Restoration of the Lower Chines Community forest for Pacific Water Shrew Stepping-Stone Habitat, Port Moody

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Executive Summary

The Chines Community Forest is a coniferous mature forest located in Port Moody, British Columbia. It is made up largely of mature cottonwood, Douglas fir, and Western Redcedar, with a herbaceous shrub understory. Our restoration site is located in the Lower Chines Community Forest, adjacent to residential housing and a gravel trail used for recreation such as dog walking and running. Historically, our restoration site was connected to the larger Chines Community Forest, with Goulet Creek being the main water body that ran through it, however, the forest and many of its creeks have been separated and fragmented as a result of urbanization. We want to reconnect the restoration site to once again be connected to the Chines Community Forest and to be stepping stone habitat for the endangered Pacific Water Shrew. The Chines Community Forest and our restoration site are managed by Angela Crampton from the City of Port Moody.

We decided to break up our site into 2 distinct site units, as each had different characteristics. Site Unit 1 which is the forested area on our site, as well as the slope generally has drier conditions, with key stressors being invasive species (predominantly Japanese knotweed and Himalayan blackberry), and bare soils with lack of herbaceous vegetation. Site Unit 2 which is the wetted depression in our site contains stressors of invasive species (predominantly Japanese Knotweed), the diversion of creeks through urbanization, and water pooling at the base of our site which could impact the adjacent slope in Site Unit 1.

The entire restoration site is currently overrun by Japanese knotweed, infiltrating the soil seed bank in the upper. Diamond Head Consulting Ltd. have treated the site using herbicide, as well as planted western cedar and Douglas fir trees in the wetted depression area in our restoration site (Site Unit 2). Current conditions do not reflect a mature coniferous forest.

Port Moody has been identified as having areas containing critical habitat for the endangered Pacific Water Shrew, while habitat fragmentation and urbanization have been noted as key causes of decline for this species.

The main goals of our restoration plan are to decrease standing water at the base of the slope to prevent it from affecting the adjacent slope, and to enhance habitat for the Pacific Water Shrew by reconnecting our restoration site to the rest of the Chines Community Forest. The treatments we

recommend to successfully meet these goals include adding coarse woody debris, revegetating with native plant species, continuing stem injection treatment to Japanese knotweed, and amending soils.

To monitor success of our treatments, we propose post-restoration monitoring of Japanese knotweed cover, native plantings cover, and mean water table depths. Our outreach plan involves contacting environmental groups for volunteers to assist with planting and monitoring to create more community involvement, and providing opportunities for these environmental groups to get hands-on experience on a restoration site. The final goal for our public outreach plan is to get local community members to form a stewardship group for long term management and monitoring in the Chines forest.

Land Acknowledgement

Our project team would like to recognize that our research project has taken place in unceded traditional territories of the Coast Salish Nations of Sḵwx̱wú7mesh (Squamish), səl̓ilwətaʔɬ (Tsleil-Waututh), and xwməθkwəy̓əm (Musqueam), Stz'uminus, Qayqayt, S’ólh Téméxw (Stó:lō), and kʷikʷəƛ̓əm (Kwikwetlem) First Nations.

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Project Overview

Our restoration site is at the base of the lower Chines forest, located 1 km south of Rocky Point Park, Port Moody, British Columbia (Figure 1). The total project area is 0.35 ha in and is bound by private property to the north, and a City of Port Moody off-leash dog park to the east. The site is at the toe of a small slope, edged by a mature forest with shrub understory. Our study area is a flat area at the bottom of the slope, which is dominated by invasive species, and, at times, pooling water. There is a depression within the flat space where both groundwater and surface water accumulate, resulting in an above ground seepage channel. There is also a channel that flows along the edge of the study area and into a private property north of the project site. According to a 2020 riparian areas regulation assessment conducted by British Columbia Institute of Technology Fish Wildlife & Recreation students, this channel is not fish bearing (BCIT 2021). LiDAR data shows a depression in the shape of a stream from the south eastern edge of the property, flowing north, and downstream, away from the property (Figure 1). We believe this is the historical course of Goulet Creek. Evidence of this includes the existence of hydrophytic plants and standing water along the depression. In addition, approximately 60 m southeast of the project area, and at the top of the slope, is a constructed sediment detention pond. We believe this pond collects both water and sediment from Goulet Creek (Figure 1).

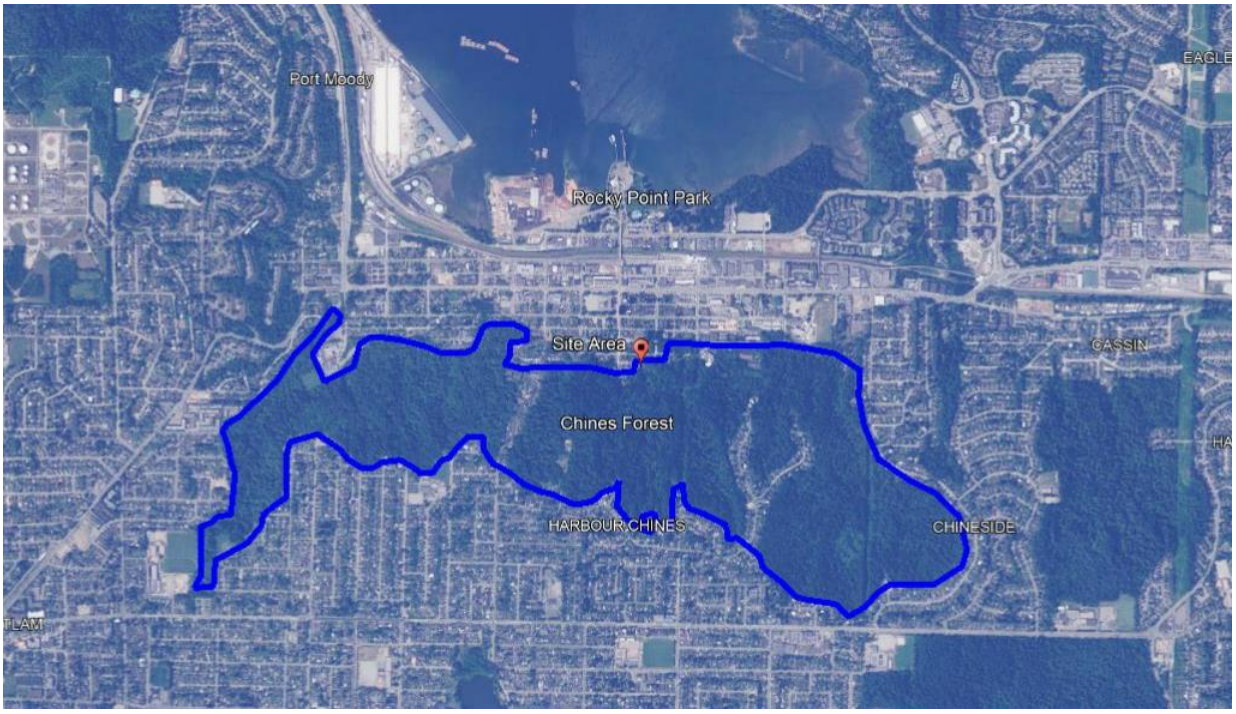

Figure 1 Site overview of entire Chines Community Forest, including the surrounding municipalities.

The lower Chines forest is located between two populations of the Pacific Water Shrew (PWS), which is considered an endangered species under the federal Species at Risk Act. It is also a red listed under the British Columbia Wildlife Act. We would like to restore this location for populations of this species to use as stepping-stone habitat (COSEWIC 2006).

For our study site, we propose two goals.

1. Create stepping-stone habitat for Pacific Water Shrew
2. Select and plant appropriate native vegetation within the study area to reduce the pooling of water on the toe of the slope, and to help establish a mature coniferous forest.

2 Pacific Water Shrew

2.1 Life history

The PWS is found in northern California, north to Oregon, Washington State, and southwestern British Columbia (Craig, Vanessa, 2007). In British Columbia, the PWS is found at low to mid-level elevations from the Fraser Valley East, Hope, and north of Vancouver between Howe Sound and Squamish (Environment Canada, 2014). They live for 18 months, with a spring-summer breeding season between February and August where they produce 2-3 litters of 3 to 6 young (Government of British Columbia 1995). PWS are specialized for aquatic environments, as their back feet have 1 mm hairs that fringe out to help them swim (Government of Canada, 2011). They feed mainly on benthic invertebrates in small streams and wetlands, making them a unique shrew species (Carmen, M. 2001). The PWS is also an important food source for garter snakes, hawks, owls, and weasels (Carmen, M. 2001).

