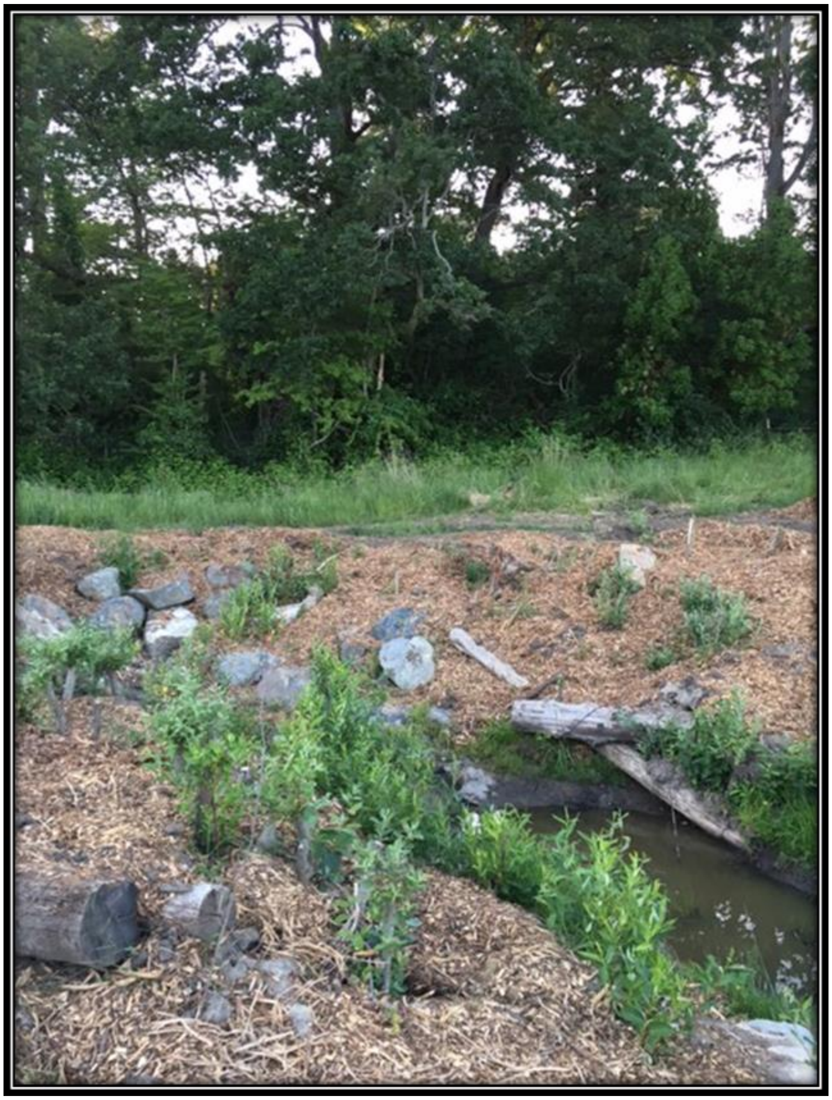


Grosbeak Creek:

Use of Bioengineering Techniques in the Restoration of an Agricultural Ditch at 1020 Beckwith Avenue, Saanich, B.C.

ER390 | Environmental Restoration Project

University of Victoria | 2016

Karen Mann

CONTENTS

ABSTRACT

A functioning riparian zone surrounding an ephemeral stream is the result of transforming thirty-five meters of an agricultural drainage ditch using bioengineering techniques. The owners of the property where Grosbeak Creek is located are interested in the beautification and recreation potential a treed corridor will bring. Increasing biodiversity richness is also important. Characteristics of riparian habitats are more abundant in biodiversity than adjacent ecosystems, these characteristics create a matchless environment that is multifaceted and irreplaceable, delivering distinct utilities not found in other ecosystems. Plants that have the ability to tolerate their roots being submerged during the wet season are foundational to riparian communities. Their roots retain soils; branches provide shade cooling water temperatures for fish. These zones are nurseries for animals whose lifecycle include an aquatic phase.

In winter 2016 the agricultural ditch at 1020 Beckwith Avenue was excavated to have bends and curves in order to dissipate flashy storm water events. The banks were widened to decrease the pitch making it more accessible. Logs, boulders and coarse woody debris (CWD) were added to protect the banks from erosion. The site was staked with Sitka Willow (*Salix sithensis*), Pacific Willow (*Salix lucida ssp. lasiandra*), Hooker's Willow (*Salix hookeriana*), Red Oiser Dogwood (*Cornus stolonifera*) and Cottonwood (*Populus trichocarpa*) because the genus *Salix* is known for the ability to quickly root from cuttings. A covering of wood chips was spread over the site to reduce weeds from germinating, keep moisture in the ground and to provide habitat for mycorrhizal spores to invade building filament structure supporting the entire ecosystem community. Restoring ecological function by building riparian woodland will benefit biodiversity.

INTRODUCTION

ECOLOGICAL CONTEXT

Jordan and Cherie Mann welcomed a restoration project on their property at 1020 Beckwith Avenue, Saanich, B.C., where an agricultural ditch was reshaped and revegetated. This project lies within the Blenkinsop Valley on Southern Vancouver Island (Figure 1). Blenkinsop Watershed (Figure 2) nests within the Colquitz Watershed. The high point on the east is Mt. Douglas, to the north Haliburton Ridge, to the west, Westervelt Ridge. Lochside Creek, Beckwith Creek and Grosbeak Creek flow into Blenkinsop Lake. This watershed drains south from Blenkinsop Lake by means of Blenkinsop Creek to Swan Lake. The municipality of Saanich shows the creek as having ecological value, potentially fish bearing (Saanich GIS, 2016). Biogeoclimatic Classification System for B.C. places the project site within the Biogeoclimatic zone Coastal Douglas-fir moist marine (CDFmm) (Ministry of Environment, 2013).

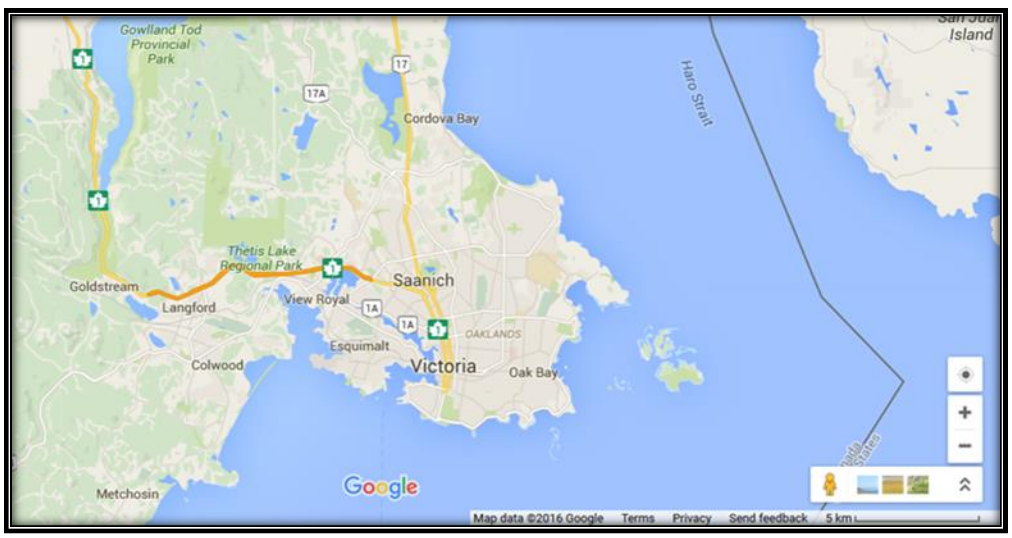


FIGURE 1. MAP OF SOUTHERN VANCOUVER ISLAND. MAP CREATED ON MARCH 10, 2016. HTTPS://WWW.GOOGLE.COM/MAPS/PLACE/VICTORIA,+BC/@48.436031,-123.3877193,12Z/DATA=!4M5!3M4!1S0X548F738BDDB06171:0X38E8F3741EBB48ED!8M2!3D48.4284207!4D-123.3656444

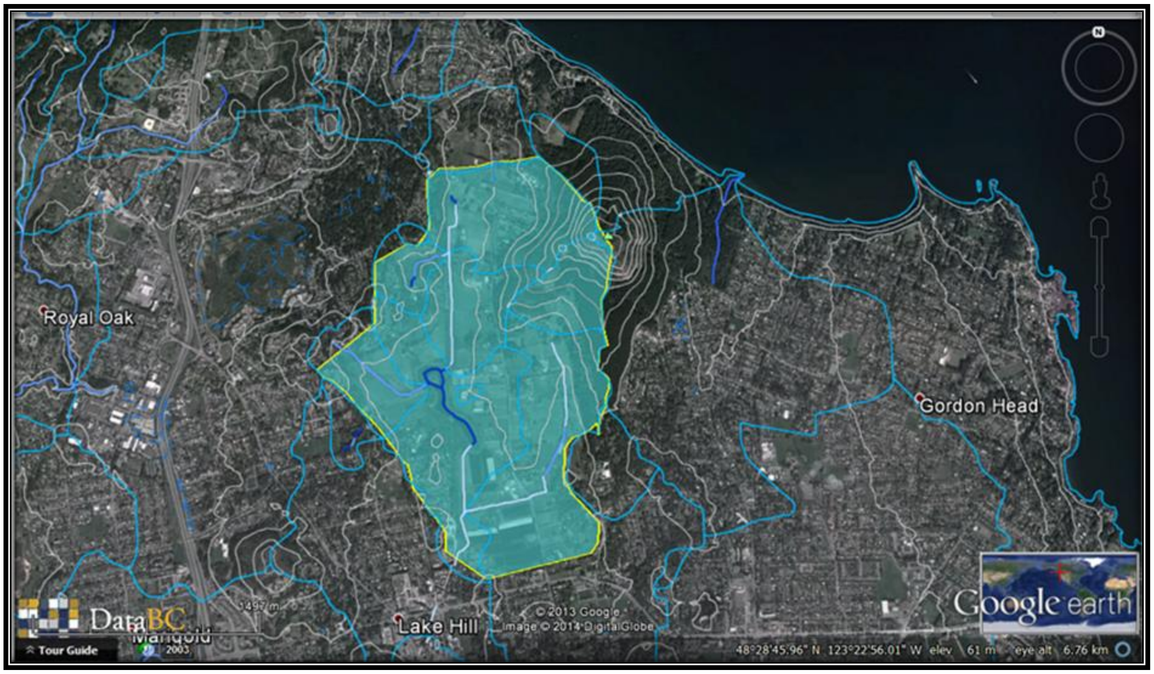


FIGURE 2. MAP OF BLENKINSOP WATERSHED (OUTLINED IN YELLOW), SAANICH MUNICIPALITY, SOUTHERN VANCOUVER ISLAND. MAP CREATED ON MARCH 10, 2016. HTTP://WWW.GOOGLE.COM/GADGETS/DIRECTORY?PID=EARTH&SYND=EARTH&HL=EN&GL=CA.

CLIMATE

The climate on Southern Vancouver Island is influenced by surrounding mountain ranges (Quinn, 2010). This creates a typical period of drought from July through November (Ministry of Environment, 2013). November through June the area receives most of its precipitation. Figure 3 provides the average monthly temperatures and Figure 4 the monthly precipitation amounts.

