

Project Title: Lower Stave River- Restoring and Enhancing Freshwater Tidal Floodplain Habitats

FWCP Project No. COA-F19-2720

March 27, 2019



Prepared for: Fish and Wildlife Compensation Program

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Prepared with financial support of the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and Public Stakeholders.

Executive Summary

The overall purpose of this project was to build on previous year's enhancement and monitoring efforts in the Lower Stave River to better understand and enhance existing habitats, support biodiversity values and plan for further multi-species approach for restoration and enhancement opportunities in the future. It aligns with **FWCP Stave River Watershed Action Plan: Ecosystem chapter: Rivers, Lakes and Reservoirs Actions 2-1, 4-1 and 7-1.**

Over the past few years significant new off-channel habitat was constructed and far exceeded the area able to plant within a single year. As of March 31 2019, approximately 13% (6,790 m²) of the total targeted low floodplain area at Stave Site 2 (51,810 m²) has been planted. Of which, 66% of the planting efforts achieved to date fall under the scope of this project. Riparian and aquatic plants are important for streambank stabilization, reducing the encroachment of invasive reed canary grass and providing leaf litter and insects (by way of falling) into the water, and is crucial for salmon growth and development. Further planting efforts will be necessary to effectively plant Stave Site 2.

A key component of this project was to have an independent third party assess the effectiveness of the planting efforts and suggest methods to improve plant survivorship. (Of note, planting in clay, which is tightly packed, retains water and has a negative ionic charge and constitutes a significant portion of the substrate at the planting locations, makes plant selection and survivorship challenging. Results indicated that planting efforts are working to reduce reed canary grass encroachment and increase biodiversity (a key target).

Monitoring of fish, birds and turtles within the lower Stave was important to understand current usage of habitat features and conditions and identify knowledge gaps and enhancement opportunities for the future. This project falls within known critical habitat for the western painted turtle, a species-at-risk. As such, monitoring of hatchling and sensitive nest sites during the mobilization of equipment was important. In addition, future opportunities for enhancement were identified.

Monitoring bird usage helped understand the biodiversity values in the Lower Stave River. 37 different birds were observed as currently using this lower floodplain system during this project. Local biologists suggest that the iconic Sandhill cranes populations are in decline and may represent a unique sub-population. Thus, monitoring efforts focussed on the crane and efforts looked at the lower Stave River and connections to known crane locations throughout the south coast. While no Sandhill cranes were observed at the project sites during the monitoring efforts, cranes have been observed in neighbouring watersheds (Whonnock) with a flight migration route into the upper Stave. More research and monitoring on this is required. Opportunities do exist in the lower river floodplain system to increase nesting, forage habitat for the Sandhill crane, and coincide with existing planting efforts completed as part of this project.

Water quality and fish monitoring indicated that both native and non-native fish use the habitats and that water quality is able to support all aquatic life stages during the winter months (over-wintering habitat). Further, mapping of tributaries along the west (right bank) of the Stave River identified opportunities for potential restoration activities to improve and create connectivity of aquatic habitats into the Stave River system.

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Introduction

The construction of the Ruskin dam on the lower Stave River permanently alienated over 90% of the historic habitats available to coho salmon in this watershed. There are limited areas remaining on the lower Stave River floodplain that support significant populations of coho salmon 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. This section of the River consists of numerous channels and gravel bars. Up to 500,000 chum salmon and hundreds of coho, pink and chinook salmon spawn in these graveled channels. In an attempt to increase viable salmon populations in this lower reach, habitat improvements for rearing and overwintering are critical for both adronomous and resident salmon species. There are significant opportunities for habitat creation and enhancement on the river left bank between Stave River and Silvermere Lake (Site 2).

Site 2, Silvermere Island, owned by Kwantlen First Nations IR3, provides an excellent opportunity to expand off channel tidal habitats creating shallow sedge benches. This restoration effort will be divided into three phases, this proposal represents year three, and access has been approved by Kwantlen First Nation and the restoration works align with the environmental values identified by Kwantlen FN Land. In addition to the physical restoration, enhancement and monitoring works associated with Site 2 and 3. The Stave River East and West river bank side channels were identified as areas of high use by remaining Stave River coho salmon populations. Coho salmon has been identified as a high priority species with high priority status for restoration in the Stave River system. This proposal is also expected to benefit natal and non-natal juvenile chinook salmon population in Stave River by providing greater opportunities for rearing in tidal channels. This project is part of a watershed-level restoration plan-meant to support viable salmon and fish habitats and populations through community engagement and collaboration.

Pursuing this project was timely as many community and partner organizations are also ready to support this project, building on the momentum and success that has been built over the last few years. In addition, the instream channel creation completed over the last two years has far surpassed the planting efforts that were able to be achieved. It is important to continue planting all these newly created habitats so that invasive species, like reed canary grass, have less "space" to re-establish, encroach and reduce these salmon and estuary habitats. It is also important to ensure natural habitats, like these are functioning so that the Fraser River corridor and the freshwater estuaries within in, act as refuge for salmonid species.

Goals and Objectives

The vision for the Lower Stave River is a river system full of wild Pacific salmon, with robust forests and wetlands that provides many wildlife values and ensures cultural areas of importance are protected and conserved.

The objectives of this project were to restore and enhance salmon habitat and collect data about species usage and aquatic conditions, with the specific goals listed below.

1. Replant Stave Site 2 to support a biodiverse freshwater floodplain system supporting in and out migrating salmon species and low floodplain flora and fauna. Anticipated replanting of min 1500 m² of habitat.
2. Monitor Stave Site 2 bird usage -to begin understanding what bird species use these newly restored lowland scrub-shrub habitats (North American Waterfowl Management Plan (NAWMP). Anticipated result of monitoring is a species presence summary.
3. Monitor Stave Site 2 and continue to monitor Stave Site 3 for fish usage and Water Quality. Anticipated result of monitoring are a species presence summary and water quality summary.
4. Map the west tributaries entering into the right bank of Stave to assist in directed identification of future restoration opportunities, restrictions/challenges to salmon habitat in the lower river system. Anticipated result is geospatial files of streams and enhancement/challenge features/limitations.
5. Complete an effectiveness assessment of enhancement activities - adaptive management.
6. Engage the community on the importance of freshwater tidal floodplain ecosystems.

Study Area

This project is located within the lower 2 km of the Stave River south of the Ruskin Hydro dam, with the municipal boundaries of the District of Mission, IR lands of Kwantlen First Nation, and Fraser Valley Regional District, Map1. Planting and monitoring works focussed on Stave Site 2 and Site 3, IR3. Mapping occurred on the west bank of the Stave River between the river, Wilson Rd and toe of slope of Iron Mountain, Mission.



Map 1 Overview Map of project scope shown as dashed red line.

Methods

Objective 1. Replant Stave Site 2 to support a biodiverse freshwater floodplain system supporting in and out migrating salmon species and low floodplain flora and fauna.

FVWC staff and volunteers completed planting by hand on the aquatic benches and the upland riparian areas in the Stave river floodplain. The substrate of these channels is made up of clay and sandy silt, and this lower Stave River area undergoes significant hydrological fluctuation due to tides, seasonal drought and tail-water releases from the Ruskin Dam. Due to this environmental factors, many sedges and rushes along the lower and middle elevation benches to help retain organic matter and help build soil. Species selection included aquatic vegetation that is fast growing and is able to root aggressively in poorer soils such as the slough sedge (*Carex obnupta*). Higher bench species included water-tolerant and drought-tolerant species such as Hardhack (*Spirea douglasii*) and Sweet gale (*Myrica gale*). A variety of native willows and black cottonwood live stakes, harvested locally, were inter-planted between the other shrubs. Planting densities were carefully chosen in order to prevent undesirable invasive species, such as Reed Canary Grass (*Phalaris arundinacea*) from colonizing the area (Lavergne & Molofsky, 2004) (Maurer, et al., 2003).

These shrub-scrub class of plants will help to increase bank stability, shade the channel, and provide important leaf litter into the system (Hicks, 1984) (Shreffler, Simenstad, & Thom, 1992). They will also provide habitat and food for birds and other wildlife (Steen, Skagen, & Noon, 2014). The plantings of live stakes were guarded with wire cages and plastic tree guards surrounding them to prevent herbivory from beaver and other small mammals. Riparian areas are important transition areas that connect the water with the land, and support a wide variety of plants and animals. Trees and shrubs that overhang streams can moderate the temperature through shading, benefiting fish and aquatic invertebrates, as well as preventing excess algae growth (Bannerman, 1998).

During the original instream construction, the site was left rough and loose, creating puddles and micro-topography which allows cottonwood seeds and other colonizer species, to germinate onsite. Species such as Red alder (*Alnus rubra*), Sweet gale (*Myrica gale*) and Black cottonwood (*Populus trichocarpa*) are beginning to colonize this site (Polster, 2010). Mycorrhizae was added to the plantings to help reduce drought stress and jumpstart plant growth.

Objective 2a: Monitor Stave Site 2 bird usage -to begin understanding what bird species use these newly restored lowland scrub-shrub habitats (North American Waterfowl Management Plan (NAWMP)). Anticipated result of monitoring is a species presence summary.

FVWC contracted TerraFauna Consulting, Myles Lamont, to assess existing bird usage and opportunities to enhance the floodplain site to support nesting and migratory birds, with specific emphasis on Sandhill crane. Visual assessments and site visits were completed.

Objective 2b: Monitor Stave Site 2 for Western Painted Turtles. Anticipated result of monitoring is a species presence summary.

FVWC contracted the Western Painted Turtle Conservation team, Aimee Mitchell and Deana McTavish, to complete a monitoring session for turtles so that planned activities can work around known emergent and sensitive areas. Visual surveys were completed.

Objective 3: Monitor Stave Site 2 and continue to monitor Stave Site 3 for fish usage and Water Quality. Anticipated result of monitoring are a species presence summary and water quality summary.

FVWC staff used minnow and feddes traps with an average soak time between 20-24 hours at Stave Site 2 and 3 to assess fish presence and usage. Traps were set at planned locations, and prior to set, water quality parameters including dissolved oxygen, temperature, depth, pH, salinity and conductivity were measured. Fish caught were counted, recorded and returned to the river system.

Objective 4: Map the west tributaries entering into the right bank of Stave to assist in directed identification of future restoration opportunities, restrictions/challenges to salmon habitat in the lower river system. Anticipated result is geospatial files of streams and enhancement/challenge features/limitations

FVWC staff conducted a preliminary desktop review of known/ existing streams and wetlands through the community mapping network, IMap BC, and the municipal web map. These were then ground-truthed using a Trimble GPS by FVWC staff, and geo-referenced by FVWC Contractors Durand Ecological, Ryan Durand. Corrected and collected files were then overlaid on a Google Earth to identify information gaps and opportunities for further investigation with the intent of informing future (potential) off-channel habitat enhancement works.

Objective 5: Complete an effectiveness assessment of enhancement activities - adaptive management.

FVWC contracted Raincoast Applied Ecological, Claudia Schaefer and Nick Page, to complete randomized transects and plots on planted and non-planted areas in Stave Site 2 to assess the species richness differences and determine if planting efforts are resulting in improved diversity and discouraging reed canary grass encroachment.

Results and Outcomes

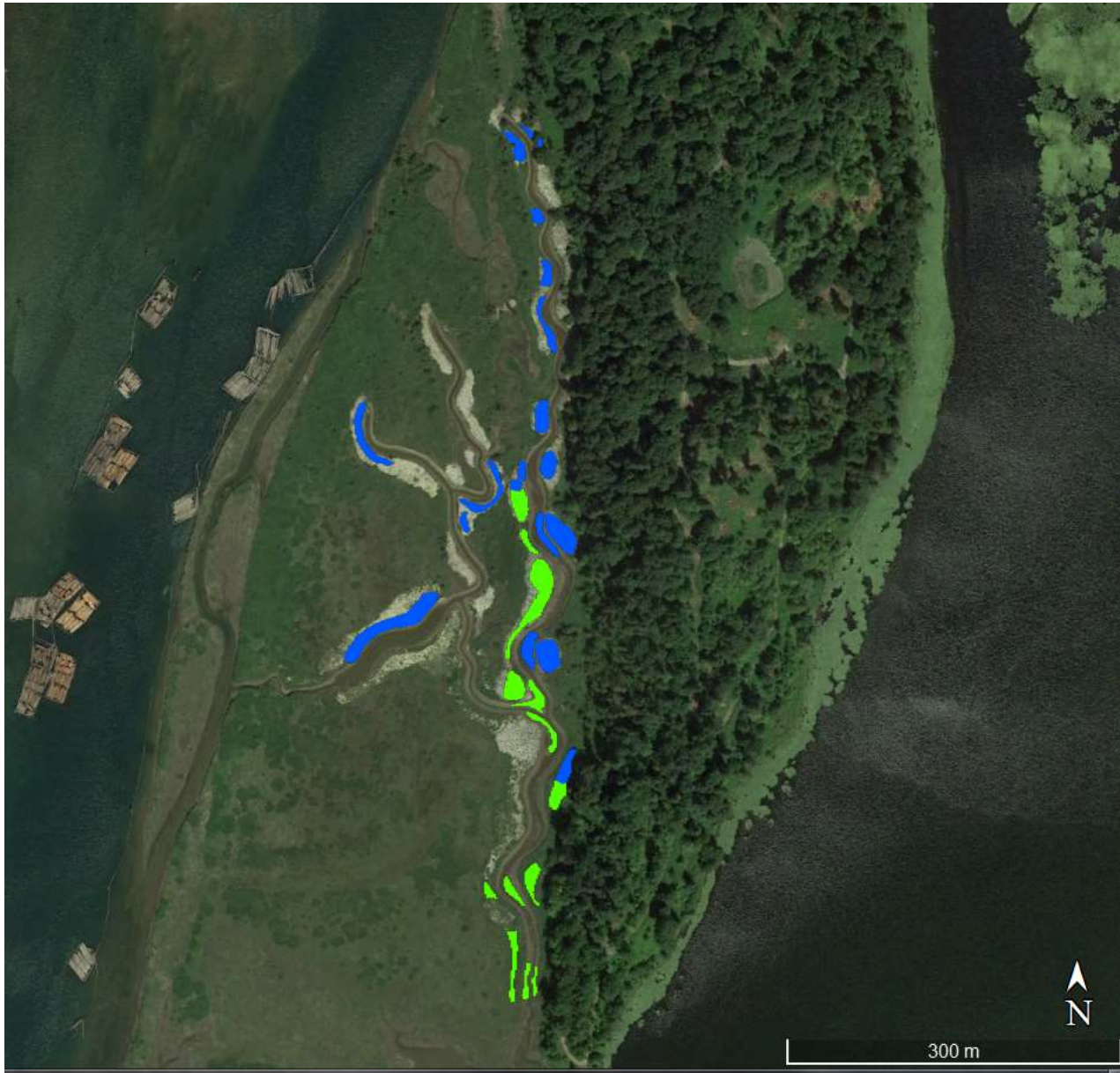
Objective 1. Replant Stave Site 2 to support a biodiverse freshwater floodplain system supporting in and out migrating salmon species and low floodplain flora and fauna. Anticipated replanting of min 1500 m² of habitat.