2.2 Habitat requirements

The PWS requires mature or old growth, temperate coniferous forests with a moist microenvironment (Government of British Columbia 1995). Optimal habitat includes coniferous forest dominated by Douglas fir. Alternatively, forests should be mixed stands of conifers, red alder and other deciduous trees and shrubs (Government of British Columbia 1995). Downed trees are important to the PWS as they require shredded bark for nesting and large woody debris for cover (PWS Recovery Team

2009). Natural streams, wetlands and channelized watercourses are also critical habitats for the PWS shrew. These water bodies are suitable habitat whether they are permanent, ephemeral, or intermittent (Government of Canada 2014). However, to qualify as suitable, these streams need to be at least 1.5 km long, with 100 m of riparian habitat on both sides (Government of Canada 2014). PWS have a low bite force, so they require soft prey such as freshwater insects, mayflies, stoneflies, snails, slugs, earthworms, and spiders, moist and saturated habitats assist with this (PWS Recovery Team 2009).

2.3 Key stressors and impacts

Urbanization in the Lower Mainland has impacted the PWS through habitat fragmentation, loss, and, degradation (COSEWIC 2006). Logging and agriculture also impede PWS habitat by destroying nests and den sites and causing litter abandonment (Zuleta et. al, 1994). The construction of roads, specifically without culverts, and the alteration of drainage patterns, creates impassable barriers for the PWS. This results in loss of habitat function and reduced genetic flow (Government of British Columbia 1995). Contaminated runoff from roads and other impervious surfaces entering water sources impacts water quality and increases turbidity, thus reducing the quality of aquatic food sources for the PWS (Craig et. al, 2010). Direct mortality also occurs through by-catch in minnow traps or small mammal traps (Catania et al., 2008).

2.4 Conservation status

Under the British Columbia Conservation Framework, the PWS is ranked a 1, or, highest concern (Government of Canada 2009). The Species At Risk Act status of the PWS is listed as endangered as of 2006 (COSEWIC 2006). The British Columbia List Status of the PWS is red, meaning they are extirpated, endangered, or threatened (British Columbia Conservation Data Center, 2021)

3 Site Assessment

3.1 Historical conditions

Using Google Earth, historical imagery as far back as the 1950s was used to assess changes in the lower Chines forest. It was in the 1950s that residential buildings and roads were constructed.

Increased human development starting in the 1950s has cut the lower Chine forest off from other continuous forested areas. Though the forest canopy has generally stayed the same in the imagery, we suspect to see negative effects from habitat fragmentation in the lower Chines forest as a whole. According to ISMP 2017, the area has been growing undisturbed for approximately 100 years, we confirmed this during our field visit where we observed second growth trees. (ISMP, 2017).

In 1960 Goulet Creek, and its tributaries was rerouted to the sediment detention pond to address hydrology concerns with residential buildings north of the lower Chines forest (Berzins, 1988). We believe that the historical flow path of Goulet Creek is causing excess water on our site at the toe of the slope.

3.2 Current conditions

Located approximately 1 km southeast of Rocky Point Park, our project site in the lower Chines forest in Port Moody. This area is classified as coastal western hemlock dry maritime (CHWdm1) biogeoclimatic zone (hereafter, BEC zone) with a 05 site-series, indicating a rich to very rich soil nutrient regime and slightly dry to moist soil moisture regime. The project area is approximately 0.35 ha in size with several identified invasive species, and saturated soils. There is residential development to the north at the top of the slope, and to the east is a sediment pond (Figure 1).

The vegetation on site can be separated into two distinct communities: Site Unit 1 (SU1), which is forested upland area and Site Unit 2 (SU2), which is unforested lowland area (Figure 2). SU1 contains species such as native red alder, western redcedar, big leaf maple, Douglas fir and elderberry. SU2 is designated as a lowland area containing shrub, and forb species that have high soil moisture tolerance such as skunk cabbage, lady fern, rushes, and sedges. Invasive species such as Japanese knotweed, Himalayan blackberry, policeman's helmet, burdock, and bull thistle were observed in both site units.

At both site units, soil samples were taken using a soil auger. High clay content was observed throughout the study area with mottling reported in SU2, indicating a fluctuating water table. Although a wetland may be suitable when considering the water content, we deem it unsuitable for this site because of the slope immediately south of the study area.

On site, we observed SU1 to have mottles in the soil, indicating a fluctuating water table (Appendix 4) and presenting slope stabilization concerns. SU2 has pooling water and very saturated soils. There were mature trees throughout the project area including western hemlock, Douglas fir, western redcedar, red alder, and big leaf maple.

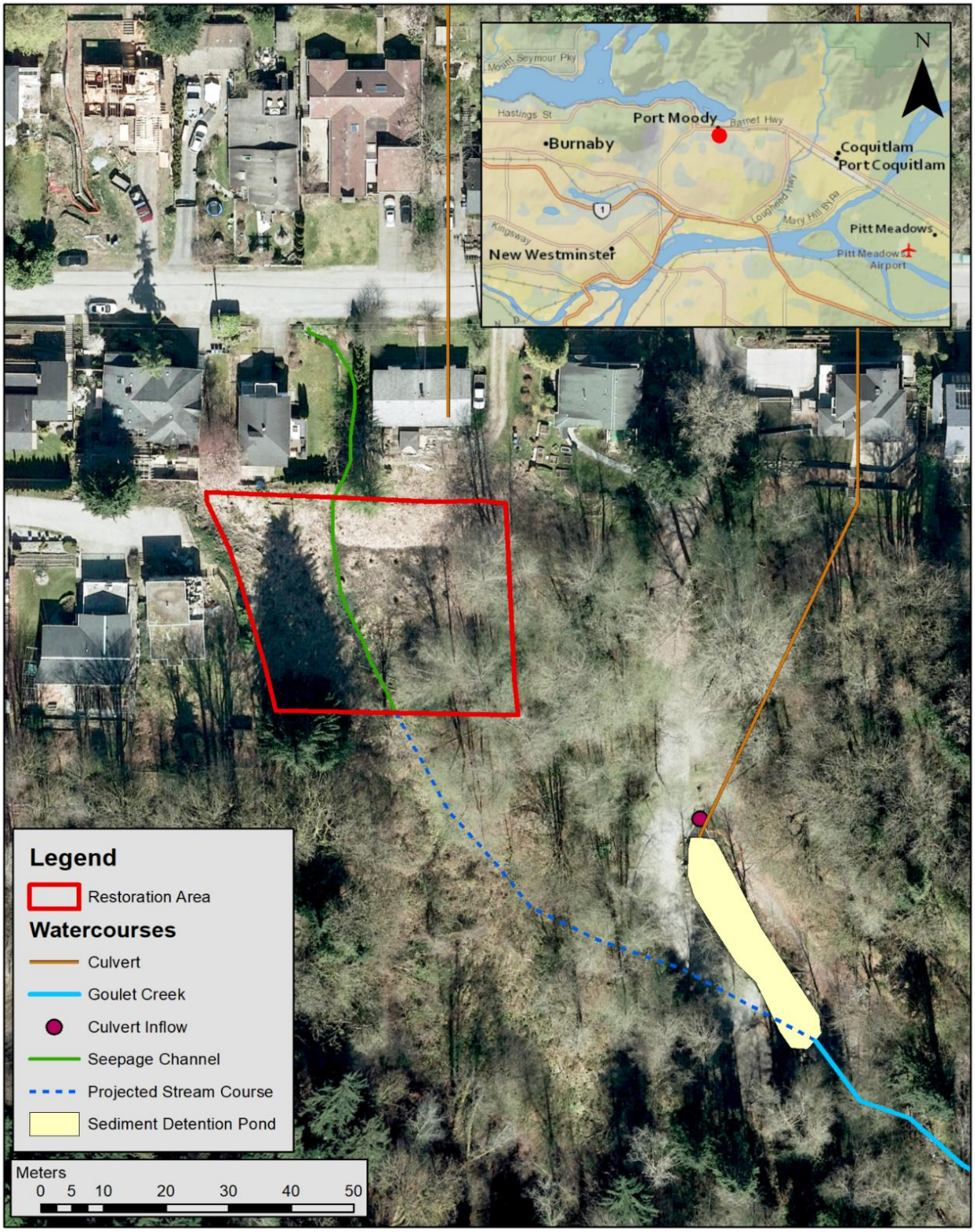

Figure 2 Outlined in red, as well as the red dot in the map shows our restoration in the lower Chines Community Forest. The sediment detention pond is outlined in yellow.

Figure 3 Contour map of the area, southwest slope poses stability concerns.

Hydrology

There are 5 creeks in the Chines forest watershed: South Schoolhouse, Kyle Creek, Slaughterhouse/Dallas, Pigeon, and Suter Brook. Goulet Creek drains into Kyle Creek, which is approximately 2.11 ha in size (ISMP, 2017).

