Bridge River Project Water Use Plan

Carpenter Reservoir Drawdown Zone Re-vegetation Program

Implementation Year 2

Reference: BRGWORKS-1

Carpenter Reservoir Drawdown Zone Re-vegetation Project Year 2 2015 Final Report

Study Period: 2015

Splitrock Environmental

January 2017

Executive Summary

The second year of the BRGWORKS-1 re-vegetation project on Carpenter Reservoir was completed during 2015. The second year efforts built and expanded upon the implementation year of 2014. The 2015 work focused on planting rooted plugs, live stake cuttings and carrying out seeding trials. Six terrain sites within the 292 ha target re-vegetation zone were the focus of the re-vegetation efforts.

Rooted plugs of lakeshore sedge (*Carex lenticularis*) and bluejoint reedgrass *(Calamagrostis Canadensis)* were the two focal species utilized in 2015. All plants were propagated at Splitrock Native Plant Nursery from locally collected seed. Several planting sites were tested for benefits of utilizing manufactured fertilizer bags.

Cuttings trials consisted of using willow *(Salix sp.)* and cottonwood (*Populus balsamifera ssp. trichocarpa*). Cuttings were planted using hand techniques as well as employing an excavator to enable deeper planting depths and planting of larger diameter cuttings.

Seeding trials were carried out using a tractor pulled seeder. Low elevation seeding trials included a trial of establishing an ephemeral cover of fall rye (*Secale cereale*) as a potential dust suppressor and potential nurse crop to lakeshore sedge, also seeded. Higher elevation drawdown zone seeding trials were carried out utilizing fall rye, and a mid and upper elevation reservoir native grass seed mix.

In addition to planting and seeding trials, rock walls and smile shaped weirs were constructed around cuttings sites to test whether such features could trap suspended fines thereby improving microsite growing conditions.

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Summary Status

Table 1 BRGWORKS-1 Status 2015

OBJECTIVES, MANAGEMENT QUESTIONS and HYPOTHESES after 2014			
Study Objectives Numbers relate to MQ.	**Management Questions**	**Management Hypotheses**	**Year 2015 (Status)**
To design and implement a reservoir planting program for the Western end of Carpenter Lake focusing on the area between Tyaughton Lake Road Junction and the Gun Creek Fan.	MQ1 Will the planting of vegetation in the drawdown area mitigate the effects of dust storms resulting from reservoir drawdown particularly in the western end of the reservoir near the Town of Gold Bridge?	H1 The planting of vegetation in the drawdown area does not mitigate the effects of dust storms resulting from reservoir drawdowns particularly in the western end of the reservoir near the Town of Gold Bridge.	Initial observations indicate dust is generated from areas of fine sands located along the river channel banks at low pool times of year March - June. This area will be targeted in future for dust mitigation trials. Closer monitoring to come with weather station
To focus on the planting of appropriate species of vegetation this is done using information gained in the BRGMON-2 program.	MQ2 Will the planting of vegetation in the drawdown area increase the aesthetic quality and recreational opportunities in the western end of the reservoir?	H2 The planting of vegetation in the drawdown area does not increase the aesthetic quality and recreational opportunities in the western end of the reservoir.	Public survey conducted to assess perceptions of reservoir aesthetic and recreational use of region pre-planting. Recreation use of region extreme varied. Aesthetic perception >50% negative. Also included questions regarding wildlife and dust storm.

Study Objectives Numbers relate to MQ.	Management Questions	Management Hypotheses	Year 2015 (Status)
To conduct evaluations of the program to assess the degree to which the planting program helps to establish natural re-colonization of the area from Tyaughton Lake Road Junction to Gun Creek Fan (This will be covered under the BRGMON-2 program).	MQ3a Will the planting of vegetation enhance the quality of riparian habitats to increase their potential to support wildlife populations and provide localized improvements in the quality and productivity of aquatic habitats in the reservoirs?	H3a The planting of vegetation in the drawdown area does not enhance the quality of riparian habitats to increase their potential to support wildlife populations and provide localized improvements in the quality and productivity of aquatic habitats in the reservoirs.	Wildlife observations recorded at sites of re-vegetation as part of baseline data collection show mainly mule deer use at site. Incidental observations many also public observations many species. Direct use at target re-vegetation site by mule deer, beaver, Canada geese, mountain bluebirds, river otter, long toed salamanders, western toad, horse, cow, .
To conduct evaluations of the program in order to assess the degree to which the planting program helps enhance the quality of riparian habitats, increases their potential to support wildlife populations, and provide localized improvements in the quality and productivity of aquatic habitats in the reservoir.	MQ3b Will planting of vegetation provide localized improvements in the quality and productivity of aquatic habitats in the reservoir?	H3b The planting of vegetation in the drawdown area does not enhance the quality and productivity of aquatic habitats in Carpenter Reservoir.	In communication with BRGMON 4 (Carpenter Reservoir and Middle Bridge River Fish) and BRGMON 10 Carpenter Reservoir Productivity Model, Study programs to include consideration of WORKS 1 Re-vegetation region in their studies.

1. Introduction

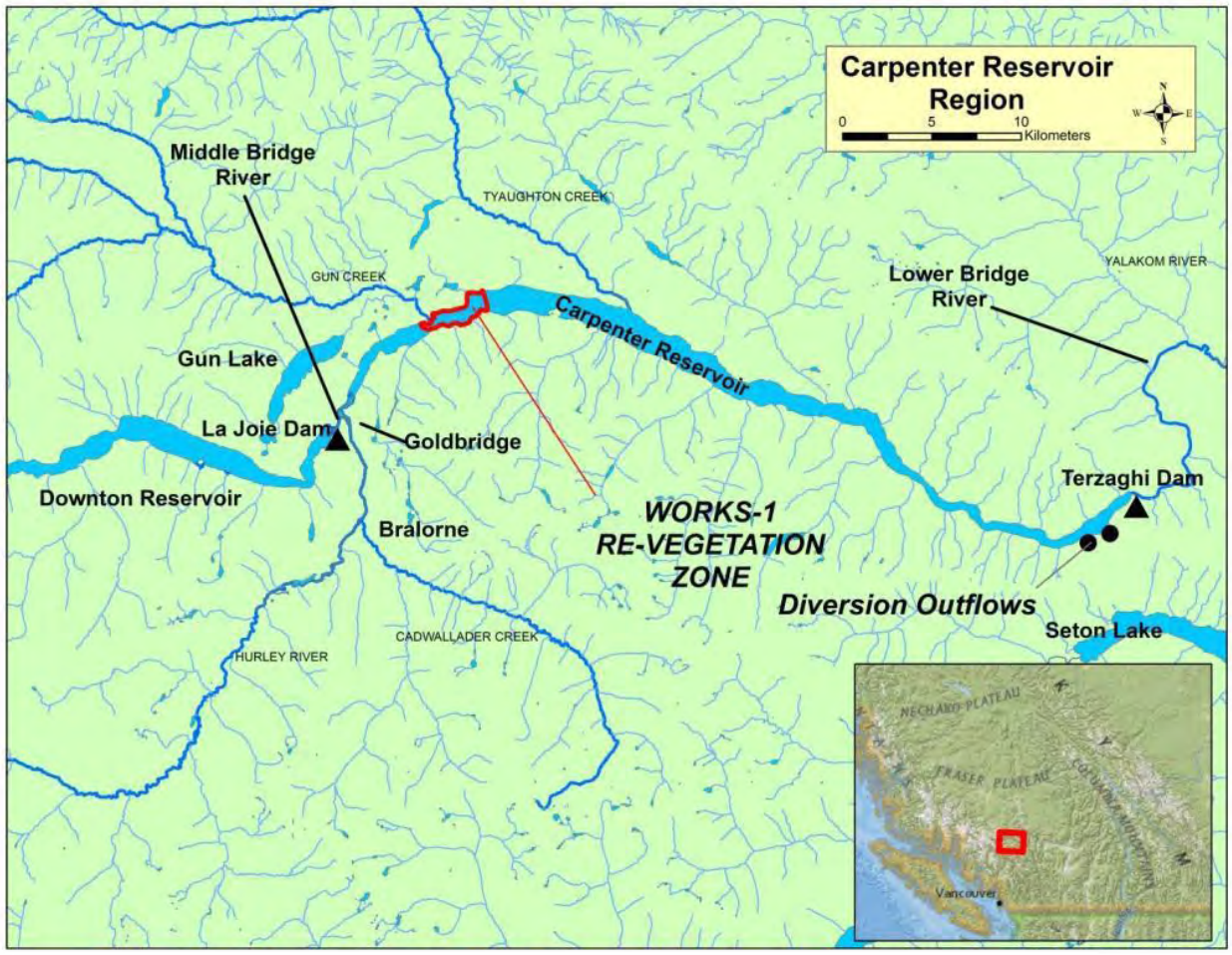
2015 was the second year of the BRGWORKS-1 five-year re-vegetation project on Carpenter Reservoir drawdown zone. The objectives of the BRGWORKS-1 project are to identify appropriate species of vegetation and effective methods for revegetation and promotion of natural re-colonization in a section of the drawdown zone of Carpenter Reservoir