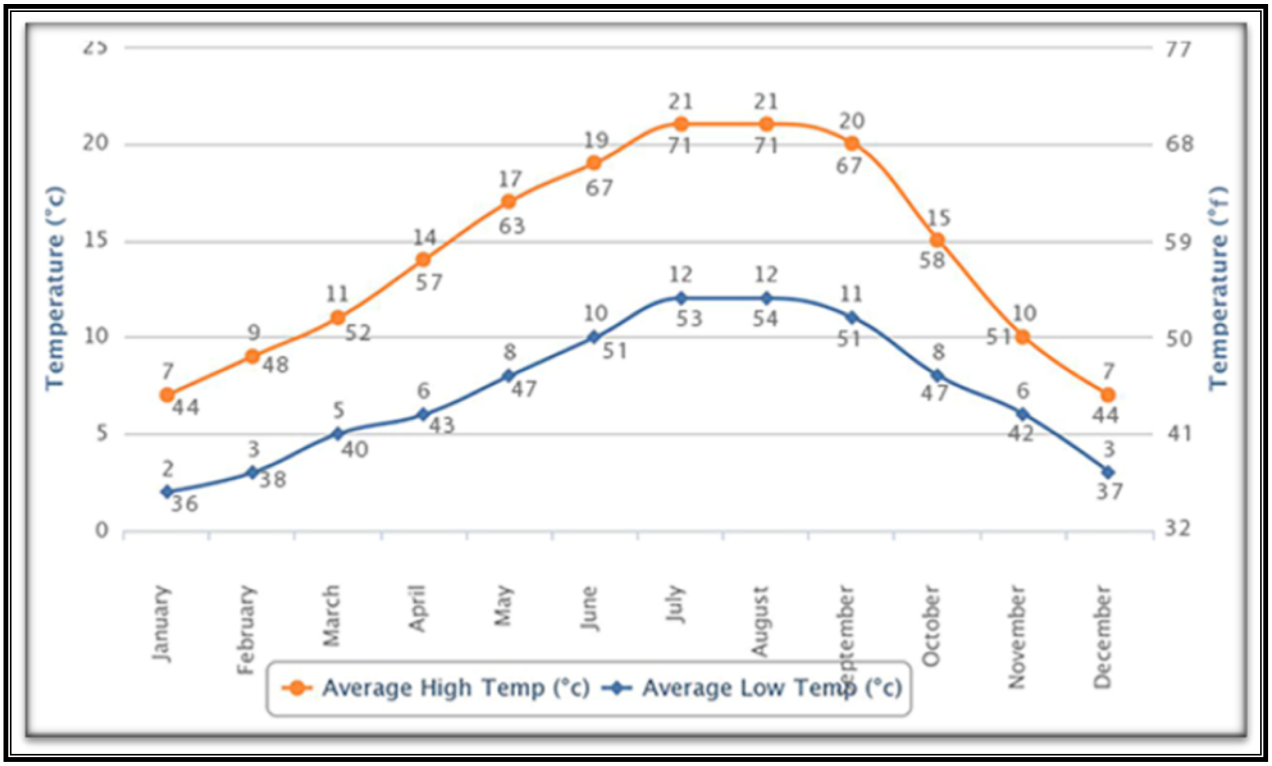


FIGURE 3. AVERAGE TEMPERATURES IN VICTORIA B.C. RETRIEVED FROM TOURISM VICTORIA, DECEMBER 28, 2015
HTTP://WWW.TOURISMVICTORIA.COM/PLAN/CLIMATE/

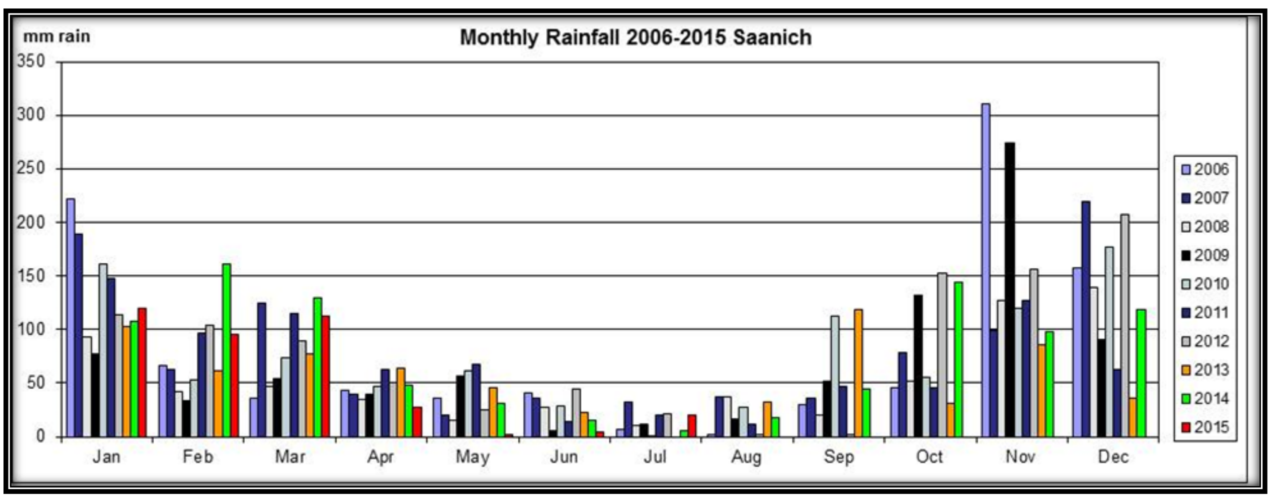


FIGURE 4. MONTHLY RAINFALL RECORDED FOR SAANICH, BC. RETRIEVED JUNE 11, 2016.
HTTP://SYMPHONYVINEYARD.COM/WP-CONTENT/UPLOADS/2015/08/SAANICH-MONTHLY-RAINFALL-END-JULY-2015.JPG

Summer temperatures can be expected to range from the high to low 20's˚C and winter rarely brings temperatures cold enough to sustain any snow fall (MOE, 2015). Many plants and animals have adapted to this climate and are significantly different from their mainland parent species.

Changing climatic conditions predicted through computer modelling show how Southern Vancouver Island's yearly drought will increase in length (RNS, 2015). This poses problems for native plants and animals as warming accelerates and the changes happen faster than indiginous species can adapt (Wilson & Hebda, 2008). As urbanisation consumes what is left of naturally vegetated areas, species unique to this area are succumbing to the effects of fragmented or destroyed habitat, edge factor and decreased connectivity (MOE, 2016), (SEI, 2015), (Primack 2014). Extended drought adds another barrier to local biodiversity.

HISTORICAL AND SOCIAL CONTEXT

European settlement on Southern Vancouver Island began with the Hudson Bay Company (HBC) building Fort Victoria in 1848. Blenkinsop Valley is named for one of the first land owners, George Blenkinsop a factor for the Hudson Bay Company (Saanich Archives, 2014), (Dictionary of Canadian Biography, 2016).

Since 1975 the Blenkinsop Valley has been protected as farmland by the Agricultural Land Act (Ministry of Agriculture, 2016). A photograph (Figure 5) taken from Mt. Douglas looking Southwest gives visual information about the agricultural use of the valley in 1905 (Saanich Archives, 2016). In this photo we see the project site in the mid to upper right quarter.

FIGURE 5. VIEW FROM THE SUMMIT OF MOUNT DOUGLAS LOOKING SOUTH WEST OVER THE VALLEY, GROSBEAK CREEK IS VISABLE AS A FAINT DARKER LINE. RETRIEVED FROM SAANICH ARCHIVES AUGUST 29, 2015

On the West side of Blenkinsop Lake, Grosbeak Creek flows through Saanich's Lake District, section 11(Saanich Archives, 2016). Municipal Records for the year 1857 show John Caspar Von Allmen (also Van Allman) as the first registered owner of 60.3 acers that includes the project area (Saanich Archives, 2016). In the 159 years since registration the land has been a seed farm for Western Forest Products, a blueberry farm and is currently producing hay.

In personal conversation Adriane Pollard (Manager, Environmental Services, Planning Department, District of Saanich) recalls Grosbeak Creek being named name when the ground work was done for the Environmentally Significant Areas Inventory (ESAI) in 1998. This name was chosen because of the Grosbeak bird community known to reside in the riparian areas of Blenkinsop Lake. At this time the creek was assigned three reaches, defined in Figure 7. The project area is in reach three.

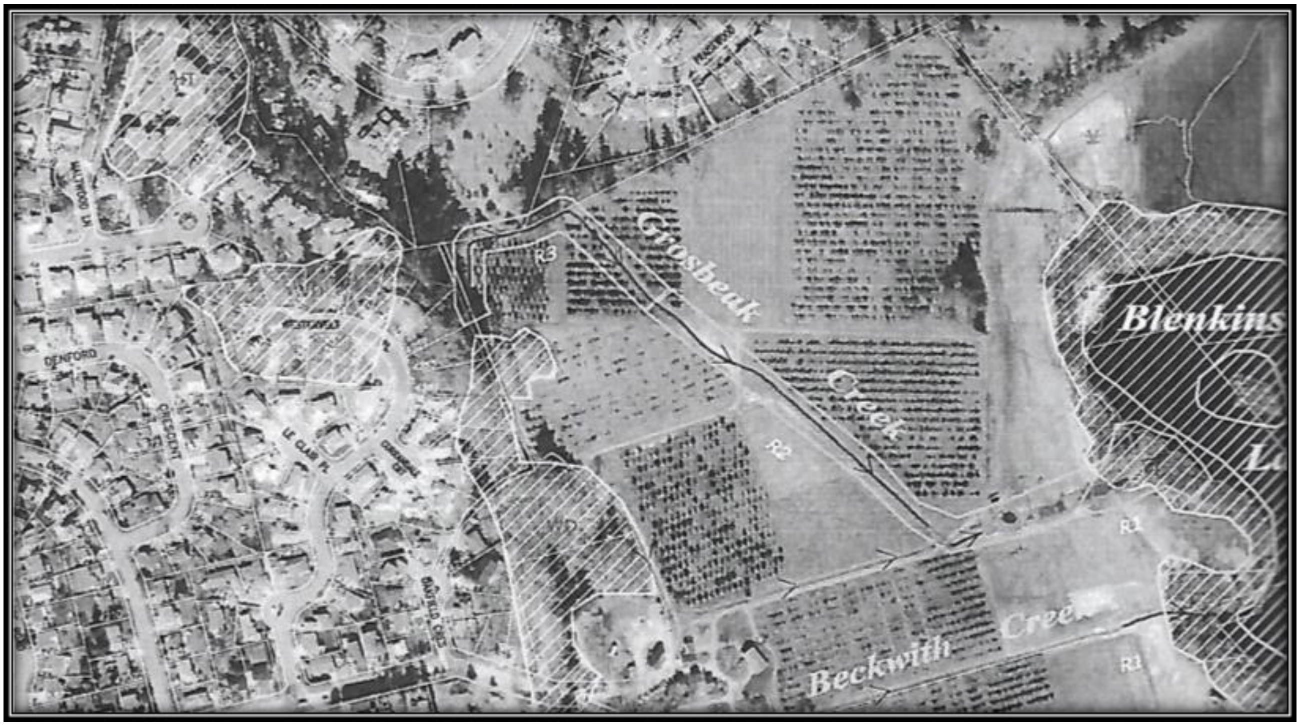


FIGURE 6. FIRST KNOW MAP TO NAME GROSBEAK AND ASSIGN REACHES. THE CORPORATION OF THE DISTRICT OF SAANICH, ESAI MAP NO. 27, 1998.

Vegetation and Topography

Maps from University Of Victoria, McPherson Library Map Collection were viewed to find clues to the hydrology and vegetation communities of the valley:

- Map of Victoria, 1855
- Victoria District Official Map, 1858 from Townsend (2009), (Figure 7)
- Maps of Victoria and Esquimalt Districts, 1861
- Victoria District Official Map, 1858 (Figure 8)
- Vegetation Description, 1973, University of Victoria Map Collection

None of these maps indicate any streams flowing into or out of Blenkinsop Lake. Figures 7 and 8 show how the surveyors used different marks to indicate coniferous from deciduous trees. The other maps are viewable in the appendix. Townsend (2009) numbered the map facilitating the search for familiar waterways and interpreting surveyor's notes from the Victoria District Official Map, 1858 (Figure 7); they describe the project area as Oak Savannah and mark out wetlands and riparian cover, coniferous trees are represented by stars and deciduous trees marked as cloud like circles. Swampy wet areas with riparian vegetation are defined by gray- green, waterways by blue. These maps provided valuable information when piecing together what the hydrological patterns were in the valley.

