Fraser Valley Watersheds Coalition
Unit 1 - 45950 Cheam Avenue
Chilliwack, B.C. V2P 1N6
www.fvwc.ca

April 27, 2020

Thompson Creek Fish ladder, Replanting and Assessments
Stave River Watershed- Restoring Salmon Habitat

Cover photo: Newly installed Thompson Creek fish ladder with partners and keen local steward.

Report prepared by:
Natashia Cox BA.,EP.,R.B.Tech Program Director
Rachel Drennan BSc.,P.Ag. Operations Manager
Fraser Valley Watersheds Coalition

Prepared for:
Fish Wildlife Compensation Program
Project number: COA-F20-F-3110

This Project is funded by the Fish and Wildlife Compensation Program (FWCP). The FWCP is partnership between BC Hydro, the Province of B.C., Fisheries and Oceans Canada, First Nations and public stakeholders to conserve and enhance fish and wildlife in watersheds impacted by BC Hydro dams. www.fwcp.ca

Fraser Valley Watersheds Coalition
Unit 1 - 45950 Cheam Avenue
Chilliwack, B.C. V2P 1N6
www.fvwc.ca

Table of contents

List of Figures

Fraser Valley Watersheds Coalition
Unit 1 - 45950 Cheam Avenue
Chilliwack, B.C. V2P 1N6
www.fvwc.ca

List of Tables

Fraser Valley Watersheds Coalition
Unit 1 - 45950 Cheam Avenue
Chilliwack, B.C. V2P 1N6
www.fvwc.ca

Executive Summary

This project is a collaborative effort to enhance, restore and promote shared conservation values in the Stave River watershed. It is a continuation of work that has occurred in the Lower Stave River region to improve the overall salmon habitat. This year's project aligned with **FWCP Action Plans:**

Stave River Watershed Action plan
Ecosystem Chapter
Rivers, Lakes and Reservoirs
Habitat-based Action

- **SFN.RLR.HB.16.01 Improve access to suitable tributaries and off-channel habitats-P1**
  By improving access to suitable tributaries ensuring productive and diverse aquatic ecosystems and maximizing the viability of anadromous salmon (coho, chum and chinook) through the replacement of a dated fish ladder.

- **SFN.RLR.HB.14.01 Implement habitat enhancements in Lower Stave River-P2**
  By implementing habitat enhancements in the lower Stave River to create productive and diverse wetland and riparian ecosystems through continued bioengineering and planting efforts.

- **SFN.ALL.ME.08.01 Assessments and Evaluation Stave River-P3**
  By completing assessments to understand the effectiveness of the bank stabilization work that was completed in 2018.

FWCP contributed $65,870.82 from June 2019 to March 31, 2020, and with matching and partner in-kind contributions the total project value of this project $93,823.47, which resulted in:

- Installation of a new Thompson Creek fish ladder -enabling fish passage ~400 linear m upstream
- 1626 m^2 of riparian planting using 5750 individual native plants.
- Effectiveness report for the Right Bank Stabilization project with recommendations and next steps.

This report summarizes the results of work completed between June 2019 and March 31, 2020 under the financial contribution of the Fish Wildlife Compensation Program (FWCP). Additional support for this project was received from the Stave Valley Salmonid Enhancement Society, Kwantlen First Nation, District of Mission, the local community members, the Fraser Valley Watersheds Coalition, and the Fraser Valley Regional District. Thanks to the momentum of on-the-ground restoration activities, the strength in partnerships and overall importance of this project, further restoration efforts and long-term management plans are being developed to continue building upon the success and ensure long-term ecological integrity is maintained.

1. Introduction

Tidally influenced freshwater estuaries and off-channel habitats are critical areas benefiting salmon, waterfowl, mammals, migratory birds, and serving as an important ecosystem for flood protection and human services. Natural off-channel habitats include beaver ponds, wetlands, alcoves, floodplains, side channels and tributaries. The Lower Stave River has been regarded as one of the most productive salmon habitats in the province and supports the second largest chum salmon (*Oncorhynchus keta*) population in the Fraser River watershed. The presence of the Ruskin dam restricts the range of habitat that the anadromous salmon can use, and currently only the lower 3 km section of the Stave River provide habitat for these spawning salmon.

The lower Stave River, between the Ruskin Dam and the Fraser River, consists of numerous channels and gravel bars, with predominantly deciduous vegetation growing on the more established bars and riverbanks. Located within the traditional territory of the Kwantlen First Nation, the area contains numerous archaeological sites and artifacts of cultural and historical significance, many of which are threatened by the continual erosion of the riverbanks. The erosion of these banks has long been a concern of the Kwantlen First Nation, a concern identified during the past Water Use Planning process (2003). There are limited areas remaining on the lower Stave River floodplain that support significant populations of coho salmon (*Oncorhynchus kisutch*) adults and juveniles, and this includes the lower 3 km section of the Stave River. This section provides the only remaining habitat for anadromous salmon within the Stave River Watershed. Up to 500,000 chum salmon and hundreds of coho, pink (*Oncorhynchus gorbuscha*) and chinook (*Oncorhynchus tshawytscha*) salmon spawn in these graveled channels. In 2007, actions to create more complex spawning habitat appropriate for the tail-water release flows of the Ruskin Dam, were completed by FVWRC (now FVWC) in partnership with DFO and FVRD.

This project focused on two areas within the Stave river watershed. Replacement of a failing fish ladder on the right bank of the Stave River and a riparian planting in the wetland area on the left bank of the Stave River.

This project represents a collaborative effort involving the Fraser Valley Watersheds Coalition, Fisheries and Oceans Canada, the Fraser Valley Regional District, BC Hydro, Kwantlen First Nation and Stave Valley Salmonid Enhancement Society.

2. Goals and Objectives

The overarching objective of this project was to enhance sections along the right bank of the Fraser River within the Stave River Watershed to support functional ecological processes, provide suitable habitat conditions for wildlife and fish and build momentum and partnerships for long-term stewardship and conservation of these areas.

Specifically, the goals of this project were:

1. **Restoration of Habitat:** Replace and upgrade an old wooden fish ladder on Thompson Creek.
   Goal: New fish ladder installed.

2. **Enhancement of Habitat:** Continue replanting using native plant species stave river site 2, expanding outwards the native vegetation band to support an overall wider riparian and scrub-shrub lowland habitat to support functional fish habitat.
   Goal: Achieving at least 500 m^2

3. **Community Engagement:** Promote increased stewardship through community and volunteer engagement.
   Goal: Minimum 40 volunteers assisting in the work.

4. **Improve Science and Knowledge:** Work with Kwantlen First Nation and archaeologists to assess the right bank erosion control measures implemented in 2018.
   Goal: Conduct assessment and share results.

5. **Improve Opportunities for Sustainable Use:** In partnership with Kwantlen First Nation – impart knowledge about the importance of this site as a salmon and wildlife refuge.
   Goal: Share the final reports, monitoring reports and archaeological reports.

Fraser Valley Watersheds Coalition
Unit 1 - 45950 Cheam Avenue
Chilliwack, B.C. V2P 1N6
www.fvwc.ca

3. Study Area

The project sites are in the Lower Stave River in Mission, B.C. Both sites are situated within Kwantlen First Nation traditional territory. The fish ladder is located on the right bank of the Stave River. Site 2 (labelled riparian planting location in figure 1) is located on the left bank of the Stave River, and is an extensive island owned by Kwantlen First Nation (IR3).

Figure 1. A map showing the project locations as they relate to the rest of the Lower Stave River in Mission, B.C. The fish ladder replacement location is located on the right bank of the Stave River (red star). the riparian planting location (also referred to as Site 2) is located on the left bank of the Stave River (green star), and water quality and fish monitoring occurred throughout the Lower stave, shown as blue stars.

4. Thompson Creek Fish Ladder Installation

4.1 Methods

The fish ladder upgrade (figure 2) was led by Fisheries and Oceans Canada in partnership with FVWC, Kwantlen First Nation archaeological reports and the bio-inventory and SAR reports. The restoration designs considered research underway regarding stranding, ordered low flow releases, high flow releases, and ramping rates as agreed upon in the Stave River Water Use Plan.

Prior to instream works, FVWC applied for a municipal street closure permit through District of Mission and hired safety flaggers for the construction. FVWC also informed the community of the restoration events through the District of Mission and social media platforms. DFO had the fish ladder fabricated according to specifications and scheduled delivery. One week before construction was set to begin FVWC isolated the site by installing exclusion fencing above and below the construction work-zone; followed by a fish salvage using roe baited Gee traps and Feddes traps to remove any fish from the area prior to works beginning.

The instream construction was completed during the 2019 instream fisheries works window. During August 6, 2019 and August 7, 2019 water was diverted from the channel with a by-pass pump diversion method to allow for upstream water to feed the waterway below and prevent any fish stranding. A 200 series excavator removed the old wooden fish ladder in sections, placed it into a dump truck and then moved it offsite. Gravel was added to the site to create a secure location for the new fish ladder and establish the correct grade. The new steel fish ladder was brought to the site and lowered into place with a crane truck. The sections were bolted together, the safety grate was installed and the area around the ladder was back filled to secure it in place. The section of creek below the fish ladder was enhanced with boulders to increase stability of the area, and to slightly backwater the base of the ladder to allow for staging pool for salmon prior to migrating up the ladder into the upper reaches. Water was allowed back through the streambed and into the newly replaced fish ladder to assess the flow and test the joints.

Figure 2. Installed fish ladder with partners and local steward.

4.2 Results

The installation of the new fish ladder at Thompson creek resulted in the stabilization and enhancement of the habitat below the ladder and fish passage approximately 400 linear meters upstream (~600m^2) representing year-long observed aquatic habitat, as per District of Mission webmap watercourse data (Appendix A; Appendix B).

5. Shrub Planting and Community Engagement

5.1 Methods

Before the community planting event took place, the site was prepared by using a 100 series excavator to remove invasive blackberry and create a rough/loose substrate to reduce erosion and encourage healthy plant growth. During site prep, strategies to prevent loss of existing topsoil such as shaking out reed canary grass (*Phalaris arundinacae*) to get separation from roots and soil were incorporated. The substrate of these channels is clay and silty-sand composition, and the whole lower Stave River reach undergoes significant hydrological fluctuation, (daily tides, tail-water releases from the Ruskin Dam, and seasonal droughts), therefore methods that could help plants retain moisture and assist in soil building formations were incorporated.

