INDIAN CREEK RIPARIAN RESTORATION PHASE 3

FWCP PROJECT COL-F19-W-2696

Prepared for:

Fish and Wildlife Compensation Program

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EXECUTIVE SUMMARY

The Indian Creek Riparian Restoration project is a multi-phase effort to restore a naturally functioning riparian ecosystem and enhance cultural values along the lower 2 km of Indian Creek. This project aligns with Objective 1 - Sub-Objective 2: "Restore degraded […] riparian habitat", and Objective 3: "Maintain or improve opportunities for sustainable use", of the FWCP Columbia Riparian and Wetlands Action Plan (2014).

Indian Creek has significant cultural value to the Lower Kootenay Band for its historic fisheries and associated wetland habitats. The area has been heavily impacted by agriculture, grazing and flood control structures that have resulted in significant modifications to the natural riparian and wetland ecosystems. Restoration of these degraded riparian and wetland habitats will enhance ecosystem function and create important habitat for a variety of fish and wildlife species and cultural plants within Yaqan Nukiy traditional lands

The target restoration area comprises approximately 7.5 ha of the riparian zone along the lower 2 km of Indian Creek within the Kootenay River floodplain. Habitat Islands 4 and 5, which occur within the wet reed canary grass vegetation unit were the location of the 2018 Phase 3 restoration activities. This unit floods in spring, and the fine textured soils generally remain moist through the summer.

In October 2018, Phase 3 of the project was implemented which included planting 865 trees and shrubs within Habitat Islands 4 and 5 throughout an area of 1800 m^2 along Indian Creek. Two solarization treatment plots were installed to treat reed canary grass and improve the competitive advantage of the plantings. Browse deterrent spray was applied to all plants to prevent ungulate damage.

Permanent monitoring plots in Habitat Islands 1-3 were revisited and monitored to ensure that restoration is successful and to provide information for ongoing adaptive management of the site. Repeat estimates of height, area, vigour, and browse was collected for each plant in each plot. Three additional plots were added to increase the number of observations.

Though browse pressure remained generally low within Habitat Islands 1-3, overall survival of plantings has declined to 55%. Several factors may be influencing this result including prolonged inundation during spring high water in 2018, drought during 2017 and 2018, and increased competition from grasses. Ongoing efforts to enhance the competitive advantage of plantings in Habitat Islands 1-5 will likely be required.

The project is successful with continued participation by LKB community members. Several individuals who have worked on the project over multiple years have gained experience in riparian planting and

maintenance techniques. Their personal sense of ownership has spread throughout LKB and inspired others to want to become involved with future projects.

A total of 1.14 ha has been planted with native species during all phases of the project to date with funding from the Fish and Wildlife Compensation Program and Columbia Basin Trust.

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1 INTRODUCTION

The Indian Creek Riparian Restoration project is a multi-phase effort to restore a naturally functioning riparian ecosystem and enhance cultural values along the lower 2 km of Indian Creek (Goat River South channel; Figure 1). Indian Creek has significant cultural value to the Yaqan Nukiy (Lower Kootenay Band; LKB) for its historic fisheries and associated wetland habitats. The area has been heavily impacted by agriculture, grazing and flood control structures that have resulted in significant modifications to the natural riparian and wetland ecosystems. Invasive weeds, bank instability, exposed soils, overgrazing and reed canary grass (*Phalaris arundinacea*) monocultures are some of the management concerns in this area. Restoration of these degraded riparian and wetland habitats will enhance ecosystem function and create important habitat for a variety of fish and wildlife species and cultural plants within Yaqan Nukiy traditional lands. The project and its related benefits are part of the Yaqan Nukiy Strategic Plan.

Restoration efforts began in 2013 and have included development of a restoration plan (MEC 2014, and MEC 2016), installation of cattle exclusion fencing, rare plant survey, planting sedges at old cattle access points, planting Habitat Islands 1-3 and the placement of coarse woody debris (CWD). This report summarizes 2018 Phase 3 restoration activities, including planting Habitat Islands 4 and 5 and provides year 3 effectiveness monitoring results.

2 GOALS AND OBJECTIVES

This project is part of a larger project with a phased approach and overall goal to restore a naturally functioning riparian ecosystem and enhance cultural values along Indian Creek. The specific goals and objectives for Phase 3 are as follows.

2.1 Planting habitat islands 4 and 5

Goal: To enhance fish and wildlife habitat by increasing cover and improving structure with native vegetation and create a habitat mosaic including woody vegetation and open wet areas.

Objective: To prepare the site and plant approximately 2000 live stakes of willow, red-osier dogwood and black cottonwood over a 0.4 ha area.

2.2 Maintenance of Phase 3 treatments

Goal: To maintain the new plantings in Habitat Islands 4 and 5 during the first growing season to aid in plant survival.

Objective: To conduct 6 days of maintenance throughout the growing season including brushing and weeding competing vegetation around planted vegetation, and application of browse deterrent.