FIGURE 7. VICTORIA DISTRICT OFFICIAL MAP, 1858. FROM TOWNSEND (2009). DEFINING NUMEROUS WETLANDS AND RIPARIAN CORRIDORS IN THE VICTORIA DISTRICT, AREA 1- SWAN LAKE, 2- SWAMPY AREAS AROUND BLENKINSOP LAKE AND OAK SAVANNAH ON WEST SIDE OF LAKE, 3- DOUGLAS CREEK.

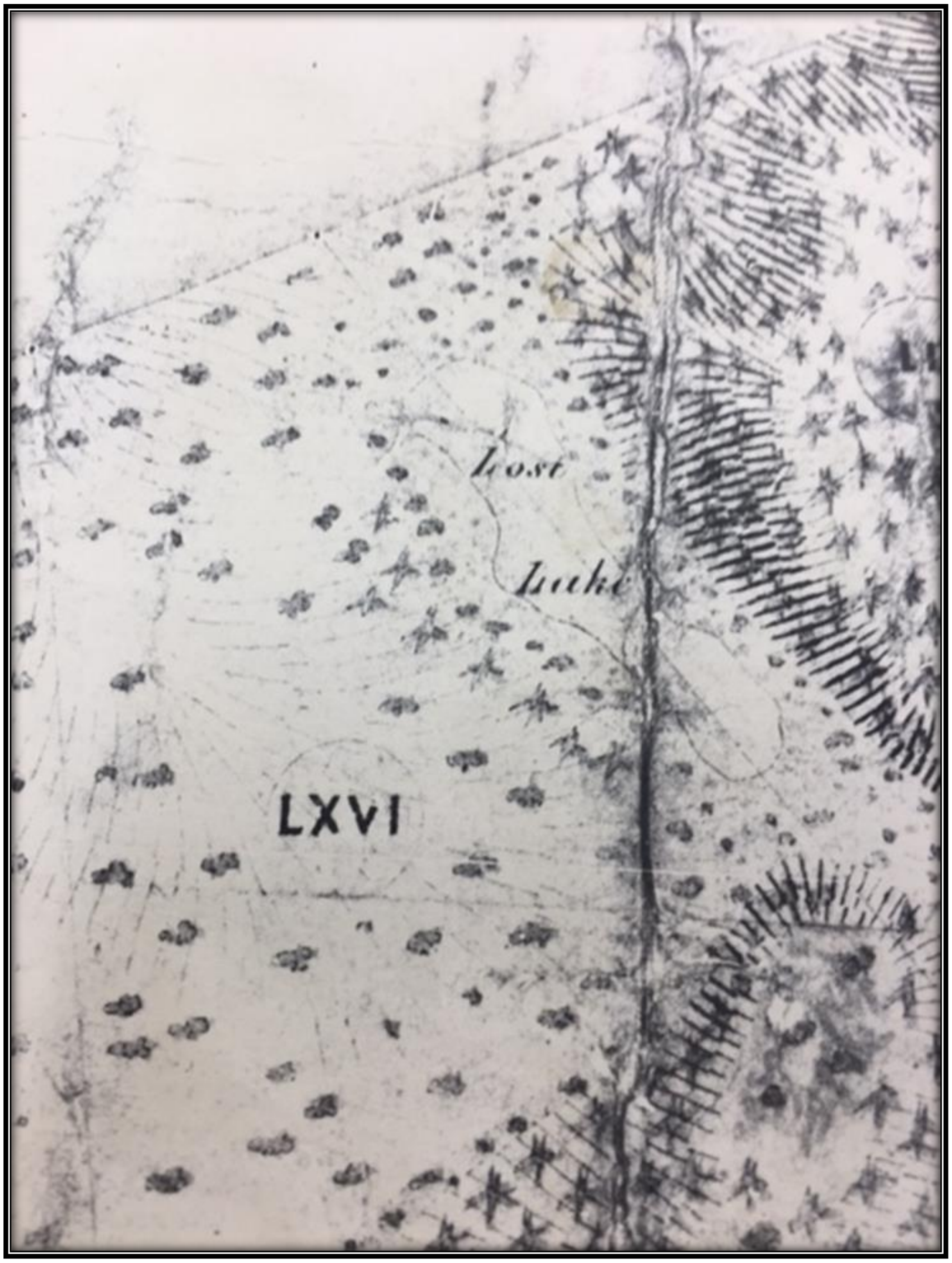


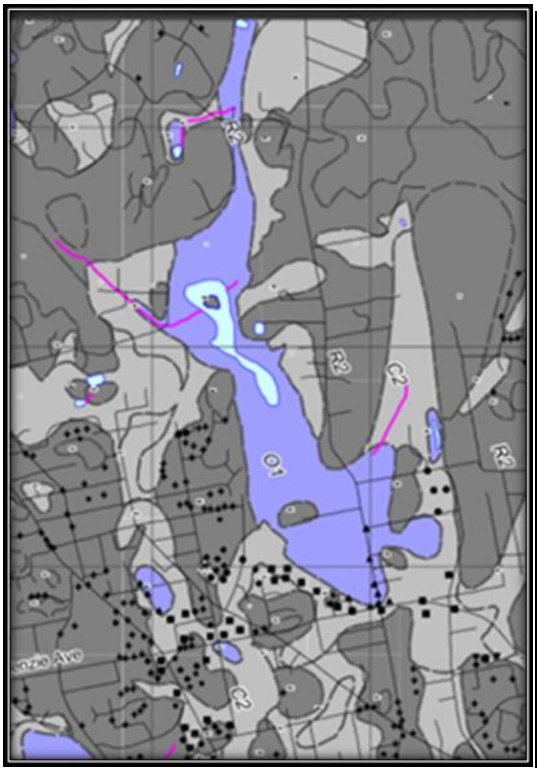
FIGURE 8. VICTORIA DISTRICT OFFICIAL MAP, 1858. UNIVERSITY OF VICTORIA MAP COLLECTION. A VISUAL DEPICTION OF CONIFERS AND DECIDUOUS TREES, MT. DOUGLAS AND LOST LAKE, AS IT WAS NAMED BEFORE GEORGE BLENKINSOP OWNED THE ADJACENT LAND.

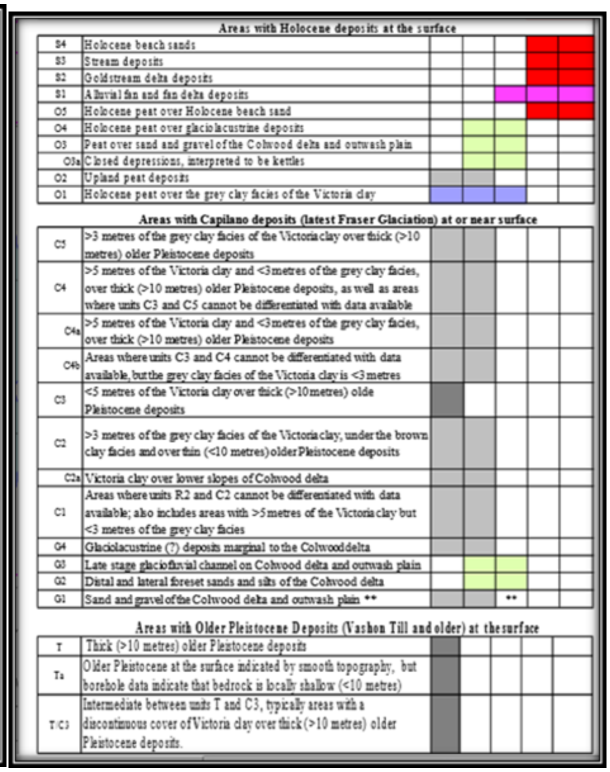
The topography lines are visible in Figure 9; each line represents a one meter drop in elevation and shows the elevational gradient directing rainwater into the creek.

FIGURE 9. CRD ATLAS TOPOGRAPHICAL MAP OF PROJECT AREA, THE WHITE LINES INDICATE A ONE METER DROP IN ELEVATION. MAP CREATED JANUARY 4, 2016.

GEOLOGY

The underlying bedrock for Southern Vancouver Island is Wark-Colquitz Gneiss (CRD, 2016) (Levinson et al, 2011). Figure 10 is a portion of the Greater Victoria Area Liquefaction Map detailing soils in the valley and the project area. Deep peat surrounds Blenkinsop Lake extending all the way East to Braefoot Park and West to Saanich Works Yard (MOE, 2015) this peat was formed by yearly biomass vegetation being submerged with the winter rains creating an anaerobic environment inhibiting full decomposition (Brady &Weil, 2013). The codes for the project area (Figure 10) describe the clays that form the base under the West slopes of Blenkinsop Lake, which are; “>3m of grey clay facies of the Victoria clay under brown clay facies over thin (<10m) older Pleistocene deposits”. The Victoria Clay is visible in the horizon profile (Figure 11).





Areas with Holocene deposits at the surface

S4	Holocene beach sands					
S3	Stream deposits					
S2	Goldstream delta deposits					
S1	Alluvial fan and fan delta deposits					
O5	Holocene peat over Holocene beach sand					
O4	Holocene peat over glaciolacustrine deposits					
O3	Peat over sand and gravel of the Colwood delta and outwash plain					
O3a	Closed depressions, interpreted to be kettles					
O2	Upland peat deposits					
O1	Holocene peat over the grey clay facies of the Victoria clay					

Areas with Capilano deposits (latest Fraser Glaciation) at or near surface

C5	>3 metres of the grey clay facies of the Victoria clay over thick (>10 metres) older Pleistocene deposits					
C4	>5 metres of the Victoria clay and <3 metres of the grey clay facies, over thick (>10 metres) older Pleistocene deposits, as well as areas where units C3 and C5 cannot be differentiated with data available					
C4a	>5 metres of the Victoria clay and <3 metres of the grey clay facies, over thick (>10 metres) older Pleistocene deposits					
C4b	Areas where units C3 and C4 cannot be differentiated with data available, but the grey clay facies of the Victoria clay is <3 metres					
C3	<5 metres of the Victoria clay over thick (>10 metres) olde Pleistocene deposits					
C2	>3 metres of the grey clay facies of the Victoria clay, under the brown clay facies and over thin (<10 metres) older Pleistocene deposits					
C2a	Victoria clay over lower slopes of Colwood delta					
C1	Areas where units R2 and C2 cannot be differentiated with data available; also includes areas with >5 metres of the Victoria clay but <3 metres of the grey clay facies					
G4	Glaciolacustrine (?) deposits marginal to the Colwood delta					
G3	Late stage glaciofluvial channel on Colwood delta and outwash plain					
G2	Distal and lateral foreset sands and silts of the Colwood delta					
G1	Sand and gravel of the Colwood delta and outwash plain **			**		

Areas with Older Pleistocene Deposits (Vashon Till and older) at the surface

T	Thick (>10 metres) older Pleistocene deposits					
Ta	Older Pleistocene at the surface indicated by smooth topography, but borehole data indicate that bedrock is locally shallow (<10 metres)					
T/C3	Intermediate between units T and C3, typically areas with a discontinuous cover of Victoria clay over thick (>10 metres) older Pleistocene deposits.					

FIGURE 10. LIQUEFACTION MAP FOR BLENKINSOP VALLEY (LEFT), KEY FOR CODES (RIGHT). GREATER VICTORIA AREA LIQUEFACTION MAPPING PRODUCED BY THE MINISTRY OF ENERGY, MINES AND PETROLEUM RESOURCES (2016).

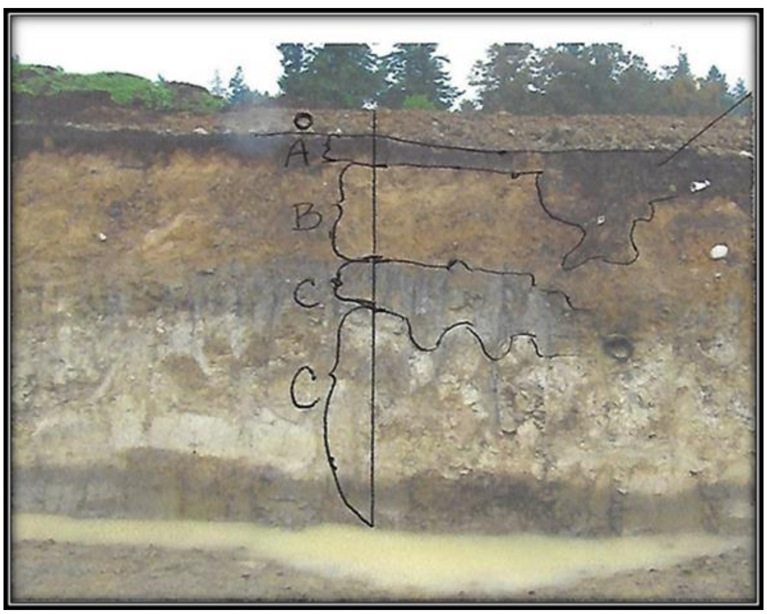


FIGURE 11. FOUNDATION EXCAVATION LOCATED 50M FROM RESTORTION SITE GIVES VISUAL OF C HORIZON.

