

# SAPPERTON LANDING BACKWATER TIDAL CHANNEL CONVERSION TO GROUNDWATER-FED WETLAND



By

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Ecological Restoration Program  
British Columbia Institute of Technology



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## Executive Summary

Sapperton Landing regional park in New Westminster was established in 2001 as compensation for the Millennium SkyTrain line. Prior to diking the Fraser River foreshore, the area was likely a tidally influenced wetland that supported native fish, wildlife, and plant communities. In 2002 a restoration project was completed to create natural conditions that are similar to Fraser River foreshore areas before development. Sapperton Landing Backwater Tidal Channel (hereafter, 'BTC') was the site of this restoration and connects to the Fraser River which was created to provide fish and wildlife habitat.

For this restoration project the BTC was divided into two site units based on elevation and vegetation differences, the Upland Area and the Wetted Channel. The main stressor we aim to eliminate in both units is invasive plants and infilling of the Wetted Channel of sediment from tidal influence which has prevented the channel from supporting aquatic life.

The main goal of this restoration plan is to convert the BTC into a functioning groundwater-fed wetland. To achieve this goal, both channel mouths will be closed off using material dredged from the Wetted Channel excavation. Invasive plants will be removed and replaced with native plants to support wetland functions. Removal efforts will focus on *Rubus armeniacus* (Himalayan blackberry) in the Upland Area and *Iris pseudacorus* (yellow iris) and *Phalaris arundinacea* (reed canarygrass) in the Wetted Channel. The Upland Area will be re-planted with native plants for site series CWHdm05 from the suggested plant list in Appendix F. The created wetland will be planted with native species representative of the Wm05 (Cattail) or Wm50 (Sitka sedge – Hemlock-parsley) site series as seen in Appendix F. We recommend annual monitoring of regrowth of invasive vegetation between September and March. To ensure the native plants are establishing and growing, for the first five years annual monitoring is also recommended.

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# 1.0 Site Assessment

## 1.1 Historical Conditions

### 1.1.1 History of Sapperton Landing Area

From 1858 to 1880 vegetation communities at the Sapperton Landing area likely included wetland shrub areas mixed with wetland forest as well as upland forest (Pearson 2015). The tidally influenced wetlands in this area would have supported a wide range of native fish, wildlife, and plants (Pearson 2015).

Compared to marshes elsewhere in the lower Fraser River, the marshes in Sapperton Landing area had less tidal influence due to greater protection by riverbanks (Metro Vancouver 2002). Diking of Fraser River foreshores for development degraded a significant amount of these marshes (Metro Vancouver 2002).

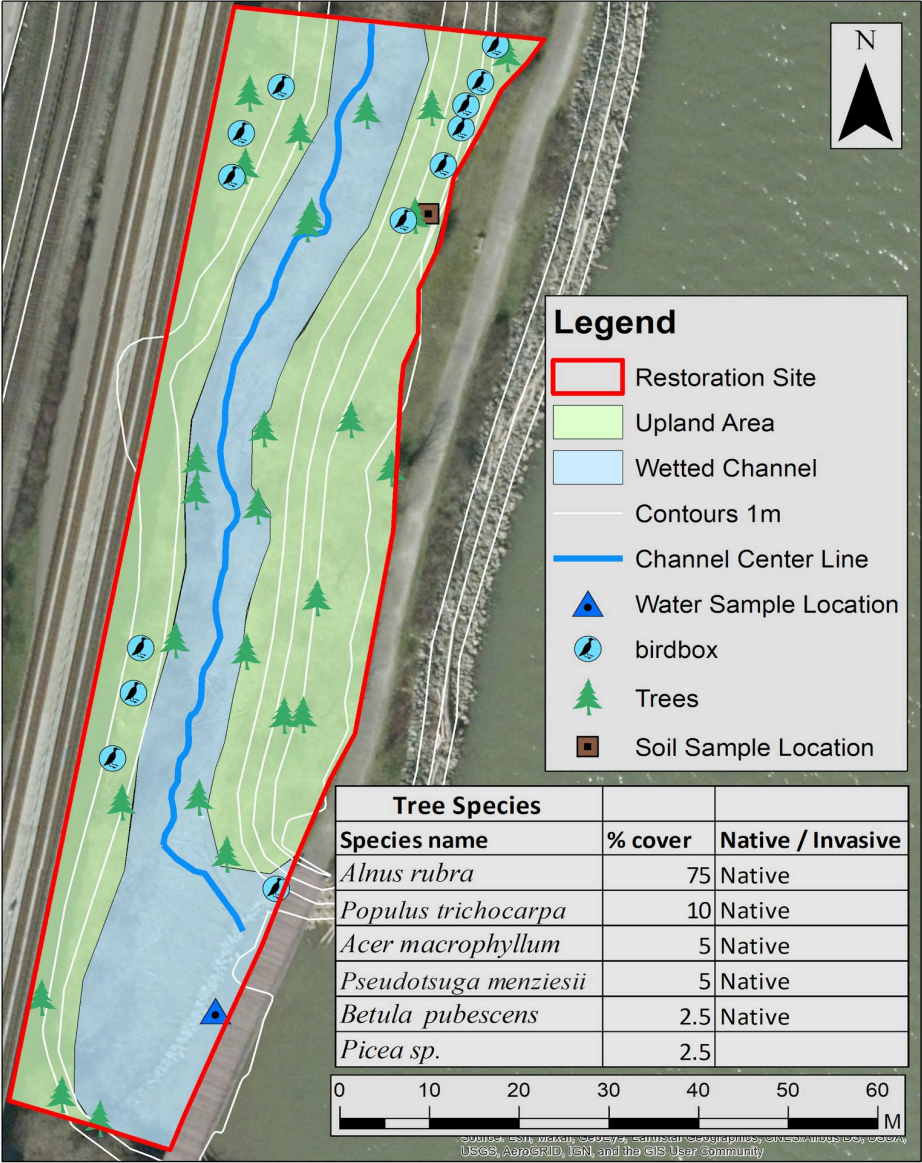
### 1.1.2 Compensation Efforts in 2002

Sapperton Landing Park was established in 2001 as compensation for the expansion of the SkyTrain by TransLink (City of New Westminster 2016). Compensation efforts were aimed at re-creating shoreline habitats that once existed near Sapperton Landing this included a backwater tidal channel and riparian woodlands (Metro Vancouver 2002). The backwater tidal channel was constructed parallel between the SkyTrain and Fraser River that has two open connections to the river (south and north mouths). The channel was constructed to provide habitat for several fish species (e.g. peamouth chub (*Mylocheilus caurinus*), northern pikeminnow (*Ptychocheilus oregonensis*), cutthroat trout (*Oncorhynchus clarkii*) and reidside shiner (*Richardsonius balteatus*). The riparian woodlands created between the backwater tidal channel and the Fraser River foreshore were intended to support many wildlife species (e.g. green heron (*Butorides virescens*), passerines, and small mammals) (Metro Vancouver 2002). Plant treatments were applied to both areas to support ecosystem services. Willow wattles were planted to stabilize the backwater tidal channel banks and the Fraser River foreshore. Native shrubs and trees that naturally occur within the Fraser Lowlands below Mission were planted in the woodlands (Metro Vancouver 2002). The creation of the park was also intended to provide visitors with opportunities to enjoy and learn about the habitats created through compensation.

# 1.2 Current Site Conditions

## 1.2.1 Restoration Site Units

The focal restoration site of this project (hereafter the South Channel Restoration Site) is located at the south end of the park. This site includes terrestrial and wetland areas which we have defined as two distinct site units: Upland Area and Wetted Channel (Figure 1).



*Figure 1 Sapperton Landing Compensation Channel Restoration Site New Westminster, including Upland Area and Wetted Channel site units and site-specific data.*

## 1.2.2 Soils

Most of the Sapperton Landing area consists of silt, clay, and loam soils (GeoMap Vancouver 1997). On 23 November 2020, we assessed soil conditions of the Upland Area to guide selection of suitable native species to plant (see Appendix A for detailed methods). While taking the soil sample we encountered large rocks at 1 m depth which we presume is riprap used to build up the bank. The soil site series was identified using the Land Management Handbook (LMH) 28 as CWDdm05 Sword fern (Green and Klinka 1994). The soil has a rich soil nutrient regime with a moderately dry soil moisture regime.

A soil sample was taken in the Wetted Channel to determine the depth of the water table. In doing so we found that large rocks below the sediment in the Wetted Channel prevented us from finding the water table. We presume the Wetted Channel was built using the same riprap material as the Upland Area.

## 1.2.3 Hydrology

BTC is influenced by tides with water levels fluctuating by up to 3 m per day (Pearson 2015). On 13 October 2020 at 0930 hours, our team observed that the Wetted Channel was not submerged at a tide level of 0.5 m, but that the soil was damp and contained a few small puddles (all tide levels were obtained from the New Westminster #7654 tide station). On 23 November 2020, water table depth was >60 cm in the Wetted Channel at 0700 hours at the lowest tide. On 23 November 2020, the Wetted Channel flooded at 1100 hours when a rising tide reached a level of 2.6 m (see Appendix B for detailed methods). We estimate that the Wetted Channel had no surface water for 20 hours on 22 November 2020 and 23 hours on 28 November 2020 (see Appendix B for detailed results). The greatest water depth we observed in the Wetted Channel was 0.3 m on 22 November 2020 at a tide level of 2.9 m and 0.1 m on 28 November 2020 at a tide level of 2.7 m (water depths were observed at the mouth of Wetted Channel). The duration of the water pooling and the water depth during the week show that the Wetted Channel is not sufficient to support aquatic species.

## 1.2.4 Water Quality

On 21 October 2020 at 1330 hours, we assessed water quality measurements at BTC (see Appendix C for detailed methods). The highest tide was 2.8 m at 1031 hours and dropped to 2.0 m until 1608 hours (the tide levels were obtained from the New Westminster #7654 tide station). All water quality parameters measured met water quality objectives for variable types of measurements in the Salmon River Watershed except for turbidity (Table 1) (The Ministry of Environment, Lands, and Parks 1998).

Table 1 Water quality measurements of South Channel Resotation Site and Sapperton Landing Park on 21 October 2020.

