Cataloguing and Analyzing Urban Waterways & their Riparian Zones:
A Baseline Data Project in Esquimalt Gorge Park and Cuthbert Holmes Park

by

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This study was done in partial fulfilment of the requirements for the Gorge Waterway Action Society Youth Community Partnership Program

GORGE WATERWAY NATURE HOUSE

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Abstract

The aim of this study was to establish and compare baseline data sets (*i.e.* riparian vegetative biophysical inventories and water analyses) from sites along the Gorge Waterway and Colquitz River, two heavily urbanized waterways on Southern Vancouver Island in the traditional territory of the Lekwungen-speaking First Nations peoples (now represented by the Songhees and Esquimalt nations) (District of Saanich Parks, n.d.; **Figure 1**). This baseline data may be used to help inform municipal decisions regarding future conservation and restoration efforts of the Gorge Creek and Gorge Creek Estuary, which are scheduled to undergo necessary but destructive structural renovations to better meet the needs of fishes, waterfowl, native vegetation and other wildlife, and to track aquatic and vegetative spatial and temporal changes within the Esquimalt Gorge Park and Cuthbert Holmes Park regions.

Keywords

Baseline Data, Water Sampling, Riparian Vegetative Survey, Esquimalt Gorge Park, Cuthbert Holmes Park, Gorge Waterway, Gorge Creek, Colquitz River

Introduction

In order to restore and/or maintain the integrity of a watershed and its ecosystem services, all aspects must be considered. Heavily utilized urban waterways, such as the Gorge Waterway and Colquitz River, and their adjacent riparian zones and natural areas (Esquimalt Gorge Park and Cuthbert Holmes Park, respectively) within the watershed require long-term and ongoing environmental monitoring programs and continued restoration efforts following degradation events, such as construction. The goal of this study was to collect and make available baseline data in the Esquimalt Gorge Park and Cuthbert Holmes Park in areas which are heavily impacted by human activities for use in future studies or restoration activities.

Despite being located within an urban center, estuarine waters (brackish mixing of marine and fresh waters), such as the Gorge Waterway (located between the Portage Inlet and the Victoria Harbour) and Colquitz River (connects to the Portage Inlet), and their adjacent riparian zones / natural areas provide important ecosystem services for both humans and other organisms. These estuaries are part of The Victoria Harbour Migratory Bird Sanctuary, the first of three regional migratory bird sanctuaries established in 1923: 1841 hectares comprising 31.03 terrestrial and 1809.97 ha marine (Canadian Wildlife Service, 2019). They are home to numerous species of migratory and resident birds (*e.g.* barred owls, Cooper's hawks, pileated woodpeckers), fishes (*e.g.* genetically distinct Pacific herring; spawning coho, chum salmon, and cutthroat trout; stickleback, sculpins, bullheads, and flatfish), mammals (*e.g.* river otters, harbour seals, racoons, deer), invertebrates (*e.g.* mossy chitons, Dungeness crab and graceful decorator crab), and plants (*e.g.*trailing blackberry, entire-leaf gumweed and sword fern) (Gorge Waterway Initiative, 2007; District of Saanich Parks, n.d.). Within these protected waters there are many species at risk *e.g.* Western purple martin (blue-listed - vulnerable species), the great blue heron (blue-listed), double-crested cormorant (blue-listed), Olympia oysters (species of special concern), and various endangered plants associated with Garry oak ecosystems (Capital Regional District, n.d.).

As part of a larger watershed, these waterways function to decrease water velocity as it travels through channels of varying widths and depths, along sediment with varying coarseness, over tidal shelves and mudflats, through eelgrass meadows, fens, marshes, etc. This process cleans the water by promoting the deposition of fine sediment and contaminants from the water column onto the basin. The clean water is stored by larger bodies of water such as Portage Inlet and Gorge Waterway, which allow the water to naturally absorb into the landscape (Capital Regional District, n.d.). The Gorge Creek Estuary alone treats storm water run-off for over 200 ha of land (Gurney & Nielsen, 2020).

The riparian zones adjacent to these waterways provide high quality wildlife habitat that link aquatic and terrestrial ecosystems (Stromberg, 2001). Other riparian benefits include increased water retention, increased bank stability, and reduced landscape redundancy (*e.g.* maintaining mixed successional stages) (Gurney, 2017; Stromberg 2001).

Since the water's path through a watershed is important to its ability to slow, clean, and store water, it is vulnerable to many anthropogenic factors such as construction, trampling, run-off, and climate change. In this study, the main concerns included construction activities (*e.g.* sediment transport into waterways which smother vegetation and clog fish gills), disturbed riparian zones with reduced natural vegetation (vegetation filters surface pollutants, prevents soil erosion, and provides shaded habitat for fish and wildlife), rapidly spreading invasive plant species (which cause overcrowding and out-compete the slower growing native species), and garbage, debris, and spills in the water and along shorelines (Gorge Waterway Initiative, 2007).

For the purpose of this study, Esquimalt Gorge Park (located along the Gorge Waterway; 11.65 ha) was considered a pre-restoration site and sampling was conducted within this region at the Gorge Creek Estuary (Township of Esquimalt, n.d.**)**. Sample site details can be found in **Table 1** and the vegetation survey site location can be seen in **Figure 2**A**.** Over the last 3 decades, Esquimalt Gorge Park (EGP) has been the focus of many restoration projects to help clean up the Gorge Waterway, which had been heavily polluted since the establishment of Fort Victoria in 1843. Industries such as ship building, sawmills, paint manufacturing and fish processing, and residential areas discharged sewage directly into the Gorge Waterway until 1955. Efforts to clean up the waterway were initiated by a local father and son in the 1990s and taken up by various local businesses, non-profit organizations, and governments (Capital Regional District, n.d.). Environmental stewardship within the local community continues today, including the Township of Esquimalt's Kinsmen Gorge Park Stream Restoration project beginning in 2002. The focus of this project was to restore the stream channel and natural watershed drainage (Earth Tech Canada Inc., 2002; Gurney, 2017). During these renovations, planting was done along the creek but not in the riparian zone of the Gorge Creek Estuary (Site #1v). Therefore, the plant assemblages found to date were mostly disturbed meadow species. At the beginning of this year, the Township of Esquimalt approved further structural renovations to the Gorge Creek's engineered channel and reinforced boulder stream bank (which was nearly vertical in orientation) to better meet the needs of water-fowl, native vegetation and other wildlife. Additionally, the World Fisheries Trust submitted an application entitled "*Gorge Creek Restoration*" to increase estuarine habitat and forage fish spawning areas suitable for the return of historically present Chum, Coho and Cutthroat salmonids and other aquatic organisms within the Gorge Creek (2021).

In comparison, Cuthbert Holmes Park (located along the Colquitz River; 19.88 ha) was considered a post-restoration site in this study and sampling was conducted within this region at the Dendritic Channels (Site #2), the Restored Tidal Shelf (Site #3), and the Mudflats (Site #4) **(**District of Saanich Parks, n.d.**)**. Sample site details can be found in **Table 1** and the vegetation survey site location can be seen in **Figure 2**B. It has been the focus of various restoration projects following major construction activities at the McKenzie Interchange, which were initiated by various local community groups, non-profit organizations, and governments. Site #2 (Dendritic Channels) has undergone several restoration efforts beginning in the summer of 2019, including formation of the dendritic channels themselves by the Ministry of Transportation and Infrastructure (MOTI) in May 2019 (Chambers, 2021; World Fisheries Trust, 2021). These channels were constructed to include various heights of "shelves" as habitat for invertebrates and plant species. Additionally, Fanny Bay oyster shells, sun-dried to decrease cross contamination, were deposited as substrate to promote habitat for water filtering species and to balance pH by increasing calcium carbonate. Within the riparian zone, clay-lined freshwater vernal ponds were installed to promote amphibian habitat, and both native and non-native vegetation species were planted (summer 2019). In the adjacent areas, large woody debris were included to mimic natural regeneration, since the urban forest is not threatened by fires or clear cutting the deadwood was added to mimic one of these disturbances. Deadwood would increase nutrients to the soil and provide habitat for wildlife (summer 2020) (Chambers, 2021). Site #3 (Restored Tidal Shelf) was excavated to increase depth and narrowed by including large chained down woody debris in strategic locations, and broken ceramic pieces were added to the bottom (presumably as substrate for invertebrates) (Chambers, 2021). The NW side of the Tidal Shelf is connected to a man-made wetland pond along the Cuthbert Holmes Park berm behind the McKenzie Interchange (Gorge Tillicum Neighbourhood News, 2021). Site #4 (Mudflats) are a large, shallow area with only minor modifications from their natural state (Clarke, 2021). See Figure

The study included riparian vegetative biophysical surveys at one site at each of the pre-restoration (Site #1v) and post-restoration sites (Site #2) for comparison of vegetative species richness, relative abundance, and diversity, as well as the identification of vegetation to the species level (when possible) and further classification into categories of: native species, exotic species, and invasive species. In collaboration with other members of the GWAS YCP program, *in-situ* water analyses (*i.e.* salinity, temperature, dissolved oxygen, and flow rate) were conducted weekly as part of the "*Gorge Waterway Expanded Baseline Analysis (GWEBA) Project*" at eight sites within the Esquimalt Gorge Park region (Sites #1w - 8) and three sites within the Cuthbert Holmes Park region (Sites #2 - 4) (**Table 1**).

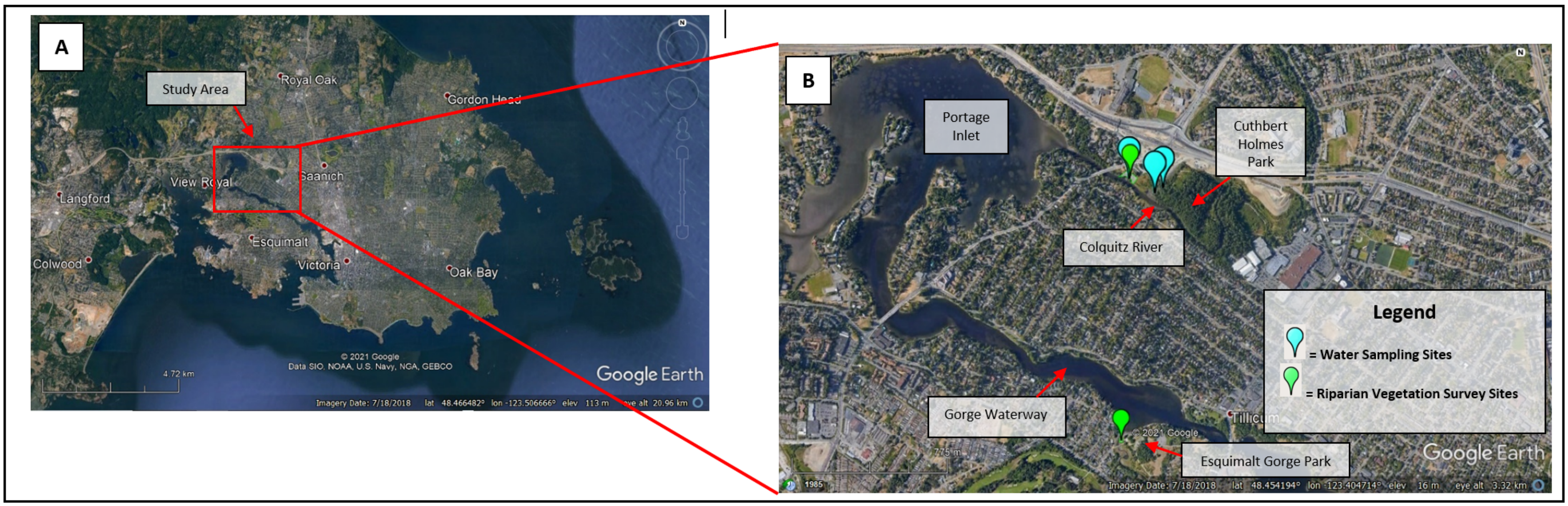

Figure 1. *A) Location of study area for the Gorge Waterway and Colquitz Creek Baseline Data Project near Victoria, British Columbia. B) The two regions included in the study were Esquimalt Gorge Park and Cuthbert Holmes Park, where water sampling and riparian vegetative surveys were conducted along the Gorge Waterway and Colquitz River. Blue pins indicate water sampling sites and green pins indicate riparian vegetation survey sites. The water sampling sites from Esquimalt Gorge Park are the same sites used in the Gorge Waterway Expanded Baseline Analysis (GWEBA) Project and are not shown. The GWEBA water sampling Sites #1 - 8 can be found in* *Figure 14**. Note: Google Earth Pro photos from 2018 (best resolution and most recent available).*

Figure 2. *Riparian vegetative site survey areas (polygons) in both Esquimalt Gorge Park and Cuthbert Holmes Park near Victoria BC. Blue pins indicate water sampling sites in Cuthbert Holmes Park (Sites #2 - 4). The "Gorge Waterway Expanded Baseline Analysis (GWEBA) Project" water sampling Sites #1w - 8 can be found in Figure 14. A) Esquimalt Gorge Park region including Gorge Creek Estuary Site #1v B) Cuthbert Holmes Park region including: Dendritic Channels Site #2, Restored Tidal Shelf Site #3 and Mudflat Site #4. Green arrows indicate where the dendritic channels connect to the Colquitz river. Note: Google Earth Pro photos from 2018 (best resolution and most recent available).*