HYDROLOGY

Blenkinsop Lake is fed by three streams; Lochside Creek, Grosbeak Creek and Beckwith Creek. All are channelized and on the West and North of the lake. To the East Mt. Douglas rises to 260m elevation. Any streams constant or ephemeral from the mountain to the lake have been redirected into storm drains and ditches since 1906 when the Blenkinsop Road was cut along the West side of the mountain (Saanich Archives, 2016), this effectively disconnected the hydrology of the watershed. Rainwater hitting Westervelt Road, Vailwood Trail and Faithwood Road forms the head water for Grosbeak Creek. With urbanisation most of this precipitation has now been funneled into storm drains carrying the water away from its historic routes. Figure 12 shows Saanich municiple storm drains for the imeadiate area.

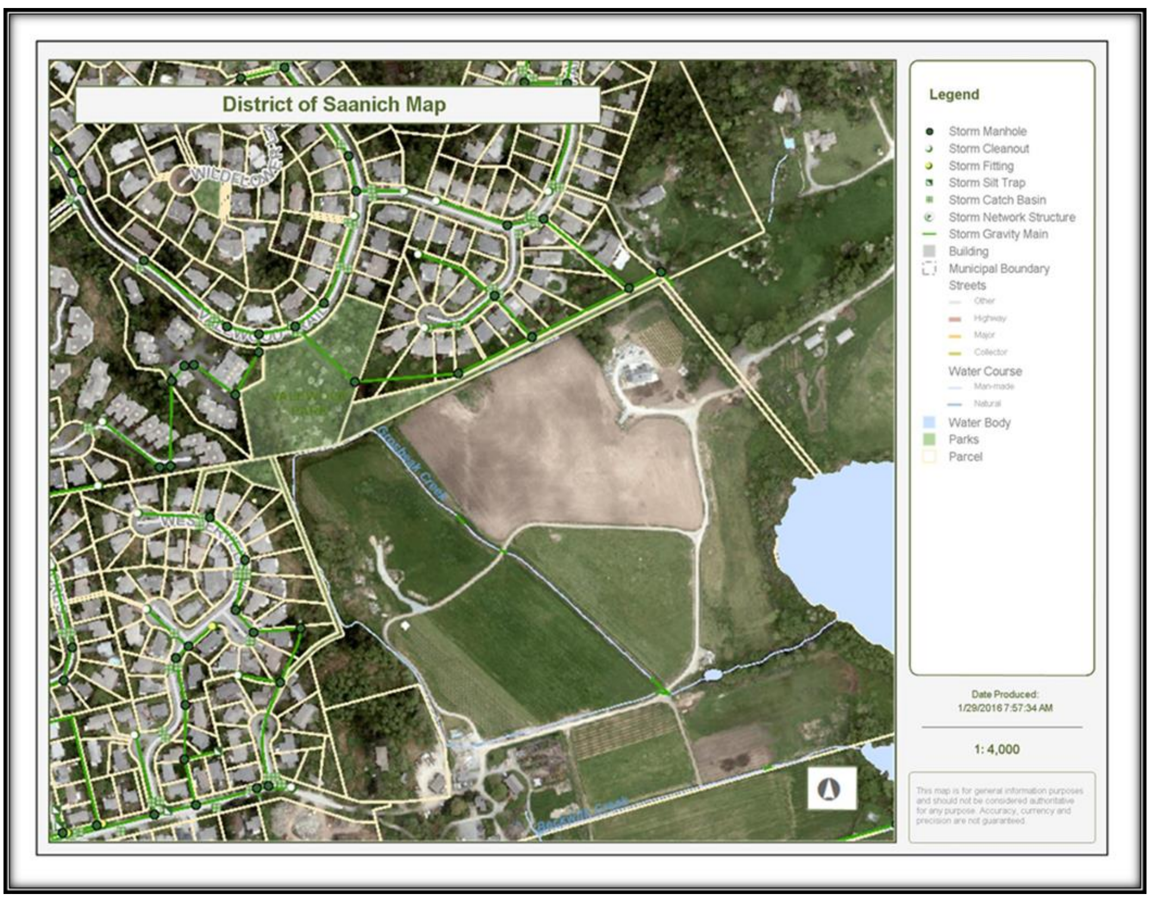


FIGURE 12. DISTRICT OF SAANICH MAP; STORM DRAIN SYSTEM SURROUNDING THE PROJECT AREA, STORM DRAIN INTAKE INDICATED BY GREEN CIRCLES AND UNDERGROUND PIPES BY GREEN LINES. MAP CREATED FROM SAANICH MUNICIPALITY GIS, JAN 18, 2016.

PROJECT PLAN

GOAL SETTING

In December of 2014 discussions began about restoring function to Grosbeak Creek. I was looking for a project to meet the requirements for graduation from the Restoration of Natural Systems Program at the University of Victoria. Jordan and Cherie Mann had just purchased the property at 1020 Beckwith Avenue and were interested in a vegetation corridor to run the length of Grosbeak Creek. During the spring of 2015 we discussed how to proceed and what the creek would look like and benefits of doing this restoration. Goals produced from these discussions were:

- Beauty
- Function
- Biodiversity

Beauty

A treed corridor is welcomed for recreation purposes. Jordan and Cherie have small children, with fond memories of growing up close to green space; they sense a similar experience for their children would build within them an affinity for nature.

White *et al* (2013) reviewed data related to greenspace as a necessary component to mental wellbeing. They found that people have less mental distress as well as a greater sense of happiness when living in areas adjacent to green space. This Restoration project will be a space where humans can observe ecosystem interactions.

Function

Transition zones, where land meets water, preform ecological services. These services are complex and cannot be duplicated by humans or machines (Primack 2014). Building a riparian ecosystem will bring a higher level of functionality to the existing ecological processes (Brennan & Culverwell. 2005). Functioning ecosystems support life on earth for all species including humans; we depend on their provisioning and regulating factors for the basic needs of life

(Raymond, *et al*., 2013). Figure 13 is a visual representation of how ecosystem function impacts our daily lives.

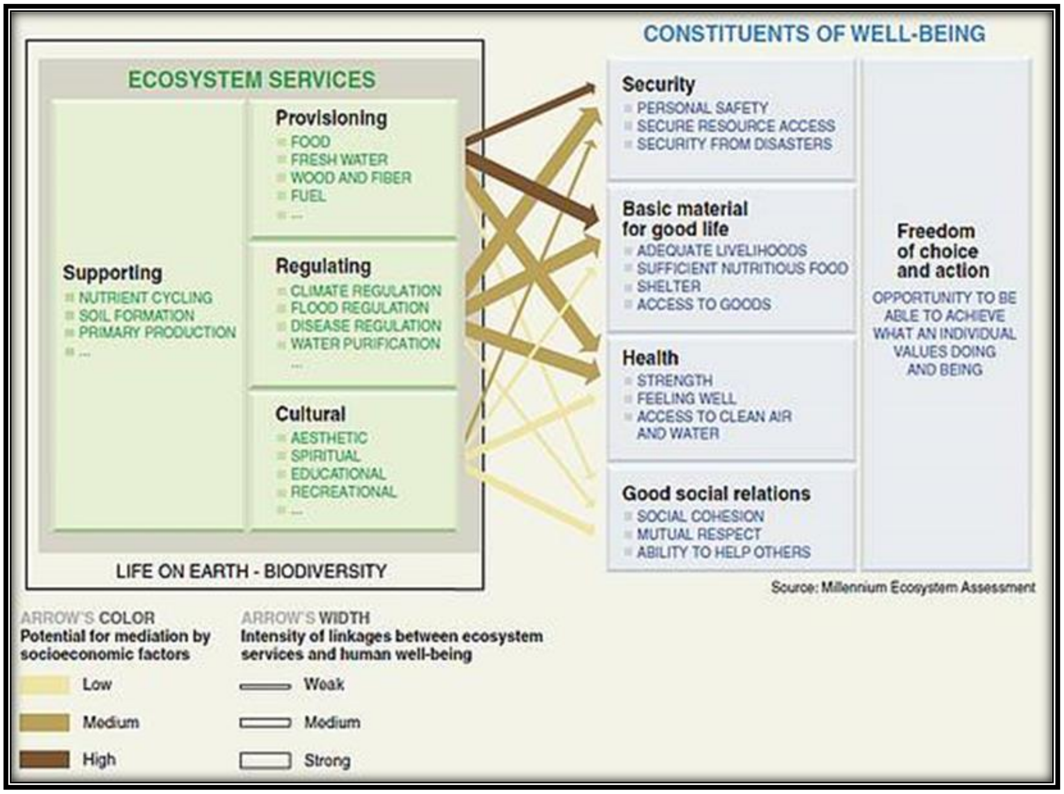


FIGURE 13. HOW ECOSYSTEM SERVICES IMPACT HUMAN QUALITY OF LIFE. IUCN, INTERNATIONAL UNION FOR CONSERVATION OF NATURE HTTP://CMSDATA.IUCN.ORG/IMG/ECOSERVSMEA_1_44635.JPG

Biodiversity

Riparian ecosystems foster a higher level of biodiversity because of their interface between water and land (Ciruna, 2005), (Brennan & Culverwell, 2005). Replacing blackberry covered banks with diverse vegetation invites colonisation from many species. A greater variety of birds begin to use the space, something as small as a few boulders strewn about make a safe perch, their droppings contain seed and new plant species appear building habitat and encouraging establishment of multiple species (Robinson & Handel, 1993).

DRAWINGS

Project drawings for Grosbeak Creek Restoration, stage one are shown in Figure 14.