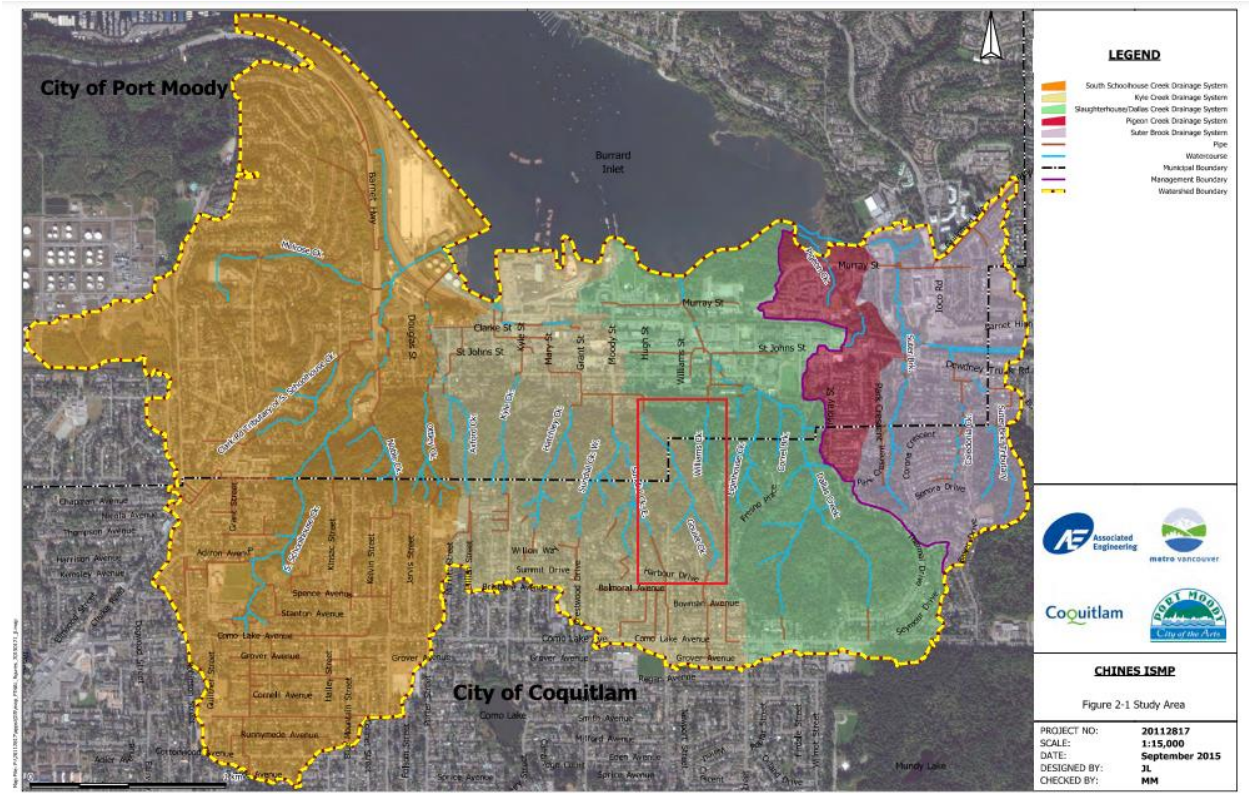

Figure 4 Map of Chines drainage systems, Goulet Creek outlined in red (ISMP, 2016).

3.2 Stressors and Impacts

Invasive species

The key stressor on site is from invasive species. A full list of invasive species can be found in the vegetation survey details in Appendix 3. In our survey, we determined that knotweed (*Reynoutria sp.*) is the most prevalent, covering up to 90% of the open area on site. Both Japanese knotweed (*Reynoutria japonica*) and Bohemian knotweed (*Reynoutria bohemica*) are also found on site.

Knotweed can grow in very moist nutrient poor soils with full to partial sunlight. Their root masses can grow up to 20 m laterally and 3-5 m horizontally (ISCBC 2017). They are typically located near streams, and occur in large numbers across the Lower Mainland (ISCBC 2017, Metro Vancouver 2019). Both species on site can reproduce through rhizomes and plant fragments. Bohemian Knotweed

can also reproduce through seed, unlike Japanese knotweed and Giant knotweed who reproduce only through plant fragments (*Reynoutria sachalinensis*), (Davenport et al. 2007, Parepa et al. 2014, Forman et al. 2003). Knotweed also releases allelopathic chemicals into the soil that inhibit other plants from establishing (ISCBC 2017). Legacy effects from knotweed can reduce nitrogen and carbon levels in the soil, making it difficult for establishment of native plants (Zhang et al. 2020). Knotweed thrive particularly well in distributed sites with bare soils as they can grow with low amounts of nitrogen, phosphorus, and carbon, which are the nutrients required in much higher concentrations for native plants to thrive (Murrell, C 2010). Knotweed root fragments separated from the main stem can also travel down watercourses into new areas and regrow into a reproducing plant. Knotweed has very strong and powerful roots that can push through concrete, causing infrastructural damage to building foundations, roads and in addition, encroaches on native vegetation, this causes stabilization and erosion concerns (ISCBC, 2017).

Slope stability

Between SU1 and the southwestern private property, there are concerns of slope failure as soil and plants are noted breaking free from the slope (Appendix 5). Contour lines of the area support this possibility as it shows the terrain is very steep, in combination with a lack of deeply rooted plants. (Figure 3, contour map). An underground retaining wall has been constructed. between SU1 and the private property (unknown date), however there is still concern as it is visually not in optimal condition (Figure 4). There are concerns that ponded water at the base of the slope may be negatively impacting the stability of the slope.

Soil conditions

Soil conditions are unknown, however they estimate that heavy metals, carbon, and nitrogen is present in the soils and that they may be at levels unsuitable for the reestablishment of the natvie plant community. To confirm this, further soil quality and nutrient level testing is required.

Dumping

We confirmed that the western slope has dumping of residential waste including metal, plastics, and styrofoam. Plastics and metals in soil can alter nutrient levels and add toxins. This can alter microbial activity, which alters plant growth and could impact project success (Machado et al. 2019).

3.3 Desired future conditions

The goals of this restoration project are removal of invasive species while supporting and enhancing the growth of mature coniferous forest to create steppingstone habitat for PWS. Select species will be chosen to increase uptake of pooling water at the base of the slope to help prevent potential erosion

Douglas fir, western redcedar, and western hemlock will be planted, with hydrophilic vegetation and large woody debris additions for the understory (Pacific Water Shrew Recovery Team 2009). Restoring corridors for the PWS is critical (COSEWIC 2006). In addition to habitat creation, planting densely with native vegetation will improve slumping of the slope through root penetration, water absorption and interception, and soil nutrient enhancement (Saifuddin et. al 2014). We will plant hydrophytic plants in this area to promote root establishment and help mitigate excess water.

4 Restoration Goals and Objectives

Goal 1.0: Enhance habitat for the Pacific Water Shrew in the lower Chines forest.

Objective 1.1: Reduce invasive species cover in the base of our site to 15% of its current level by October 2022.

Objective 1.2: Increase native species to a minimum of 80% cover onsite by October 2023. Plants will be conducive for a mature coniferous forest with moist microenvironments.

Goal 2.0: Decrease standing water at the base of the slope in the lower Chines forest site

Objective 2.1: Plant water-retaining plant species at and along the base of the slope to cover 75 % of the slope by May 2022.

5 Restoration Treatments

This section outlines our proposed site preparation techniques, timing and materials required for the suggested restoration treatments. All treatments are described and laid out in the order they will be performed on site. Our treatments are a mix of conventional and innovative methods mainly focusing on lowering legacy invasive species colonization on this site.

Table 1 List of restoration treatments and their respective timing and equipment required.

Treatment	Timing (By month)	Materials (What we need to carry out treatment)
Stem injection	May 2022 - June 2022	Registered herbicide applicator, injection gun, herbicide
Selective herbicide application	August 2022 - May 2023	Registered herbicide applicator, Backpack sprayer, herbicide
Waste removal	October 2022	Truck, extended garbage pickers or gloves, garbage bags
Soil amendments	September 2022	Biochar, rototiller, gasoline, truck, wheelbarrow, rack, shovel
CWD addition to site	January 2023 - February 2023	Backhoe
Site Preparation	October 2022	Rakes, shovels, gloves, tarps

Treatment	Timing (By month)	Materials (What we need to carry out treatment)
Plant salvaging	August 2022	Hand trowels, shovels, gloves, burlap sacks, recycled plastic pots, fresh soil
Planting	September 2022	Hand trowels, shovels, gloves, planting stock

5.1 Site Preparation Treatments

Stem injection & herbicide application

Management of knotweed will occur in a phased approach, with two planned stem injection treatments in month 2022 and a follow up selective application in 2023. The first stem injection treatment will occur before plants have set seed in May or June (MV, 2021). We will use Round-Up WeatherMax with TransOrb 2 (active ingredient glyphosate), which is a non-selective herbicide. Using a foliar spray of a large area could cause major drift, damaging non-target species, which is why we will be focusing on stem injection. Round up was selected because it can be used within the 10 m pesticide free zone (PFZ) and as close as 1 m to highwater mark, it is also the only herbicide registered for use in a stem injection gun (Government of British Colimbia (2), 2003). Before application, we will lay out a PFZ of 1 m from the high-water mark to prevent any application of herbicide getting into the stream. Using the stem injection tool, 5 ml of herbicide will be injected into each standing stem, between the second and third internode, to ensure the highest efficacy as per label requirements. Second stem injection treatment will occur in August 2022. In August, any stem that was not injected in the first round will be injected This is timed to be completed, before plants have set seed and begin to go into dormancy. There are approximately 1500 stems on site, which will require a total of 7.5 L at 5 ml per stem. We suggest acquiring 10 L as they are sold in 5 & 10 L containers. This will allow for 2.5 L of herbicide for spot spraying.