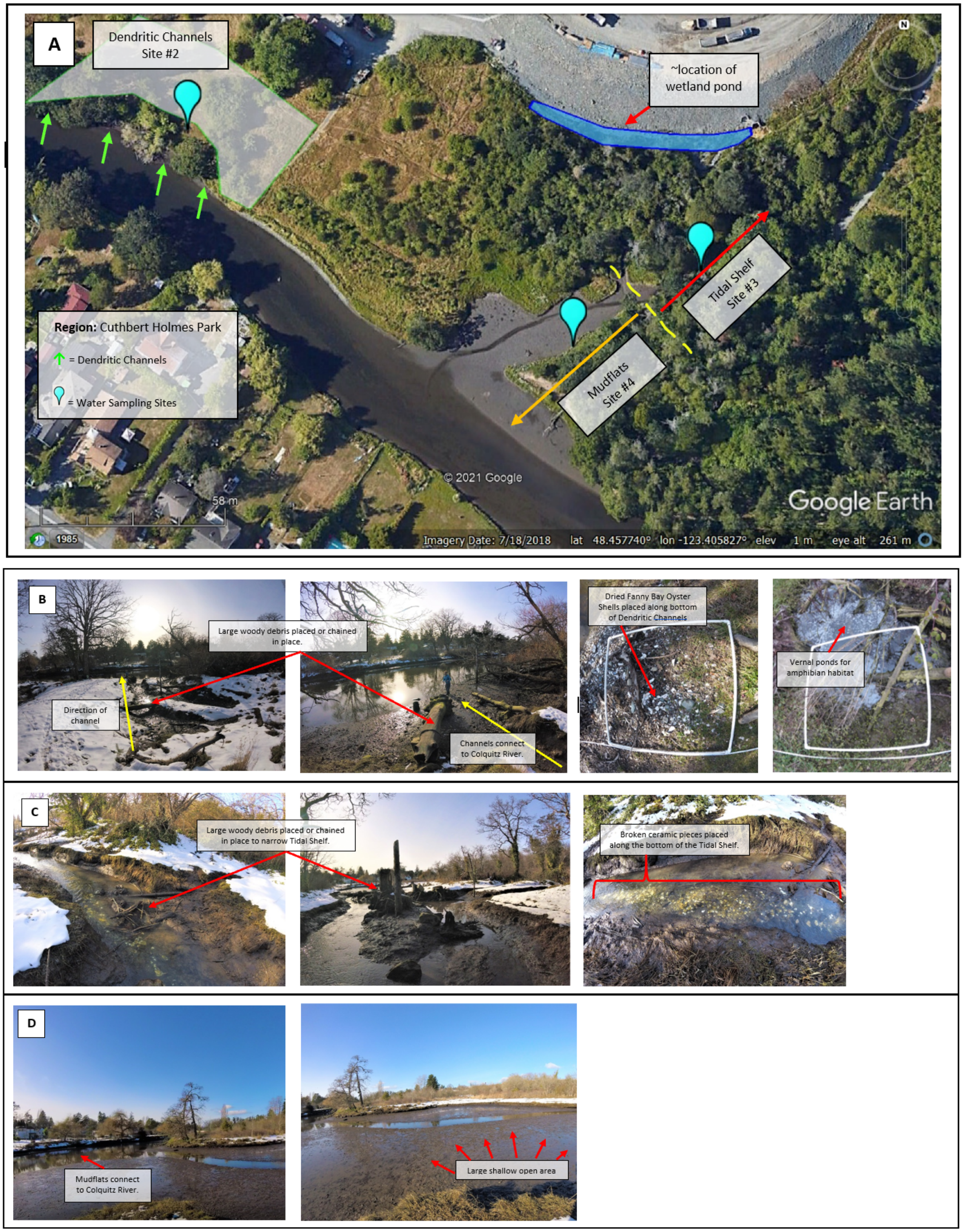

Figure 3. *Photos of the sites selected for the collection of water quality data in Cuthbert Holmes Park, Saanich, BC. A) Map of Cuthbert Holmes Park region with labelled study sites (#2 - 4). Green arrows indicate dendritic channels B) Features of Site #2 C) Features of Site #3 D) Features of Site #4. Photos: Aniesha Schencks. Note: Google Earth photo was from 2018 (best resolution and most recent available).*

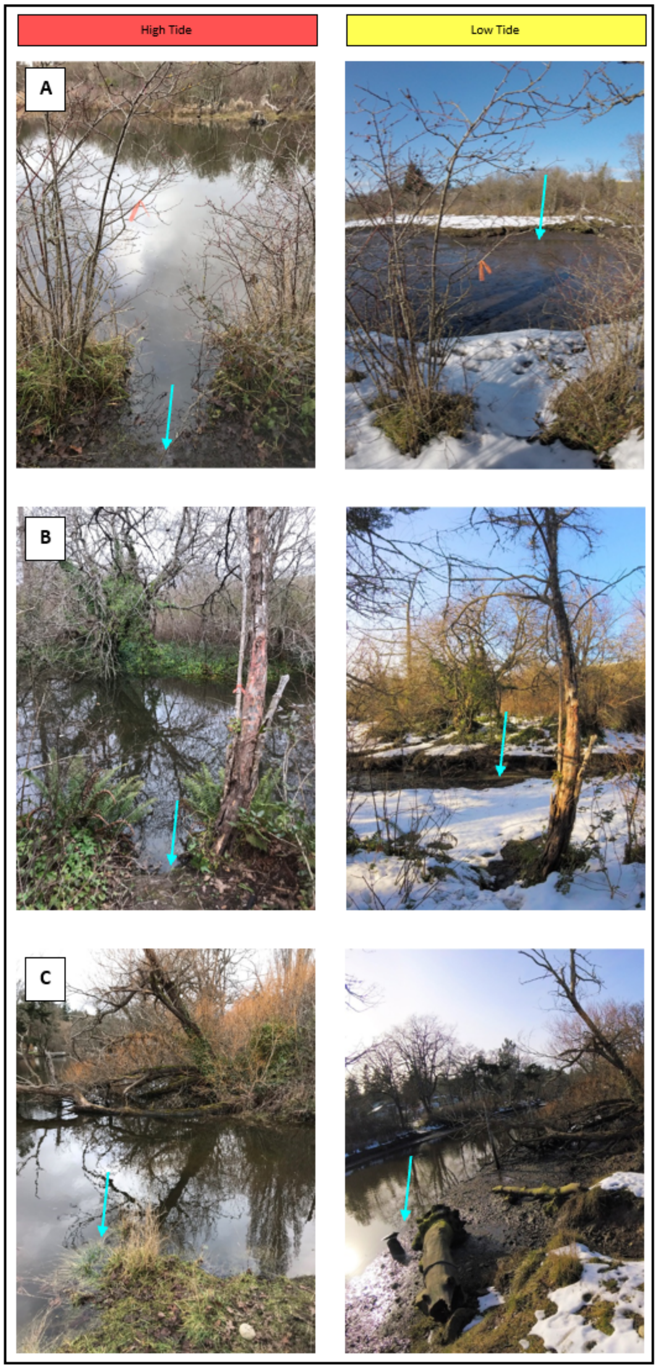

Figure 4. *Water sampling locations in Cuthbert Holmes Park during high and low tide. Water level indicated by blue arrow. A) Mudflats (Site #4) water sampling location. B) Restored Tidal Shelf (Site #3) water sampling location. C) Dendritic Channels (Site #2) water sampling location. Photos: Aniesha Schencks.*

Materials & Methods

1. Desktop review

Prior to fieldwork, research was conducted on Cuthbert Holmes Park, the Colquitz River, Esquimalt Gorge Park, and the Gorge Waterway, including historic information, past and present conservation efforts, known plant and animal species, and a literature review on specific methodology for vegetative survey procedures.

2. General Shoreline survey

For each site, a walk-through was conducted prior to surveying and visual observations were recorded on the field data sheets to determine any areas of concern, for example: garbage / pollution, debris build-up, and hazards (*e.g.* harmful plants, bank instability, slippery rocks, etc.).

3. Water Sampling

The physical characteristics of water (*i.e.* salinity (ppt), temperature (°C), dissolved oxygen (mg/L and %) and flow rate (cfs)) were analyzed weekly *in-situ* by members of GWAS YCP biology and restoration streams as part of the "*Gorge Waterway Expanded Baseline Analysis (GWEBA) Project*". There were eight sites within the Esquimalt Gorge Park region and three sites within the Cuthbert Holmes Park region (**Figure 1**, **2**, & **14**).

i. Salinity

A Hanstronik refractometer was used to record the salinity of water in parts per thousand (ppt). The protocol below was used:

- Water from the site was flushed into and out of a pipette (~3x).
- The pipette was filled with water and several drops were placed onto the angled prism of the refractometer.
- The clear plate was slowly lowered onto the angled prism to seal the area.
- The refractometer was read through the eye-piece, while level, and directed at a light source.
- The value was recorded.
- The refractometer was rinsed with fresh water after each use and before storing.

ii. Water Temperature

A standard thermometer was used to record the temperature of water in degrees Celsius (°C). The protocol below was used:

- The distal end of the thermometer was submerged into the water from the site (~20 s).
- The temperature was quickly read at eye level.
- The value was recorded.

iii. Dissolved Oxygen

A Hanna OxyCheck HI 9147-10 DO meter was used to record the dissolved oxygen (DO) in the water in milligrams per litre (mg/L) and percent of saturation (%) (Hanna Instruments, 2005). The protocol below was used:

- The meter was calibrated by setting the percent air saturation to 100%
- The probe was submerged near the surface of the water column until stabilization occurred (~5-8 min).
- The DO was read on the display.
- The meter was rinsed with fresh water after each use and before storing.

iv. Flow Rate

The “Float Method” was used to record flow rate of water in cubic feet per second (cfs) (Arizona Department of Environmental Quality, 2018). Three flow rate measurements were taken at each site (Sites #3 - 4) on days with varying total precipitation within one week of measurement and at varying tidal heights (Government of Canada, n.d.; Fisheries and Oceans Canada, n.d.; **Table 2**). The protocol below was used **(Figure 5)**:

- Two observers were needed for this measurement technique.
- Observer 1 stood upstream along the stream bank (referred to as the ‘*upstream point*’).
- Observer 2 stood a minimum of 10 feet downstream from the first observer (referred to as the ‘*downstream point*’).
- Note: The intermediate point between the upstream and downstream points was referred to as the ‘*midpoint*’.
- Measurements were taken using a measuring tape:
  - *Distance* = between the two observers
  - *Width* = of the stream at the midpoint

        - *Depth* = the average of three water depths equally spaced apart across the midpoint
- The upstream observer placed a partially filled plastic water bottle at the upstream point and released the bottle while signalling to the downstream observer to start the time using a stopwatch.
- The downstream observer recorded how long it took for the bottle to float across the downstream point.
- This measurement was repeated three times and the average was recorded (=*time*).
- These measurements, along with the correction factor, were used to calculate flow rate in the equation below.

$$Flow\ Rate\ (cfs) = \ Width \times Depth \times (Distance\ \div\ Time) \times Correction\ Factor$$

Width = width of the stream at the mid-point
Depth = average of 3 stream depths taken at the mid-point
Distance = between the 2 observers
Time = average of 3 bottle tosses from upstream point to downstream point
Correction Factor = 0.85 (standard used to correct for higher velocity at the surface)

4. Riparian Vegetative Biophysical Inventory

A vegetative survey in the riparian zone of each Site #1v - 2 was conducted to 1) identify vegetation to the species level (when possible) 2) determine the species percentage of ground cover and 3) the species distribution pattern. These data were used to calculate vegetative species richness, relative abundance, and diversity, as well as to further classify species into categories of: native species, exotic species, and invasive species. Surveying was conducted from February 3 - March 10, 2021, over 5 days with the help of various members of GWAS YCP biology and restoration streams.

i. Alternating Belt Transect Method:

A standard 1x1m Alternating Belt Transect quadrat analysis was used to perform vegetative surveys within a site (Gurney & Nielsen, 2020) with the following protocol:

- A benchmark line was established at each site depending on the length of the study area (**Figure 2**; **Table 1**). Detailed benchmark descriptions are included below due to the unavailability of recent aerial photos (2018 were the best resolution and most recent photos available):

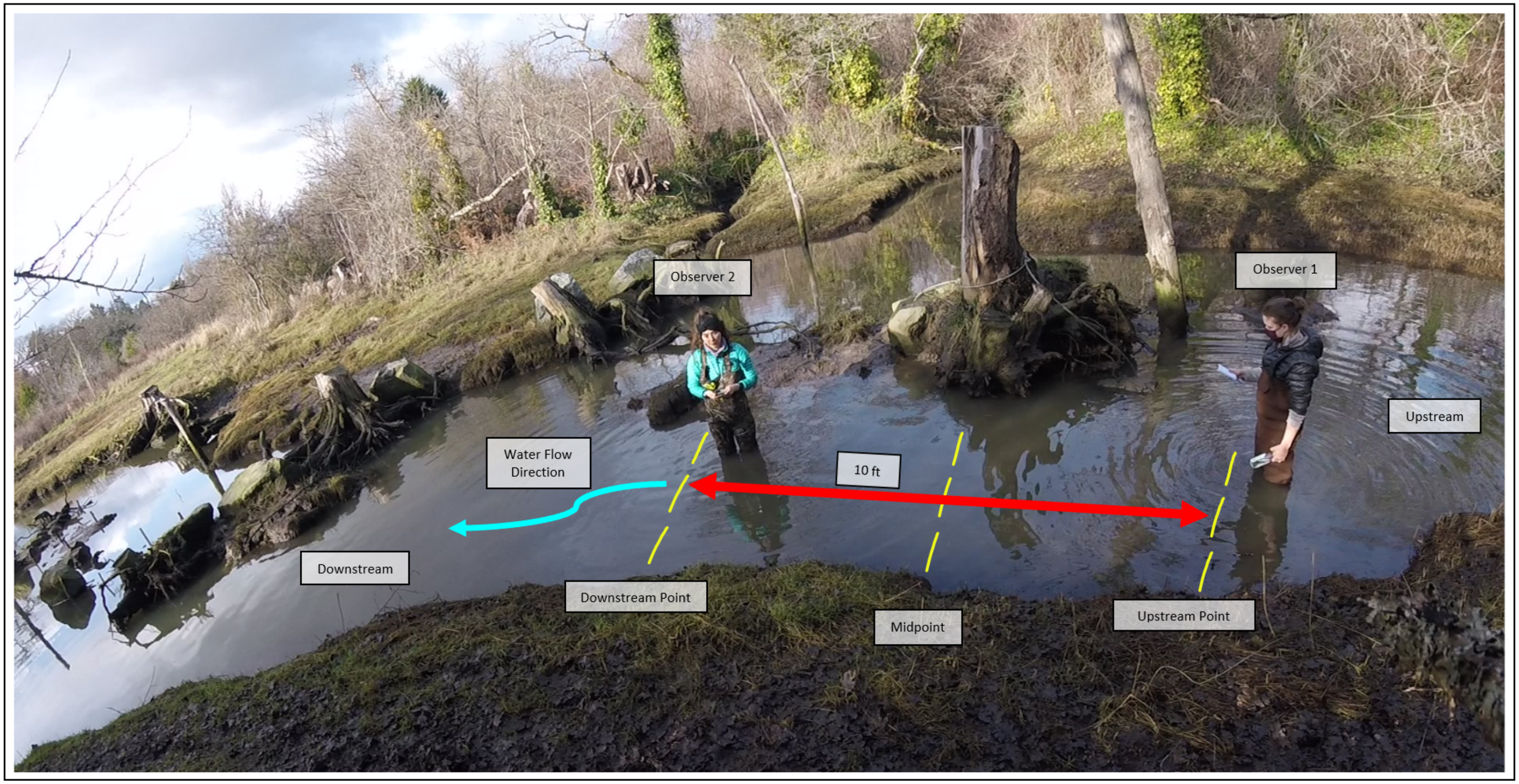

Figure 5. *Gorge Waterway Action Society technicians demonstrating the 'Float Method' for measuring flow rate (cfs) of a stream (Arizona Department of Environmental Quality, 2018). Photo taken during 0.9 m falling tide at Site #3 in Cuthbert Holmes Park, Saanich, BC. Photo: Aniesha Schencks.*

***Site #1v*:** The benchmark line originated at the N end of Gorge Creek Estuary from the reinforced boulder stream bank (exposed at low tide). The benchmark extended 22 meters S at a 154° angle across the site to a Douglas fir tree (~3 meters N of the pedestrian walkway / bridge at the mouth of Gorge Creek Estuary).

