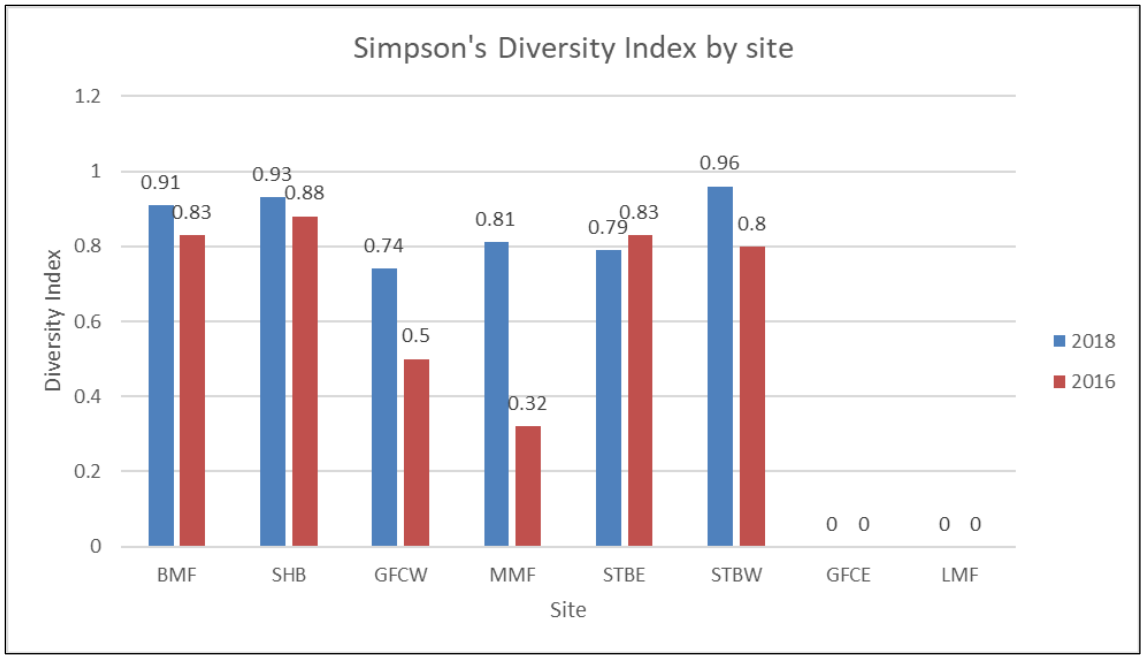


Figure 24 Simpson's Diversity Index by site

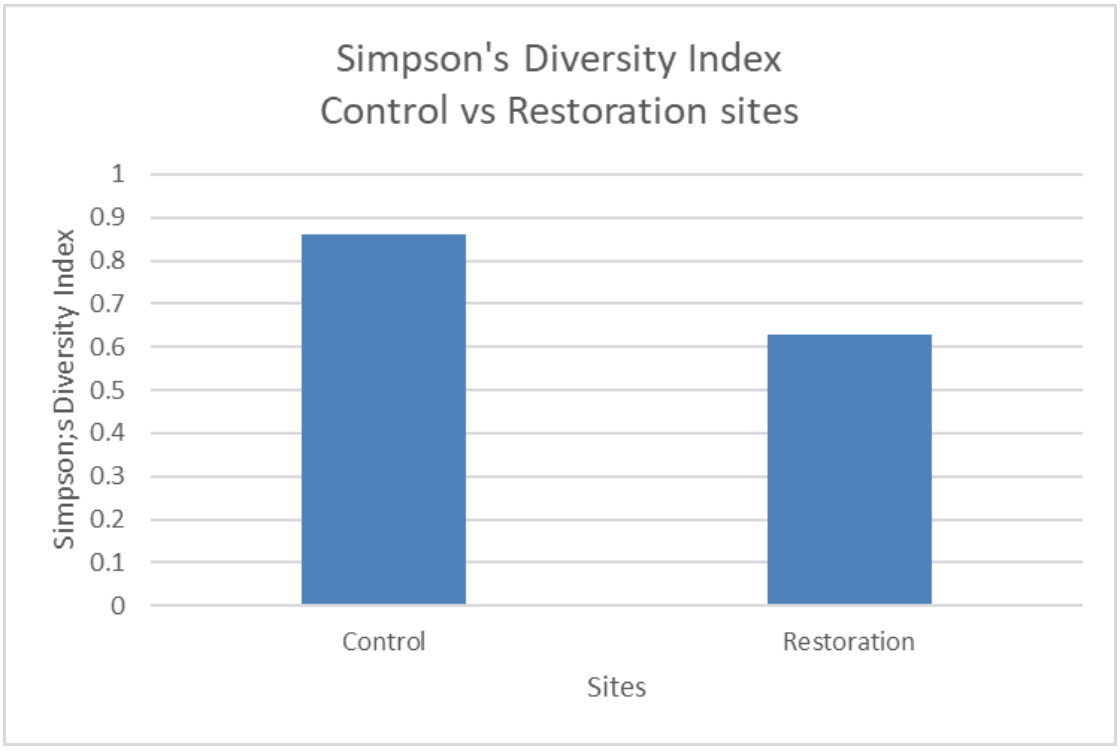


Figure 25 Simpson's Diversity Index comparison of control sites and restoration sites.

Overall, Canada Geese and Mallards were the most common bird species throughout both control and restoration sites. While American Robins and Warbling Vireos were the most common songbird species in the control sites and American Robins and Western Tanagers were more common songbirds in the restoration sites.

Table 12. Comparison of the most common bird detections by habitat type

Site	***# Point Counts***	***# Detections***		***# Species Detected***		***Most Detected Species (100m Radius)***	***Simpson's Index of Diversity (100m radius)***
		Unlimited	**100m**	**Unlimited**	**100m**		
BMF	3	52	33	23	15	American Robin/Warbling Vireo	0.94
MMF	3	49	30	12	6	Common Merganser/Spotted Sandpiper	0.80
LMF	3	9	0	7	0	Canada Goose/Western Tanager	0.90
GCFW	3	63	15	10	6	Canada Goose	0.56
GCFE	3	9	1	3	1	Canada Goose	0.50
SHB	3	33	27	14	12	American Robin	0.89
STBW	3	38	31	10	10	Canada Goose/American Robin	0.77
STBE	3	95	69	9	7	Mallard/Canada Goose	0.53
Total	**24**	**348**	**206**	**39**	**30**		**0.83**

Breeding-related behaviour was observed in 19 of the 30 species encountered during point count surveys (Table 6). 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 American Robin, Western Tanager and Warbling Vireo.

Table 13 Number of breeding observations of each species detected during point count surveys

Species	***# Breeding detections*** (Includes drumming male woodpeckers and grouse)
American Robin	15
Black-headed Grosbeak	1
Cassin's Vireo	1
Chipping Sparrow	2
Dark-eyed Junco	1
Dusky Flycatcher	4
Hammond's Flycatcher	4

Hairy Woodpecker	1
Ruby-crowned Kinglet	3
Red-tailed Hawk	1
Song Sparrow	5
Spotted Towhee	3
Swaisnon's Thrush	3
Townsend's Solitaire	3
Veery	1
Warbling Vireo	6
Western Tanager	12
Wilson's Warbler	2
Western Wood Peewee	1
Yellow Warbler	2

The Buffer Mud Flats (BMF) control site had by far the most breeding detections (41%) followed by the Shallow Beach restoration site (Figure 9).

