Bridge River Project Water Use Plan

Carpenter Reservoir Drawdown Zone Riparian Enhancement Program

Implementation Year 6

Reference: BRGWORKS-1

Carpenter Reservoir Drawdown Zone Riparian Enhancement Program 2020 Yearly Report

Study Period: April 1, 2020 – March 31, 2021

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BRGWORKS -1 Carpenter Reservoir Drawdown Zone Riparian Enhancement Program

Year 7, 2020 Annual Report

Prepared for: **St'at'imc Eco Resources and BC Hydro**

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Cover photo: Drone photo across Low mud flat and Gun Creek Fan East, project mounding, seeding and planting trials evident. Photo June 2020 by Awan Ned.

Executive Summary

In 2020, the final year of scheduled riparian enhancement treatments were carried out in the Carpenter Reservoir drawdown zone under the BRGWORKS-1 Bridge Seton Water Use Plan program. This report addresses the program management questions (Table 1) and summarizes treatments completed in 2020. The treatments applied in 2020 were implemented based on recommendations developed through the accompanying monitoring program BRGMON-2, as well as the input and experiences from the previous 6 years of trials. Treatments in 2020 included substrate mounding, seeding and planting. Treatments were largely combined, i.e., physical works and seeding, or seeding and planting, and were built on work done in previous years. Physically mounded polygon areas on the low mud flats of Carpenter Reservoir initially treated in 2019, had been left fallow for a season of inundation. Post inundation in 2020, the stable, compact and smoothed substrates, were planted and seeded. Freshly mounded polygons created on the lacustrine mud flats in 2020 were seeded with native species. Newly mounded polygons at upper elevation sites unlikely to experience annual inundation, were planted with native riparian tree, shrub and grass species. Domestic species fall rye (*Cereale secale*) was seeded across the low mud flats and patches of native species Kellogg's sedge (*Carex kelloggii*) were planted within the seeded matrix. Seed was harvested from previously planted patches of sedges on the low mud flat. This freshly harvested seed was densely sown in patches within the polygons mounded in 2019. Dust monitoring indicated wind erosion continues to be primarily from the steep cut banks and low elevation sand and gravel bars along the channel of the Bridge River. Wildlife use of the site is sporadic with most occurrences tied to the vegetated mud flats to the west where the SARA listed western toad (*Anaxyrus boreas*) Schedule 1 Special Concern (June 2018) has been observed to spawn. Maintenance of treatments were carried out with particular focus on upper elevation treatments where coarse soils and low inundation make vegetation more prone to stress of prolonged dry summer conditions. As with every year, treatments are greatly influenced by the timing and peak level of Carpenter Reservoir.

Summary Status Table
Table 1 BRGWORKS-1 Status 2020

OBJECTIVES, MANAGEMENT QUESTIONS and HYPOTHESES after 2014			
Study Objectives **Numbers relate to MQ.**	**Management Questions**	**Management Hypotheses**	**Year 2020 (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.	4 years of monitoring dust indicates that most originates from steep cut banks and instream sand bars both very difficult sites to vegetate. As dust particles are blown across the mud flats it is likely that planted and seeded vegetation traps some of the dust and that vegetation reduces some of the potential for resuspension; therefore, established vegetation in the drawdown zone partially mitigates the suspension of dust particles from dust storms but currently does not mitigate for the source of the dust particles.

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 in 2014. The survey also included questions regarding wildlife and dust storms. Public feedback showed that fall rye green up was viewed positively aesthetically
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 incidental observations throughout the BRGWORKS-1 project have indicated infrequent presence of wildlife at most treatment areas. Species of note, spotted sandpiper have utilized patches of planted sedges for nesting, Canada geese have feed on planted sedges, dispersing juvenile western toads likely emerged from drawdown zone ponds to the west and transported downstream by the flowing Bridge River have been observed in mounded mud flat polygons as have juvenile terrestrial garter snakes. Mule deer browse on planted cottonwoods in the buffer zone and beaver have cut planted cuttings.

			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. Although the magnitude of this increase and duration of effectiveness is not known.

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1. Introduction

The 2020 field season was year 7, the final year of treatments scheduled under the BRGWORKS-1 revegetation project in the Carpenter Reservoir drawdown zone (BC Hydro, 2017). The BRGWORKS-1 riparian enhancement program was initiated in 2014 with treatments completed in years 2014, 2015, 2016, 2017, 2019 and 2020. The program has been implemented using a staged approach to test physical works and revegetation techniques and treatments. Treatments have been monitored and guided through the BRGMON-2 monitoring program with annual recommendations from those findings guiding the following year's workplan (Scholz and Gibeau, 2019, Scholz and Gibeau, 2018, Scholz and Gibeau, 2017, Scholz and Gibeau, 2016, Scholz and Gibeau, 2015). The area of focus for the project is located at the western end of Carpenter Reservoir drawdown zone from the Gun Creek alluvial fan east several kms to the Tyaughton Road turnoff (Figure 1). Through the program, Splitrock has attempted to identify the candidate native species and restoration techniques to maximize revegetation success and where, within the artificially regulated drawdown zone terrain classes, these techniques are most effective.

There are three management questions associated with BRGWORKS-1 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 annual report summarizes 2020 treatments and prework requirements as well as maintenance and monitoring.

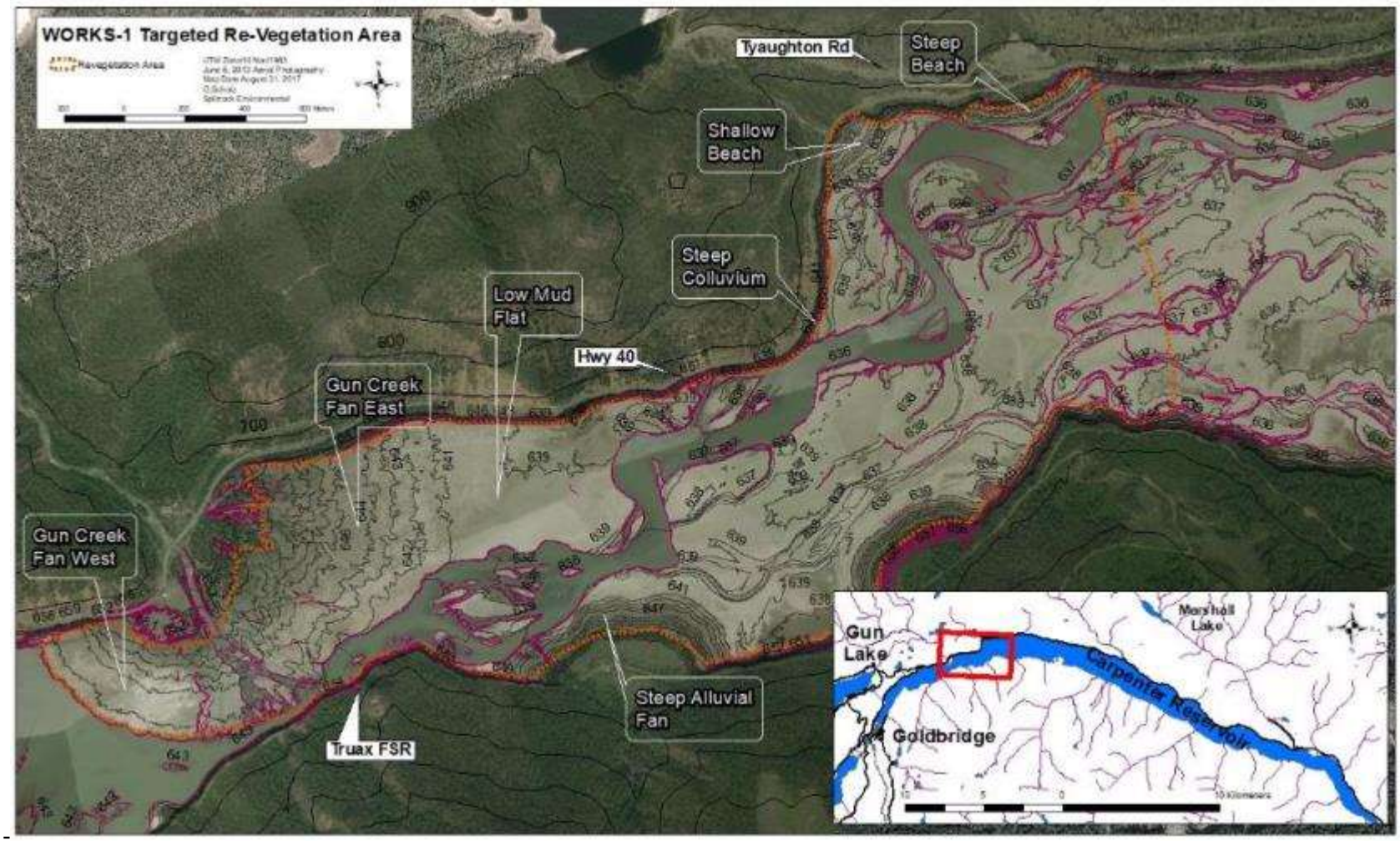

Figure 1. Target revegetation area of the Carpenter Reservoir drawdown zone. 2020 focus on Low Mud Flat and Gun Creek Fan East and West.

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 3). The site is located within St'at'imc traditional territory. The area is in the Southern Interior Eco province 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 east side of the fan has a BC Hydro operated 13 site, public recreation campground. Historically (1934-1950), the mining town of Minto was also located on the east side of the fan, within the Carpenter Reservoir drawdown zone (Figure 2). The Ministry of Transportation and Infrastructure holds 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.

Carpenter Reservoir water levels are managed between licensed minimum and maximum levels of 606.55 mASL and 651.08 mASL (BC Hydro, 2011). Since 2000, in order to manage the reservoir for generation and fish habitat and to minimize water spills to the Lower Bridge River, BC Hydro makes reasonable efforts to target a maximum water elevation of 648 mASL for the end of snowmelt season in mid-August. Surcharging and drafting below the minimum elevations are possible in accordance with operational procedures. The 648 mASL maximum target has mostly been achieved since 2000, effectively maintaining a 3.08 vertical m buffer zone. Based on observed inundation patterns and considering elevation, inundation duration and length of the site's growing season, all BRGWORKS-1 treatments have been carried out at elevations between 639 mASL and 651 mASL where one may expect in any given year that a plant may experience 50% of the inundation growing season above water (Scholz and Gibeau, 2014).