The BRGWORKS-1 program was designed to follow a staged approach to re-vegetation. 2015 efforts expanded and built upon the test plots established in the 2014 (Scholz, 2014). 2014 plots were targeted plantings of nursery grown plugs of lakeshore sedge (*Carex lenticularis*), foxtail barley (*Hordeum jubatum*), blue wildrye (*Elymus glaucus*), bluejoint reedgrass (*Calamagrostis canadensis*), slender wheatgrass (*Elymus trachycalus*), fowl bluegrass (*Poa palustris*) and Baltic rush (*Juncus balticus*). Trial plots were also hand sown with locally collected bluejoint reedgrass and Canada wildrye (Elymus canadensis) seed. In 2014 live staking of black cottonwood (*Populus balsamifera ssp. trichocarpa*) and local willow species *(Salix sp.)* were planted. 2014 trials were carried out between 644-649m elevations.

Trials in 2015 focused on planting lakeshore sedge, foxtail barley and bluejoint reedgrass plugs, as well as willow and cottonwood cuttings. Seeding trials were also completed using fall rye, lakeshore sedge, bluejoint reedgrass, as well as a lower and upper reservoir seed mix. 2015 trial plots were located lower down in the drawdown zone than in 2014 and were established at elevations as low as 640m.

In addition to planting and seeding and in an effort to capture suspended sediments from the reservoir at high water periods some physical works trials were conducted by hand construction of rock walls and weirs using boulders and cobbles. If fines can be trapped in the rock structures the result could be the creation of improved microsites for vegetation colonization and growth. Dust storm origin and frequency are a component of the WORKS 1 project as are monitoring aesthetic perception and recreation use of the reservoir. Monitoring wildlife use of the re-vegetation area is also a component of the project.

1.1 Project Location



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

1.2 2015 Water Levels and Drawdown Zone Elevations

BC Hydro makes efforts to maintain a 3m elevation buffer zone around Carpenter Reservoir by having a target maximum elevation of 648.00masl. Hydro manages Carpenter reservoir for power generation, fish habitat, and to minimize spills from Terzaghi Dam into the Lower Bridge River (BC Hydro, 2011). BC Hydro states that reservoir incursions above 648.0 m are expected as a result of meeting other constraints with higher priorities such as safety. Over the past 16 years the average full pool level for Carpenter Reservoir has been approximately 646masl or 2 vertical meters below the lower limit of the riparian buffer zone (Figure 1). The water levels for Carpenter in 2014 and 2015, as well as the average annual levels for the past 16 years, are shown in Figure 1.

2014 experienced a relatively low full pool relative to the 16 years annual average resulting in no inundation of any of the re-vegetation works (Scholz, 2014). In contrast, in 2015 water levels rose quickly from a relatively high winter low of 630.89 m on 21 March 2015 (16 year average low on same date 627.01m) and rose into the buffer zone (>648masl) by 02 September 2015.

Water levels in 2015 were above the 90th percentile during freshet in May and June as well as when at full pool in September holding through to the end of December. Due to the high winter low pool and Carpenter spring inflows the 2015 water levels reached 644masl on 16 June 2015, a month sooner than the 16-year average of hitting 644m on 15 July 2015.

The 2015 field season was initiated at the end of April and continued through to 10th June 2015. Planting trials were carried out down to as low as 640masl. Carpenter reached 640m on 02 June 2015 thereby significantly shortening the establishment and growing period for planted plants and seeds at the lower elevations.

4. Methods

4.1 Re-Vegetation

During 2015 re-vegetation efforts on Carpenter Reservoir were carried out at six sites within the target re-vegetation zone; Steep Beach, Shallow Beach, Low Mud Flat, Gun Creek Fan East, Gun Creek Fan West and the Steep Alluvial Fan site. Re-vegetation techniques ranged from planting potted plants, to live stake cuttings and sowing seed mixtures. The three main techniques are further described here and the results of the revegetation works are presented on a site-by-site basis.

4.1.1 Potted Plants

Seed for plug stocks was primarily collected within 2 km of the treatment sites. Seed was propagated and grown locally at Splitrock Native Plant Nursery in Lillooet (Figure 1).

Lakeshore sedge seedlots were sown at two different times - late summer 2014 and again in February 2015 - in a heated greenhouse. Native grasses were sown in the fall and overwintered at the nursery.

Plants were transported to the site using a FIST truck to keep the plants cool up to the time of planting. Crew technicians transported the seedlings to the site in planting bags with silvacool inserts and planting was carried out using regular tree planting shovels (Figure 2).

Figure 1 Top: Carex lenticularis plugs staged for transport 27 May 2015

Figure 2 Planting lakeshore sedge at the Shallow Beach site 04 June 2015

4.1.2 Live Stake Cuttings

Black cottonwood (*Populus balsamifera*) and willow species (*Salix sp*.) were harvested from the local region. Most of the willow was harvested within 5 km of the planting site, and cottonwoods were from as far away as 60 km from site. Most of the cottonwoods used were harvested from a gravel pit on the Jones Creek alluvial fan (Figure 3).

Figure 3 Cottonwood trees growing in the Jones Creek Gravel Pit Carpenter Reservoir 20 April 2015

Cuttings were harvested, stripped of side branches and transported to the planting sites. Cuttings were soaked for at least 24-hours prior to planting (Figure 4). Cottonwood cuttings ranged in diameter from <5cm to several just over 10 cm diameter. Willows were more consistently sized around 4 cm in diameter. Cuttings were harvested long enough to allow for a minimum of 1 m to remain above ground and in some cases as much as 3m + above ground. The tall cuttings were intended to allow the cuttings to remain above water for a longer period of time.

Figure 4 Unloading cottonwood cuttings at the Gun Creek Fan and storing/soaking cuttings prior to plant 22 April 2015

Steel bars were used for making holes for planting the stakes on the steep and shallow beaches, the alluvial fan and at several upper elevation sites on both the Gun Creek Fan East and West sides (Figure 5). All efforts were made to plant the cuttings >1m in the ground. With the variable and often rocky substrate planting depths for the cuttings varied from 0.5 to 1.25m.

Cuttings were planted in patches targeting microsite conditions at the sites. All cuttings were watered in after planting via a gas pump and hoses.

Figure 5 Hand planting cuttings using steel bars on Gun Creek Fan East 28 April 2015

On the Gun Creek Fan East and West sides an excavator was employed to plant the cuttings. Planting was targeted around the outflow of Gun Creek where there was an increased potential of finding subsurface water.

An excavator was employed to dig trenches 1-2 m deep for planting into. Crews then entered the trenches and set the cuttings in the bottom of the trenches, distributed with approximately 1 m spacing (Figure 6). Trenches were partially back filled by hand to stabilize cuttings and then the machine backfilled the rest of the trench (Figure 7).

Figure 6 Planting cottonwood cuttings in machine-dug trench on the Gun Creek Fan 05 May 2015.

Figure 7 Machine back-filling trenches on Gun Creek Fan 28 April 2015

4.1.3 Seeding Trials

Seeding trials were carried out on the Low Mud Flats and between 644 and 648m on the Gun Creek Fan East side using a tractor pulled 'plotmaster' seeder (Figure 8). The seeder was equipped with a seed hopper, plough discs, a chain grid harrow and compactor.