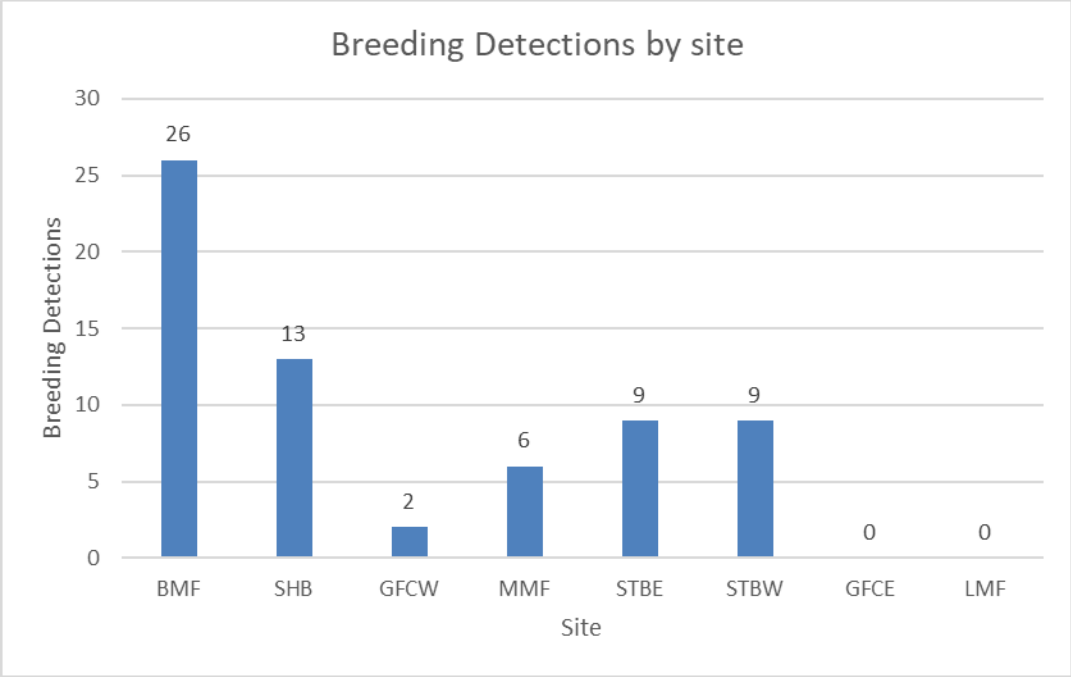


Figure 26 Breeding detections by site

Nesting Guilds

Detections within the 100m radius were divided into nesting guilds based on the preferred nesting strata for each species (Table 7). The Shallow Beach (SHB) site had the most guilds followed by

the Buffer Mud Flats (BMF) site (Figure 10). Ground nesters were by far the most commonly detected guild across all sites except for the Buffer Mud Flats (Figure 11) where no ground nesters were detected.

Table 14 Nesting Guilds detected within each site

Site		***# Detections per Nesting Guild***										
	Total # Nesting Guilds	Ground	Shrub	Coniferous	Generalist	Low Shrub	Cavity	Tall Shrub	Tree	Tree/shrub	Deciduous Tree	Cliff/Large Tree
BMF	6	0	7	7	4	0	5	8	0	3	3	0
MMF	4	25	3	1	0	0	0	0	0	1	0	0
LMF	0	0	0	0	0	0	0	0	0	0	0	0
GCFE	1	1	0	0	0	0	0	0	0	0	0	0
GCFW	3	7	0	0	0	0	4	0	4	0	0	0
SHB	8	1	5	7	4	5	0	1	2	0	0	1
STBW	4	14	5	3	4	4	0	0	0	1	0	0
STBE	3	85	2	3	2	1	0	0	0	0	0	0
Total	**11**	**133**	**22**	**21**	**14**	**10**	**9**	**9**	**6**	**5**	**3**	**1**