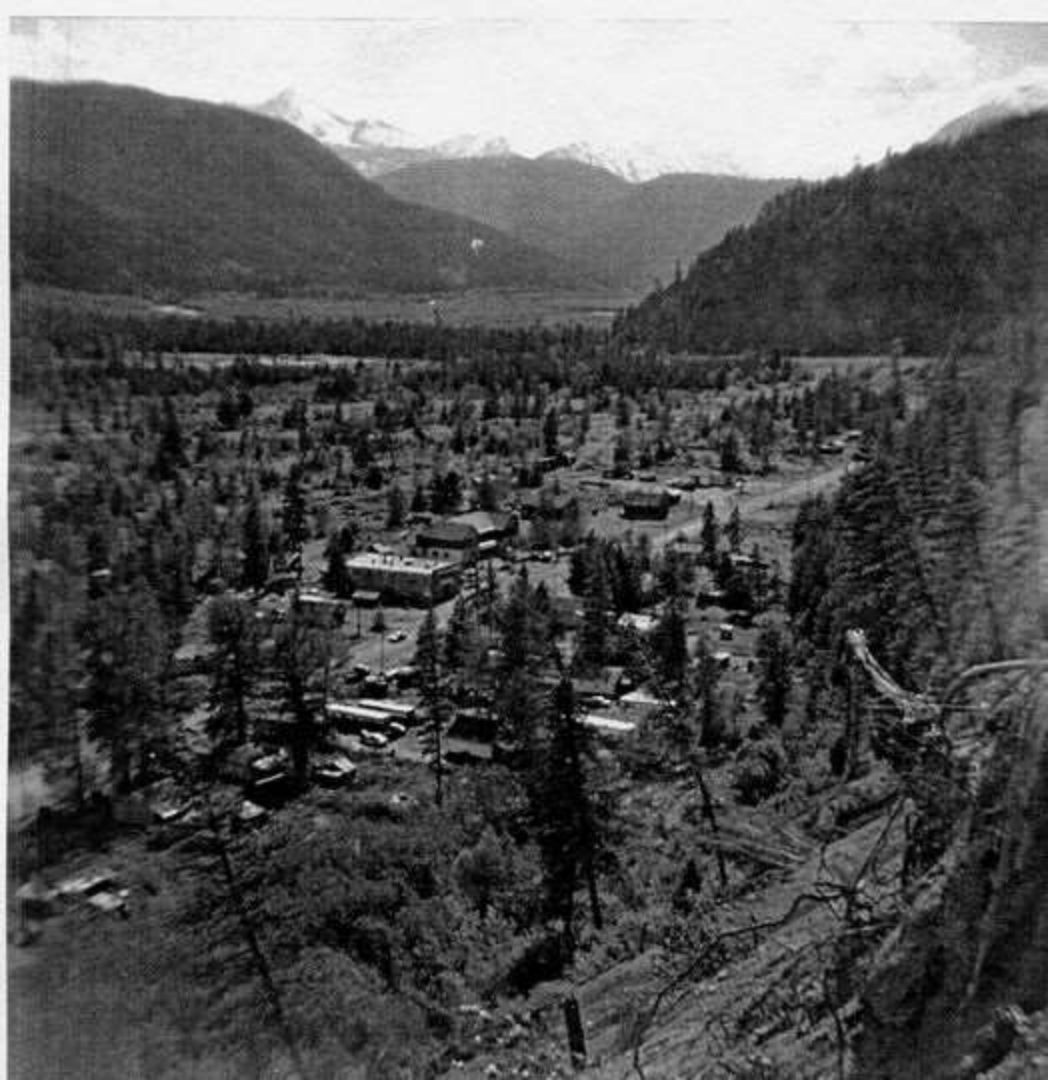

Figure 2 Photo looking west across Minto town site and Bridge River valley circa estimated 1948 pre reservoir.

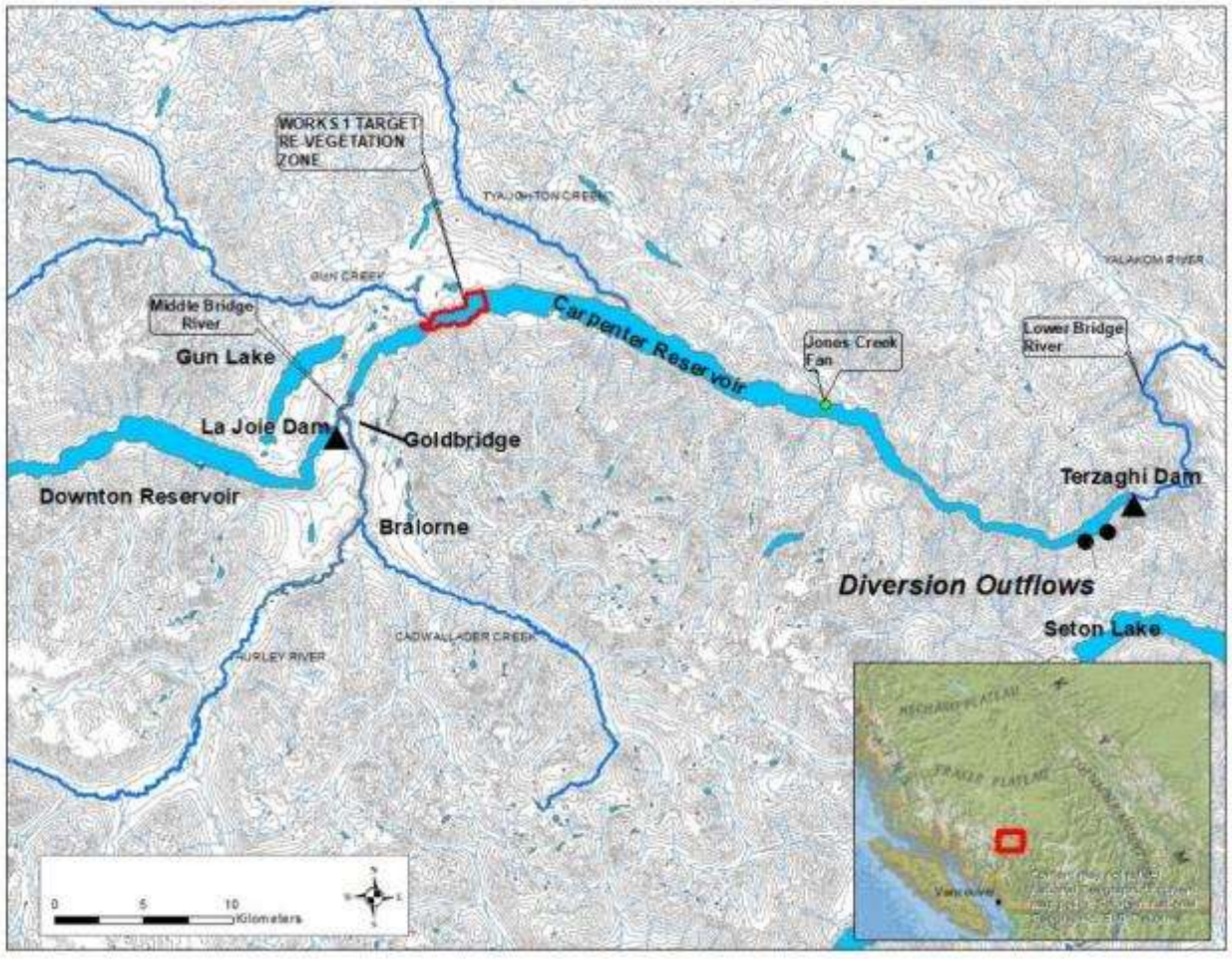

Figure 3. Geographic location of Carpenter Reservoir in British Columbia and the 292 ha targeted revegetation region of the Carpenter Reservoir BRGWORKS-1 Revegetation Program

2. Methods

2.1 Water Levels and Drawdown Zone Elevations

Daily water levels are issued by BC Hydro Power Records. The 2020 annual data was compiled and figures were generated in to depict the annual hydrograph for Carpenter Reservoir. The annual hydrograph was developed and presented along with annual water levels from 2000 to present. The 10th and 90th percentiles were graphed along with the mean daily levels for the same period.

2.2 Permitting

A Section 11 BC *Water Sustainability Act* application for "Changes In and About a Stream" was submitted on behalf of BC Hydro in January 2020. Permit approval to proceed under terms and conditions was received on March 20th, 2020 (Permit # R3-3006649). All work areas were well above water levels at the time of treatment.

Archaeology impact assessments (AIA) were conducted across all target treatment areas in 2017 by Amec Foster Wheeler and St'at'imc Government Services, and again in 2019 by Wood and Associates and St'at'imc Government Services. Beyond the areas where archaeology impact assessments were previously conducted, no new areas were scheduled for treatment in 2020. Maps of proposed treatment sites were provided to archaeologists for review. In response to our indication of our planned treatment sites for 2020 we were advised:

> "There is no overlap with registered archaeology sites and your treatment areas. Generally, BC Hydro requests archaeology work for projects located within 50 metres of a registered archaeology site or within 100m of two or more registered sites. However, given your familiarity with the area and the location of the archaeology sites, site avoidance can be achieved with your proposed treatment plan. Please let us know if the treatment plan changes or if Hydro does request archaeology work. We have a permit in place for this work." (N. Gray, email March 6, 2020).

A no work zone buffer was placed around archaeology sites identified in the 2017 AIA. This no work area has been respected each year of the project including 2020.

Previous WORKS 1 treatment trials and BRGMON-2 monitoring has recommended that planted plants be irrigated through drier parts of the growing season. This is particularly important for higher elevation site that do not receive annual inundation. A temporary water use permit was sought through the BC Ministry of Environment Water Sustainability Branch. Permit approval to draw water from a local site to use in irrigating revegetation treatments was received June 4, 2020. The permit was effective through to the end of September 2020. An attempt to extend the permit for a second year was unsuccessful and another application will be required if maintenance is to be continued through 2021.

2.3 Riparian Enhancements

Riparian enhancements were concentrated on the Low Mud Flat east of the Gun Creek Fan, the alluvial fan east of Gun Creek and the alluvial fan west of Gun Creek (Figure 4, Table 2). Implemented treatments consisted of physical works, seeding with a tractor pulled seeder, and planting on the Low Mud Flat and on Gun Creek Fan East at the transition zone between the alluvial fan and the lacustrine deposition of the mud flats. Tractor tilling and seeding was performed on the Low Mud Flat, and planting and hand seeding were implemented on the Low Mud Flat and within physical treatment areas on the Gun Creek Fan West. The bulk of the planted native species used were Kellogg's sedge with lesser amounts of bluejoint reedgrass. In addition, trees and shrubs were planted at upper elevations.

Table 2 Polygon Treatments carried out in 2020. Seeding was by hand sown except in T2001, Refer to locations in Figure 4

Poly ID	Treatment	Area	X	Y
MW1900A	mounding, seeding	3287	516808.3	5638448.82
MW1900B	seeding, planting	6700	516779.27	5638348.73
MW1900C	seeding, planting	6943	516777.84	5638236.08
MW1900D	seeding, planting	4405	516777.1	5638127.69
MW1900E	seeding, planting	1411	516593.59	5637957.91
MW1900F	mounding, seeding	2363	516518.34	5637950.33
T1921	mounding, planting, seeding, watered, mulched	504	515600.23	5637853.67
T1922	mounding, planting, seeding, watered, mulched	682	515651.97	5637830.62
T1923	mounding, planting, seeding, watered, mulched	401	515718.55	5637786.62
T1924	mounding, planting, seeding, watered, mulched	980	515761.42	5637747.27
T1925	mounding, planting, seeding, watered, mulched	1217	515816.28	5637752.22
T2001	tractor seeding, planting	119043	517097.02	5638172.55

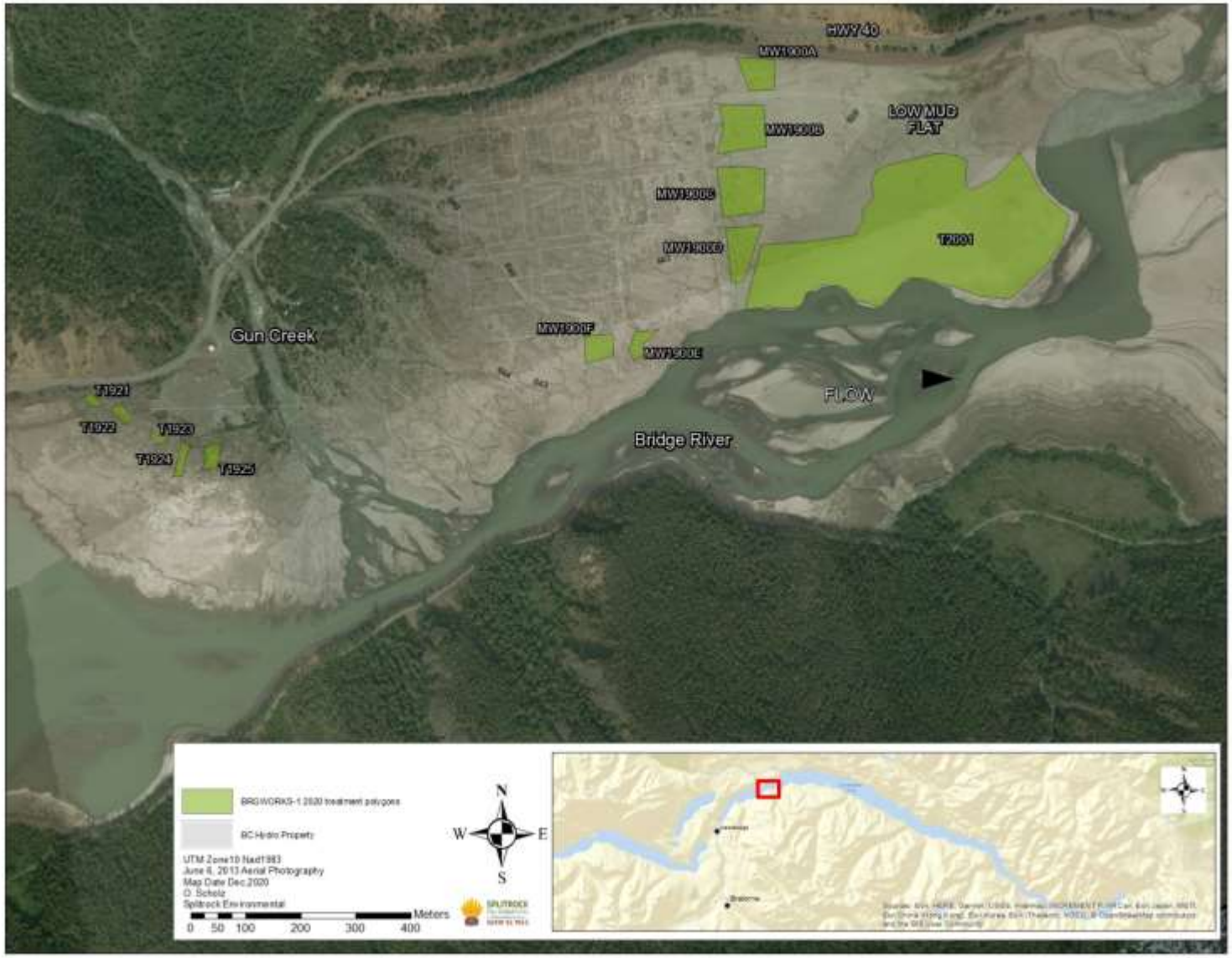

Figure 4 Map of 2020 BRGWORKS-1 treatment polygons.