2.3 Monitoring Phase 1 and Phase 3 treatments

Goal: Monitoring Phase 1 and Phase 3 treatments after the third growing season with the results intended to direct future phases of the project through an adaptive management approach.

Objective: To revisit and measure permanent monitoring plots in Habitat Islands 1-3 and install and measure baseline information in Habitat Islands 4-5.

2.4 Linkage of FWCP Action Plans

Table 1 demonstrates alignment between Indian Creek Riparian Restoration Project objectives and the objectives outlined in the FWCP Columbia Riparian and Wetlands Action Plan (2014).

Table 1. Project applicability to FWCP program objectives and action plans.

Program Objective	Applicability
Objective 1 - Sub-Objective 2: "Restore degraded […] riparian habitat".	Project aims to restore riparian and wetland habitat.
Objective 3: "Maintain or improve opportunities for sustainable use"	Project located in an area with significant cultural values. Increasing abundance of culturally important plants and improving hunting and fishing opportunities are objectives of the project.

3 STUDY AREA

The project area is located at the confluence of Indian Creek (Goat River South Channel) and the Goat River within the floodplain of the Kootenay River near Creston, B.C. It lies within the Yaqan Nukiy wetland complex which provides core wildlife habitat and connectivity through the region. The target restoration area comprises approximately 7.5 ha of the riparian zone along the lower 2 km of Indian Creek, from the confluence with the Goat River North Channel up to the forested area (Figure 1).

Habitat Islands 4 and 5 are the location of 2018 restoration activities (MEC 2016, Figure 1). These restoration areas occur within the wet reed canary grass vegetation unit (MEC 2016). This unit floods in spring, and the fine textured soils remain moist over summer, gradually becoming drier further upstream from the mouth. This flood regime will likely maintain the dense stands of reed canary grass that dominate this unit. Other non-native pasture grasses such as quackgrass (*Elymus repens*), orchard grass (*Dactylis glomerata*), common Timothy (*Phleum pratense*) and redtop (*Agrostis stolonifera*) are also present, and sedges are scattered in pockets throughout. Invasive weeds including curly dock (*Rumex crispus*), absinthe wormwood (*Artemisia absinthium*), Canada thistle (*Cirsium arvense*) and sulphur cinquefoil (*Potentilla recta*) are problematic in this unit, especially along compacted cattle trails.

Historically, this unit was tilled and harvested for hay which has contributed to the lack of diversity. Vegetation in this area had been heavily grazed by cattle prior to fencing, and over-steepened banks and exposed soils are present along the stream margin due to channelization and cattle access.