A follow up application of spot spraying will occur in May 2023 when any small plants may be emerging. Knotweed can grow 5 meters from previous year's growth, so it is important to survey those areas on follow up spot treatments. We will be using an application rate of 1.27 L/ha in accordance with the pesticide label.

Waste removal

Survey of potentially harmful waste should be done before waste removal happens on site, to prevent any unforeseen injuries. Professional waste removal company may need to be hired if harmful waste is found. Non-toxic garbage will be handpicked and disposed of using proper personal protective equipment (leather gloves, steel toe/shank boots, large sleeve pants and shirts), and brought to landfill and recycling facilities.

Soil amendments

Biochar will be used to amend soil carbon and nitrogen levels on our site. The addition of biochar at rates of 400 g/m^2 into the soil helps to immobilize allopathic chemicals from *Reynoutria sp.* which may be preventing re-establishment of a mature forest ecosystem (Zhang et al. 2020). As a tertiary result, biochar can increase water holding capacity, decreasing pooling water and increasing nutrient availability for plants on site (Yu et al. 2013). At an application rate of 400 g/m^2 , we will spread approximately 1400 kg across the entire site.

We will add white clover seed at a rate of 0.8 g/m^2, a total of 2.8 kg of seed will be added to our 3500 m^2 site. Sweet clover species also alter soil properties by increasing soil structure by adding roots systems that increase soil drainage (LRN, 1993). Although white clover is seen as a potentially invasive species, we opted to sew nitrogen fixing plants to increase nitrogen levels instead of adding in fertilizer because of the close proximity to water. In addition, this will minimize downstream impacts on wildlife.

Once both site units have been prepared, the biochar will be applied by hand spreading, while white clover seeds will be spread by a seeder. Once they are both spread, we will use a rototiller to incorporate the biochar into the soil.

Habitat complexing & coarse woody debris (CWD)

The addition of CWD on site is to mimic structural complexity of a mature forest stand in which the PWS are more frequently found (Government of Canada 2014). PWS use CWD as security cover, and the bark as nesting material. CWD will also shade out portions of our site, which will inhibit invasive knotweed from reestablishing.

To replicate CWD conditions in our target BEC zone, we suggest using 179 m^3/ha of CWD. On our site, this equates to 63 m^3 of CWD (Feller 2011). For species types, we suggest 60% coniferous and 40% deciduous trees. Coniferous trees will take longer to decompose, creating varied vegetation structure, lowering bareground on our site, and providing PWS security cover. Deciduous trees will decompose on site much quicker, adding more nitrogen and carbon into the soil. (Caza 1991). For the selection of CWD

species, western redcedar and Douglas fir should be used, which are the two dominant species on site. For deciduous trees, we will use Alder as it is most dominant on site.

5.2 Planting Plan

Site preparation

In November 2022, after both stem injection treatments, we will prepare the site for planting by removing above ground knotweed biomass, piling it on a designated area of the site to ensure knotweed is not spreading into clean areas of our site (MV, 2021). If there is an excess of invasive materials, and we are unable to designate an additional site area, we suggest removing the material and disposing it at the Vancouver landfill which is a designated dumping area for invasive plant materials and infested soils. A portion of the topsoil may need to be removed from site as there could be invasives in the seedbank. Until excavation on the ground, it is difficult to know how much material will need to be removed.

Plant salvaging

Plants that will be worth salvaging in our project area including smartweed, lady fern, deer fern, red elderberry, skunk cabbage, sedges, and rushes will be salvaged. Applying for additional permitting to go into other areas in the Chines forest to salvage these species beyond the site area could reduce plant costs. Previously planted species will be replanted, these include approximately 3–5-year-old red alder, western redcedar, big leaf maple, and Douglas fir. We will do a plant salvage to collect black cottonwood, vine maple, red osier dogwood and pacific willow species to harvest them from cuttings. They will be planted mainly around the wetted section on our site, SU2, where water flows, as they naturally do well along stream banks (Fetter et. al 2015). Spacing will be at 0.5 m apart due to the higher chance of mortality (Fetter et. al 2015).

Species selection

Our project area is classified as CHWdm site series 05 as species found existing on site included predominantly western redcedar, Douglas fir, big leaf maple, vine maple, and sword fern. Species selected for our revegetation plan were chosen to eliminate invasives and provide habitat for PWS by mimicking a mature conifer forest. Berry producing species were not chosen as we do not want to attract animals (racoons, rats, and bears) to the area that could be a nuisance. Knotweed grows best in high sun areas and is the most difficult to eradicate. The species chosen to increase shade cover and

root growth before invasives begin to establish include black cottonwood, red osier dogwood, and vine maple.

Planting method

Live cuttings of red alder, red osier dogwood, black cottonwood, and, pacific willow will be spaced intermittently throughout the slope on SU1 to promote soil fixations. These plants have been shown to increase nutrients, nitrogen-fix and reduce erosion, this will improve overall growing conditions (Polster, 1997). The herbaceous ground cover species such as foamflower and smartweed will be spread throughout the entire site, deer fern will also be planted at low numbers in SU1 to promote soil stabilization. Additionally, pacific willow stakes will be planted in SU2 to increase water retention and decrease pooling.

Wattle fencing will be used in SU1 to gradualize the 75% slope and form benches for other plants to root into more easily. SU2 will focus on water retaining plants such as foamflower and deer fern. Live cuttings should be planted densely at 10 cm spacing. Species that are live staked will be focused in SU2 where water pooling is a concern, less cottonwood will be planted than the other three staking species (Table 2).

We recommend spacing of 5 m for our tree species to promote dense understory vegetation to prevent knotweed from reestablishing as it is a shade intolerant species (Montana field guide 2022). These trees will be planted as 1-year-old plug seedlings as these are available locally and are most feasible to obtain, transfer, and to plant. Red alder will also be purchased as 1-year-old plug seedlings.

Deer fern will be planted from 1-gallon pots using a 1 m spacing throughout the SU1 slope to provide soil stability (Chau et. al 2016). Deer fern can handle moist sites, so using larger stocktypes it will stabilize ground more quickly and allow their root systems to be established before planting. Lastly, the foamflower and smartweed will be planted with 1 m spacing as bare root nursery stock, this is most cost effective when needing large quantities. These herbaceous plants have extensive rhizomes and will self-spread (NCSU 2022).

Our two conifer tree species, Douglas fir and Western Redcedar, will be planted evenly throughout the entire 3500 m^2 site at 1 m spacing (Figure 4).

Table 2 Proposed revegetation species including total number of need plants. Our SU1 covers 1500 m2, with 650 m2 encompassing the upper slope of concern, and SU2 moist area covers 2000 m2. This was the factor for the number of each species.

Species	Douglas fir	Western redcedar	Red alder	Red osier dogwood	Vine maple	Black cottonwood	Pacific willow	Deer fern	Foam flower	Smartweed
Site Unit 1	55	55	30	1200	900	-	-	-	-	-
Site Unit 2	-	-	-	-	-	500	900	650	1750	1750

6 Monitoring plan

Our Monitoring plan will track the progress in achieving the following restoration objectives:

Objective 1.1: Reduce invasive species cover in the base of our site to 15% of its current level by October 2023.

Objective 1.2: Increase native species to a minimum of 80% cover onsite by October 2023. Native plant species will be suitable for a mature coniferous forest with moist microenvironments.

Objective 2.1: Plant water-retaining plant species at and along the base of the slope to cover 75 % of the slope by May 2022.

6.1 Monitoring Methods

Monitoring schedule

We suggest conducting a pre-restoration survey of both native and invasive species in June of 2022 (Table 1). Post-restoration surveys will be conducted once per year in June from 2023-2026, when plant budding, and growth is most abundant and easy to identify. Post-restoration water table measurements will be taken twice per year, in June and October until 2026. Seasonal measurements will ensure the water table will be measured during all potential fluctuation, lowering confounding variables of external pressures.