2.3.1 Machine treatments

An experienced machine operator using a 200 series Hitachi excavator carried out the physical works treatments in 2020. The areas treated in 2020 were initially planned, mapped and flagged in the spring of 2019. Treatment objectives were to provide microtopographic relief by roughening the relatively smooth lacustrine deposited substrate of the drawdown zone. Treatment objectives were to create a pitted and mounded substrate similar to rough and loose treatments described by Polster (2009). Treatment areas were located outside of the historic Minto lot sites (Figure 4). Archaeological assessments including shovel tests, were performed across all of the treatment area polygons in 2019. The machine operator was instructed during project orientation to maintain vigilance for any archaeological or cultural objects that may be of importance and to stop work if any such observations were made.

2.3.2 Seeding Trials

Seeding treatments were carried out across the fine silty lacustrine deposits that characterize the Low Mud Flat situated at approximately 639.5 mASL. Hand-seeding and mechanical seeding methods were used. Mechanical seeding was completed using a tractor pulling a Plotmaster© seeder. The tractor seeded area was flagged and the tractor operator was provided with an iPad and digital map of the treatment area polygon that indicated tractor location in real time to assist with locating polygon boundaries. Within the targeted tractor seeding area, patches planted with container stock in 2019 were flagged prior to seeding. Flagging was done as a visual aid to enable the tractor operator to avoid running through them and potentially disturbing establishing plants. Operator was also asked to avoid running over any naturally recruited Kellogg's sedge plants.

Seed from three species were used in 2020 trials. Domestic grass fall rye (*Secale cereale*), chosen for its rapid and robust growth, was seeded across the broadest area, at a density of approximately 50 kg/ha. Locally harvested native annual meadow birds-foot trefoil (*Lotus denticulatus*) was hand-seeded at approximately 25kg/ha and the ground was hand-raked after application. Kellogg's sedge (*Carex kelloggii*) was hand-seeded and raked in at a density of approximately 15kg/ha.

Targeted standing crop biomass sampling was carried out on July 10th. Plot frames (1m^2) were subjectively placed to sample sites considered representative of the amount of vegetation growth in control areas and in areas seeded with fall rye. Clip plots were sampled by cutting only above ground vegetation using scissors and entire plants were sampled by digging up plants to sample both root and shoot biomass (Figure 5). Three clip plots and three dug plots were sampled in both control and fall rye seeded treatment areas.

A new seeding approach included harvesting Kellogg's sedge seed by hand from stands planted in 2016 (Figure 6). The seed was harvested on July 3, 2020. The seed was cleaned and re-sown by hand and raked into approximately 100m^2 patches within MW1900D and MW1900C on July 15, 2020. Seed was sown at a rate of approximately 16 kg/ha.

Figure 5 Sampling biomass in fall rye seeded treatment polygon T2001. 10 July 2020.

Figure 6 Crew harvesting Kellogg's sedge seed from patch planted in 2016. 03 July 2020.

2.3.3 Planting

All planted species were grown from seed collected from the Carpenter Reservoir area. Kellogg's sedge was the main species planted in the 2020 program due to its high tolerance to inundation as well as being adapted to drought conditions. Sedge plugs were targeted for finer substrate, low mud flat, elevations between 639mASL-643mASL. Kellogg's sedge was planted in patches including within areas that were seeded with fall rye in 2020. Sedges were also planted into patches within polygons mounded in 2019. Polygons mounded in 2019 had been left fallow for one inundation cycle to allow the substrate to settle prior to being planted. Bluejoint reedgrass (*Calamagrostis canadensis*) a native rhizomatous grass was also planted in small patches within polygons mounded in 2019. Bluejoint was also planted into freshly mounded polygons located in the higher elevation, buffer zone on the west side of the Gun Creek Fan. Black cottonwood (*Populus balsamifera ssp. trichocarpa*), willow (*Salix sp.*) and Ponderosa pine (*Pinus ponderosa*) were also planted in buffer zone elevation polygons. Several patches of common horsetail (*Equisetum arvense*) were planted on the Low Mud Flat. A summary of the 2020 plantings by location appears in the Results section. Much of the basis for deciding where species were to be planted was rooted in elevation and inundation frequency, therefor plant tolerance to flooding and drought.

During planting, plants were kept cool under reflective Silvicool tarps in a shaded location. Crew technicians transported plants in planting bags and 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 10m 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 between individuals (surviving and newly planted). To increase moisture retention, plants planted in 2020 in the buffer zone elevations that are unlikely to be flooded, based on analysis of hydrograph data for past 20 years, were mulched with partially composted bark mulch. Plants were watered throughout the 2020 growing season. Irrigation was carried out by spot watering plants using a 350gallon water trailer and ¾ inch garden hose, and a 4 stroke Honda pump, 7000 r.p,m 30gallon/minute capacity. Spotted knapweed a noxious weed species found on some of the treated sites was hand pulled.

2.4 Dust Storms

Weather and photo data was captured throughout the 2020 growing season at the 5 Mile Ridge Weather Station (Figure 7). Photos 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 wind erosion 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 each category. 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 analyzed for sites that are primary sources of dust generation. The subject photo region was divided into 4 regions

from top to bottom or west to east. Each photo capturing blowing dust was attributed to one of the 4 regions: 1. west of the Gun Creek Fan; 2. Low Mud flat; 3. Low Mud flat south and east of treatment; 4. Low Mud Flat foreground (Figure 8).

Figure 7. Map showing location of the dust storm monitoring weather station with cameras orientation relative to project area. Example of station photo inset.

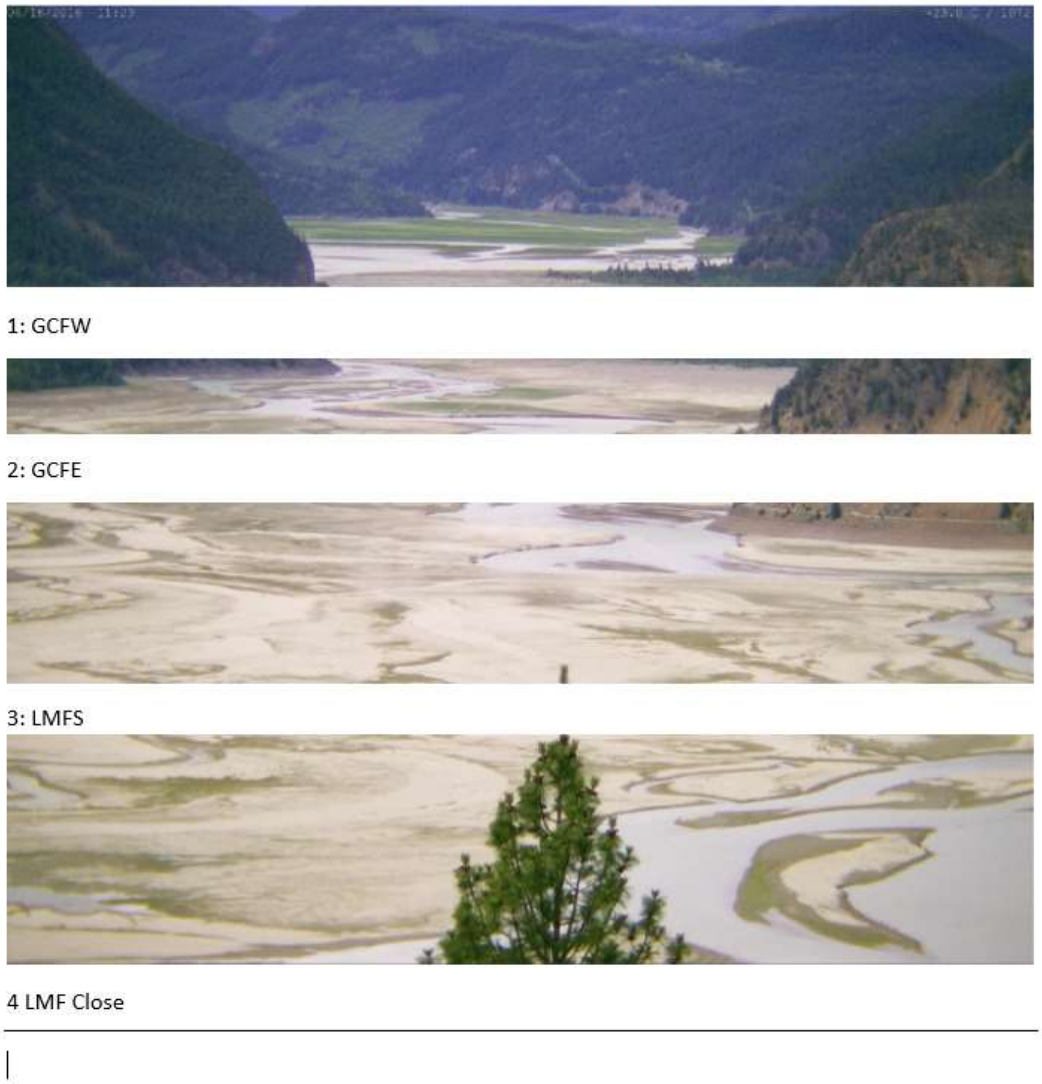

Figure 8 Typical weather station perspective photo split to indicate dust storm origin regions.

2.5 Wildlife Use

Wildlife presence and use in the study area is being monitored by recording direct observations and 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. Based on incidental observations of amphibians and reptiles in treatment areas in 2019 (Scholz, 2020) a targeted search for amphibians and reptiles was conducted within select treatment and control areas on July 15, 2020. An area constrained approach was used to search for presence of amphibians and reptiles. For searches, surveyors formed a line and walked systematically across a target area moving slowly and visually scanning the ground for any sign of wildlife. Surveyors were spaced approximately 5m apart ensuring full coverage of the survey area. Entire polygon areas were methodically searched. Polygons MW1701, MW1701CON,

MW1900B, MW1900D, MW1900C were surveyed. The amount of area searched, number of surveyors and time spent searching was recorded.

Generally, local people have provided wildlife observations across the study area as a component of the public survey conducted in 2014-2015, and the results were reported in the 2014 annual report (Scholz, 2015). Breeding songbird surveys were carried out in 2016 (Heinrich, 2016) and 2018 (Heinrich, 2020) through the BRGWORKS-1 program, to establish avian species composition at both revegetation treatment sites and reference sites around the reservoir.

3. Results

The results section is divided into six sub-sections to address Carpenter water levels, growing season weather, riparian enhancement treatments, dust storm monitoring, aesthetic and recreation use and wildlife summaries for 2020.