Actual Achieved: 4,454 m² (From September 4, 2018 to March 31, 2019).

Between September 4, 2018 and March 31, 2019 FVWC staff, Kwantlen First Nation field technicians and volunteers planted 11,829 individual plant species over 4,454 m² of aquatic-bench riparian areas on Stave Site 2, Table 1, Map 2. Figure 1. This years planting efforts represents 66% of the total planted areas at Stave Site 2, of which since planted efforts began, has resulted in a total planted area of 6,790 m², Map 3. Of the approximate linear 1,727 m of recently constructed off-channel habitats, of which require an estimated minimum 15m riparian area on both left and right bank (totalling an approximate 51,810 m²) is required. Efforts of replanting focussed on highest elevations areas so that planted stock can withstand the freshet and high-water tides, and were closest to the newly constructed channel.



Map 2 Stave Site 2 Planted areas (totalling 4,454m²) from September 1, 2018 to March 31, 2019



Map 3 Stave Site 2 Cumulative planting areas (totalling 6,790m² and represents 13% of total replanting needed within lower floodplain). Green polygons represent efforts up to April 1, 2018. Blue polygons represent efforts from September 1, 2018 to March 31, 2019.

Table 1. Native vegetation planted at Stave Site 2

Common name	Latin name	Size	Number
Red-osier dogwood	<i>Cornus sericea</i>	1gal	210
Red-osier dogwood	<i>Cornus sericea</i>	2gal	110
Sweetgale	<i>Myrica gale</i>	1gal	115
Scoulers willow	<i>Salix scouleriana</i>	1gal	60
Hardhack	<i>Spiraea douglasii</i>	1gal	450
Hardhack	<i>Spiraea douglasii</i>	2gal	350
nutka rose	<i>Rosa nootkatensis</i>	2gal	280
Hookers willow	<i>Salix hookeriana</i>	1gal	120
Scoulers willow	<i>Salix scouleriana</i>	1gal	60
Salmonberry	<i>Rubus spectabilis</i>	1gal	60
Salmonberry	<i>Rubus spectabilis</i>	2gal	30
Twinberry	<i>Lonicera involucrata</i>	2gal	100
cottonwood	<i>Populus trichocarpa</i>	1gal	30
Total potted stock			1,975
Sedge mats	<i>Carex obnupta</i>	60 cm ² trays	30
Wool grass	<i>Scirpus cyperinus</i>	1gal	173
Small flowering bulrush	<i>Scirpus microcarpus</i>	1gal	100
Wool grass	<i>Scirpus cyperinus</i>	50pl	150
Cattail	<i>Typha latifolia</i>	72pl	144
Sawbeak sedge	<i>Carex stipata</i>	50pl	100
Tall Mana grass	<i>Glyceria elata</i>	50pl	100
Common rush	<i>Juncus effusus</i>	72pl	144
Hard stem bullrush	<i>Scirpus acutus</i>	50pl	150
Slough sedge	<i>Carex obnupta</i>	72pl	288
Total Aquatics			1,379
Willow live stakes	<i>Salix sp.</i>		3,700
Cottonwood live stakes	<i>Populus sp.</i>		1,050
Hardhack live stakes	<i>Spiraea douglasii</i>		2,700
Sweet gale live stakes	<i>Myrica gale</i>		1,000
Chokecherry live stakes	<i>Prunus virginiana</i>		25
Total live stakes			8,475
Total plants			11,829



Figure 1. Planting Stave Site 2. a) Sedge mats b) muruca volvo to haul plants and herbivory guards to the floodplain c) adding mycorrhizal fungi to the soil d) volunteer planting event e) University of Fraser Valley - geography volunteer planting event

Objective 2a: Monitor Stave Site 2 bird usage -to begin understanding what bird species use these newly restored lowland scrub-shrub habitats (North American Waterfowl Management Plan (NAWMP)). Anticipated result of monitoring is a species presence summary.

Actual Result Achieved: Assessment Completed. Please Refer to [Appendix A](#). for Report.

Details: Visual monitoring resulted in confirmation of 37 bird species using the lower Stave River with greatest diversity occurring in the late Fall during known migration times and coincides with the return of the salmon to natal spawning grounds. With a keen interest in understanding the local Sandhill Crane population, no on-site observations were made. However, research of local crane flight patterns may indicate upper Stave River watershed habitat use. Further, enhancements for foraging and nesting Sandhill Cranes in the lower Stave may provide opportunity for future establishment.

Objective 2b: Monitor Stave Site 2 for Western Painted Turtles. Anticipated result of monitoring is a species presence summary.

Actual Achieved: Assessment Completed. Please Refer to [Appendix B](#) for Report.

Details: Sections of the lower Stave River fall within known critical habitat for the Western Painted Turtle. As such, monitoring and identifying for their presence and sensitive ground nesting sites is important in designing access routes for machinery, equipment mobilization and replanting efforts to restrict any negative impacts to hatchling turtles. Further, biologists provided recommendations for future nesting habitat enhancement opportunities.

Objective 3: Monitor Stave Site 2 and continue to monitor Stave Site 3 for fish usage and Water Quality. Anticipated result of monitoring are a species presence summary and water quality summary.

Actual Achieved: Assessment Completed. Please Refer to [Appendix C](#). for Report.

Details: The purpose of monitoring water quality and fish presence is that it provides an understanding of the aquatic ecology and provides information about habitat usage, and can indicate overall habitat diversity over-time. Overall, of the fish caught in minnow traps were (50%) Northern Pikeminnow (native), 20% Pumpkinseed (non-native), 20% Largescale suckers and 10% Redside Shiners (native). Overwintering aquatic temperatures and dissolved oxygen remained within the minimum required to sustain fish and wildlife, as set by British Columbia Ministry of Water, Land and Air Protection. Water Quality guidelines. However, water depth at Stave Site # 2 prevented fish sampling in September 2018. According to BC Hydro, record-breaking “dry” years and low snow pack levels affected tail-water release minimums and may be reason for limited fish sampling opportunities.

Objective 4: Map the west tributaries entering into the right bank of Stave to assist in directed identification of future restoration opportunities, restrictions/challenges to salmon habitat in the lower river system. Anticipated result is geospatial files of streams and enhancement/challenge features/limitations

Actual Achieved: Assessment Completed. Please Refer to [Appendix D.](#) for Report.

Details: The Lower Stave River is confined to roughly the lower 2km from the Ruskin power station and the confluence of the Fraser River. In an effort to identify and pursue future enhancement opportunities to re-connect and create additional off-channel habitat in this lower system, mapping and board assessment of the existing waterways and data gaps is necessary. Preliminary mapping identified numerous watercourses flowing from Iron Mountain, Mission BC southeast towards the Fraser River. Six identified waterways, three of which appear to be red-coded fish bearing flow into the Stave River. Also identified are springs and seepages occurring at the base of the mountain slope above Reidal St. and Wilson St. The elevation at the toe of the mountain is about 30 meters, while the lowest floodplain immediately on the river is approximately 5 meters. Ten culverts fall within the scope of mapping assessment. Opportunity to construct off-channel habitats that connect to the Lower Stave River exist- additional investigation of these areas and consultation with key stakeholders is recommended as next steps.

Objective 5: Complete an effectiveness assessment of enhancement activities - adaptive management.

Actual Achieved: Assessment Completed. Please Refer to [Appendix E.](#) for Report.

Details: The vegetation assessment answered five important questions about the effectiveness of the planting efforts. Understanding these helps refine our planting efforts and designs.

1. **Question:** Are our restoration and enhancement sites creating more diversity and becoming more complex?

Answer: **Yes!** 78% more native plant species than non-planted sites. The complexity is greater in restored sites – in planted sites there is 100% shrub-tree presence and cover increased by 9%.

2. **Question:** Are we able to see this change within a year or two of restoration and enhancement activities?

Answer: **Yes!** The increase in species richness can be seen within one year of enhancement activities. The complexity (number of strata or diversity of layers) has increased within one year of enhancement activities.

3. **Question:** Are we seeing a change from more invasive species to more native species?
Answer: **Yes!** 78% more native plant species than non-planted sites. Reed canary grass was found at substantially lower cover in planted sites than in non-planted sites (42% vs. 98% average cover; the non-planted sites had **233%** more canary grass).

4. **Question:** Are there certain species that are more dominant and more effectively competing against the reed canary grass than others?
Answer: **Difficult to determine site-specifically at this time**, however certain ecological trait are known to increase competitive ability. Black cottonwood was found in 90% of the plots within the planted sites and had the highest cover of the planted species,

5. **Question:** Do the planted areas appear to be growing and surviving?
Answer: **Predominantly, yes.** The large majority of observed tree and shrub plantings above the channel banks had survived the first summer and were growing well.

Discussion

Restoring riverine floodplain habitats is important for ensuring the integrity and availability of off-channel habitat availability for pacific salmon, water-fowl and wildlife. This is particularly true in that 70% of these connected habitat types have been lost from the Fraser River floodplain (Mackenzie & Shaw, 1999) (Wetland Stewardship Partnership, 2010) (Brinson, 2002). Thus, efforts to restore and enhance these aquatic ecosystems not only provide benefit to nature, they also provide valuable services to the community including increased area to absorb and retain high-water flows (Martin, Maris, & Simberloff, 2016) (Verschelling, Perk, & Middelkoop, 2018).

The riparian vegetation will have lasting benefits. Full results will take an estimated five to ten years for stock to mature before changes are observed. The benefits include providing shade to the channel, regulating water and soil temperature on a microhabitat level, and increasing bank stability, particularly where deep-rooted species were planted (Pringle, 2003). By increasing riparian vegetation on site, organic and detritus material will be added into the system which creates suitable habitat for riparian and aquatic invertebrates and makes the area less susceptible to invasive plant re-establishment. Insects falling from riparian vegetation into streams represent an important food source for drift-feeding fishes in headwater streams (Allan, Wipfli, Caouette, Prussian, & Rodgers, 2003) (Beechie, Richardson, Gurnell, & Negishi, 2013) (Bannerman, 1998). Further, complex habitats provide the foundation for a variety of species (Reynolds, et al., 2017). The efficacy of commercial inoculants has advanced tremendously in recent years. The effects of mycorrhizal colonization are often noticeable in early growth, the plants may be taller, have more foliage and larger root systems (Quoreshi, Siddiqui, Akhtar, & Futai, 2008). If water is scarce in the years right after planting mycorrhizae will help reduce drought stress on the native plants.

Recommendations

- Continue replanting Stave Site 2 using a diversity of plant species in high densities to discourage and displace reed canary grass from establishing and encroaching on the riparian and aquatic habitats.
- Continue to monitor for aquatic fish populations in the lower Stave River.
- Consider opportunities to support greater soil building accumulation methods to support the riparian and aquatic bench plantings.
- Consider, where appropriate raising island elevations to above freshet levels to support Sandhill crane populations as part of their migratory route throughout the lower south coast.
- In collaboration with the Western Painted Turtle team, identify opportunities to enhance critical habitats within the Lower Stave River to benefit juvenile and adult turtles.
- In collaboration with DFO, Kwantlen First Nation, BC Hydro and local stakeholders identify opportunities to increase and create viable off-channel habitats to benefit salmon, especially in light of climate change impacts to water resources (Verschelling, Perk, & Middelkoop, 2018).

List of Appendices

- A. Bird Usage Report- Sandhill Crane
- B. Western Painted Turtle Monitoring Report
- C. Water Quality and Fish Monitoring Report
- D. Mapped Tributaries Report
- E. Planting effectiveness assessment Report

Acknowledgements

Thank you to our funders:

- Fish & Wildlife Compensation Program
- BC Hydro
- National Wetlands Conservation Fund
- TD Friends of the Environment

Thank you to our partners and team

- Kwantlen First Nation
- DFO Resource Restoration Unit
- BC Hydro - Ruskin Power substation
- District of Mission
- Stave Valley Salmonid Enhancement Society
- Fraser Valley Regional District
- Ducks Unlimited Canada
- Ministry of Transportation and Infrastructure
- University of the Fraser Valley
- Coastal Painted Turtles Conservation Program
- TerraFauna Wildlife Ltd.
- Raincoast Applied Ecology
- Durand Ecological Ltd.

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Lower Stave River- Sandhill Crane Survey Results & Recommendations

Prepared For
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12 March 2019





Lower Stave River- Sandhill Crane Survey

Background & Historical Overview

The Sandhill Crane (*Antigone canadensis*) is a large wading bird found throughout North America. Typically breeding in the Canadian boreal or tundra barren lands, a few populations are non-migratory, resident breeders; those being the Mississippi race (*A. c. pulla*), Florida race (*A. c. pratensis*) and Cuban race (*A. c. nesiotetes*), with both the *pulla* and *nesiotetes* populations classified as being endangered under the U.S. Endangered Species Act (Endangered Species Act 1973).