FVWC staff and volunteers completed a planting of the riparian area in September 2019 on Kwantlen First Nation IR3, continuing to create the floodplain forest along the constructed channels. On the top of the channel banks, potted stock was dug in by hand, and a variety of native willows (*Salix spp.*), hardhack (*Spirea douglasii*) and black cottonwood (*Populus trichocarpa*) whips, harvested locally, were live staked. The presence of beaver and small mammal herbivory is high in the area, so preferential beaver fodder was guarded with wire cages and tree spirals.

Fast growing, pioneering plant species characteristic of this zone were selected for planting. Most of these species can tolerate inundation and have some ability to withstand drought. Mycorrhizae (beneficial fungus) were added into the planting holes of each shrub to help the plants better find and retain moisture. The planting strategy was to plant each species at different topographic locations, because the slight variances in topography can have a substantial effect on survival due to moisture differences over the years.

The shrub species selected will provide shade and facilitate insect drop. They are also very tolerant to high water levels, fast growing and aggressive. Most of the shrubs selected are multi-stemmed species; this helps them to colonize the area faster and tolerate some browsing. The more water tolerant shrubs selected, such as hardhack are fast growing, rapidly spreading species that will help to colonize the aquatic/terrestrial zone between the water and reed canary grass more successfully.

The purpose is to establish transitional shrub thickets along the stream channels to reduce edge effects, shade the waterway, and create defensible boundaries against invasive species such as reed canary grass.

5.2 Results

The volunteer planting event hosted at Site 2 saw 15 volunteers lending their hands. A total of 1626 m^2 of riparian area was planted with a total of 5750 native trees and shrubs (table 1; figure 3).

Table 1. Native trees and shrubs planted at Site 2 located in the Lower Stave River in Mission, B.C. at a planting event hosted by FVWC in September 2019.

Common name	Latin name	Size	Number
Potted stock			
Nootka rose	*Rosa nutkana*	1 gal	170
Red-osier dogwood	*Cornus sericea*	2 gal	193
Scoulers willow	*Salix scouleriana*	1gal	181
Hardhack	*Spiraea douglasii*	1gal	424
Twin berry	*Lonicera involucrata*	1 gal	82
Sweetgale	*Myrica gale*	1gal	100
	Total potted stock		**1150**
Live stakes			
Black cottonwood	*Populus trichocarpa*		600
Willow	*Salix sp.*		1700
Hardhack	*Spiraea douglasii*		2300
	Total live stakes		**4600**
	Total plants		**5750**

Figure 3. Potted trees and shrubs ready for a volunteer planting event hosted by FVWC in September 2019 at Site 2 in the Lower Stave River, Mission, B.C.

Fraser Valley Watersheds Coalition
Unit 1 - 45950 Cheam Avenue
Chilliwack, B.C. V2P 1N6
www.fvwc.ca

6. Effectiveness Report for the Right bank Stabilization Project

6.1 Methods

A key goal for this project was to assess the right bank stabilization pilot project, completed in 2018, reference COA-F-2851-DCA, to understand whether the placement of large wood rootwads, boulders and gravel top-dressing on Kwantlen First Nation IR2 would be successful in reducing the bank erosion and thus reducing the loss and degradation of the culturally important artifacts; and provide habitat features to support salmon and aquatic ecology.

To assess the cultural consideration, Cordillera Archaeologist and Kwantlen First Nation completed an independent assessment of the bank during low marine tide and low-winter tide with the purpose of visually assessing the bank for archaeological clues about stability. Their findings indicated that the pilot bank stability project is functioning as intended, and that the works completed in the mainstem river (Channel 5) have also supported reduced velocity, particularly during low flows, on the bank. Appendix C: Cordillera Archaeology Right Bank Assessment Memo.

Wade and Associates surveying were contracted to complete an empirical geospatial assessment of the right bank pilot project to provide quantitative analysis answering the following questions listed below. Appendix D. Wade Surveyed Drawing and Analysis. Following the analysis permanent monitoring points were installed into the wood to increase future monitoring assessment accuracy.

6.2 Results

1. **Has the boulder-log reef structure moved, and if so how much?**
   With an empirical movement threshold between 0.1m-0.5m of shifting, the surveyors compared the as-built surveying drawings and re-surveyed the bank and reef structure. The findings indicate that there is some movement within the reef structure, almost all movement falls beneath the 0.1m threshold. On average the boulders “rocks” have moved an average of 0.21 m, the north end of the logs (bankside) have moved on average 0.17m and the south end (river-side) have moved on average 0.85m. Two logs G-G and H-H have slightly greater shift 3.2m and 2.5m change respectively. This shift may be due to the extent the south ends are within the river, movement being caused by hydrological push (river current).

2. **Has the gravel top-dress remained in-tact?**
   The placemat of the gravels and top-dress atop the right bank are remaining in place, as shown as a brown hatched polygon on the surveyed drawing.

Fraser Valley Watersheds Coalition
Unit 1 - 45950 Cheam Avenue
Chilliwack, B.C. V2P 1N6
www.fvwc.ca

3. **Within the scope of the reef structure has the bank changed?**
   Some erosion has occurred within and around the reef structure, represented as purple shading in the surveyed drawing, ranging from 0.3m to 1.04m. Particularly, it is occurring at the uppermost section where the mainstem flows intercept the right bank. Further downstream there is minimal erosion until nearing the end of the reef where some erosion action is still observed.

4. **Outside the scope of the reef structure, is there bank erosion occurring?**
   Further downstream where no reef structure was installed, the surveyors measured the banks between March 2019 and February 2020, shaded as light grey in the surveyed drawing. Downstream erosion of the cut-bank ranges from 0.25m to 1.61m of active erosion. Just Upstream of boulder 52, where no rootwads were installed active erosion has been surveyed and observed.

7. Monitoring

7.1 Returning adults in Thompson Creek

7.1a Methods

Long-time steward and local resident, Phillip Northrop, observed and recorded returning coho and chum salmon using Thompson Creek between November 12th, 2019 and December 25th, 2019. Mr. Northrop counts the fish starting from the pool immediately below the fish ladder and walks the creek the entire length of the spawning creek up to Reedal St.

7.1b Results

From November 12, 2019 until December 25, 2019 Phillip Northrop observed 194 chum and 217 coho returning to Thompson Creek (figure 4). His observations indicate the timing of arrival between salmon species; chum arriving with the onset of fall rains, and coho arriving predominately later in the season.

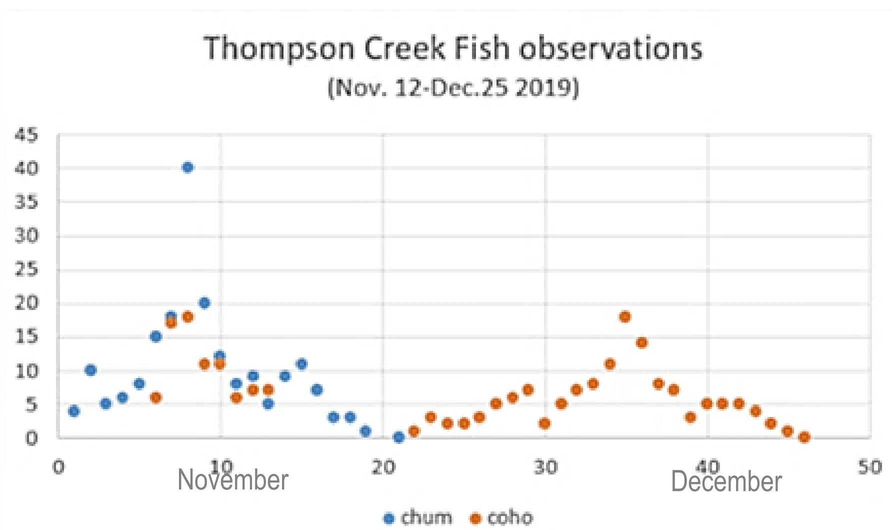


Figure 4. Number of returning adult chum and coho salmon using Thompson Creek as observed by a local resident.

7.2 Water Quality and Fish Presence in the Lower Stave River

The monitoring efforts completed as part of this project help to set a baseline and track the spatial and temporal changes to the project locations as a result of restoration efforts and natural processes and helps fill in information about known data gaps. Monitoring activities include measuring water quality and surveying for fish presence in the constructed off-channels. Water quality and fish surveys were completed three to four times per year between November 2017 and February 2020 to encompass seasonal changes in water quality and fish presence in the constructed channels. Monitoring was completed in the constructed channels in Site 2 located along the left bank of the Stave River (figure 1) and completed in a site across Highway #7 called Site 3. Site 3 will act as a control site to compare data collected from Site 2 and to determine if restoration efforts are working as intended to create suitable aquatic habitat for salmonids and other aquatic life.

7.2a Methods

Water Quality

Water quality was measured to understand the aquatic habitat conditions of Site 2 and to determine if the water in the constructed channels is suitable for aquatic life. Seven water quality parameters were measured and recorded. These include temperature, dissolved oxygen in both percentage and milligrams per litre, conductivity, salinity, pH, and turbidity. Dissolved oxygen, temperature, and conductivity were all measured using a YSI Pro probe. Dissolved oxygen readings were taken in both % and mg/L to ensure that no false readings were recorded. Temperature and dissolved oxygen are important parameters because they ensure that water quality in the site are suitable for fish life. Temperatures should remain below 15 ^{o}C and dissolved oxygen should remain greater than 5 mg/L to ensure optimal conditions for salmonids. Salinity, conductivity, and pH were measured using an Oakton Pctstestr Series 50 Pocket Tester. All water quality parameters measured at the control site, Site 3, were measured using the same methods mentioned above for Site 2.

Fish Presence

Fish presence surveys were completed to determine what species of fish use the constructed channels at Site 2 and to determine the overall health and life-stage of fish, particularly salmonids, using Site 2. At Site 2 fish presence was surveyed six times between November 2017 and February 2020. Fish were caught using Gee traps at seven sampling sites within Site 2. Prior to setting traps, water quality and water depth were measured to ensure that conditions were safe for trapping. Traps were only set if the water depth was deep enough to fully submerge the trap, the water temperature was between 0^{o}C and 15^{o}C, and if dissolved oxygen was at least 5 mg/L. If these water conditions were met, then two minnow traps were set at each sampling location. Traps were checked no longer than 24 hours after being set and fish were counted by species, weighed, and measured in body length. The time the trap was set and pulled was recorded to determine catch per unit effort. The same method of trapping was used at Site 3, except fish presence was measured ten times between January 2017 and February 2020 and included ten sampling locations within Site 3.