3.1 Water Levels

In early May of 2020, Carpenter Reservoir water levels were drawn down to 617.55 m, close to the lowest 10th percentile over the past 21 years (Figure 8). Rising water levels reached the lowest elevation of BRGWORKS-1 treatments (639.5-640 mASL) by July 18th. Water levels rose to full pool that peaked around 647.6 mASL by Oct 09th, 2020. Full pool for 2020 was very close to the 648mASL target maximum and the low elevation of the WUP period-initiated buffer zone (Figure 10). Upper drawdown and buffer zone treatment zones, particularly the polygons mounded in the buffer zone in 2017 and 2020, were once again not directly affected by inundation. Carpenter Reservoir water levels dropped below the Low Mud Flat (639.5m) elevation by the end of January 2021; the lowest elevation treatment areas were inundated for over 6 months.

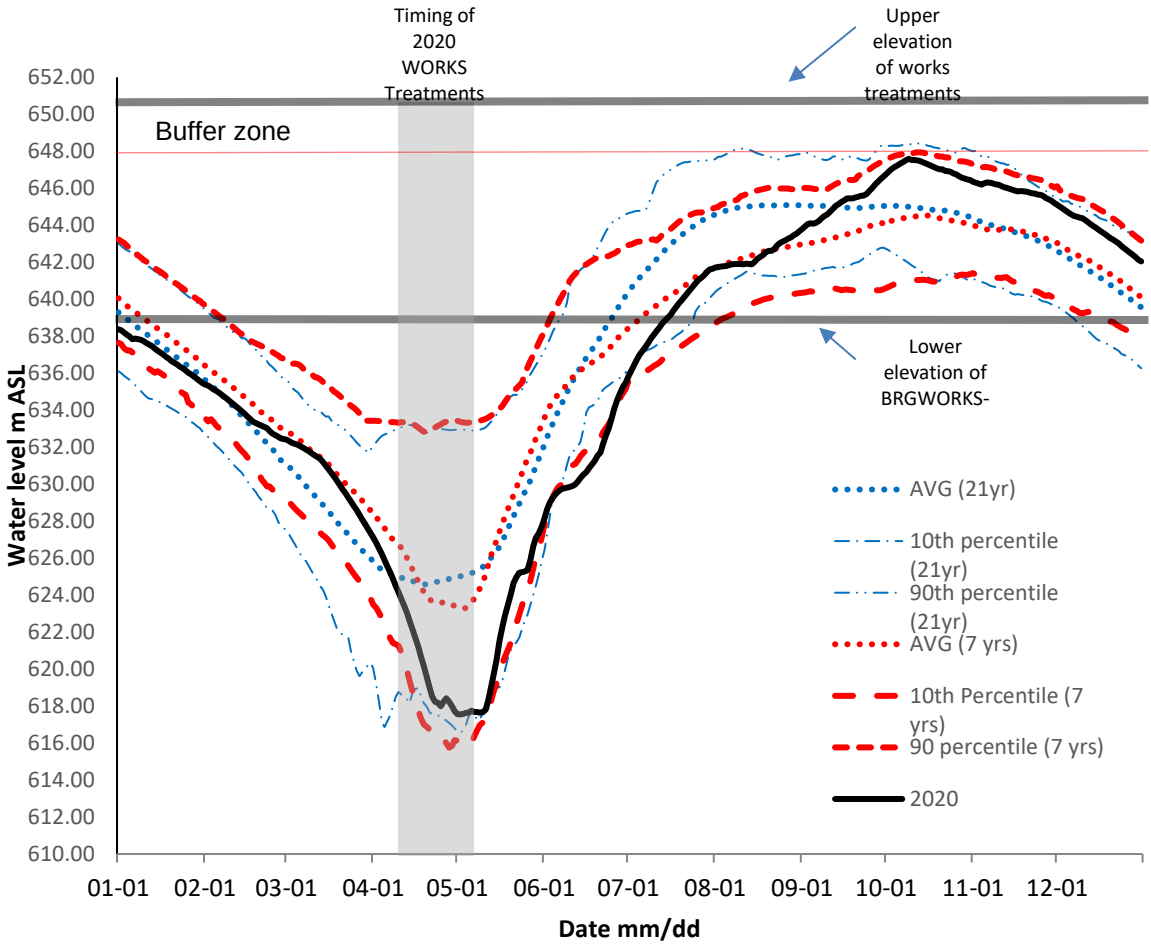

Figure 9. Carpenter Reservoir hydrograph for 2020 with annual daily average 21-year WUP period as well as the BRGWORKS-1 WUP period averages (2014-2020). Elevation zone of WORKS treatments is for all treatment years.

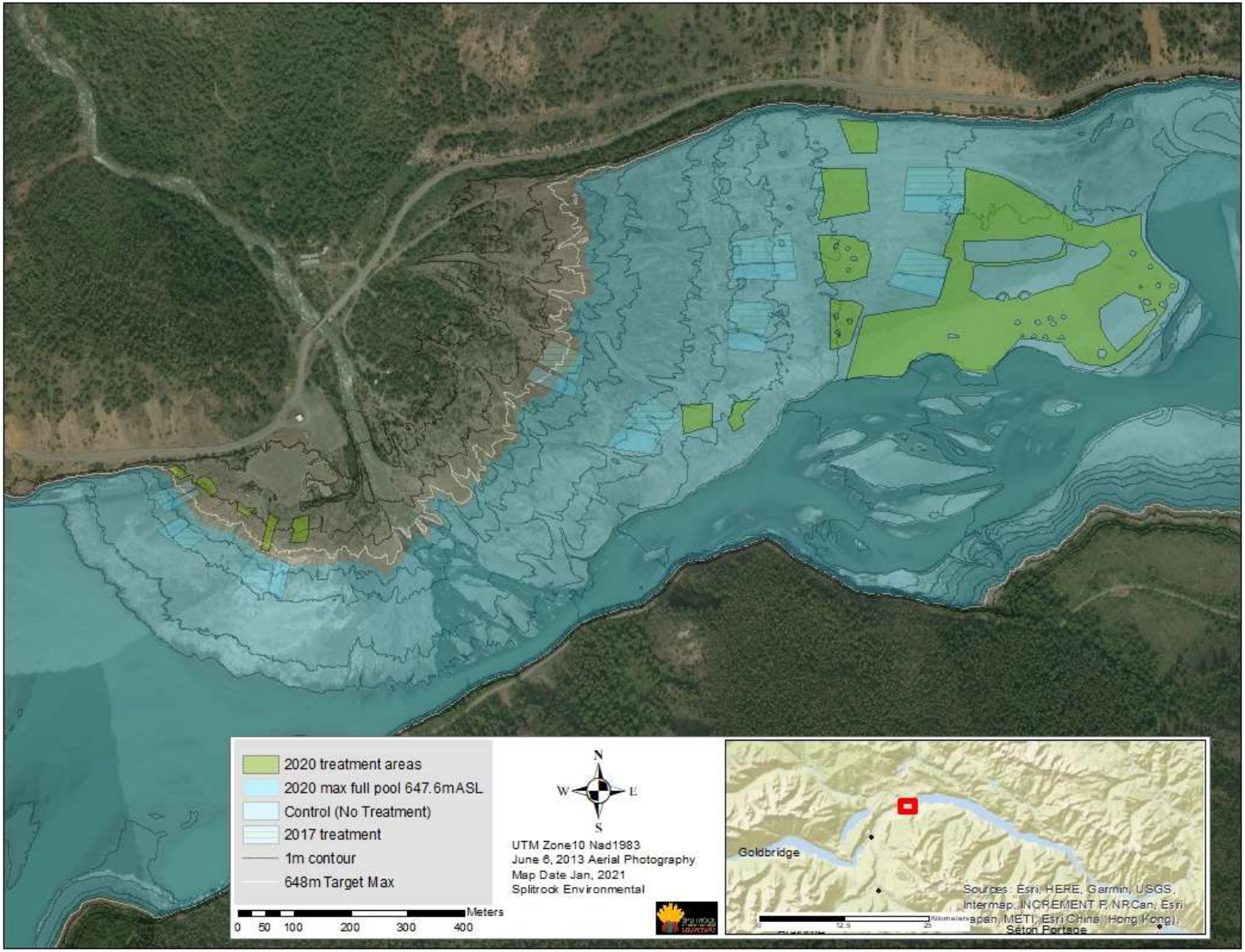

Figure 10 Treatment area around Gun Creek Fan depicting 2020 water level at full pool on August 22.

3.2 Weather

Average daily temperatures rose above 0°C for five consecutive days by March 22. However, ice continued to cover much of the low mud flats on the east side of the Gun Creek Fan until early April, with most ice gone from the mudflats by April 11th (Figure 11). Average daily temperatures dropped below zero for a week in early April. Ice cover was gone and average daily temperatures had stayed above zero for five consecutive days by April 10. Growing degree days (GDD) were calculated for the Low Mud Flat assuming start up (Fraser, 2006) on April 10 (Table 3). Treatments located at the lowest elevations on the Low Mud Flat (639m) were inundated by July 18th 2020.

During the 2020 growing season, much of the rainfall occurred in June and July with the years highest rainfall event occurring on July 01, 2020 (28mm). Plants planted, and seeds sown in the 2020 Low Mud Flat treatment sites received approximately 66.6 mm of rain during their establishment period and 1054 GDD prior to inundation. Upper drawdown zone treatment sites in the buffer zone (≥648mASL) received 195mm of precipitation throughout the entire growing season. Average daily temperature throughout the growing season was 14ºC. Maximum daily temperatures rose above 30°C on 13 days from July-September including 5 days at the end of July (Figure 12).

Figure 11 Ice cover, Top left March 30th, top right April 11th 2020, lower image July 18 2020.

Table 3 2020 growing degree days and BRGWORKS-1 treatments.

Date Range	GDD base °0	Sites affected	Treatments Affected	Precipitation	Extended dry days
April 10-July 18th	1282.4	Low Mud Flat (639.5m)	2016-2019 plantings and naturals	84 mm	6 days (July 13-18)
May 6-July 18th	1054.4	Low Mud Flat (639.5m)	2020 plantings and seeding	66.6 mm	6 days (July 13-18)
May 6- Oct 21	2551.7	Buffer Zone	2020 plantings Buffer Zone	177.4 mm	9days (Jul 13-21) 12days (July 25-Aug 5) 13 days (Aug8-Aug19) 13days (Sep1-13)
April 10-Oct 21 Full growing season	2779.7	Buffer zone ≥648m	2017-2019 plantings	195 mm	9days (Jul 13-21) 12days (July 25-Aug 5) 13 days (Aug8-Aug19) 13days (Sep1-13)

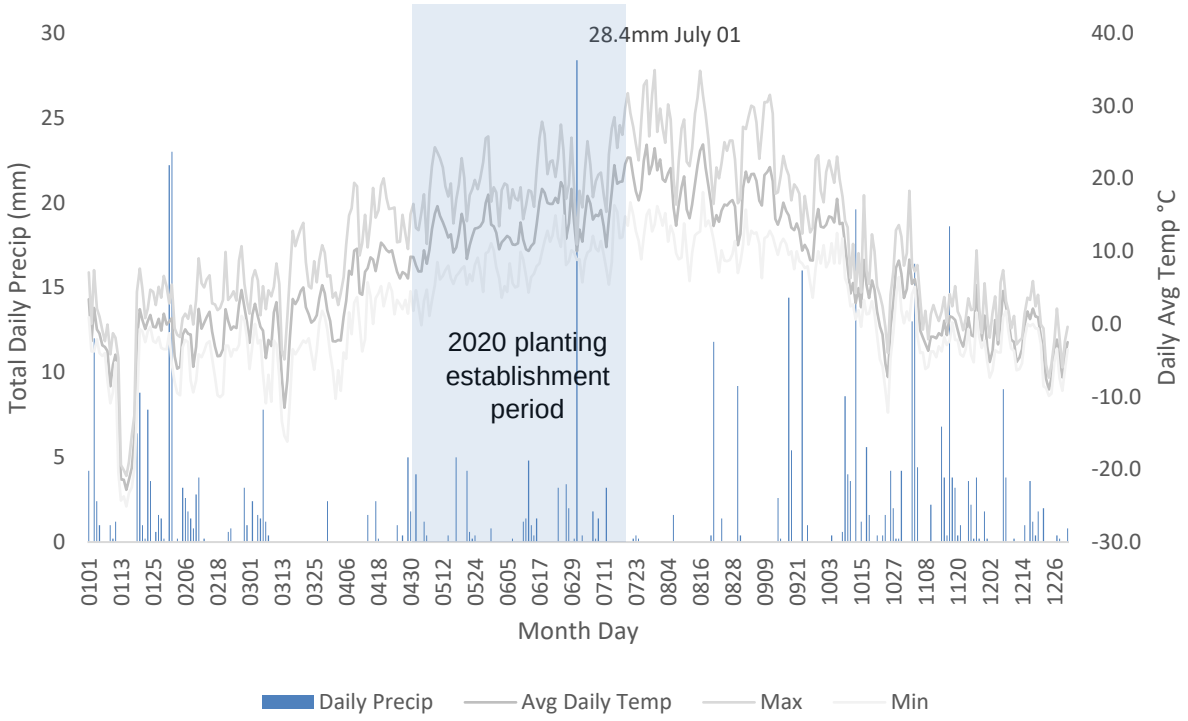

Figure 12 Precipitation during 2020 growing season. Period from planting and seeding to inundation of Low Mud Flat (639.5mASL) is shaded in grey

3.3.1 Permitting

An archaeology impact assessment carried out by Wood and Associates between May 14, 2019 and May 18, 2019 included the polygons treated in 2020. No sites or concerns were identified during the survey. Splitrock was given clearance to initiate restoration treatments. Archaeology sites identified in 2017 on the Gun Creek Fan West were avoided in all project planning and operations.