A local, resident population of Sandhill Crane also exists in the Fraser Valley. This population has never been formally surveyed or assessed other than through localized and concentrated survey efforts, mostly around Burns Bog (Harding 2010; Gebauer 1999) and more recently in Delta for part of a provincial highway expansion project (Hemmera 2009). This population is unique in that it is composed of, seemingly both migratory and non-migratory residents (M. Lamont pers. obsv.) and represents the northernmost, over wintering population of Sandhill Cranes anywhere within their range. Sadly, this unique population has been overlooked and underappreciated by provincial and federal authorities and has only been of interest to a handful of private researchers and local naturalist clubs for the last several decades. The Georgia Depression population for which the Fraser Valley population is part of, was downgraded in 2009 from Red-listed (endangered) to Yellow-listed (not threatened). The reasoning for this downgrade is not well understood, even by provincial biologists (pers. comm. John Cooper), but presumably arises from an additional nesting pair located in Port Hardy on Vancouver Island.

The first attempts at formal population assessments were undertaken by the Robinson family living in Pitt Meadows in the early 1970's, with estimates of nine pairs occupying just the Pitt Polder region at the south end of Pitt Lake (Leach 1979). Today, the total number of pairs at this site is likely less than three and may be down to one breeding pair (M. Lamont, pers. obsv.). Sadly, this unique population of Sandhill Cranes in the Fraser Valley has continued to decline due to habitat loss, degradation, increased urban predators and the continued conversion of mixed agricultural fields into monoculture crops such as blueberry fields. An attempt at marking individual birds with colour coded leg bands and the use of leg mounted GPS-GSM transmitters is currently in progress by the author.

As part of a larger biodiversity and restoration study on the Lower Stave River, a visual ground survey was undertaken in the Lower Stave watershed in 2017, 2018 and 2019 to detect the presence of overwintering or staging Sandhill Cranes. This site is part of a restoration project being undertaken by the Fraser Valley Watershed Coalition (Figure 1) and other partners to improve the lower portion of the river to create new spawning and rearing habitat for both anadromous salmon and other resident fish species (pers. comm. N. Cox; see Figure 2).



Figure 1: Overview of restoration and survey areas

Ethnographic & Cultural History

Sandhill Cranes once dominated the landscape in the Lower Stave and were reported by the Katzie First Nations as being plentiful in early spring ‘in the thousands’ (Suttles & Jenness 1955), with March being known as the “month of the crane”. Cranes were considered guardian spirits to the Katzie and were called *haha’w* meaning ‘superior in everything’. According to Katzie legend, the deity, *Khaals* found two sisters digging up Arrowhead root because they lacked other food items at the time. When the sisters mocked *Khaals*, he turned them into cranes which then had to spend the rest of their days wandering



the meadows, to laugh and dance (Suttles & Jenness 1955). Clearly, the importance of this species to the Katzie was significant enough for them to name a month after their appearance and to incorporate it into their oral histories.



Figure 2: Photograph of part of the restoration project to provide additional salmon rearing habitat (which by association was also observed to provide excellent foraging opportunities for snipe, dabbling ducks and herons)

Project Challenges

The permitting process for banding and telemetry use on Sandhill Cranes has been an ongoing challenge for this project, and up until the time of writing is still being reviewed by the Canadian Banding Lab in Ottawa. Multiple reviews, permit modification requests and outside comment was required over the last 18 months, including the request of additional letters of support from local stakeholder groups. As a result of these unforeseen delays, we have pushed the anticipated banding and deployment of a transmitter into mid-to-late 2019.

In place of obtaining telemetry data due to permitting delays, emphasis was placed on undertaking additional ground surveys to attempt to determine if this site is being utilized by Sandhill Cranes or in any of the adjacent wetlands.



Methodology

Visual ground surveys were undertaken on 16 and 18 November 2017, 08 and 16 December 2018, 09 February and 10 March 2019, respectively. Ground surveys were composed of 2-4-hour observation periods, walking the length of the eastern portion of Stave River and through observation points on the west side of Stave River (see Figures 3). Given the physical size and stature of Sandhill Cranes, in addition to their loud, rattling, bugle territorial calls, detection of birds was believed to be high if present. Weather conditions on November 16 were good; clear skies and sunshine allowed for good visual range. Conditions on November 18 2018, 08 December and 10 March 2019 were fair, with some low cloud cover. Surveys on 09 February were cold and windy.

To gain good vantage points for visual detection, foot surveys were undertaken on the crest of the restored streams that had been dug out several weeks prior (Figure 2). These were also walked to detect signs of foot prints in the sediment (Figure 4). Habitat that is typical for the species was targeted wherever feasible.

While undertaking surveys, other avian and wildlife species were recorded incidentally. These results are summarized below in Table 1.

Results

A total of six survey days were undertaken from fall 2017 through winter 2019, combining for a total of 20 hours of survey time. Winter and early spring months were targeted due to increased likelihood of usage by resident, non-migratory cranes which are known to occupy the Fraser Valley during the fall through spring period and would not yet be holding territories at known breeding locations outside of the study area.

Unfortunately, no documented use or observations of Sandhill Cranes were made at this site during any of the six survey dates. Footprints of a large wading bird were detected at two points in the restoration project, however upon closer inspection, these were determined to be made by Great Blue Heron (*Ardea herodias fannini*) due to the presence of a large hallux (Figure 4).

Avian diversity was recorded during some site visits and recorded (Table 1). A total of 37 species were found to utilize the study site across survey dates. Unsurprisingly, both species diversity and overall abundance was highest during the late fall during the peak salmon spawning periods and was lowest in early February when nearly all waterbodies had frozen over. Harbour seals were also documented in November 2018 but not seen in 2019.

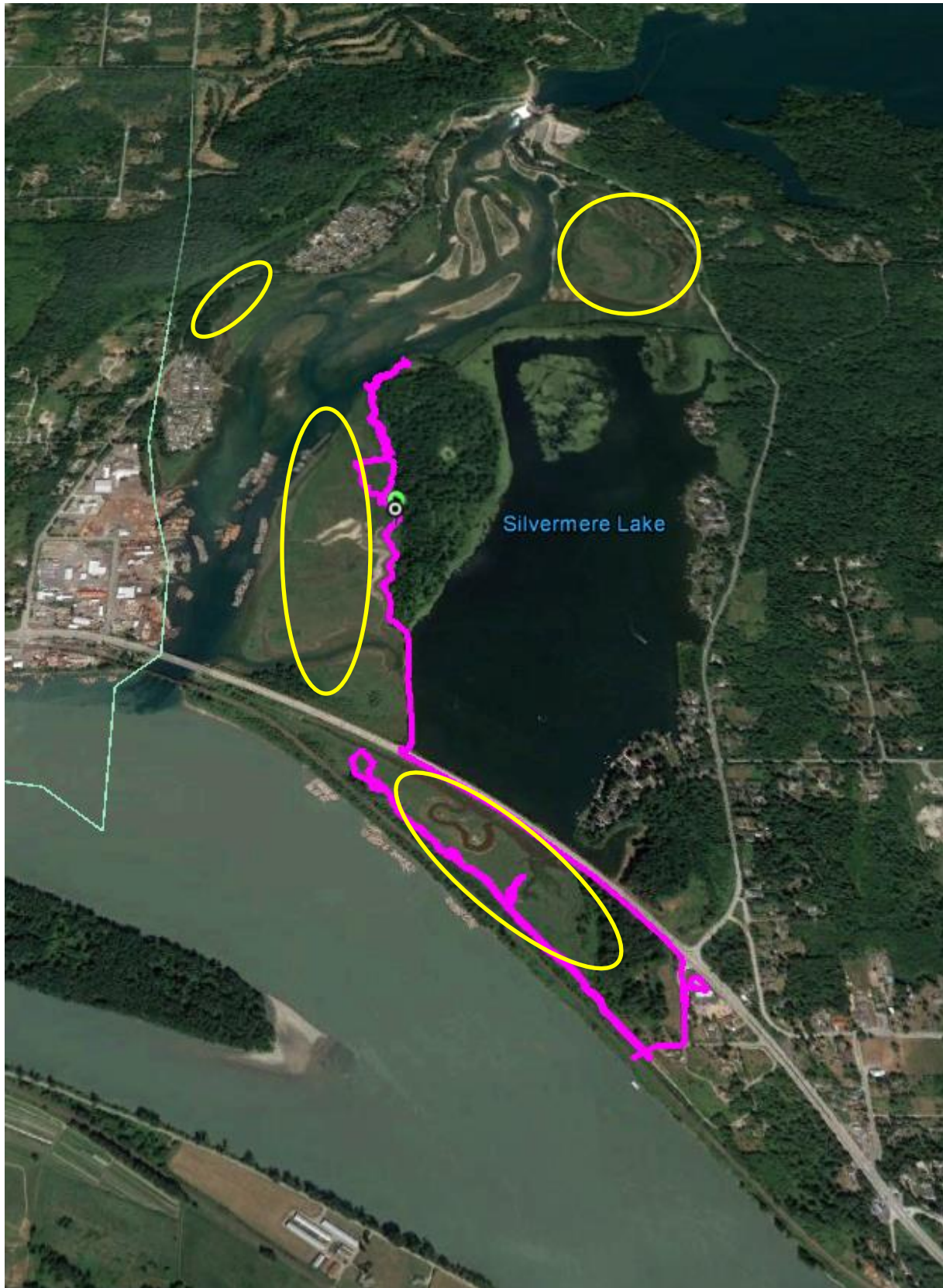


Figure 3: Tracklog of ground survey undertaken on Nov 16 2017 in pink and survey locations and observation points used for subsequent surveys in 2018 and 2019.



Table 1: Avian Species Recorded Across Select Survey Dates

SPECIES	18-Nov-18	08-Dec-18	09-Feb-19	10-Mar-19
AMERICAN COOT		10		
AMERICAN GOLDENEYE	62	50		1
AMERICAN ROBIN		3		
AMERICAN WIDGEON		3		
BALD EAGLE	29	22	8	3
BELTED KINGFISHER		1		
BLACK CAPPED CHICKADEE		2		
BUFFLEHEAD	20	3	2	2
CANADA GOOSE				15
COMMON MERGANSER		50		8
COMMON RAVEN		3		
GADWALL		6		5
GOLDEN CROWNED KINGLET		6		
GREAT BLUE HERON	2	2		10
GREEN-WINGED TEAL		69		
HAIRY WOODPECKER				1
HERING GULL				15
HOODED MERGANSER	1			
HOUSE FINCH				5
KILLDEER				2
MALLARD	25	39	2	
NORTHERN FLICKER		1		3
NORTHERN HARRIER		3		
NORTHWESTERN CROW	3	1		10
PURPLE FINCH			5	
RED-BREASTED MERGANSER	5			
RED-WINGED BLACKBIRD				1
RING BILLED GULL	10			
SCAUP SP.		10	5	
SONG SPARROW		5		12
SPOTTED TOWHEE	1	1		10
TUNDRA SWAN		50		
UNIDENTIFIED GULL	13		4	5
VARIED THRUSH				4
WILSONS SNIPE		1		
WINTER WREN	1			
WOODUCK				3



Discussion

While no Sandhill Cranes were detected during the two survey dates, the habitat surrounding the Lower Stave River provides for good foraging and potential nesting habitat. Sandhill Cranes are known to prefer tall mounds on which to nest to allow for good visibility of potential predators and site restoration may be able to incorporate this into their activities.

Sandhill Cranes have been documented to utilize Whonnock Lake only three kilometers to the northwest of the study site since at least 2006, including the first known breeding attempts at this location in 2018 with observations of a pair with a juvenile bird in June 2018 (Figure 6). A further incidental observation of one bird flying overhead north of Hayward Lake was made in 2015 (eBird 2018). This suggests that there is a high likelihood that Sandhill Cranes may be encouraged to use this site in the future if they are not already using it, albeit to a lesser extent and not for breeding, currently, and have simply avoided detection. No records from the Lower Stave area exist in eBird, granted this may be due in part to a lack of public access to this area.

Sandhill Cranes have also been documented to be feeding in the fields directly south of the study site in Glen Valley, including two observations in late April and May 2018 that are likely the same birds that were found to breed in Whonnock Lake in June (eBird 2018).

Crescent Island, just south of this site may also yield good forage and potential nesting habitat.

Continued monitoring of avian biodiversity and abundance at this restoration site over time may yield an interesting trend given preliminary work seems to have created additional habitat niches that were unavailable prior to restoration efforts.

Conservation Status & Knowledge Gaps

While the population of Sandhill Cranes across the province appears to have a short-term increasing trend, likely as a result of decreased hunting pressures over the last number of decades, the species as a whole within the province, has still declined from 30-70% of historic numbers (BC Conservation Data Center 2018). Of note is the continued loss of habitat and poor recruitment of juvenile birds into the breeding population within the Fraser Valley (M. Lamont unpub. data). Continued issues with predation of colts, injuries or mortalities as a result of occupying golf courses and other agricultural pressures continue to thwart population increase for the south coast population.

Described in 1958-1862 as “very common east and west of the Cascades” by naturalist John Keast Lord (1866), “tolerably abundant” in 1891 (Leach 1983), “breeding regularly in Sumas Prairie” in 1902 (Brooks 1918) and “once common in the bog between Serpentine and Nicomekl” in the 1920s (Leach 1983), the



species has undergone a steady decline throughout the Fraser Valley for much of the 20th and 21st centuries.

In 2009, the BC Conservation Data Center down listed the Georgia Depression population from Red-listed (endangered) to Yellow-listed (not threatened) and no longer tracked the Georgia Depression population as its own subpopulation (BC Conservation Data Center 2018). The reasoning for this decision is still not clear, but is believed to be in part due to the species being found in two ecoregions of Vancouver Island and the South Coast after a pair of birds was documented in 2006 nesting near Port Hardy.

Recent conversations with the BC CDC staff have suggested they would consider re-assessing this species with adequate evidence and data to suggest it should be reviewed (pers. comm. Leah Ramsay).