7.2b Results

Water Quality

At Site 2 average temperatures exceeded 15^{o}C between May and September 2019 (figure 5; table 2) when temperatures were warmer in the summer months and water levels were lower. This data is comparable to the temperature data measured at Site 3 where the highest average temperatures were also between May 2019 and September 2019 (figure 6; table 3). Overall average temperature at Site 2 remained within optimal levels for most salmonids to survive. Average dissolved oxygen remained within optimal levels year-round at Site 2 (figure 5; table 2) whereas at Site 3 dissolved oxygen dropped below 5 mg/L in September 2019 (figure 6; table 3). Dissolved oxygen data is missing for March 2019 at Site 2 due to technical difficulties with the YSI Probe. All other parameters during the March 2019 sampling date were measured using the Oakton Pctstestr Series 50 Pocket Tester. Overall, average dissolved oxygen at Site 2 and Site 3 remained within optimal levels for aquatic life to survive.

Other water quality parameters are summarized in table 1 and table 2 for Site 2 and Site 3 respectively. pH at Site 2 was the highest in March 2019 at 7.6 and remained between 6.4 and 6.9 for the rest of the sampling dates. pH at Site 2 is comparable to the pH measured at Site 3 where pH ranged between 6.7 and 7.3. Turbidity was found to be greater than 21 NTU at both sites. Trends in conductivity were similar at both Site 2 and Site 3 with only slight seasonal changes in conductivity where it increased in the summer and decreased through the winter. There were no sudden increases or decreases in conductivity at either Site 2 or Site 3 across the sampling period indicating that there were no sudden changes in site conditions or the surrounding watershed that would negatively impact water quality. Overall, the water quality at Site 2 between November 2017 and February 2020 was suitable for salmonids to survive and complete their life cycles.

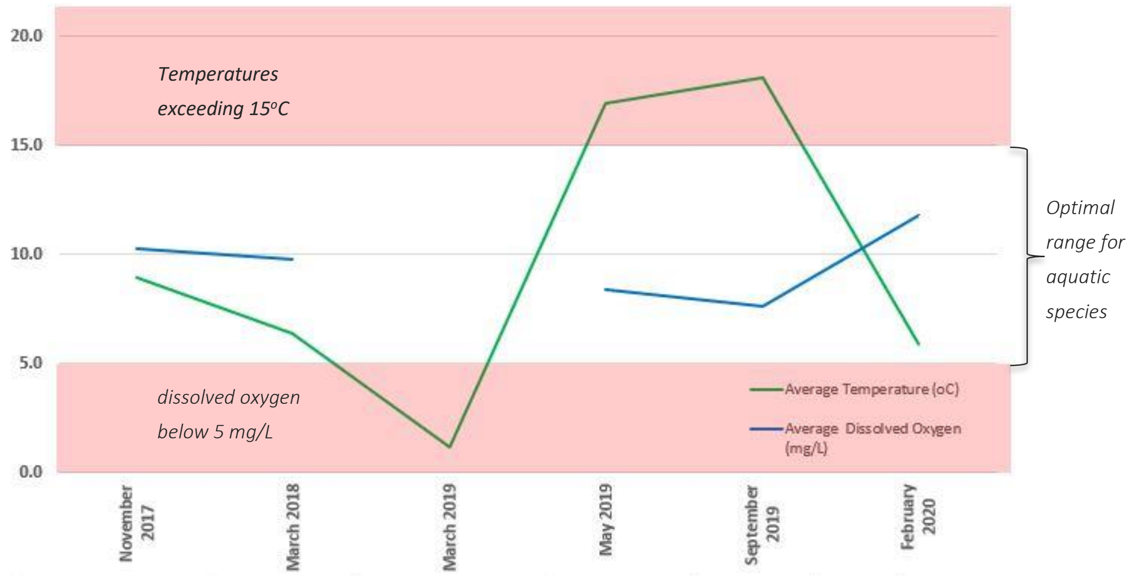


Figure 6. A graph showing temperature and dissolved oxygen over time at Site 2 in the Lower Stave River. Water quality was sampled 6 times between November 2017 and February 2020. The red sections indicate thresholds at which the water quality is no longer optimal for aquatic life. Temperatures exceeding 15°C and dissolved oxygen below 5 mg/L indicate unsuitable aquatic habitat. Dissolved oxygen data is missing for March 2019 at Site 2 due to technical difficulties with the YSI Probe

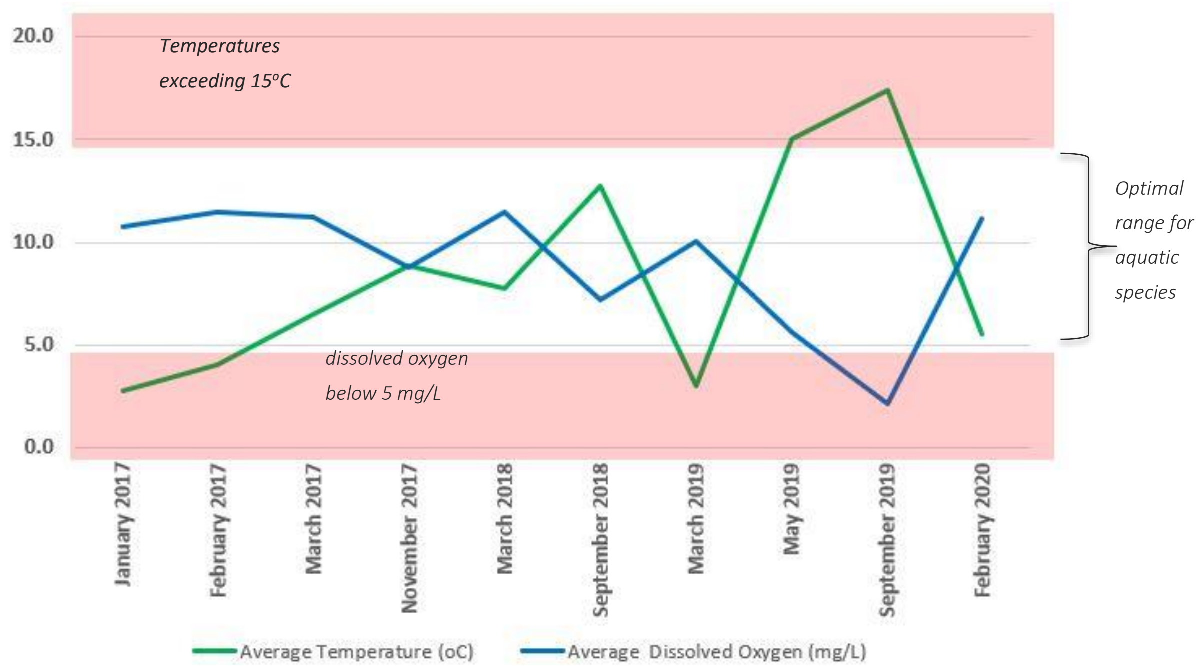


Figure 5. A graph showing the average temperature in °C and the average dissolved oxygen in mg/L at Site 3 in the Lower Stave River. Water quality was measured between January 2017 and February 2020. The red sections indicate thresholds over which water quality is no longer optimal for aquatic life. Temperatures exceeding 15°C and dissolved oxygen below 5 mg/L indicate unsuitable aquatic habitat.

Table 3. Average water quality parameters measured at Stave Site 2 between November 2017 and February 2020. Dissolved oxygen was not measured in March 2019 due to technical difficulties with the YSI Probe. All parameters were measured using the Oakton Series 50 Pocket Tester for the March 2019 sampling date. Salinity was not measured after May 2019 because sampling was done using a new Pocket Tester that measured salinity in ppt instead of ppm which is not sensitive enough to detect salinity in freshwater systems.

Sampling Date	Average Temperature (°C)	Average Dissolved Oxygen (mg/L)	Average Dissolved Oxygen (%)	Average Turbidity (NTU)	Average pH	Average Conductivity (µS/cm)	Average Salinity (ppm)
November 2017	9.0	10.2	88.6	21.0	6.7	37.0	20.0
March 2018	6.3	9.7	79.4	21.0	6.8	40.7	20.0
March 2019	1.2	-	-	21.0	7.6	30.3	15.4
May 2019	17.0	8.4	88.1	21.0	6.9	54.7	38.8
September 2019	18.1	7.6	80.4	21.0	6.6	21.5	-
February 2020	5.9	11.8	93.8	21.0	6.4	16.1	-

Table 2. Average water quality parameters measured at Site 3 in the Lower Stave River in Mission, B.C. Water quality was measured between January 2017 and February 2020. Salinity was recorded starting in March 2017 but was not recorded after May 2019 because sampling was done using a new Pocket Tester that measured salinity in ppt instead of ppm which is not sensitive enough to detect salinity in freshwater systems.

Sampling Date	Average Temperature (°C)	Average Dissolved Oxygen (mg/L)	Average Dissolved Oxygen (%)	Average Turbidity (NTU)	Average pH	Average Conductivity (µS/cm)	Average Salinity (ppm)
January 2017	2.8	10.8	79.8	-	-	-	-
February 2017	4.1	11.5	87.5	21.0	-	-	-
March 2017	6.5	11.2	91.6	21.0	7.2	82.5	41.7
November 2017	8.9	8.8	75.7	21.0	7.1	93.2	48.5
March 2018	7.8	11.5	96.7	21.0	7.0	93.6	47.7
September 2018	12.8	7.2	67.7	21.0	6.7	114.1	55.7
March 2019	3.0	10.1	74.7	21.0	7.3	117.1	59.9
May 2019	15.1	5.6	55.0	21.0	6.8	83.7	60.0
September 2019	17.4	2.1	23.8	21.0	6.8	133.3	-
February 2020	5.5	11.1	88.9	21.0	6.9	62.6	-

Fish Presence

A total of 552 fish were caught at Site 2 between November 2017 and February 2020 (figure 7). The only salmon species caught at Site 2 was the coho salmon which attributed 0.9% of the total fish caught with 5 individuals over the sampling period (table 4; figure 7). Threespine stickleback (*Gasterosteus aculeatus*) attributed the largest proportion of the total fish caught with 471 individuals making up 85% of the total. The lowest proportion of fish caught was represented by the largescale sucker (*Catostomus macrocheilus*) with one individual caught making up 0.2% of the total. The only invasive species that was caught at Site 2 was pumpkinseed (*Lepomis gibbosus*) which represents 3.6% of the total. At Site 3 a total of 449 fish were caught between January 2017 and February 2020 (figure 8). Like Site 2, Site 3 also saw coho salmon as the only detected salmon species using the habitat with 23 individuals making up 4.6% of the total (table 5). The most caught species was threespine stickleback representing 36.3% of the total fish caught and the least caught species was the prickly sculpin (*Cottus asper*) representing 0.4% of the total fish caught at Site 3. Site 3 saw more invasive species than Site 2 with three detected invasive species including pumpkinseed at 23.8%, brown bullhead (*Ameiurus nebulosus*) at 22.2%, and largemouth bass (*Micropterus salmoides*) at 6.8%.