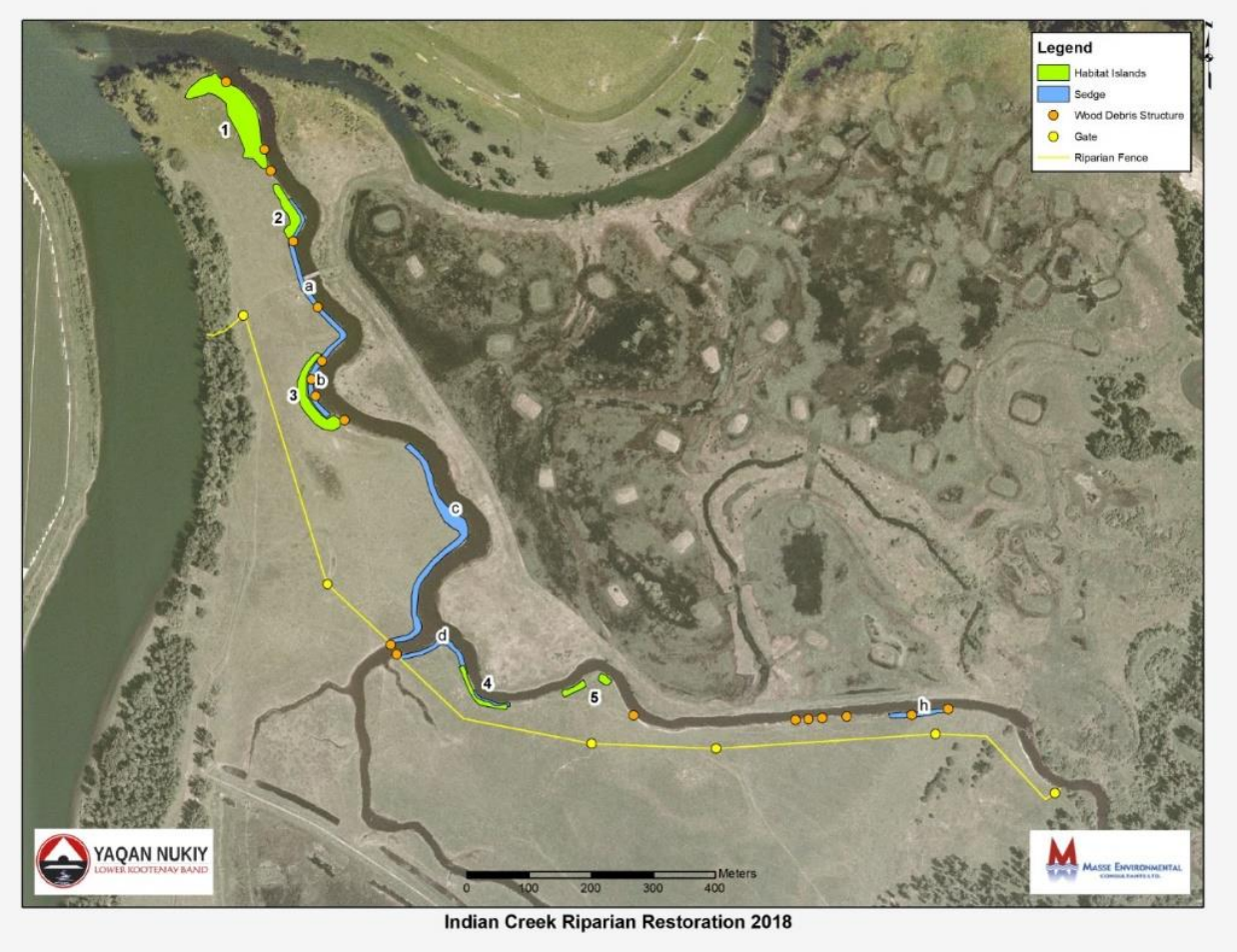


Figure 1. Site Map.

3.1 Restoration Activities Completed to Date

Restoration activities that have been completed to date are summarized below and indicated in Figure 1.

2014	Phase 1 installation of cattle exclusion fencing.
2015-2016	Phase 1 planting Habitat Islands 1-3 with native trees and shrubs over a 6000 m^2 area, planting old cattle access points (a-h) with sedges over a 3535 m^2 area and installation of various weed suppression and browse protection techniques.
2016-2017	Phase 2 installation of 17 coarse woody debris structures, maintenance and monitoring of Phase 1 treatments.
2018	Phase 3 planting Habitat Islands 4-5 and is the subject of this report.

4 METHODS

4.1 Restoration Activities

Planting of Habitat Islands 4 and 5 was completed over 7 field days between October 15 – 28, using hand tools. Plants were installed by LKB staff with assistance, training and supervision from MEC. To prepare the ground for planting, both areas were mowed and disced using a tractor. This treatment loosened the soil to a depth of 15 cm and broke the tough upper root systems of the grasses. It was not intended to kill the grasses; however, it loosened the soil surface creating more suitable conditions for planting and installing solarization plots and brush mats. The latter two methods were utilized to reduce grass competition in planting areas (Johnson 2005 and Geum 2009; Table 5).

4.2 Maintenance

Maintenance activities were conducted from July to October. The main activities in 2018 were maintenance of browse protection cages, cones, and vole protectors; and application of browse protection spray. Browse protection cages and cones were repaired when necessary and removed from plants when they were no longer necessary. Removed cages, cones and vole protectors were moved onto new plants which were planted in October 2018. Application of Bobbexx browse deterrent was used on planted tree and shrub stock to discourage browse from ungulates and rodents.