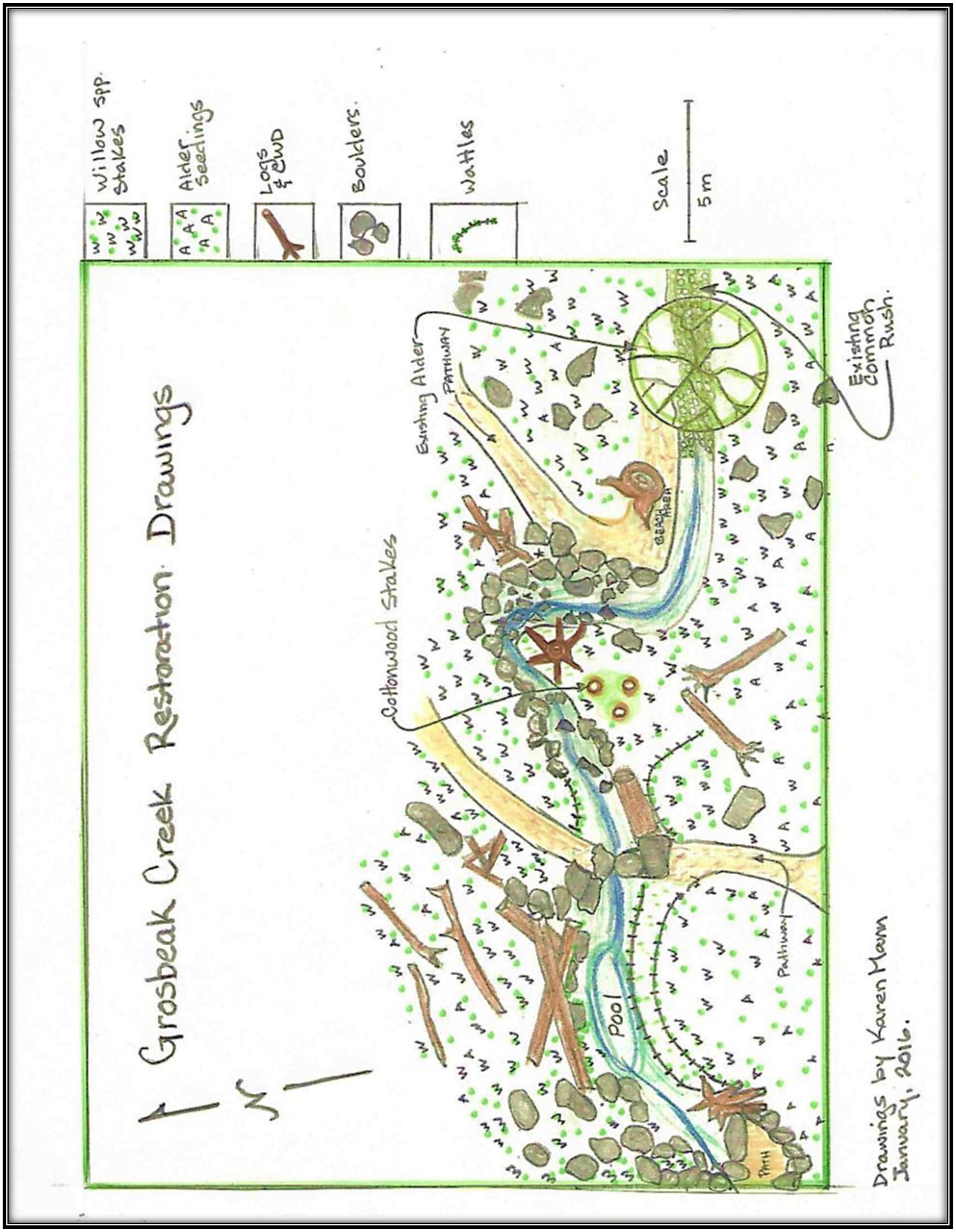


FIGURE 14. PROJECT DRAWINGS FOR GROSBEAK CREEK RESTORATION PROJECT.

PROJECT SCHEDULE

Table 1 is the project schedule. Having a schedule is helpful to keep the process on track as well as understanding the time the project will take, supplies and volunteers needed, and cost incurred.

TABLE 1. SCHEDULE FOR RESTORATION OF GROSBEAK CREEK.

Restoration Stage	Task	Who	Resources	Budget	Schedule
Stage 1. Establish the context and objectives for the site	Set goals /Prioritize Define physical boundary of restoration area	Property Owner & Karen	Tape measure/ topographical map/ GPS/ air photo/ camera	2 Volunteer Hours $25.00/ hr.	July 2015
Stage 1.	Define end goals of restoration	Property owner and Karen	Paper/ pencil	1 Volunteer Hours $25.00/ hr.	July 2015
Stage 2. Inspect the project site	Define the site/ class soils/survey birds and plants	Karen	Species identification book/ GIFs/ shovel / field notebook/ camera	4 Volunteer Hours $25.00/ hr	Aug 2015
Stage 3. Inspect reference site	Define the site/survey birds and plants	Karen	Species identification book/ GIFs/ field notebook/ camera	2 Volunteer Hours $25.00/ hrs.	Aug. 2015
Stage 4. Online research	Research site history and historical data	Karen	Laptop/ wireless connection/ visit municipality	20 Volunteer Hours $25.00/ hrs.	Aug. 2015
Stage 5. Develop and verify restoration plan	Create project drawings/ check for applicable bylaws and permits	Karen/ Municipality, Environmental Dept./ property owner	Paper /pens/ collected data/	4 Volunteer Hours $25.00/ hrs.	Aug 2015
Stage 6 Carry out the restoration excavation	Contour / place rock & CWD	Volunteers/ equipment operators	excavator/ drawings/ camera	30 excavator hours @ $124. /hrs. 3 tandem loads of boulders @$125/load 2 tandem loads of CWD, Tandem rental $89/hrs.	Driest time of year August 2015
Stage 6. Willow staking and	Cut stakes/ insert stakes/ create	Karen /volunteers	Pruning saw / loppers / secretors/ excavator /	48 hrs. Cutting and staking/ $25.	Jan & Feb 2016

Watling Mulching	wattles Spread mulch		camera / shovel and pitch fork	Excavator hrs. 20/$124. Inserting stakes/6 loads of mulch@$350.	May, 2016
Stage 7 Monitor the site after the restoration and make adjustments	Observe and record data; assess riparian plant growth/ invasive weed control/ Bird survey	Karen	Field notebook/ pencil/ camera	4 Volunteer Hours @ $25 / hrs.	August – yearly for 5 years Assess and adjust

BUDGET

From the beginning of discussions about this project the landowners and I aimed to do the work ourselves and seek out supplies by donation. Equipment was supplied by Don Mann Excavating, we ran the machines ourselves. Peninsula Bulldozing supplied the stone from their "overs" pile. "Overs" are the stone and sticks left over after screening soil. The woodchip mulch was also supplied by Peninsula Bulldozing; it consists of full trees and shrubs including their leaves run through a chipper. Coase woody debris, boulders and labour was donated by Brent Hoeppner the neighbour immediately to the West. Some of the large stumps and Carex were rescued from construction sites. The plant material required Willow (*Salix spp*.), Red-osier Dogwood (*Cornus solonifera*) and Black Cottonwood (*Populus trichocarpa*) used in the bioengineering techniques grow on the farm property.

METHODS

SITE INSPECTION AND DATA COLLECTION

Discussion with the landowners of Grosbeak Creek began in December of 2014.
During the spring of 2015 we discussed how to proceed and what the creek would look like and what would be the benefits of doing this restoration. In August first contact was made with Adriane Pollard, Manager of Environmental Services and Planning Department in the District of Saanich. Dispensation was received from Saanich in February, 2016 (available in appendix).

An inventory was taken during the month of August 2015. The site walked and boundaries defined. An iPhone compass was used to provide site coordinates and to find aspect. A clinometer was used to assess slope. Data and notes were recorded with a camera, and a field notebook. A backhoe was used to dig the holes for soil evaluation. Field Manual for Describing Terrestrial Ecosystems (RNS, 2013), A Field Guide for Site Identification and Interpretation for the Vancouver Forest Region (Ministry of Forests, 1994), plant books (Pojar and MacKinnon, 1994) and bird identification tools (Sibley, 2003) (Cornell University Merlin Bird ID App) were used to aid in methodology, interpretation and identification. Bioengineering techniques and their ability to advance natural seral succession were researched.

Biogeoclimatic protocol was used to assess the project area, soil assessment led to a site series of 05 CwFd- Kindbergia. The plant community for this site series is listed in Table 2.

TABLE 2. PLANT COMMUNITY FOR SITE SERIES 05 CWFD- KINDBERGIA.

Douglas-fir (*Pseudotsuga menziesii*)	**Sword Fern (*Polystichum munitum*)**
Western Red Cedar (*Thuja plicata*)	**Vanilla leaf (*Achlys triphylla*)**
Salal (*Gaultheria shallon*)	**Bracken (*Pteridium aquilinum*)**
Dull Oregon Grape (*Mahonia nervosa*)	**Oregon Beaked Moss (*Kindbergia oregana*)**
Baldhip Rose (*Rosa gymnocarpa*)	**Step Moss (*Hylocomium splendens*)**
Oceanspray (*Holodiscus discolor*)	

An online search found a Greater Victoria area soils map from the Ministry of Energy, Mines and Petroleum Resources (2016) and sites that recorded recent history in the valley. CRD Atlas and Saanich GIS system was used to locate and define the property; layers were used to show topography, watercourses and storm drain system. A watershed map was created using Google Earth. Plant lists were recorded. Historic maps were accessed from University of Victoria Library.

On August 30, 2015, starting at the point where the creek enters the property from Vailwood Park, elevations and waypoints were recorded (Table 3) using a GPS unit set to UTM 10. Obtaining readings from creek bed proved difficult because of thick blackberry growth. A tape measure was laid along the upper west bank and elevation readings taken every ten meters along the project area.

TABLE 3. WAYPOINTS AND ELEVATION MEASUREMENTS TAKEN AT TEN METER INTERVALS STARTING AT THE WEST END OF THE PROJECT AREA.

	Waypoint	Elevation	Meters from start of project area
UTM 10	0472761 N /5370330 W	41 meters above sea level	0
UTM 10	0472767 N /5370323 W	40 meters above sea level	10
UTM 10	0472773 W /5370314 W	38 meters above sea level	20
UTM 10	0472781 N/ 5370308 W	36 meters above sea level	30
UTM 10	0472785 N/ 5370304 W	33 meters above sea level	40

Aspect is East and South with a slope of 5%. The project site sits mid slope. Percent of canopy cover is zero. At the twenty meter waypoint a back hoe was used to cut a cross section of the creek. Blackberry bushes were removed and a cut made to the bank exposing the soil horizons. Horizon layers were assessed. Figure 15 shows creek soil horizons.

HOW SMR AND SNR WERE CALCULATED.

The purpose of digging a soil pit is to assess soil moisture regime (SMR), soil nutrient regime (SNR). The soil moisture was calculated by hand texturing. A palm full of soil from the pit was wetted and compressed between palm and fingers, it held firmly together. It was rolled between the palms to form a worm; it was durable enough to form worms ten to fifteen centimeters long and one centimeter thick. The key to hand texturing soil (RNS 2013) indicated that this soil was clay to heavy clay. Using the slope information, which was mid slope, the key to relative soil moisture was consulted, because some seepage was noticed the SMR was calculated to be 6.

The SNR is also calculated by using the information from the hand texturing. The heavy clay findings paired with soil depth less than 30 cm, very little humus and no mycelia, and the A horizon greater than 5 cm concluded in the designation of poor/medium richness in soil nutrients.

SOIL LAYERS DESCRIBED

FIGURE 15. SOIL HORIZON LAYERS A AND B FOR CREEK BANK.

O horizon;

- Leaf layer; <1 cm
- No discernable leaf parts, some roots visible

A horizon;

- Some porosity
- Heavy clay little to no organic matter but darker in colour than the B horizon layer
- Coarse fragment content less than 20%, almost none

- The soil was assessed by hand texturing, easy development of a "worm" showing this layer to be clay
- Using the biogeoclimatic protocol, SMR and SNR were calculated
- The SMR is 6 and the SNR is Medium giving a site classification of 05 Kindbergia

B horizon;

- Starts at 20 cm depth
- Poorly draining mineral soil
- Root restricting layer at 30 cm, hardpan clay
- Signs of flooding, sandy deposits mid bank

C horizon;

- Alluvial clay deposit
- C horizon was assessed from the house excavation (Figure 11)

Approximately fifty meters from the project area a house construction is beginning, the foundation excavation (Figure 11) gives visual detail of what is lying under the restoration area. Compass reading for this excavation is 48 29'5"N, 123 22'6"W and elevation is 40m.

The creek profile (Figure 16) at the thirty meter waypoint shows where a second test hole was dug in the creek bed, results showed heavy clay with pockets of sandy grey to blueish grey colour, there was some reddish mottling, and the ground was damp. Biogeoclimatic protocol assigned this area to 06 Foam flower.

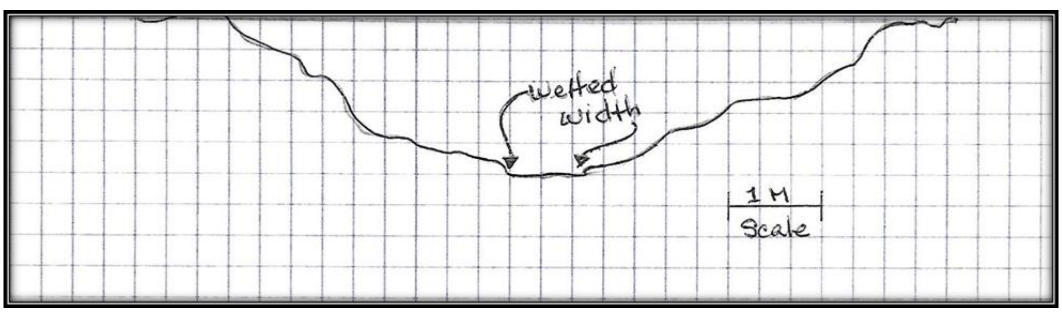


FIGURE 16. CREEK PROFILE AT THE 30 METER WAYPOINT WHERE CREEK BED SOIL ASSESSMENT PIT WAS DUG.