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

1. fall rye alone
2. a mix of fall rye and lakeshore sedge
3. lakeshore sedge alone
4. mechanical scarification with no seeding
5. a control site with no treatment will also be monitored alongside the mechanical treatments

Plots were established within a 20m X 50m area consisting of 4 approximately 3 m wide seeded strips of fall rye alone, mix of fall rye & lakeshore sedge, lakeshore sedge alone and mechanical treatment only. A 1 meter plus gap was maintained between seed strips (Figure 9).

Higher up in the drawdown zone 644-646m seeding trials were carried out with:

1. fall rye
2. fall rye and a native grass mix (ticklegrass (*Agrostis scabra*) 26% , bluejoint reedgrass (*Calamagrostis canadensis*) 37% , northern wheatgrass (*Elymus lanceolatus*) 7.5%, slender wheatgrass (*Elymus trachycalus*) 7.5%, fowl bluegrass (*Poa palustris*) 22%[1].
3. Native grass mix
4. Mechanical treatment only

At 648m seeding trials were carried out with:

1. Upper Reservoir Seed mix (bluejoint reedgrass 63%, fowl bluegrass 37% seed)
2. Mechanical treatment only

[1] Values represent targeted percent by species within the mix.

Figure 8 Tractor and Plotmaster seeder out on the Lower Mud Flats 22 May 2015

Figure 9 Seeding trials on Lower Mud Flats 22 May 2015

4.4 Dust Storms

Reducing dust storm frequency is one of the a goals of the WORKS-1 project. To assess whether the re- vegetation efforts has an impact on dust storm frequency it is necessary to establish a baseline of how frequent dust storms are occurring within the revegetation area.

To establish a baseline for dust storm frequency a weather station equipped with a high-resolution camera, precipitation and wind monitoring gear were purchased ready for installation. An optimal location for setting up the dust storm/weather monitoring equipment was decided upon through field exploration and discussions on the 5-Mile Ridge site overlooking the reservoir to the east of Gun Creek (Figure 10).

The chosen site was also the site of a pre- existing weather station run by the Lillooet Fire Zone. Contact was made with the Fire Zone representative in charge of the site and a request made to explore the opportunity of sharing the existing facility by mounting the dust monitoring equipment on the Fire Zone antennae. This request was denied due to public safety concerns around additional weight and equipment on the antennae; however, we were encouraged to pursue setting up the monitoring station alongside the Fire Zone station. This process required a permit, to be held by BC Hydro, for occupation of crown land through the Ministry of Forests, Lands and Resource Operations. This process was initiated by BC Hydro. It was anticipated that the permit would be in place for installation of the station by spring 2016. In the meantime, handheld photographs were taken in an attempt to capture pictures of dust storms originating from the revegetation areas with the intention to determine where dust seems to be originating.

Figure 10 Site of existing Fire Zone Weather monitoring station. Proposed site of WORKS1 weather/camera monitoring station 19 March 2015.

4.5 Aesthetics and Recreational Use

A public survey was designed and solicited to locals in the Gold Bridge area through local channels (library, museum and other public places) and by crews attending community events to introduce the project and have participants fill out print versions during those events. The survey was also made available on line at https://splitrock.typeform.com/to/R5Sk5C.

Questions were crafted to gather feedback on personal experiences of dust storms, aesthetics, recreational use and wildlife seen along Carpenter Reservoir.

4.6 Wildlife Use

Wildilfe use of the area was monitored by recording wildlife sign as a component of the data collected at each of the 1m X 1 m plots. Incidental observations of wildlife and wildlife sign were also recorded during the gathering of data and while crews are working in the field during revegetation efforts.

A component of the public survey also provided information on wildlife observed by the public on the Carpenter Reservoir.

5. Results

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

5.1 Re-Vegetation

Results of the 2015 Works re-vegetation efforts are presented in six sections by each of the six treatment sites:

- Steep Beach (STB)
- Shallow Beach (SHB)
- Low Mud Flat (LMF)
- Gun Creek Fan East (GCFE)
- Gun Creek Fan West (GCFW) and
- Steep Alluvial Fan (SAF) on the south shore of Carpenter (Map 2).

An overall summary of the plant materials, number and area planted and seeded is contained in Table 2.

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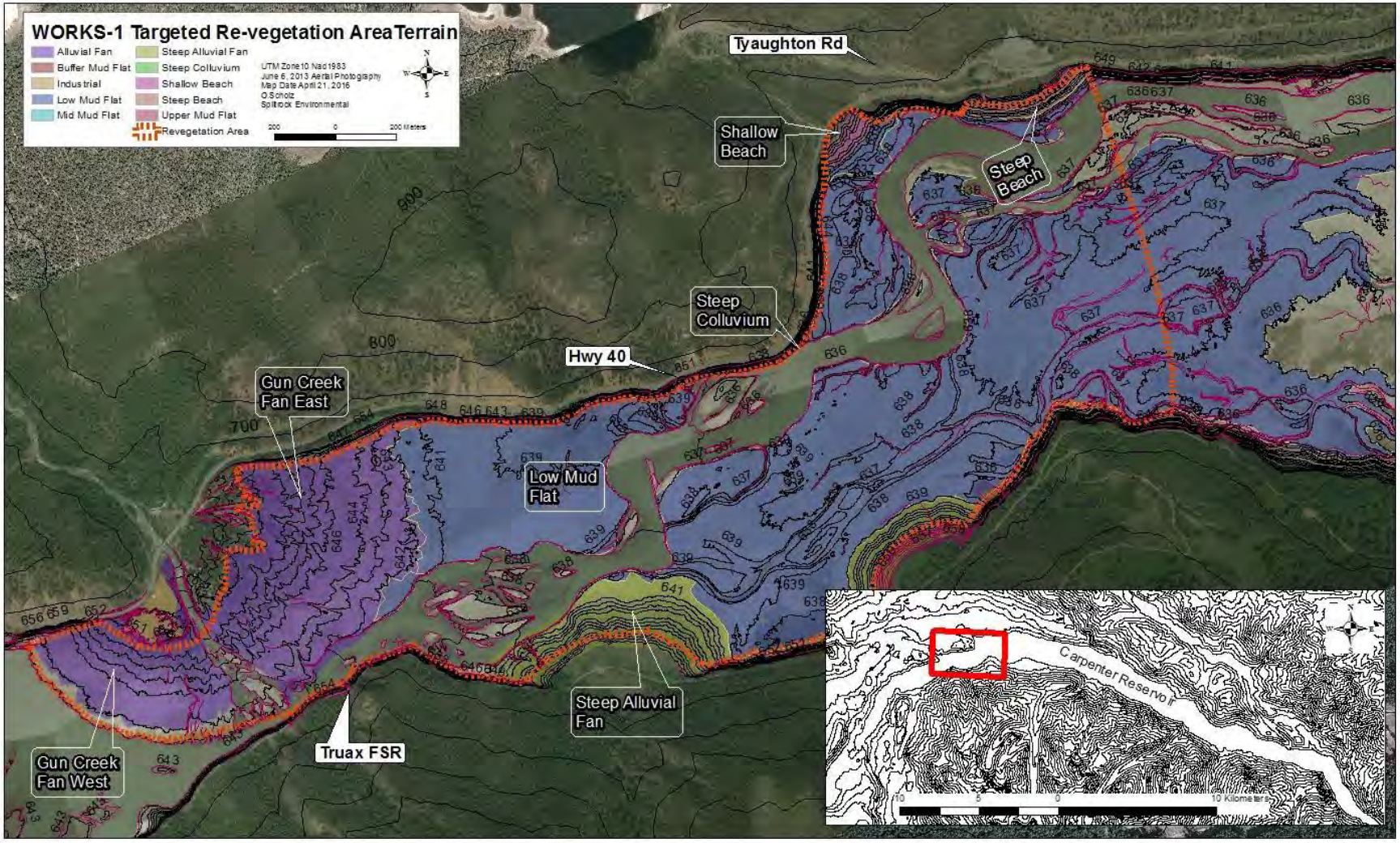


Map 2 WORKS-1 Re-vegetation area: 6 main planting areas indicated. Steep colluvium was not a treatment area.

Table 2 Summary table of Sites and re-vegetation 2015 Works at each site.