Variable	Measurement taken	Water Quality Objective*
turbidity	36.1 FNU	≤5 NTU over background ≤10 NTU over background (short term)
pH	7.11	6.5 - 8.5
temperature	9.8 °C	≤14.2
dissolved oxygen	107.9%	≥11.0 mg/L
specific conductivity	98.4 uS	
conductivity	71.1 uS	
pressure	764.8 mmHg	

\*Water quality objectives are based on a recommended 30-day average conditions for the Salmon River watershed (The Ministry of Environment, Lands, and Parks 1998).

### 1.2.5 Vegetation

On 13 October 2020, we conducted a presence/not-detected survey entailing five person hours (see Appendix D for detailed methods). An additional relative abundance survey was conducted on 23 November 2020 to map the location of all invasive species in the two site units using a Trimble GeoExplorer 6000 unit. We identified a total of 10 native and 7 exotic or invasive plant species (Figure 2). Approximately 85% of the Upland Area was dominated by *Rubus armeniacus* (Himalayan blackberry). The *R. armeniacus* has overtaken the native vegetation in the Upland Area and in the Wetted Channel significant cover of invasive *Iris pseudacorus* (yellow iris) and *Phalaris arundinacea* (reed canarygrass) were observed. Most of the *I. pseudacorus* on site was located at the southern mouth of the Wetted Channel, accounting for about 25% of total cover of the aquatic plant species. Locations of *R. armeniacus* thickets and locations of concentrated *I. pseudacorus* and *P. arundinacea* were mapped using a Trimble GeoExplorer 6000 GPS unit in tandem with Trimble TerraSync data collection software (detailed methods in Appendix E).

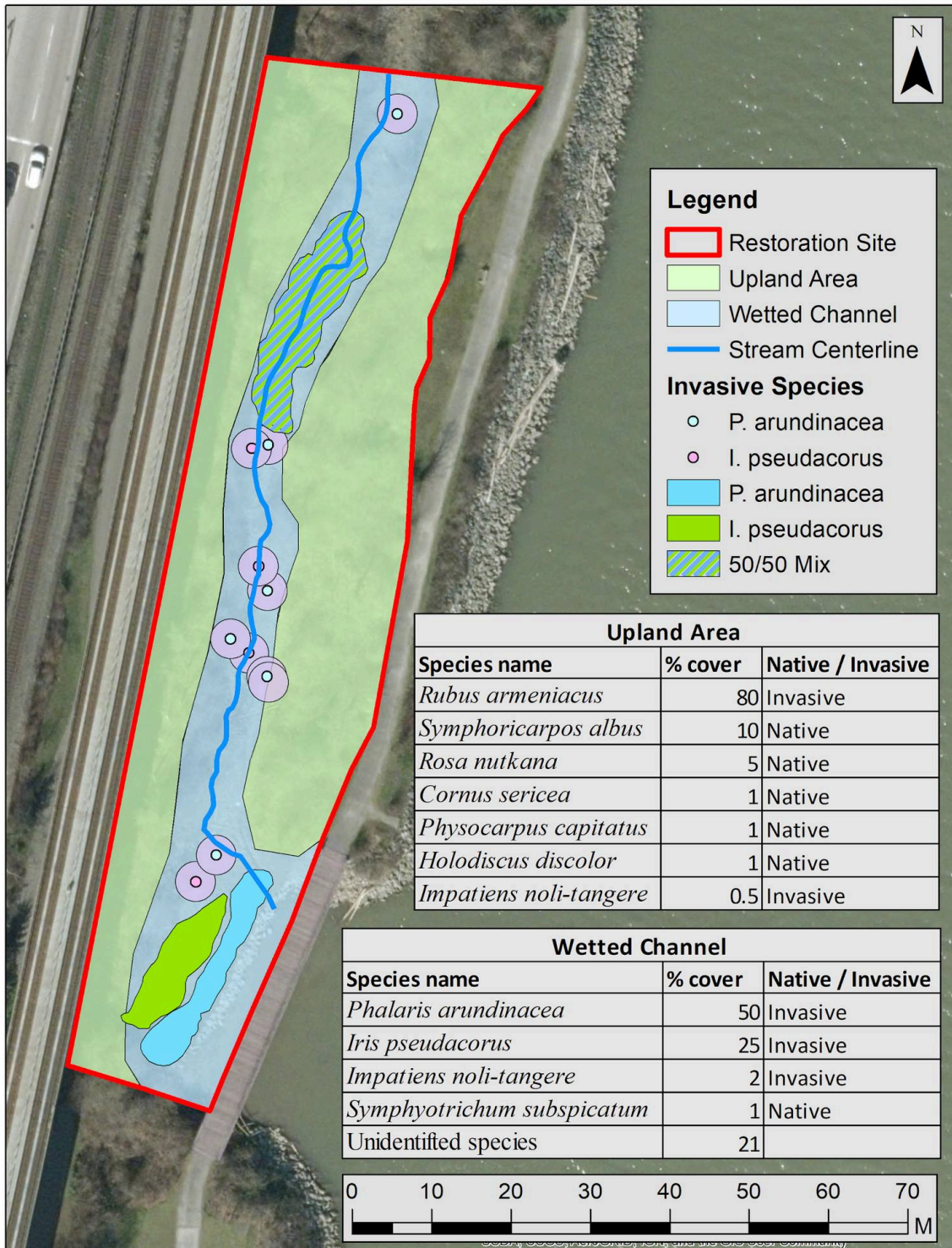


Figure 2 Map of invasive vegetation distributed at the South Channel Restoration Site based on surveys on 23 November 2020. Species data collected as points were <math><5\text{m}^2</math> whereas polygons were areas >math>>5\text{m}^2</math>. Survey methods found in Appendix D.

## 1.2.6 Birds

In 2013, 48 bird species were recorded in the City of New Westminster (Butler et al. 2013). As of 2020, 42 bird species have been observed at Sapperton Landing (eBird 2020). We compiled this list of 42 species for Sapperton Landing Park using observations reported on eBird and reported by WildResearch (Appendix F). Four BC blue listed species were observed on site including two subspecies of Great Blue Heron (*Ardea herodias fannini* and *Ardea herodias*), Double-crested Cormorant (*Phalacrocorax auritus*), Black Swift (*Cypseloides niger*), and Green Heron (*Butorides virescens*) (Arbeider 2015, eBird 2020).

## 1.2.7 Recommended Additional Assessments

We recommend further site assessment for the replacement of the Wetted Channel with a groundwater-fed wetland. We recommend assessment of how the water table elevation varies seasonally and with the tide to decide if the wetland will be ephemeral or permanently wetted. The soil pit that we dug was 60 cm to riprap. Deeper digging in the channel will inform how deep riprap is, and where the water table begins.

## 1.3 Site Stressors and Impacts

### 1.3.1 Urbanization and Human Development

Expanding urbanization of areas surrounding Sapperton Landing Park is one the major off-site stressors that impact the site specifically due to the significant number of impermeable surfaces (Appendix G). In addition to expanding urbanization, human development along the banks of Fraser River is another off-site stressor.

### 1.3.2 Impacts

#### 1.3.2.1 Impacts to Water Quality

We measured turbidity on 13 October 2020 and found it was 36.1 FNU which is too high for aquatic organisms according to the recommendations for a 30-day average in the Salmon River watershed being less than 10 NTU (The Ministry of Environment, Lands, and Parks 1998). With the high turbidity levels of the Fraser River the channel has filled in with sediment over time. In addition, the Wetted Channel is not submerged by water long enough to sustain aquatic life.

#### 1.3.2.1 Impacts of Invasive Vegetation

The main impacts we aim to eliminate at BTC are those caused by the presence of terrestrial and aquatic invasive plant species. Invasive plants are easily established and dispersed in urban areas due increased

impervious surfaces, high concentrations of people, industry, and infrastructure (Chadwick and Francis 2015).

The Upland Area is dominated by *R. armeniacus*, which acts as a visual obstruction, and degrades the ecological value of the area by outcompeting native vegetation and increasing flooding and erosion (ISCBC 2014). *R. armeniacus* creates a monoculture by shading out meadows, shade intolerant shrubs and tree species. Monocultures negatively impact bird diversity and pushes them out of potential breeding habitats or entire areas (Astley 2010). Although *R. armeniacus* berries provide a food source for birds, they attract nest predators (e.g. Eastern grey squirrels (*Sciurus carolinensis*), raccoons (*Procyon lotor*), rats (*Rattus sp.*), and garter snakes (*Thamnophis sp.*) and allow easier access to low level nests (Astley 2010).

Aquatic invasive plants, especially *I. pseudacorus* and *P. arundinacea* dominate the Wetted Channel. *I. pseudacorus* outcompetes native cattails, sedges, and rushes used for nesting by many bird species (ISCBC 2017). *I. pseudacorus* reduces a wetlands ability to store water (ISCBC 2017). *P. arundinacea* also aggressively takes over wetlands and competes with native wetland plant species (Metro Vancouver 2002). Removal of *P. arundinacea* is crucial as this species can take over wetland areas within 5-6 months of being introduced (Anderson 2012). *P. arundinacea* grows rapidly forming thick mats and prevents native wetland and riparian species from growing (ISCBC 2017). *P. arundinacea* lacks forage value for some native species that a constructed wetland could bring to the area (Anderson 2012).

### 1.3.2.2 Increased Pollutants

Impervious surfaces increase contaminated runoff from vehicle and atmospheric pollution which degrades aquatic ecosystems (Chithra et al. 2015). The extensive impermeable surfaces above Sapperton Landing Park including streets and parking lots likely increase surface runoff and associated contaminants into the Wetted Channel.

### 1.3.2.3 Impacts Off-site Bank Hardening

Human development along the banks of the Fraser River is an off-site stressor that cannot be eliminated but associated impacts must be considered and reduced. The west bank of the Fraser River that runs along the BTC has been hardened using riprap. Installation of riprap impedes the natural functions of a riverbank, effectively destroying the riparian area (Smith 2009).

## 1.4 Desired Site Conditions

We recommend that the Wetted Channel be transformed into a marshland, with a plant community typical of the Wm05 (Cattail) or Wm50 (Sitka sedge – Hemlock-parsley) site series (Appendix H). Marsh ecosystems support diverse species, including plankton and invertebrates that form the foundation of large food webs (LMH 52 2004, MacKenzie and Moran 2004). Marshes are one of the easiest wetland ecosystems to engineer, as they are an early-seral stage of wetland development and will form naturally in these artificial systems (MacKenzie and Moran 2004).