INVASIVE SPECIES REMOVAL

Through August and September Blackberry (*Rubus armeniacus*) bushes were removed from the project area (Figure 17), it was important to dig them out as they are tenacious and will easily regenerate. An excavator was used to scrape the bank edges and then removed the brambles and root balls to a compost pile.

FIGURE 17. BLACKBERRY REMOVAL COMPLETE SEPTEMBER 2015.

WILDLIFE RECORD

Through the process of data collection and restoration work a record of the wildlife encountered was kept.

REFERENCE SITES

The project area dissects hay fields and no native vegetation is established there. The reference area is located within Vailwood Park at the South West edge of the adjacent property at the foot of a rock bluff; Westervelt Road sits at the top of this bluff. The plant community growing here was recorded (Table 4). The GPS waypoint for the site is UTM 10, 04722685N, 53770315W.

CREEK VELOCITY

Water velocity has proven difficult to acquire, at the start of data collection the creek was dry. With the onset of autumn rains evidence of flashy episodes were indicated by the grass in the stream bed being flattened in the direction of flow. It was mid November before the flow became a constant trickle. As there was no depth to the creek, flow rate was not calculated until a pool was excavated, this allowed for an orange to float the distance of one meter. After many tries velocity was obtained from the excavated pool area February 14. Wetted width was 2.15 meters; three measurements across the width were 0.34 m, 0.34 m and 0.36 m, these were averaged to obtain a depth measurement of 0.34666 rounded up to 0.35m. An orange was dropped and timed as it floated past two markers defining 1 meter of flow. Area was calculated using the formula $A = wetted\ width\ x\ average\ depth = 2.15\ m\ x\ 0.35\ m = 0.745405\ m^2$.

The flow velocity of 1 minute 11 seconds was converted to 71 seconds and divided by 1 m equalling 0.014 m/s. $Flow\ velocity = \frac{71s}{1\ m} = 0.014\ m/s$. From the area and flow velocity the flow rate was calculated. $Flow\ rate = Area\ x\ Flow\ velocity = 0.745405m^2\ x\ 0.014\frac{m}{s} = 10.49865 = 10.5\ \frac{m^3}{s} = 10.5\ \frac{L}{s}$.

Therefore, flow rate of Grosbeak Creek was calculated as 10.5 L/s

As of May 7 the flow has stopped, water remains in the pool and pockets of the creek bed.

ENGINEERING NEW CREEK

TOOLS

Tools used in this restoration were; Excavator, Tandem (Figure 18), Loppers, Pruning saw, Secateurs (Figure 19), Shovel, and Chain Saw.

FIGURE 18. TANDEM AND EXCAVATOR USED IN THIS RESTORATION.

FIGURE 19. LOPERS, PRUNING SAW AND SECATEURS USED IN THIS RESTORATION.

EXCAVATION

The Creek has five to six clear dividing areas and restoration will be divided into stages, one per year. The ESAI has labelled the creek into three reaches (Figure 6), stage one of the project starts with the area designated reach three at the forty-one meter elevation, beginning at the West property line where the creek enters from Vailwood Park.

The restoration extends thirty-five meters along the creek and planting extends approximately fifteen meters wide along that length. January 8, 2016, the creek was reshaped. Figure 20 shows the end of the first day of reshaping.

FIGURE 20. FIRST DAY OF RESHAPING ACCOMPLISHED BY MEANS OF AN EXCAVATOR.

The existing ditch was reshaped to include a pool; shelves carved along the steep banks have created more accessibility. The creek has been gradually directed North for seven meters then bends sharply to the West forming an elbow. 75mm minus round stone placed along the creek bed will dissipate storm water velocity and stabilize the stream bed. Larger rock and small boulders have been placed in the stream to create riffles.

January 9, 2016, boulders and coarse woody debris (CWD) where placed. The banks have been lined with boulders and willow wattles to protect them from erosion in heavy rain events.

BIOENGINEERING

Through January and February bioengineering took place. To keep the stake material viable, stakes were cut in the morning and staked into the project area in the afternoon. Four wattle sets were built, three on the South bank and one on the North bank. Figure 21 depicts a wattle being constructed. Long strait branches were sought. They were cut where their diameter was 10 to 15 centimeters, and then divided along their length into one meter segments. The upper thinner ends were used horizontally in wattle building. The excavator was used to help insert the cuttings three quarters of their length into the ground (Figure 22). With each rain event the mud became deeper and began to hinder progress. Figure 23 shows a completed wattle.

FIGURE 21. BUILDING A WATTLE ON THE SOUTH BANK.

FIGURE 22. COTTONWOOD STAKES ARE BEING INSERTED BY THE EXCAVATOR BUCKET EXERTING GENTLE PRESURE.

Three hundred and sixty four stakes were cut from vegetation growing close by the site. These included Sitka Willow (*Salix sithensis*)**,** Pacific Willow (*Salix lucida ssp.lasiandra*)**,** Hooker's Willow (*Salix hookeriana*), and Red Osier Dogwood (*Cornus stolonifera*).

A Cottonwood (Populus *balsamifera ssp*. *trichocarpa*) six inches in diameter was felled and cut into five 6 foot lengths and inserted into the bank at the creeks elbow (see site plan, Figure 14).

FIGURE 23. A FINISHED WATTLE, FEBRUARY, 2016.

PLANTING

Forty five Red Alder (*Alnus rubra*) seedlings were dug from a donor site and transplanted along the upper banks in mid-February. In March Carex *sitchensis* were rescued from a job site where they were about to be buried in fill and placed in pockets along the water's edge (Figure 24).

FIGURE 24. CAREX SITCHENSIS PLANTED ALONG THE WATER'S EDGE.

FIGURE 25. RECONSTRUCTION COMPLETE.

MULCHING

Figure 25 shows the restoration complete and ready for mulch. In May 2016 the project area had dried out enough to be able to move mulch onto the site. This last stage of restoration was to spread mulch to protect the bare soils. Six tandem loads of wood chippings were spread approximately eight centimeters thick.

RESULTS AND INTERPRETATION

ECOLOGICAL CONTEXT AND DATA COLLECTION

Combined Information about the areas climate and from historical maps for the Blenkinsop valley present a landscape of ephemeral creeks channeling storm water across the West slope. The absence of creeks leading in or out of Blenkinsop Lake communicates that winter rainwater was held in the valley and slowly decreased through percolation into groundwater and aquifers (Brady & Weil, 2013) and evapotranspiration (Ciruna, 2005). The historical maps also provided good visual information of swamp boundaries and riparian vegetation. Studying the Saanich storm drain map (Figure 12) it was estimated fifty percent of precipitation has been circumvented directly into storm drains, emptying into Blenkinsop Lake without benefit of natural filtration streams and riparian zones provide.

In 1858 the Official Map of Victoria shows that above the high water mark the West side of Blenkinsop Lake was Oak Savannah. Turner and Bell (1971) attribute these Oak meadows to management practises of First Nations. These included burning the landscape to discourage shrubs and maintain open meadow. This practise also suspended the biogeoclimatic zone seral climax of CDF-mm (RNS, 2013). Combined this information was interpreted to infer the final climax ecosystem of this restoration should be Garry Oak *(Quercus garriana)*.

The clay soil makeup seen in the horizon detail (Figure16) is what was indicated on the Greater Victoria Area Liquefaction Mapping (Ministry of Energy, Mines and Petroleum Resources, 2016).

The soil test hole dug in the creek bed was encouraging as damp soils in August during a prolonged dry season provided optimism that the newly staked area will have enough moisture held in the ground to survive the summer drought period in 2016.

The plants listed for the Biogeoclimatic zone of CDFmm site series of 05 CwFd- Kindbergia, calculated from the soil inspection did not match what was in fact growing on the field boarders and within the reference site, Vailwood Park. The project area is hay field; growing in the reference site area are mature Garry Oak (*Querkus garryana*), Snowberry (*Symphoricarpos albus*), Indian Plum (*Oemleria cerasiformis*) and Alders (*Alnus rubra*). One-hundred and fifty-nine years of farming on this site has altered the soils and they no longer reflect the plant communities seen on historical maps or the plant communities growing in the peripheral fringes.

Table 4 records the plants growing in the reference site. The site series that includes most of the reference site vegetation is 02 FdPl-Arbutus, this information builds an image of what should be growing in the higher elevations of reach three.

TABLE 4. LIST OF PLANTS GROWING IN THE REFERENCE SITE

Garry Oak (*Querkus garryana*)	**Oceanspray (*Holodiscus discolor*)**
Big Leaf Maple (*Acer macrophyla*)	**Nootka Rose (*Rosea nutkana*)**
Douglas-fir (*Pseudotsuga menziesii*)	**Baldhip Rose (*Rosea gymnocarpa*)**
Black Cottonwood (*Populous balsamifera ssp. trichocarpa*)	**Snowberry (*Symphoricarpos albus*)**
Arbutus (*Arbutus menziesii*)	**Common Rush (*Juncus effuses*)**
Indian Plum (*Oemleria cerasiformis*)	**Bracken Fern (*Pteridium aquilinum*)**
Red Alder (*Alnus rubra)*	**Sword Fern (*Polystichum munitum*)**
Himalayan Blackberry (*Rubus armeniacus*)	**Scotch Broom (*Cytisus scoparius*)**
English Hawthorne (*Crataegus monogyna*)	

For this project the reference site becomes the seed donor for regeneration; Robinson & Handel (1993) found that native species newly planted on the Fresh Kills Restoration site took many years to become mature enough to produce seed. Regeneration came first from fringe plant communities, their seed dispersed by wind and birds.

The addition of logs and boulders help bring birds to the sight, they are used as perches, and seed is dispersed through bird droppings (Robinson & Handel, 1993). Rough and lose soils enhance the germination of these seeds by trapping them in depressions or pockets that also maintained a moister environment (Polster, 2015).

WILDLIFE

While collecting data and restoring the creek an effort was made to record the wildlife using the area. Table 5 is this record.

TABLE 5. WILDLIFE SEEN WHILE RESTORING GROSBEAK CREEK

Bald Eagle (*Haliaeetus leucocephalus*)	**Barn swallow (*Hirundo rustica)***
American Crow (*Corvus brachyrhynchos)*	**Red-tailed hawk (*Buteo jamaicensis)***
American Robin (*Turdus migratorius)*	**European starling (*Sturnus vulgaris)***
Western Meadow Lark (*Sturnella negecta)*	**Canada Goose (*Branta canadensis)***
Wilsons Snipe (*Gallinago delicate)*	**Columbian Black-tailed Deer (*Odocoileus hemionus columbianus*)**
European Wall Lizard (*Podarcis muralis)*	

ENGINEERING NEW CREEK

EXCAVATION

As the creek was reshaped the excavated excess soil was placed to the West, building a mound where the large stump now sits (Figure 26) and the Cottonwood stakes were placed, this area was much easier to stake as the soil was loose. Soil became highly compacted where excavator moved alongside the creek to enable reaching across the span when shaping the creek, placing boulders and CWD. Compaction here made staking more difficult. Future monitoring will assess the vegetation survival rate between the loose and compacted soil.

BOULDERS & COARSE WOODY DEBRIS

FIGURE 26. A LARGE STUMP PLACED IN RESTORATION.

Four loads of boulders were placed along the creek bed and within the restoration area. The stump in Figure 26 was rescued from a construction site.

STAKING

FIGURE 27. AFTER A HARD RAIN CLAY BEGAN TO OOZE UNDER AND THROUGH THE WATTLE.

Figure 27 is a picture of the clay oozing through one of the wattles. With each rain event the clay became more liquid, four of the stakes in this wattle became unseated and fell toward the creek 45 degrees, but the stakes have now rooted and put out leaves (Figure 28), as they continue to grow they will become more stable. Winter rains transformed the heavy clay to a semi liquid form making it difficult to maneuver through the site.