Table 3 Monitoring schedule for native vegetation and water table depth in the lower Chines forest in Port Moody, British Columbia

Survey Type	Frequency	Timing – Pre-Restoration	Timing – Post-Restoration
Plant species percent cover	Once per year	June 2022	June 2023-2026
Soil Nutrients	Twice per year	June 2022, October 2022	June 2023, October 2026

Native vegetation

We will use a combination of systematic and random sampling when collecting pre and post restoration data. A 1 × 1 cm box grid will be overlain on a map of the site area using a randomly selected starting point and bearing. A sampling plot of 1.78 m radius (10 m^2) will then be established at each intersection. From there, we will randomly select 20 intersections for which we will establish 10 plots in each of the two site units (Figure 4).

The restoration site lacks tree canopy so we will estimate cover classes in each of two height categories: forb/herb (<0.5 m) and shrub (>0.5 m). This method will enhance detection of smaller herbaceous species that are often missed using methods such as line-intercept sampling (Hanley, 1978). For each height category we will visually estimate the percent cover of all native species combined, as well as Japanese knotweed cover (see Appendix 2 for vegetation survey data sheets).

Water table depth

Water present on soil surface has been taken as yes or no at each of the 20 sampling plots and should be compared to each year post-restoration. In the center of plots described, depth to the water table (mm from soil surface) with a soil auger was measured to confirm appropriate site unit break up, we do not recommend continuing with soil augering as this will disrupt growing conditions (see Appendix 3 for water table survey data sheets).

Soil Nutrients

We recommend soil samples be taken at each monitoring point, pre and post-restoration, these numbers can be averaged per site unitu. This will confirm the levels of soil nitrogen and carbon. To

capture the soil nitrates, samples from 0-30 cm in the soil profile should be collected (Poon 2010). This will allow us to see if our soil amendments have any effect on soil nutrient levels.

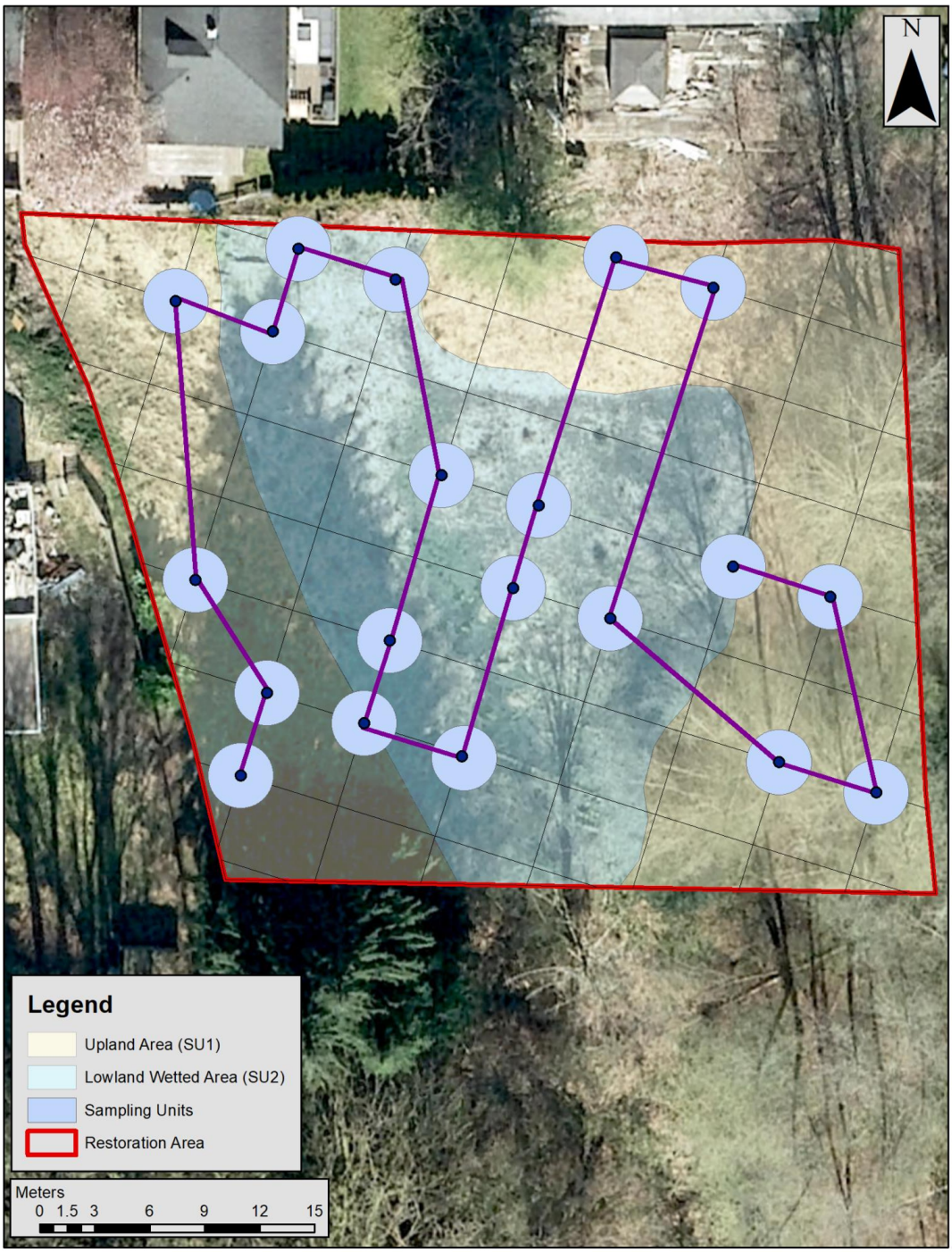

Figure 5 Map of the 20 plots to be sampled in the lower Chines forest. Plots were randomly selected based on where the grid intersections were located when overlaid on our map. At each plot we will be sampling for percent native vegetation cover and water table

7 Maintenance plan

To ensure success of our restoration site, we have suggested several post treatment methods that will be informed by data collected during on site monitoring. We are aware of the potential issues that may arise and propose the following maintenance treatments below.

Table 4 Schedule of potential maintenance on site from May 2023-2026.

Maintenance Effort	Timing (By month)	Duration	Description
Native plant replacement	August - September	2023-2026	Infilling site unit with dead plants if monitoring shows a native plant cover of less than 80%.
Invasive species treatment	May - June	2024-2026	If regrowth of Knotweed and or invasion of other species exceeds 20% site area.
Soil nutrients	May , September	2023-2026	Two soil samples to be collected. Additional soil amendments will be added to soils if targets are not being met.
Soil saturation	May , September	2023-2026	If planting does not lower the pooling water at base of the slople, site expansion or different approach

7.1 Vegetation

Native plant replacement

If our post restoration monitoring shows a native species cover below 80% we suggest supplemental planting. The reason for mortality will inform the species that are replanted on site. We noticed some small mammal browse on nursery stock planted on site previously, an application of repellent for the first year of planting and a high stem count should allow for desired future conditions. If we notice plants showing nitrogen deficiency (yellowing leaves) we may need to rethink application of soil amendments. If native species cover does not reach the goal of 80% by 2026, we suggest re-surveying the area, as a shift in temperature and annual precipitation could be favorable for drought tolerant native and invasive species.

Invasive species

Knotweed may take more than two years to control, if treatments are not managing the knotweed on site, it could be forming a resistance to herbicide treatments and further researching management methods could be beneficial (Skinner 2012). From monitoring efforts on site, a second round of stem injections and selective foliar application may be required in 2024-2025 to prevent the species from reestablishing on site. Other invasive species found on site (appendix 3) should be monitored, and pulled annually using shovels, trowles and other manual means. This can be completed by city staff or volunteers once a group has been established (see section 10). This general maintenance will be important to prevent invasive species from overtaking native plants. If invasive species cover does not reach below 15% by 2026, we suggest revisiting frequency of manual and chemical management on site.

7.2 Soil Nutrients

Post restoration monitoring will inform whether addition of more soil amendment will be needed. If soil carbon and nitrogen levels are not increasing, then an additional application of biochar and sweet clover should be added to the site. If these soil amendments do not get us to desired soil nutrient levels, we suggest an additional soil analysis and review of other potential soil amendment methods (Bertrand 1991).

8 Public outreach plan

Restoration, maintenance, and monitoring of our project area will be most successful if a local stewardship group is created and informed to assist where needed. The site is highly concentrated with invasive species, so as of right now, we believe it is best to limit public disturbance until the site is demonstrating success.

There are many environmental volunteer groups that are associated with the City of Port Moody that can be sourced for equipment and volunteer hours. Groups include Burke Mountain Naturalists, Port Moody Ecological Society and youth groups such Girl Guides of Canada. By creating a stewardship group it will allow for a specialized crew of individuals to focus on the site to ensure succession (Appendix 6).

9 Preliminary project budget

For our budget, we have included projected costs from the year 2022-2026. The budget outlines the costs of surveying, herbicide application, site preparation, planting plan, soil amendments, CWD and habitat complexing, monitoring, and maintenance to achieve our native plant cover objectives (Appendix 7). This budget has been created under the assumption that volunteer hours will be contributed to the collection of plant stakes, executing the planting plan, and monitoring the site into the. We have built in a line item that is 20% of the projected planting plan price, to be used for monitoring data.