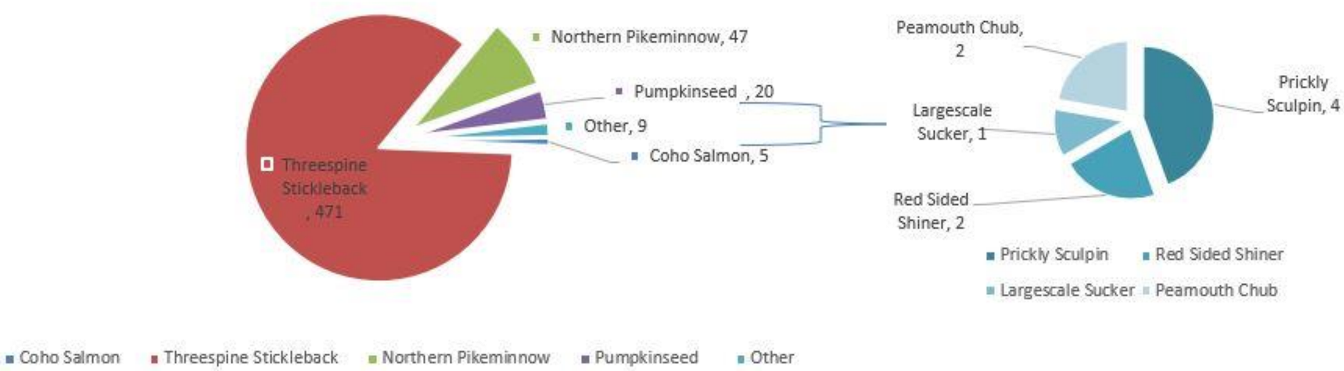


Figure 7. Proportion of fish species caught at Site 2 in the Lower Stave River. Fish sampling was completed 6 times between November 2017 and February 2020. The smaller chart to the right represents the proportion of fish species that make up “other”.

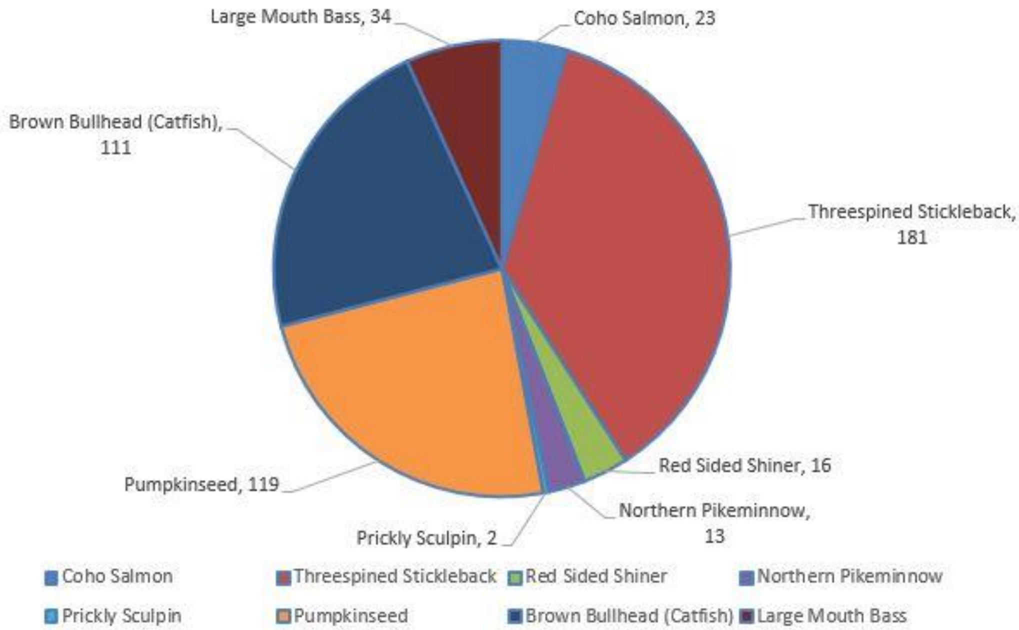


Figure 8. Proportion of fish species caught at Site 3 in the Lower Stave River. Fish sampling was completed 10 times between January 2017 and February 2020.

Table 4. The species of fish caught and their proportions on each sampling date at Site 2 in the Lower Stave River. Average mass and average length were calculated by averaging the values recorded across all sampling dates.

Date	Coho Salmon	Threespine Stickleback	Red Sided Shiner	Northern Pikeminow	Pumpkinseed	Largescale Sucker	Prickly Sculpin	Peamouth Chub
Nov-17	3	5	1	9	3	0	0	0
Mar-18	0	3	0	0	0	0	0	0
Mar-19	0	0	1	5	2	0	0	0
May-19	0	463	0	32	0	1	4	2
Sep-19	1	0	0	0	12	0	0	0
Feb-20	1	0	0	1	3	0	0	0
Total	5	471	2	47	20	1	4	2
Percentage of Total Fish Caught (%)	0.9	85.3	0.4	8.5	3.6	0.2	0.7	0.4
Average Mass (g)	3.65	3.3	0.0	6.6	1.1	3.0	10.3	6.5
Average Length (mm)	60	62.8	32.0	73.1	28.2	56.0	80.3	76.5

Table 5. The total number of fish caught and their species, length, and mass, and percentage proportions of fish caught at Site 3 in the Lower Stave River. Average mass and length were calculated by averaging the values measured and recorded across all sampling dates.

Date	Coho Salmon	Threespine Stickleback	Red Sided Shiner	Northern Pikeminnow	Prickly Sculpin	Pumpkinseed	Brown Bullhead	Largemouth Bass
Jan-17	2	1	4	0	0	4	0	0
Feb-17	1	0	5	0	0	0	0	0
Mar-17	2	0	1	0	0	1	0	0
Nov-17	3	0	5	2	0	12	0	0
Mar-18	9	4	1	8	0	5	0	0
Sep-18	1	0	0	0	1	30	8	15
Mar-19	2	0	0	0	0	0	0	0
May-19	1	174	0	2	0	0	0	0
Sep-19	0	0	0	0	1	62	101	19
Feb-20	2	2	0	1	0	5	2	0
Totals	23	181	16	13	2	119	111	34
Percentage of Total Fish Caught (%)	4.6	36.3	3.2	2.6	0.4	23.8	22.2	6.8
Average Mass (g)	8.0	3.7	-	17.7	11.2	4.5	6.4	6.2
Average Length (mm)	80.5	63.2	-	106.0	87.5	48.5	67.2	61.1

The results of fish sampling highlight the varied use of the site by different fish species. At Site 2 the summer months are dominated by threespine stickleback and northern pikeminnow (*Ptychocheilus oregonensis*) because the channel provides good spawning habitat for the stickleback and preferred warmer water temperatures (table 4). Cooler water temperatures in the fall and late winter bring young coho to the channels. The low number of invasive species detected is promising as they are not present in large enough number to inhibit the use of the site by native species. The average length of coho found at Site 2 was 60 mm and the average mass was 3.7 g (table 4) indicating that coho less than one year old are primarily using the site (Raymond, 1986). At Site 3 the average length of coho was 80.5 mm and the average mass was 8 g (table 5) which falls within a healthy size range of 80-90 mm for coho following their second summer (Raymond, 1986).

8. Discussion

The FVWC seeks to foster cooperation between groups and individuals from diverse backgrounds for the protection and restoration of watersheds within the Fraser Valley Regional District. Most of the individuals involved in this organization freely volunteer their time and skills towards this common goal. The involvement of the FVWC raised the awareness amongst its members, as well as the broader public of the values of the Stave River and the role the FWCP is taking in protecting and restoring those values. This was accomplished through regular updates of the website and targeted media outreach. Volunteers from the community and/or local schools and associations participated in tree planting activities on the Stave River. This project is a prime example of the value of partnerships. DFO, BC Hydro, the Fraser Valley Regional District, Fraser Valley Watersheds Coalition, Stave Valley Salmonid Enhancement Society, and Kwantlen First Nation fully support these works as a component of the long-term management regime required to protect the health of the Stave River fisheries resources into the future.

The focus of this project was to enhance salmon habitat at two locations in the Lower Stave River. A new fish ladder was installed at Thompson Creek to replace an old, failing fish ladder and a riparian planting was completed to enhance the previously constructed channels at Site 2 (Kwantlen First Nation IR3) on the left bank of the Lower Stave River. Overall, the goals of this project were met as follows:

1. **Restoration of Habitat:** Replace and upgrade an old wooden fish ladder on Thompson Creek.
   Goal: New fish ladder in place and improve long-term fish passage access to ~400 linear meters (~600m^2) upstream habitat.
   Actual Result Achieved: New fish ladder installed and habitat below the ladder stabilized.
   Status: Complete.

2. **Enhancement of Habitat:** Continue replanting using native plant species stave river site 2, expanding outwards the native vegetation band to support an overall wider riparian and scrub-shrub lowland habitat to support functional fish habitat.
   Goal: Achieving at least 500 m^2 of new riparian area
   Actual Result Achieved: A total of 5750 native trees and shrubs were planted, Table 1, encompassing 1626 m^2 of new riparian area. In addition, 190KG of garbage was removed from the aquatic and riparian area.
   Status: Complete.

3. **Community Engagement:** Promote increased stewardship through community and volunteer engagement.
   Goal: Minimum 40 volunteers assisting in the work.