## 2.0 Restoration Goals and Objectives

Dates are set to the theoretical start date of 01 January 2021.

**Goal 1:** Convert the South Channel Restoration Site into a functioning wetland ecosystem January 2022.

**Objective 1.1:** Increase abundance of native plant species and decrease presence by 100% of invasive vegetation in the Wetted Channel by January 2022.

**Action 1.1.1:** Remove *I. pseudacorus* and *P. arundinacea* in the Wetted Channel using rubber matting and manual hand removal by March 2021.

**Action 1.1.2:** Plant native species of trees, shrubs, and herbs (Appendix H and Appendix I) at the South Channel Restoration Site May 2021.

**Objective 1.2:** Convert the compensation channel into a groundwater-fed wetland ecosystem by January 2022.

**Action 1.2.1:** Block tidal influence into wetland by building gradual berms using new fill material by April 2021.

**Objective 1.3:** Improve habitat quality of the Upland Area to support breeding bird species by January 2022.

**Action 1.1.1:** Remove 100% *R. armeniacus* in the Upland Area with grubbing mowing by March 2021.

**Action 1.1.2:** Plant native tree and shrub species (Appendix H) to provide habitat for native birds by May 2021.

## 3.0 Restoration Treatments

### 3.1 Create Marshland Ecosystem

We recommend blocking the tidal influence on the Wetted Channel by creating berms 2.5 m high underneath the bridges located at the northern and southern mouths. The rising tide reached the ground underneath the bridges at 1.3 m and the highest tides in 2020 were measured 3.2 m (tide levels obtained from New Westminster #7654 tide station). Building the berms is crucial to prevent soil erosion into the Fraser River that possibly contains seeds of invasive plants. By doing this we will be able to safely dredge the Wetted Channel to the water table and create a groundwater-fed wetland. We propose digging the channel down to a depth >60 cm that would allow the wetland to be wetted for most of the year but dry up in the summer months. By making this an ephemeral wetland, we will prevent some invasive species from taking over such as *Lithobates catesbeianus* (American bullfrog). It will also help prevent native species like *Typha sp.* from overtaking the area from a stable water table (Bansal et al. 2019). The Wetted Channel was originally designed with two elevations: a higher elevation intended to support cattails and willow, and a lower elevation to support sedges (Metro Vancouver 2002). We recommend the wetland has two elevations to support two different vegetation communities. An excavator will be used to construct the banks at both the northern and southern mouths of the channel. The armoring that is already present on site will be used to reinforce the banks on the side of the river.

### 3.2 Invasive plant removal

Removal of these invasive species should be done following the creation of the proposed berms that would cut off the Wetted Channel from the Fraser River. This will allow for easier excavation of the invasive species and soil out of the Wetted Channel, for the formation of the wetland ecosystem.

#### 3.2.1 *R. armeniacus* Removal

The Upland Area is dominated by *R. armeniacus*, covering about 80% of the total area as determined by our relative abundance survey (Figure 2). We recommend managing *R. armeniacus* in the upland by removing large patches using an excavator, and in remaining areas by mowing the standing plants to the ground and grubbing root structures. Following removal, jute matting will be applied to prevent soil erosion and assist in soil stabilizing and invasive regrowth out competing native vegetations. Jute matting is a good alternative to plastic and polyester-plastic blend matting as it will biodegrade within two to four

years (Swan River Trust 2009). Removal of *R. armeniacus* should happen in the winter months, when the number of nesting bird species are at their lowest (GOERT 2002).

Herbicide use is not recommended for management of *R. armeniacus*, this location is also in a major portion of the pesticide free zone defined by the Ministry of Environment. (ISCBC 2017, MoE 2006)

### 3.2.2 *I. pseudacorus* and *P. arundinacea* Removal

*I. pseudacorus* dominates the Wetted Channel and outcompetes native species that provide habitat for birds, fish, and other animals, by creating thickets (Thurston County 2016). We recommend removing this species by excavation, removing the infested soils off site (locations of this species are noted in Figure 2). Soils with low amounts of root fragments will be used to construct berms at the mouths of the BTC. If soils are found to be too infested with invasive seeds, clean soil should be brought in for the construction. Possible issues are regrowth of *I. pseudacorus* from root fragments (Thurston County 2016).

We recommend the same process of management and removal of *P. arundinacea*. Excavate the species and remove material off of the site to prevent regrowth. Soils possibly containing seedbanks of the invasive species will be removed from site and replaced with clean soil (Metro Vancouver 2020). Removal of these species should happen when the Wetted Channel is dry.

As for herbicide use, According to BC regulations, herbicide cannot be used within 10 m of a stream or wetland area, as defined by the Forest Range and Practices act (MoE 2006).

## 3.3 Plant Prescriptions

After invasive removal and the creation of the groundwater fed wetland, we plan to undertake planting prescriptions for our two different site units. Each prescription has been selected to reflect suitable plant species for the soil structure, nutrients, and moisture levels in our site units.

### 3.3.1 Upland Area Plant Prescription

In the Upland Area we want to ensure prevention of *R. armeniacus* from reinvading the area and provide additional habitat for bird species.

Using the site series CWHdm05 as a guide, taken from the Land Management Handbook 28 (Appendix H), the prescription will contain four major tree species, three shrub species, and three herb species. Some

species are already onsite such as *Rosa nutkana* and *Symphoricarpos albus*, these will be used as they establish quickly, and are good for erosion control (USDA, 2013). We will also be adding *Gaultheria shallon* as it provides good ground cover and could therefore reduce growth room for *R. armeniacus*.

Tree species will consist of *Thuja plicata*, *Tsuga heterophylla*, *Alnus rubra*, and *Acer macrophyllum*. The shrub layer will be made up of *Gaultheria shallon*, *Rosa nutkana* and *Symphoricarpos Albus*. Lastly, the herb layer will contain *Polystichum munitum*, *Blechnum spicant*, and *Tiarella trifoliata*. Local stocktype ten containers will be used for the trees, spaced 2 m apart. The shrub layer will consist of stocktype one containers, spaced one 1 m apart, and the herb layer will contain stocktype one as well, spaced 0.5 m apart.

Our prescription will achieve a plant community of:

Tree layer- 30% *T.plicata*, 30% *A. rubra*, 25% *A. macrophyllum*, and 15% *T. heterophylla*.

Shrub later- 45% *G. shallon*, 35% *R. nutkana*, and 20% *S. albus*.

Herb layer- 40% *P. munitum*, 30% *B. spicant*, and 30% *T. trifoliata*.

### 3.3.2 Wetted Channel Plant Prescription

As per Land Management Handbook (LMH) 52 handbook, two possible wetland site series would work well for an ephemeral wetland, Wm05 (Cattail) and Wm50 (Sitka sedge - Hemlock - parsley). Since we do not have water table depths, we will work to describe our planting prescription for site series Wm05 (Cattail).

Our wetted channel planting prescription will contain four species, *Typha latifolia*, *Carex utriculata*, *Nuphar lutea* and *Spiraea douglasii*. These species were selected as they are the major species found in this site series according to the LMH 52. *T. Latifolia* will be planted densely to prevent the possible invasive species from propagating after excavation activities. The four plants selected occupy different areas of a wetland ecosystem and do well in submerged and saturated soils. (Mackinnon et al. 2016)

Where available stock type one containers will be used for *T. Latifolia* and *C. utriculata* and planted at a 1 m spacing. Stock type one will also be used for *N.lutea* and *S. douglasii* at a spacing of 2 m, interspersing the species in their respective ecotypes.

Our prescription will achieve a plant community of:

75% *T. Latifolia*, 15% *C. utriculata*, 5% *N.lutea* and 5% *S. douglasii*.

## 4.0 Monitoring Plan

We recommend monitoring to assess the success of the following objective:

**Objective 1.1:** Increase abundance of native plant species and decrease presence by 100% of invasive vegetation in the Wetted Channel by January 2022.

### 4.1 Invasive Vegetation Monitoring

We recommend three years of annual monitoring for the re-growth of invasive vegetation, including *R. armeniacus* in the Upland Area and *I. pseudacorus* and *P. arundinacea* in the restored Wetted Channel. Monitoring can take place between September to mid-March to avoid disturbing native passerine birds in their sensitive nesting season (Garry Oak Ecosystem Recovery Team 2002). The yearly observation and recording re-growth of invasive vegetation will ensure native plants are not outcompeted. This monitoring and yearly maintenance, will reduce the need for further large-scale removal, reducing the overall cost of restoration efforts.

We recommend a presence/not-detected survey be conducted in both site units. To avoid bias and achieve good coverage of the site, we suggest evenly spaced transects are established along a random bearing. Observers should then record any invasive species within 1 m of either side of the transects, coordinates and photos should be taken. Data can be recorded in a data dictionary using a GPS equipment or a smartphone with downloaded Pdf Avenza app.

### 4.2 Native Vegetation Monitoring

We suggest native plants in the Upland Area and Wetted Channel be monitored once a year for the first five years after being planted. Photos should be taken to monitor progress and ensure healthy establishment. This can be done at the same time and on the same transects as invasive monitoring. The location of the first sample should be selected randomly. Location, species, signs of wildlife damage (browsing, grazing or trampling), disease and dead/alive can be recorded in a data dictionary using a GPS equipment or a smartphone with downloaded Pdf Avenza app.

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<https://www.dpaw.wa.gov.au/images/documents/conservation-management/riverpark/Management/Best%20management%20practices%20for%20foreshore%20stabilisation%20-%20Erosion%20control%20matting.pdf>

## Appendix A: Soil sampling methods.

### Equipment:

- LMH 28 handbook (Green and Klinka 1994)
- Meter stick
- Soil auger

A soil auger was used to extract soil from the ground. One soil sample was taken in the Upland Area and one in the Wetted Channel (Figure 2.). For the Upland Area sample, soil was removed from the auger and laid out on the grass to display the soil profile for a 1 m depth. Soil was hand textured according to LMH 28 handbook methods (Green and Klinka 1994).



Upland Area soil profile obtained on 23 November 2020.