4.3 Monitoring

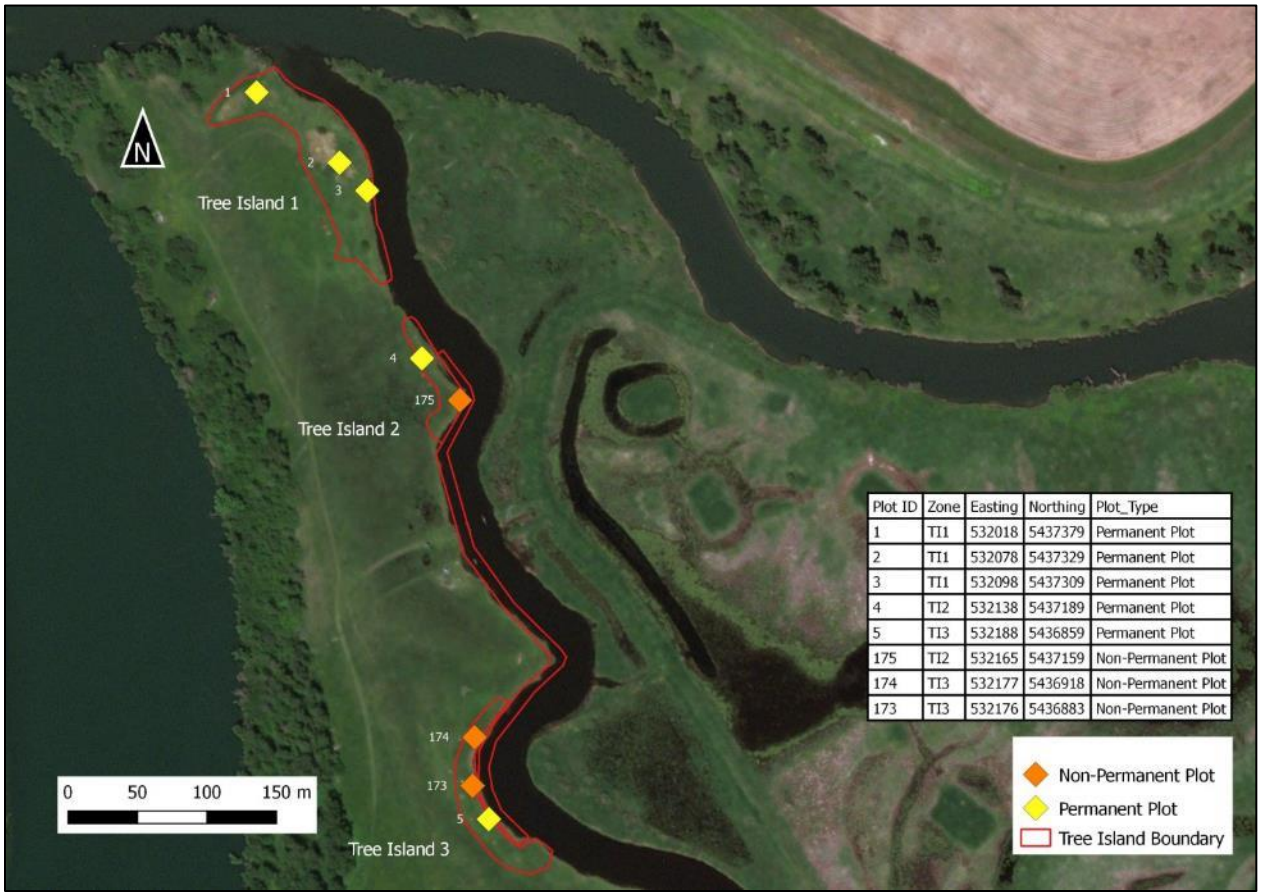
In June 2016, five permanent 50 m^2 monitoring plots were randomly established throughout Habitat Islands 1-3 to monitor vegetation establishment (Figure 2). Baseline data was collected in June 2016, and repeat surveys were conducted in September 2016, and September 2017. The location for all plants surveyed within each plot was recorded and mapped and the following information was collected and recorded:

- Species, height, and type of plant installed (plug, potted stock, TRS, live cutting).
- Plant browse and vigour based on coding and utilization ratings from the Field Manual for Describing Terrestrial Ecosystems Land Management Handbook No. 25 (B.C. MoF, & B.C. MoE 2010).
- Type of browse control and weed suppression technique implemented.
- Percent cover (in percent of total area) including trees, shrubs, herbaceous (total herbaceous including weeds), herbaceous (non-weeds), herbaceous (weeds), and exposed soils for each plot (B.C. MoF, & B.C. MoE 2010; Table 2).

In addition to plants located within sample sites, numerous randomly selected plants were sampled throughout the site to facilitate an assessment of height, vigour and browse for all species planted.

The permanent monitoring plots were revisited and monitored by Iraleigh Anderson A.Ag. and Norm Allard on August 3, 2018. Repeat estimates of height, area, vigour, and browse were collected for each

plant in each plot. Three additional non-permanent plots were added to increase the number of observations (Figure 2).



Plot ID	Zone	Easting	Northing	Plot_Type
1	TI1	532018	5437379	Permanent Plot
2	TI1	532078	5437329	Permanent Plot
3	TI1	532098	5437309	Permanent Plot
4	TI2	532138	5437189	Permanent Plot
5	TI3	532188	5436859	Permanent Plot
175	TI2	532165	5437159	Non-Permanent Plot
174	TI3	532177	5436918	Non-Permanent Plot
173	TI3	532176	5436883	Non-Permanent Plot

Figure 2. Vegetation monitoring plot locations within restoration area.

Table 2. Utilization Ratings (UT) - Coding for utilization (present use) of browse and forage species and plant vigour.

Browse Utilization			**Plant Vigour**	
Code	**Utilization (%)**	**Description**	**Code**	**Description**
0	0	Nil	0	Species dead
1	1-15	Slight	1	Vigour poor
2	16-36	Light	2	Vigour fair
3	36-65	Moderate	3	Vigour good
4	66-80	Heavy	4	Vigour excellent
5	> 80	Extreme		

(B.C. Ministry of Forests and Range, & B.C. Ministry of Environment 2010)

4.3.1 Photo point monitoring

A series of 10 permanent photo monitoring points were established throughout Habitat Islands 1-3 on June 20, 2016 (Appendix 2). Baseline images were recorded at these points, along with precise geographic location and camera position data to facilitate ongoing monitoring of riparian vegetation

growth, and other site objectives. Each photo point image was re-recorded on August 3, 2018. Additional photo monitoring points were established at Habitat Islands 4 and 5 during planting in October 2018 (Appendix 2).

5 RESULTS AND OUTCOMES

A summary of work completed during the project is outlined in Table 3.

Table 3. Summary of work completed.