10 Project Recommendations

As this project was completed in the span of two school semesters, there are a few things we suggest completing to make the project more complete. The first is a soil analysis that will hopefully confirm our assumptions that soil carbon and nitrogen are a limiting factor on site. A plant survey should be done in August to ensure all species on site have been properly identified, as surveys were only done in October 2021 and March 2022. The development of a planting plan map would be helpful as a visual aid if planting plans were to be implemented on site. Finally we would like to have set up an experiment design for BioChar application on site, this is so we can replicate the effectiveness of previous studies, and determine if in fact it can lower knotweed biomass and reduce effectiveness of allopathic chemicals in the soil.

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Appendix 1: Safety Plan

RENR Student Applied Research Project Safety Plan					
Date	October 1st 2021	Submitted by	Torin Kelly	Submitted to	Lisa Henault

Section 1: Project Details

Project Title:	Wetland Restoration in Chines forest	
Brief Project Description:	We plan to restore an open area on the north aspect of Chines forest into a productive wetland area. Current site conditions	
Primary Project Sponsor Contact	Name	Angela Crampton
	Position	Environment and Parks
	Organization	City of Port Moody
	Phone number	N/A
	Email:	acrampton@portmoody.ca
Primary Academic Supervisor	Name	Lisa Henault
	Phone number	604-992-9757
	Email:	lhenault@bcit.ca
Project Location 1:	Site Name:	Chines forest
	Address	Hugh Street & Jane Street (entrance to site is down an unmarked gravel trail, towards Port Moody off-leash park).

	Extent:	0.34 Ha (this is the area that we would mostly be in conducting surveys, some surveys may be conducted up slope of project area)		
	Description of area:	Project area is at the edge of Chines forest in a lower elevation area. From first observation it seems this area had been cleared in the past. Angela also noted that the site has been used as a dumping area from Ivy Street which is elevated above the site. The site is surrounded by residential properties. The western most border of the site is also a steep slope leading right up to a property.		
	Northing	511012.51 m	Easting	5457884.50 m
Project Location 2	Applicable?	X Yes ☐ No		
	Site Name:	Reference site		
	Address	South of Hope Street & Douglas Street crossroads		
	Extent:	0.35 Ha		
	Description of area:	Wetland area at the base of Chines forest we hope to use as a reference site.		
	Northing	5457966	Easting	510047

Section 1 - Project Details continued		
Caretaker / Contact on site?	Applicable?	☐ Yes X No
	If yes, please provide contact information	
	Name(s)	
	Phone number	
	Email:	
Permits	Applicable?	X Yes ☐ No

Note: Include permits required by project sponsor/ client Ensure your project supervisor has copy and that all members carry permits in field	If permits are required for this project, please list below			
	Agency	Permit description	Start/End date	
	City of Port Moody	Research Permit	Oct 6th, 21 / Feb 28, 22	
Provide a map of the project site(s):				
Project Team Information				
	Student 1	Student 2	Student 3	Student 4
Name	Torin Kelly	Nicole Laughlin	Talia Kilmmer	
Cell Phone Number:	778-772-0433	778-955-7119	604-302-8959	

Emergency Contact External to British ColumbiaIT	Yvonne Kelly	Paul Titmus	Roberta Lacroix	
Relationship to student:	Mother	Partner	Mother	
Cell Phone Number of Emergency Contact	778-858-6921	604-317-6056	604-302-3155	
Existing Medical Conditions? Medication or allergies?	N/A	N/A	Spinal Fusion- no MRI	

Section 2 - Check-In/Out Procedure

Coordinate check-in/out procedures for each field day.
Inform supervisor 48 hrs. ahead of any field day to confirm the communication plan, including the expected time of the first text/phone call as well as the interval of check-ins throughout the day.
If there is a failure to check-in at the end of the field day, the supervisor will attempt to contact students on provided numbers 1 hour after scheduled check in. If the supervisor is unable to reach any members of the team, emergency contacts will be called 2 hours after scheduled check in. Following this step, British ColumbiaIT security and local emergency services will be contacted.

Anticipated Field Dates: If you require more space for field dates, please attach schedule as appendix.	Field dates	Expected duration of work	Expected time of day in field
	October 8th 2021	4 hours	9 am
	October 15th 2021	4 hours	9 am
	October 29th 2021	4 hours	9 am

Communication	Applicable?	X Yes ☐ No
	If yes, then cellphone will be the primary method of communication.	

	If no, explain the alternate communication method in space below:	
Main Contact for Check-In/Out	Name	Lisa Henault
	Role	Project supervisor
	Cell phone number	604-992-9757
Frequency of Check-Ins	X At the start of field day	
	X Arrived on site	
	X Every 3-4 hours	
	X Leaving site	
	X At the end of the field day	
Secondary Check in / our contact:	Name	Emily MacInnis
	Role	Colleague
	Cell phone number	778-708-0234
Frequency of Check-Ins	X At the start of field day	
	X Arrived on site	
	X Every 3-4 hours	
	X Leaving site	
	X At the end of the field day	

Section 3 - First Aid & Emergency Response

For Emergency purposes: CALL 911
Emergency Transport: If a person becomes injured and requires transportation to a hospital, it is recommended that you request an ambulance. You will need to ensure the ambulance is met at the access point to your site and thus may need to move the injured person. Make sure to stay on the phone with the 911 operator so that they can help facilitate the safe move of the injured person.
Injury Transport: Only transport an injured individual if the person is stable, ambulatory, and able to move themselves. If there is a head injury, do not move the patient.

Nearest Hospital to Project Location 1:	Name	Eagle Ridge Hospital
	Address	475 Guildford Way, Port Moody, British Columbia V3H 3W9
	Driving distance (km)	3.2
Nearest Hospital to Project Location 2:	Name	Royal Columbian Hospital
	Address	330 E Columbia St, New Westminster, British Columbia V3L 3W7
	Driving distance (km)	8.1

Level of First Aid Training of Team Members:	Name	Level of Training
	Torin Kelly	OFA Level 1 (first aid attendant)
	Nicole Laughlin	OFA Level 1
	Talia Kilmmer	OFA Level 1

First Aid Kit (personal or other)	Project team will be required to carry a basic first aid (personal) in the field.	
	Where are the first kits located?	In the vehicle of first aid attendant

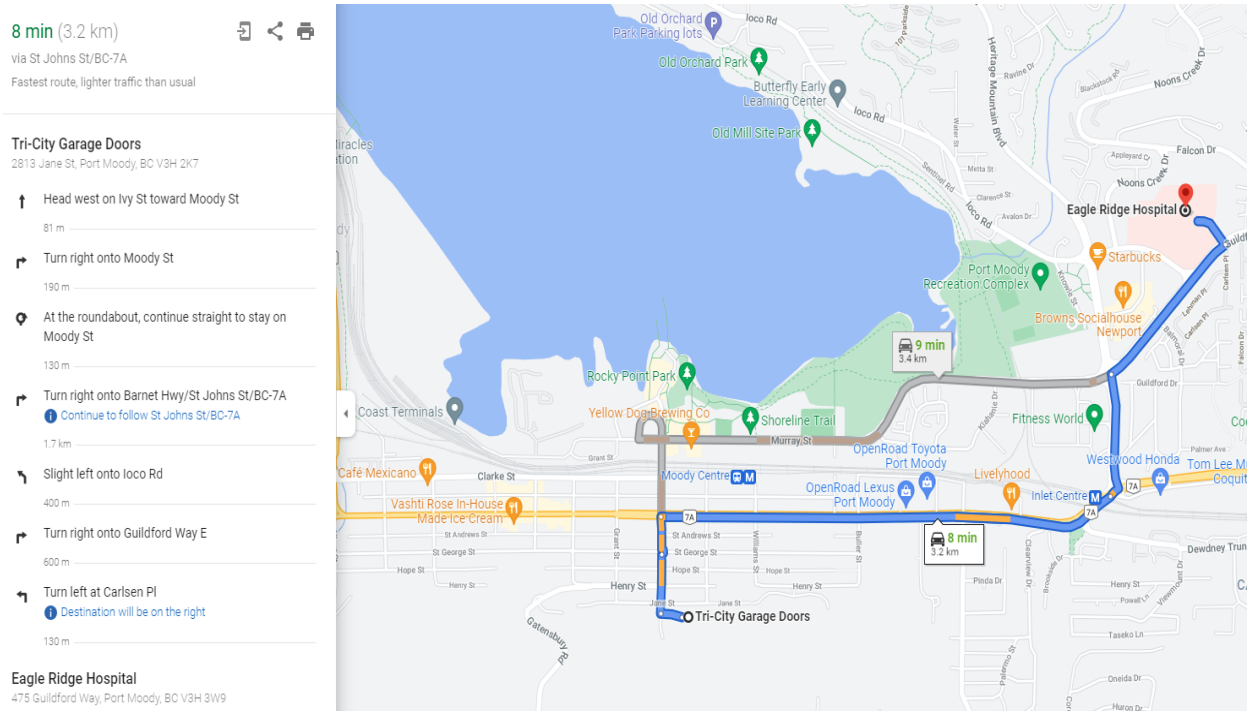


Figure Direction from lower Chines forest restoration site to Eagle Ridge Hospital

Section 4 - Hazard Assessment & Mitigation Measures

Instructions for the following section:
List all potential hazards (e.g., slips trips falls, danger trees, wildlife, driving to/from site, hypothermia, etc.). Consider the nature of your project.
Briefly describe each hazard as they pertain to your project
List measures used to mitigate or reduce the risk or exposure to those hazards. Include necessary PPE for risk and exposure reduction, as well as other appropriate strategies.
Keep realistic and practicable.