Actual Result Achieved: 15 volunteers assisted with the planting, 1 volunteer supported the update of the fish ladder and ongoing maintenance, 9 directors supported the project. Volunteerism was lower than anticipated this year. However, online social media and engagement and discussions about projects has been ongoing with hundreds of people.
Status: Modified-complete.

4. **Improve Science and Knowledge:** Work with Kwantlen First Nation and archaeologists to assess the right bank erosion control measures implemented in 2018.
   Goal: Conduct assessment and share results.
   Actual Result Achieved: Assessment completed recommendations to pursue additional bank structures for future.
   Status: Complete.

5. **Improve Opportunities for Sustainable Use:** In partnership with Kwantlen First Nation – impart knowledge about the importance of this site as a salmon and wildlife refuge.
   Goal: Share the final reports, monitoring reports and archaeological reports.
   Actual Result Achieved:
   Status: Complete- planned continuation.

9. Recommendations

Further actions recommended for this project include:

- Continue planting aquatic and riparian habitats.
- Continue to guard planted stock to reduce herbivory impacts.
- Consider adding nesting boxes to the project sites to increase biodiversity values.
- Consider extending the right bank LWD reef upstream and downstream to improve bank stability, conserve culturally important artifacts and create instream habitat complexity to support salmon and aquatic species.

10. Acknowledgements

Thompson Creek Fish ladder, Replanting and Assessments was managed and delivered with financial support from the Fish and Wildlife Compensation Program. www.fwcp.ca. Fraser Valley Watersheds Coalition gratefully acknowledges the financial support of the Fish and Wildlife Compensation Program for its contribution to the Thompson Creek Fish ladder, Replanting and Assessments. www.fwcp.ca

Special thanks to Julie Fournier, Trevor Oussoren, Lorraine Ens and Angus Glass.

Thank you

FVWC staff:

- Natashia Cox, Rachel Drennan, Winter Moon, Michael Gaultier, Bridgette Knowlan, Leah Alexis Tysan Dowdle

FVWC partners:

- Kwantlen First Nation & Seyem Qwantlen
- DFO Resource Restoration Unit – Dave Nanson, Al Jonsson and Jonathan Bulcock
- Stave Valley Salmonid Enhancement Society – Jim and Terry Taylor, Barb Strachan
- District of Mission
- Fraser Valley Regional District

FVWC contractors:

- Cordillera Archaeology-Brendan Gray
- ADS Bobcat - Sean Peters
- Mission Contracting - Jim
- Wade and Associate Surveying - Devon Pullman and Tanya Khan

Thanks to local stewards: Phillip and Elaine Northrop

Many thanks to our FVWC directors and community volunteers!
Together, we are working towards "*healthy watersheds and healthy communities*."

11. References

Allan, JD., Wipfli, M.S., Caouette, J.P., Prussian, A., and Rodgers, J. 2003. Influence of Streamside vegetation inputs of terrestrial invertebrates to salmonid food webs. Canadian Journal of Fisheries and Aquatic Sciences: 60, 309-320.

Bannerman S. 1998. Riparian Areas: Providing Landscape Habitat Diversity PART 5 of 7. https://www.for.gov.bc.ca/hfd/pubs/docs/en/en17.pdf

BC Ministry of Water Air and Land Protection. Biodiversity Branch. Forest Renewal. Ecological Restoration Guidelines. Accessed Dec. 9, 2019. http://www.env.gov.bc.ca/fia/documents/restorationguidelines.pdf

Blackwell, C.N., C.R. Picard, and M. Foy. 1999. Smolt productivity of off-channel habitat in the Chilliwack River watershed. B.C. Ministry of Environment, Lands and Parks, and B.C. Ministry of Forests. Watershed Restoration Project Report No. 14: 46 p.

Clewall. A.F. and Aronson. J. 2013. Ecological Restoration Principles, Values, and Structure of an Emerging Profession. 2nd ed. Island Press. Derrick, D. Coastal and Hydrualics Laboratory. US

FVRD. 2009. Chilliwack River Watershed Strategy. Accessed online Dec 9, 2019. http://www.fvrd.bc.ca/InsidetheFVRD/RegionalPlanning/Documents/Watershed/CRWSStrategy.pdf

Lapointe N., Cooke S J., Imhof JG., Boisclair D., Casselman JM., Curry R.A., Langer O.E., McLaughlin R.L., Minns C.K., Post J.R., Power M., Rasmussen J.B., Reynolds J.D., Richardson J.S., and Tonn W.M. 2013. Principles for ensuring healthy and productive freshwater ecosystems that support sustainable fisheries. Enviro. Rev. Vol. 22.

Polster, D.F. 2011. Natural Processes: Restoration of Drastically Disturbed Sites.

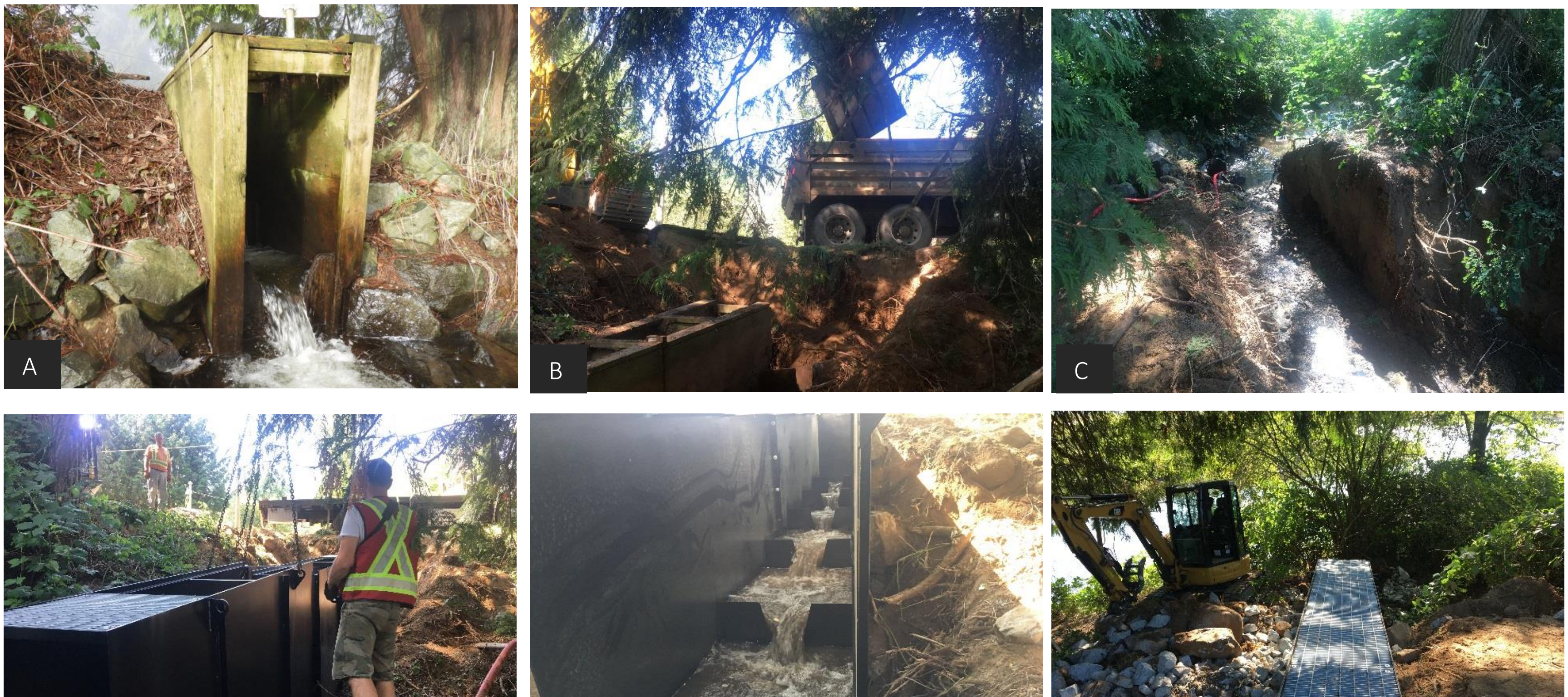
Raymond, J.A. (1986). Growth of wild and hatchery juvenile coho salmon in an interior Alaska stream (Report No. 60). Juneau, AK: Alaska Department of Fish and Game.

Rosenau, M.L. and Angelo, M. 2005. Conflicts between Agriculture and Salmon in the Eastern Fraser Valley. Pacific Fisheries Resource Conservation Council

Fraser Valley Watersheds Coalition
Unit 1 - 45950 Cheam Avenue
Chilliwack, B.C. V2P 1N6
www.fvwc.ca

Appendix A. Photo-documentation

Installation of Thompson Creek fish ladder Mission BC.