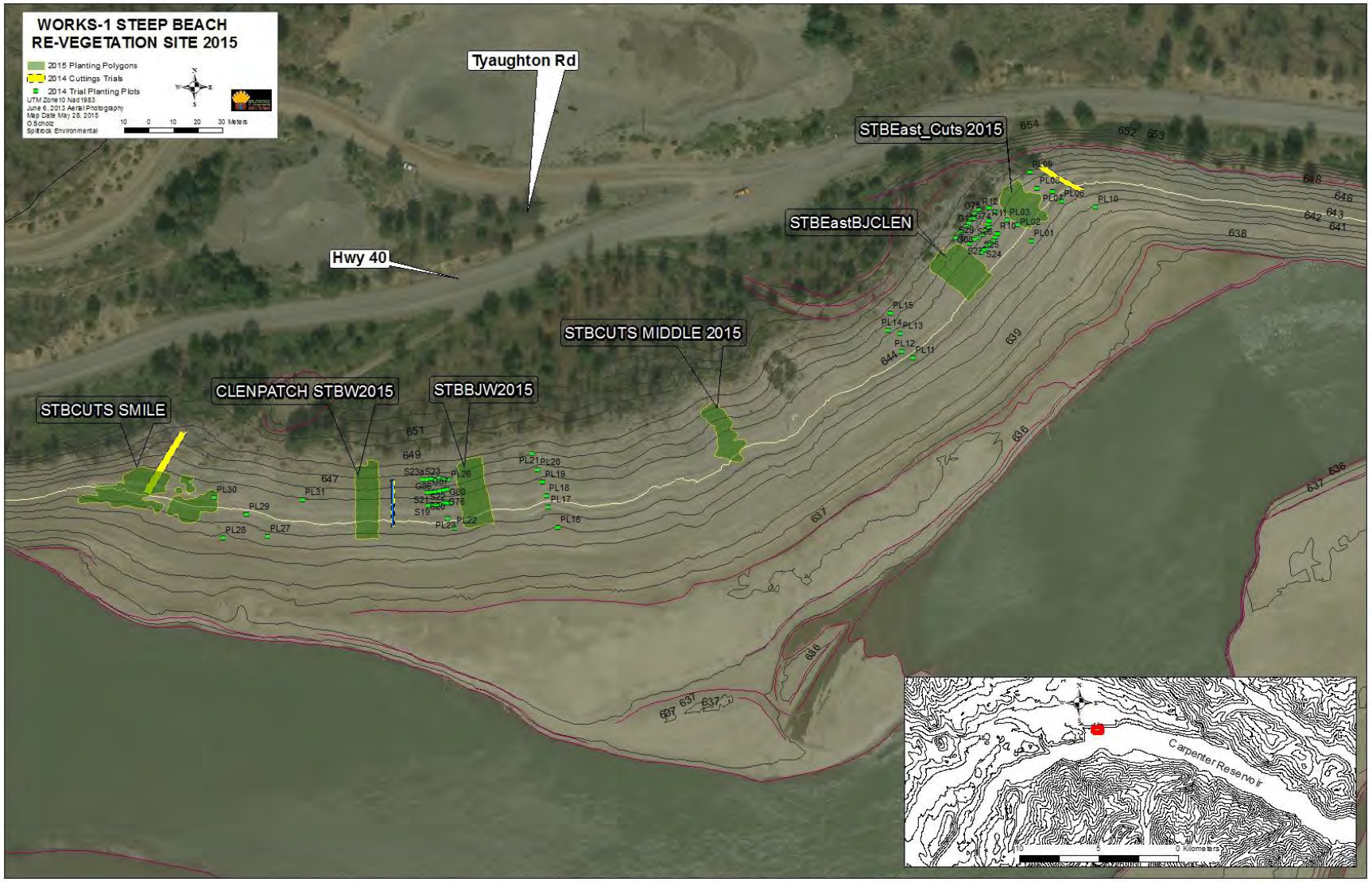
Carpenter Works 2015 Phase 2 Summary Table																		
CODE	TERRAIN TYPE	Total terrain area	Treatment Dates	Sedge Plugs	BJ Plugs	Foxtail Plugs	Fowl bluegrass	CWR	Area planted plugs m²	Total Number plugs	Number Cuttings Willow	Number Cuttings Cottonwood	Total Area planted cuttings m²	Area SP2:U10eeded Fall Rye m²	Area Seeded Fall Rye/Carex Lenticularis m²	Area Seeded Carex Lenticularis m²	Area Mechanical treatment only m²	Area seeded Upper Reservoir Grass Mix m²	Area seeded Upper Reservoir Grass Mix and Fall Rye m²
STB	Steep Beach	3.8	June 8 plugs/ April 29th	991	1219	0	0	0	928	2210	185	30	1,012	0	0	0	0	0	0
SHB	Shallow Beach	3.85	Cuttings April 29th, June 3rd-5th plugs	2864	1956	0	0	0	2190	4820	22	94	484	0	0	0	0	0	0
LMF	Low Mud Flat	192.7	June 4th-5th	1647	0	0	0	0	949	1647	0	0	0	1457	1457	1457	1457	0	0
GCFE	Gun Creek Alluvial Fan East	45	April 27-28 cuttings, Seeding May	2610	1253	0	0	0	2347	3863	482	266	870	143	0	0	0	469	219
GCFW	Gun Creek Alluvial Fan West		cuttings April 30 May 4, June 9-10 plugs	1263	3512	50	50	1050	3911	5925	308	243	2621	0	0	0	0	0	0
SAF	Steep Alluvial Fan	22.3	April 24-25	0	0	0	0	0	0	0	500	33	2500	0	0	0	0	0	0
SC	Steep Colluvium	19.5																	
	TOTAL	267.65		9375	7940	50	50	1050	10325	18465	1497	666	7,487	1,600	1,457	1,457	1,457	469	219

5.1.1 Steep Beach

Four polygons were planted with either lakeshore sedge or bluejoint reed grass plugs on the Steep Beach site. The east end polygon was split, with sedges planted at lower elevations (644m +) and bluejoint planted at upper elevations (646m+) (Map 3).

Three polygons were planted with cuttings of willow and cottonwood; one at the east end, one in the mid-section and one at the west end. The west end polygon was also the site of hand building of rocks and boulder piles to create smile shaped features with the potential of trapping sediment and improving microsite growing conditions (Figure 10; Map 3).

Figure 11 Steep Beach West end cuttings (STBcuts Smile) with rock smile features 08 June 2015