## Appendix B: Water depth by tidal influence methods.

On 23 November 2020, the lowest tide in the Wetted Backwater Tidal Channel was 0.9 m at 0700 hours and rose to about 2.6 m until 1130 hrs. The channel started to flood at 1100 hours at a tide level of 2.6 m. The tide levels for each observation time were obtained from the closest DFO tide station (i.e., #7654 New Westminster, BC) (DFO 2020).



Rising tide of 2.6 m tide height at 1100 hours in the Wetted Channel at the South Channel Restoration Site on 23 November 2020.

Based on our observation of water depth versus tide level on 23 November 2020 in the South Channel Restoration Site, we estimated the daily duration over which the channel had no surface water during 22 to 28 November (see red outlines in the table below).

### Predicted Hourly Heights (m)

Date	Hour																								
	PST	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2020-11-22	1.7	1.5	1.3	1.1	0.9	0.7	0.7	0.8	1.1	1.6	2.1	2.6	2.9	3.0	2.9	2.7	2.4	2.1	1.8	1.6	1.5	1.5	1.6	1.6	1.7
2020-11-23	1.7	1.7	1.6	1.4	1.2	1.0	0.9	0.9	1.0	1.3	1.8	2.2	2.6	2.8	2.9	2.8	2.5	2.2	1.9	1.6	1.4	1.3	1.3	1.3	1.4
2020-11-24	1.5	1.7	1.7	1.6	1.5	1.4	1.2	1.1	1.1	1.2	1.5	1.9	2.3	2.6	2.8	2.8	2.6	2.3	2.0	1.6	1.3	1.1	1.0	1.0	1.1
2020-11-25	1.3	1.5	1.7	1.8	1.8	1.7	1.6	1.4	1.3	1.3	1.5	1.8	2.1	2.4	2.7	2.8	2.7	2.4	2.1	1.7	1.3	1.0	0.9	0.9	0.9
2020-11-26	1.0	1.3	1.6	1.9	2.0	2.0	1.9	1.8	1.6	1.5	1.5	1.7	2.0	2.3	2.6	2.7	2.7	2.5	2.2	1.8	1.4	1.1	0.8	0.7	0.7
2020-11-27	0.8	1.0	1.4	1.8	2.1	2.3	2.2	2.1	2.0	1.8	1.7	1.7	1.9	2.2	2.5	2.7	2.7	2.6	2.3	1.9	1.5	1.1	0.8	0.7	0.7
2020-11-28	0.6	0.8	1.2	1.7	2.1	2.4	2.5	2.5	2.3	2.1	1.9	1.9	1.9	2.2	2.4	2.6	2.7	2.6	2.4	2.0	1.6	1.3	0.9	0.7	0.7

## Appendix C: Water quality methods.

### Equipment:

- LaMotte Turbidimeter
- YSI multiparameter meter

Both instruments were calibrated according to the manufacturer’s specifications. Three samples were then taken with a LaMotte Turbidimeter to measure the turbidity in Formazin Nephelometric Units (FNU). The mean of the three measurements was taken to determine the turbidity of the water at the site. Two samples were then taken using the YSI meter along the edge of the channel at the surface of the water, and at 70 cm depth (Figure 3) to measure pH level, the temperature in degrees celsius, dissolved oxygen as a percentage and specific conductivity in microsiemens, conductivity in microsiemens and pressure in millimeters of mercury.



## Appendix D: 13 October 2020, vegetation survey methods and results.

On 23 November 2020, a GPS survey was conducted using 2 person hours to determine the location and extent of invasive plants on site using a Trimble GeoExplorer 6000. The centerline of the channel was walked and all insunes of invasive species were marked. If the area the species occupied was less than or equal to 5 m<sup>2</sup> it was noted as a point with a polygon around it. If the extent was larger than 5 m<sup>2</sup> is noted as a polygon.

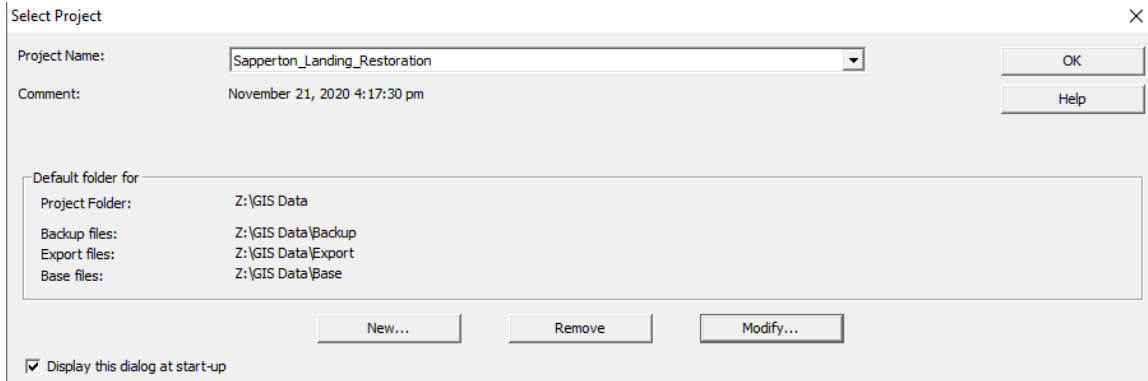
Common name	Scientific name	BC List	Site Unit: Upland Area (UA) or Wetted Channel (WC)
Himalayan blackberry	<i>Rubus armeniacus</i>	Exotic	UA
common snowberry	<i>Symphoricarpos albus</i>	Yellow	UA
Nootka rose	<i>Rosa nutkana</i>	Yellow	UA
oceanspray	<i>Holodiscus discolor</i>	Yellow	UA
red-osier dogwood	<i>Cornus sericea</i>	Yellow	UA
downy birch	<i>Betula pubescens</i>	Exotic	UA
Pacific ninebark	<i>Physocarpus capitatus</i>	Yellow	UA
red alder	<i>Alnus rubra</i>	Yellow	UA
bigleaf maple	<i>Acer macrophyllum</i>	Yellow	UA
field bindweed	<i>Convolvulus arvensis</i>	Exotic	UA
common touch-me-not	<i>Impatiens noli-tangere</i>	Yellow	UA and WC
reed canarygrass	<i>Phalaris arundinacea</i>	Exotic	WC
yellow iris	<i>Iris pseudacorus</i>	Exotic	WC
Bracken fern	<i>Pteridium aquilinum</i>	Yellow	UA
European bittersweet	<i>Soloanum dulcamara</i>	Exotic	UA

Douglas' aster	<i>Symphyotrichum subspicatum</i>	Yellow	WC
Robert's geranium	<i>Geranium robertianum</i>	Exotic	UA

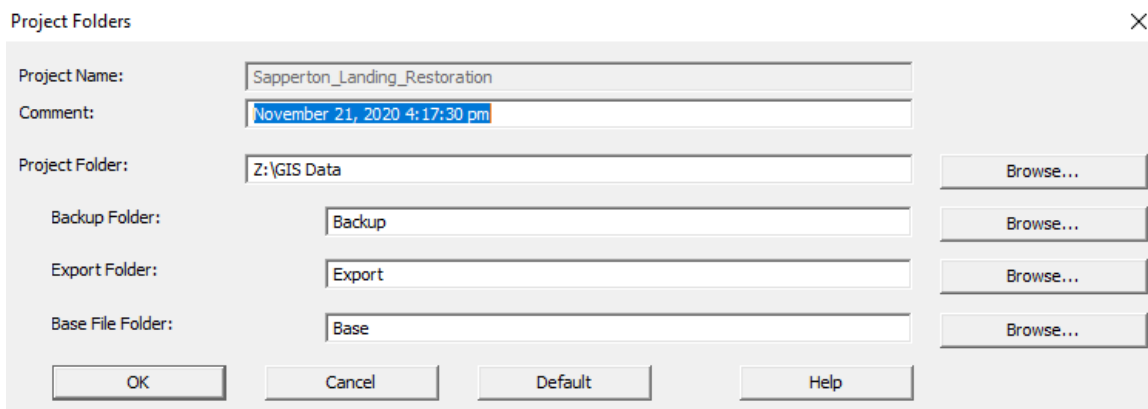
## Appendix E: Methods for data collection and transfer to ArcMap.

### Step 1: Preparing to Collect Field Data

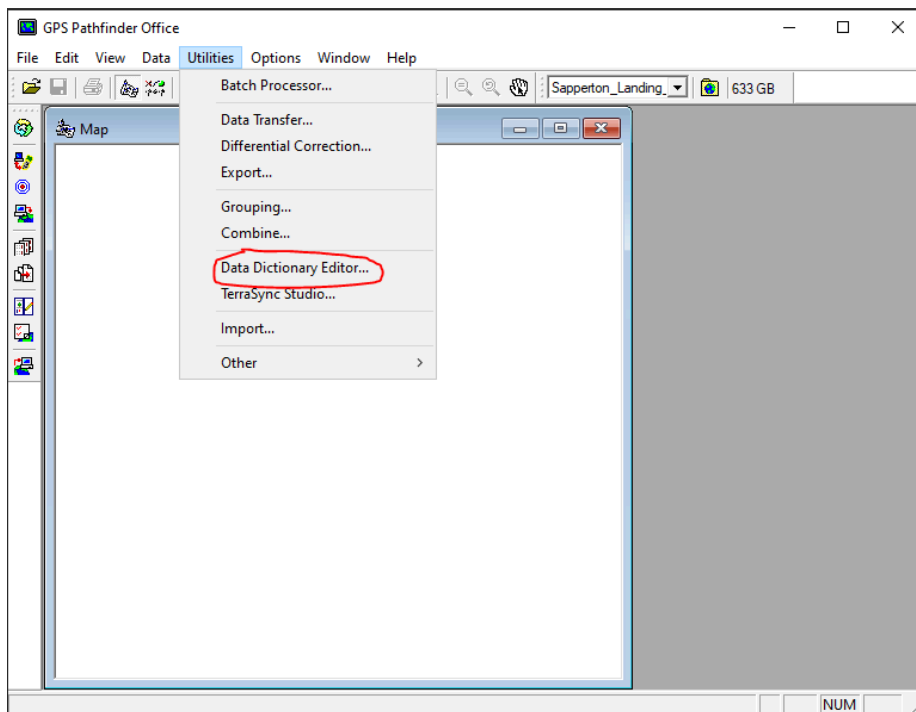
1. Opening a file
  - open "GPS Pathfinder Office" to create a custom data dictionary.
  - create a project name, and folder that can be accessed in future use. For this project we put it into our Z: folder which is attached to our BCIT A00 number.