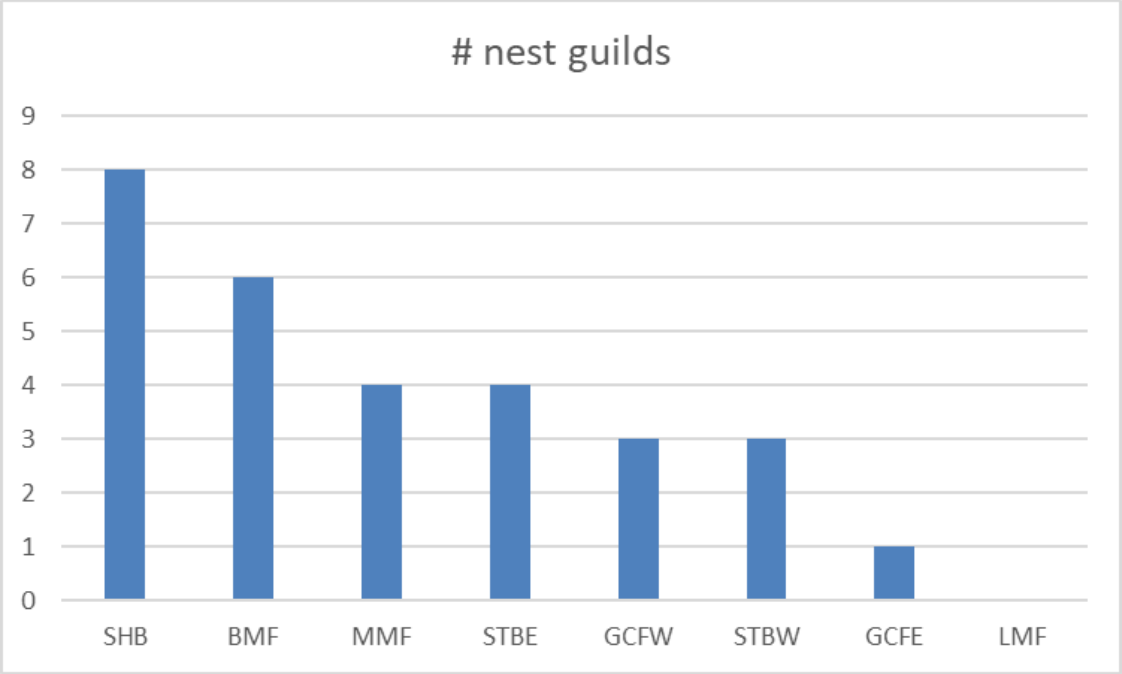


Figure 27 Number of nest guilds detected per site

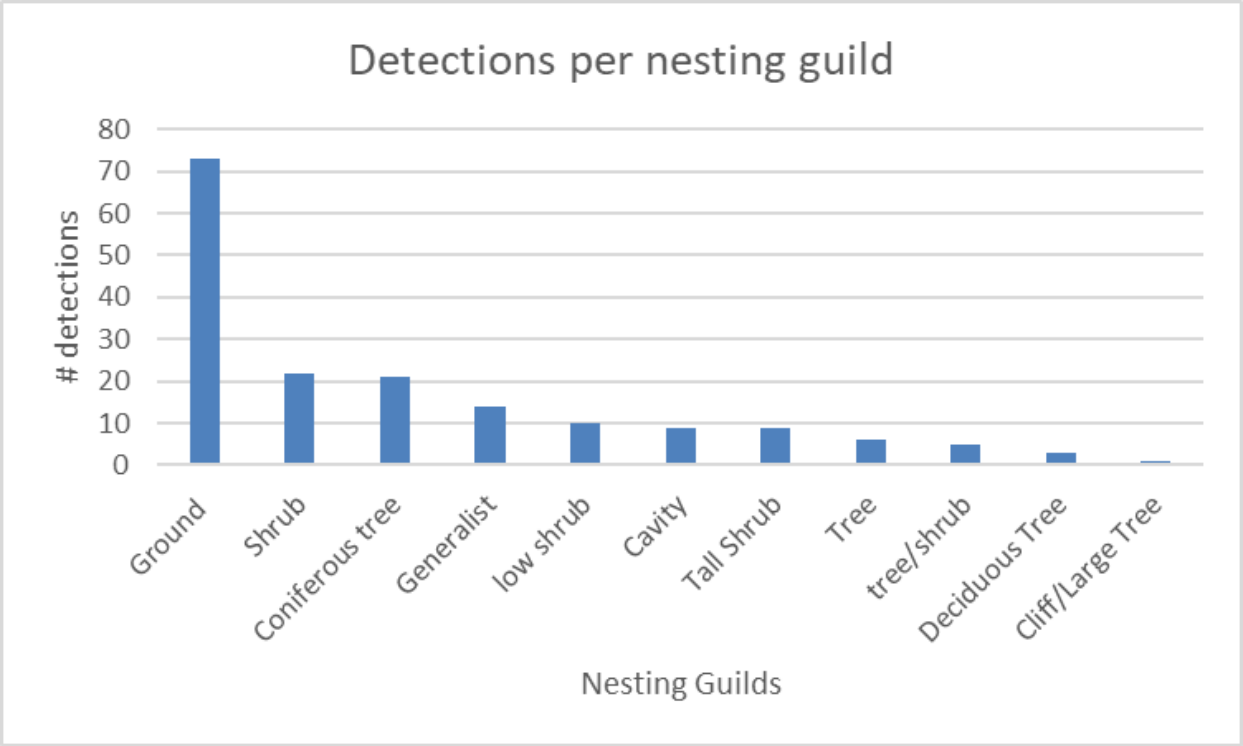


Figure 28 Number of detections per nesting guild. Note: Mallards (60 detections) have been removed from the ground nesting guild to accommodate they-axis scale for visual purposes.

Summary

Amphibians

During the auditory surveys only the Pacific Tree Frog (*Pseudacris regilla*) was detected. This is not surprising since there are only a handful of amphibian species in BC that have audible calls and the Pacific Tree frog is likely the only one present in the study area. Western Toads are divided into two populations (calling and non-calling) and the toads present within the study area are likely the non-calling variety. One other possible species that may occur within the study area could be the Columbia Spotted frog (Rana luteiventris) although the study area may be just outside of its known range. Although Columbia Spotted Frogs do make a mating call, it is very weak and difficult to hear. In addition, spotted frogs mate very early in the spring (as soon as ice starts to melt) and our surveys in mid-May were likely too late to detect this species.