A Section 11 *Water Sustainability Act* Application "Changes In and About a Stream"-was authorized by Ministry of Forests, Lands and Natural Resource Operations and Rural Development with adherence to terms and conditions in a letter dated March 20, 2013. Reservoir water levels were well below the treatment zone elevations at the time 2020 treatments were completed.

Short Term Use of Water Approval was applied to and received from the Ministry for Forests Lands and Natural Resource Operations and Rural Development Assistant Water Manager, June 4, 2020. Use approval enabled drawing water from Gun Creek and Carpenter Reservoir directly to water planting sites.

3.3 Riparian Enhancements

3.3.2 Machine Treatments

Mounding treatments were carried out between April 20 and 27, 2020. Approximately 9,434m² of newly mounded area was created within 7 separate polygons. Two polygons were located on the Gun Creek Fan East transition between the alluvial fan and the mud flats (MW1900A, MW1900F) (Figure 4). Five polygons were situated within the buffer zone elevations of the Gun Creek Fan West (T1921, T1922, T1923, T1924, T1925) (Table 4, Figure 4).

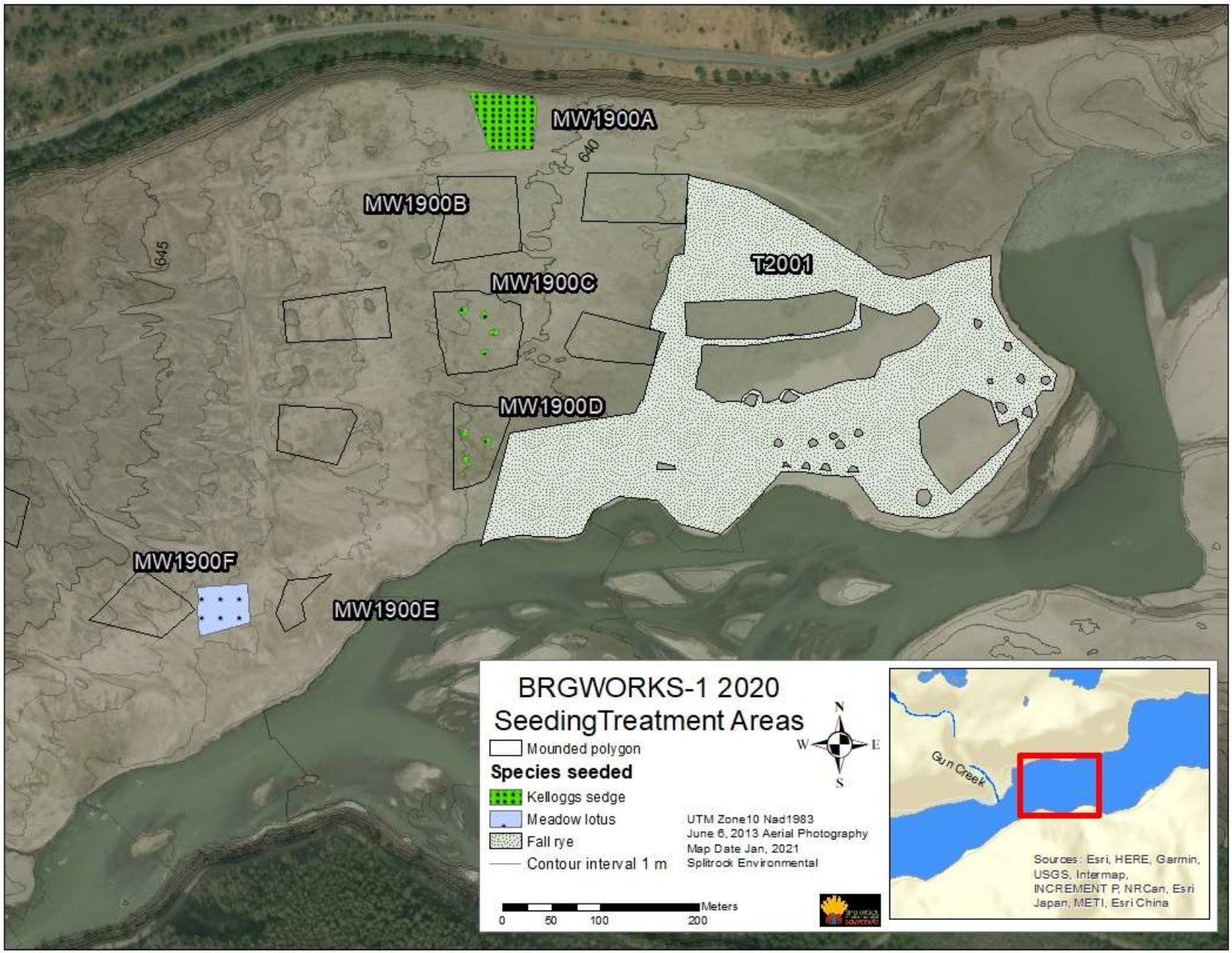

Figure 13 Map of seed treatments carried out in 2020.

Table 4 2020 Riparian Enhancement Treatments summary.

2020 Treatments	Area (m2)	Polygons	Terrain Type
Mounding, seeding Kellogg's sedge	3287	MW1900A	Low Mud Flat
Mounding, seeding meadow birds-foot trefoil	2363	MW1900F	Low Mud Flat
Planting sedges, bluejoint, rushes	6700	MW1900B	Low Mud Flat
Planting sedges, bluejoint, rushes, willow	9911	MW1900C, MW1900D	Low Mud Flat
Seeding Kellogg's sedge	370	MW1900C, MW1900D	Low Mud Flat
Mounding Planting	3784	T1921, T1922, T1923, T1924, T1925	Gun Creek Fan West
Tractor seeding, hand planting Kellogg's sedge, Scouring rush	89464	T2001	Low Mud Flat
Planting Kellogg's sedge, bluejoint, willow	1411	MW1900E	Gun Creek Fan East

3.3.3 Seeding

In 2020, riparian enhancement treatments included mechanical seeding using a tractor and hand-seeding and hand-raking. Annual fall rye was sown across 89,464m² polygon T2001 of the low mud flats (Figure 13). Fall rye was sown at a targeted density of 50 kg/10,000m². The tractor operator was instructed to seed around patches of sedges planted in previous treatment years as well as to avoid seeding over naturally recruited sedges as much as possible.

Meadow birds-foot trefoil seed was hand-sown and hand-raked into 2,363m² (polygon MW1900F) on May 5th, 2020 (Figure 13). Three and a half kilograms of trefoil seed was sown at a rate of approximately 15kg/ha.

In total, 0.715 kg of Kellogg's sedge seed harvested in 2019 was hand-seeded and hand-raked across most of polygon MW1900A (Figure 13). Freshly harvested Kellogg's sedge seed mostly from plants growing in polygons planted in 2016 was hand-seeded and hand-raked into patches in MW1900C and MW1900C. In total 1.750 kg of clean seed was harvested. Fresh sedge seed was sown fairly heavily putting .250 kgs into approximately 55m² patches (45kg/ha). Four patches were sown into polygon MW1900C and three patches into MW1900D (Figure 14).

Fall rye was mechanically sown between April 27th and May 6th 2020. The rye had at minimum 73 days of growth prior to inundation. During the period of growth 1054.4 growing degree days (GDD), base 0°C were accumulated. A visual observation on July 10th, 2020 estimated 1-5% of sprouted fall rye plants were in the reproductive or 'heading' stage of growth (Zadoks et al, 1974). Most plants were still in the vegetative or 'tillering' stage by the time of inundation.

Figure 14 Hand raking patch sown with Kellogg's sedge seed, polygon MW1900C mounded in 2019, seeded and planted in 2020.

Figure 15 Fall rye growth July 1 left and July 10th on right. July 10th date of biomass sampling.

3.3.4 Planting

Kellogg's sedge was the main species planted during the 2020 BRGWORKS-1 program (MAP 20). In this final year of scheduled treatments, sedges were targeted for planting as part of combined treatments. Sedge plugs grown in 77/125ml styro block cells, were planted as patches of 100 or 150 plants within areas treated with mounding in 2019, and areas tilled and seeded with fall rye in 2020 (Table 5). Machine mounded polygons treated in 2019 (MW1900B, MW1900C, MW1900D, MW1900E) were left fallow for a year. The 2019 mounded polygons experienced 5 months inundation between July and December 2019 while laying fallow. Inundation effects included settling and compressing the soils such that sedges were planted into a firmer and more stable substrate (Figure 16).

Figure 16 Left image an example of loose mounded substrate immediately post treatment, (23 April 2020), compared with right image MW 1900C treated one year earlier in 2019, shown here after one year of inundation, substrate compressed, smoothed by water (15 April 2020)

Table 5 Container plants planted across the Low Mud Flat under the 2020 BRGWORKS-1 project. Note all plants were grown in 77/125ml styro block cells except *grown in 1-gallon pots.

Row Labels	MW1900B	MW1900C	MW1900D	MW1900E	T2001	Species Total
Bluejoint reedgrass	586	648	648	108	0	1990
*Black cottonwood	75	75	50	20	0	220
*Common horsetail	0	0	0	0	50	50
*Scouring rush	10	10	10	0	20	50
Kellogg's sedge	2850	3804	3000	1050	6898	17602
*Willow	80	85	50	25	0	240
Plants per Polygon Total	3601	4622	3758	1203	6967	20152