Map 3 Steep Beach site near the Tyaughton Road junction with Highway 40

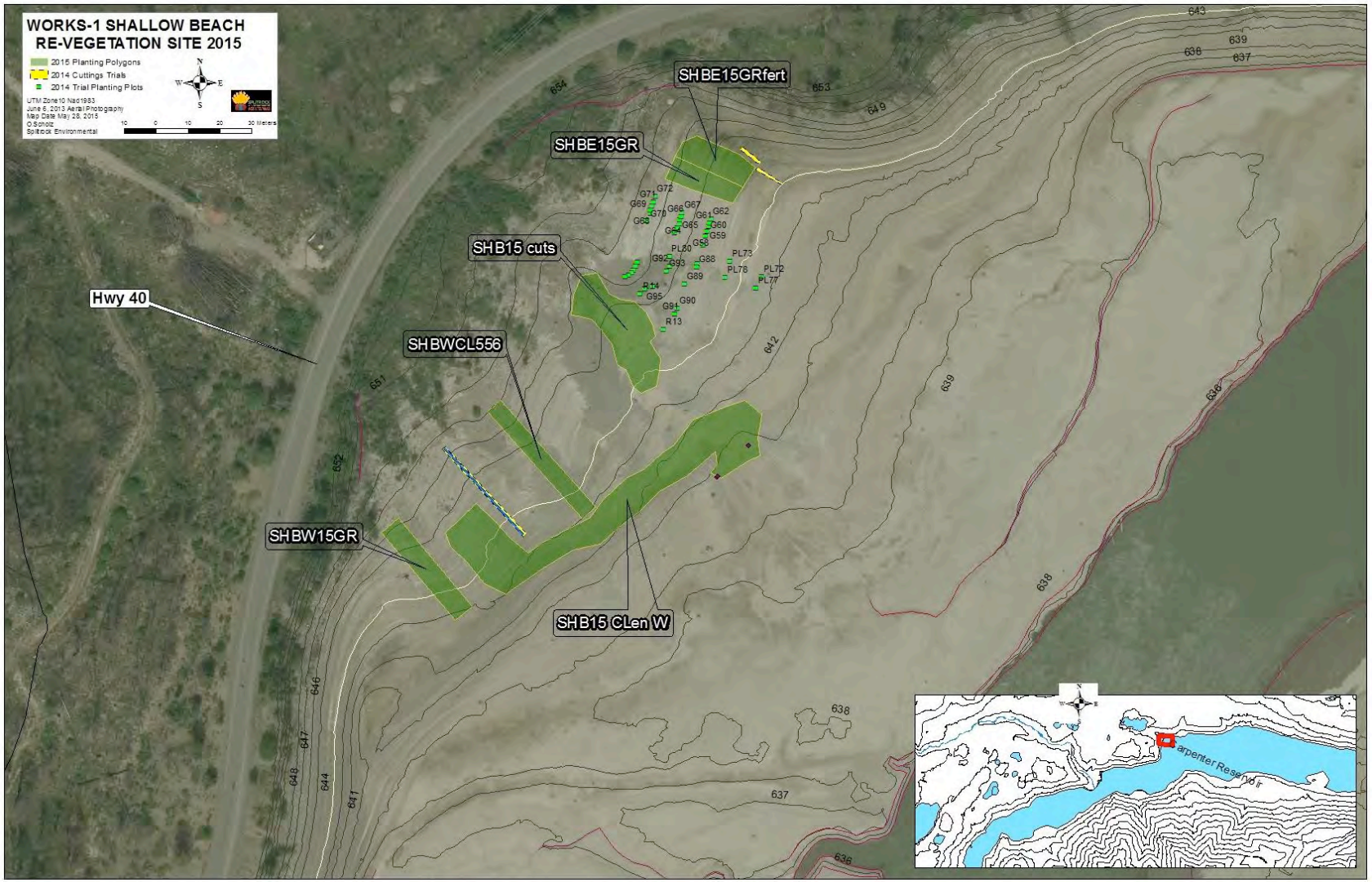
5.1.2 Shallow Beach

Cuttings, bluejoint reedgrass and lakeshore sedge plugs were planted out on the Shallow Beach site in 2015 (Figure 12). Fertilizer bags, Chilcotin 17-5-7 purchased from Reforestation Technologies International, were also trialed to research whether they improved the success of planted plugs.

Three polygons were planted in bluejoint reedgrass and two were planted with lakeshore sedge, for a total of 4,820 plants. Half of each of the west and the eastern most polygons on the beach were planted with fertilizer bags. Bluejoint plots spanned 644 m – 648 m on the steep beach and sedge plots spanned 642 m – 648 m (Map 4).

One polygon in the center of the beach was planted out with cuttings of willow and cottonwood (Map 4). 484 cuttings were planted into the polygon spanning 644 m - 648 m. The cuttings were planted into a relatively unique microsite on the beach where a shallow concave swale formed from historic fluvial processes. This depression site was selected for the increased likelihood of finding subsurface growing season moisture.

Figure 12 Cuttings polygon on Shallow Beach, low swale between two more coarse sites 04 June 2015



Map 4 Shallow Beach site 2014 and 2015 treatment areas

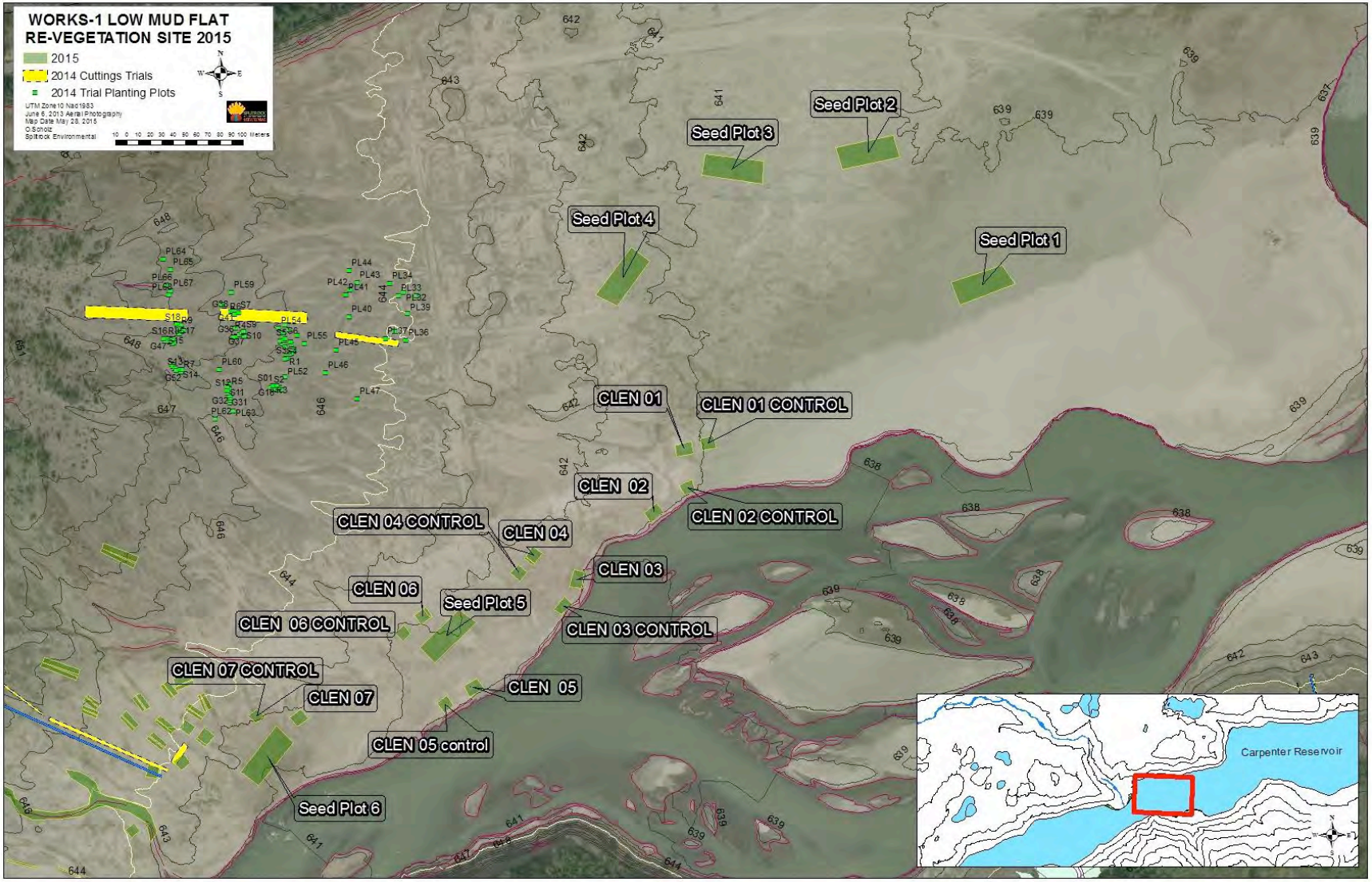
5.1.3 Low Mud Flat

Plots were laid out on the Low Mud Flats down to 640 masl. Each plot measured approximately 10 X 10 m in dimension and 1,647 lakeshore sedge plugs were planted to a target density of 40,000 plants per hectare (4 plants per square meter). Nine equal sized control plots were established adjacent to each planting plot to enable comparison of vegetation recruitment and cover through time (Figure 13).

Separate seed trial plots were established on the Lower Mud Flat, seed plots were treated using a tractor pulling a seeder (Figure 14). The seeder was used to create four seed plot trial strips within each plot consisting of fall rye, fall rye and lakeshore sedge mix, lakeshore sedge alone, mechanical treatment only and a control of no treatment. Seed plots were located between 640 and 644m elevation.

Figure 13 Left: C. Len polygon 02 planted with plugs on the Lower Mud Flat. 05 June 2015 Right: CL08 some of planted sedges are barely visible - arrows indicate plants 05 June 2015

Figure 14 Fall rye seedlings in Seed Plot 03 Gun Creek Fan East 05 June 2015.



Map 5 Revegetation 2015 polygons on Low Mud Flat accessed from Gun Creek Fan East side

5.1.4 Gun Creek Fan East

In 2015 on the Gun Creek Fan East cuttings were planted by hand and with machine assistance, grass seeding trials were carried out with a tractor-pulled seeding machine, 2,063 lakeshore sedge plugs and 1,210 bluejoint plugs were planted and eight rock wall features were constructed (Map 6, Figure 15).