***Site #2*:** The benchmark line originated at the SE end of Site #2 in the midline of a packed-gravel pedestrian path which ran perpendicular to the shoreline. The benchmark extended 45m NW at a 308° angle, running along a second packed-gravel path which ran parallel to the shoreline, until intersecting a black hawthorn tree line. The transect continued through the tree line at a NW 308° angle for another 25m for a total of 70m.

- Transects were spaced evenly along the benchmark (lengths and number varied between sites) and ran perpendicular to the benchmark, toward the shoreline (**Figure 6**; **Table 1**; **Table 3**).
- Quadrats were spaced along each transect every 1m and alternated sides (when facing the shoreline, the first quadrat for each transect originated on the right-hand side of the transect) (**Figure 6**).
    - Quadrats were labelled in ascending order from the benchmark line according to the meter at the top edge (**Figure 7**). Note: if the transect tape is on the right edge of the quadrat it is an even numbered quadrat; if it is on the left edge of the quadrat, it is an odd numbered quadrat.

e.g. if bottom of the quadrat was placed at the 0 m mark and the top edge of the quadrat was at the 1 m mark = quadrat '1'

- For areas which were considered inaccessible to survey with a quadrat (*e.g.* dangerous conditions, steep slope, dense vegetation, body of water, potential for surveyor to cause damage to the site), the distance was recorded in meters and the reason was stated in the notes section along with visual observations of types of vegetative and / or non-vegetative cover (% cover and distribution pattern were not included).

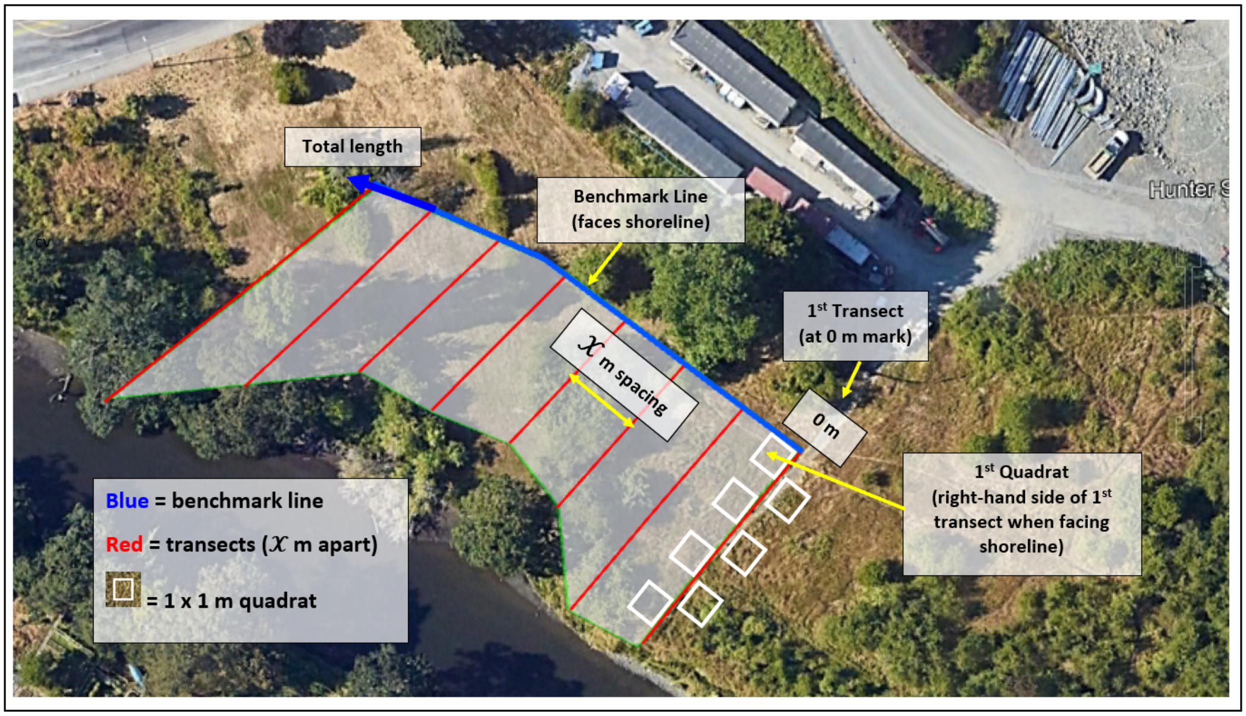

Figure 6. *The Alternating belt transect method used for riparian vegetation surveys within the Esquimalt Gorge Park and Cuthbert Holmes Park regions (not to scale). Photo: Google Earth Pro (2018).*

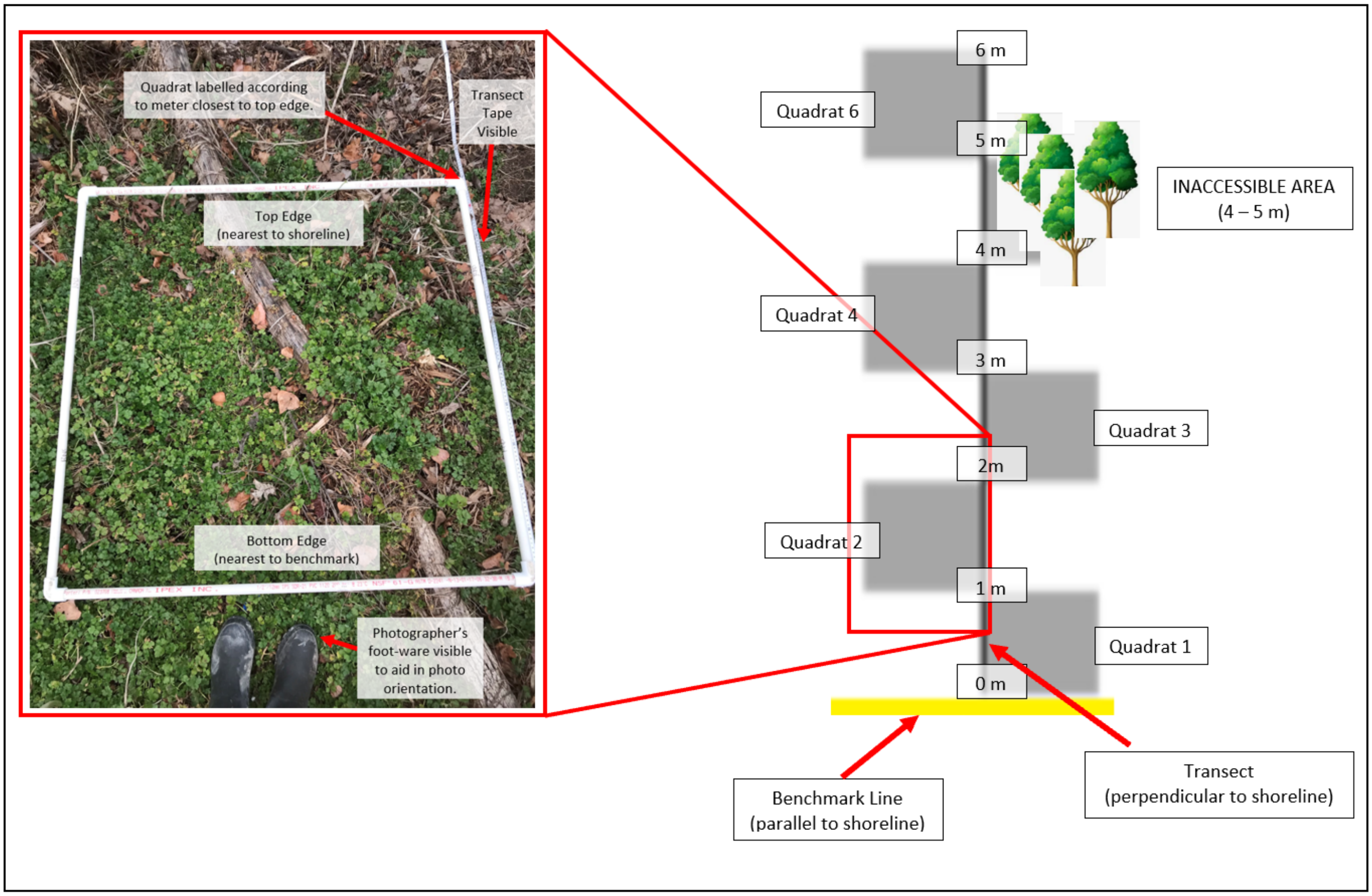

Figure 7. *Quadrat placement along a transect using the Alternating Belt Transect method and quadrat labelling (including inaccessible areas) and photographing technique. Photo: Aniesha Schencks.*

ii. Quadrat Analysis:

For each 1 x 1 m quadrat, species ID, % cover, and distribution pattern were recorded using the following protocol:

- Photos were taken of each quadrat (looking down from above), including the entire quadrat and the transect tape. Quadrat photos can be found in the 'Site 1 Quadrat Catalogue' and 'Site 2 Quadrat Catalogue' (**Figure 7**).
    - To reduce human error when sorting photos and help orient the viewer, it was recommended that the photo be taken while standing at the bottom of the quadrat (bottom of quadrat is the edge nearest the benchmark) with the tip of the photographer's footwear in the shot.

- Photos were taken of each unique vegetative species. Species photos were included in the Sites #1 - 2 'Species Catalogues'.
    - At least one photo of the species was taken as-is and additional close-up photos were taken of plant parts which were helpful for identification (*e.g*. flowers, berries, seed pods, leaves / leaflets, stem, branches, bark pattern / colour, cones, needles) (**Figure 8)**.
    - Note: a blank white sheet of paper was sometimes used as a background to show the plant more clearly.

- Vegetation was identified to the species level (when possible) either on-site or off-site (by photo and / or specimen sample) using personal knowledge and / or consulting reference material and recorded (Pojar & Mackinnon, 2014; iNaturalist, n.d.; Klinkenberg, 2021) (**Table 4**).
    - When plant species were not easily identifiable (*e.g.* due to seasonality or lack of expertise) they were left as "unidentified species" or grouped within their genus for future identification (**Table 4; Figure 9**).

- Percent cover was visually assessed using standardized foliage comparison cover charts to record species and other ground cover within each quadrat (Luttmerding *et al.,* 1998; **Figures 10** & **11; Table 5**). Total % coverage was used to calculate species and other ground coverage relative abundance values.
- Vegetative distribution patterns were assigned to species according to standardized categories (Meidinger *et al.,* 1998; **Table 6**).

    - If a quadrat or transect were considered inaccessible, then distribution pattern was not recorded.

- For all quadrats, additional notes were recorded as needed *e.g.* site condition, any debris / litter / pollution, wildlife, signs of wildlife such as droppings.

Figure 8. *Examples of species photos taken at the two vegetation sampling sites in Esquimalt Gorge Park and Cuthbert Holmes Park near Victoria, BC. Each specimen had two types of pictures taken; "as-is" pictures (i.e. how the plant looks in-space growing) and close-up pictures of plant parts for identification in the '[Species Catalogue]'. Close-up pictures were taken with a white sheet of paper behind the subject to aid identification. Photos: Aniesha Schencks*