Hazards	Description of tasks where this hazard is pertinent	Risk and Exposure Mitigation Measures
Slips, trips & falls	Most of our site is a hazard for slips, trips and fall. Especially the slope from our open area.	Proper footwear, always being aware of your footing. When working on a slope, make sure to always work with your body facing the ground.
Danger trees	Our site is in the wildland interface and is surrounded by deciduous trees that are at a higher risk of falling into our open site area.	Do a perimeter survey of danger trees, noting any issue trees. If danger trees are noted, make sure to wear hardhats and hold off work during cases of high winds.
Mass wasting	Our site is located at the base of a steep slope, debris flows are a possible hazard we may encounter during heavy rains of fall and winter.	Survey site area for any debris flow tracks, as well as looking up slope for any unstable terrain. If located, make sure to work in areas away from the debris tracks / spending as little time as required in areas of high debris flow risk.
Wildlife	The interface between urban and forested areas often sees high levels of wildlife present (Racoons, coyotes, bears)	Look for any bear / coyote dens when doing site surveys. Make sure we stay within eye shot of one another, and never be too far apart when unnecessary.
Wasps	Wasp nests may be in the tall grass of our open site, this could lead to severe reactions if stung enough times, even without an allergy present.	During site survey, avoid any areas where you have located, or by a reasonable doubt think one may be located, stay clear of those areas.
Dogs	Our site is located adjacent to an off-leash dog park. Off leash dogs can become aggressive.	Signage at the entrance of the project site to notify dog owners that survey work is happening. If a dog runs onto site, make sure to stay

		calm and notify the dog's owner of its location.
Residents	Our site is surrounded by private property, with a direct view of all works that we will be doing. It is also located beside a public dog park.	Notifying all residents who would be affected by works are notified well in advance of any site activity. If members of the public approach, make sure to keep open body language and answer all their questions to the best of our abilities.
Extreme weather	Unpredictable rain and snow events may happen in the higher elevations of the Chines forest, which may lead to flash floods or adverse terrain.	Observe the weather forecast before making it to the site. If extreme weather starts, be sure to exit areas that may become issues, such as the lowest portions of the site where water will accumulate.
Driving	Driving into the steeper roads of Port Moody, may lead to patches of black ice and sever car accidents	Vehicles with winter tires and those who have experience driving in adverse conditions should be permitted to drive to site under these circumstances

Section 5 – COVID-19 Exposure Control Plan

Address all situations /activities and types of exposure risks presented by each.
Determine Elimination, Engineered, Administrative, Hygiene/Sanitation & PPE control measures and protocols for each.

Situations/ Activities	Description of exposure risk	Control Measures
Working near group members.	Higher risk of direct contact to someone with COVID-19	Make sure if we are within 2 meters of one another that we are wearing face masks. All members to bring hand sanitizer
Someone comes to site showing symptoms	Higher risk of spreading the virus when you are symptomatic	All members should conduct a self-screening through the British Columbia self-assessment tool. (https://bc.thrive.health/covid19/en) If the tool says you are clear to go but you still do not feel well, stay home, and keep everyone else healthy.
Member of the public approaches	Those people may not observe social distancing rules outside	Allow the public member to approach, at the same time make it clear you are putting your mask on (if it was off). If they come within the 2-meter space, allow yourself some room by stepping back. If you find them approaching into your space further, let them know you and your team members are observing a 2-meter social distancing rule without masks on
Sharing equipment	Un-sanitized equipment can spread COVID-19	If there is not enough equipment for each person to have their own, all equipment will be wiped down with Lysol wipes before giving to someone else to use.

Appendix 2 Gantt Chart

Restoration of the Lower Chines Forest for Pacific Water Shrew Stepping Stone Habitat, Port Moody					Year:	2021															
					Month:	September				October				November				December			
Task	Person/people responsible	Start date	End date	Duration (days)	Week of:	15	17	19	26	1	8	15	22	1	8	15	22	1	8	15	22
Group meeting with project sponsor	Nicole, Talia, Torin	9/28/2021	9/28/2021	1																	
Group meeting with project supervisor (Lisa)	Nicole, Talia, Torin	10/5/2021	10/5/2021	1																	
Preliminary sites visit to take photos	Nicole, Talia, Torin	10/15/2021	10/15/2021	1																	
Soil sample on site	Nicole, Talia	10/15/2021	10/15/2021	1																	
Vegetation survey including invasives	Torin	10/15/2021	10/15/2021	1																	
Group meeting to confirm goals/obj	Nicole, Talia, Torin	10/17/2021	10/17/2021	1																	
Create invasive and native species	Talia	11/12/2021	11/13/2021	2																	
Second soil sample/water table depth	Nicole, Talia	11/29/2021	11/29/2021	1																	
Map wetted area of site	Torin	11/29/2021	11/29/2021	1																	
Decide native species planting plan	Nicole, Talia, Torin	12/1/2021	12/8/2021	8																	
					Year:	2022															
					Month:	January				Febuary				March				April			
Task	Person/people responsible	Start date	End date	Duration (days)	Week of:	1	8	15	22	1	8	15	22	1	8	15	22	1	8	15	22
Water table depth measurements on site	Talia, Nicole	3/18/2022	3/18/2022	1																	
Detailed plant survey on site	Torin	3/18/2022	3/18/2022	1																	

Appendix 3 Vegetation Survey Details

Survey methods:

We conducted a survey of both site unit areas by walking transects and noting different plant species we encountered. Larger communities were noted but were not mapped out during this preliminary survey work. We believe that a more in-depth survey should be done to determine percent cover of plants on site, to better understand and create our planting plan.

Plants found on site:

Site Unit 1 (Forested Upland Vegetation)			
Common Name	Scientific Name	Vegetation Layer	Designated Invasive
Big leaf maple	Acer macrophyllum	Tree	N
Bunchberry	Cornus canadensis	Herb	N
Deer fern	Struthiopteris spicant	Herb	N
Douglas fir	Pseudotsuga menziesii	Herb	N
English holly	Ilex aquifolium	Tree	Y
English ivy	Hedra helix	Herb	Y
Himilayan blackberry	Rubus armeniacus	Shrub	Y
Lady fern	Athyrium filix-femina	Herb	N
Red alder	Alnus rubra	Tree	N
Red cedar	Thuja plicata	Tree	N
Salmonberry	Rubus spectabilis	Shrub	N
Yellow archangel	Lamium galeobdolon	Herb	Y

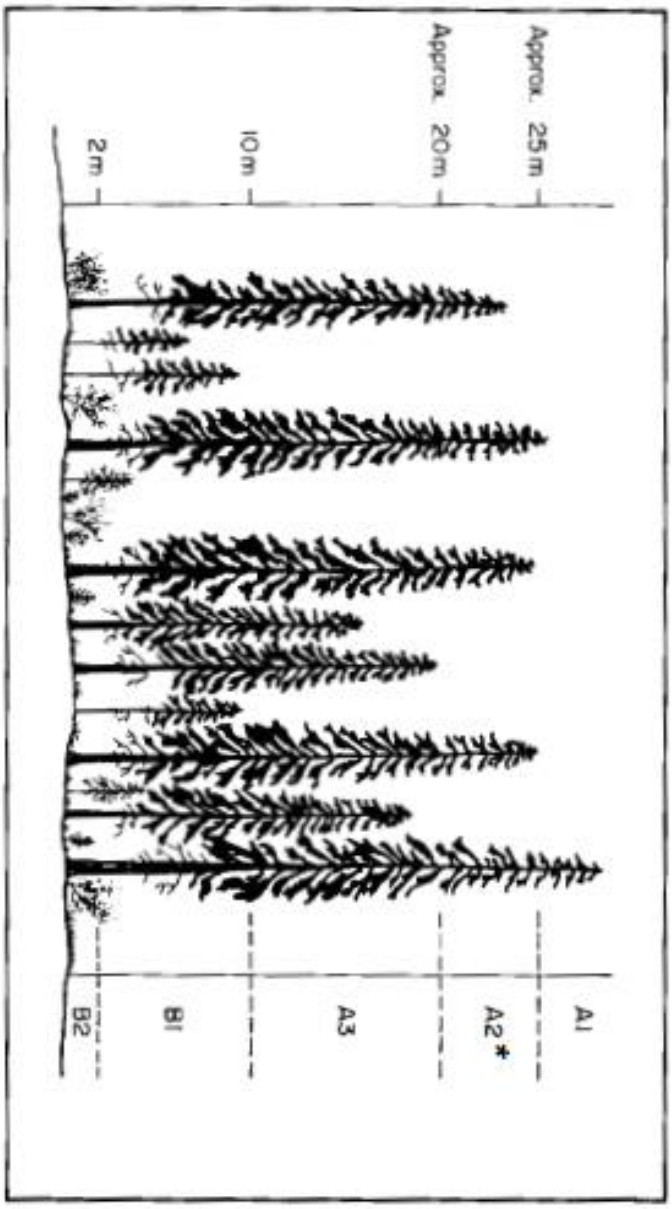
Site Unit 2 (Unforested lowland Vegetation)			
Common Name	Scientific Name	Vegetation Layer	Designated Invasive