Hemmera (2009) has provided some of the most current and intensive study on habitat usage by staging/wintering Sandhill Cranes within the Fraser Valley resulting from the South Perimeter Road Expansion Project from 2008-2010. These data provide useful information to wildlife managers to help determine what habitat types are preferred, or more importantly perhaps, avoided, by Sandhill Cranes in Delta and Ladner area. No study has yet occurred on habitat usage north of the Fraser River.

Additionally, no fine scale habitat use using telemetry has been undertaken in the province that the author is aware of. New satellite tag technologies can allow for data collection every second and allow for two-way communication to adjust duty cycles and capture accelerometer data to determine activity levels which was previously impossible, even a few years ago.

Presuming a resident breeding adult can be trapped and deployed with a transmitter, time budgets, local movement and utilization of wetlands and bogs along with potential seasonal migrations can be captured and help fill in many of the knowledge gaps we currently have for this species within the Fraser Valley.

Future Objectives

The Sandhill Crane was last assessed by COSEWIC (Committee on the Status of Endangered Wildlife in Canada) in 1979, representing a 40 year gap since the species conservation status was last reviewed and making it long overdue for a subsequent evaluation. COSEWIC defines the status of the species as Not at Risk, however this assessment is only for the *A. c. tabida* subspecies. Rather ironically, the name *tabida* infers a shrinking or wasting away, which was meant to reflect the species diminishing numbers and habitat availability (Johnsgard 1991).

A concurrent genetic study is currently underway to evaluate the phylogenetic relationship of this coastal *tabida* race which is known to occupy and breed on coastal bogs and island wetlands from Vancouver Island north to south-eastern Alaska. The premise of this study is to see if coastal British Columbia provided a glacial refugia for the species during the last ice age and whether these coastal breeding birds are distinct enough from the rest of the continental population to warrant reclassification



(pers. comm. Ruth Joy). Should the results from this study demonstrate that this coastal population is indeed genetically unique, it will help provide further evidence for reevaluation by COSEWIC and the province to consider an updated conservation assessment.

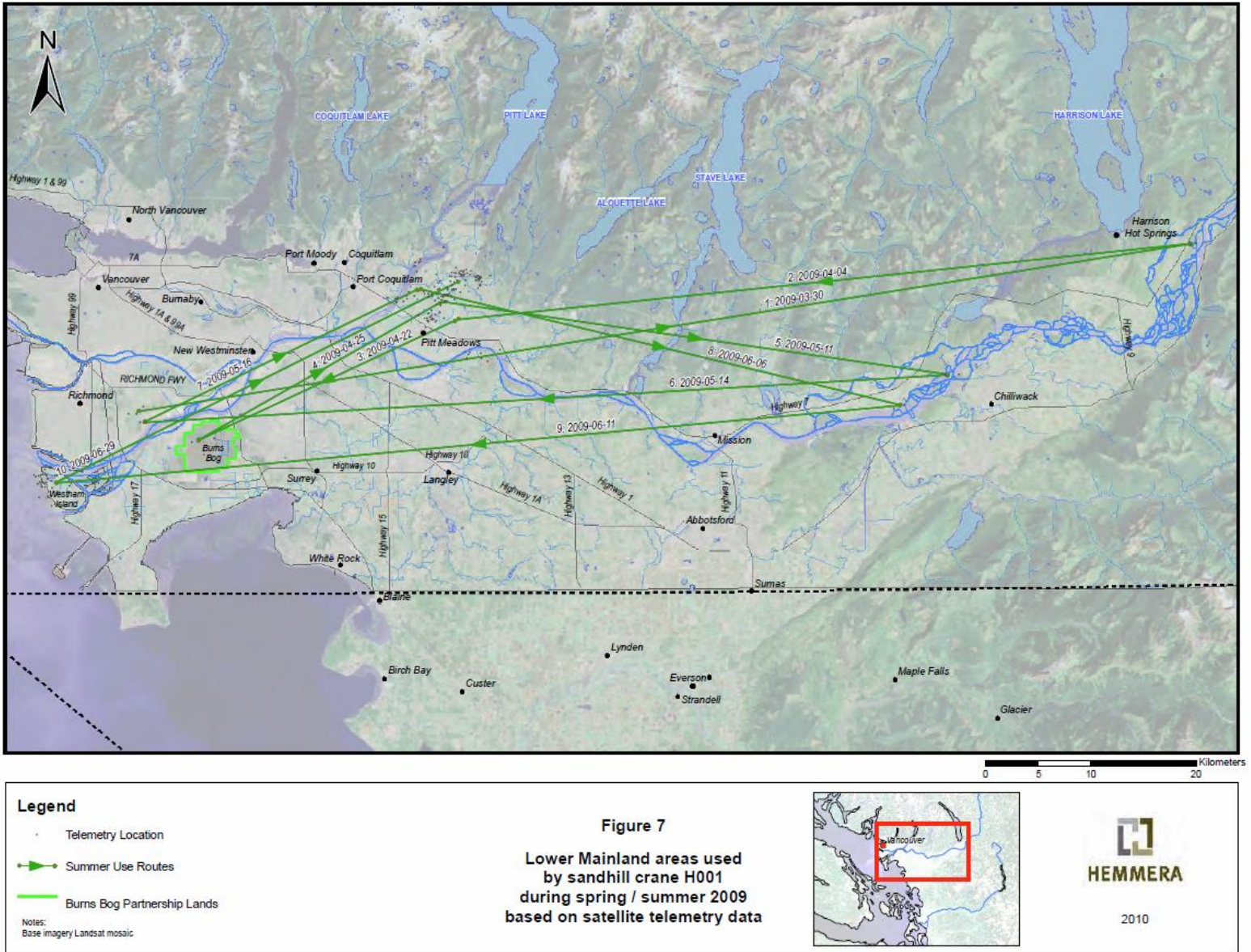


Figure 4: Lower mainland areas used by a Sandhill Crane fitted with telemetry in 2009 by Hemmera Consultants



Community Engagement

A major goal of this project is to involve local community members and citizen scientists to help with submitting observations and reports of this species within the Fraser Valley. This passive form of data collection has been ongoing since 2017 (see www.cranesightings.com) and has been capturing data that has not been submitted to eBird and hence would not have made it into the scientific realm.

Multiple presentations to naturalist groups and non-government organisations have been undertaken since this project has been initiated with recently talks having been presented to the Delta Field Naturalists, Langley Field Naturalists, Derby Reach-Brae Island Park Association and the Burnaby Lake Park Association representing a total audience of several hundred people.

Multiple letters of support have been received from these groups, among others, which demonstrates the interest and desire for work on this species to continue and help conserve this species both locally



Figure 5: Potential location for the creation of small, nesting islands for Sandhill Cranes and the creation of a potential site for the growth and harvesting of wapato



and regionally.

Generally speaking, community members and naturalist seem very concerned about continued declines of this subpopulation within the Fraser Valley and have expressed a strong desire to see additional studies being undertaken to help with conservation efforts. Interest as also expressed in regards to helping with re-sightings of birds once banded.

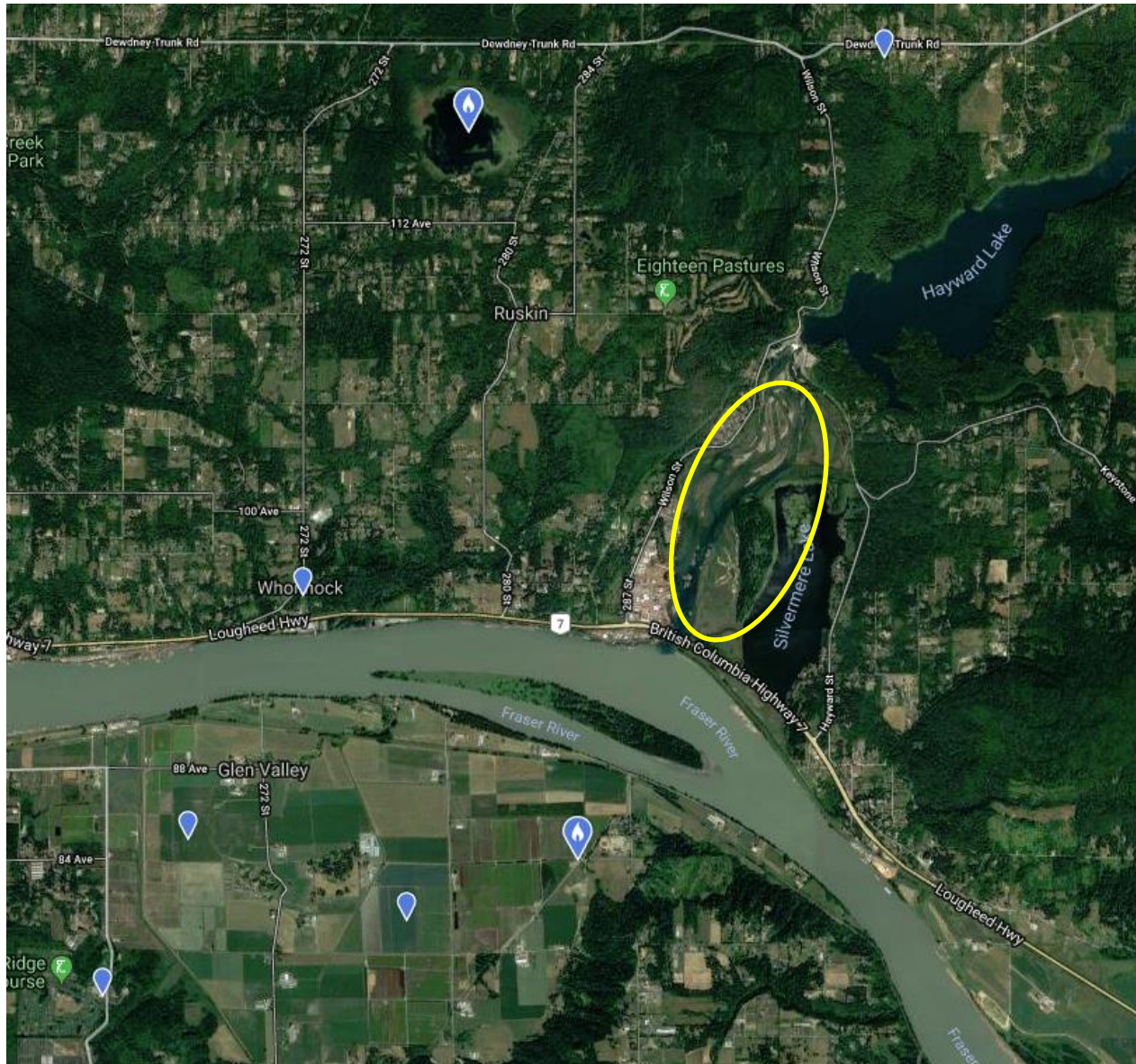


Figure 6: Locations of known observations of Sandhill Cranes in proximity to the study site in yellow



Site Specific Recommendations

Given that site restoration is ongoing and may involve further excavator work, the following recommendations are being made to both improve the habitat in the area for both Sandhill Cranes and other wading birds, but also increase the potential for nesting/foraging habitat for a variety of species:

- 1) The creation of ponds or pools with island habitats that can maintain a moat of water at low tide and high enough to avoid inundation at freshet.
- 2) The removal or ‘scraping off’ of Hardhack and Canary Grass in low level areas that may be suitable for encouraging bog species such as *Vacciniums*, *Oxycoccus*, *Rubus*, *Cornus*, *Ledum’s*, etc.
- 3) The creation of tidally influenced terraced or benched mud flats that would provide substrate for various large invertebrates such as annelids and shellfish and other taxa such as amphibians. This would provide for excellent forage habitat for not only Sandhill Cranes but other migratory wading and shorebirds that use the Lower Fraser River as a staging ground during migration.
- 4) Prescribed burns in certain areas to control Hardhack and Canary Grass as was undertaken by First Nations in the past, and of particular interest, was used to promote the presence of species such as *Vaccinium* and *Rubus*, both bog species (Parminter 1995).
- 5) Working with Indigenous groups to potentially create a portion of the site dedicated to harvesting wapato (*Sagittaria latifolia*) as was done previous to European settlement. This would in turn create natural foraging habitat for many species and perhaps help revitalize the historic relationship between the Katzie First Nations and their most revered animal– the Sandhill Crane.

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Grass mound nest



Natural island nest



Floating grass nest



Dirt mound nest



**MEMO:
ENVIRONMENTAL MONITORING IN THE
STAVE RIVER WETLAND (STAVE SITE 2) BY THE
COASTAL PAINTED TURTLE PROJECT IN 2018**

SEPTEMBER 2018



View from south of Stave Site 2 (looking north)– August 2015. Photo by Aimee Mitchell.

Prepared by
Aimee Mitchell and Deanna MacTavish
Of
The Coastal Painted Turtle Project

For
Natashia Cox, Fraser Valley Watersheds Coalition, Chilliwack, BC

MEMORANDUM: Coastal Painted Turtle Project Environmental Monitoring at Stave River Site 2

Introduction: Members of the Coastal Painted Turtle Project (CPTP) visited and monitored sites of historic nesting observations in the path of the Stave Site 2 restoration works in May through July 2018 (Fig. 1).



Figure 1. Stave Site 2 (red circle), path of machinery (blue line) in September 2017 and turtle basking habitat enhancement area of Silvermere Lake (brown circle) that was enhanced in August 2016.

Summer Nesting Activity Monitoring: During the turtle nesting season (May to July) this area was visited four times by CPTP member, Aimee Mitchell. Areas surveyed were based on past observations of signs of nesting (Fig. 2a). During one session on June 7th, 2017, while out with Fraser Valley Conservancy interns, one unmarked female turtle was captured on land near a minimum of four test pits (Nesting Site 1) (Fig. 3.). No nests were confirmed to have been laid at this time, however, due to the observation of test pits and a female turtle on land at this location it is highly likely that nests were/are present.