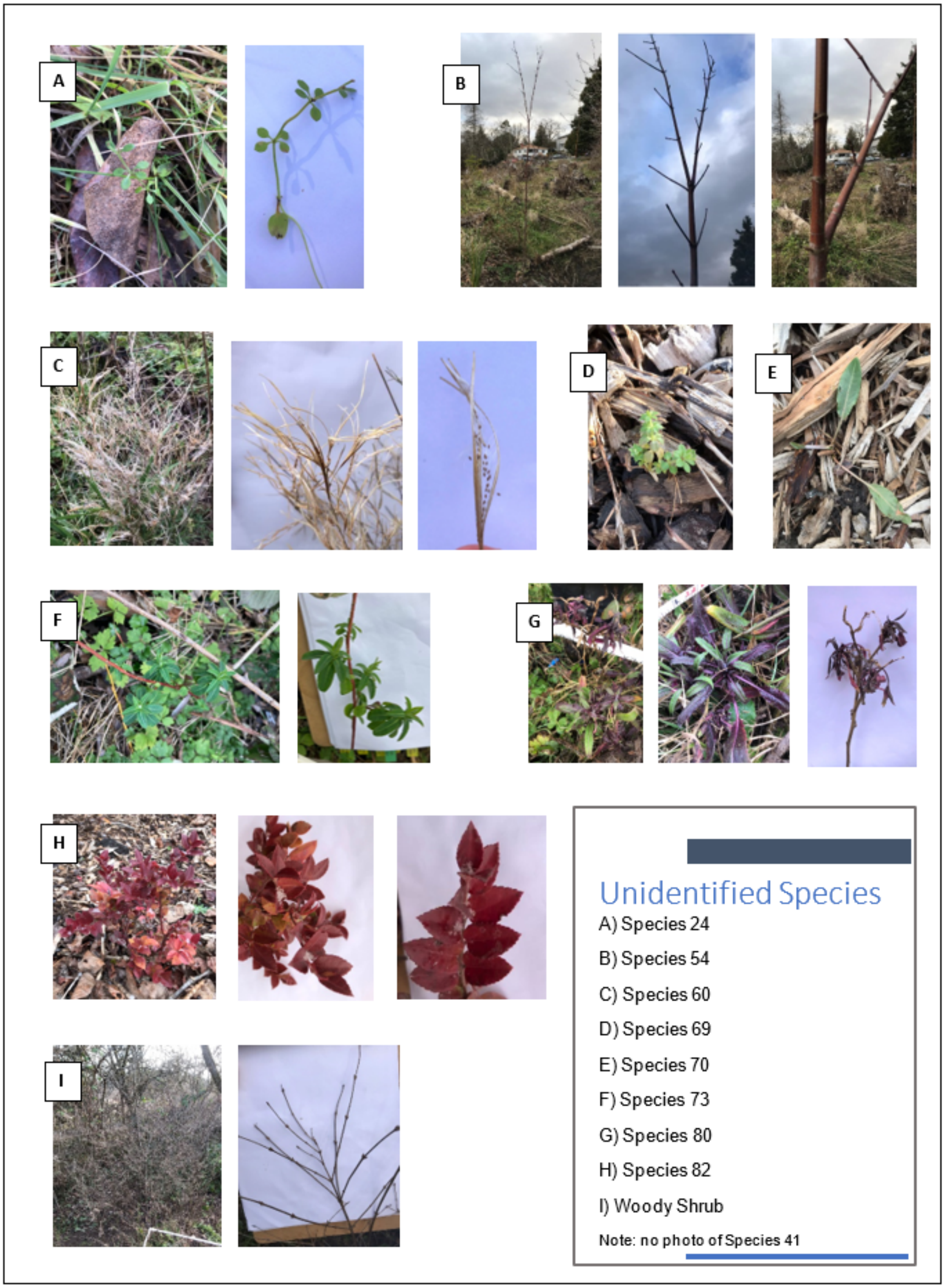

Figure 9. *Photos of unidentified vegetative species from Sites #1v - 2 riparian vegetative surveys in Esquimalt Gorge Park and Cuthbert Holmes Park near Victoria, BC. The associated species number refers to the order in which they were observed. Identified species are not shown. Photos: Aniesha Schencks and Michelle Thompson*

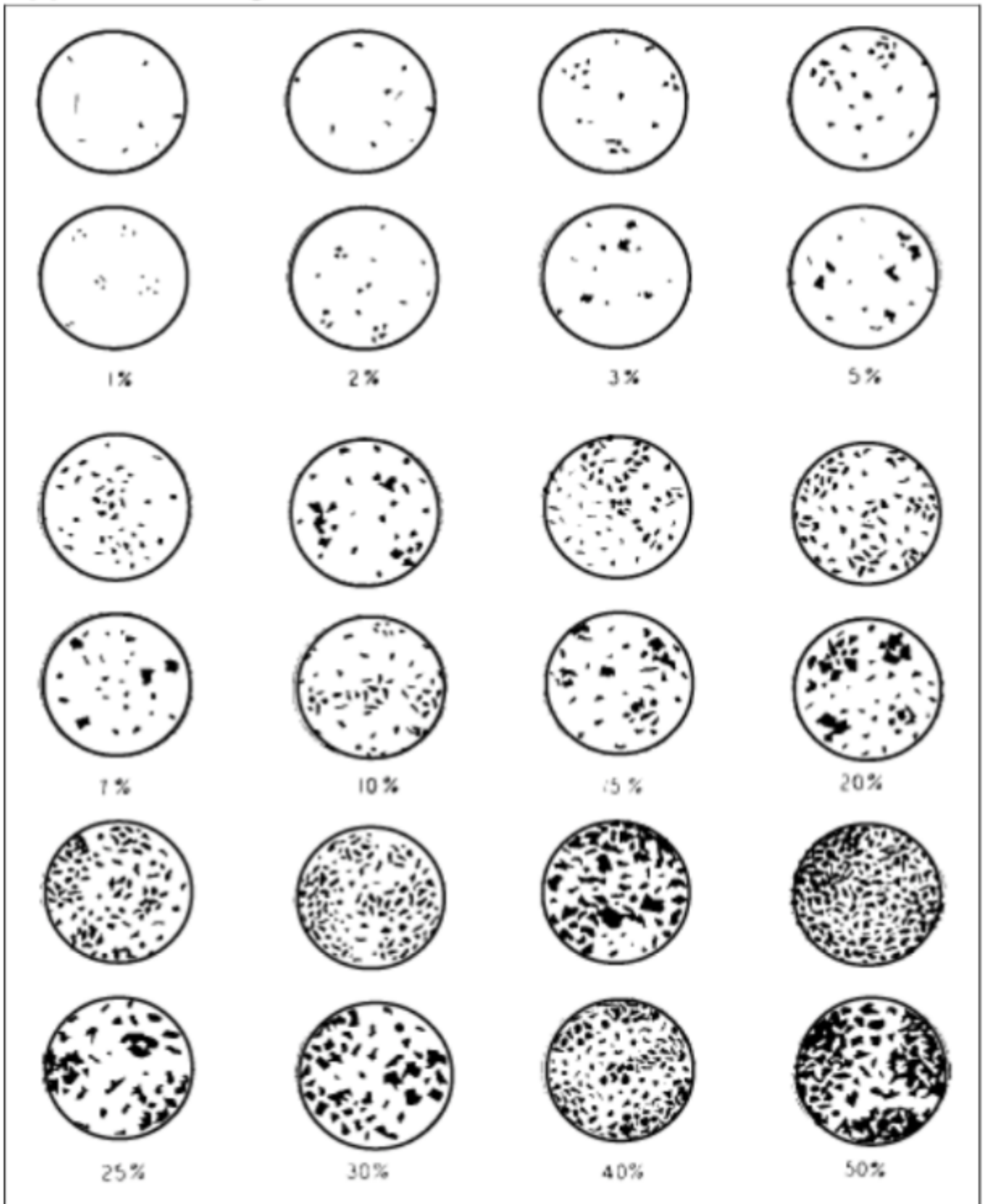

FIGURE 3.2. Comparison charts for visual estimation of foliage cover.

Figure from the *Field Manual for Describing Terrestrial Ecosystems* (Meidinger et al. 1998).

Figure 10. *Foliage comparison cover charts used to estimate vegetative species and / or non-vegetative % coverage within a quadrat (Luttmerding et al., 1998).*

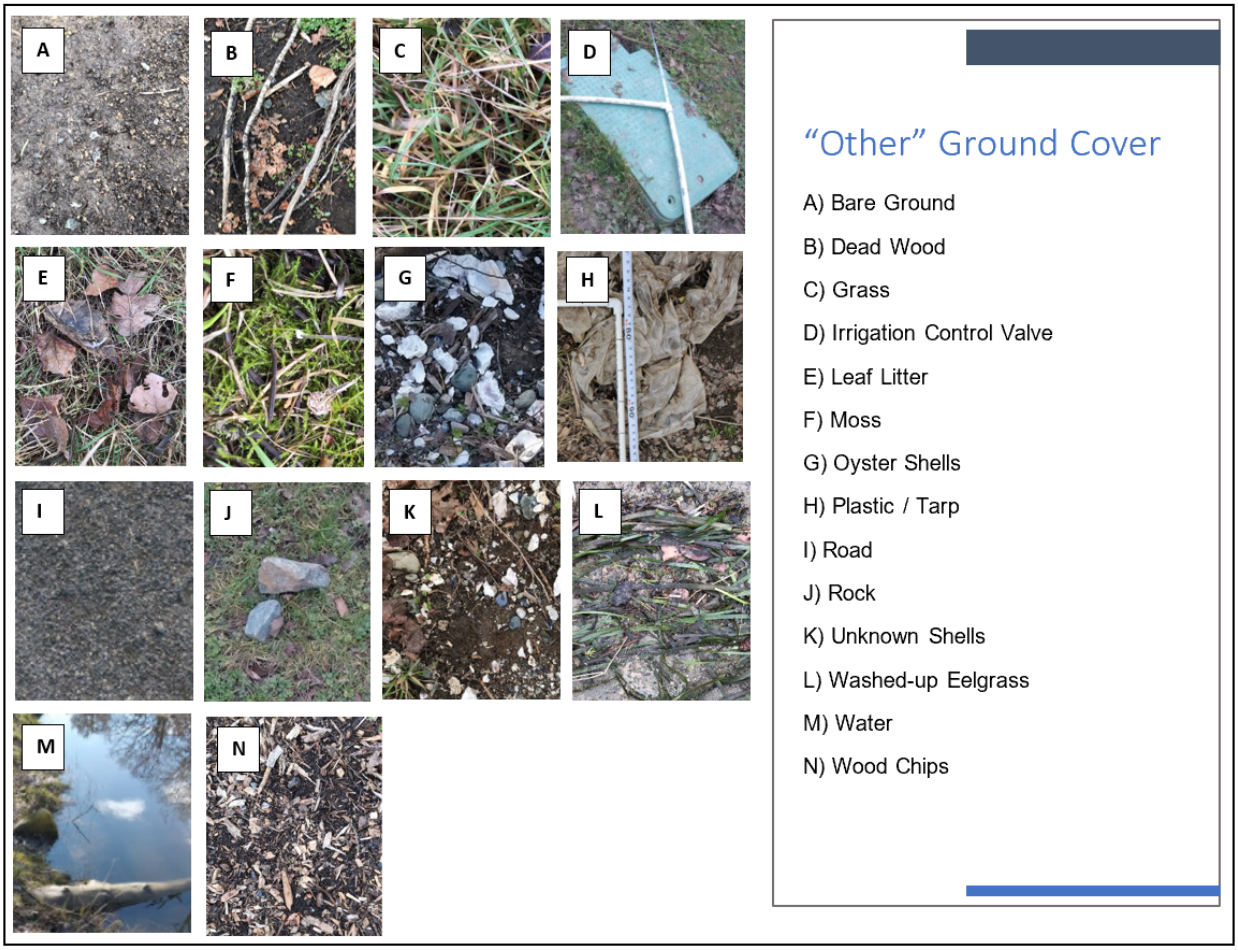

Figure 11. *Photos of "Other" Ground Cover categories used in quadrat percent coverage estimates for Sites #1v - 2 riparian vegetative surveys within Esquimalt Gorge Park and Cuthbert Holmes Park near Victoria, BC. Photos: Aniesha Schencks and Michelle Thompson.*

Results

1. Vegetation Results

At Site #1 (Gorge Creek Estuary), the transects (A - E) covered 22.64% of the total targeted area (296 m^2) while the transects (A - H) at Site #2 (Dendritic Channels) covered 11.90% of the targeted area (2117 m^2). The species richness for Site #1 was 20 and there were 4 unique species. The species richness for Site #2 was 65 and there were 49 unique species. There were 16 species common to both sites (**Table 4**).

The diversity index (Shannon-Wiener) was 0.91 at Site #1 while Site #2 had a higher diversity index of 2.54. At Site #1, the top ten species which covered the most ground (% cover) included: *sea asparagus (79.18%), entire-leaved gumweed (9.00%), clover (2.8%), small flowered lotus (2.22%), common vetch (1.52%), dovefoot geranium (1.33%), dock species (0.96%), creeping buttercup (0.93%), trailing blackberry (0.68%), and English daisy (0.56%).* At Site #2, the top ten species were: *creeping buttercup (38.87%), clover species (10.62%), small flowered lotus (7.85%), English ivy (4.65%), Himalayan blackberry (3.80%), dovefoot geranium (3.60%), oxeye daisy (2.92%), Queen Anne's lace (2.77%), hairy bittercress (2.44%) and vetch species (2.35%).*

The species coverage compared to other ground cover (% cover) at Site #1 was 5% to 95% respectively (based on relative abundance values). The top five 'other' ground covers included: *grass (65.01%), bare ground (20.37%), leaf litter (15.22%), rock (4.07%) and moss (3.55%).* The species coverage compared to other ground cover at Site #2 was 50% to 50% respectively. The top five 'other' ground covers included: *grass (20.52%), deadwood (18.51%), bare ground (13.45%), road (12.68%) and leaf litter (12.09%)* (**Figure 12**).

At Site #1, the proportion of classified vegetation (*i.e.* native, exotic, invasive or unlisted / unknown) based on percent cover was: *Native (91%), Exotic (7%), Invasive (1%) and Unknown/Unlisted (1%)*. Of that 1% invasive species coverage, the species composition was: *creeping buttercup (76%), spurge-laurel (17%) and English ivy (7%).* At Site #2, the proportion of classified vegetation was: *Native (14%), Exotic (23%), Invasive (54%) and Unknown/Unlisted (9%)*. Of that 54% invasive species coverage, the species composition was: *creeping buttercup (82%), Himalayan blackberry (8%), English ivy (8%) and common periwinkle (2%)* (**Figure 13**).