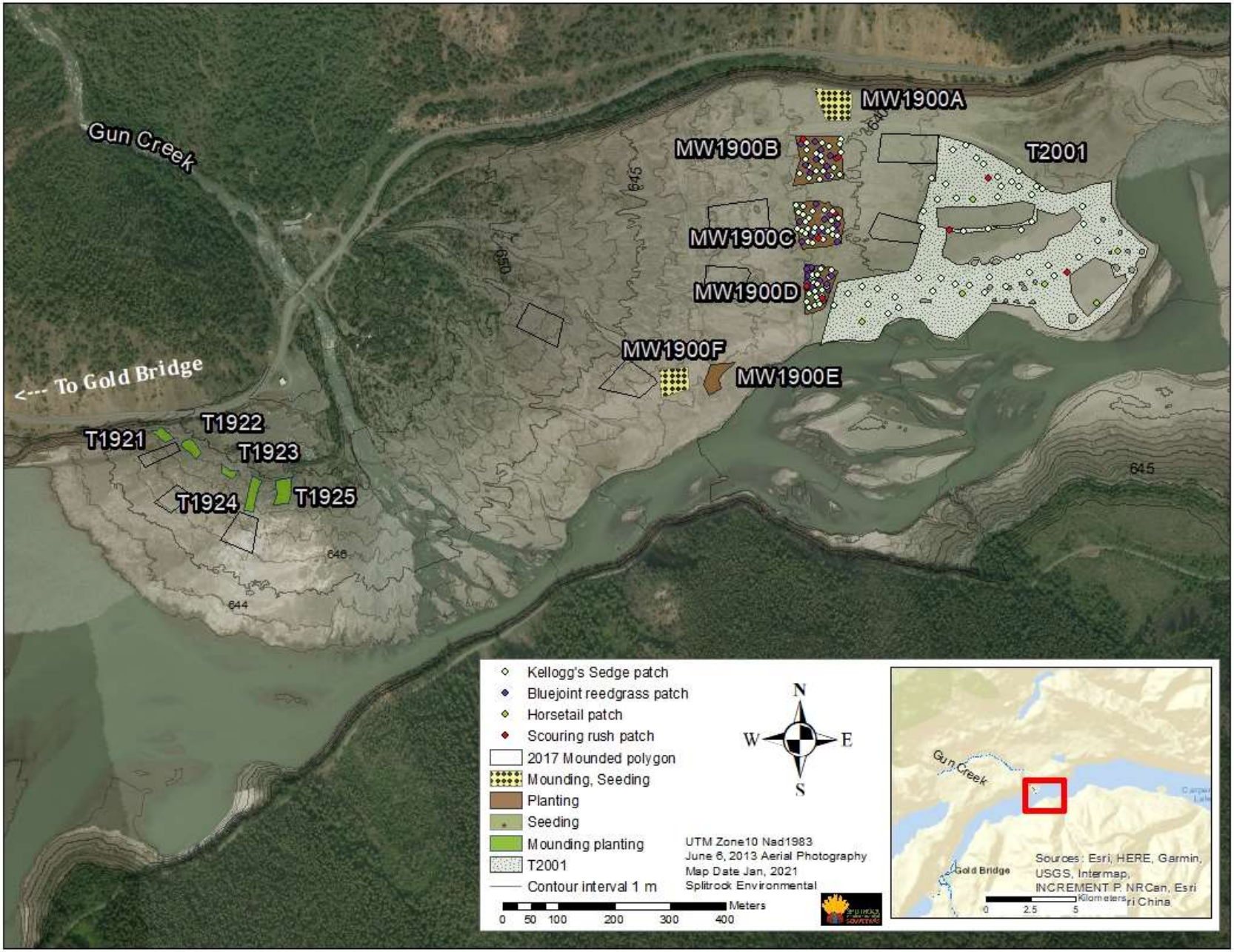

Figure 17 Map of planting treatments carried out in 2020.

Patches of Kellogg's sedge plugs were also planted within polygon T2001 that was pre-sown with fall rye. A small amount of horsetail and scouring rush were planted in patches of 3-5 plants across the T2001 seeded polygon as well as within the polygons mounded in 2019 (project. Table). Container plants in one-gallon pots of black cottonwood, willow and red-osier dogwood were individually, sparsely planted across the 2019 mounded polygons.

Black cottonwood and ponderosa pine trees as well as willow and red-osier dogwood shrubs grown in 1-gallon pots, and bluejoint reedgrass 77/215ml plugs were planted into 5 buffer zone polygons mounded in 2020 of the Gun Creek Fan West (Table 6). Gun Creek Fan West polygons were irrigated and maintained through the summer of 2020. Upper elevation polygons were irrigated 5 times through the growing season (Table 7). Noxious and invasive weed removal within the Gun Creek Fan West buffer zone polygons was completed. Spotted knapweed (*Centaurea stoebe*) is the most prevalent invasive species colonizing mounded polygons in addition to oxeye daisy (*Leucanthemum vulgare*) and Dalmatian toadflax (*Linaria genistifolia*). Knapweed was the main species removed from the treatment sites.

Table 6 Container plants planted into Buffer zone polygons Gun Creek Fan West in 2020. Note Bluejoint was grown in 77/125ml plugs and the other species were grown in 6-inch pots.

	T1921	T1922	T1923	T1924	T1925	Total
bluejoint reedgrass	150	162	150	150	210	822
black cottonwood	25	25	25	15	40	130
willow sp.	15	17	13	15	15	75
ponderosa pine	25	25	25	25	25	125
red-osier dogwood	10	10	10	10	10	50
Total plants per polygon	225	239	222	215	300	1201

Figure 18 left planting patches of sedges into 2019 mounded polygons. Right, example of patch of Kellogg's sedge plants showing nice establishment and growth 3 months later in 2020. (July 15, 2020).

Figure 19 Left; patch of Kellogg's sedge planted on the Low Mud Flat after fall rye seeding. Planting on the right.

Figure 20 tree and shrubs planted in 2020 into polygons mounded in 2020. Ponderosa pine left, willow right. Plants planted on the Gun Creek Fan West polygons were irrigated 5 times through the summer.

Table 7 BRGWORKS-1 2020 maintenance days.

Date	Activity	Site
July 1, 2020	Watering weeding	MW1900D, MW1900C
July 15, 2020	Water, weed	GCFW T1920-T1925 polygons
August 5, 2020	Water Weed	GCFW T1920-T1925 polygons
August 13, 2020	Weeding	GCFW MW1710, T1920-T1925 polygons
August 25, 2020	Water, weed, monitor	MW1708, MW1709, MW1710 cuttings and cottonwoods, T1921, T1922, T1923 trees and shrubs, tally dead pine,
September 3, 2020	Maintenance, water	GCFW T1921, T1922, T1923,

Figure 21 Crews weeding MW1710 Gun Creek Fan West. Aug 15, 2020.

3.4 Dust Storms

Images captured from the weather station were analysed for dust events from March through June 2020. During this span of time 2230 images were captured that together identified 154 dust storms (Figure 22). Most dust events took place in April-July and subsided after the river banks and the mud flats east of Gun Creek were inundated (mid to late July).

Most of the subject area was under snow and ice until the beginning of April. Any dust arising before snow and ice melt was from the edges of the river banks. Eroding river bank edges continue to be the primary source of dust events as reported in previous years of the program (Scholz, 2020). For analysis, the subject area was divided into 4 regions (Figure 8, Figure 23). Region 3 was the source of 69.5 % of all dust capture images between March and June 2020. Most of the dust was arising from along the eroded river bank and gravel or sand bars along the river (Figure 24). Nineteen and a half per cent of dust captures were within

Region 2 that included much of the Low Mud Flat treatment areas, however the primary source of dust within this area is confined to instream sand and gravel bars and river banks. Region 1 to the west had dust events recorded in April and a few in May but none in June. This is likely related to vegetation growth across the mid mud flats but higher river flows may also be a factor covering dust generation sites.

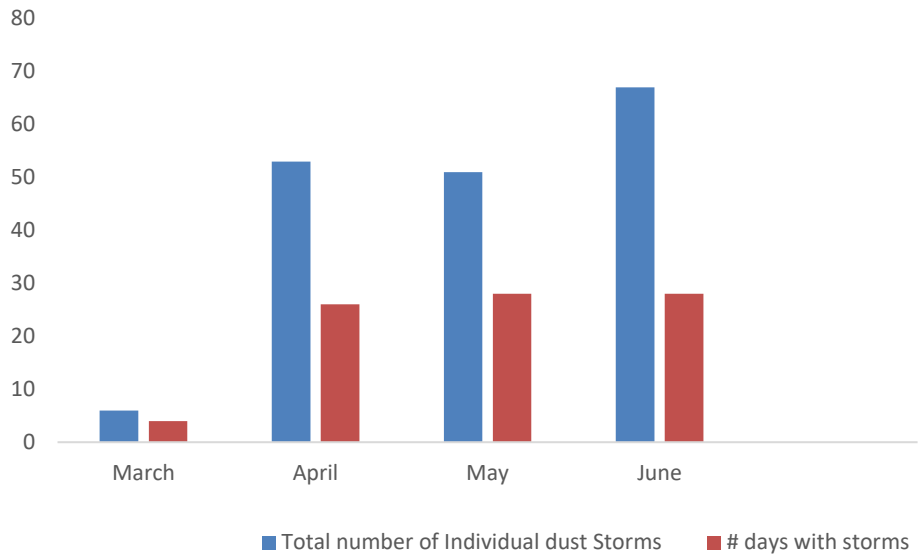

Figure 22 The total number of dust storms and individual days with dust storms during 2020 through end of June.

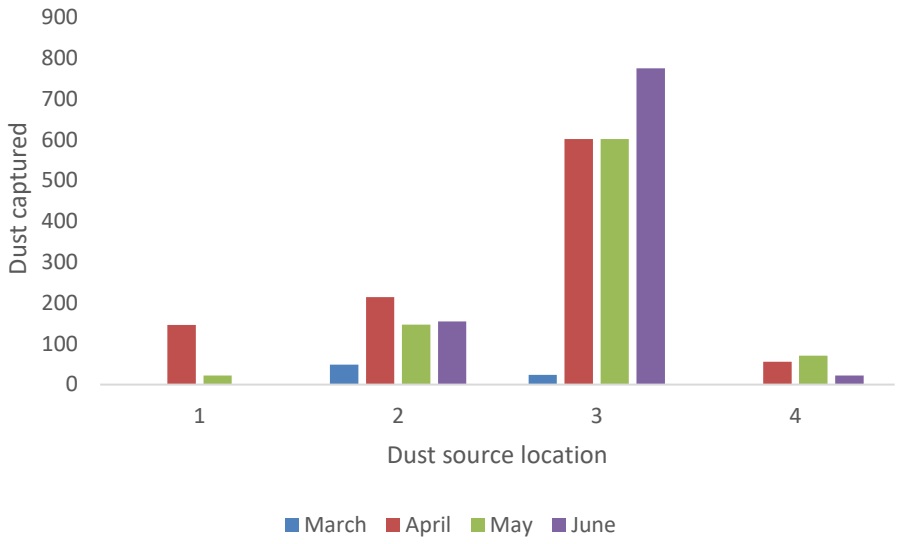

Figure 23 The number of photos that captured a dust event, presented by region.

Figure 24 Photo capture from May 15, 2020 showing river edge sand bars a common source of dust throughout 2020 in region 3. Also, indicated is the typical direction of dust movement from east to west.

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 throughout the summer weekdays and is busier on weekends. During the Covid-19 pandemic the campground was closed to vehicles and camping for the summer. Several unofficial camp sites were observed to spring up along the edge of the Gun Creek Fan East access road during the summer.

Road access to the east side mud flats was open throughout the summer. All terrain vehicles (ATV) and off-road motorcycle recreation activity was observed fairly regularly on the mud flats during BRGWORKS-1 (and BRGMON-2) treatments and monitoring. It was obvious that prior to WORKS-1 treatments in April there had been a significant amount of off-road motorcycle and ATV activity across the mud flats (Figure 25). Some of the concentrated ATV activity used marker flags to race around on the mud flats. Flags were left over from marking planting locations for patches of sedges in 2019. Flags were left to make it easier to identify planted patches in 2020 during treatments and monitoring. All flags used as markers in 2019 and in 2020 were removed from the Low Mud flat to avoid attracting recreation users. Some motorcycle activity occurred within the mounded areas including MW1702 where mounds were larger and more sculpted. None of the vehicle activity within mounded polygons was of a scale to cause significant disturbance.

Figure 25 Photos from mid April showing disturbance from motorcycle and ATV activities out on the Low Mud Flat. Left image taken along the 'track' marked by the arrow in the image on the right.

3.6 Wildlife Use

Incidental observations of wildlife species are summarized in Table 8. Species observed to be utilizing the BRGWORKS-1 target restoration areas include mule deer (*Odocoileus heminonus*). Tracks were occasionally observed across the Low Mud Flat and within mounded polygons. In September, a high level of browse was observed on planted cottonwoods in the Gun Creek Fan West side buffer zone polygons.

A juvenile western toad (*Anaxyrus boreas*) (SARA Schedule 1-SC (June 2018) was observed on July 01 in polygon MW1900C of the Low Mud Flat (Figure 26). July 01 was one

of the wettest days of 2020 (Figure 12). The western toad observed was a juvenile toadlet likely spawned in and grown from seasonally wetted pools upstream within the reservoir drawdown zone or tributary drainages.

Avian species observed included Canada geese (*Branta canadensis*) and spotted sandpipers (*Actitis macularius*) heard and observed along the riverbanks and mud flats to the east of the Gun Creek Fan. Savannah sparrow (*Passerculus sanwichensis*) were observed and heard on the Gun Creek Fan west side in the upper drawdown and buffer zone. Mountain bluebirds (*Sialia currucoides*) were more frequently observed in the upper drawdown zone and buffer zone. Western bluebirds were observed in mounded polygons on the Low Mud Flat. Osprey (*Pandion haliaetus*) were observed flying overhead across the Low Mud Flat and the Gun Creek Fan.