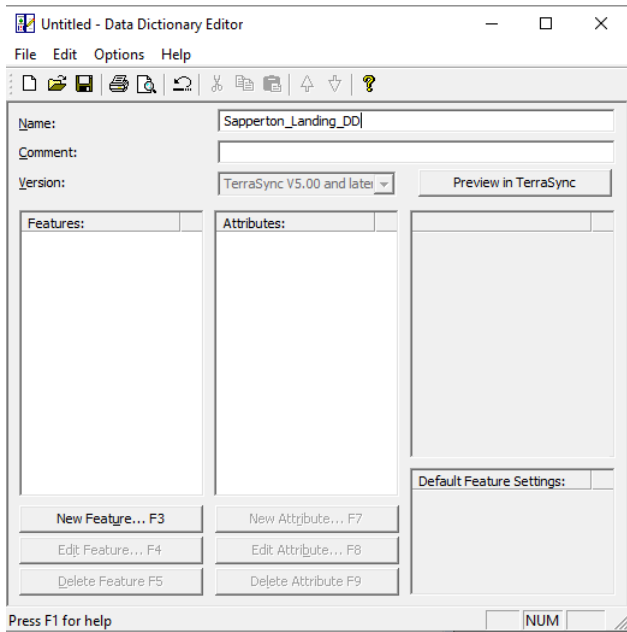
- Make sure backup, export, and base file folders are under the Project folder by clicking browse after clicking OK



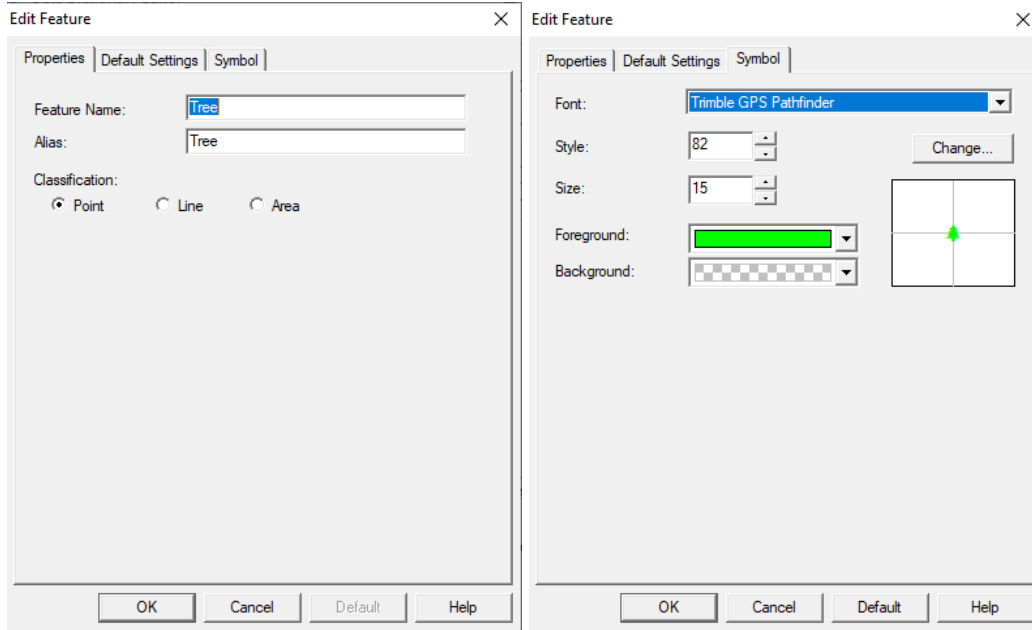
0. Set up data dictionary.



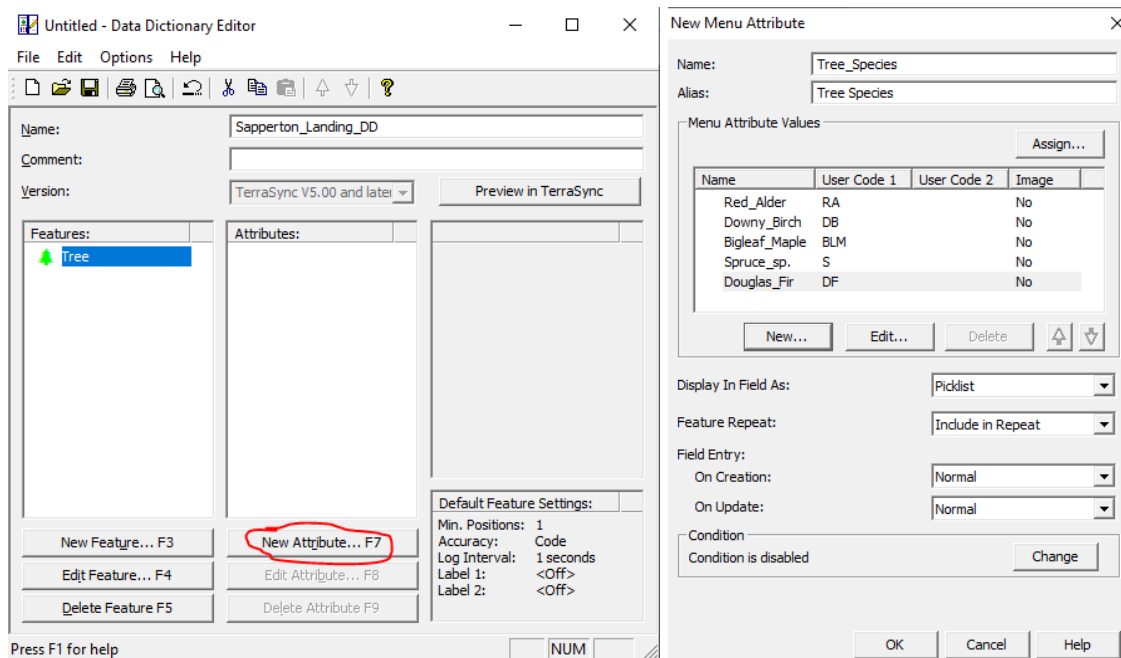
- Once project folder has been selected, and the main GPS Pathfinder Office screen opens, select Utilities > Data Dictionary Editor.
- This screen is where we make our custom data dictionary for our data collection at Sapperton Landing. As an example we wanted to collect specific tree locations on our site. So we start by selecting “New Feature”



- When creating Tree feature, name the feature and its alias. The difference between these two names is what will appear in the GPS unit screen, which will be the alias name.
- Decide what kind of feature should be collected (Point, Line, Polygon) this project will use point data.
- To keep track of this tree data, and keep it separate from other point data collected
- Change the symbol to a tree. Select “Change” which will pull up the window of several symbols.



- Once the features are created add in “Attributes” to be collected for the feature.
- For the tree point feature tree “Attributes” are species, heath, and if it is providing any bird habitat.
- List of tree species we expect to see on the site was generated as a drop-down menu for easy selection. If a tree species is found on site that is not in the drop-down menu, a detail note will be added to a Generic tree point.



## Step 2: Field Data Collection

Once the data dictionary has been uploaded to our GPS unit, field data can be collected. A Trimble GeoExplorer 6000 unit was used to conduct a presence/not detected survey.

### Data collected on site:

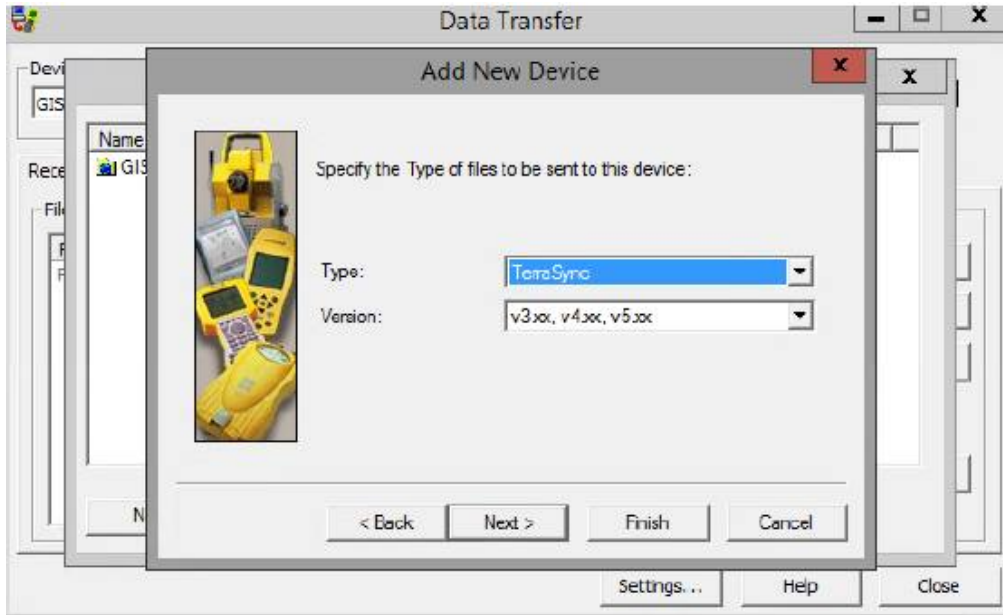
Data Collected	Data Type	Attributes Captured
Tree Species	Point	Species, comments, date of collection, time of collection
Soil Pits	Point	Comments, date of collection, time of collection
Stream Center Line	Line	Comments, date of collection, time of collection
Invasive Species	Point	Species, comments, date of collection, time of collection
Plant Communities	Polygon	Comments
Generic Point	Point	Comments
Generic Polygon	Polygon	Comments