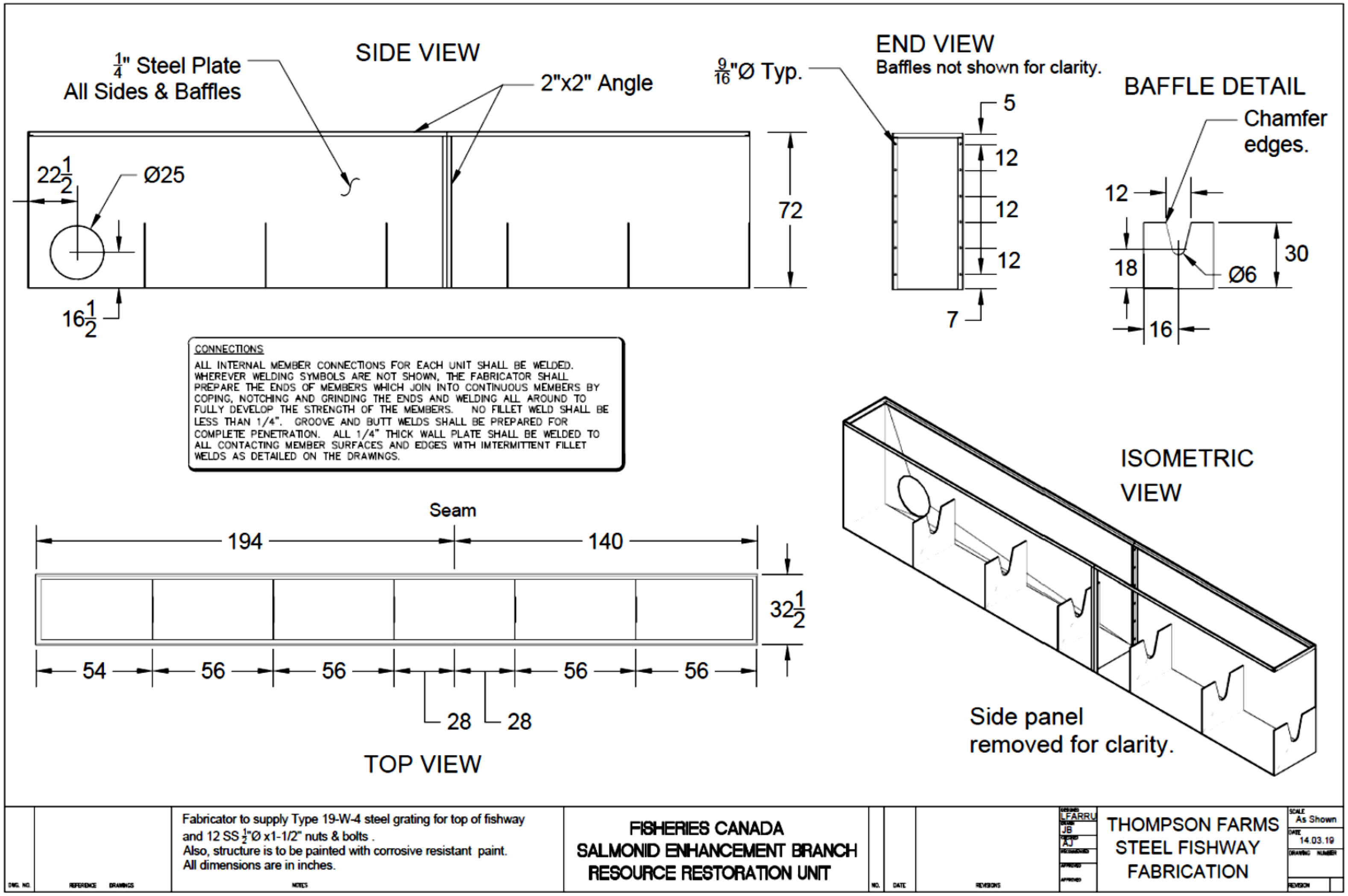
A. Wooden fish ladder to be replaced B. Excavator removes wooden fish ladder. C. Gravel added to site for correct grade. D. Steel fish ladder being lifted into place with crane truck. E. First water flowing through new fish ladder. F. New fish ladder installed and habitat below being enhanced and stabilized

Fraser Valley Watersheds Coalition
Unit 1 - 45950 Cheam Avenue
Chilliwack, B.C. V2P 1N6
www.fvwc.ca

Shrub planting on Stave site #2 Mission BC.

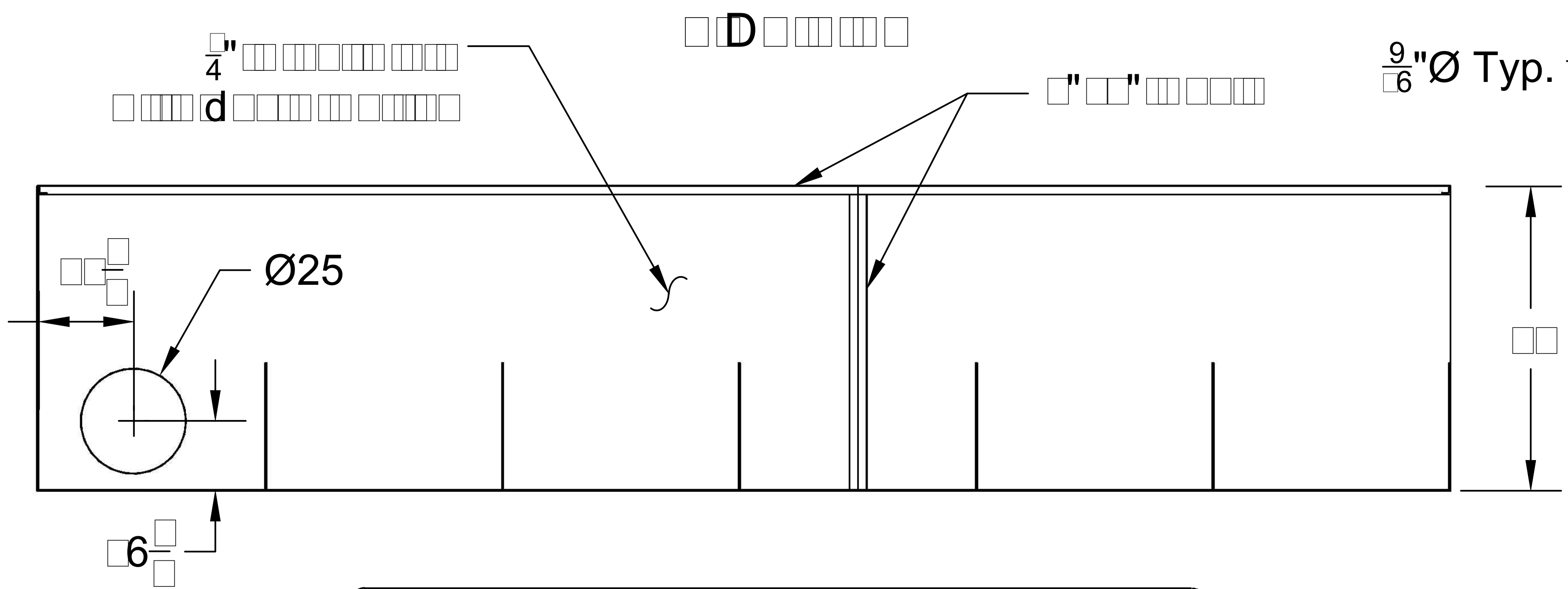
A. Excavator preparing site for fall planting. B. Plants laid out for volunteer planting C. 190 kg garbage removed from the site and disposed of properly. D. Volunteers planting. E. Shrubs guarded against beavers. F. Newly planted riparian area on Stave site #2

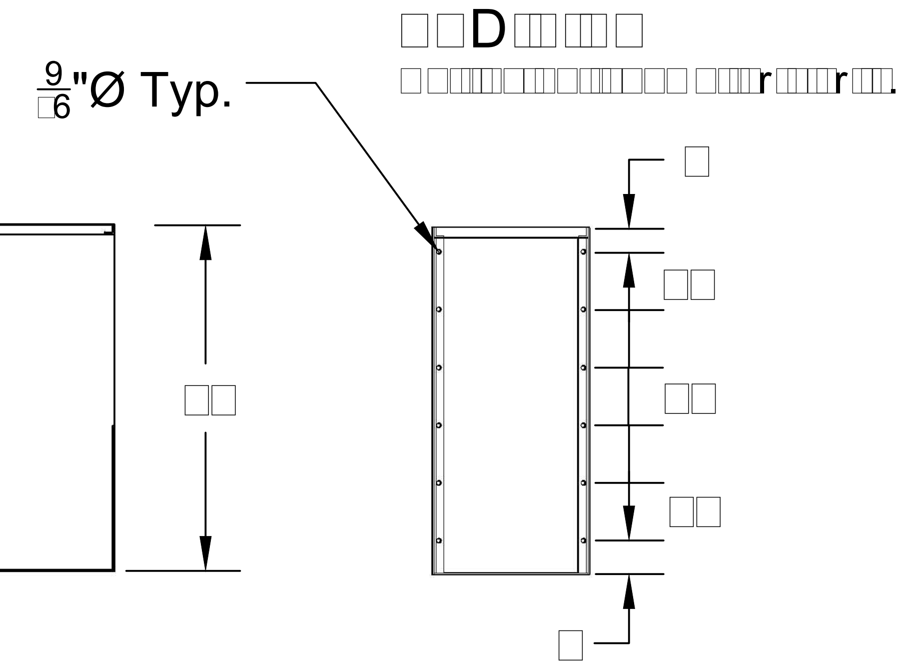
Appendix B. As-Built Diagrams

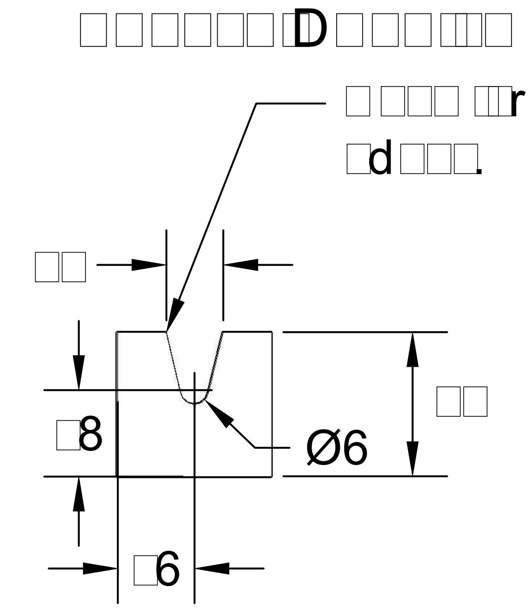


Design for the Thompson Creek fish ladder.

Cumulative planting areas (totalling 8416m^2 and represents 16% of total replanting potential of KFN IR3 within the lower floodplain). Pink polygons show areas planted in the fall 2019/winter 2020. Green and blue polygons show plantings from previous years.