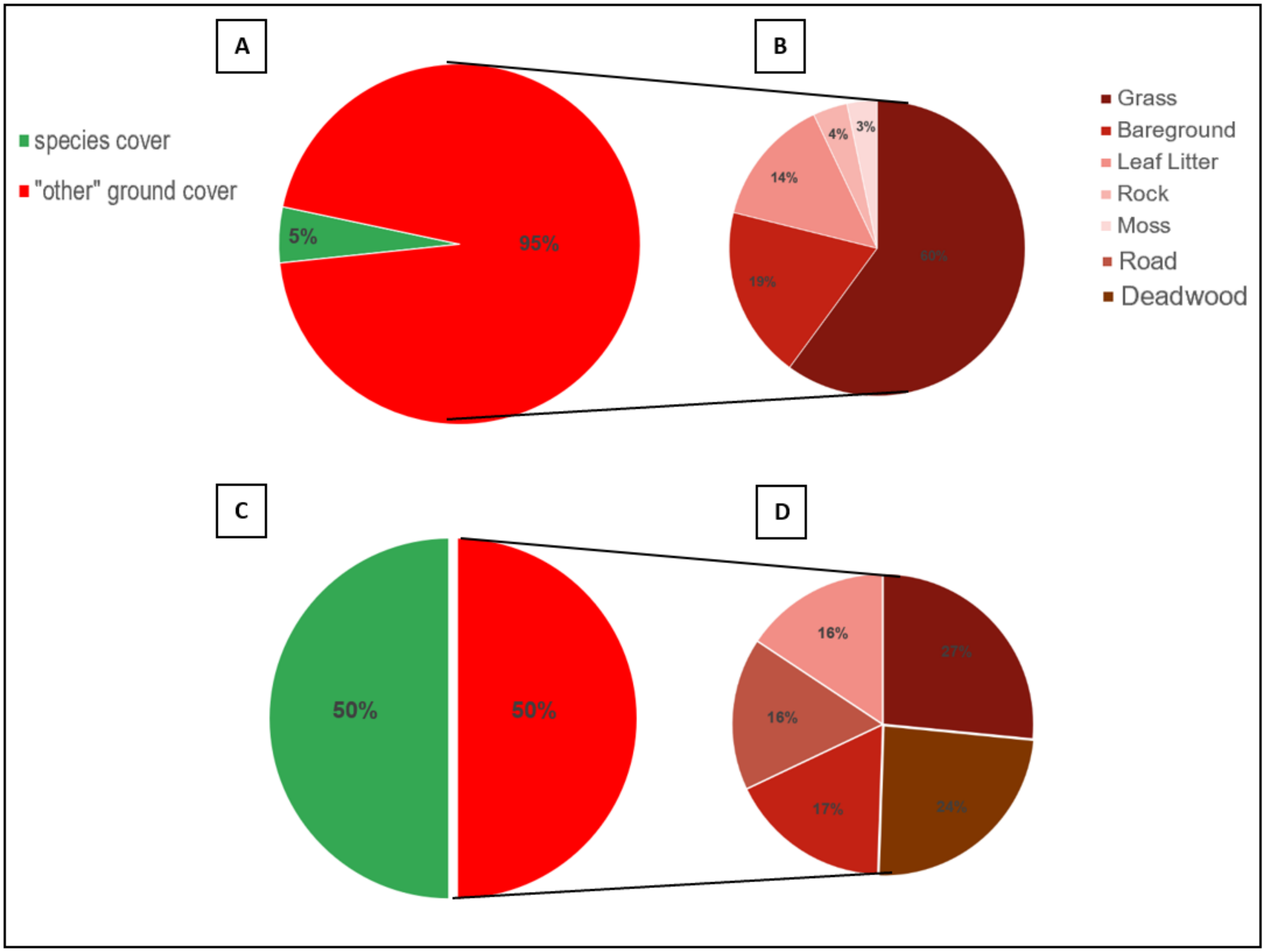

Figure 12. *Percent cover of vegetation from site #1 in Esquimalt Gorge Park in Esquimalt, BC, and site #2 in Cuthbert Holmes Park in Saanich, BC. The species coverage is compared to other kinds of ground cover and the composition of the top 5 'other' ground covers are shown using percent cover values. A) Proportion of species vs. 'other' ground cover at site #1. B) The relative abundance of different kinds of 'other' ground cover found at Site #1. C) Proportion of species vs. 'other' ground cover at site #2. D) The relative abundance of 'other' ground cover types found at Site #2.*

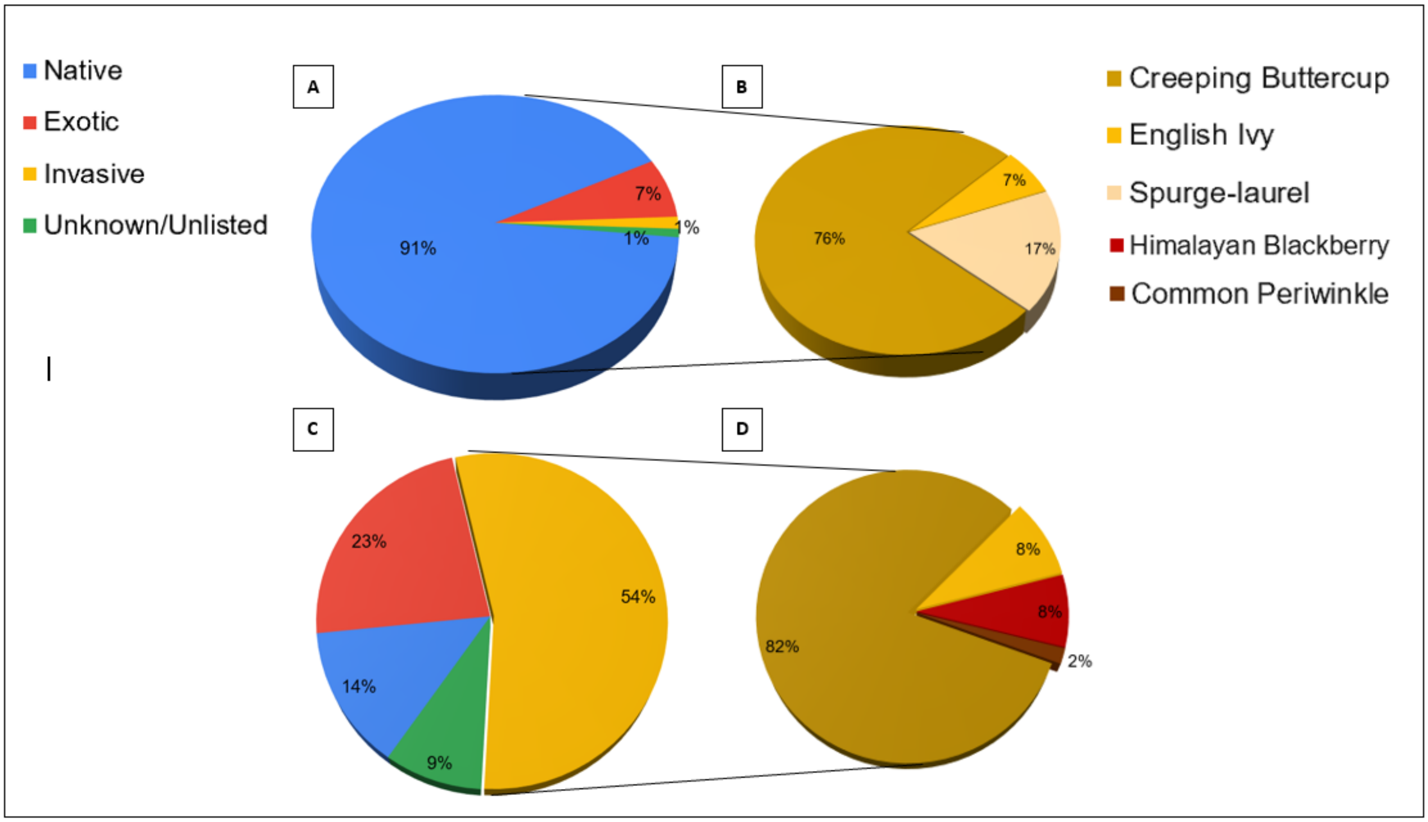

Figure 13. *Relative percent cover of the different vegetation classifications (i.e. native, exotic, invasive or unknown/unlisted) and relative abundance of invasive species (by common name) at site #1 in Esquimalt Gorge Park in Esquimalt, BC, and site #2 in Cuthbert Holmes Park in Saanich, BC. A) Relative percent cover of different vegetation categories found at site #1. B) Relative abundance of the different invasive species found at site #1. C) Relative percent cover of different vegetation categories found at site #2. D) Relative abundance of the different invasive species found at site #2. Note: Unknown/unlisted refers to species which were only identified to the family classification or species which were considered "unlisted" by the BC Ministry of Environment (2020).*

2. Water Results

In the Esquimalt Gorge Park region (Sites #1w - 8) (**Figure 14**), average salinity (ppt) steadily increased between water sampling sites moving from the south (Site #1w - Craigflower Culvert 1.16 ppt; the southernmost sampling point) to the north (Site #8 - Mudflat Estuary 17.00 ppt; the northernmost sampling site) end of the study area; with the exception of 2.00 ppt at Site #2 (Pool 1) which was slightly higher than 1.75 ppt at Site #3 (Gosper Crescent Outfall). In the Cuthbert Holmes Park region (Sites #2 - 4), salinity was highest at Site #2 (2.29 ppt), lowest at Site #3 (1.63 ppt) and intermediate at Site #4 (1.75 ppt) **(**See

Table 7 and **Figure 15**). Tidal data was used from the Portage inlet tidal station, the chart used can be found in the Portage Inlet Tidal Chart Document.

Additionally, in the Esquimalt Gorge Park region, it was found that tidal height corresponded with ranges in salinity values across water sampling sites: higher average salinity with higher tides (1.14 - 20.63 ppt), intermediate values with intermediate tides (0.60 - 14.83 ppt) and lower values with lower tide heights (0.00 - 17.00 ppt). Similarly, this trend was found in the Cuthbert Holmes region: higher average salinity with higher tides (1.27 - 1.30 ppt), intermediate values with intermediate tides (0.75 - 0.80 ppt) and lower values with lower tide heights (0.50 ppt) **(Table 8; Figure 16).**

In the Esquimalt Gorge Park region, average temperature (℃) ranged from 6.84 - 7.58℃ (Site #5 - Fen and Site #1w - Craigflower Culvert, respectively). In the Cuthbert Holmes Park region, temperature ranged from 5.89 - 6.31℃ (Site #4 - Mudflats and Site #2 - Dendritic Channels, respectively) **(Table 7; Figure 15)**.

In the Esquimalt Gorge Park region, average dissolved oxygen (mg/L and %) ranged from 11.77 - 12. 24 mg/L or 96 - 98% (Site #1w - Craigflower Culvert and Site #6 - Pool 2, respectively). In the Cuthbert Holmes Park region, dissolved oxygen ranged from 12.26 - 12.61 mg/L (Site #2 - Dendritic Channels and Site #3 - Restored Tidal Shelf, respectively) or 98 - 99.86% (Site #4 - Mudflats and Site #3 - Restored Tidal Shelf, respectively) **(Table 7; Figure 15)**. Note: Oxygen was recorded in both mg/L and percent; this was done since mg/L is more precise, but percentage is often easier to comprehend. When comparing mg/L and percent these values can appear inconsistent, but this is because percent values are less precise and are equivalent to multiple mg/L values e.g. 100% = 11.9 - 12.3. Therefore, the mg/L values should be used if further analysis is completed with the data sets.

Water flow rate (cfs) at both sites within Cuthbert Holmes Park fluctuated depending on rain events and tide height. At the Restored Tide Shelf (Site # 3) flow rates were: 0.023 cfs (Low tide), 0.108 cfs (Mid Tide) and 0.169 cfs (High Tide). At the Mudflats (Site #4) flow rates were: 0.053 cfs (Low tide), 0.089 cfs (Mid Tide) and 0.191 cfs (High Tide) (**Table 2**).

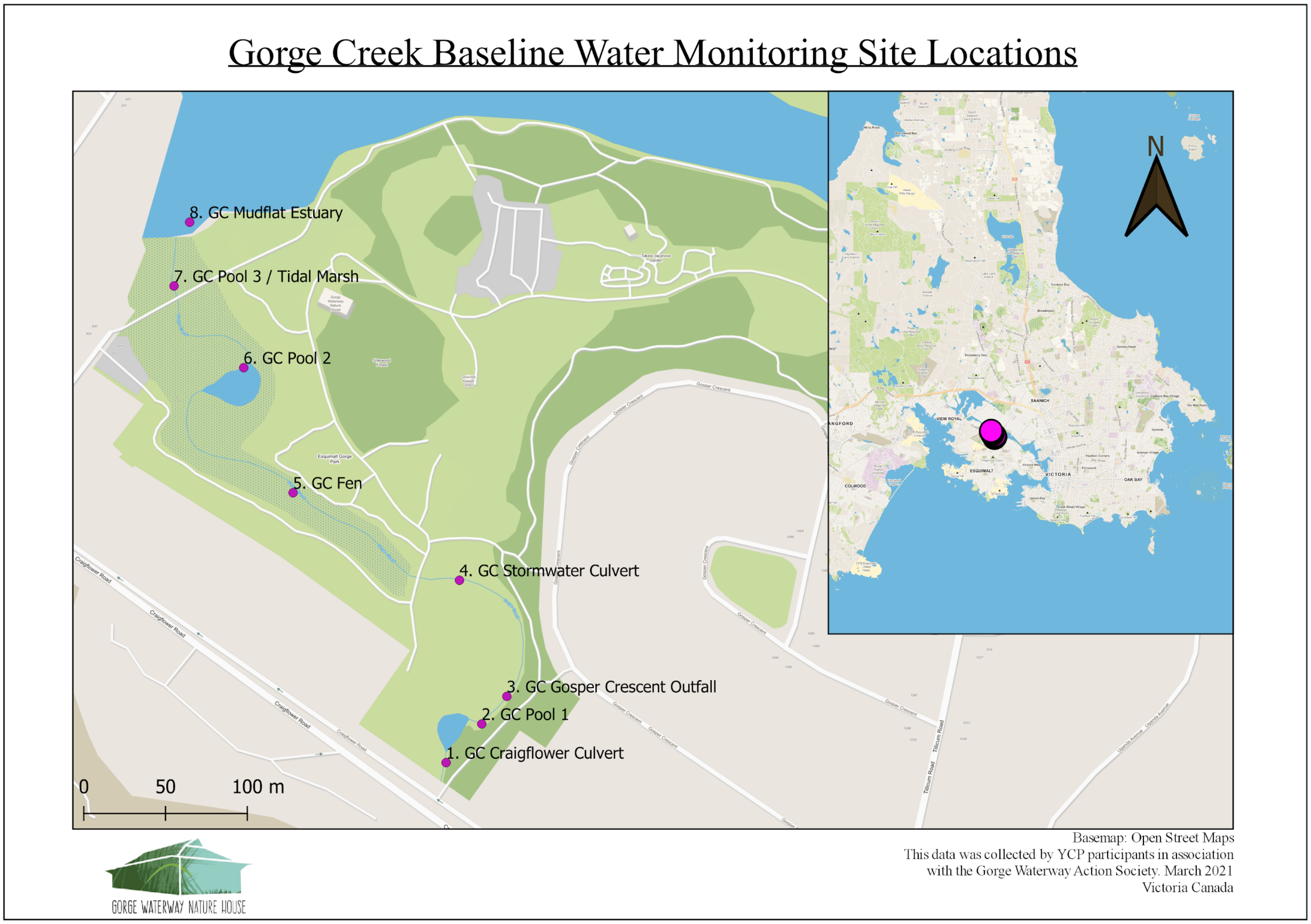

Figure 14. *Sampling locations for the collection of water quality data along Gorge Creek in Esquimalt Gorge Park, Esquimalt, BC. Sites #1w – 8 are labelled and marked by purple dots (site 1w correlates to site 1 at the Craigflower culvert). Created by: Alex Newall (GWAS YCP Participant - Biology).*