Date	Tasks
July 11	Initial site inspection. Repair of browse protection structures in Habitat Islands 1-3.
August 3	Effectiveness monitoring
September 29-31	Removal of browse protection cones and browse cage repairs in Habitat Islands 1-3.
October 12	Mowed planting area in Habitat Islands 4 and 5
October 15 & 16	Field planning and planting layout in Habitat Islands 4 and 5. Discing and soil preparation.
October 22, 23, & 26-28	Planted Habitat Islands 4 and 5 and installed solarization plots and brush mats. Installed vole protection on plants in Habitat Island 4. Applied browse protection spray to all plantings in Habitat Islands 4 and 5. Browse protection spray in Habitat Islands 1-5. Installed vole protection on all plants in Habitat Island 5. Install beaver protection on TRS plants in Habitat Island 4.

5.1 Restoration Activities

In October 2018, 865 trees and shrubs were planted throughout an area of 1800 m^2 along Indian Creek (Table 4). The layout for Habitat Island 4 was a linear strip of approximately 100 m long by 4-8 m wide, which covered an estimated 600 m^2 along the bank of Indian Creek (Figure 1). Habitat Island 5 comprised two rectangular patches along the top of bank; 400 m^2 and 800 m^2 (Figure 1).

The species composition included black cottonwood (*Populus trichocarpa*), red osier dogwood (*Cornus stolonifera*), sandbar willow (*Salix exigua*), and Bebb's willow (*Salix bebbiana*). Bobbex browse deterrent spray was applied to each plant to prevent ungulate browse. Plastic spiral vole protectors were installed on each plant in Habitat Island 4 to prevent wintertime girdling by small mammals (Table 3). At the time of planting, all plants had good vigour and no signs of browse.

Two solarization treatment plots were installed to treat reed canary grass in Habitat Island 4 and improve the competitive advantage of the plantings (Table 5). The solarization plots consisted of two patches of landscape fabric installed along the top of bank. The north patch covered an area of approximately 150 m^2 and the east patch covered and area of approximately 130 m^2. The fabric was secured in place with 15 cm steel landscape staples, and the edges were keyed in to the soil at depths of ≥20 cm. Additional staples were used to secure the edges of the fabric to the bottom of the trench. Holes of 15 cm in diameter were hand cut in the fabric at 1 m spacing in preparation for planting. In addition to reducing

competition with surrounding agronomic grasses by suppressing light availability, the landscape fabric should also deplete the seedbank within the treatment area by increasing soil temperature (Johnson 2005 and Geum 2009).

The remaining plants were planted at 1.5 m spacing and protected from competition with brush blankets. The brush blankets were also secured with 15 cm steel landscape staples. A summary of 2018 restoration activities is outlined in Table 3.

Table 4. Summary of planted trees and shrubs.

				Stock Size			
Location	**Area (m^2)**	**Species**	**Plants #**	**1 Gal**	**TRS**	**Plug**	**Comments**
Island 4	600						~1 m spacing throughout 2
		willow spp.	212	212			solarization plots with a total area of
		cottonwood	125	110	15		~280 m^2. All other plants at ~1.5 m
		dogwood	100	85	15		spacing with brush blankets*.
subtotal			437				
Island 5i	400						~1.5 m spacing throughout 10x40 m
		willow spp.	12	12			patch along top of bank. All plants
		cottonwood	90	90			with brush blankets.
		dogwood	14	14			
subtotal			116				
Island 5ii	800						~1.5 m spacing throughout 10x80 m
		willow spp.	86	26		60	patch along top of bank. All plants
		cottonwood	185	200			with brush blankets.
		dogwood	11	26			
subtotal			312				
total	**1800**		**865**	775	30	60	

Table 5. Summary of grass competition control techniques.

Treatment	**Description**	**Area Treated**
Brush Blankets	Perforated pieces of polyethylene film measuring ~90x90 cm. 15 cm steel landscape pins hold each blanket in place around the stem of a tree or shrub.	488 m^2 of coverage distributed around each plant within a 4520 m^2 planting area with 603 plants.
Solarization	Sunbelt brand 3 oz. landscape fabric, with a five-year lifespan. Fabric is keyed into the soil at a depth of 20 cm and held in place with 15 cm steel landscape pins.	280 m^2 forming complete coverage of entire planting area with 262 plants.

Photo 1. Habitat Island 4 solarization plot. Plants laid out at 1 m spacing on landscape fabric, and 1.5 m spacing on exposed ground.

Photo 2. Lower Kootenay Band staff planting tall rooted spike cuttings in Habitat Island 4.

Photo 3. Keying in landscape fabric, Habitat Island 4 solarization plot.

Photo 4. Plants protected with brush blankets (left) and solarization plot (right), Habitat Island 4.

Photo 5. Plants installed in Habitat Island 5i.

Photo 6. Plants laid out in Habitat Island 5ii.