Seeding trials with grasses were carried out between 644 m and 648 m elevation bands. Seeding trials included strait fall rye (FR), fall rye native grass seed mix (FR/NG), native grass mix (NG), and mechanical treatment only (Figure 16). Plugs of bluejoint reedgrass were planted alongside the seeding plots across the 644 m – 646 m elevation bands (Figure 16).

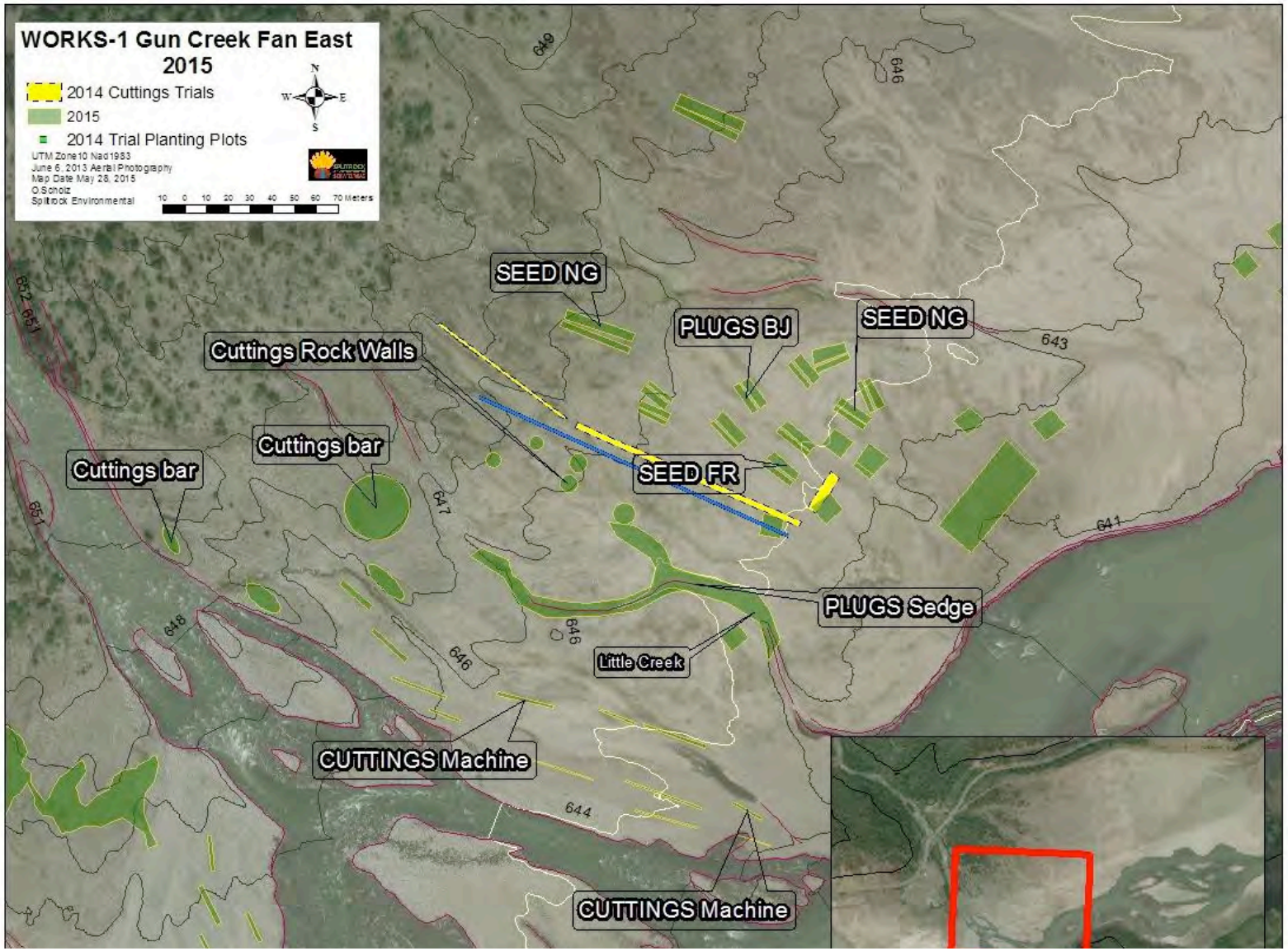
A microsite area labeled the 'Little Creek' was planted with lakeshore sedge. The Little Creek site was a flowing at the time of planting as it was connected to high runoff flows in Gun Creek. The Little Creek site was planted to take advantage of available early season moisture possibly giving advantage to sedge establishment. It was noted that in a few places sedges had naturally established along the Little Creek site (Figure 17).

Several sites close to Gun Creek were planted with cuttings of willows and cottonwoods using metal bars, rock piles and walls were constructed around some of the planting sites
12 trenches were dug by an excavator and cuttings planted in the bottom. 266 cottonwood and 482 willow cuttings were planted on the GCFE site, planted cuttings measured between 1.5-4 m in height.

Figure 15 Left: constructing rock wall features around hand-planted cottonwood cuttings 22 May 2015. Right: bluejoint plugs planted parallel to grass seed plots 05 June 2015

Figure 16 Seeded grass plots GR01 and 03 immediately after seeding 25 May 2015

Figure 17 Left: Planting lakeshore sedge plugs into the Little Creek polygon, along the lower banks of the creek feature. Right: Some C. Len naturals established along the Little Creek site 05 June 2015



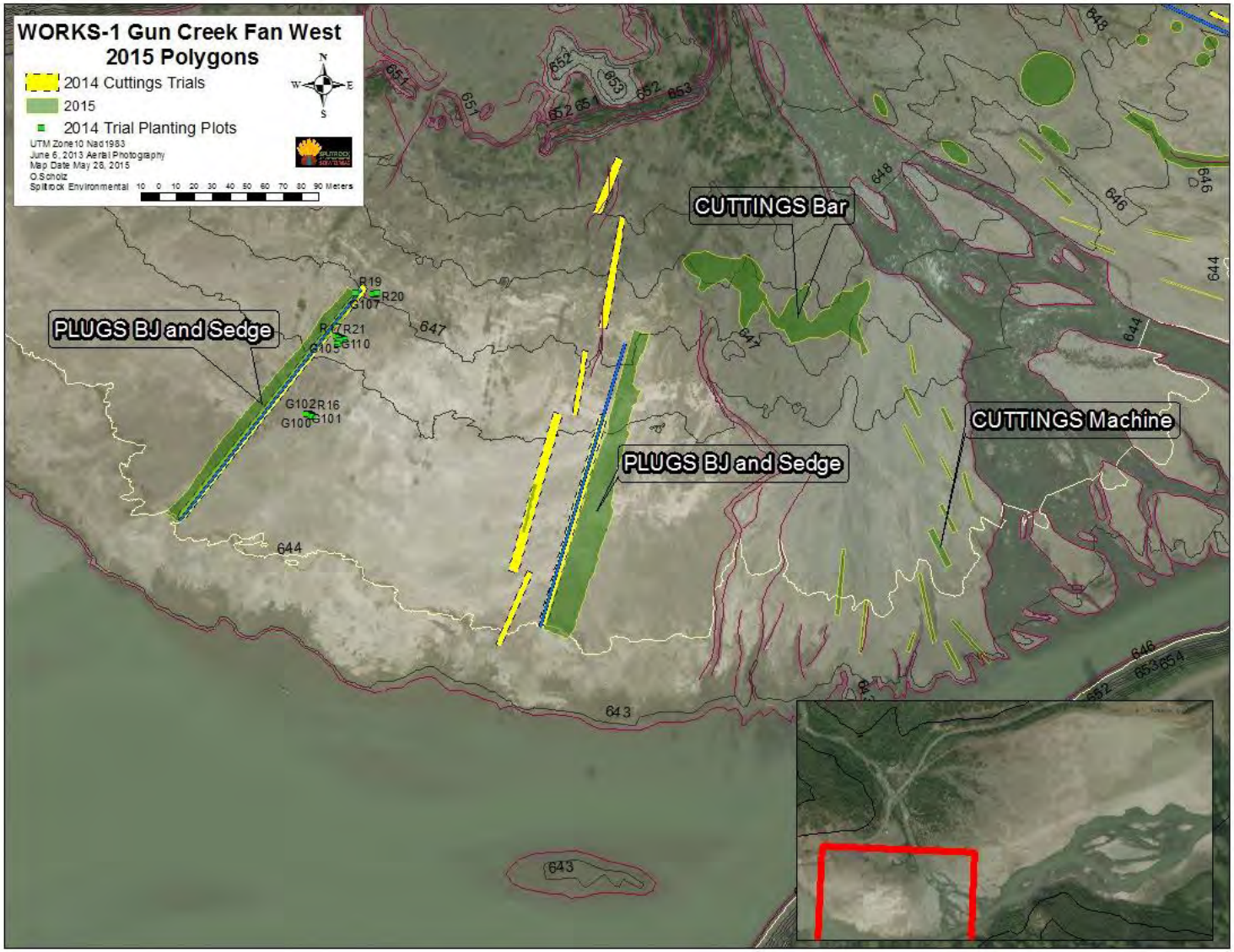
Map 6 Gun Creek Fan East re-vegetation polygons 2015