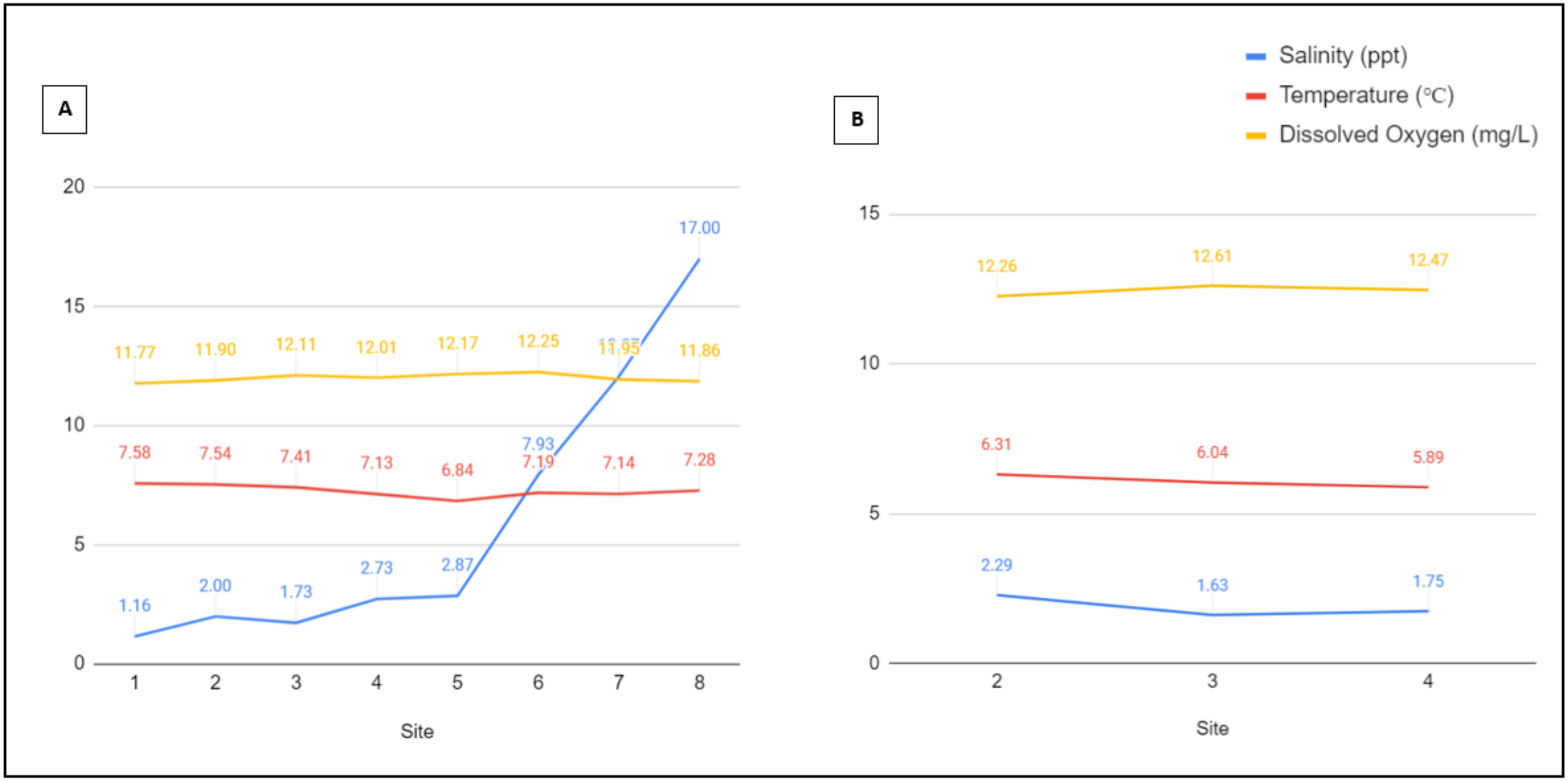

Figure 15. *Average water salinity (ppt), temperature (℃), and dissolved oxygen (mg/L) values for the eight sampling sites within Esquimalt Gorge Park, Esquimalt, BC, and the three sampling sites in Cuthbert Holmes Park, Saanich, BC. A) Esquimalt Gorge Park (Sites #1 - 8). B) Cuthbert Holmes Park (Sites #2 - 4). Salinity values are shown in blue, temperature values are shown in red, and dissolved oxygen values are shown in yellow.*

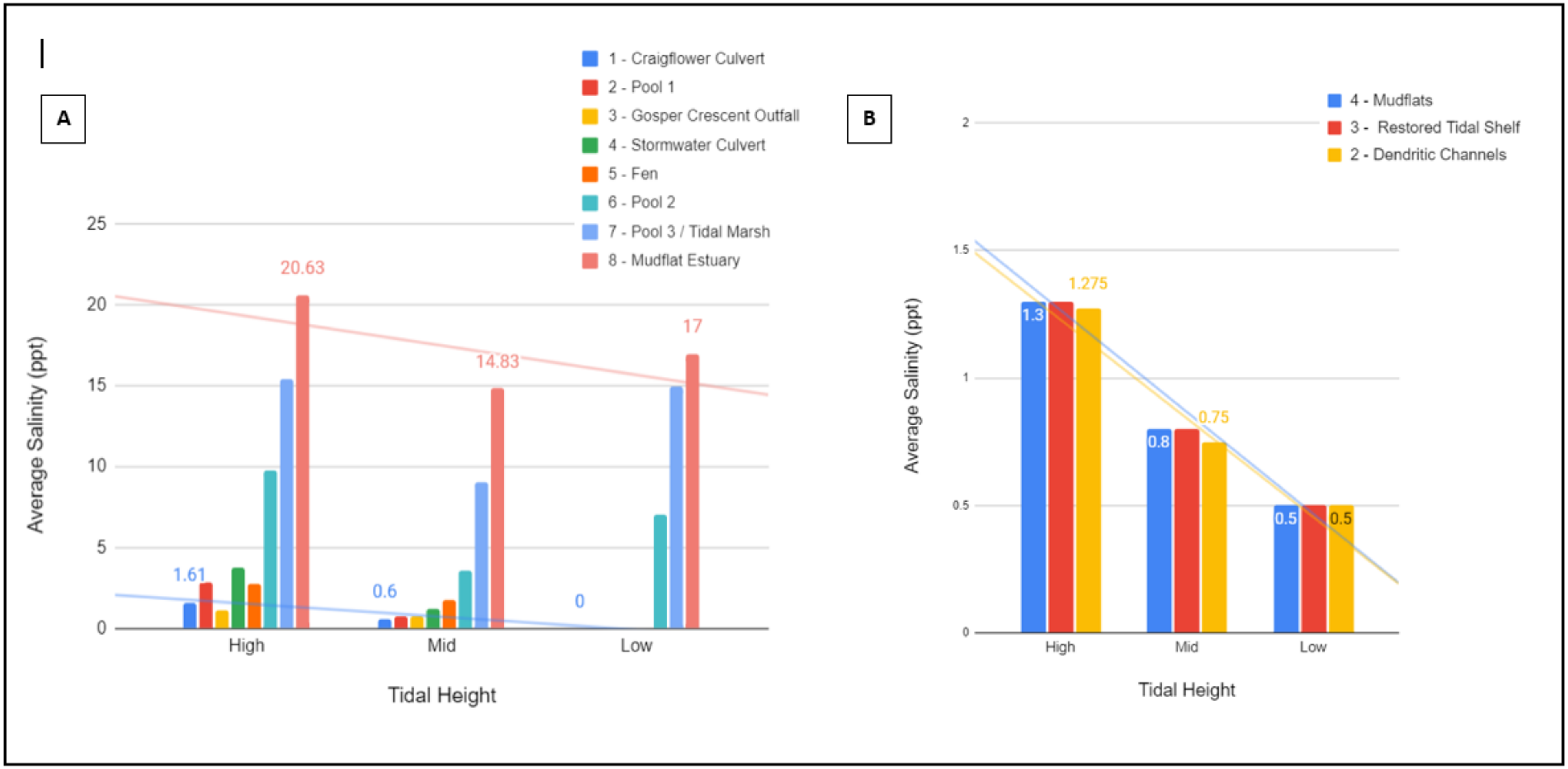

Figure 16. *Average salinity (ppt) compared to general tidal height (i.e. high, mid and low) for Esquimalt Gorge Park and Cuthbert Holmes Park regions. A) Average salinity values for the eight sites along the creek in Esquimalt Gorge Park, Esquimalt, BC. B) Average salinity values for the three sites in Cuthbert Holmes Park, Saanich, BC. Note: Tidal heights defined as: Low (0 - 0.6), Mid (0.7 - 1) and High (> 1.1) (Clarke, 2021).*

Discussion

1. Species Diversity

Baseline data, such as species diversity, are critical for providing reference points in time which are a useful source of information. In particular, the species diversity index for Esquimalt Gorge Park (0.91) may be referenced by the Township of Esquimalt or other community groups when making restoration decisions following the upcoming restructuration of the Gorge Creek / Estuary. For example, they may wish to increase the riparian vegetative species diversity and focus on native plants which serve important ecosystem functions (*e.g.* bank stabilization, habitat / shelter, food, shade / bank cooling). From a post-restoration perspective, this data is helpful to evaluate whether project objectives were met and how species diversity changed over time.

When comparing Esquimalt Gorge Park (pre-restoration) and Cuthbert Holmes Park (post-restoration) sites, the data showed that the species diversity at Cuthbert Holmes Park (2.54) was considerably higher. However, much of the species diversity consisted of invasive and exotic species, with only 22/67 species native to Vancouver Island. Out of the ten most frequent species in both regions, only one species was native within Cuthbert Holmes Park compared to four native species within Esquimalt Gorge Park. Unfortunately, documentation for which vegetative species were planted within Cuthbert Holmes Park (Site #2) and by which organizations during restoration efforts were unavailable. It can therefore only be speculated whether a mixture of native, exotic and / or invasive species were planted at the site or if these invasive / exotic species were opportunistic settlers. If native species diversity is a priority, then continued restoration efforts are needed to increase native species and remove invasive species at Cuthbert Holmes Park.

2. Creeping Buttercup

Creeping buttercup (*Ranunculus repen*) was the most prevalent invasive species found at both sites (**Figure 17**). Its presence dominated the Cuthbert Holmes Park with a total relative abundance (based on percent cover) of 38.85% compared to 0.93% within Esquimalt Gorge Park. *R. repen* is a threat to species diversity since it has the ability to grow quickly, with individual plants able to cover areas up to 40 ft^2 within one year and can have detrimental effects on neighbouring plants by depleting potassium in the soil (a micronutrient required by most plants for growth) (O'Keeffe *et al.*, 2002; King County, 2019). At the Cuthbert Holmes Site, *R. repen* was dominant in transects E - H (NW transects) and less so in transects A - D (SE transects) ([Figure 17](#)). This may indicate that the plant originated near transect H and is spreading SW throughout the site, or that the conditions near transect H are more favourable to *R. repen* and possibly other invasive species. Not only is the percent cover much higher in transects E - H, the distribution pattern was mostly continuous *i.e.* widespread occurrence of species with low to dense abundance. This information may be used to target key areas within both regions for eradication efforts of *R. repen* and other invasive species.

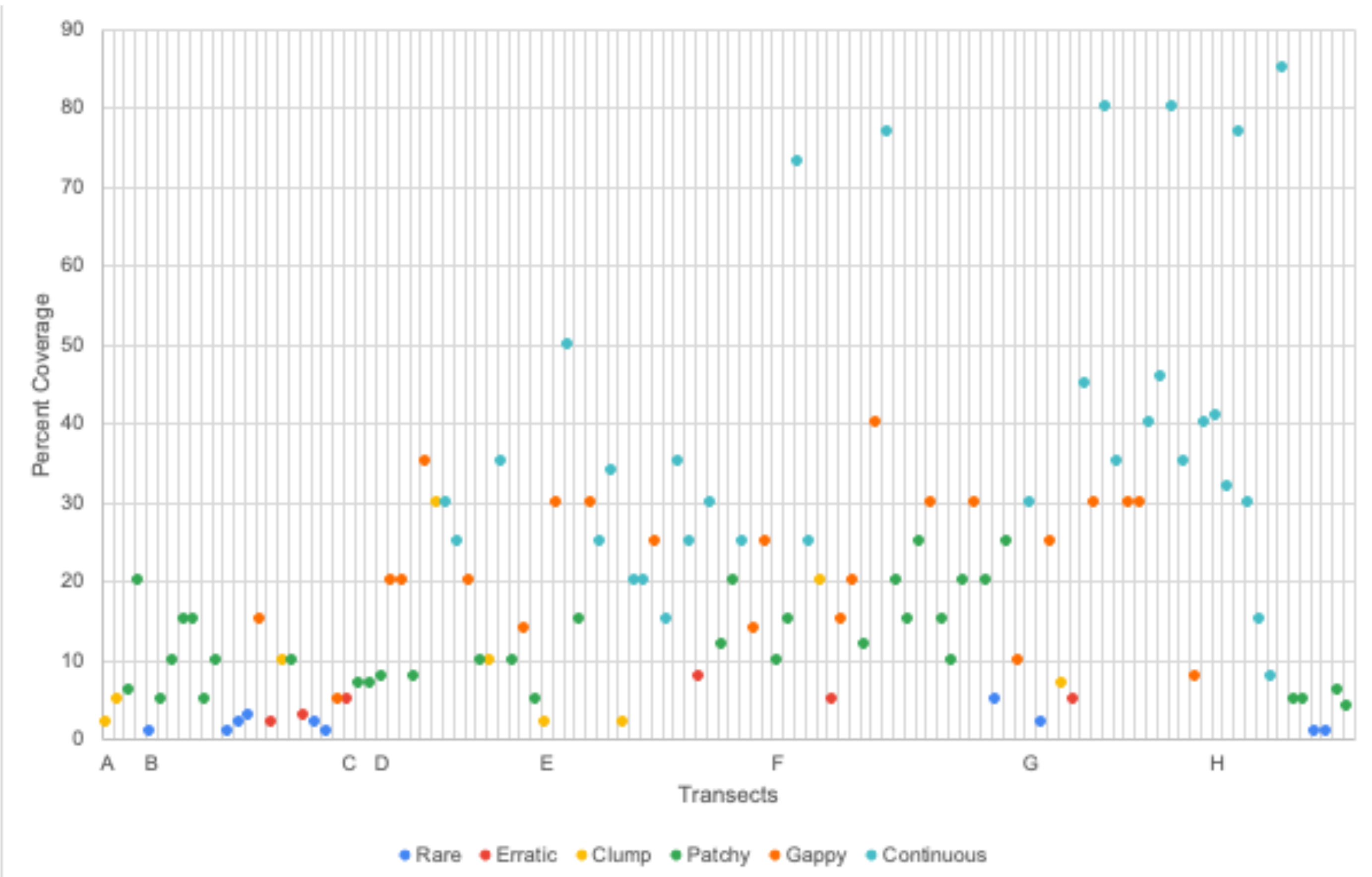

Figure 17. *Spreading pattern of Creeping Buttercup (Ranunculus repen) based on percent cover and pattern type (rare, erratic, clump, patchy, gappy and continuous) in Cuthbert Holmes Park (Site #2), Saanich, BC. Note: Pattern types are defined as: rare - limited to a few individuals; erratic - too few individuals to make discrete patches; clump - one patch of species within quadrat, with sparse to moderate abundance; patchy - more than one clump, low dense abundance; gappy - widespread but with gaps; and continuous - widespread occurrence of species, could have low to dense abundance.*