5.2 Maintenance

Maintenance of plantings in Habitat Islands 1-3 included the re-application of Bobbex browse deterrent spray and repair of browse protection cages and cones. Maintenance conducted in 2018 is summarized in Table 3. Incidental observations from maintenance are summarized below:

- No brushing of invasive weeds occurred in 2018. Cover of problem species such as Canada thistle did not appear to increase in the absence of brushing.
- Chicken wire browse protection cages were often found to be collapsed and could not be easily repaired. The damage is thought to be from cattle rub when they accessed the site prior to fence repair in 2017 and snow.
- Heavy gauge wire browse protection cages were often found in good shape although some wood stakes required repair. These cages could easily be removed and replaced on new plantings.
- Yellow jacket wasp nests were encountered in almost every plastic browse protection cone. This safety hazard caused a delay in the removal of all browse protection cones until after the nesting season in the fall. Plants inside of the cones have grown vigorously since 2016, and by the fall of 2018 many of the plants had come to fill the cones. Unfortunately, the structural strength of some plants had been setback by the support provided by the cones. Upon removal of cones, these plants slumped over. The form and vigor of affected plants will continue to be monitored.

5.3 Monitoring

In 2018 the survival of plantings in Habitat Islands 1-3 was 55% with an average density of 2225 plants per hectare (Table 6). This is a decline from 2017 when survival was measured at 75%. Browse levels observed in 2018 had an average utilization rating of light, and the vigour of plantings had an average rating of fair (Table 7).

Table 6. Summary of plant survival and stem density in Habitat Islands 1-3, 2016-2018.

Plot	Area	Survival 2016 (%)	Survival 2017 (%)	Survival 2018 (%)	Plants/ha 2018
1	Habitat Island 1	100	80	60	2400
2	Habitat Island 1	90	40	40	800
3	Habitat Island 1	100	82	47	1600
4	Habitat Island 2	95	75	65	2600
175	Habitat Island 2	-	-	-	2115
5	Habitat Island 3	100	100	65	2200
173	Habitat Island 3	-	-	-	1824
174	Habitat Island 3	-	-	-	2029
	Average	**97**	**75**	**55**	**2225**

Table 7. Summary of plant browse and vigour 2016-2018.

Plot	Area	Browse 2016	Browse 2017	Browse 2018	Vigor 2016	Vigor 2017	Vigor 2018
1	Habitat Island 1	Nil	Slight	Nil	Fair	Good	Good
2	Habitat Island 1	Nil	Slight	Slight	Good	Poor	Fair
3	Habitat Island 1	Nil	Slight	Slight	Good	Good	Fair
4	Habitat Island 2	Nil	Moderate	Slight	Good	Fair	Fair
175	Habitat Island 2	NA	NA	Light	NA	NA	Fair
5	Habitat Island 3	Nil	Light	Light	Good	Good	Fair
173	Habitat Island 3	NA	NA	Light	NA	NA	Good
174	Habitat Island 3	NA	NA	Moderate	NA	NA	Good
	Average	**Nil**	**Slight**	**Light**	**Good**	**Good**	**Fair**

The following patterns were noted in 2018 browse and vigor data (Table 8 and Table 9):

- Snowberry (*Symphoricarpos albus*) appears to perform well on this site with generally good vigour and almost no browse. However, despite low browse pressure, and good vigour going into the winter of 2017, mortality increased from 20% in 2017 to 40% in 2018.
- Saskatoon (*Amelanchier alnifolia*) and rose (*Rosa sp.*) tend to display little evidence of browse pressure. Vigour for both species dropped from generally excellent in 2017 to between poor and fair in 2018, with a large increase in mortality whereas none was observed for either species in 2017.
- Despite browse pressure, both willow (*Salix sp.*) and dogwood had good vigour in 2018, which is similar to observations in 2017.
- Though browse pressure on cottonwoods decreased in 2018, mortality increased from 38.5% in 2017 to 61.5% in 2018.
- No mortality of hawthorn (*Crataegus douglasii*) has been observed in two years of monitoring this site. However, the sample size is low with generally less than 7 hawthorn observations each monitoring session. Only 75 hawthorns were planted in 2016, and all in Habitat Island 1, because this was the highest elevation planting site.

The structural composition and percent cover within sampled areas is primarily herbaceous (Table 10).

5.3.1 Photo point monitoring

Photo point monitoring was conducted on August 3, 2018. Photo monitoring results are presented in Appendix 1. Photos pp3a and pp3b show a distinct reduction in Canada thistle cover between September 2017 and August 2018.

Table 8. Summary of vigour by shrub species.

	Vigor Category*				
Species	**Dead**	**Poor**	**Fair**	**Good**	**Excellent**
cottonwood	**61.5**	3.8	7.7	26.9	0.0
dogwood	35.3	8.8	14.7	**41.2**	0.0
hawthorn	0.0	0.0	**100.0**	0.0	0.0
rose	**33.3**	**33.3**	16.7	16.7	0.0
Saskatoon	**42.9**	14.3	**42.9**	0.0	0.0
snowberry	**40.0**	0.0	20.0	**40.0**	0.0
willow	17.0	1.9	34.0	**41.5**	5.7

*Column values represent percent of individuals of each species displaying each category of vigour. Largest percentage in bold.