Table 8 Incidental wildlife observations during BRGWORKS-1 field work.

Species	Note	Location	Date
Common Raven	two adults	mud flat	29-Apr
Spotted sandpiper	likely breeding	along river	April-June
Canada geese	ground and in flight	mud flats and over river	April-Sept
Western toad	juvenile,	MW1900C	01-Jul
mule deer	tracks, browse	mud flat, Gun fan East	April-Sept
savannah sparrow	likely breeding	Gun Creek Fan West	June
Mountain bluebird	Likely breeding	Buffer zone Gun Creek Fan East and West	June

Figure 26 Wildlife and wildlife sign observed during BRGWORKS-1 field work in 2020. Clockwise from top right, adult ravens on recently seeded mud flats, western toad in MW1900C, mule deer browse on GCFW m mounded polygon, relatively fresh mule deer tracks on low mud flat early spring 2020.

A targeted search for reptiles and amphibians was carried out within the Low mud flat treated and control areas on July 14, 2020. Both 2019, and 2017 mounded polygons were studied as well as a mud flat control area. July 14, 2020 was a clear warm day with no precipitation. Surveys were conducted between 9 am and 2pm. No reptiles or amphibians were observed on the July 14th survey. Incidental observations during the monitoring included hearing spotted sandpipers along the river, hearing Osprey flying overhead, observing mountain bluebird, and encountering bees, hoverflies and horseflies.

Table 9 July 14th wildlife survey summary.

Polygon	Area m²	Time search	Observations
MW1900D	3687	135 min	Several horned caterpillars observed
MW1900C	6225	135 min	Recent mule deer tracks
MW1701CON	2808	135 min	Old mule deer bones in poly, large bird droppings in plot
MW1701	3584	90 min	Damsel flies
MW1702	2000	45 min	Damsel flies, Reservoir water levels partially inundating Polygon.

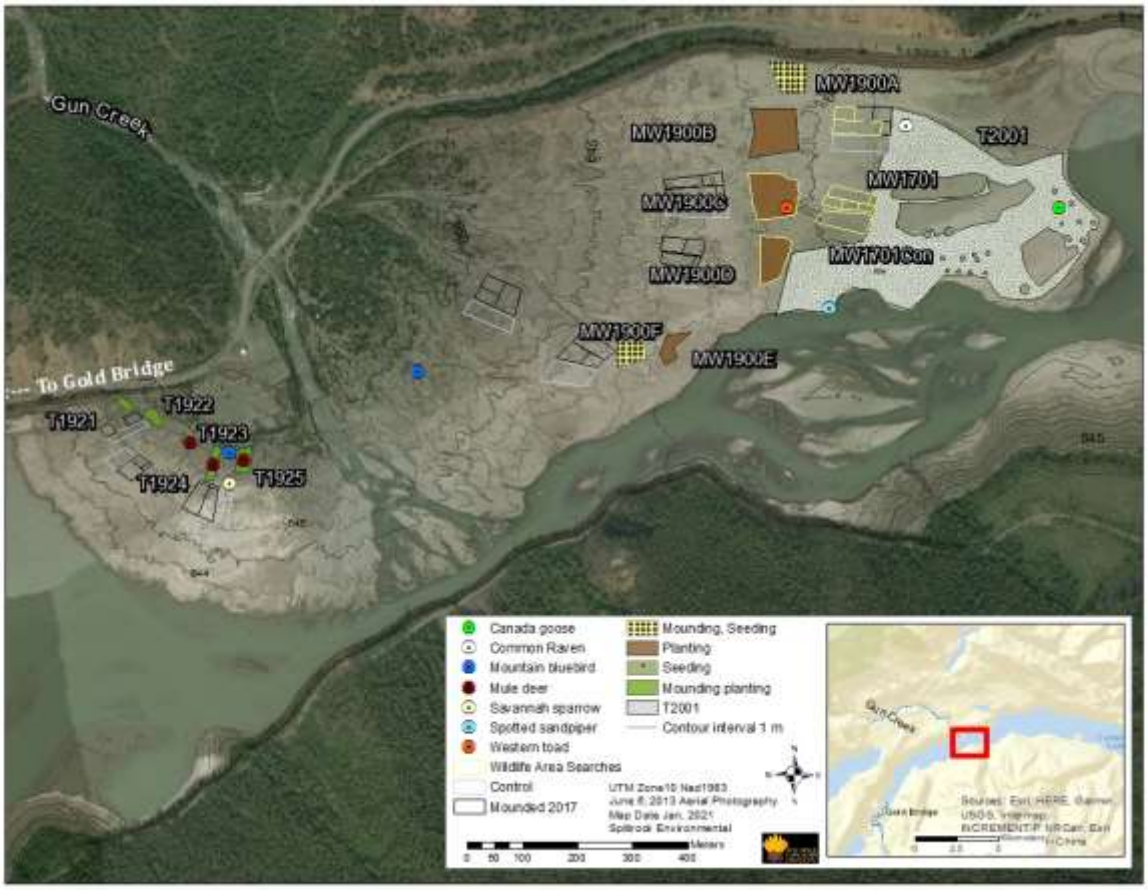

Figure 27 Wildlife observations and targeted survey polygons.

4. Discussion

The 2020 BRGWORKS-1 program was the final year of scheduled revegetation treatments on the Carpenter Reservoir drawdown zone. In 2020, emphasis was on seeding, planting and substrate mounding with a focus on combined treatments. Planted plants were irrigated and some invasive species removal was carried out through the growing season. Wildlife monitoring was done anecdotally throughout the project as well as through a targeted search for amphibians and reptiles using treatment sites.

Carpenter Reservoir water levels typically reach their lowest elevations between mid April and mid May. Reservoir levels rise throughout spring freshet and over much of the annual growing season peaking between early August and November (Figure 9). The rate and timing of filling as well as peak pool reached, determines the length of the growing season for drawdown zone plants including riparian enhancement treatments. 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, and the targeted maximum full pool of 648mASL. During the period of BRGWORKS-1 treatments (2014-2020, Figure 9) the timing of riparian enhancement inundation, elevations above 639.5 mASL, have occurred on average 2 weeks later than the 20-year average. This favourable management pattern

amounts to an additional 200 growing degree days for vegetation over the long-term average. This favourable pattern was again experienced in 2020 although the cold spring weather conditions were felt into April. Another latent factor of reservoir inundation and drawdown is that when water levels drop during late winter and early spring, a shelf of ice is left stranded on the mud flats to the east of the Gun Creek Fan. It is hypothesized that the ice shelf slows the start of the growing season on the mud flats even as warmer weather commences.

Seeding fall rye was the largest area-based treatment on the Low Mud Flat. Perrin et al (2007) reported that fall rye in particular provides the basis for increased diversity in benthic invertebrates within reservoir drawdown zones due to its high production of biomass. Organic matter is vital to the presence of benthic invertebrates that breakdown and recycle nutrients forming the basis of complex aquatic food webs (Palmer, 1997. Covich et al., 1999). Presumably more organic produced during the growing season means greater potential for higher biomass in benthic invertebrates and greater diversity. Cool spring weather in 2020 delayed fall rye seeding until late April-early May. Seeding was further delayed by a week due to a mechanical issue. The growing period during 2020 was reasonable at 73 days and rye plants attained over 1000AGDD units. Average fall rye standing crop sampled in 2020 was much greater than in 2019 when only 600 AGDD were tallied and 180kg/ha produced prior to inundation. It was predicted that a minimum of 1000 AGDD would be necessary to produce any substantial amount of standing crop from fall rye. In 2020 fall rye received just over 1000 AGDD, which produced over 1000kg/ha. In 2019, reference ecosystems sampled at higher elevations in the drawdown Mid Mud Flat 644m, averaged 1700kg/ha standing crop when sampled around peak growth in 2019 (Scholz and Gibeau, 2020). The reference plots were dominated by perennial species bluejoint reedgrass and Kellogg's sedge. Plots planted with Kellogg's sedge in 2016 on the Low Mud Flat were also sampled in 2019 with an average standing crop produced at 1500kg/ha. While 2020 fall rye growth eclipsed that of the 2019 production, it was evident that there was no significant increase in recruited standing crop from fall rye seeding vs naturally recruited vegetation on non treated control areas in 2020. Control areas had a longer growing season by about 240 AGDD over seeded fall rye (Figure 28). Control area standing crop plots were limited in number and may not have captured the full range of vegetation growth. Fall rye seeding resulted in a consistent level of vegetation distribution and cover compared with control areas, and if grown for the same length of time, fall rye would produce more biomass than the suite of annual exotics that inhabit the Low Mud Flats. The variability in growing season length due to timing of the onset of warm spring weather as well as inundation timing, make it difficult to predict if fall rye seeding will result in a high enough production of standing crop to make it worth while. Seeding fall rye at elevations above 639m in the Carpenter Reservoir drawdown zone prior to the end of April should result in standing crop production equal to or greater than that naturally recruited.

Figure 28 Photo taken July 1, 2020, the growth of seeded fall rye in contrast to naturally recruiting vegetation within the circular patch to the left of the shovel. Patch was not seeded in 2020 to avoid disturbance to 2019 planted Kellogg's sedge plugs, species recruiting naturally are exotic annuals including sand spurry, common knotweed, lamb's quarters.

Control area standing crop on the LMF in 2017 was <50kg/ha, in 2019 was <200kg/ha, and 2020 was <1300 kg/ha. This indicates a possible trend of increasing in growth, or at least a broad range in standing crop produced. More objective sampling may be needed to determine if there is a long-term trend in vegetation growth. This question may be addressed in the final year of monitoring for BRGMON-2.

BRGMON-2 monitoring from 2018 indicated that seeding fall rye followed by planting sedge plugs seemed to result in good sedge establishment (100% survival) and robust plant growth (Scholz and Gibeau, 2019). It is hypothesized that the fall rye acts as a nurse crop for the sedges during the year it is grown. In subsequent years, the dead fall rye plants, including roots, may then provide nutrients for establishing sedges resulting in good growth. The combined treatment of fall rye seeding and Kellogg's sedge plug planting carried out in 2020 resulted in similar fall rye growth as was experienced in 2016 at sedge plug planted polygon PLG16-04. Similar combined fall rye seeding and sedge planting treatments implemented in 2019 were marred by a low number of AGDD resulting in very low volumes of fall rye standing crop produced that may have negated any beneficial effects of seeding fall rye and planting.

Two types of sedge seeding were carried out in 2020; seed collected in 2019 was sown into a 2020 mounded polygon (MW1900A), and freshly harvested Kellogg's sedge seed was sown in patches within two of the 2019 mounded polygons (MW1900C, MW1900D). Freshly

harvested seed was gathered primarily from patches of sedge that were planted in 2016. The two age class seed trials should be monitored under the BRGMON-2 2022 field study with particular attention to the assisted local dispersal trials from the planted patches. If successful colonization and seedling establishment is observed in sown patches this patch-based approach to restoration could be a useful approach to gradual restoration of vast disturbed areas. Densely planted patches provide habitat islands while producing seed that without assisted local dispersal would remain in dense concentration very close to parent plants or become greatly dispersed by flooding and flowing reservoir waters.

In 2016, a test patch of Kellogg's sedge was sown within a larger polygon area of fall rye (PLG04 approximately 400m²). In 2019, PLG04 was lightly sown with meadow birds-foot trefoil seed. Trefoil plants were observed growing a year later (Figure 29). Based on observed hand seeding trials, trefoil is a leading candidate of an annual native legume species that could contribute to drawdown zone revegetation success. Continuing with the patch-based approach, overseeding established patches of sedges with trefoil seed would increase native species diversity and improve soil fertility and possibly sedge growth through the plant's nitrogen fixing abilities. More work may need to be done with seeding trials including trying inoculating trefoil seed with beneficial rhizobium bacteria. An initial literature search has indicated no reference to use of this species in other restoration projects. Polygon MW1900F was fairly heavily sown with meadow bird's-foot trefoil seed; this polygon should be monitored at least in 2022 for persistence of this annual native species.