3. Other Invasives

The Coastal Invasive Species Committee (Coastal ISC) classifies Himalayan blackberry, English ivy, common periwinkle and spurge-laurel as “Priority Invasive Species'' (Coastal ISC, 2021). The Coastal ISC recommends controlling all of these species, especially in high value conservation areas, which would include public parks like Esquimalt Gorge Park and Cuthbert Holmes Park which are also part of the ecologically important Victoria Harbour Migratory Bird Sanctuary (Coastal ISC, 2021). Since both sites are in heavily used urban areas and adjacent to residential developments, educational outreach is necessary to promote environmental stewardship to allow community members to properly identify and eradicate invasive species from their own properties, which will help prevent further spread of invasive species into the parks. GWAS does have existing online materials that cover these subjects but finding other ways to reach the public is encouraged.

4. Other Ground Cover Components

Grass (Site #1 55.01%, Site #2 28.52%) was the most abundant ‘other’ ground cover component for both sites, followed by bareground (20.37%), leaf litter (15.22%), and rock (4.07%) at Site #1; and deadwood (18.51%), bareground (13.85%), and road (12.58%) for Site #2 (**Figure 12**). Unfortunately, since surveying was conducted in the winter, grasses were not identifiable to a species level and it was unknown whether these grasses were considered native, exotic, or invasive. The large proportion of bareground may be seasonal, since spring and summer growth will likely result in reduced bareground. Site #2 had such high numbers of deadwood (18.51%) likely due to the large woody debris which was added during previous restoration efforts. Documentation of this methodology was unavailable.

5. Tide and Salinity

It was found that the Esquimalt Gorge Park water sampling sites increased in salinity from Sites #6 - 8 (**Table 7**; **Figure 15**). One can speculate that the water becomes more brackish as it travels northward, along the Gorge Creek to the Gorge Creek Estuary where it joins the Gorge Waterway, since there is a large (>1 km) stretch which has direct drainage to the ocean in addition to the tidal influence (*i.e.* tide travels NW from the Pacific Ocean, up the Victoria Harbour to the Gorge Waterway; reverses during a falling tide) (**Figure 18**; Capital Regional District, 2015). This gives a sense of how far southward up the creek the water can travel during different tidal events. As such, it is important to collect salinity data during each season to monitor trends.

According to the recent application for funding for '*Gorge Creek Restoration'*, submitted by the World Fisheries Trust, their main objective is to increase estuarine habitat and forage fish spawning areas suitable for the return of historically present chum, coho and cutthroat salmonids and many other aquatic organisms within the Gorge Creek (2021). By knowing how far brackish waters travel southward along the Gorge Creek, we can determine where ideal spawning habitat is located. For example, this is an important distinction for chum salmon who prefer to spawn adjacent to estuaries in freshwater where their fry emerge from gravel spawning beds in the spring and move directly (1 - 2 days) from "risky" urban fresh waters to the ocean (unlike other species of salmon *e.g.* coho, Chinook and sockeye) (World Fisheries Trust, 2021; Fisheries and Oceans Canada, 2019).

It was found that the Cuthbert Holmes Park water sampling sites had higher salinity values at Sites #2 and #4 compared to Site #3 (**Table 7; Figure 15**). Similar to the Esquimalt Gorge Park region, these sites may be influenced by the greater connectivity to the Portage Inlet where the entire basin is surrounded by areas of direct drainage to the ocean. Overall, the salinity range for this region was lower than at Esquimalt Gorge Park (1.16 - 17.00 compared to 1.75 - 2.29, respectively), which may be explained by the sites' farther distance from the ocean and the larger size and volume of fresh water from the Colquitz River compared to the Gorge Creek.

6. O2 and Temperature

Both regions had consistent temperature and oxygen values, likely due to the short data collection period during the winter months (January - March 2021). In order to compare water column properties regionally, seasonally and inter-annually, a long-term water sampling program would need to be established. This data would be especially valuable with ongoing climate change and to understand how these changes may impact the environmentally sensitive organisms which reside within these regions.

As far as winter trends go, it was found that the sites in the Cuthbert Holmes Park region were cooler and had higher dissolved oxygen values on average than the Esquimalt Gorge Park sites (5.89 - 6.31°C and 2.26 - 12.61 mg/L compared to 6.84 - 7.58°C and 11.77 - 12. 24 mg/L, respectively) **(Table 7; Figure 15).** This is consistent with the inverse relationship between temperature and dissolved oxygen (*i.e.* cooler water temperatures can hold higher concentrations of dissolved oxygen). Dissolved oxygen in surface water of streams is also influenced by atmospheric input and groundwater discharge (United States Geological Survey, n.d.). The cooler average temperatures in the Cuthbert Holmes Park region may be explained by site specific conditions (*e.g.* geography, cover from trees, weather patterns) for which more data is needed.

7. Identification Limitation

Field data were collected during the winter months (January - March) which created some uncertainty with identification accuracy. Many identifying features of species were flowering or seed parts which were not visible in the winter months. Therefore, for the purpose of this study, similar species were grouped together to reduce identification error and, when possible, a second opinion was consulted to help or confirm the species ID. To increase precision, data should be collected in the spring and summer months to compare to the 'Species Catalogue' and confirm correct species names.

8. Human Error

Due to time constraints, data were collected by various members of GWAS biology and restoration streams which increased the likelihood of inconsistencies: mainly in species identification, percent coverage values, and distribution patterns. To limit identification error, prior to data collection, each individual was provided with a species ID booklet which was based on the Species Catalogue. A few days prior to arriving on site, all members were sent a Site Orientation package to increase consistency between surveying teams, including: site background information, study objectives, meeting and site locations, review of the alternating belt transect method, survey information to collect, photo and directions for taking quadrat and species photos, definitions and photos for recording percent cover and distribution patterns, and definitions for 'other' ground cover types. Additionally, an on-site demonstration was done with all participants to ensure the methods were understood and to address any questions or concerns. After the first group survey, there was confusion with quadrat photos *i.e.* participants were unsure whether quadrat photos for transect B (all) and transect F (1 - 9, 11, 13, 15, 17, 19, 21, 23, 25) were in the correct order and / or orientation when uploaded to the 'Quadrat Catalogue'. Due to this, members in the following vegetative surveys were asked to take the quadrat photos with their shoes (located at the bottom edge of the quadrat) in the shot in order to provide a visual reference when later uploading the photos; this significantly reduced uploading errors and time spent.

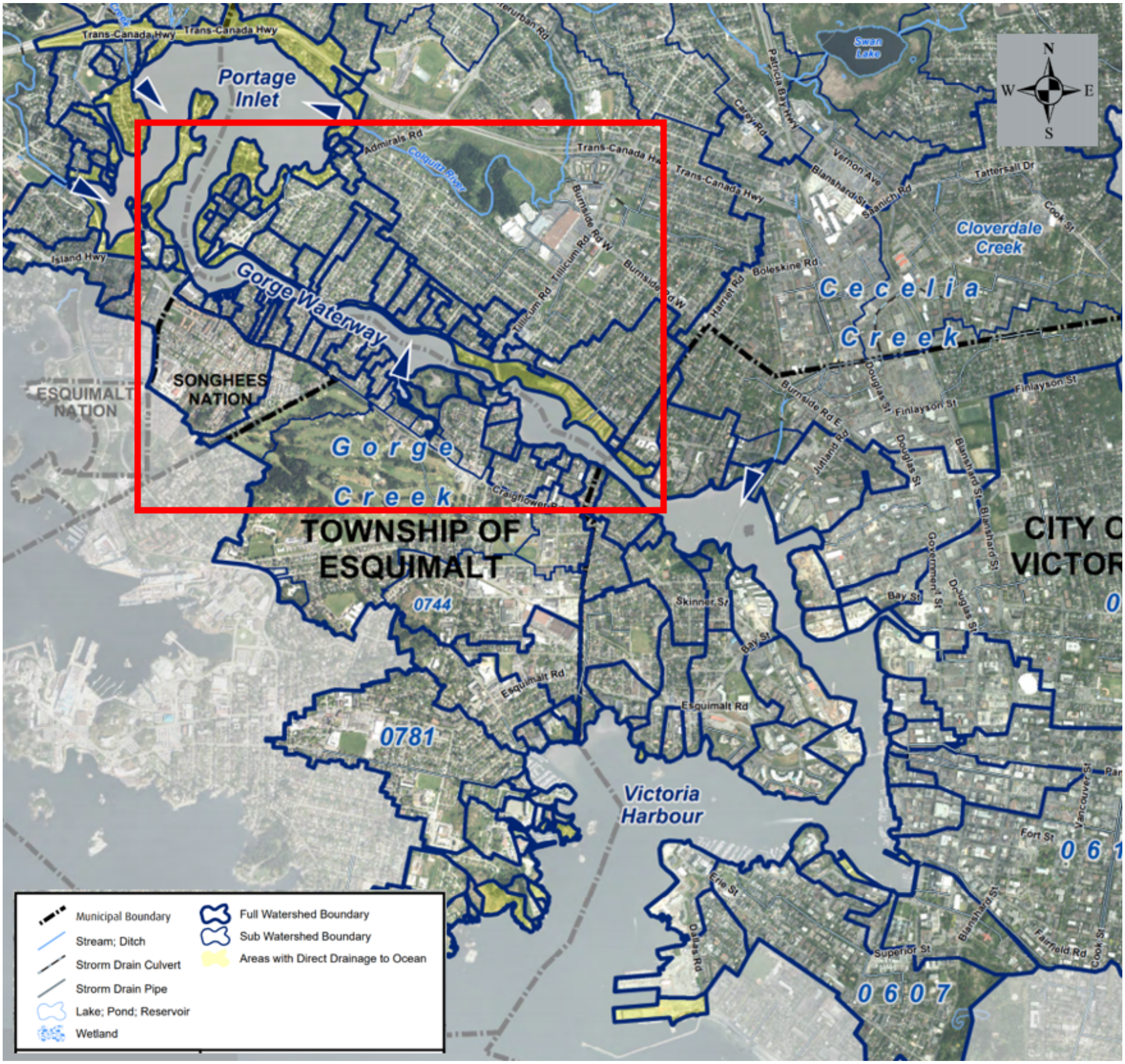

Figure 18. *Map of the Portage Inlet, Gorge Waterway & Victoria Harbour Watersheds near Victoria, BC (Capital Regional District, 2015). Red box indicates areas mentioned in the report.*

Future

1. In-Lab Analyses

Originally, this project included sending away water, sediment, and benthic invertebrates samples for in-lab analyses to Biologica Environmental Services Ltd. However, due to time and budget constraints they were delayed throughout the project. In the future, it is recommended that samples from each site be collected and sent away for analysis. Suggestions for testing include: water samples - dissolved total metal, mercury, polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), fecal & total coliforms, and E. coli & total coliforms (Biologica Environmental Services Ltd., 2021); sediment samples - particle size, organic matter, microbial activity, and list of contaminants (Batley, 2016); benthics invertebrate samples - species identification and species abundance (Biologica Environmental Services Ltd., 2021).

2. Species Diversity

If species diversity / inventory is of further interest for these sites, it is recommended that vegetation sampling be conducted during the spring and / or summer months to delineate the species which have been grouped together or left as "unidentified" and to strengthen the winter species identification (**Table 9**). Species pictures can also be added to the Species Catalogue or to a new spring / summer / fall catalogue to obtain seasonal variations of each species (*e.g.* flowering parts, berries). Additionally, grass and moss species can be identified to enhance diversity and abundance analyses.

3. pH Profile

A future area of interest would be to collect pH data at sites within both regions to create a pH profile. This would be valuable pre-restoration baseline data for Esquimalt Gorge Park. Additionally, it could help determine if the addition of sun-dried oyster shells within the dendritic channels at Cuthbert Holmes Park had the desired effect per 2020 project goals (Chambers, 2021).

4. Amphibians

Another restoration goal for Cuthbert Holmes Park was to increase amphibian habitat by establishing fresh water vernal pools close to the dendritic channels (Chambers, 2021). Unfortunately, the surveying took place during the winter months which was an inactive period for most amphibians. Further monitoring could be done in the spring and summer months to record amphibian activity and to determine if this restoration goal was met.

5. Gorge Creek Restoration Recommendations

When comparing the two sites, it became apparent that within the Cuthbert Holmes Park region, three of the top five most abundant species (relative abundance values) were invasive: creeping buttercup (38.85%), English ivy (4.65%) and Himilyan blackberry (3.08%). Compared to Esquimalt Gorge Park, where there were no invasive species in the top five most abundant species. In order to keep invasive species to a minimum, it is recommended that native ground cover species are incorporated into the restoration plan at Esquimalt Gorge Park following renovations to prevent invasive species from dominating.