In 2018, test pits were also observed in all the identified nesting sites identified in 2017. In Site 1 and 2, 3 test pits were observed at each. Sites 3 and 4 had 1 test pit each observed. In July, project members Deanna MacTavish and Aimee Mitchell, met with the landowner to discuss installation of nesting habitat at this site. Two sites were chosen to focus on for installation near Sites 1 and 2 (see below for enhancement details).

Female Western Painted Turtles are very site-fidelic to where they lay nests year after year, so it is also likely that this area, as well as other areas identified as have nesting activity in the past, are used annually. Once laid in the summer the eggs will take approximately three months to hatch (fall). Once hatched, some hatchlings will emerge in the fall and be on land temporarily making their way to the lake. However, a subset of nests or even just a portion of hatchlings in the same nest will remain underground all winter and not emerge until the spring. Due to the potential for there to be emerging hatchlings on land and/or remaining underground in the fall, monitoring of past and recent nesting sites took place prior to the movement of equipment in this area to mitigate any potential impact to hatchling Western Painted Turtles (Fig. 2b).

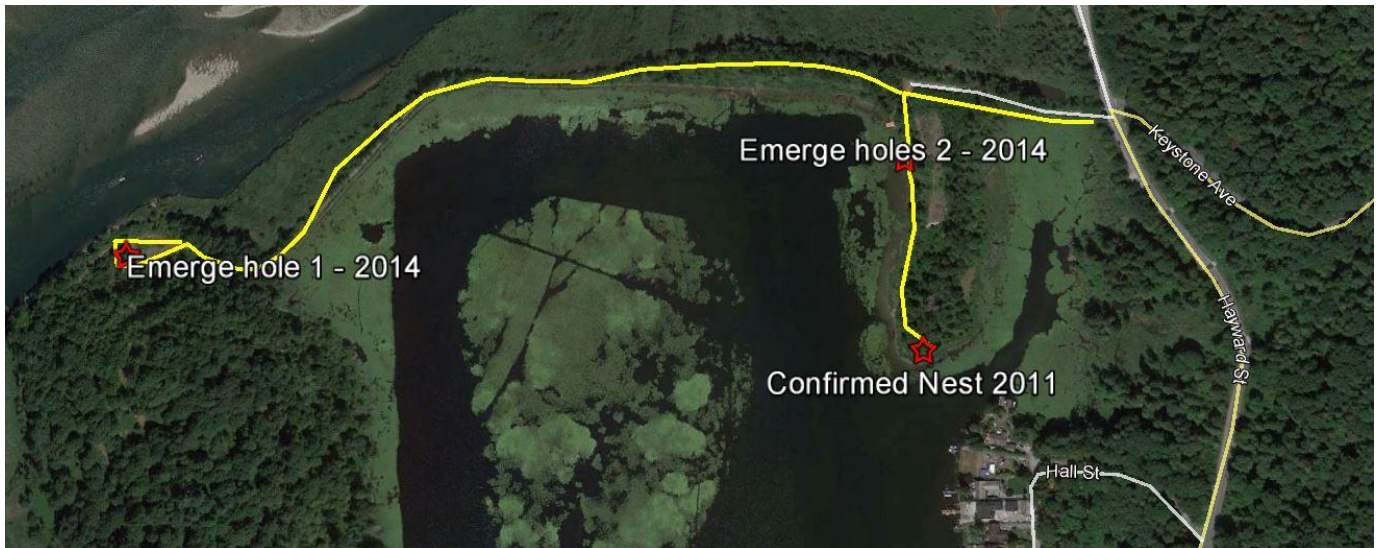


Figure 2a. Historical observations of Western Painted Turtle nesting activity at Silvermere Lake near Stave Site 2. Yellow line is the path of nesting monitoring activities in the summer of 2017.



Figure 2b. Western Painted Turtle nesting activity observations in 2017.



Figure 3. Female Western Painted Turtle on land at Nesting Site 1 on June 7th, 2017. One test pit highlighted with red circle in right of first photo. Photos by Aimee Mitchell.

Nesting habitat enhancements: Based on past years of nesting activity observations, two areas were selected to enhance turtle nesting habitat near Silvermere Lake (Fig. 4) in 2018. The goal of the enhancements is to provide highly suitable nesting material close to areas they are already nesting to draw them away from using the road. Nesting on the road leaves females, eggs and hatchlings vulnerable to crushing from machinery on the road during Stave River restorations as well as impending residential development in the area.



Figure 4. Sites of observed turtle nesting activity (Nesting Sites 1-4) and nesting enhancement locations planned for late September 2018.

At enhancement site 1 (near nesting site 1) an excavator will be used to remove the top layer of plants and substrate to expose the sandy edge of the lake. This area is already quite sandy, but is overwhelmed with plants so no additional substrate is needed at this location. At enhancement site 2 (near nesting site 2) the excavator will dig shallowly to remove the top substrate before installing the new sand.

Recommendations: Due to confirmed nesting activity and emerged hatchlings directly in the path of equipment utilized for restoration activities in the Stave River Site 2 it is highly recommended that CPTP members continue to be consulted prior to any works in this area and provided an opportunity to check for nests and/or hatchlings and possibly salvage nests that are known to be in harm's way. In addition, a sweep would be made for adult or hatchling turtles on land. It is difficult to provide recommendations on the best timing of works in order to mitigate potential impacts because there are risks to either adult turtles, nests (eggs or hatchlings) underground and/or hatchlings emerging throughout the entire year. Therefore, works at any time of year should have mitigation monitoring incorporated into the work plan.

March 31, 2019

Fish and Water Quality Monitoring Memo



Prepared for the Fish Wildlife Compensation Program. COA-F19-2720

Field monitoring completed by Winter Moon, Michael Gaultier, Ashley Gibson, Bridgette Knowlan
Report Prepared by Natasha Cox & Rachel Drennan, Fraser Valley Watersheds Coalition

1. Introduction and Monitoring Parameters

Monitoring was completed by FVWC Field Operations Manager and Field Crew to assess water quality conditions and juvenile fish usage to help inform designs and communications, future restoration and enhancement and actions needed. The variables included in the monitoring plan were:

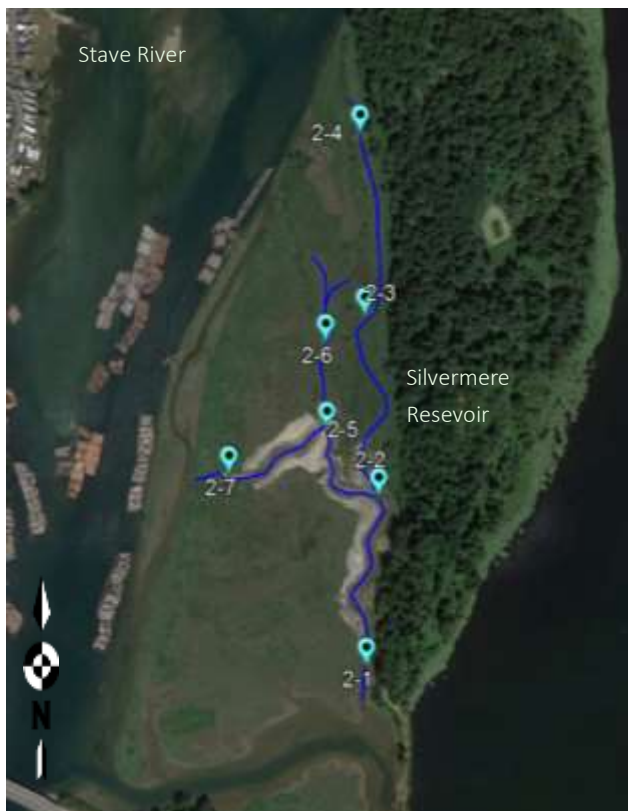
- **Dissolved Oxygen** – dissolved oxygen (DO)-(mg/L and %) is measured using a YSI hand meter. *Rationale:* DO is a key habitat parameter for fish and amphibian species, and indicates aquatic system health. Dissolved oxygen levels will in part determine whether fish trapping will occur based on the British Columbia Ministry of Environment.
- **Temperature** – Water temperature (degrees Celsius) is recorded at each sampling site during water quality measurements. *Rationale:* Water temperature is a critical factor for many aquatic animal species during varying life stages. It can influence fish survival and amphibian breeding cycles. Mature vegetation moderates water temperature, and we expect that temperature fluctuations would be mitigated once vegetation matures. Temperature levels will in part determine whether fish trapping will occur.
- **Turbidity** – Turbidity is measured using with a Triton turbidity wedge at each sampling point. In cases where turbidity is lower than the range of the instrument turbidity will be recorded as ‘none visible’ or ‘some visible’. *Rationale:* The suspended /dissolved substances in a water column can impact the ability of aquatic species and salmon to survive and reproduce at certain thresholds and can have varying effects including suspended fallout covering spawning grounds/redds, reduce predation/increase predation among others. It can also impact the macrophytic habitat. It will be measured in NTU’s and will help to determine background trends.
- **Specific Conductivity** - is a measure of how effectively water conducts electricity, which varies with its ion concentration. It rises with salinity, water hardness, nutrient loading and other forms of pollution. It is valuable as an indicator of productivity and of pollution; however, the cause of high readings cannot be determined without additional testing. Specific conductivity is able detect high levels of a very wide range of substances.
- **pH** – is a measure of the concentration of hydrogen ions in water. It is a negative log scale, with a neutral value of 7. Each unit decrease in pH (e.g. from 7 to 6) indicates a tenfold increase in hydrogen ion concentration. *Rationale:* pH is an important water chemistry parameter. Changes in pH can indicate contaminated water, or changes to the waterway. Levels outside the range of 6.5-9 are unsuitable for most aquatic life. Levels close to neutral are most productive.

- **Fish Use** - Fish are trapped using standard G-traps (2 per site) in accordance to DFO and MOE permits and standards. Baited traps will were set for approximately 22 hours at ten standard locations. Fish were identified to species and counted. These results will provide an indication of overall habitat diversity and use.

2. Monitoring Results

2.1 Stave Site 2

A total of seven monitoring locations were established across Site 2. Monitoring locations were identified in partnership with DFO salmon enhancement program biologists, and monitoring began in the fall of 2017. Map 1, Table 1. The average water quality conditions at each monitoring station are shown in Table 2. Of note, the water quality conditions met the minimum requirements set out by the BC Ministry of Water, Land and Air Protection for temperature and Dissolved oxygen. Water levels at Stave site #2 prevented fish sampling in September 2018. According to BC Hydro, record-breaking “dry” years and low snow pack levels impacted tail-water releases minimums and may be reason for limited fish sampling opportunities. The fish surveying results are shown in Table 3.



Map 1. Monitoring Locations Stave Site 2

Table 1. Monitoring Locations Stave Site 2

Site	Station	Type	GPS UTMS Easting	Northing
Stave Site 2	2-1	Water Quality & Fish	10 U 542592.00 m E	5446970.00 m N
	2-2	Water Quality & Fish	10 U 542609.00 m E	5447218.00 m N
	2-3	Water Quality & Fish	10 U 542586.00 m E	5447481.00 m N
	2-4	Water Quality & Fish	10 U 542577.00 m E	5447747.00 m N
	2-5	Water Quality & Fish	10 U 542530.00 m E	5447314.00 m N
	2-6	Water Quality & Fish	10 U 542527.00 m E	5447442.00 m N
	2-7	Water Quality & Fish	10 U 542382.00 m E	5447248.00 m N

Table 2. Average Water Quality Conditions at each Stave Site 2 Monitoring Station and Across Project Site (December 2018- March 2019)

Station	Temp (°C)	DO (%)	DO (mg/L)	Turb	pH	cond (µS/cm)	sal (ppm)
Site 2-1	2.9	99	12.85	21	7.605	38.5	19
Site 2-2	2.75	90.1	11.53	21	7.535	36	18.5
Site 2-3	3.25	73.5	9.29	21	7.305	42.5	21
Site 2-4	4.7	38.7	4.66	21	6.585	62.5	31
Site 2-5	3.5	104.7	14.6	21	7.04	21.5	10.5
Site 2-6	3.3	103.4	12.94	21	6.99	16	8.5
Site 2-7	3.55	107.8	13.31	21	6.945	16	8
Cumulative average across all stations	3.42	88.17	11.31	21	7.14	33.28	16.64

^A Red highlighted indicates DO levels below 5.0mg/L

^B Orange highlighted indicates Temperature levels above 15° Celsius

¹ British Columbia. Ministry of Water, Land and Air Protection. *Water Quality Guidelines for Dissolved Oxygen Overview Report* Environmental Protection Division.

Table 3. Fish species Stave Site 2 (December 2018- March 2019)

Station #	Total # Fish Caught	PMB	CSU	RSC	NSC
Site 2-1	2	0	2	0	0
Site 2-2	2	0	0	1	1
Site 2-3	0	0	0	0	0
Site 2-4	6	2	0	0	4
Site 2-5	0	0	0	0	0
Site 2-6	0	0	0	0	0
Site 2-7	0	0	0	0	0
Totals	10	2	2	1	5

*PMB =Pumpkinseed (non-native), CSU= Large Scale Sucker RSC= Redside Shiner, NSC = Northern Pikeminoow. *One crayfish was also caught.

Fish Monitoring Stave Site 2

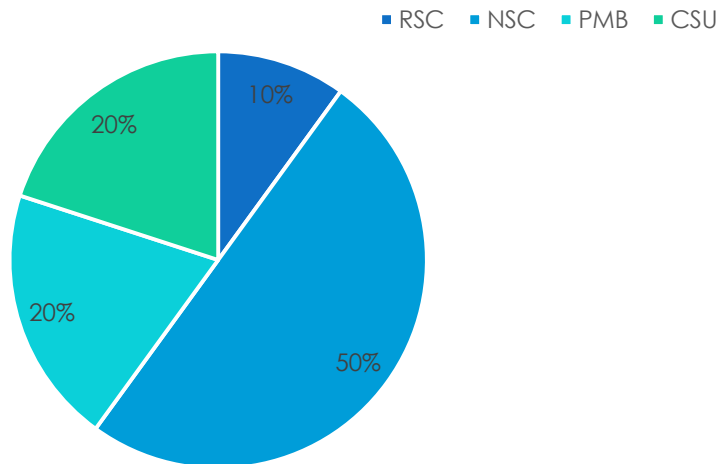


Figure 1. Fish Monitoring by Species Caught at Stave Site 2 across all monitoring stations (Dec 2018- Mar 2019). No salmonids caught at Stave site #2.