## Step 3: Data Processing

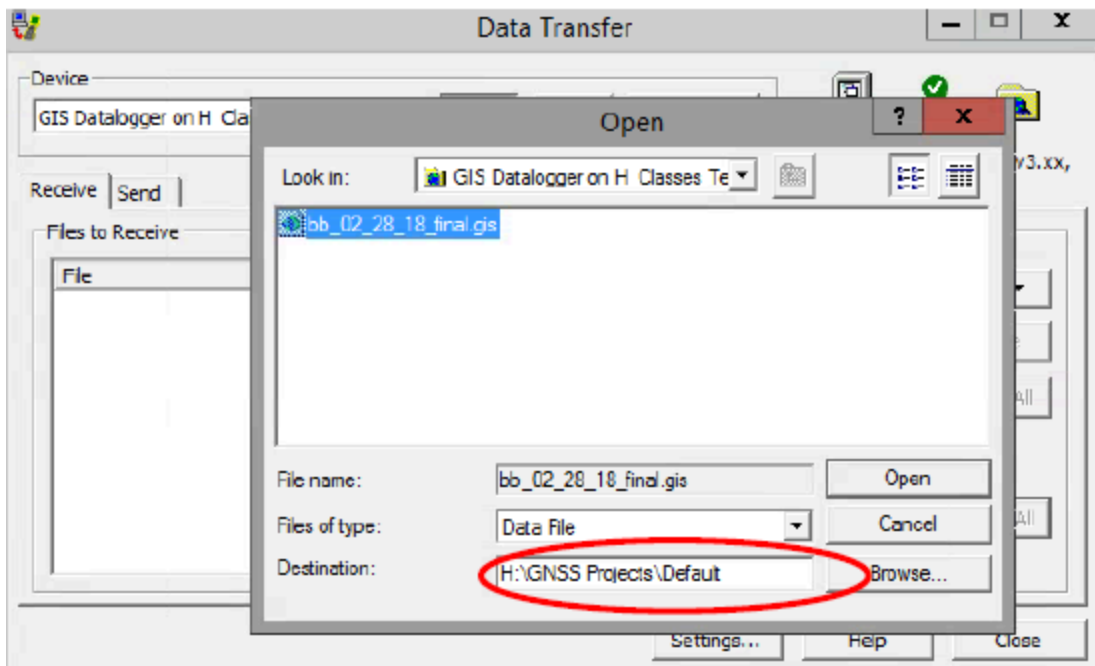
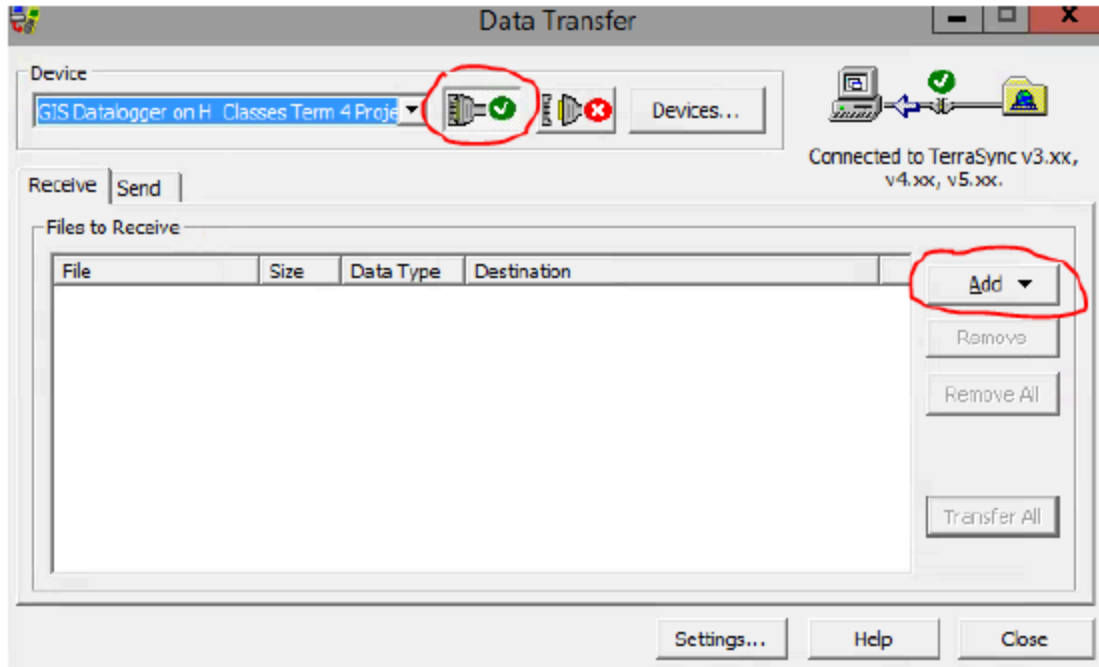
### 1. Extract Data from GeoExplorer 6000:

- Download latest version of Windows Mobile Device center.
- Plug GeoExplorer 6000 into computer with USB cable.
- Press “Press connect without setting up device” to access file directory on the unit





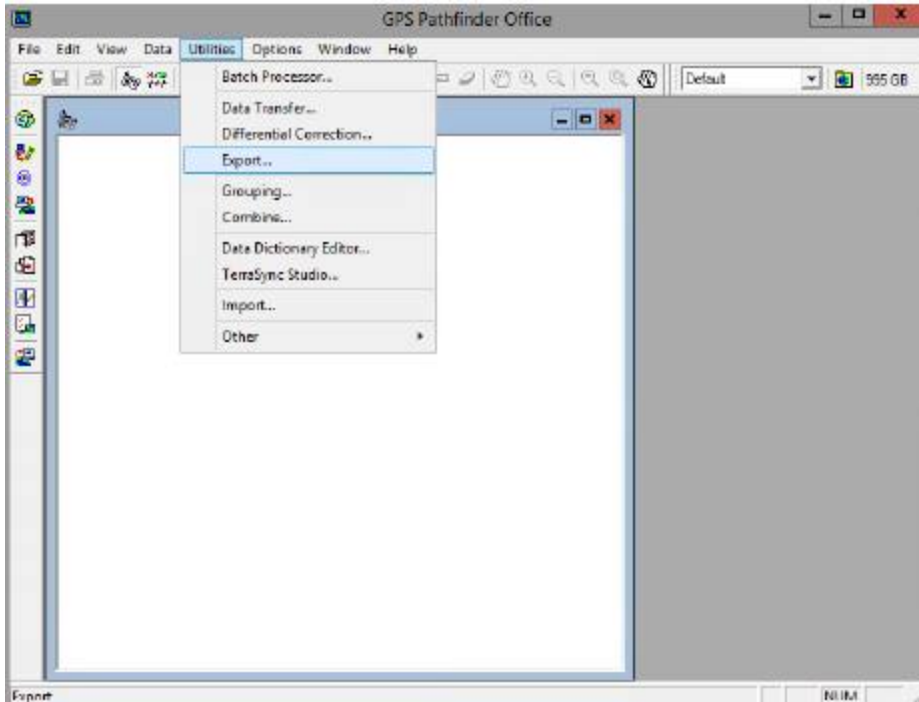
- Once folder connection is created click the green connection button, and then “Add” button, select the .gis file and then press transfer all.



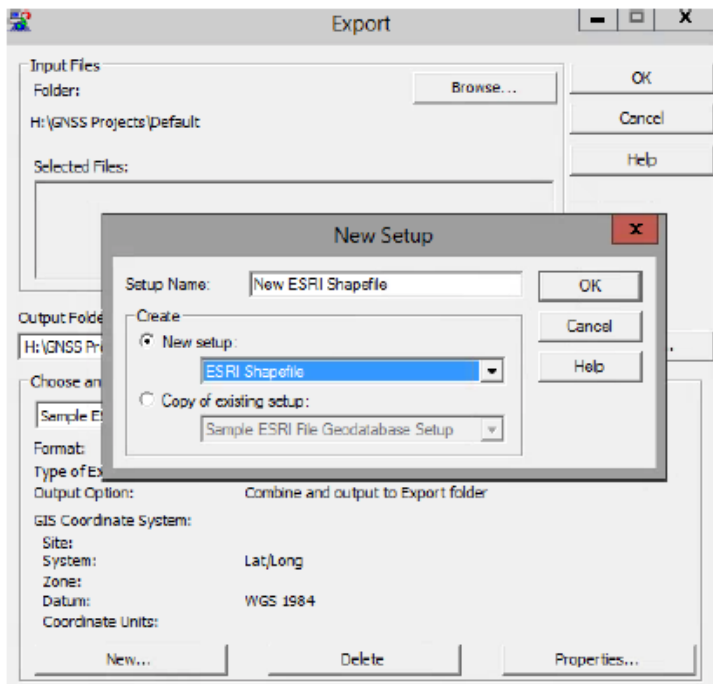
- Once this process is complete, we will find the destination folder you selected previously and there we will find the .ssf file.

**0. Convert .cor into Shapefiles for ArcMap:**

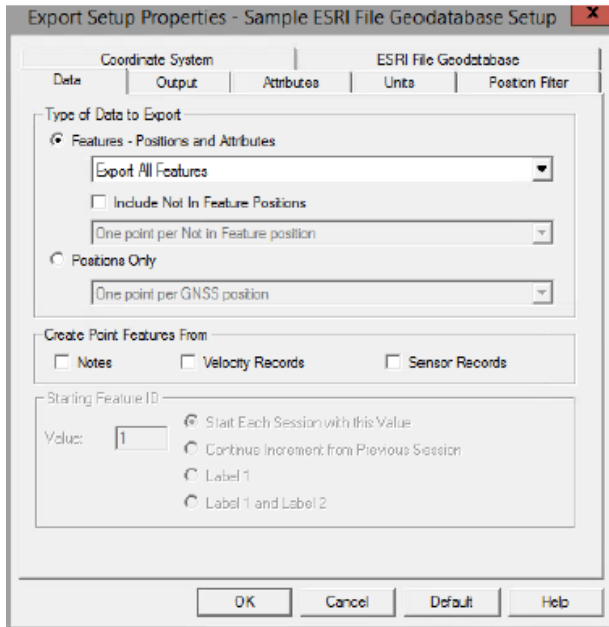
- With Pathfinder Office open, click the “Utilities” tab and select “Export”



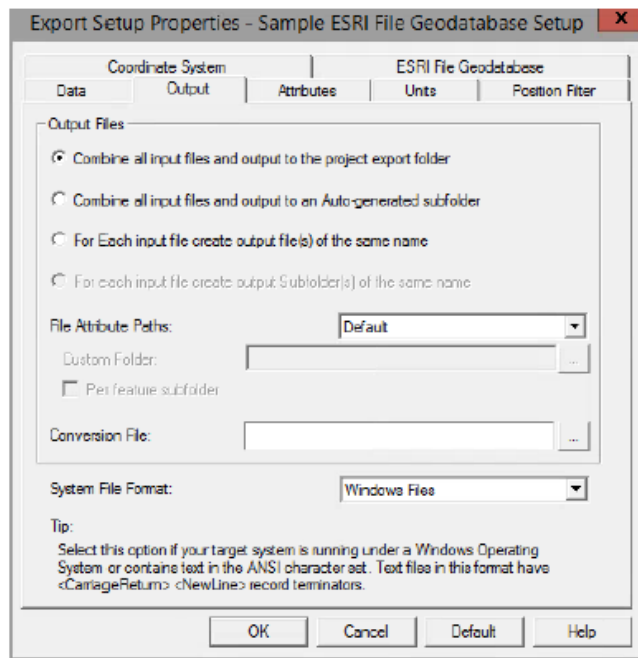
- Now that the export menu is open, change options for export. Begin by clicking on the “New” button, and select “ESRI Shapefile” for type, then hit ok.