Bullthistle	Cirsium vulgare	Herb	Y
Douglas aster	Symphyotrichum subspicatum	Herb	N
Horsetail	Equisetum arvense	Herb	N
Knotweed sp.	Reynoutria sp.	Shrub	Y
Policeman's helmet	Impatiens glandulifera	Herb	Y
Red elderberry	Sambucus racemosa	Shrub	N
Rush sp.	Juncus sp.	Herb	N
Sedge sp.	Carex sp.	Herb	N
Skunk cabbage	Lysichiton americanus	Herb	N
Smartweed	Persicaria maculosa	Herb	N

Appendix 4 Soil Pit Analysis

Image of soil core taken October 15 2021 dug from the southwestern slope with stability concerns at the Lower Chines Forest. Red circles show mottling, sandy clay soils.

Appendix 5 Vegetation Layer stratification



Stratification of vegetation layers that we will follow during surveys. Pulled directly out of Land Management Handbook 25 from FLNRORD.

Appendix 6 Vegetation Survey Data Sheets

VEGETATION SURVEY

Name			**Location**		
Date			**Time**		
Weather:	**Wind**	**Humidity**		**Temp**	
Site 1	**Species:**	Native Knotweed		**% cover:**	Native Knotweed
Site 2	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 3	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 4	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 5	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 6	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 7	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 8	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 9	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 10	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 11	**Species:**	Native Knotweed		**% cover:**	Native Knotweed
Site 12	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 13	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 14	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 15	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 16	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 17	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 18	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 19	**Species**	Native Knotweed		**% cover**	Native Knotweed
Site 20	**Species**	Native Knotweed		**% cover**	Native Knotweed

Appendix 7 Water table Survey Data Sheets

WATER TABLE SURVEY					
				*Depth units are in mm's	
Name			**Location**		
Date			**Time**		
Weather:		**Humidity**		**Temp**	
Site 1		**Depth to WT**		**Notes**	
Site 2		**Depth to WT**		**Notes**	
Site 3		**Depth to WT**		**Notes**	
Site 4		**Depth to WT**		**Notes**	
Site 5		**Depth to WT**		**Notes**	
Site 6		**Depth to WT**		**Notes**	
Site 7		**Depth to WT**		**Notes**	
Site 8		**Depth to WT**		**Notes**	
Site 9		**Depth to WT**		**Notes**	
Site 10		**Depth to WT**		**Notes**	
Site 11		**Depth to WT**		**Notes**	
Site 12		**Depth to WT**		**Notes**	
Site 13		**Depth to WT**		**Notes**	
Site 14		**Depth to WT**		**Notes**	
Site 15		**Depth to WT**		**Notes**	
Site 16		**Depth to WT**		**Notes**	
Site 17		**Depth to WT**		**Notes**	
Site 18		**Depth to WT**		**Notes**	
Site 19		**Depth to WT**		**Notes**	
Site 20		**Depth to WT**		**Notes**	

Appendix 8 Volunteer Contact Information

Organization	Contact Information	Resource
Burke Mountain Naturalists	https://www.burkemountainnaturalists.ca/contact/	Planting and monitoring volunteers
Green Teams Canada - Lower Mainland Green Team (2022 contact)	https://greenteamscanada.ca/ ashton@greenteamscanada.ca	Invasive removal and planting volunteers
Port Moody Ecological Society	portmoodyecologicalsociety@hotmail.com 604-469-9106	Water sampling
The PoCo Garden Club	https://pocogardenclub.wordpress.com/about/contact-us/	Planting and maintenance volunteers
Local Youth Groups Girl Guides of Canada Scouts Canada	https://register.girlguides.ca/web/en/unit-search https://www.scouts.ca/programs/scouts-for-sustainability/overview.html	Youth volunteers

Appendix 9 Project Budget

Expense Catergory	Equipment and Supplies			Personnel			Category total	Notes
	Cost per unit	Count	Cost	Per hour	Pers. Hours	Cost		
Pre-Restoration Monitoring								
Technologist1				$50.00	60	$3,000.00		
Subtotal =						$3,000.00	$3,000.00	
Plant List2								
Douglas fir	$2.50	55	$137.50					
Western redcedar	$4.00	55	$220.00					
Red alder	$2.00	30	$60.00					
Red-osier dogwood		1200						Stakes will be harvested from surrounding park areas
Vine maple	$7.00	900	$6,300.00					
Black cottonwood	$15.00	500	$7,500.00					
Pacific willow		900						Stakes will be harvested from surrounding park areas
Deer fern	$8.00	650	$5,200.00					
Foam flower	$1.00	1750	$1,750.00					
Smartweed	$5.00	1750	$8,750.00					
Drinks & Snacks	$15.00	20	$300.00					
Subtotal =			$30,217.50				$30,217.50	
Planting Plan								
Shovels	$50.00	10	$500.00					
Trowls	$10.00	10	$100.00					
Gloves	$5.00	20	$100.00					
Wheelbarrow	$100.00	4	$400.00					
Drinks & Snacks	$15.00	20	$300.00					
Skilled labour				$25.00	200	$5,000.00		
Volunteers					200			We estimate volunteer hours to around 200 for planting and mainteanace for the first 5 years
Subtotal =			$1,400.00			$5,000.00	$6,400.00	
Soil Amendments								
BioChar (kg)	$0.98	3500	$3,430.00					
Sweet clover seed (kg)	$15.00	3	$45.00					
Chest seeder	$80.00	2	$160.00					
Rototiller	$300.00	1	$300.00					
Fuel (liters)	$10.00	30	$300.00					
Skilled labour				$25.00	120	$3,000.00		
Subtotal =			$4,235.00			$3,000.00	$7,235.00	
Pesticide Application								
Backpack sprayer	$180.00	1	$180.00					
Stem injection tool	$400.00	2	$800.00					
Herbicide (L)	$8.00	15	$120.00					
Certified applicator3				$40.00	36	$1,440.00		
Subtotal =			$1,100.00			$1,440.00	$2,540.00	
Habitat Complexing								
CWD (m3)4	$50.00	63	$3,150.00					
Operator time5				$100.00	16	$1,600.00		
Subtotal =			$3,150.00			$1,600.00	$4,750.00	
Waste Removal								
Garbage bags (25 pce)	$20.00	2	$40.00					
Canvas bags	15	5	$75.00					
Skilled labour6				$25.00	16	$320.00		
Bin turck7				$50.00	6	$300.00		
Subtotal =			$115.00			$620.00	$735.00	
Post-Restoration Monitoring								
Technologist				$50.00	100	$5,000.00		
Subtotal =						$5,000.00	$5,000.00	
Fill Planting								
Assorted plants8	$8,203.50	1	$8,203.50					
Drinks & Snacks	15	20	$300.00					
Skilled labour				$25.00	36	$900.00		
Volunteer					36			
Subtotal =			$8,503.50			$620.00	$9,123.50	
						Subtotal =	$69,001.00	
						Tax (15%) =	$10,350.15	
						Budget Total =	$79,351.15	

Budget Rational:

1. Technologist wage was estimated by looking at the median wage of environmental technology from Glassdoor.com
2. Certified applicator wage was estimated by looking at the median wage of Certified pesticide applicators in British Columbia, and personal experience.
3. Skilled labor wage was estimated from Glassdoor.com
4. Estimates of bintrucks were taken from multiple waste removal services in the Lower Mainland.
5. CWD estimates were taken from another report, further conversations need to be had with Dave Harper who the original personal communication was with.
6. Operator time was estimated with from a conversation had with Dave Harper, and Bob Biebhauser
7. All plant prices were taken from multiple nurseries in British Columbia, Washington, Alberta
8. Assorted plants is a line item consisting of 20% the original planting plan. The actually plants will be decided on as monitoring consists but should be used to purchase for any infilling that will need to happen over the years of monitoring.