2.2 Stave Site 3

A total of ten monitoring locations were established across Site 3. Monitoring locations were identified in partnership with DFO salmon enhancement program biologists, and monitoring began in 2016 Map 4, Table 4. The average water quality conditions at each monitoring station is shown in Table 5. Of note, the water quality conditions met the minimum requirements set out by the BC Ministry of Water, Land and Air Protection for temperature and Dissolved oxygen. The fish surveying results are shown in Table 6, Figure 2.



Map 2. Monitoring Locations Stave Site 3

Table 4. Monitoring Locations Stave Site 3

Site	Station	Type	GPS UTMS Easting	Northing
Stave Site 3	3-1	Water Quality & Fish	10 U 542637.00 m E	5446457.00 m N
	3-2	Water Quality & Fish	10 U 542371.37 m E	5446597.81 m N
	3-3	Water Quality & Fish	10 U 542337.00 m E	5446617.00 m N
	3-4	Water Quality & Fish	10 U 542553.00 m E	5446453.00 m N
	3-5	Water Quality & Fish	10 U 542645.00 m E	5446283.00 m N
	3-6	Water Quality & Fish	10 U 542835.00 m E	5446109.00 m N
	3-7	Water Quality & Fish	10 U 542893.00 m E	5446010.00 m N
	3-8	Water Quality & Fish	10 U 543055.00 m E	5445845.00 m N
	3-9	Water Quality & Fish	10 U 543030.00 m E	5446048.00 m N
	3-10	Water Quality & Fish	10 U 543022.00 m E	5445936.00 m N

Table 5. Average Water Quality Conditions at each Stave Site 3 Monitoring Station and Across Project Site (Sept 2018 –Mar 2019)

Station	Temp (°C)	DO (%)	DO (mg/L)	Turb	pH	Depth	Conductivity (µS/cm)	Salinity (ppm)
Site 3-1	8.60	9.50	0.94	21.00	6.63	0.22	154.00	69.00
Site 3-2	8.60	65.00	6.84	21.00	6.59	0.40	98.50	49.50
Site 3-3	8.70	69.40	7.32	21.00	6.75	0.67	99.00	50.00
Site 3-4	7.50	89.80	9.44	21.00	6.86	0.47	111.50	55.00
Site 3-5	7.95	128.70	13.45	21.00	6.92	0.55	110.50	55.00
Site 3-6	7.90	68.50	7.27	21.00	6.94	0.47	110.50	55.50
Site 3-7	7.55	73.60	8.91	21.00	7.00	0.44	109.00	56.00
Site 3-8	7.40	73.90	9.05	21.00	7.70	0.72	126.00	68.50
Site 3-9	7.80	67.40	8.19	21.00	7.22	0.66	109.50	56.00
Site 3-10	6.90	57.65	7.22	21.00	7.39	0.82	127.50	63.50
Cumulative average across all stations	7.89	70.35	7.86	21.00	7.00	0.54	115.60	57.80

^A Red highlighted indicates DO levels below 5.0mg/L

^B Orange highlighted indicates Temperature levels above 15° Celsius

¹ British Columbia. Ministry of Water, Land and Air Protection. *Water Quality Guidelines for Dissolved Oxygen Overview Report* Environmental Protection Division.

² British Columbia. Ministry of Water, Land and Air Protection. *Water Quality Guidelines for Temperature Overview Report* Environmental Protection Division.

Table 6. Fish Monitoring Results at Stave Site 3 across all stations (September 2018- March 2019)

Station #	Total # Fish Caught	PMB	CO	LMB	BNH	CAS
Site 3-1	0	0	0	0	0	0
Site 3-2	2	2	0	0	0	0
Site 3-3	19	15	1	0	2	1
Site 3-4	8	5	1	2	0	0
Site 3-5	19	8	0	8	3	0
Site 3-6	6	2	1	0	3	0
Site 3-7	5	2	0	3	0	0
Site 3-8	0	0	0	0	0	0
Site 3-9	4	3	0	1	0	0
Site 3-10	0	0	0	0	0	0
Totals	63	37	3	14	8	1

*CO= Coho salmon, PMB =Pumpkinseed (non-native), BNH= Brown Bullhead (non-native), LMB = Large Mouth Bass (non-native), CAS= Prickly Sculpin

Fish Monitoring Stave Site 3

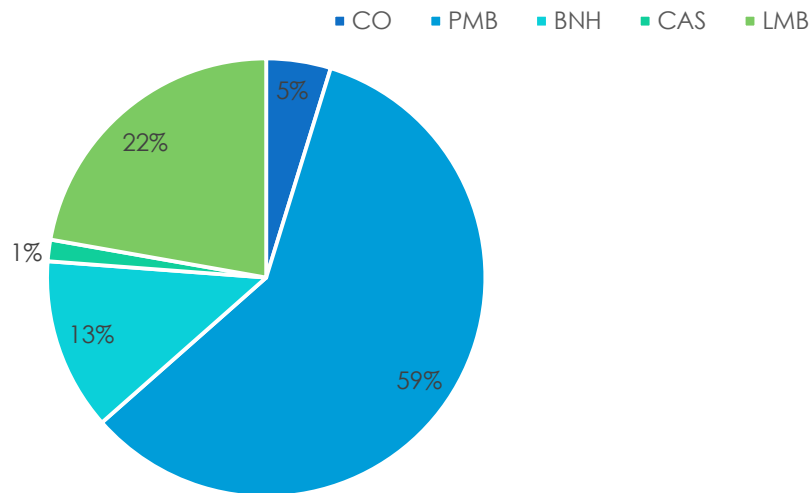


Figure 3. Fish Monitoring by Species Caught at Stave Site 3 across all monitoring stations (Sept 2018- March 2019). Juvenile Coho Salmon accounted for five percent of fish caught at site #3.

3. Discussion

Field observation and measures identified Site 3-1 has having low dissolved oxygen levels that fall below the minimum required to support aquatic life. One possible reason for this is the depth of the water (0.22m) and micro-site specific conditions such as lack of canopy cover shading this specific location. Another possible reason could be errors and limitations of the water quality probe. FVWC staff will be looking further into this.

Further to micro-site water quality conditions, a noticeable observation is the presence of warm water species. Monitoring and possible management may be necessary at Stave Site 3 to address invasive predators including large mouth bass and brown bullhead impact on native fish populations.

Key consideration moving forward is to setup a meeting with BC Hydro, DFO, Kwantlen First Nation and FVWC to discuss river hydrology in light of climate change and resource management.

4. References

British Columbia. Ministry of Water, Land and Air Protection. *Water Quality Guidelines for Dissolved Oxygen Overview Report* Environmental Protection Division. Web. March 7, 2017. <http://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/wqgs-wqos/approved-wqgs/dissolvedoxygen-or.pdf>

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5. List of Attachments

- Attachment A: Raw WQ and Fish Monitoring Data

APPENDIX D Mapping Tributaries to the Stave River

FWCP Project No. COA-F19-2720

March 27, 2019



Prepared for: Fish and Wildlife Compensation Program

Prepared by: Natasha Cox Fraser Valley Watersheds Coalition

Prepared with financial support of the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and Public Stakeholders.

Objective

To map the west tributaries entering into the right bank of Stave to assist in directed identification of future restoration opportunities, restrictions/challenges to salmon habitat in the lower river system. Anticipated result is geospatial files of streams and enhancement/challenge features/limitations.

Rationale

The Lower Stave River is confined to roughly the lower 2km from the Ruskin power station and the confluence of the Fraser River. In an effort to identify and pursue future enhancement opportunities to re-connect and create additional off-channel habitat in this lower system, mapping and board assessment of the existing waterways and data gaps is necessary.

Methods

FVWC staff conducted a preliminary desktop review of known/ existing streams and wetlands through the community mapping network, IMap BC, and the municipal web map. These were then ground-truthed using a Trimble GPS by FVWC staff, and geo-referenced by FVWC Contractors Durand Ecological, Ryan Durand. Corrected and collected files were then overlaid on a Google Earth to identify information gaps and opportunities for further investigation with the intent of informing future (potential) off-channel habitat enhancement works.

Results and Outcomes

Preliminary mapping identified numerous watercourses flowing from Iron Mountain, Mission BC southeast towards the Fraser River. Six identified waterways, three of which appear to be red-coded fish bearing flow into the Stave River. Also identified are springs and seepages occurring at the base of the mountain slope above Reidal St. and Wilson St. The elevation at the toe of the mountain is about 30 meters, while the lowest floodplain immediately on the river is approximately 5 meters. Ten culverts fall within the scope of mapping assessment- Table 1, Figure 1. Figure 2

Table 1. Culverts beneath 287th St. and Wilson Rd. conveying flows into Stave River

Map ID	Diameter/Width	Length	Type	Owner
1	600 mm	15 m	Concrete	DOM
2	300 mm	14 m	Concrete	DOM
3	300 mm	16 m	Corrugated Metal Pipe	DOM
4	600 mm	15 m	Concrete	DOM
5	300 mm	25 m	Corrugated Metal Pipe	DOM
6	400 mm	20 m	Concrete	DOM
7	600 mm	20 m	Concrete	DOM
8	600 mm	20 m	Concrete	DOM
9	600 mm	20 m <td Concrete	DOM	
10	600 mm	20 m	Corrugated Metal Pipe Thompson Creek	DOM