Table 9. Summary of browse by shrub species.

	Browse Category*				
Species	**Nil**	**Slight**	**Light**	**Moderate**	**Heavy**
cottonwood	**50.0**	40.0	10.0	0.0	0.0
dogwood	**27.3**	4.5	13.6	**27.3**	**27.3**
hawthorn	0.0	0.0	**50.0**	**50.0**	0.0
rose	**100.0**	0.0	0.0	0.0	0.0
saskatoon	**75.0**	25.0	0.0	0.0	0.0
snowberry	**66.7**	33.3	0.0	0.0	0.0
willow	18.2	**43.2**	20.5	13.6	4.5

*Column values represent percent of individuals of each species displaying each category of ungulate browse. Largest percentage in bold.

Table 10. Summary of vegetation structural composition and percent cover.

		Cover (%)					
Plot	**Area**	**Tree**	**Shrub**	**Herb**	**Weeds**	**Exposed Soil**	**Wood/Mulch**
1	Habitat Island 1	0	1	99	<1	0	<1
2	Habitat Island 1	0	<1	99	0	0	0
3	Habitat Island 1	0	<1	99	4	0	<1
4	Habitat Island 2	0	1	99	0	0	0
5	Habitat Island 3	0	1	99	0	0	0
	Average	**0**	**0.6**	**99.4**	**1**	**0**	**0**

6 DISCUSSION

All works as part of this project have been completed as of October 2018. The goals and objectives were not met exactly as originally proposed however the changes were approved prior to project implementation as per change request dated October 11, 2018. Those changes include:

- As-built: Planted 865 potted stock native shrubs throughout a 0.18 ha area.
  Original: Plant approximately 2000 live stakes in to enhance 0.40 ha of the Indian Creek riparian area. Rationale for this change is based on our observation that potted stock has performed better than live stakes in similar growing conditions during past phases of this project and on budget constraints (the total amount of funding requested from Columbia Basin Trust was not

received). In addition, the plants were installed at a tighter spacing to increase the competitive advantage in reed canary grass dominated habitat.

- As built: maintenance was conducted on the old (Phase 1) plantings in Habitat Islands 1-3. Original: site preparation and maintenance of new (Phase 3) plantings in Habitat Islands 4-5. Rationale for this change is that the Phase 3 plants were installed in the fall instead of the spring which did not allow time within the contract period to maintain the new plantings.

At the end of the third growing season the overall vigour and survival of Phase 1 plantings in Habitat Islands 1-3 has dropped even though browse pressure remained generally low. Though vigour decreased generally, this result was not consistent among species. While snowberry, dogwood and willow are performing reasonably well cottonwood are experiencing increasing mortality. It is possible that prolonged seasonal inundation of Habitat Islands 1-3 is causing mortality of black cottonwood, as this species typically only occupies floodplain sites that flood for less than 25 days (McKenzie and Moran 2004). Seasonal drought and competition from grasses may also be contributing to plant mortality and generally fair vigour observed among all species.

While competition from grasses may have been initially low after planting in 2016, the cattle exclusion fencing installed in 2015 has been successful in reducing grazing pressure within the Indian Creek riparian area and native sedges, grasses and forbs have recolonized the site particularly at the old cattle access points along the banks of Indian Creek. It has also allowed the grasses to regrow and perhaps compete more effectively with the plantings. Monitoring of these growth patterns will help inform future phases of the project so that habitat island planting locations are synergistic with natural moisture regimes and topographic variation and appropriate microsite planting locations are clearly identified to ensure areas of open habitat with desirable native sedges are maintained.

Based on these observations measures to increase the competitive advantage of new plantings in Habitat Islands 4 and 5 have been implemented by suppressing adjacent grass growth through two treatments: solarization plots and brush blankets installed around individual plants. Ongoing efforts to enhance the competitive advantage of plantings in Habitat Islands 1-5 will likely be required.

Canada thistle cover appears to have declined in Habitat Islands 1-3. The mowing treatments conducted in 2017 were likely effective in setting back growth and reducing spread. No mowing occurred in 2018 so the site should be monitored to identify if additional mowing may be required in the future to continue to decrease Canada thistle cover throughout the planted areas.

The project is successful with continued participation by LKB community members. Several individuals who have worked on the project over multiple years have gained experience in riparian planting and maintenance techniques creating an increased sense of stewardship on this long-term project. Their

personal sense of ownership has spread throughout LKB and inspired others to want to become involved with future projects.

7 RECOMMENDATIONS

To improve and accelerate the restoration process, ongoing maintenance and monitoring is recommended for the site as outlined in Masse Environmental 2014 and summarized below.