6. Post Gorge Creek Restoration

Riparian vegetative surveys and water data should be collected within the Esquimalt Gorge Park region following the upcoming Gorge Creek and Gorge Creek Estuary structural renovations and related restoration efforts. The data in this report may be used as a benchmark to evaluate whether future restoration efforts were successful.

7. Long-term

To identify long-term trends, and to compare data regionally, seasonally, and inter-annually, data should be collected at sites within both regions on an ongoing basis. The succession of the riparian area and the restoration or deterioration of the streams are both valuable long-term insights. Long-term studies are becoming increasingly important as climate change is altering environmental trends with increased frequency compared to previous decades. This data would be especially valuable to understand how changes may impact the environmentally sensitive organisms which reside within these regions.

Acknowledgments

We would like to acknowledge our colleagues at the Gorge Waterway Action Society (thank you for hiring us during the pandemic), World Fisheries Trust (without whom we would not have had water sampling equipment), Parks Esquimalt and the Lekwungen-speaking (Songhees and Esquimalt) First Nations for allowing this project to take place. Thank you to our supervisors Jameson Clarke and Stephanie Gurney for their continuous support throughout the project. A big thank you to everyone who helped with the vegetation surveys and water sampling and to Dorothy Chambers for her valuable insights and for allowing us to borrow her waders for three months.

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Appendix

Table 1. *Description of sampling sites within the Esquimalt Gorge Park (EGP) and Cuthbert Holmes Park (CHP) regions. Vegetative surveys were conducted at EGP Site #1v and CHP Site #2, water analyses were performed at EGP Sites #1w - 8 and CHP Sites #2 -4, and flow rate was performed at CHP Sites #3 - 4.*

Region	Site Name	Site #	Survey Type	Transects	Geolocation or Benchmark (DDD.DDDDDD°)	Benchmark Length (m)	Transect Spacing (m)	Site Area (m^2)	Site Perimeter (m)
Esquimalt Gorge Park	Gorge Creek Estuary	1v	vegetative	A-E	Benchmark: +048.446628° / -123.407600° to + 48.446431° / -123.407554°	22	5	296	243
	Craigflower Culvert	1w	water	-	Geolocation: +048.443726°N, -123.405581°	-	-	-	-
	Pool 1	2	water	-	Geolocation: +048.443938°N, -123.405286°	-	-	-	-
	Gosper Crescent Outfall	3	water	-	Geolocation: +048.444089°N, -123.405078°	-	-	-	-
	Stormwater Culvert	4	water	-	Geolocation: +048.444726°N, -123.405470°	-	-	-	-
	Fen	5	water	-	Geolocation: +048.445206°N, -123.406847°	-	-	-	-
	Pool 2	6	water	-	Geolocation: +048.445892°N, -123.407255°	-	-	-	-
	Pool 3/Tidal Marsh	7	water	-	Geolocation: +048.446340°N, -123.407832°	-	-	-	-
	Mudflat Estuary	8	water	-	Geolocation: +048.446690°N, -123.407703°	-	-	-	-
Cuthbert Holmes Park	Dendritic Channels	2	vegetative	A-H	Benchmark: +048.458202° / -123.406587° to +048.458485° / -123.407392°	70	10	2117	71.8
			water	-	Geolocation: +048.458186 / -123.407131	-	-	-	-
	Restored Tidal Shelf	3	water (incl. flow	-	Geolocation:	-	-	-	-

			rate)		+048.457772 / -123.404867				
	Mudflats	4	water (incl. flow rate)	-	Geolocation: +048.457551 / -123.405429	-	-	-	-

Table 2. *Flow rates (cfs) for Sites #3 - 4 in the Cuthbert Holmes Park region. Estimated total precipitation over 7 days leading up to collection of the water flow rate data and tide height with direction (i.e. ↑ = rising tide or ↓ = falling tide) are indicated (Government of Canada, n.d.).*

Region	Site Name	Site #	Date (DDMMYYYY)	Total Precipitation (mm)	Tide Height (m)	Flow Rate (cfs)
Cuthbert Holmes Park	Restored Tidal Shelf	3	3-02-2021	27.8	0.9↓	0.1083160903
			17-02-2021	3.0	0.6↑	0.02275416533
			10-03-2021	7.0	1.1↓	0.1693565028
	Mudflats	4	3-02-2021	27.8	0.9↓	0.08935882948
			17-02-2021	3.0	0.6↑	0.05252909735
			10-03-2021	7.0	1.1↓	0.1910108391

Table 3. *Transect descriptions for riparian vegetative surveys within Esquimalt Gorge Park (Site #1v) and Cuthbert Holmes Park (Site #2) regions. Geolocations were recorded at the beginning of each transect (originating on the benchmark line).*

Region	Site Name	Site #	Transect ID	Transect Geolocation (DDD.DDDDDD°)	Transect Length (m)
Esquimalt Gorge Park	Gorge Creek Estuary	1v	A	48.446631° / -123.407671°	10.0
			B	48.446641° / -123.407635°	13.0
			C	48.446536° / -123.407589°	13.0
			D	48.446480° / -123.407583°	14.0
			E	48.446448° / -123.407561°	17.0
Cuthbert Holmes Park	Dendritic Channels	2	A	048.458215° / -123.406576°	34.0
			B	48.458208° / -123.406681°	36.5
			C	48.458321° / -123.406779°	26.4
			D	48.458373° / -123.406893°	23.0

			E	48.458403° / -123.407016°	26.0
			F	48.458501° / -123.407146°	26.8
			G	48.458486° / -123.407198°	35.0
			H	48.458566° / -123.407314°	44.0

Table 4. *Common and scientific names of vegetative species found within the Esquimalt Gorge Park and / or Cuthbert Holmes Park regions. 'X' denotes presence within a region. Note: species which were not easily identifiable (e.g. due to seasonality or lack of expertise) were labelled "unidentified species" or grouped within their genus or given a general description for future identification.*

Common Name	Scientific Name	EGP	CC	Notes
American Glasswort (Sea Asparagus)	*Salicornia virginica* aka *Salicornia pacifica*	X		
Apple Tree (Domestic)			X	Various species
Beach Pea	*Lathyrus japonicus*		X	
Black Hawthorn	*Crataegus douglasii*		X	
Blackberry Species	Himalayan Blackberry (*Rubus armeniacus);*		X	
	Trailing Blackberry (*Rubus ursinus)*	X	X	
Bulbed Spring Flower			X	Various species
Chickweed Species			X	Various species
Clover Species	White Clover (*Trifolium repens);* Black Medick (*Medicago lupulina)*	X	X	
Common Groundsel	*Senecio vulgaris*		X	
Common Periwinkle	*Vinca minor*		X	
Common Privet	*Ligustrum vulgare*		X	
Creeping Buttercup	*Ranunculus repen*	X	X	
Daisy Species	Common Daisy;		X	
	English Daisy (*Bellis perennis);*	X	X	
	Oxeye Daisy (*Leucanthemum vulgare Lam.*)		X	
Dandelion Species	Common Dandelion (*Taraxacum officinale);* Common Cat's Ear (*Hypochaeris radicata)*	X	X	
Deer Fern	*Blechnum spicant*		X	
Dock Species	Curled Dock (*Rumex crispus);*		X	
	Western Dock (*Rumex occidentalis)*		X	
Douglas Fir	*Pseudotsuga menziesii*		X	
English Ivy	*Hedera helix* L.	X	X	
Entire-leaved Gumweed	*Grindelia integrifolia*	X	X	
Dovefoot Geranium	*Geranium molle*	X	X	
Grand Fir	*Abies grandis*		X	
Grape Species	Dull Oregon-grape (*Mahonia nervosa*);		X	

	Tall Oregon-grape (*Mahonia repens*)			
Ground Ivy	*Hedera helix* L.	X	X	
Hairy Bittercress	*Cardamine hirsuta* L.	X	X	
Mayweed	*Anthemis cotula*		X	
Miner's-lettuce	*Claytonia perfoliata*		X	
Mushroom			X	Various species
Nettle Species	Red Dead Nettle		X	
Ocean Spray	*Holodiscus discolor* (Pursh) Maxim.		X	
Pacific Sanicle	*Sanicula crassicaulis*		X	
Pampas Grass	*Cortaderia selloana*	X		
Prunella Species	*Prunella vulgaris ssp. Lanceolata* (native species); *Prunella vulgaris ssp. Vulgaris* (non-native species)		X	
Queen Anne's Lace (Wild Carrot)	*Daucus carota*	X	X	
Red Flowering Currant	*Ribes sanguineum*		X	
Rose Species	Baldhip Rose (*Rosa gymnocarpa);* Nootka Rose (*Rosa nutkana*)		X	
Scotch Broom	*Cytisus scoparius* (L.)		X	
Shore Pine	*Pinus contorta*		X	
Sitka Spruce	*Picea sitchensis*		X	
Small Flowered Lotus	*Lotus micranthus*	X	X	
Snow Drop	*Galanthus*		X	
Snowberry Species	Symphoricarpos albus		X	
Spurge-laurel	*Daphne laureola*	X	X	
Thistle Species	Bull Thistle (*Cirsium vulgare)*;	X	X	
	Canadian Thistle (*Cirsium arvense*)		X	
Vetch Species	Bird Vetch (*Vicia cracca*);	X	X	
	Common Vetch (*Vicia sativa*);	X		
	American Vetch(*Vicia americana);*			
	Hairy Vetch (*Vicia hirsuta)*			
Western Red Cedar	*Thuja plicata*		X	
Willow			X	Various species
Yarrow	*Achillea millefolium*		X	
Yellow Archangel	*Lamiastrum galeobdolon*		X	

UNIDENTIFIED SPECIES				
Sp 24		*X*	*X*	
Sp 41			*X*	
Sp 54			*X*	
Sp 60			*X*	
Sp 69			*X*	
Sp 70			*X*	
Sp 73			*X*	
Sp 80			*X*	
Sp 82			*X*	
Woody Shrub		*X*		Various species

***Table 5.** Other ground cover types and descriptions used in quadrat percent coverage estimates for Sites #1v - 2 riparian vegetative surveys within Esquimalt Gorge Park and Cuthbert Holmes Park regions.*

Cover	Description
Bare Ground	Soil exposed within the quadrant.
Deadwood	A branch or part of a tree that is dead.
Grass	Vegetation consisted of typically short plants with long, narrow leaves, growing wild or cultivated on lawns and pastures.
Irrigation Control Valve	Municipal infrastructure.
Leaf Litter	Decomposing but regonziable leaves and other debris.
Moss	A small flowerless plant that lacks true roots, growing in damp habitats and reproducing by means of spores released from stalked capsules.
Oyster Shells	A largely calcareous covering of mollusc or a brachiopod.
Plastic /Tarp	A synthetic material that was placed there by humans.
Road	An area cleared and compacted for walking paths, bike paths or motorized vehicles.
Rock	Rock exposed within the quadrant.
Unknown Shells	Shells broken down to an unidentifiable size.
Washed-up Eelgrass	Detached Eelgrass.
Water	Refers to either a puddle in the quadrant or a water body that is along the transect line.
Wood Chips	Small to medium sized pieces of wood formed by cutting or chipping.

***Table 6.** Distribution categories used to classify patterns of species within a quadrat for Sites #1v - 2 riparian vegetative surveys within Esquimalt Gorge Park and Cuthbert Holmes Park regions (Luttmerding et al., 1998).*

Code	Distribution	Description
R	Rare	Rare abundance Limited to a few individuals
E	Erratic	Sparse abundance Too few individuals to make discrete patches
C	Clump	One patch of species within quadrat, with sparse to moderate abundance
P	Patchy	More than one clump, low to dense abundance
G	Gappy	Widespread but with gaps
W	Continuous	Widespread occurrence of species, could have low to dense abundance

Table 7. *Average water data (salinity (ppt), temperature (℃), and dissolved oxygen (mg/L and %) from January - March 2021 at water sample sites (Esquimalt Gorge Park Sites #1w - 8; Cuthbert Holmes Park Sites #2 - 4).*

Region	Site	Average Salinity (ppt)	Average Temperature (℃)	Average O2 (mg/L)	Average O2 (%)
Esquimalt Gorge Park	1w. Gorge Creek Pool Craigflower Culvert	1.16	7.58	11.77	96.00
	2. Gorge Creek Pool 1	2.00	7.54	11.90	97.00
	3. Gorge Creek Gosper Crescent Outfall	1.73	7.41	12.11	97.13
	4. Gorge Creek Stormwater Culvert	2.73	7.13	12.01	96.46
	5. Gorge Creek Fen	2.86	6.84	12.16	97.40
	6. Gorge Creek Pool 2	7.93	7.18	12.24	98.06
	7. Gorge Creek Pool 3 / Tidal Marsh	12.06	7.14	11.94	96.73
	8. Gorge Creek Mudflat Estuary	17.00	7.28	11.86	96.93
Cuthbert Holmes Park	Site #2 Dendritic Channels	2.29	6.31	12.26	98.14
	Site #3 Restored Tidal Shelf	1.63	6.04	12.61	99.86
	Site #4 Mudflats	1.75	5.89	12.47	98.00

Table 8. *Average Salinity (ppt) by Tide Height Range (High, Mid, Low) from January - March, 2021 at water sample sites (Esquimalt Gorge Park Sites #1w - 8; Cuthbert Holmes Park Sites #2 - 4) (Fisheries and Oceans Canada, n.d.).*

		Average Salinity (ppt)		
Region	Site	High Tide (>1.1m)	Mid Tide (0.7 - 1.0m)	Low Tide (0 - 0.6m)
Esquimalt Gorge Park	1. Gorge Creek Pool Craigflower Culvert	1.61	0.60	0.00
	2. Gorge Creek Pool 1	2.89	0.80	0.00
	3. Gorge Creek Gosper Crescent Outfall	1.14	0.80	0.00
	4. Gorge Creek Stormwater Culvert	3.78	1.20	0.00
	5. Gorge Creek Fen	2.78	1.80	0.00

	6. Gorge Creek Pool 2	9.75	3.60	7.00
	7. Gorge Creek Pool 3 / Tidal Marsh	15.38	9.00	15.00
	8. Gorge Creek Mudflat Estuary	20.63	14.83	17.00
Cuthbert Holmes Park	2. Dendritic Channels	1.27	0.75	0.50
	3. Restored Tidal Shelf	1.30	0.80	0.50
	4. Mudflats	1.30	0.80	0.50