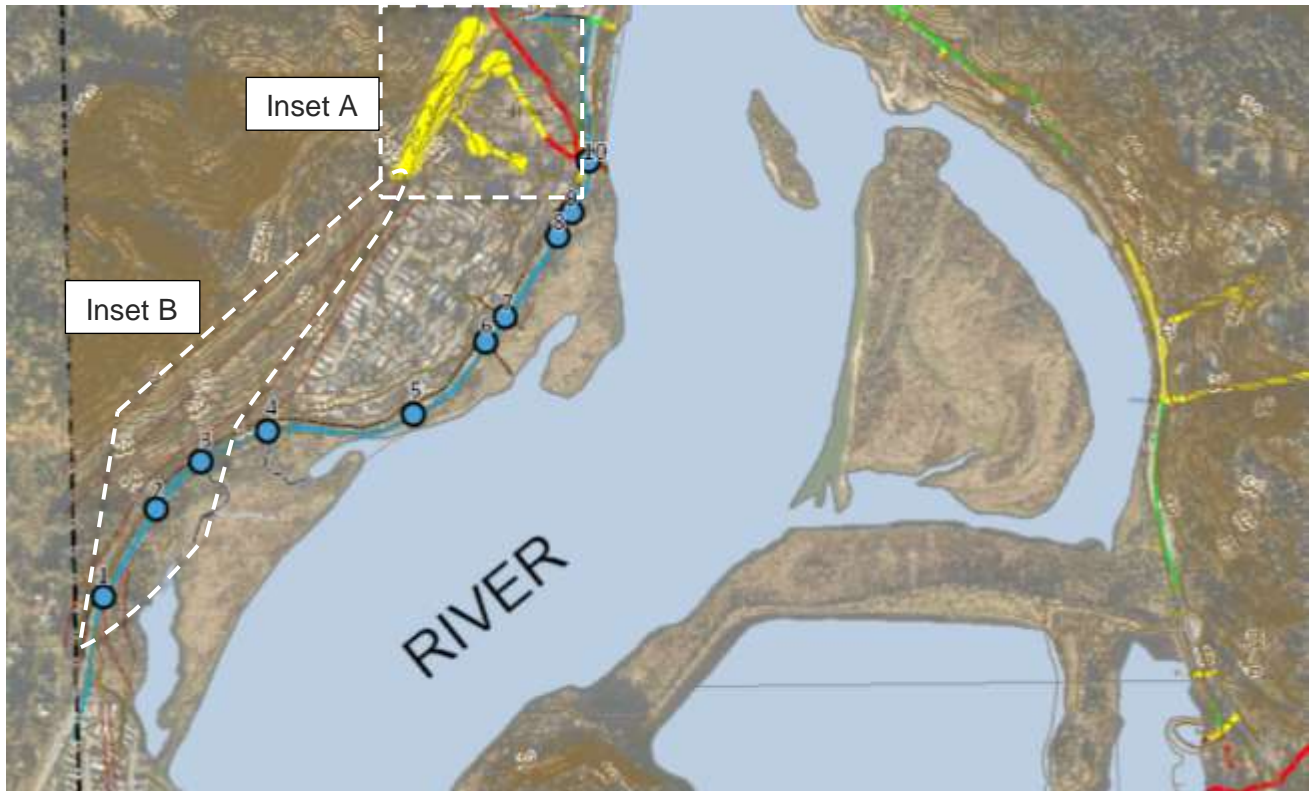
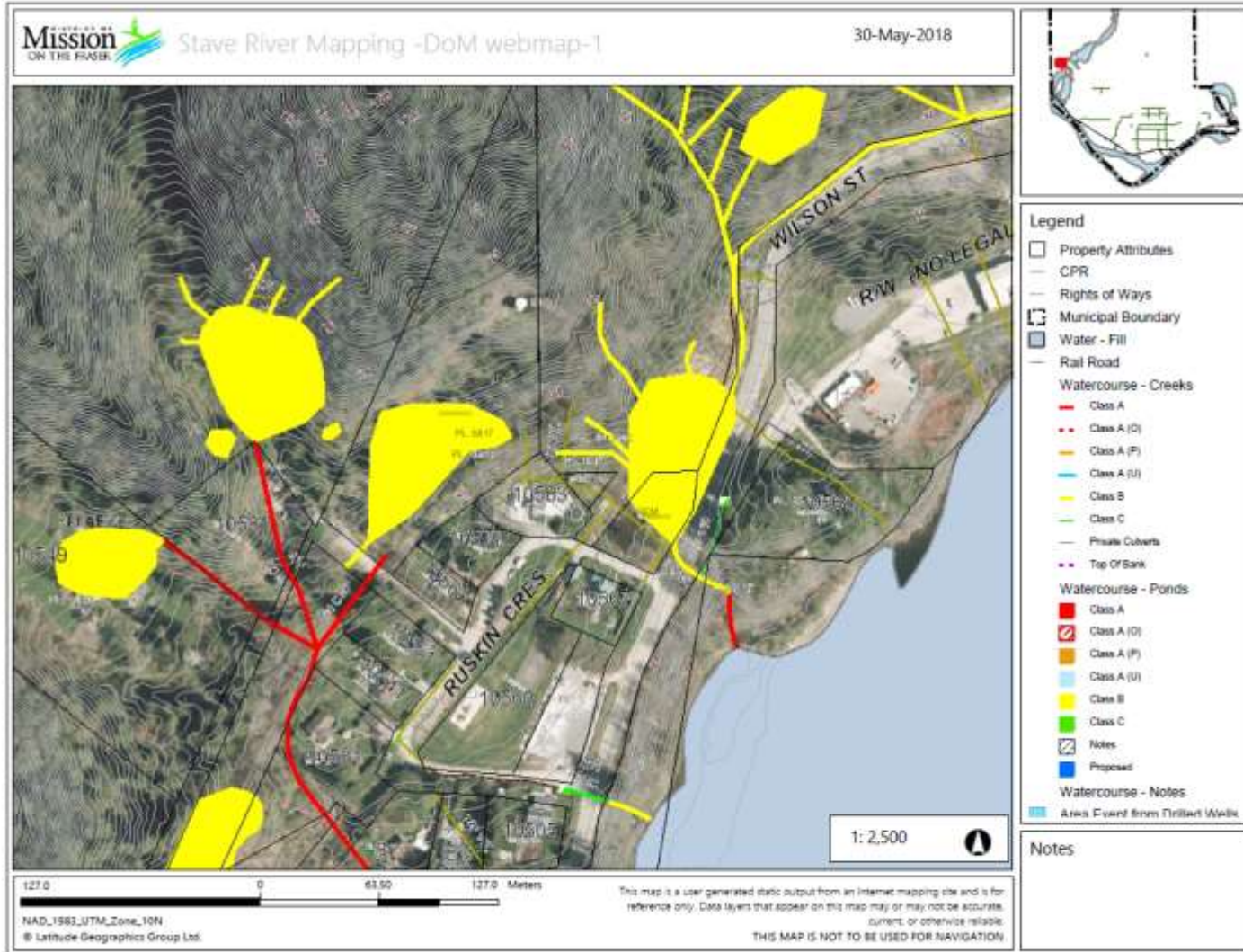
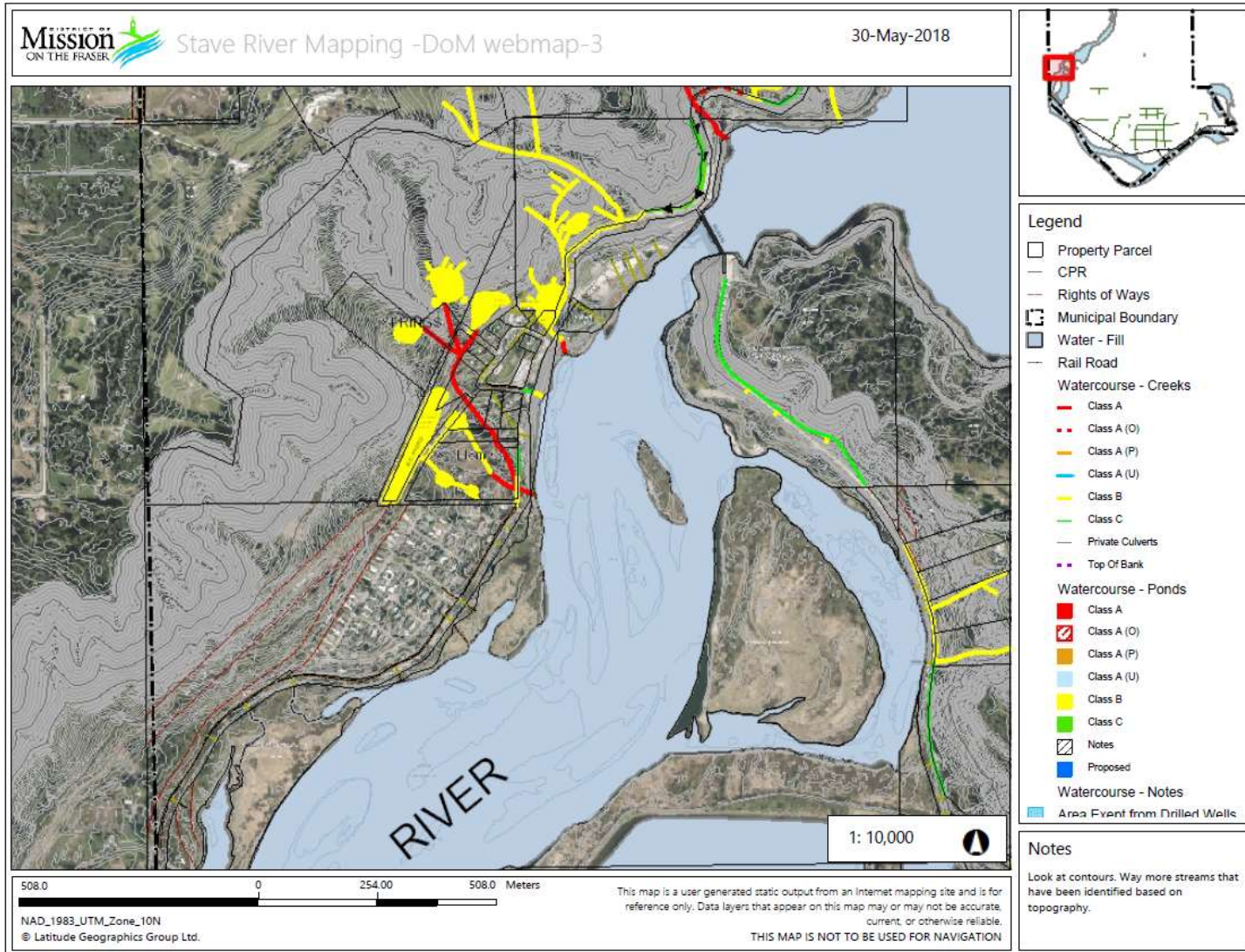
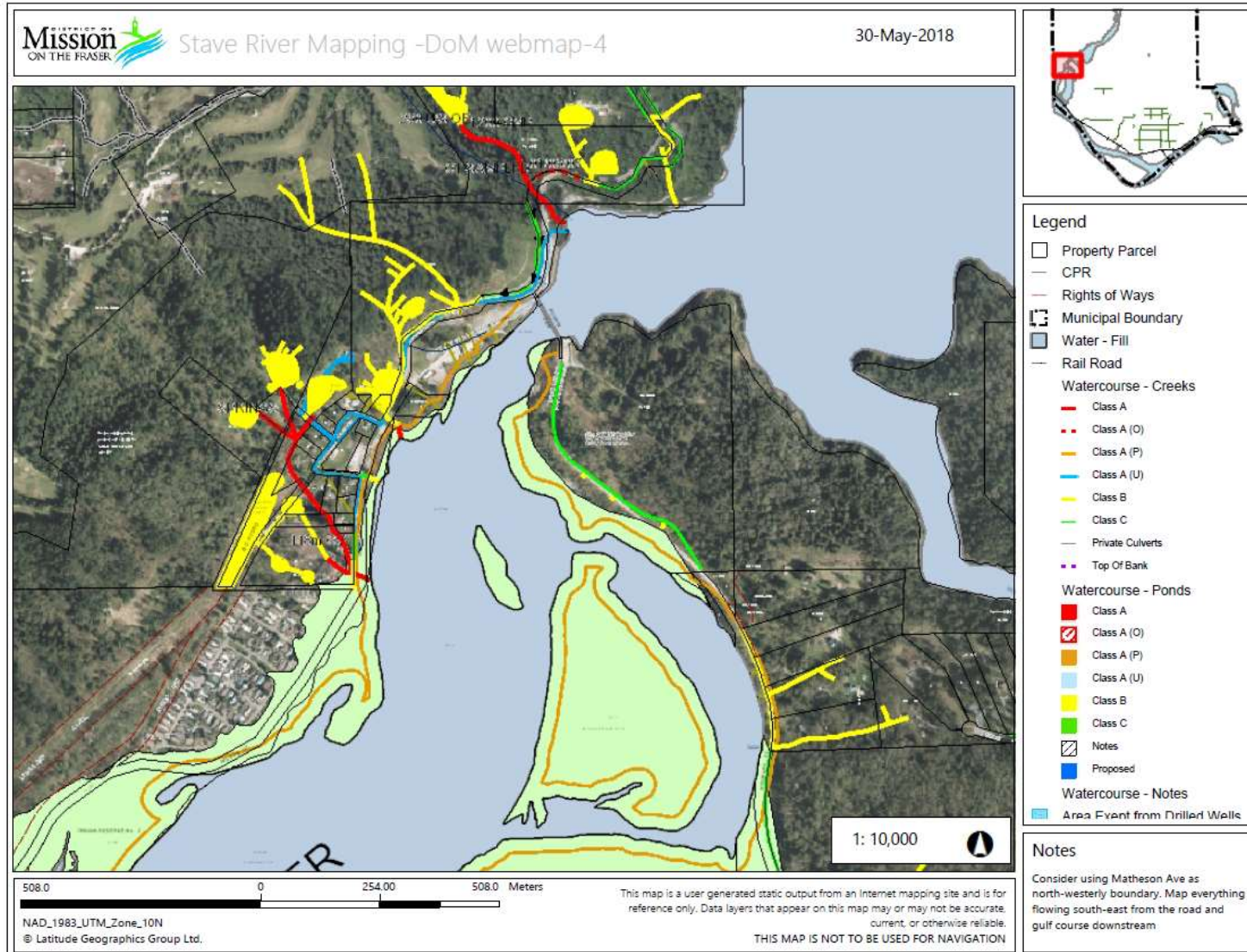


Figure 1. Identified culverts beneath 287th St. and Wilson Rd. conveying flows into the Stave River. Of which, further investigation of inset maps shown below.



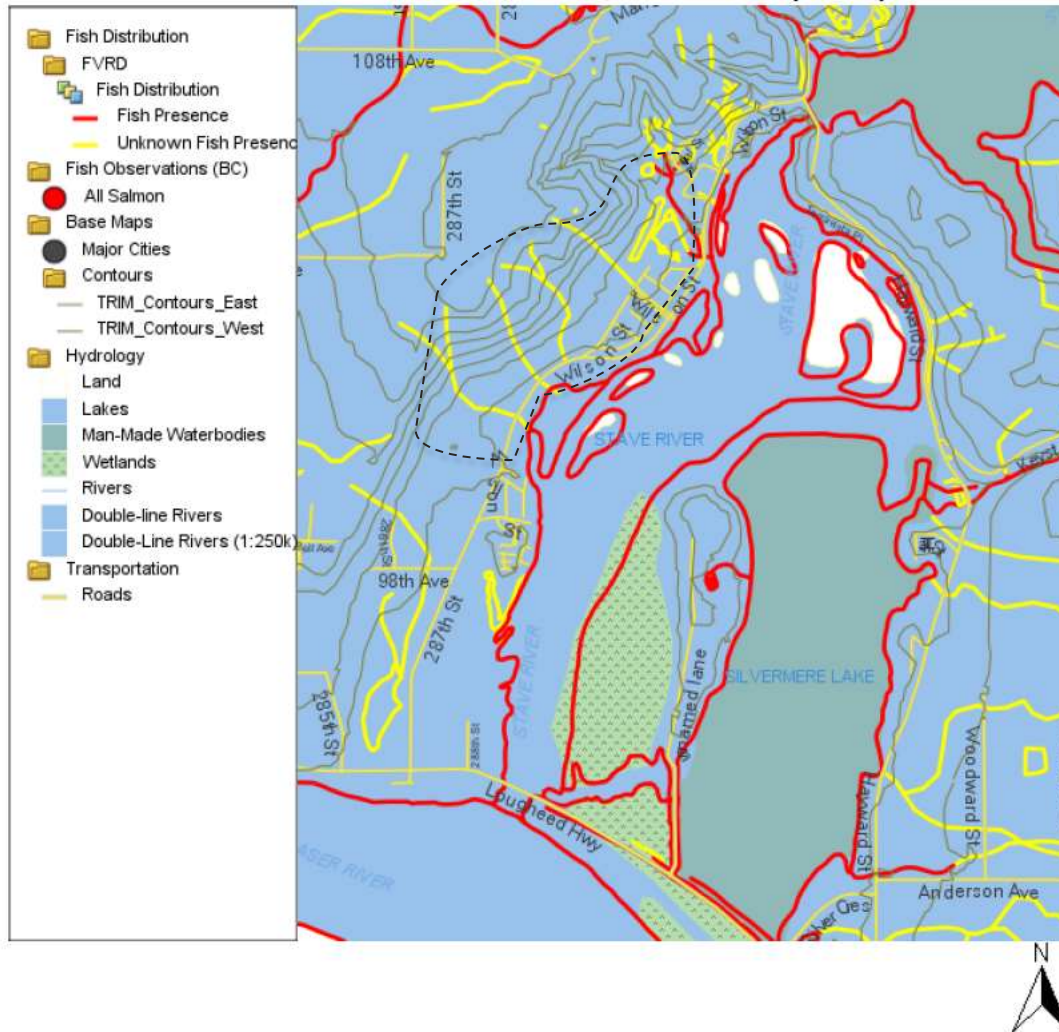




5/30/2018

STAVE RIVER TRIBUTARIES- SHIM (FISS)

STAVE RIVER TRIBUTARIES- SHIM (FISS)



Based on Watershed Atlas and SHIM there are information gaps of known and potential waterways between municipal and community driven mapping. Area of interest outlined in black polygon.