5.1.5 Gun Creek Fan West

Gun Creek Fan West side was treated in 2015 with two large polygon areas planted with bluejoint reedgrass and Carex lenticularis plugs for a total of 5,925 plugs planted (Map 7). Small plots of Canada wildrye (*Elymus canadensis*), foxtail barley (*Hordeum jubatum*) and fowl bluegrass (*Poa palustris*) were planted in a quarter-hectare sized south end polygon on the Gun Fan West side.

In addition, a total of 551 cuttings were planted on the west side of the Gun Creek Fan (Map 7). One large polygon spanning 647 m – 648 m elevation bands was hand planted using steel planting bars. In addition fourteen trenches were dug by an excavator and planted with large cottonwood and willow cuttings (Figure 18). Machine trenches were situated within 100 m of Gun Creek in order to increase the possibility that sub-surface water would be available to the cuttings for an extended period. At the time of installation only the lowest elevation polygons had any indication of water in the bottom of the 1.5 m deep trenches. As on the Gun Fan East side trenches were staggered up the height of the fan with the intention of growing a windbreak of woody vegetation up the fan with the aim of possibly providing an erosion deterrent once the vegetation becomes established.

Figure 18 Planting cuttings in machine-due trenches on Gun Creek Fan West 30 April 201



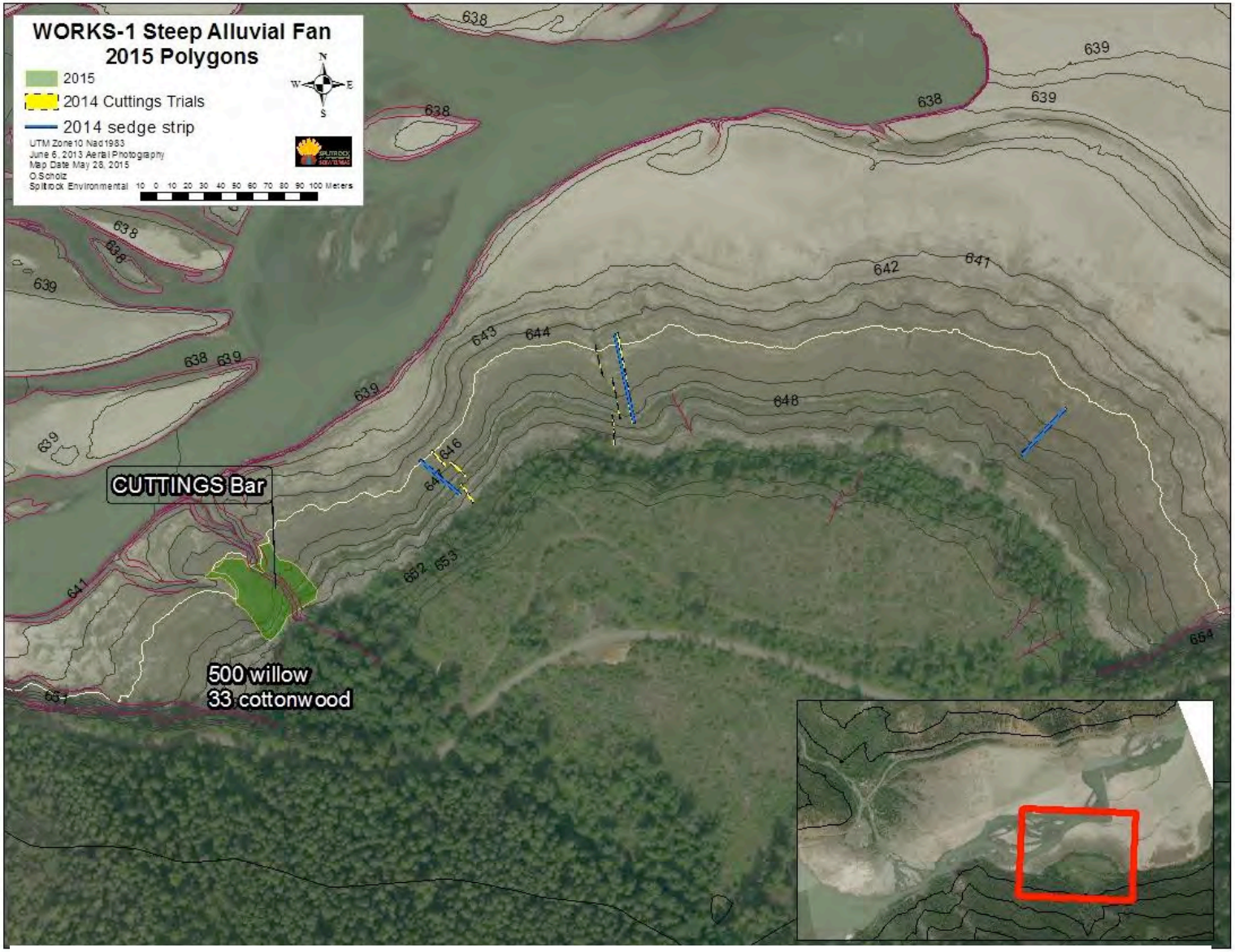
Map 7 Gun Creek Fan West side polygons 2015

5.1.6 Steep Alluvial Fan

In 2015, 500 willow and 33 cottonwood cuttings were planted on the Steep Alluvial Fan, on the south side of Carpenter Reservoir (Map 8; Figure 19). The cuttings were all planted by hand and the site of the cuttings was concentrated around the creek that flows through the fan on its West side (Figure 20).

Figure 19 Planting cuttings at SAF 29 April 2015

Figure 20 Summer view of cuttings planted along the creek 18 June 2015



Map 8 Steep Alluvial Fan cuttings polygon around creek 2015

5.2 Dust Storms

Dust storms were observed during WORKS 2015 fieldwork (Figure 21). Incidental observations and photographs were taken of dust storms.

It was noted that most of the dust arises from the banks of the Bridge River where the substrate is a very fine sand (Figure 22). This sand is mobilized to varying degrees depending on the wind speed and re-deposited across the relatively firmly packed surface of the low mud flats. The aeolian deposited sand is later mobilized by strong winds.

It was noted that the majority of the wind patterns were from west to east, indicating dust is normally blown east away from Gold Bridge.

Figure 21 View from the proposed weather and camera monitoring station 16 April 2016

Figure 22 Dust storm captured on film from Gun Creek Fan East side. Image looking North toward 5 Mile Ridge and the future site of weather station indicated by arrow 21 April 2015

5.3 Aesthetics and Recreational Use

Thirty-two respondents filled out the survey created to solicit feedback on dust storm observations, aesthetic perceptions, recreational use and wildlife sightings. Results have been compiled into an excel spreadsheet for comparison over time of public perceptions.

Sixty-one per cent of respondents stated they used Carpenter Reservoir for recreation activities. People indicated in the survey that they use the reservoir in all months of the year. The majority of recreational use occurs during the summer months from April through September (>50 % respondents claimed to use Carpenter Reservoir during these months). Eighty-five per cent of respondents used the reservoir <20 days out of the year, while 10 per cent used it between 21-50 days a year.