The buffer mud flats (BMF) and the mid-mud flats (MMF) control sites are the only sites that have suitable breeding habitat for amphibians. At the time of the surveys the remaining sites did not have any suitable standing water for amphibians to breed in. The lower mud flats (LMF) site may have potential. Soil mounding trials designed to enhance micro-climatic conditions for plant regeneration may provide areas for temporary water storage, in the depressions created during the mounding process, that may be attractive to pond breeding amphibians such as Western Toads. Western toads breed in early spring, likely early to mid-May within the study area. Eggs are laid in mid to late May and begin to hatch approximately 10 days later depending on water temperatures. Tadpoles will complete metamorphosis approximately 6-8 weeks later.

Auditory surveys are not the best way to inventory amphibians in the study area especially since only one species is present that can be readily detected using this method. These sites are much better suited to time constrained or area constrained searches focusing on potentially suitable habitats.

Songbirds

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 Fan 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. Not surprisingly, the shallow beach site also had the highest number of nesting guilds (eight) compared to the buffer mud flats which had six nesting guilds. The key difference is that there were no ground or low shrub nesters detected at the buffer mud flats. Overall, across all sites, ground nesters made up the majority of detections, reflecting the disproportionate lack of other nesting strata for birds to take advantage of. As restoration progresses, a change in nesting guilds would be expected in relation to revegetation success.

Bird detection and numbers of species in each round were similar to 2016 however over three rounds, more species were detected than during a single round in 2016. Three rounds of surveys

provided a more complete picture of avian use within each site over the full breeding period capturing both early breeders and late arrivals. Ideally, point count monitoring should continue to incorporate three rounds to ensure the full range of each breeding season is sampled.

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APPENDIX 1

COMPLETE LIST OF BIRD SPECIES ENCOUNTERED

Species Code	***Common Name***	***Latin Name***
AMCR	American Crow	*Corvus brachyrhynchos*
AMRO	American Robin	*Turdus migratorius*
BAEA	Bald Eagle	*Haliaeetus leucocephalus*
BCCH	Black-capped Chickadee	*Poecile atricapillus*
BHGR	Black-headed Grosbeak	*Pheucticus melanocephalus*
CAGO	Canada Goose	*Branta canadensis*
CAVI	Cassin's Vireo	*Vireo cassinii*
CHSP	Chipping Sparrow	*Spizella passerina*
COLO	Common Loon	*Gavia immer*
COME	Common Merganser	*Mergus merganser*
CORA	Common Raven	*Corvus corax*
DEJU	Dark-eyed Junco	*Junco hyemalis*
DUFL	Dusky Flycatcher	*Empidonax oberholseri*
GRCA	Gray Catbird	*Dumetella carolensis*
HAFL	Hammond's Flycatcher	*Empidonax hammondii*
HAWO	Hairy Woodpecker	*Dryobates villosus*
KILL	Killdeer	*Charadrius vociferus*
MALL	Mallard	*Anas platyrhynchos*
NOFL	Northern Flicker	*Colaptes auratus*
OSPR	Osprey	*Pandion haeliaetus*
RBNU	Red-breasted Nuthatch	*Sitta canadensis*
RCKI	Ruby-crowned Kinglet	*Regulus calendula*
RTHA	Red-tailed Hawk	*Buteo jamaicensis*
RUHU	Rufous Hummingbird	*Selasphorus rufus*
SASP	Savannah Sparrow	*Passerculus sandwichensis*
SOSP	Song Sparrow	*Melospiza melodia*
SPSA	Spotted Sandpiper	*Actitis macularis*
SPTO	Spotted Towhee	*Pipilo maculatus*
SSHA	Sharp-shinned Hawk	*Accipiter striatus*
SWTH	Swainson's Thrush	*Catharus ustulatus*
TOSO	Townsend's Solitaire	*Myadestes townsendii*
VEER	Veery	*Catharus fuscescens*
VESP	Vesper Sparrow	*Poecetes gramineus*
VGSW	Violet-green Swallow	*Tachycineta thalassina*
WAVI	Warbling Vireo	*Vireo gilvus*
WETA	Western Tanager	*Piranga ludoviciana*

WIWA	Wilson's Warbler	*Cardellina pusilla*
WWPE	Western Wood Peewee	*Contopus sordidulus*
YEWA	Yellow Warbler	*Setophaga petechia*