An informational piece on how bioengineering can advance an ecosystem by circumventing the early seral stages was researched and produced and is available in the appendix.

FIGURE 28. WILLOWS HAVE LEAFED OUT AROUND THE DAMAGE FROM OOZING WET CLAY.

The Willow varieties will grow rapidly to a mature height of ten meters (Pojar & MacKinnon, 1994) crowding out competitors (Polster 2015), affecting sun loving seedlings making them weak, and holding the soils against invasion from unwanted species such as Scotch Broom (*Cytisus scoparius*) and Blackberry (*Rubus discolor*).

On February the 14th an inspection of the first area staked January 11th found the stakes budding up and several leaves showing. Stakes continued to leaf out through March and April; on May 8th stakes that had been assumed dead were found beginning to leaf out. Red Osier Dogwood (*Cornus stolonifera*) has been later than the other species.

FIGURE 29. COTTONWOOD STAKE WITH NEW GROWTH EMERGING.

Cottonwoods (*Populus trichocarpa*) are large trees and will eventually reach a height of 50 meters (Pojar & MacKinnon, 1994). Figure 29 shows emerging new growth on a Cottonwood. Figure 30 shows the half meter growth on the willow stakes as of May, 2016.

FIGURE 30. STAKES HAVE PUT OUT HALF A METER OF NEW GROWTH, MAY 2016.

MULCHING

A mulch covering will reduce weeds from germinating, keep moisture in the ground and encourage the colonisation from natural biofilm consisting of microbiota, bacteria and mycelium (Rodrigues et al. 2015). These create a synergy when interacting with soils and plants, supporting the entire ecosystem community (Brady& Weil, 2013), (McCoy, 2016).

BUDGET

This project was accomplished through donations:

- Use of Equipment- donation from Don Mann Excavating,
- Mulch and Stone- donated by Peninsula Bulldozing.
- Boulders and Coarse Woody Debris- donated by Brent and Elise Hoeppner
- Large stumps and Carex sp. were salvaged from job sites

It is good practise to know what the real costs would be if attempted without donations. Table 6 is a record of the hours of labour. It also gives a value for the supplies and equipment used.

TABLE 6. BUGET INCLUDING SUPPLIES, EQUIPMENT AND LABOUR

Item	Cost per Hour/ per Load	Hours Incurred	Total Cost
Planning and Research	$25.00/Hr.	35	$875.00
Labour	$25.00/Hr.	48	$1200.00
Excavator Rental	$124.00/Hr	30	$3150.00
Tandem Rental	$89.00/Hr.	10	$980.00
Stake Cutting Tools	$80.00/ one time	N/A	$80.00
Mulch	$350.00/Ld.	6 Loads	$2100.00
Stone	$0/Ld.	1 Load	$0.
Boulders	$125.00/Ld.	4 Loads	$500.00
		Total	8,805.00

DISCUSSION

Bringing the compiled data together depicts what Blenkinsop Valley looked like pre European colonisation. The area topography, climatic winter rainy season and deep peat underlying surface soils that surround the lake combine with the historical maps were considered. The early maps record swampy marshy areas but no creeks. Combined these factors define a bowl that fills up with the winter storms and dries out in the summer drought.

The historical maps used in defining the pre European settlement ecosystem community were clear in their representation that the project area is above the seasonal high water mark and Oak Savannah was the ecosystem community on the project site in 1858. Garry Oak (*Quercus garriana*) ecosystems support a diversity of unique species adapted to this region's Mediterranean like climate. Southern Vancouver Island is losing species to increasing pressures of urbanisation, the Garry Oak Ecosystem Recovery Team (GOERT) state hundreds of species are already inexistent.

Climate change models for this region are showing temperature norms to rise and seasonal drought to become longer (Hamann & Wang (2006). Garry Oak (*Quercus garriana*) ecosystems are being studied as they are proving to have a greater potential to survive warming temperatures (GOERT, 2003). Hamann & Wang (2006) studied the potential effects of climate change on how and where trees will disperse across British Columbia. They employed computer modeling to assess many tree species and their ecosystem communities. Their findings anticipated an increase in Garry Oak (*Quercus garriana*) communities over the coming century. *Quercus garriana's* percent of habitat loss was zero and its robustness will enable it to move North and claim new habitat. The modeling predicted a gain of 318% in Garry Oak (*Quercus garriana*) habitat by the year 2085. Using willow for this project has started the seral succession mid-way, it will take many decades to move through the seral stages from willow to oak.

Use of Bioengineering was very cost effective, 364 stakes were inserted. An estimate of using potted plant material was $ 2025.00 and consisted of saplings but with more variety than the staked material.

One of the problems encountered was scheduling restoration work around school deadlines and job demands. This meant that the excavation that should have been done in the early fall to prepare for November staking was pushed to January creating problems with soil compaction and difficulties working in deep mud on site.

With this restoration we have built the foundation to achieve our goals of function, biodiversity and beauty. As the stakes take root and the trees begin to form canopy cover the area ecosystem function will increase and become more resilient. Leaves will drop and nutrient cycling will increase soil productivity (Brady, & Weil, 2013). Leaf litter on the ground will increase colonization of insects, birds and small mammals will follow. A new ecosystem will emerge. As the plantings grow function will continue to rise. The intricate relationships within riparian zones and wetland systems are still not fully understood; when ecosystems are restored research shows their functionality has a success rate of 60 to 70 % (Moreno-Matos, 2012) compared with protected untouched ecosystems. Restoring natural processes even at 70% functionality will always be beneficial to biodiversity which in turn is beneficial to humanity.

This new riparian ecosystem will have higher ecological function than the agricultural ditch it replaced (Brennan & Culverwell, 2005). Meeting the objectives of function and biodiversity will take time. The first milestone will be to achieve canopy cover allowing for the understories to develop. The restoration will need to be monitored closely this summer as water could be an issue for the newly rooted stakes.

RECOMMENDATIONS

1. To protect the ground against compaction and for ease of movement of equipment the excavation should be done between July and early October before the rains begin. Boulders and CWD should be in place at this time and mulch should be available onsite.

2. The bioengineering was labour-intensive, having more people to help will allow the next stages to be completed sooner. Inviting non-profit groups and/or the University of Victoria to come along side and help is recommended for the remaining stages of this restoration.

3. It is recommended to pursue the possibility of facilitating a bioengineering workshop in partnership with David Polster and Peninsula Stream Society.

4. Invasive species are present in the peripheral fringes and will seed into the site along with the preferred species. It is recommended that English Hawthorne (*Crataegus monogyna*), Scotch Broom (*Cytisus scoparius*) and Himalayan Blackberry (*Rubus armeniacus*) be regularly removed.

5. Garry Oak should be encouraged though the harvesting and planting of acorns in the restoration site, climate change research is showing the Garry Oak ecosystem to be adapted to warming temperatures and will fair favorably as our area becomes warmer and dryer (Hamann & Wang, 2006). This could be a fun family teaching event to be done with the children.

6. Although the right to farm (Right to Farm Act, 2016) surpasses the riparian laws (Ministry of Environment, 2015) for British Colombia it is recommended that to fully realise the goals of function, beauty and biodiversity the complete 30 meters on each side of the creek be allowed to regenerate into a fully functioning ecosystem.

MONITORING STRATEGY

Data collected for this report will form a baseline from which success can be evaluated. Using the same data collection methods and tools used in this report, future monitoring will build a picture of successful and not so successful elements in the design and implementation of this restoration. A form for the purpose of collecting data is shown in Table 7.

Recommendations for monitoring:

- Useful data to include; photographic records (a series of pictures taken from the same spots to evaluate vegetation growth), records of bird, amphibian and mammal species will tell if any new species moved into the restoration area.
- Summer of 2016 the site will need to be visited weekly to ensure the new willow staking has rooted sufficiently to cope with summer drought, watering may need to take place to ensure success. Blackberries are already reclaiming the site and weekly removal is the best way to keep them under control until the willows shade the area.
- Monitoring is recommended to take place in all four seasons for the first 2 years and then yearly in summer, adjusting as need dictates after 5 years.
- Monitoring protocol is important for this restoration but also for future restorations. Well-kept records point to what worked, what didn't and how to adapt on the next project.

TABLE 7. DATA COLLECTION SHEET FOR FUTURE MONITORING

	Y/N	Notes
Date of observations		
Changes in site.		
Has drought or flood affected vegetation?		
Is there Adequate vegetation/ mulch cover?		
Are there any places where erosion is noticeable?		
Have photos been taken?		
New species observed?		
Species missing from site?		
Agricultural considerations.		
Assess the vegetation survival rate between the loose and compacted soil staked areas.		
Rate of growth in willows per year.		

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- David Polster, taught me the bioengineering techniques and made himself available to answer questions as they arose
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APPENDIX

SERAL STAGES AND BIOENGINEERING

In nature nothing stays the same, disturbance such as fire, flood, wind; even volcanic events create a mosaic within the landscape, patches at different stages of growth. This fosters biodiversity by varying seral stages (Primack, 2014). The landscape regenerates through stages of succession, starting with weeds and grasses covering and holding the soil against erosion (RNS, 2013). as these plant communities seasonally grow and die they begin to lay down organic material which causes a chemical reaction with weathered parent rock or sub soil allowing minerals essential to plant growth to become absorbable (Brady & Weil, 2013) this process also amends soils through the dropping of leaves, creating soils specific to a plant community's needs (RNS, 2013).

Plants from the Willow family are full of the hormones, salicylic and indolebutyric acids foster root growth and will generate plants from cuttings (Chalupa, 1983). Bioengineering techniques allow us to pass over several seral stages (grasses and weeds, small woody shrubs) in the process of succession (Polster, 2015). The key below is used to define seral stages; it has been included to help give an understanding of the process, showing how they move toward a climax ecosystem.

Code	Structural stage	Description
0a	Pavement	Large Impervious surfaces, no vegetation cover. Suspended in this state by ongoing interference.
0b	Gravel	Large porous area, no vegetation cover. Suspended in this state by ongoing interference.
1	Sparse/Bryoid	Initial stages of primary and secondary succession; bryophytes and lichens often dominant can be up to 100%; total shrub and herb cover less than 20%; total tree layer less than 10%.
1a	Sparse	Less than 10% vegetation cover.
2	Herb	Early successional stage or herbaceous communities maintained by

		environmental conditions or disturbance (e.g. snow fields avalanche tracks wetlands grass lands flooding intensive grazing intense fire damage)Dominated by herbs(forbs, graminoids, ferns);some invading or residual plants may be present; tree layer cover less than 10%, shrub layer cover less than or equal to 20% or less than 1/3 of total cover, herb layer cover greater than 20%, or greater than or equal to1/3 of total cover; time since disturbance less than 20 years for normal forest succession; many herbaceous communities are perpetually maintained in this stage.
2b	Graminoid-dominated	Herbaceous communities dominated (greater than ½ the total herb cover) by grasses, sedges, reeds, and rushes.
3	Shrub / Herb	Early successional stage dominated by shrubby vegetation; seedlings and advanced regeneration may be abundant; tree layer cover less than 10%, shrub layer cover greater than 20%
3a	Low shrub	Communities dominated by shrub layer vegetation less than two meters tall
3b	Tall shrub	Communities dominated by shrub layer vegetation that are two to ten meters tall
4	Pole/ Sappling	Trees greater than ten meters tall, typically densely stocked and have overtopped shrub and herb layers
5	5Young Forest	Self-thinning has become evident and the forest canopy has begun to differentiation into distinct layers(dominate, main canopy, and overtopped); vigorous growth and a more opened stand than in the pole/sapling stage; time since disturbance is generally 40- 80 years but may begin as early as age 30, depending on tree species and ecological conditions.
6	Mature Forest	Trees established after the last disturbance have matured; a second cycle of shade tolerant trees may have become established; understories become well developed as the canopy opens up; time since disturbance is generally 80-140 years for bioclimatic group A and 80-250 for bioclimatic group B
7	Old Forest	Old, structurally complex stands composed mainly of shade tolerant and regenerating tree species

Willow (*Salix spp*), Red-osier Dogwood (*Cornus solonifera*) and Black Cottonwood (*Populus trichocarpa*) are referred to as pioneering species. These plants are indigenous species adapted to thrive in our climate (Wilson & Hebda, 2008).They will quickly generate vegetative cover, shading out invasive species, this shade should also lower soil temperatures helping conserve moisture content in soil.