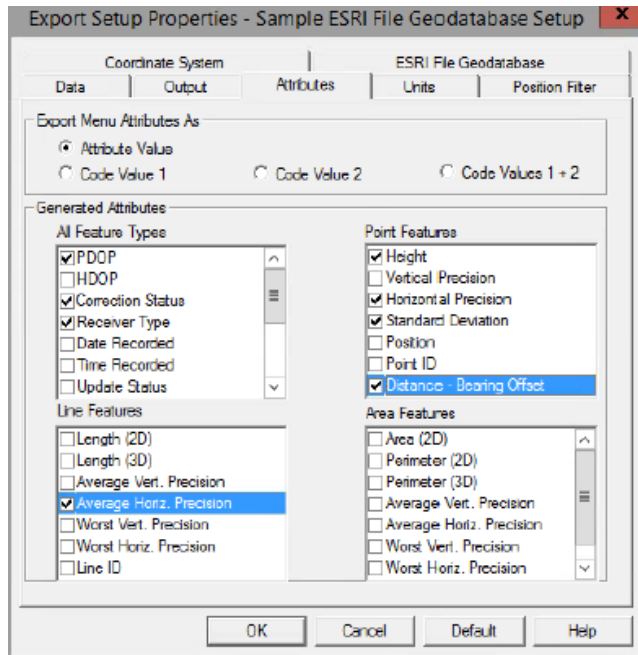
- Go through all the tabs in the Export Properties Menu
  - a. Data



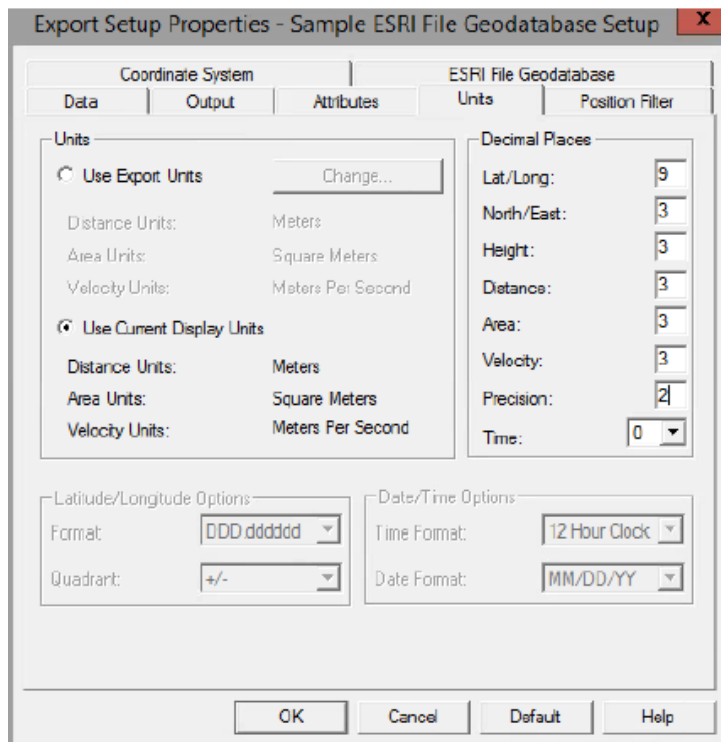
## b. Output



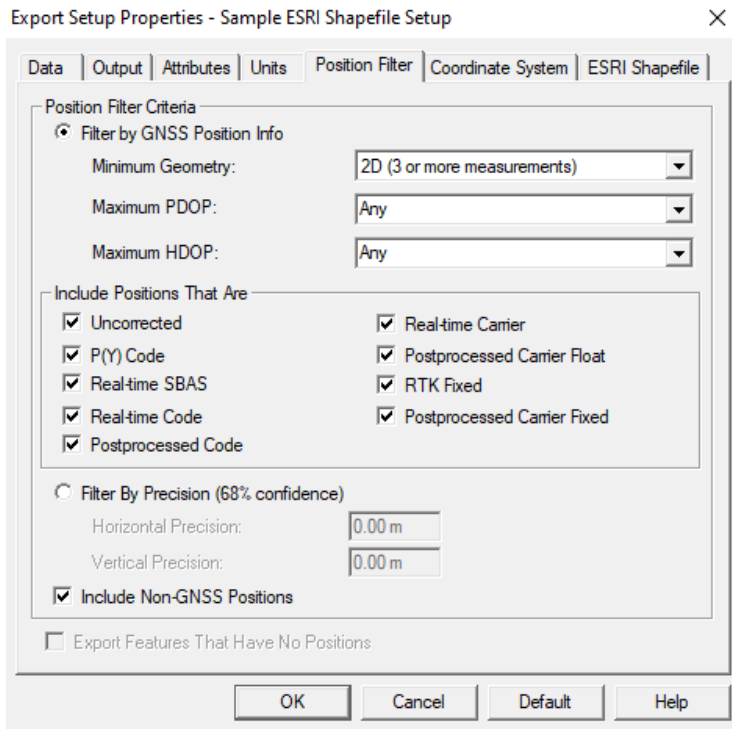
## c. Attributes



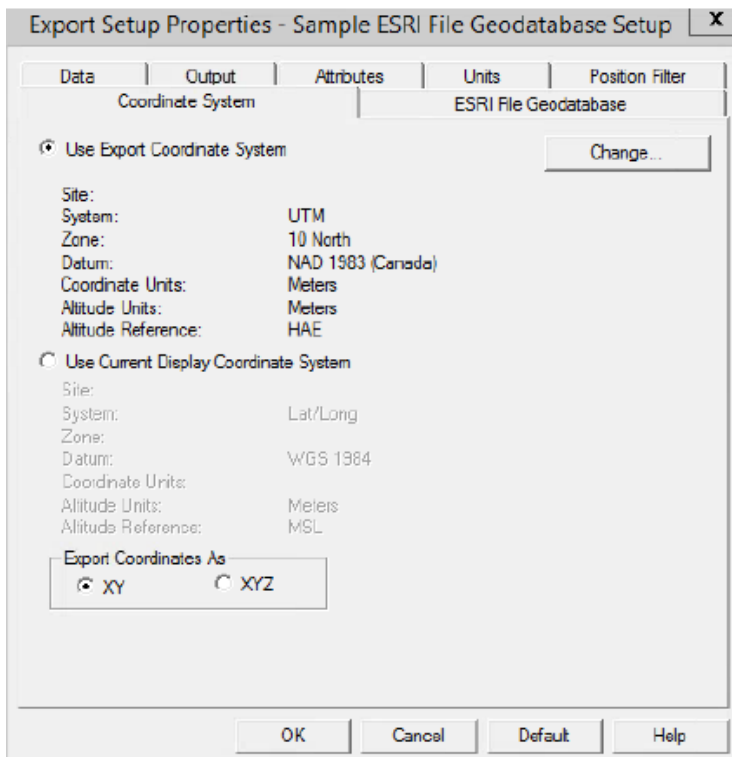
d. Units



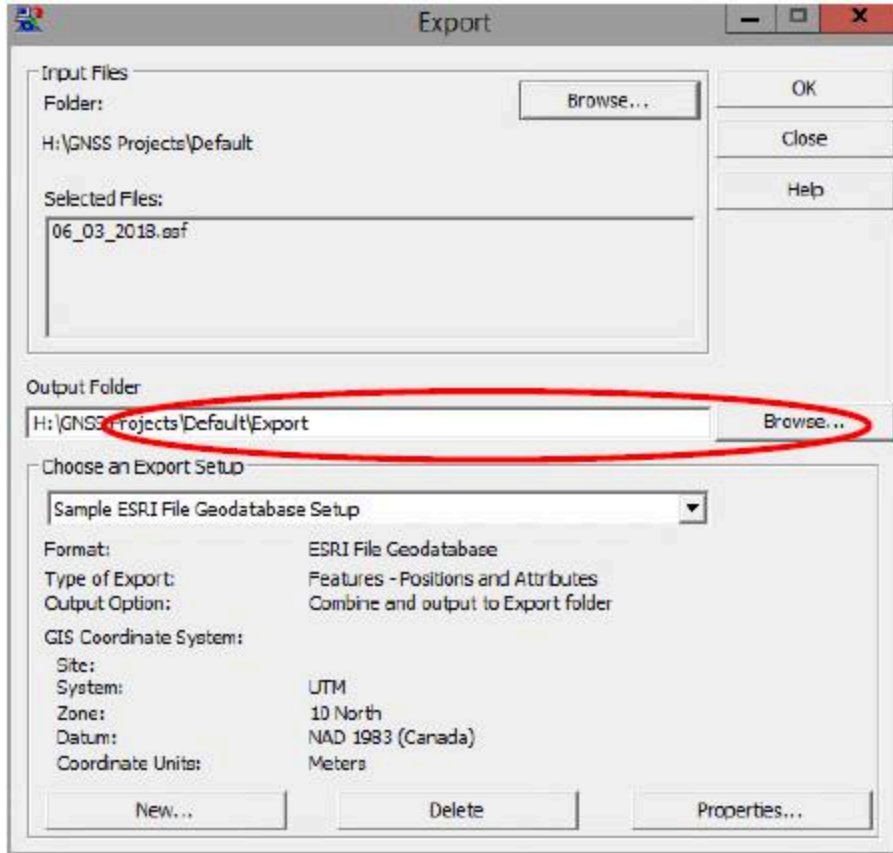
e. Position Filter



#### f. Coordinate System



- Once all the settings found in the above pictures hit “OK”. Now select the .cor file you want to convert into shapefiles
- select a location shapefiles should to go to



## Appendix F. Bird species(Arbeider 2015, eBird 2020).

Bird list was collected from the eBird database. Noted are three separate classification systems in BC showing how at risk each species is. Information compiled from a 2015 Wild research survey.