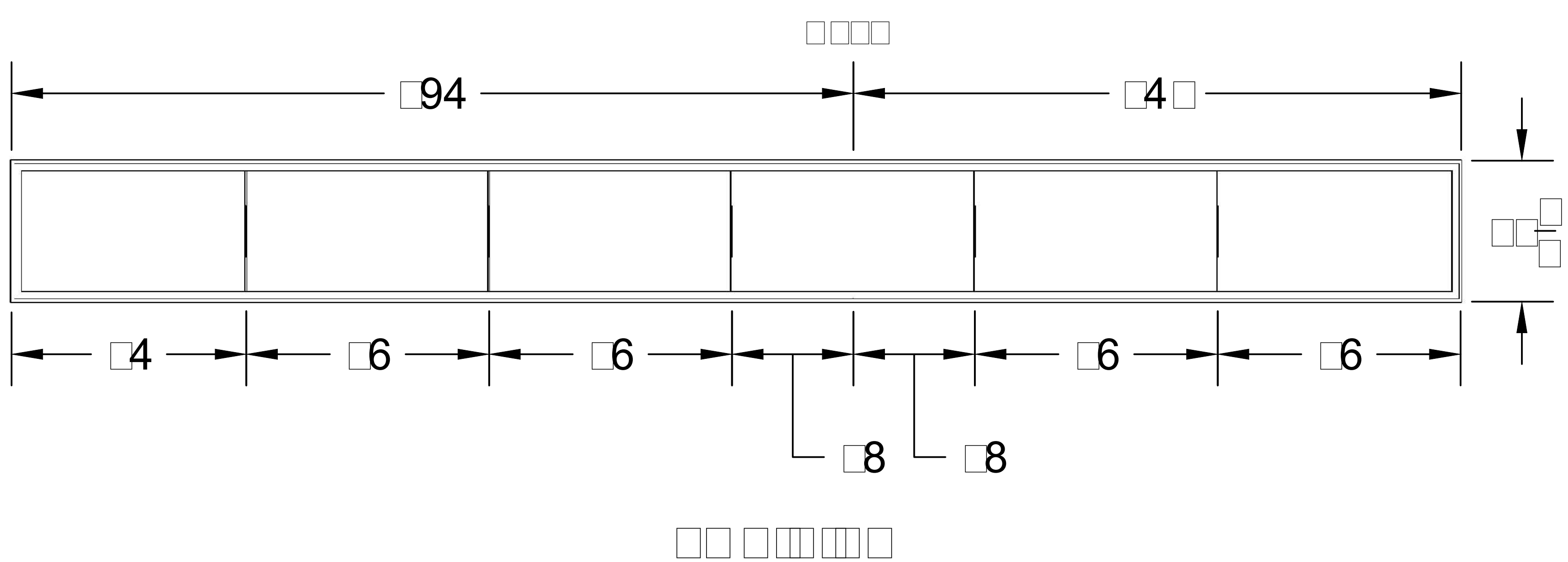


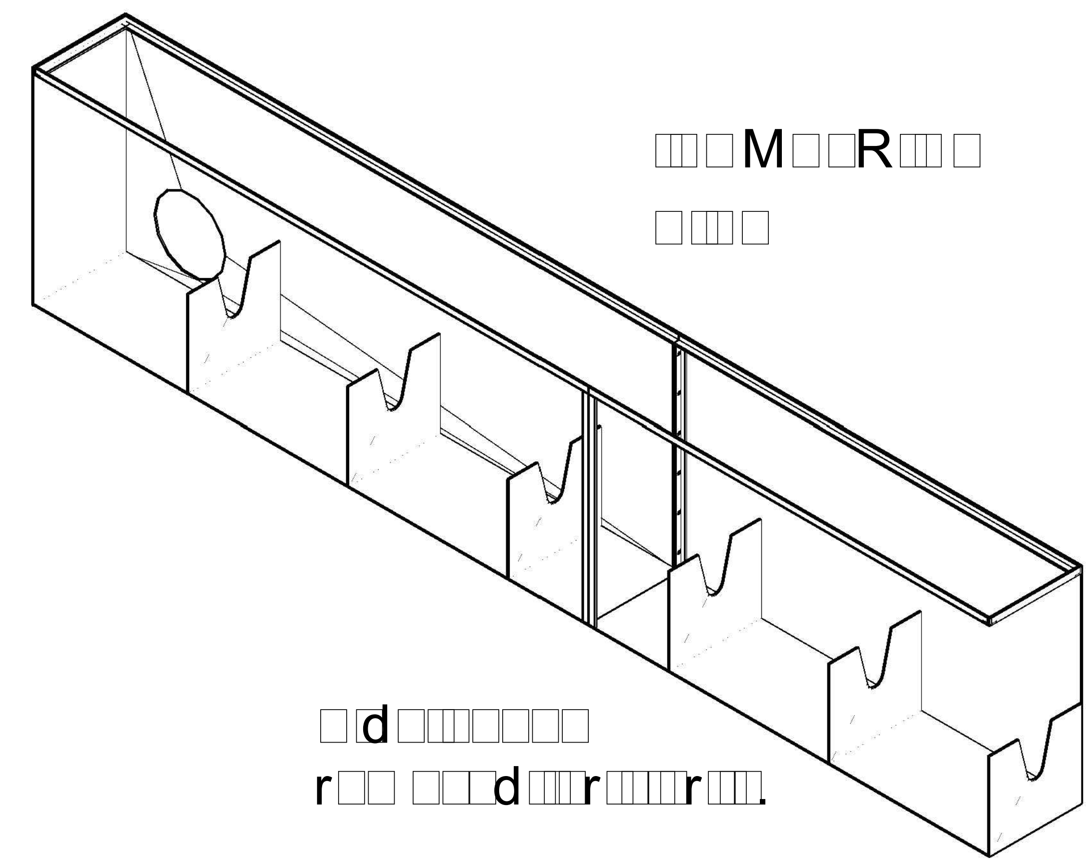




CONNECTIONS

ALL INTERNAL MEMBER CONNECTIONS FOR EACH UNIT SHALL BE WELDED. WHEREVER WELDING SYMBOLS ARE NOT SHOWN, THE FABRICATOR SHALL PREPARE THE ENDS OF MEMBERS WHICH JOIN INTO CONTINUOUS MEMBERS BY COPING, NOTCHING AND GRINDING THE ENDS AND WELDING ALL AROUND TO FULLY DEVELOP THE STRENGTH OF THE MEMBERS. NO FILLET WELD SHALL BE LESS THAN 1/4". GROOVE AND BUTT WELDS SHALL BE PREPARED FOR COMPLETE PENETRATION. ALL 1/4" THICK WALL PLATE SHALL BE WELDED TO ALL CONTACTING MEMBER SURFACES AND EDGES WITH INTERMITTENT FILLET WELDS AS DETAILED ON THE DRAWINGS.





DWG. NO.	REFERENCE DRAWINGS	NOTES		NO.	DATE	REVISIONS
		"Ø x1-1/2" nuts & bolts .	FISHERIES CANADA SALMONID ENHANCEMENT BRANCH RESOURCE RESTORATION UNIT			

DESIGNED / DRAWN / CHECKED / RECOMMENDED / APPROVED / APPROVED

SCALE / DATE / DRAWING NUMBER / REVISION

Briefing Note on DhRo-1 and Artificial Reef Site Visit

Date of site visit: February 12, 2020
Report Written February 13, 2020
Written by Brendan Gray
Field Crew: Joey Antone (Kwantlen First Nation) and Brendan Gray (Cordillera Archaeology)

This briefing note reports on a half day field visit to archaeological site DhRo-1, on the west bank of the Stave River delta, downstream from BC Hydro's Ruskin Dam. Previous archaeological excavation at the site has recovered numerous rare organic archaeological finds including cedar-woven baskets, cordage and fishing implements. Monitoring of the area and analysis of satellite imagery have revealed that significant erosion was occurring at the site. An artificial reef consisting of large interwoven sections of trees, boulders, cobbles and cables (and capped with gravels) was installed by the Fraser Valley Watershed Coalition (FVWC) and the Department of Oceans and Fisheries (DFO) Restoration Unit in fall of 2018 at the completion of archaeological excavation. The purpose of the reef was to stabilize the bank (Figure 1) thereby protecting the remaining archaeological deposits and enhancing salmon habitat. The original plan was to construct an artificial reef along the 150 linear meters of bank; however, in discussions with stakeholders and shared knowledge it was suggested that artificial reefs (historically) have had limited success (with unintended detrimental consequences) elsewhere in the Stave River delta. It was therefore decide that this installation would be a "test case" to determine if the reef would function as intended. The purpose of our current site visit was to assess the efficacy of the reef in protecting the archaeological deposits.

Figure 1. Artificial reef (photographed during current site visit) looking north (upstream) at DhRo-1.

The site visit was conducted in the early morning to take advantage of the daytime low tide window. New Westminster low tide was at 3:00 am on February 12, 2020, and was 0.40 m. We anticipated that the tide delay from New Westminster to Stave River delta was roughly three hours, and we arrived at 6:30 am and utilized flashlights to inspect the bank until daylight (Figure 2). From about 8:00 am onwards the tide rose quite quickly, obscuring the bank. Communication with BC Hydro indicated that minimal generation or spilling would be occurring at Ruskin Dam during our visit.

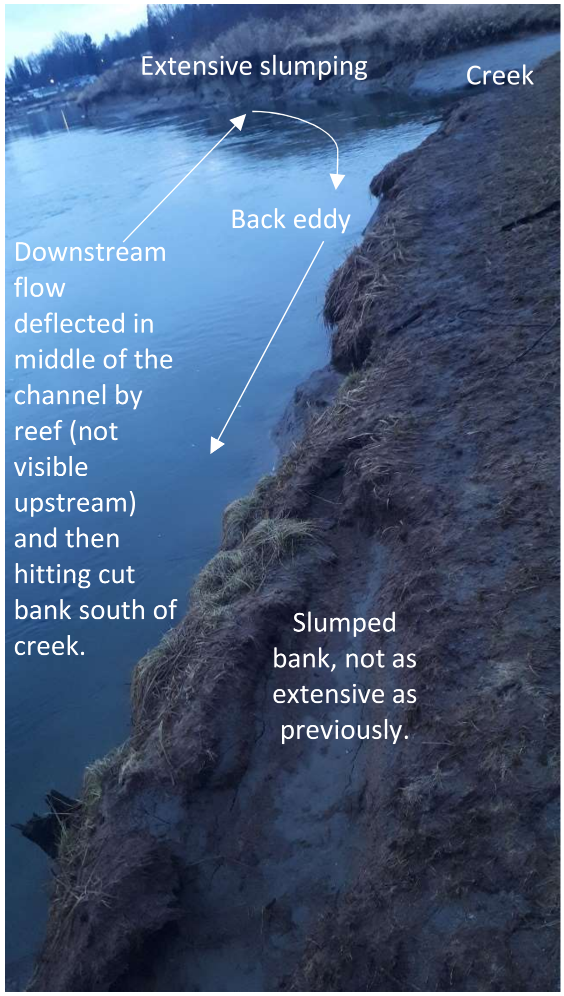
Figure 2. Survey by flashlight at 6:30 am.

Observations

1. The artificial reef appears to be doing a very good job at protecting the areas where it is installed. Not only is the reef holding the cut bank in place, but the gravels on top are preventing more erosion on the surface of the site. Geomatic mapping funded by grants from the Fish Wildlife Compensation Program (applied for by the Fraser Valley Watershed Coalition) should be able to confirm this qualitative observation with empirical data.