With the aid of bioengineering this restoration will bring a higher level of function into the local ecosystem and rebuild habitat lost to agriculture. Loss of habitat results in extinction for most species that are unable to adapt to changes we make in their landscape. Globally human caused extinctions are being reported at a higher rate than ever before in known history. Biodiversity is important; each species has a place and function in the greater ecosystem. Redundancy in nature helps to maintain resiliency but each extinction handicaps an ecosystems ability to repair itself, functionality becomes more difficult (Brady & Weil, 2013).

The intended outcomes of applying Bioengeneering techniques are the regeneration of a working natural system with all the benefits: water storage (through ground water recharge), water filtration and increased habitat.

Letter of Invitation

Jordan & Cherie Mann

1020 Beckwith Ave

Victoria, BC

V8X 3S4

July 2015

Re: Creek rehabilitation

To whom this may concern,

Karen Mann has permission to work on my property rehabilitating Grosbeak Creek.

If you have any questions feel free to contact me at 250.686.7307.

Sincerely,

Jordan Mann

EMAIL COMMUNICATION WITH ADRIANE POLLARD.

RE: Grossbeak Creek

Adriane Pollard <Adriane.Pollard@saanich.ca>

You replied to this message on 14/02/2016 11:46 AM.

Sent: Thu 11/02/2016 10:57 AM

To: Karen Mann

Hello Karen,
Engineering and Environmental Services have reviewed your proposal and find that it is eligible for an exemption from a Streamside Development Permit. Please be aware that the exemption does not extend to any other bylaws, Provincial, or Federal approvals.

We would appreciate receiving some before and after photos, or your final report.

I recommend adding some tree cover along the top of bank if it is within your budget and the property owners vision.

Thanks for contacting Saanich, good luck with your project!
Adriane

Adriane Pollard, MCESM, MCIP, RPBio

***note my new phone number as of Nov 26, 2015**

Manager
Environmental Services
Planning Department
District of Saanich

RE: Grossbeak Creek

Adriane Pollard <Adriane.Pollard@saanich.ca>

Sent: Mon 15/02/2016 12:21 PM

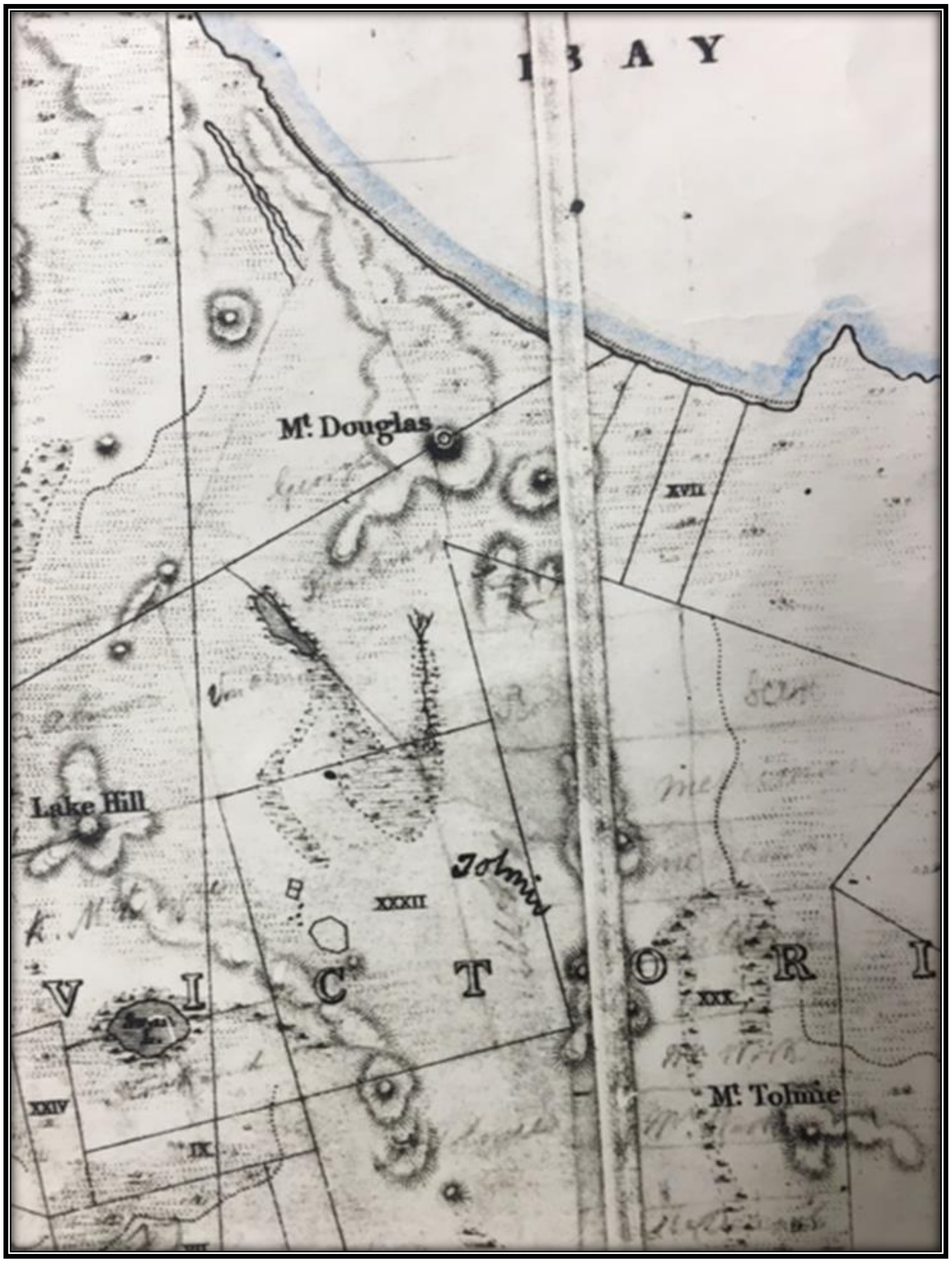
To: Karen Mann

Hi Karen,
We have a file of information and some field data from the mid 90's if you would like to come in and view the file--just let me know.

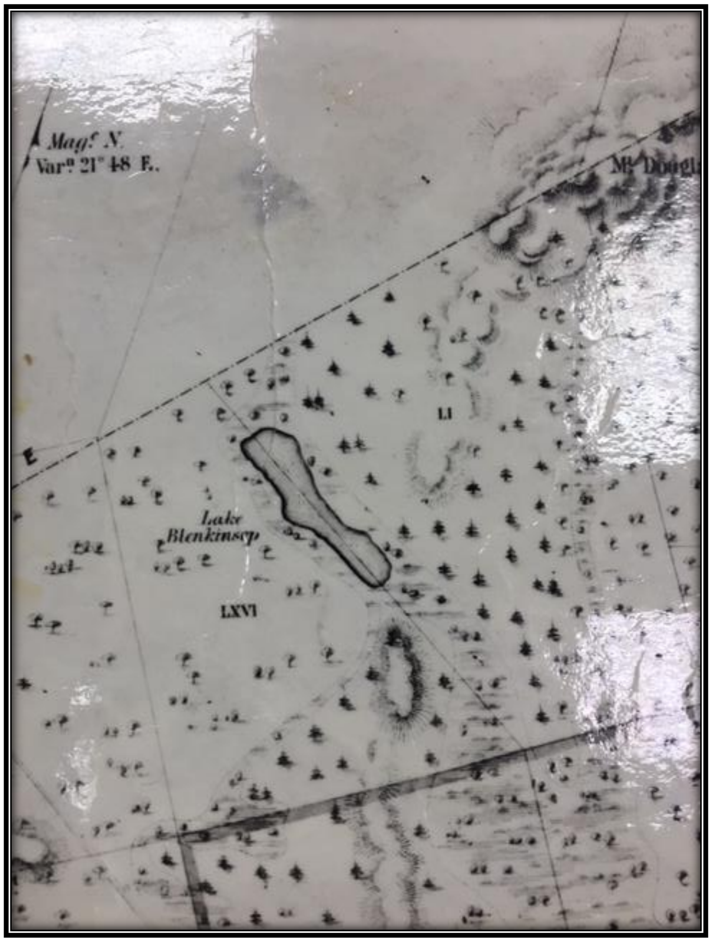
In terms of the ALR--the Farm Practices Act (Right to farm) does 'trump' many other laws. So while an ALR property does not have to use the riparian setbacks under RAR, a farmer can be charged under the Water Act, Fisheries Act, or Watercourse Bylaw for polluting a stream. Therefore it is considered best practice for farmers to maintain a riparian leave strip, not allow livestock in the creek, and not store manure near the creek.

Adriane

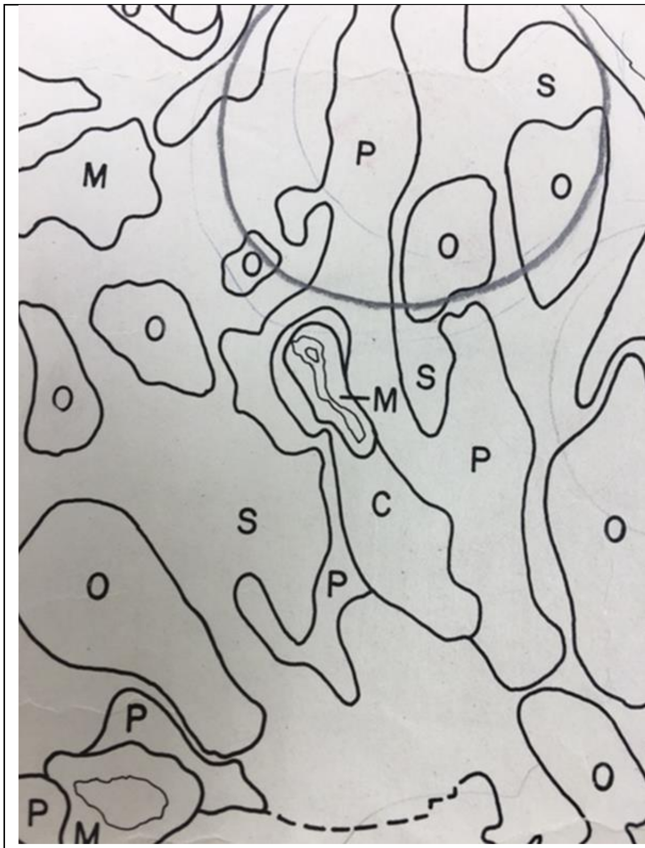
HISTORICAL MAPS OF VICTORIA AREA



Map of Victoria, 1855



Maps of Victoria and Esquimalt Districts, 1861



NATIVE PLANT COMMUNITIES

O - Garry oak on dry rocky hilltops or on deeper soils following selective removal of other trees.

O-A - Garry oak - arbutus transition.

A-O - Arbutus - Garry oak transition.

A - Arbutus - Douglas fir on steep rocky slopes at lower elevations.

L - Salal - lichen at higher elevations on exposed bedrock sites which are dry in summer.

Ap - Arbutus - Lodgepole pine - Douglas fir on hilltops and steep slopes at higher elevations.

S - Salal - Oregon grape on well drained glacial soils on slopes and on level coarse textured soils.

P-S - Swordfern - salal on sites with seepage which may be absent in summer.

P - Swordfern on sites with permanent seepage.

B - Swordfern - hemlock - amabilis fir on higher elevat.on sites with permanent seepage.

C - Black cottonwood - crab apple - willow on sites which flood in winter.

M - Skunk cabbage - peat moss swamps.

Prepared by: Pacific Forest Research Centre, Canadian Forestry Service, Victoria, B.C.

Vegetation Description Map, 1973, University of Victoria Map Collection