Figure 29 Polygon PLG04 consistent though sparse growth of meadow birds-foot trefoil among 5-year-old sedge plugs.

Machine mounding treatments carried out on the Low Mud Flat (seeded with trefoil and Kellogg's sedge) were inundated in 2020. It is anticipated the substrates will settle dramatically as has been observed in other mounded polygons. Settling soil may benefit increased depth of seed burial. Seeded areas were hand raked to provide initial seed cover, the mounded profile should also trap and keep seeds on site through inundation. It is hoped that germination and growth will be observed in 2021 and/or 2022.

Patches of Kellogg's sedge plugs planted in 2020 across the low mud flats and in polygons mounded in 2019 were observed to be growing well during follow up maintenance days (Figure

30). In particular, within the mounded polygons, sedges appeared to put on rapid growth prior to inundation. Sedge root growth should reflect top growth indicating plants should be well rooted into the settled substrate (Figure 30)Treatments were adapted to include one reservoir inundation cycle post physical treatments, before planting and seeding. This adaptative management approach was initiated to avoid loss of planted plants due to inundation caused erosion and settling of loosely mounded soils. Settling and erosion left exposed planted plug roots and completely extruded plugs, many plants floated away from wave and water impacts

Figure 30 Left photo 1.5-year-old 2020 planted Kellogg's sedge plugs in MW1900C mounded in 2019 (July 15, 2020). Right; 3-year-old planted Kellogg's sedge plugs in polygon PLG04. Eroded bank reveals the plants extensive fibrous root development and dense top growth (June 14, 2018).

Mounded polygons on the Gun Creek Fan West were not inundated. and soils will settle at a slower rate allowing 2020 planted plugs to establish. On the Gun Creek Fan West, the upper drawdown and buffer zone has a high presence of exotic and noxious weed species. High cover of spotted knapweed (*Centaurea stoebe*) is invading freshly disturbed soils of mounded polygons. Other invasive species observed colonizing mounded areas include Dalmatian toadflax (*Linaria genistifolia*), oxeye daisy (*Leucanthemum vulgare*) and great mullein (*Verbascum thapsus*). Many mature knapweed plants were removed from the site during maintenance days however, numerous rosettes were observed during follow up irrigation. Longer-term effort will be required to control the presence of knapweed within mounded sites while planted native species become established.

Through camera image monitoring from the 5 Mile Ridge, 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 known 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 within the region of the BRGWORKS-1 project is coming from sites directly along the Bridge River banks and sand bars. These are steep cut-banks with high unconsolidated and rapidly eroding

soils and flat low elevation sand bars prone to flooding in spring from high river flows and then flooded by Reservoir inundation in summer limit any potential for vegetation establishment and growth (Scholz 2019). Increasing both annual and perennial vegetation cover across the Low Mud Flat traps secondary fines deposited from riverbank erosion sites and may lower the potential for resuspension of eroded materials but it is difficult to address the primary sites of erosion.

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?".

Quantifying the impacts of the BRGWORKS-1 program on aesthetics and recreation is difficult to measure. Conducting a revised version of the public survey issued in 2014 should provide some feedback to the program and should be considered for 2021. Recreational use of the area seems diverse with high impact 4X4 off roading and mud bogging contrasted with walking, kite flying and fishing. The public profile of the historic Minto town site was a point of focus during the BRGWORKS-1 project as provincial recognition of WWII Japanese internment camps extended to Minto with the addition of signage at the town site.

Figure 31 Sign designed and installed by BC Hydro in 2020. The intent was to provide information regarding the BRGWORKS-1 project. Part of the motivation is to try and mitigate ATV and 4X4 disturbance to treatment sites.

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 vast, open, sparsely-vegetated mud flats provide a minimal level of terrestrial habitat. Incidental observations indicate mule deer frequent the area. Mule deer use is confirmed by observed tracks, scat and browse. Individual tracks are more common on the low mud flats indicating animals passing through. Browse and scat more frequently observed in the buffer zones of both the east and west side of the Gun creek fan indicate feeding and longer site presence. Browse was more notable on the Gun Creek Fan West side and seemed to target 2020 planted cottonwoods. A rare set of moose (Alces alces) tracks were observed in the mud of the flats.

Avian species were observed traveling overhead including ravens, osprey, bald eagles, as well as utilizing the river and river edges and shorelines. Spotted sandpiper, and Canada geese utilize sedge patches, including planted sites, along the edges of the river. Canada goose scat observed during the BRGMON-2 field study, indicated Kellogg's sedge seed is being consumed along with leaves. In 2018, a spotted sandpiper nest was observed in a patch of planted sedges.

In previous years juvenile reptiles (likely terrestrial garter snakes) and amphibians (Western toads, Schedule 1, Special Concern) have been observed utilizing the mounded polygons on the mud flats. In 2020, one western toadlet was observed in mounded polygons on what turned out to be the day with the highest precipitation in 2020. It is likely the toadlets are emerging from wet ephemeral pools in the drawdown zone to the west and are dispersing from the river bank (Figure 32). During previous years' programs, high numbers of juvenile toads were observed moving along the edges of the river. It is certain that any increase in vegetation cover along the terrestrial edges of the river banks will enhance habitat by providing cover and food resources.

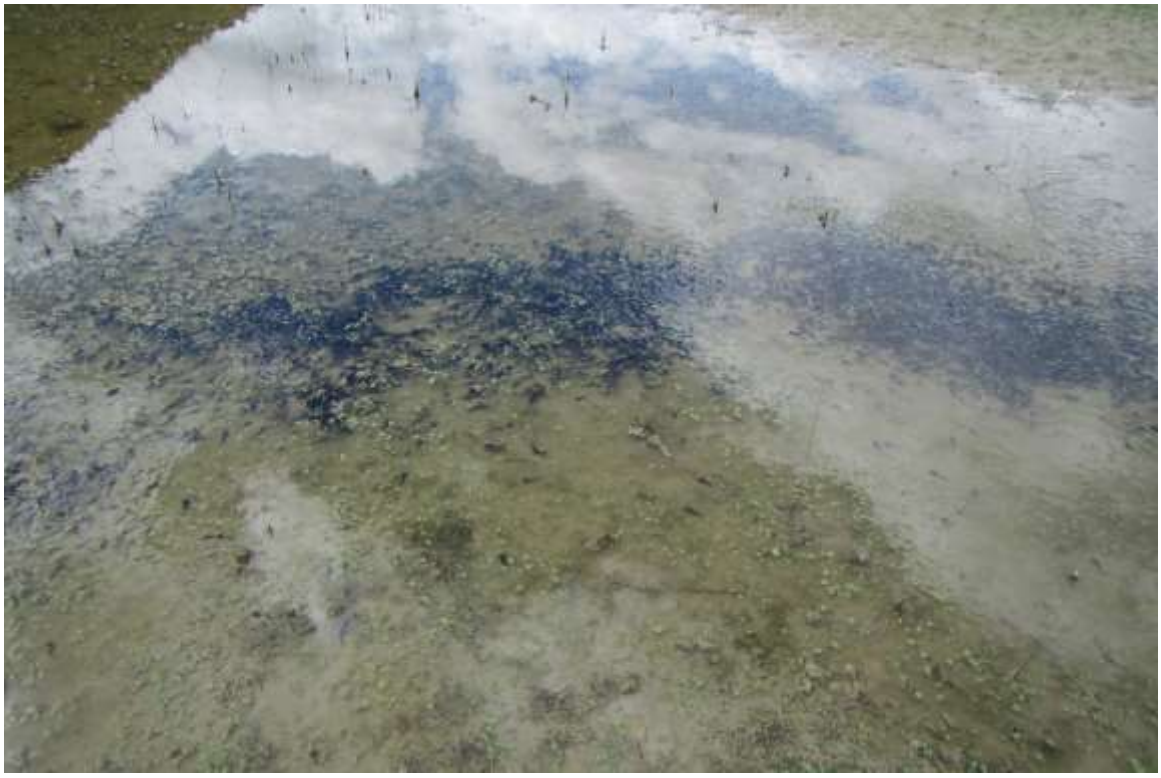

Figure 32 Larval stage western toad in pool on Mid Mud Flats west of Gun Creek Fan, within the Carpenter Reservoir drawdown zone. Pool observed under BRGMON 2 survey June 18, 2013.

Based on incidental observations, mounding treatments have resulted in increased sightings of amphibian and reptile species. A one-day targeted search for amphibian and reptile species was carried out in 2020 but it did not reveal any target species, although this day was very dry and warm and likely not conducive to amphibian movement. Given that main species observed seem to be juvenile western toads and juvenile western terrestrial garter snakes, it may be that a predator is following prey and that prey or toads tend to move away from the river and cross into the mounded or mudflat areas during a certain dispersal timeframe or perhaps during wetter conditions. If a broader understanding of amphibian species within the reservoir is desired, a broader area targeted study could be designed and implemented.

Observations in previous project years questioned whether toads could be breeding in pools found in depressions within mounded polygons. In spring of 2020, pools that may have been in the mounded terrain were dry by mid-April effectively removing any opportunity for breeding at least in 2020.

With regard to the effect of BRGWORKS-1 efforts on aquatic habitat quality and productivity, findings of Perrin et al., 2002 that showed that an increase in vegetation cover increases aquatic productivity. Although productivity was most directly associated with fall rye detritus, where native perennial vegetation becomes established and thrives, it can be expected that aquatic habitats would improve in quality and productivity. The magnitude of

effect from changes created by BRGWORKS-1 treatments on aquatic habitats and productivity are largely unknown..

5. Recommendations

2020 was the final year of scheduled treatments for the BRGWORKS-1 project. Currently a final report is the only scheduled action for 2021-2022. If possible, another season of maintenance and monitoring would be beneficial to the long-term project results. In particular, irrigation in 2021 of buffer zone plantings and invasive species management particularly on the Gun Creek Fan West side are recommended. It is anticipated that BRGMON-2 monitoring should include some assessment of BRGWORKS-1 treatments in 2022 and should help inform some of the BRGWORKS-1 management questions. A public survey was conducted in 2014 to gauge local perspectives and gather public input on the management questions. It would be beneficial to conduct a follow up survey to assess and solicit public feedback post treatments. Dust storm monitoring and the associated weather station lease expired at the end of 2021, dismantling, and or repurposing of the weather station will need to be considered and any necessary remediation of the footprint will be required.

6. Conclusion

Riparian enhancement treatments in 2020 were the seventh and final year of scheduled treatments in the Carpenter Reservoir drawdown zone. Although 2020 is the final scheduled program year, treatments continued to be experimental in nature. While some treatments have shown positive results, the scale of treatments and trials is small relative to the scale of the disturbed drawdown zone area. Physical treatments, seeding and planting have all been applied mostly in combination. A diversity of native species continued to be used with an emphasis on Kellogg's sedge. Fall rye was seeded with high initial standing crop and cover values, if the growing season prior to inundation was long enough. The amount of standing crop produced by fall rye in 2020 was comparable to that produced by naturally recruiting exotic species. Polygons mounded in 2019 were planted with Kellogg's sedge plugs one year post physical treatment when substrates had experienced inundation and were more compacted and stable to hold rooted plugs. This contrasts with typical terrestrial mounding which has a goal of maintaining a loose rough texture. The mounds appear to be performing valuable functions of improving planted plant and seed establishment and growth, capturing seed and assisting plant colonization. The loose rough textured mounds located in upper drawdown zone elevations in the buffer zone were physically treated and planted in 2020. Approximately 9,434m² of freshly mounded area was treated in 2020. Treatments included hand seeding native Kellogg's sedge and meadow birds-foot trefoil and planting with native trees, shrubs and grasses. Over 17,500 Kellogg's sedge plugs were planted in patches across the Low Mud Flat in polygons seeded with fall rye and throughout polygons mounded in 2019. Bluejoint reedgrass, willow, black cottonwood, red-osier dogwood, scouring rush, common horsetail and ponderosa pine were also planted. Seed was harvested from established patches of Kellogg's sedge plants planted in 2016. Seed was cleaned and sown into patches within 2019 mounded polygons in a trial of patch based assisted dispersal. Dust monitoring

continues to indicate the active river channel as the primary source of dust. Incidental wildlife observations indicate some use of riparian enhancement sites. Irrigation and invasive species management are necessary for some of the treatment areas to improve chance of long-term success.

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