2. While the reef is protecting the cut bank, downstream from the reef the bank is still slumping and slowly eroding. In the past it was eroding much more quickly due to direct, fast-flowing water from upstream. What we observed is that this area is now a back eddy: the fast-flowing water has been deflected into the middle of the channel by the artificial reef, and then is hitting the bank south of the creek outflow (and causing significant erosion there), while the back eddy causes minor slumping/erosion to the area adjacent to the reef. Figure 3 below shows what we believe is occurring.

Figure 3. Slumping of the bank to the south (downstream) from artificial reef. Note extensive erosion of cut bank at top of image where downstream flows hit the bank, and then presumably back eddy towards the artificial reef.



3. The small creek which flows into the main Stave River delta channel is down cutting significantly (Figure 4). Perhaps the reef is removing the deposition of sediments from upriver where this creek located, or perhaps some other factor is at play, but sediments are both washing away and being down cut at the mouth of this creek.

4. A new exposure of the organic layer has been identified. We suspect this is the Layer IV from the large excavation from which many of the baskets and other cultural materials were recovered. The exposure of this layer is located just south of the creek mouth. This layer was 35 cm below water surface at 8:00 am. The location of this exposure is shown in Figure 5 and Figure 6 below.

Figure 4. Creek downcutting and emptying into Stave River channel.

Figure 5. Showing location of exposed organic layer. Photo looking upstream (north).

Figure 6. Joey Antone pointing trowel at organic layer underwater.

Recommendations

- Continued monitoring of the area (when feasible) should be undertaken to identify any archaeological remains eroding from the bank and to assess erosion. This can be conducted opportunistically *en route* to other archaeological projects when time and tides permit.

- Evaluative testing should be conducted (one or two 50x50 cm units) just south of the creek outflow to assess the density of organic archaeological material eroding from Layer IV. This area appears most susceptible to erosion due to back eddying and stream downcutting. Tides will likely need to be below 0.4 m in order to excavate here.

- Follow-up with BC Hydro, Kwantlen and the Fraser Valley Watershed Coalition once the results of the mapping are known.

- Follow up with all stakeholders listed above to discuss the possibility of extending artificial reef south (downstream) as far as the small creek outflow.

Summary

The Fraser Valley Watershed Coalition is thanked for providing funding for this visit, and continuing to monitor the efficacy of the artificial reef. The reef itself is doing an excellent job of protecting the cut bank, and is likely reducing erosion downstream by deflecting water flows away from the bank. One unintended result of this deflection is that a back eddy is eroding the areas downstream from the reef, and may be exacerbating downcutting by a small stream in the same area. However, we assess this new erosion to be significantly reduced compared to the previous erosion downriver flows before the reef was installed. We also observed an exposed organic layer we suspect may have significant numbers of organic artifacts directly south of the creek outflow; this area should be subsurface tested when feasible.

Further discussions with all stakeholders would be useful to determine whether the reef could be extended downstream and whether this might benefit both the protection of archaeological deposits as well as enhancing fish habitat.

www.wadesurvey.com

WADE & ASSOCIATES LAND SURVEYING LTD.
B.C. LAND SURVEYORS

22713 – 119th Ave.
Maple Ridge, B.C. V2X 8S5
Phone: (604) 463-4753 Fax: (604) 463-9115
Email: mapleridge@wadesurvey.com

104 – 32559 Logan Ave.
Mission, B.C. V2V 6W8
Phone: (604) 826-9561 Fax: (604) 826-9586
Email: mission@wadesurvey.com

Stan Wade, B.C.L.S. *Jack Wade, B.C.L.S. (1997)* *Devon Pallmann, B.C.L.S.*

ALL DISTANCES IN METRES - DISTANCES MAY BE SUBJECT TO GROSS DIFFERENCES DUE TO SUBMERSION IN RIVER AT TIME OF SURVEY.
DISTANCES ARE ACCURATE TO WITHIN BETWEEN+/- 0.1m TO +/- 0.5m, ANGULAR MEASURMENTS ARE ACCURATE TO WITHIN +/- 1' DUE TO DIFFERENCES IN SURVEY OUTFIT ACCURACIES.

LOGS

A= OBSERVATION MADE 2019 03 21
A' = OBSERVATION MADE 2020 02 13

IDENTIFIER	LOG MOVEMENT (NORTH END)	LOG MOVEMENT (SOUTH END)	AZIMUTH OF LOG 2019 03 21	AZIMUTH OF LOG 2020 02 13	ANGULAR SHIFT
A-A'	0.0	0.6	111°32'	103°09'	8°23'
B-B'	0.2	0.3	107°02'	101°46'	5°16'
C-C'	0.1	0.1	94°33'	92°43'	1°50'
D-D'	0.1	0.6	89°16'	85°08'	4°07'
E-E'	0.2	0.1	123°06'	124°53'	1°47'
F-F'	0.7	0.1	67°50'	67°19'	0°31'
G-G'	0.1	**3.2**	111°08'	105°49'	5°19'
H-H'	0.1	**2.5**	140°03'	116°06'	**23°57'**
I-I'	0.2	0.9	103°00'	97°40'	5°21'
J-J'	0.4	0.1	28°11'	31°06'	2°55'

ROCKS

1= OBSERVATION MADE 2019 03 21
1' = OBSERVATION MADE 2020 02 13 - ALL OBSERVATIONS TAKEN FROM CENTER OF ROCK

IDENTIFIER	ROCK MOVEMENT	AZIMUTH OF MOVMENT
1-1'	0.1	347°19'
2-2'	0.2	180°20'
3-3'	0.2	188°34'
4-4'	0.2	107°07'
5-5'	0.1	308°16'20
6-6'	0.1	77°05'
7-7'	0.1	215°06'
8-8'	0.2	289°27'

IDENTIFIER	ROCK MOVEMENT	AZIMUTH OF MOVMENT
9-9'	0.1	95°25'
10-10'	0.2	77°22'
11-11'	0.4	104°08'
12-12'	0.2	117°17'
13-13'	0.2	337°13'
14-14'	0.1	38°08'
15-15'	0.3	89°03'
1616'	0.4	49°38'
17-17'	0.2	256°47'
18-18'	0.2	100°48'
19-19'	0.1	216°53'
20-20'	0.2	190°41'
21-21'	0.2	305°53'
22-22'	0.2	276°30'
23-23'	0.1	224°19'
24-24'	0.1	23°59'
25-25'	0.2	75°03'
26-26'	0.3	317°32'
27-27'	0.2	14°30'
28-28'	0.3	61°49'
29-29'	0.1	166°27'
30-30'	0.3	252°56'
31-31'	0.1	93°38'
32-32'	0.2	150°40'
33-33'	0.1	354°31'
34-34'	0.1	151°25'
35-35'	0.2	53°17'
36-36'	0.1	98°43'
37-37'	0.1	298°09'
38-38'	0.2	151°13'
39-39'	0.2	106°55'
40-40'	0.0	312°13'
41-41'	0.1	210°51'
42-42'	0.1	68°02'
43-43'	0.1	56°00'

IDENTIFIER	ROCK MOVEMENT	AZIMUTH OF MOVMENT
44-44'	0.1	6°31'
45-45'	0.2	183^{2}17'
46-46'	0.0	318°36'
47-47'	0.2	144°09'
48-48'	0.4	120°50'
49-49'	0.1	259°59'
50-50'	0.3	302°19'
51-51'	0.2	261°04'
52-52'	0.1	101°25'

TOPOGRAPHIC SURVEY OF PART OF RIGHT BANK OF STAVE RIVER

SCALE 1 : 100

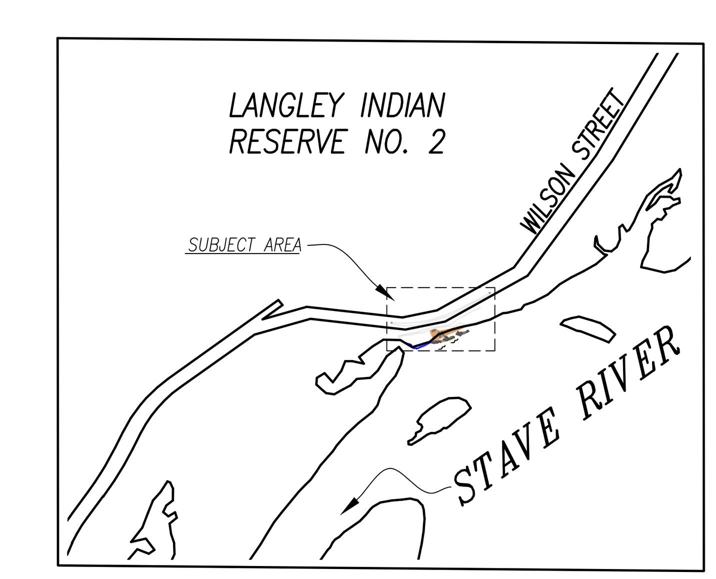
ALL DISTANCES ARE IN METRES AND DECIMALS THEREOF UNLESS OTHERWISE INDICATED.

CIVIC ADDRESS: APPROXIMATELY 7724 WILSON STREET, MISSION

PARCEL IDENTIFIER: (PIN) 15266540

KEYPLAN

SCALE: 1 : 7500



REEF ANALYSIS
PLEASE REFER TO SPREADSHEET FOR COMPARISON BETWEEN ROCKS AND LOGS THAT WERE OBSERVED MARCH 21, 2019 AND FEBRUARY 13, 2020

LEGEND
A–A' = MOVEMENT OF LOGS (2019–03–21 – 2020–02–14)
1–1' = MOVEMENT OF ROCKS (2019–03–21 – 2020–02–14)

ELEVATIONS ARE IN METRES (GEODETIC)
ELEVATIONS REFERENCED TO CGVD28

SURVEYED:
FEBRUARY 13, 2020
FEBRUARY 24, 2020

DATED THIS 25TH DAY OF FEBRUARY, 2020

WADE & ASSOCIATES LAND SURVEYING LTD.
BC LAND SURVEYORS
MISSION & MAPLE RIDGE
PHONE: (604) 826–9561 OR 463–4753
FILE: M4015–01 R1

PREPARED FOR: FRASER VALLEY WATERSHED COALITION

DEVON PALLMANN, B.C.L.S.