Ranges from roughly 66 m to 113 m wide Right of Way that follows the toe of slope, captures the mountain streams and may provide opportunity for capturing seepages, surface water, and groundwater for the creation of additional off-channel habitat, and tie in to existing infrastructure.



Inferences for stream locations using image interpretation and elevation contour lines. Dashed blue lines represents potential opportunity to construct habitat within toe of slope to collect surface, groundwater and tie into existing waterways and infrastructure and expand off-channel habitats in the Lower Stave.

Next Steps

- Obtain permission to further investigate area within inset map B, to identify springs, seepages, waterways and opportunity to construct off-channel habitat.
- Pending results, engage stakeholders on opportunity to expand off-channel habitats and identify decision matrix for what is required to proceed.

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TECHNICAL MEMORANDUM

Date: October 26, 2018

To: Natasha Cox
Project Manager
Fraser Valley Watersheds Coalition

By email

From: Claudia Schaefer, M.Sc., R.P.Bio.

Re: **Stave River (Site 2) vegetation assessment of planted versus unplanted areas on disturbed soil following channel construction**

BACKGROUND

Fish habitat enhancement by the Fraser Valley Watersheds Coalition (FVWC), in partnership with the Department of Fisheries and Oceans (DFO), has been ongoing at the junction of the Stave and Fraser rivers, north of Lougheed Highway between 287th and Hayward streets, Mission, BC. Existing water channels have been enlarged and new channels were created to improve coho salmon habitat and wildlife habitat in general.

The Stave River study site falls within the Coastal Western Hemlock Dry Maritime subzone (CWHdm). The area lies adjacent to the Stave River. It is a flat, low bench that is mostly flooded in winter and/or during the freshet of the Fraser River. Site 2 is dominated by the aggressive, non-native reed canarygrass (*Phalaris arundinacea*).

OBJECTIVES

The vegetation assessment addresses the following questions identified by FVWC:

1. Are our restoration and enhancement sites creating more diversity and becoming more complex?
2. Are we able to see this change within a year or two of restoration and enhancement activities?
3. Are we seeing a change from more invasive species to more native species?
4. Are there certain species that are more dominant and more effectively competing against the reed canarygrass than others?
5. Do the planted areas appear to be growing and surviving?

METHODS

The site was visited on September 12, 17 and 18, 2018 by Claudia Schaefer of Raincoast Applied Ecology (RAE). Fifteen plots of 2 m x 2 m were randomly situated in planted and unplanted areas that had been disturbed during channel construction. Plant species, native or non-native species status, strata (tree, shrub, or herbaceous) and cover values (visual estimate of vertical plant cover as a percent) were recorded. Plot locations are shown in Appendix 1.

Plant species richness was calculated by determining the average number of species present within plots; the richness value was then be compared between planted sites and non-restored, unplanted sites.

The complexity of the communities between sites was assessed based on the occurrence of different strata such as trees, shrubs, or herbaceous plants within plots.

Qualitative observations were made on the growth and survival of shrubs/trees and emergent aquatic species (i.e. rooted in soil with leaves or stems extending out of the water) that were planted within the channels.

Site photographs were taken and representative images can be found in Appendix 2.

RESULTS

The collected plant data is included in Appendix 3. The following table summarizes the comparative results of the study:

Table 1. Plant species richness (number of species on average in randomly selected 2m x 2m plots), reed canarygrass dominance and shrub/tree cover in planted and unplanted sites.

	Planted Sites	Unplanted Sites
Total Species Richness (average) per plot	8.3	5.2
Native Plant Species Richness (average)	5.7	3.2
Average cover of reed canarygrass	42%	98%
% of plots with < 30% RCG	50%	0%
% cover of shrub or tree species (average)	10%	1%

The above results address the following questions of the study:

Question 1. Are the restoration and enhancement sites creating more diversity and becoming more complex?

- Yes.
 - Planted sites have 78% more native plant species than non-planted sites (richness values of 5.7 vs. 3.2).
 - 50% of the plots in planted sites had less than 30% cover of reed canarygrass, compared with 0% in unplanted sites.

- Species and structural diversity in unplanted sites was negligible, with an average 98% cover of the invasive canarygrass, creating a one-stratum monoculture.
- The complexity is greater in restored sites, given that shrub and/or tree species were found in 100% of the plots in planted areas, at an average of 10% cover, while shrubs/trees occurred in only 60% of non-planted samples with negligible cover (1%).

Question 2. Are we able to see this change within a year or two of restoration and enhancement activities?

- Yes.
 - The increase in species richness can be seen within one year of enhancement activities.
 - The complexity (number of strata or diversity of layers) has increased within one year of enhancement activities.
 - However, the occurrence and cover of reed canarygrass was found to be high in planted/restored sites. Recommendations below address this issue.

Question 3. Are we seeing a change from more invasive species to more native species?

- Yes.
 - There are 78% more native species in planted sites than non-planted sites.
 - Reed canarygrass was found at substantially lower cover in planted sites than in non-planted sites (42% vs. 98% average cover; the non-planted sites had 233% more canarygrass).
 - Several native species were found to have established naturally (i.e. not planted) in restored areas (e.g. lesser spearwort, Douglas' aster), and were absent from unplanted areas, indicating that the planted areas may provide more opportunity and better environmental conditions for native species in the area to establish.

Question 4. Are there certain species that are more dominant and competing more effectively against the reed canarygrass than others?

- It is difficult to determine site-specifically at this time, however certain ecological traits are known to increase competitive ability.
 - There is no clear pattern in the data after one season of growth as to which species are competing effectively against reed canarygrass. For example, the plots in the planted sites that had the most cover of shrub and tree species also had the most cover of canarygrass.
 - Reed canarygrass, once on-site, can outcompete almost all native herbaceous species. Creating shady conditions is the only non-chemical measure found that effectively reduces reed canarygrass growth. Continuing to restore sites by planting tree and shrub species that are fast-growing and well-suited to the site conditions is the best method to control this invasive grass in sensitive habitats.
 - While it is not possible to measure precisely the rate of growth of planted species (without permanent plots being established during the planting phase and successive monitoring), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) was found in 90% of the plots within the planted sites and had the highest cover of the planted species, despite less individuals being planted

overall (e.g. 80 individuals vs. 200 red-osier dogwood). However, this may be a function of the location of plots and plantings, as there were other areas enhanced that were not sampled and where other species may have been found to dominate.

Question 5. Do the planted areas appear to be growing and surviving?

- Predominantly, yes.
 - The large majority of observed tree and shrub plantings above the channel banks had survived the first summer and were growing well.
 - The plantings of emergent, aquatic vegetation on the benches of the channels were qualitatively assessed for survival. A very general estimate is that approximately half of the plantings survived the first growing season. This is not an unexpected result, as the rates of mortality are high when planting in aquatic habitats. Monitoring in 2019 will aid in determining which species (and in which micro-habitats) were most successful and can guide future planting plans.

RECOMMENDATIONS

The following recommendations are made to increase the success of continuing enhancement measures:

- 1) Plan to restore future areas directly adjacent to existing planted sites.
 - Restoring neighbouring sites increases the size of a restored area, thereby decreasing the amount of edge and invasion opportunity from non-restored sites dominated by reed canarygrass.
- 2) Plant right to the edge of bank.
 - It was observed that where a gap was left between the top of channel bank and planting sites, reed canarygrass invaded and created a dense meadow (see Figure 1). This gap allows the invasive to more readily encroach into the planted site. Plantings should begin immediately at top of channel banks.
- 3) Plant more densely.
 - Planting distances recommended by nurseries should be reduced given the pervasiveness of reed canarygrass at the site. While this will increase costs of plant materials, dense plantings will shade out bare ground and prohibit the growth of reed canarygrass, which is a main objective of enhancement efforts.
- 4) When cutting a channel with existing shrubby vegetation adjacent, pile material in areas dominated by reed canarygrass.
 - This will leave the native shrub cover intact, while burying the invasive grass. Plantings can then be targeted on disturbed sites, and there may be less area to restore.
- 5) Investigate the availability of seeds of appropriate aquatic plants, which can reduce plant material costs and planting efforts.
- 6) Consider reviewing proposed planting lists with a botanist.
 - Some nursery taxa used at the site may have questionable native status, or be ill-suited to the habitat being restored. Examples are:
 - Wood's rose (*Rosa woodsii*) predominantly grows in grasslands and savannas in the steppe and montane zones east of the Coast-Cascade Mountains. Other native rose species available at local nurseries may result in a better survival rate than Wood's rose.

- *Juncus patens* is not known to occur in Canada; *Juncus supiniformis* is also known by the common name spreading rush and does occur in BC; it should be confirmed if this is the species that was provided by the nursery, rather than *J. patens*.
- Dense sedge (*Carex densa*) is native to California and does not occur in Canada.



Figure 1. Plantings of trees and shrubs are visible on the right side of the photo. A relatively large area between the plantings and the channel allows reed canarygrass to invade.

- 7) Conduct a similar vegetation assessment in 2019 and/or 2020.
- It is currently undeterminable whether reed canarygrass cover will increase in planted scrub/shrub sites in the coming years due to its aggressive nature or decrease due to shading of shrub and tree species. The latter is expected but needs confirmation.
 - The success of the aquatic plantings in the channels will be more apparent in the coming year.

SUMMARY

- The enhancement efforts on site have been successful at improving habitat within one year.
- Species richness of native plants has increased significantly in areas of enhancement.
- Habitat complexity has increased in enhanced sites and therefore complexity and diversity of the wetland as a whole has increased.

Raincoast Applied Ecology would be pleased to provide any follow-up advice or clarifications about the results of the assessment. Please contact me at (778) 847-2940 or by email at SchaeferImages@gmail.com, if you have any questions or require more information.

Sincerely,

A handwritten signature in black ink, appearing to read 'Claudia Schaefer', written in a cursive style.

Claudia Schaefer, M.Sc., R.P.Bio.

Appendix 1. Map of the vegetation assessment plots sampled in September 2018 at Stave River Site 2.



Appendix 2. Site photographs of the Stave River Site 2 study on enhancement activities.



a



b



c



d



e



f

Photographs from the study area: a) and b) examples of a planted site adjacent to a channel; c) a willow whip planting without much growth but likely to be more successful next year as roots become better established; d) example of a planted area where denser planting is advised to reduce the chance that reed canarygrass will invade; e) randomized transect through unplanted area, post-construction disturbance; f) example of a plot in a planted area (note the abundance of reed canarygrass despite it being an enhanced site).

Appendix 2 (continued).



g



h



i



j

Photographs from the study area (continued): g) overview of plantings in a channel bottom; h) and i) emergent plant species mats and plugs with variable survival rates after the first season; and j) an excavated channel where existing hardhack shrubby vegetation (dark green, right side of photo) was left undisturbed and intact.

Appendix 3. Plant species data collected September, 2018, from Stave River Site 2.

		Percent Cover Value in Disturbed, Replanted Areas										Disturbed, Unplanted Areas								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15				
		Plot Number																		
		GPS Mark	562	572	582	592	602	671	681	691	701	711	721	731	741	751	761			
		Common Name	Scientific Name											Avg Cover						Avg Cover
Native Plant Species	Red-osier dogwood	<i>Cornus stolonifera</i>	20									1	2.10							
	Shining willow	<i>Salix lucida</i>									1		0.10							
	Hardhack	<i>Spiraea douglasii</i>	0.01		0.1		5		0.2	0.1	0.1	0.05	0.56	4		1		0.5	1.10	
	Black cottonwood	<i>Populus balsamifera ssp. trichocarpa</i>		15	10	25	5	0.5	2	3	1.5	5	6.70							
	Willow	<i>Salix sp. (unidentifiable to species)</i>			0.1				4	2		4	1.01							
	Marsh speedwell	<i>Veronica scutellata</i>	0.01	0.1	0.01	0.1	0.01	0.1	0.3	0.1	0.1	0.2	0.10	0.1	0.02	0.5	1	5	1.32	
	Field mint	<i>Mentha arvensis</i>	0.01		1	0.5		0.1	0.02	1			0.26	1	0.01	0.1			0.22	
	Douglas' aster	<i>Symphiotrichum subspicatum</i>		2	0.1								0.21							
	Small-flowered bulrush	<i>Scirpus microcarpus</i>					25						2.50							
	Rush	<i>Juncus sp. (unidentifiable to species)</i>					1		0.2	1		0.1	0.23							
	Sedge	<i>Carex sp. (unidentifiable to species)</i>			0.1	0.01		0.1	1	0.5	0.1	2.5	0.43		0.1	0.5	0.2	0.05	0.21	
	Horsetail	<i>Equisetum sp. (unidentifiable to species)</i>										0.1	0.01							
	King gentian	<i>Gentiana sceptrum</i>											0.00		0.1				0.03	
	Tall mannagrass	<i>Glyceria cf. elata</i>					10						1.00							
Lesser spearwort	<i>Ranunculus flammula</i>					0.001	0.01					0.00								
Non-native Species	Reed canarygrass	<i>Phalaris arundinacea</i>	80	83	89	73	45	6	23	10	8	1	41.80	90	99	100	99.5	100	97.7	
	Self-heal	<i>Prunella vulgaris</i>			0.1	0.1							0.02							
	Yellow iris	<i>Iris pseudacorus</i>			0.1	0.01							0.01	2	0.2				0.44	
	Common dandelion	<i>Taraxacum officinale</i>								0.1			0.01							
	Hairy cat's-ear	<i>Hypochaeris radicata</i>			0.1								0.01							
	Common plantain	<i>Plantago major</i>				0.1							0.01							
	Marshpepper smartweed	<i>Poylgonum persicaria</i>				0.5		0.1	0.2	0.1			0.09							