Recreational use includes, fishing, kite flying, walking, dirt biking, snowmobiling, 4X4 driving, camping, canoeing, kayak, quad driving, gold panning, photography, cooling off in river, picnicking, beach bathing, mud bogging, bon fires, mountain biking, swimming, bird watching, wildlife viewing, exploring.

One question on how do you rate the aesthetic quality of Carpenter Reservoir currently (on a 1-4 scale, 1 being least favorable and 4 being most favorable) 61% of respondents rated the reservoir either 1 or 2. 16% rated it a 4.

5.4 Wildlife Use

Wildlife sign and observation data were collected as part of BRGMON-2 monitoring of 1m X 1m plots. A summary of the wildlife observations from these surveys appears in Table 3

Table 3 Summary of observations from 1m X 1m plots surveyed in 2014 and 2015.

Year	No Plots	Mule Deer	Canada Goose	Cow	Horse	Small Mammal
2014	238	7	8	1	2	0
2015	235	33	1	1	0	1

Incidental observation of wildlife recorded by WORKS-1 field crews included mountain blue bird (*Sialia currucoides*) hawking insects on the Gun Creek Fan using the installed cutting as perches (Figure 23), yellow rumped warbler (*Dendroica coronata*) foraging among the annual plant cover on Gun Creek Fan east (Figure 24), western toad (*Anaxyrus boreas*) (Figure 25 – 26), long-toed salamander (*Ambystoma macrodactylum*) (Figure 27), river otter (*Lutra canadensis*) (Figure 28).

Observations of amphibians using the Gun Creek Fan are usually seen with a short distance of the water's edge (1 m to 10 m). The most frequent observation during the BRGMON-2 surveys of 1X1m plots was of mule deer tracks.

Wildlife observations were also the subject of a section of the public survey as noted above. In particular, respondent were asked to comment on what species they have observed using Carpenter Reservoir and where (Figure 29). Mule deer and black bear were the most commonly observed species on Carpenter Reservoir. 40% of respondents indicated they saw wildlife around the west end of Carpenter Reservoir somewhere between Marshall Lake turn off and Goldbridge.

Figure 23 Mountain blue bird atop a WORKS 1 2014 live stake cutting staked on the Gun Creek Fan West side, 21 April 2015.

Figure 24 Yellow-rumped warblers foraging on mud flats Gun Creek Fan East 24 April 2015

Figure 25 Immature western toad observed on the Gun Creek Fan East 27 April 2015

Figure 26 Mature Western toad observed in reservoir drawdown zone in tributary creek on Steep Alluvial Fan site 29 April 2015

Figure 27 Long-toed salamander spotted on Gun Creek Fan East near Gun Creek – in bottom of cuttings excavation trench 28 April 2015

Figure 28 River otter tracks from Shallow Beach site 23 April 2015

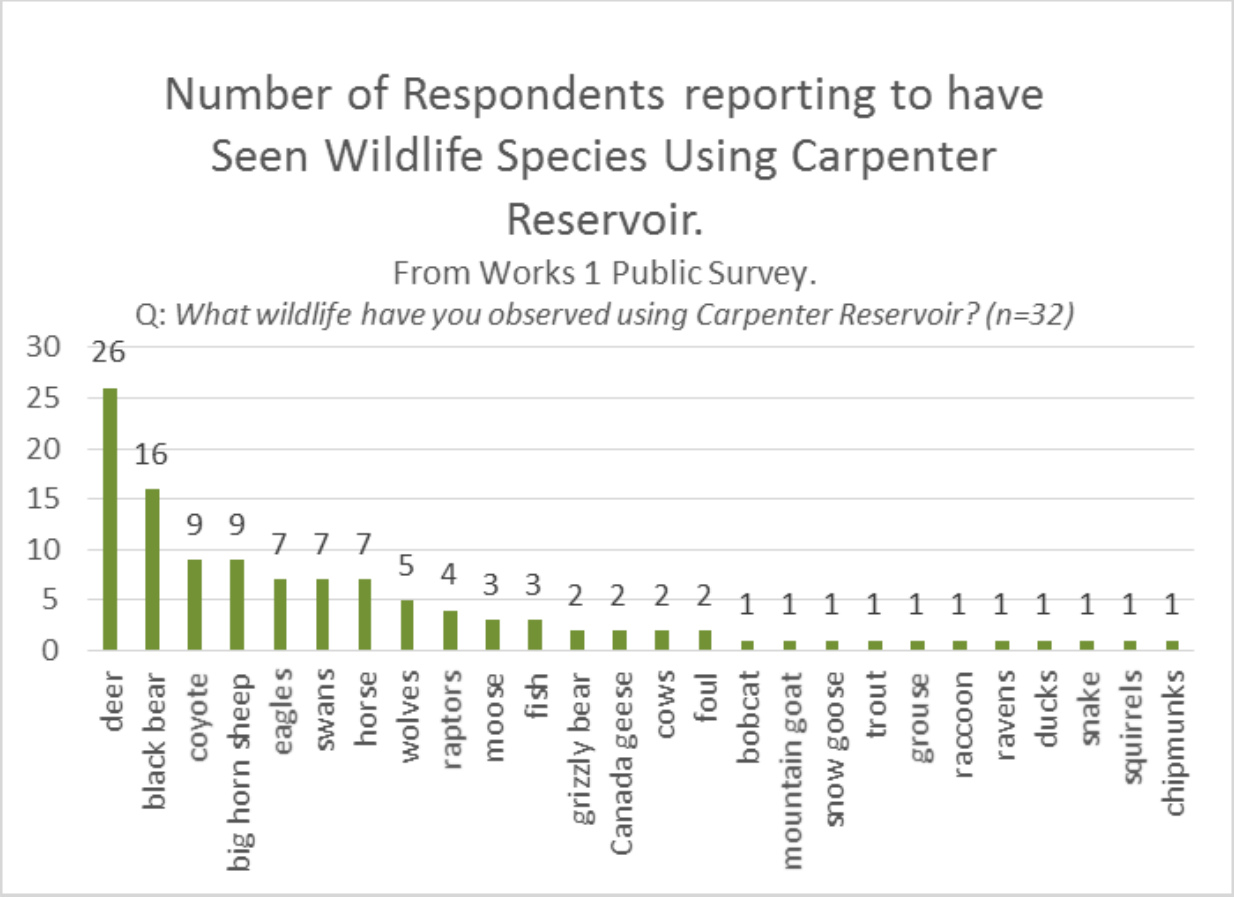


Figure 29 Measure of wildlife reported using Carpenter Reservoir by survey respondents

8. Summary

2015 WORKS-1 re-vegetation trials were expanded from small 1X1m plots and narrow strips to broader area plantings than what was completed in 2014. Plantings were also expanded deeper down into the drawdown zone going as low as 640 masl and as high as 650 masl. Expanded trials were carried out at each of the main test sites referred to as the Steep Beach, Shallow Beach, Low Mud Flat, Gun Creek Fan East and West and the Steep Alluvial Fan.

Over 9,000 lakeshore sedge plugs were planted out in test plots at lower elevations particularly on the Low Mud Flats. Lakeshore sedge was planted in polygons up to 648 m on the Steep Beach and Shallow Beach sites in broader polygons.

Bluejoint reedgrass plugs were second in the amount of plug species planted, nearing 7,940 distributed throughout five terrain sites. Fertilizer bags were experimented with for the first time in 2015. Fertilizer bags were used in trials with both lakeshore sedge and bluejoint reedgrass in polygons on the Shallow Beach site.

Based on survival of cuttings planted in 2014, cuttings trials were expanded on each of the six treatment sites. Hand plantings were targeted at specific microsites, focusing on water receiving sites and sites deemed to have a higher likelihood of sub-surface moisture. On the Gun Creek Fan cuttings were targeted for close proximity to Gun Creek. The cuttings on the fan were also planted in trenches oriented parallel to the flow of Gun Creek across the breadth of the fan with the intention of providing a windbreak once the vegetation became established. If shrubs are successfully established it is speculated that a wind break could reduce dust storm generation. BRGMON-2 program will monitor the outcome of the re-vegetation works, and future works will adapted based on findings and recommendations.

Dust storm frequency will commence in 2016. Dust storm origins will continue to be observed first hand and re-vegetation and mitigation techniques will be developed to attempt to reduce the issue.

Incidental wildlife observations will continue as part of the WORKS 1 project and the BRGMON-2 monitoring.

References

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

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