Monitoring:

- Determine maintenance requirements annually.
- Repeat photo monitoring of all treatments annually. Install additional photo monitoring point(s) to document the extent of annual spring flooding.
- Record annually the extent and duration of seasonal flooding to gain a better understanding of flood patterns on site. Results will inform updated planting prescriptions within the Indian Creek restoration area and for similar sites within the Kootenay River floodplain.
- Remeasure permanent monitoring plots every two years to evaluate survival and growth. Install additional plots to help analyse which strategies are most successful and best inform future phases.

Maintenance:

- Determine maintenance requirements annually. Identify invasive weed treatment areas, competing vegetation, integrity of browse protection.
- Evaluate effectiveness of cattle exclusion fence and repair if damage is encountered.
- Evaluate vole presence and effect on Phase 3 plantings and install protection if damage is encountered.
- Remove competing vegetation from the area within 1 m^2 of new plantings if competing vegetation is impacting plant establishment.
- Install brush blankets or equivalent brush suppression material to decrease the competitive ability of grasses around plants in Habitat Islands 1-3.
- Maintain brush blankets and solarization plots in Habitat Islands 4-5 and remove competing vegetation until the plantings have grown taller than the surrounding grasses.
- Continue to apply browse protection spray to all plantings in the spring and fall until they are vigorous/tall enough to persist despite browse pressure.
- Continue to treat invasive plant infestations that are interfering with native plant establishment. Specifically, ongoing mowing may be required to continue to decrease Canada thistle cover throughout the planted areas.
- Repair, remove and/or expand browse protectors when plants fill or overgrow the existing capacity.
- Irrigate plantings in the mid to late growing season as soil moisture decreases to ensure adequate soil moisture through the growing season and improve the competitive performance.

8 LESSONS LEARNED AND ADAPTIVE MANAGEMENT

Lessons learned during restoration activities are summarized below and should be applied to future phases of the project.

- Preferred native species for planting habitat islands are willow, red osier dogwood, black hawthorn and snowberry. Elevation threshold for black cottonwood is to be determined.
- Browse protection should consist of either heavy gauge wire cages or deer repellent spray. Chicken wire is not sturdy enough to withstand ungulate rub or snow and although cost effective initially cannot be reused. Plastic tree cones attract wasps which present a hazard to field crews. If they are reused ensure timely removal in early spring or fall when wasps are not active.
- Allow additional site preparation time in reed canary grass areas prior to planting to accommodate deeper and repeated cultivation. This would help reduce the competitive ability of reed canary grass by breaking up and desiccating the root structures.
- Use a melting tool in future solarization plots to cut planting holes in the landscape fabric and create uniform holes with cauterized edges.
- Improve record-keeping of maintenance activities conducted by LKB members to ensure lessons learned are gained during field work. Create a brief reporting template to document daily maintenance activities and ensure photographs are taken.

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Appendix 1 – Photo Monitoring Images

Tree and shrub island photo point monitoring station descriptions.

Photo ID	Zone	Easting	Northing	Azimuth (°)
PP1a	Habitat Island 1	532018	5437379	118
PP1b	Habitat Island 1	532018	5437379	238
PP2a	Habitat Island 1	532078	5437329	166
PP2b	Habitat Island 1	532078	5437329	328
PP3a	Habitat Island 1	532098	5437309	166
PP3b	Habitat Island 1	532098	5437309	328
PP4a	Habitat Island 2	532138	5437189	162
PP4b	Habitat Island 2	532138	5437189	331
PP5a	Habitat Island 3	532098	5437309	140
PP5b	Habitat Island 3	532098	5437309	350
PP6a	Habitat Island 5	532635	5436376	316
PP7a	Habitat Island 4	532441	5436393	324
PP7b	Habitat Island 4	532441	5436393	122
PP8a	Habitat Island 4	532421	5436420	66
PP9a	Habitat Island 4	532453	5436382	96

PP1a. September 2, 2016.

PP1a. September 9, 2017.

PP1a. August 3, 2018.

PP1b. September 2, 2016.

PP1b. September 9, 2017.

PP1b. August 3, 2018.

PP2a. September 2, 2016

PP2a. September 9, 2017

PP2a. August 3, 2018.

PP2b. September 2, 2016.

PP2b. September 9, 2017.

PP2b. August 3, 2018.

PP3a. September 2, 2016.

PP3a. September 9, 2017.

PP3a. August 3, 2018.

PP3b. September 2, 2016.

PP3b. September 9, 2017.

PP3b. August 3, 2018.

PP4a. September 2, 2016.

PP4a. September 11, 2017.

PP4a. August 3, 2018.

PP4b. September 2, 2016.

PP4b. September 9, 2017.

PP4b. August 3, 2018.

PP6a. October 15, 2018. Baseline image of Habitat Island 5ii.

PP7a. October 15, 2018. Baseline image of north end of Habitat Island 4.

PP7b. October 15, 2018. Baseline image of east part of Habitat Island 4.

PP8a. October 26, 2018. Initial image of Habitat Island 4 in detail.

PP9a. October 26, 2018. Initial image of Habitat Island 4 in detail.

PP10a. October 22, 2018. Initial image of Habitat Island 5ii.