List of Bird Species Observed at Sapperton Landing				Conservation Status for Each Three Conservation Systems		
Common Name	Scientific Name	Number of Observations	Date of First Observation	SARA Classificaiton	COSEWIC Classification	BC Species List
Downy woodpecker	<i>Dryobates pubescens</i>	1	4-Oct-20			
Nothorn flicker	<i>Colaptes auratus</i>	1	4-Oct-20			
Black-capped chickadee	<i>Poecile atricapillus</i>	2	4-Oct-20			
American robin	<i>Turdus migratorius</i>	10	4-Oct-20			
Fox sparrow	<i>Passerella iliaca</i>	5	4-Oct-20			
Canada Goose	<i>Branta canadensis</i>	3	31-May-20			
Mallard	<i>Anas platyrhynchos</i>	2	31-May-20			
Anna's hummingbird	<i>Calypte anna</i>	1	31-May-20			
Great blue heron	<i>Ardea herodias</i>	1	31-May-20	Special concern (For Fannini & Herodias subspecies)	Special concern (For Fannini & Herodias subspecies)	Blue
Turkey vulture	<i>Cathartes aura</i>	1	31-May-20			
Osprey	<i>Pandion haliaetus</i>	1	31-May-20			
Bald eagle	<i>Haliaeetus leucocephalus</i>	2	31-May-20			
Northwestern crow	<i>Corvus caurinus</i>	5	31-May-20			
Tree swallow	<i>Tachycineta bicolor</i>	3	31-May-20			
Violet-green swallow	<i>Tachycineta thalassina</i>	5	31-May-20			
House finch	<i>Haemorhous mexicanus</i>	1	31-May-20			
Song sparrow	<i>Melospiza melodia</i>	2	31-May-20			
Spotted sandpiper	<i>Actitis macularius</i>	1	21-May-20			
Glaucous-winged gull	<i>Larus glaucescens</i>	10	21-May-20			
Double-crested cormorant	<i>Phalacrocorax auritus</i>	20	21-May-20		Not at Risk	Blue
Warbling viero	<i>Vireo gilvus</i>	1	21-May-20			
Bushtit	<i>Psaltriparus minimus</i>	2	21-May-20			
European starling	<i>Sturnus vulgaris</i>	4	21-May-20			
Spotted towhee	<i>Pipilo maculatus</i>	1	21-May-20			
Brown-headed cowbird	<i>Molothrus ater</i>	2	21-May-20			
Gadwall	<i>Mareca strepera</i>	8	8-Nov-19			
Bufflehead	<i>Bucephala albeola</i>	2	8-Nov-19			
Golden-crowned kinglet	<i>Regulus satrapa</i>	1	8-Nov-19			
Common golden eye	<i>Bucephala clangula</i>	3	5-Apr-18			
Iceland gull	<i>Larus glaucooides</i>	1	17-Feb-18			

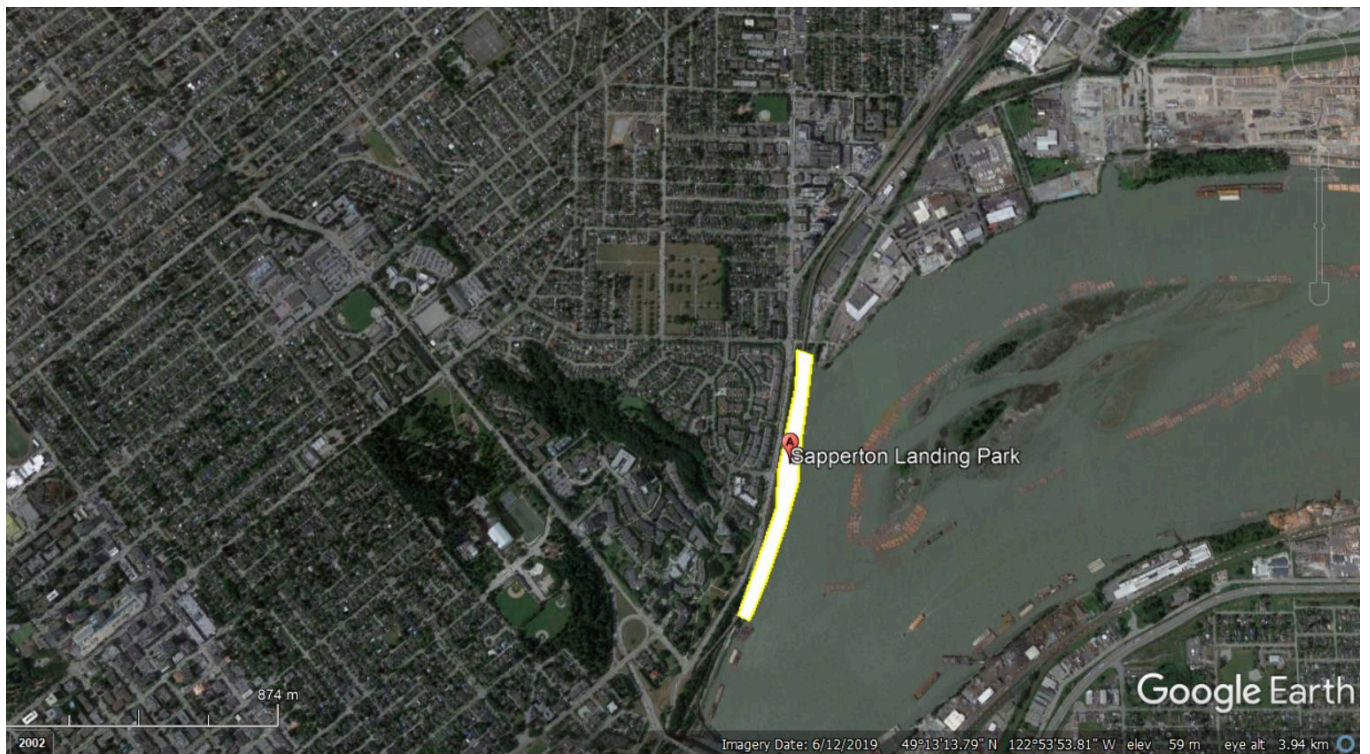
Common merganser	<i>Mergus merganser</i>	5	26-Mar-16			
Rock pigeon	<i>Columba livia</i>	2	26-Mar-16			
Eurasian collared-dove	<i>Streptopelia decaocto</i>	1	26-Mar-16			
House sparrow	<i>Passer domesticus</i>	10	26-Mar-16			
Common redpoll	<i>Acanthis flammea</i>	22	21-Feb-16			
Pine siskin	<i>Spinus pinus</i>	12	16-Feb-15			
Chestnut-backed chickadee	<i>Poecile rufescens</i>	2	16-Feb-15			
Dark-eyed junco	<i>Junco hyemalis</i>	1	16-Feb-15			
Black swift	<i>Cypseloides niger</i>	5	16-Jun-14		Endangered	Blue
Ruby-crowned kinglet	<i>Regulus calendula</i>	2	31-Jan-14			
Green heron	<i>Butorides virescens</i>	1	20-Jul-07			Blue
White-crowned sparrow	<i>Zonotrichia leucophrys</i>	1	20-Jul-07			

Bird species list produced from eBird Survey <https://ebird.org/canada/hotspot/L683723?yr=all&m=&rank=mrec>

Table classifications referenced from Wild research list produced in August 2015

## Appendix G: Google earth aerial image showing extensive urbanization and impermeable surfaces surrounding Sapperton Landing park taken 6 December 2019.

This aerial image shows the urbanization of the area surrounding Sapperton Landing park. The urbanization has caused external stressors to impact the site from pollution, runoff, and increased human disturbances.



## Appendix H. Recommended plant species for marshland put together from LMH 28.

A list made of suitable plants for CWHdm05, taken from the Land Management Handbook 28 to create our Upland Area Planting Prescription.

BEC	SITE SERIES	SPECIES	LAYER
CWHdm	5	<i>Thuja plicata</i>	tree
CWHdm	5	<i>Tsuga heterophylla</i>	tree
CWHdm	5	<i>Pseudotsuga menziesii</i>	tree
CWHdm	5	<i>Acer macrophylla</i>	tree
CWHdm	5	<i>Gaultheria shallon</i>	shrub
CWHdm	5	<i>Vaccinium parvifolium</i>	shrub
CWHdm	5	<i>Acer circinatum</i>	shrub
CWHdm	5	<i>Pteridium aquilinum</i>	herb
CWHdm	5	<i>Polystichum munitum</i>	herb
CWHdm	5	<i>Dryopteris expansa</i>	herb
CWHdm	5	<i>Tiarella trifoliata</i>	herb
CWHdm	5	<i>Blechnum spicant</i>	herb
CWHdm	5	<i>Hylomium splendens</i>	moss
CWHdm	5	<i>Kindbergia oregana</i>	moss
CWHdm	5	<i>Plagiothecium undulatum</i>	moss
CWHdm	5	<i>Rhytidiadelphus loreus</i>	moss

## Appendix I: Site series and recommended plant community to be planted in the marshland.

Two site series were considered as we could not obtain depths of the actual water table. Decisions could be made once this information is known.

<b>BEC</b>	<b>SITE SERIES</b>	<b>SPECIES</b>	<b>LAYER</b>
CWH	wm05	<i>Typha latifolia</i>	Shrub
CWH	wm05	<i>Nuphar lutea</i>	Shrub
CWH	wm05	<i>Spiraea douglasii</i>	Shrub
CWH	wm05	<i>Carex rostrata</i>	herb