Bus Exchange Restoration Project

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1. Introduction

The University of Victoria (UVic) bus loop is one of the main hubs of the university. It is the central location for public transportation on campus and an area of high pedestrian traffic because of the services offered by the surrounding area. Every day, "Over 17,000 trips are made to and from UVic by public transit" (BC Transit, 2013). Campus tours often start here, and around it stands the schools bookstore and the Student Union Building. With the recent plans for the expansion of the UVic Bus exchange in the process to be finalized, there is an opportunity to restore the bus loop's negative impacts on surrounding ecosystems.

As stated on the campus sustainability webpage, "At the University of Victoria, we strive to model sustainability -- applying ingenuity to find new and creative solutions and practices that can serve as examples for others" (University of Victoria). Being that the bus loop is one of the key entrance points to Ring Road, it should be reflective of this vision. Through the implementation of this restoration plan, the campus bus loop will encompass modern-day initiatives concerning water management and native ecosystems.

2. Site Analysis

The purpose of the site analysis is to identify natural and cultural heritage values. Such an analysis should involve the collaboration of partners, stakeholders, and the public so that conflict is avoided and a broad understanding of the site is developed. By incorporating a multitude of resources such as comparative ecosystems, case studies, local knowledge, and traditional ecological knowledge, a diverse and inclusive understanding of the site can be formed (Parks Canada and the Canadian Parks Council).

2.1 Location

On the easterly side of Finnerty Road lies the University of Victoria Campus bus loop. This campus "landmark" is outside of the main campus road, Ring Road, and is surrounded by three main buildings on campus, The University Bookstore, The Student Union Building and University Center. Its approximate location is 48°27'58.70"N, 123°18'34.47"W.

2.2 History

Prior to European Settlement, Garry Oak Ecosystems (GOE) existed along Southern Vancouver Island and Gulf Islands. Today, in coastal British Columbia "less than 5% of these ecosystems remain in near-natural condition" (GOERT: Garry Oak Ecosystems Recovery Team). The threats to these native ecosystems can be attributed to invasive species, habitat fragmentation and removal of indigenous management strategies. According to the HR GIS Solution Inc Map called *Historical Garry Oak Ecosystems of Greater Victoria & Saanich Peninsula*, prior to the 1800 GOE existed over parts of the University of Victoria Campus (GOERT: Garry Oak Ecosystems Recovery Team). These ecosystems are primarily important for their contribution to ecological diversity. According to Parks Canada, Garry Oak and associated ecosystems provide more plants and animals than any other terrestrial ecosystem in British Columbia (Erickson).

Coastal Douglas-Fir (CDF) ecosystems, which were once the dominant ecosystem on Southern Vancouver Island, are now disappearing at an increasingly disturbing rate. Since the 1840s, logging, mining and fishing have been the main reasons for the destruction of old growth forests (Erickson). Due to Douglas-fir trees being one of the most prized trees used for timber, today only 0.5% of the formally CDF ecosystems can still be classified as “older forests” (greater than 120 years old) (Capital Region District, 2013). In these ecosystems Douglas-fir trees are the keystone species, providing a damp, shaded environment for understory plants. Douglas-fir ecosystems are not only important in maintaining biodiversity, but they also help to prevent flooding by soaking up rainwater, filtering contaminants from runoff, and purifying the air (Franklin, Cromack, Denison, 1981).

2.3 Culture

Before the Indian Act of 1870, the Chekonein family group of the Lekwengen Nation inhabited the land that is now occupied by the University of Victoria campus. This indigenous group relied on harvesting of camas and pit cooks to prepare vegetables and meat. The university campus, was once an important site for trade, first among different indigenous groups and then between the indigenous populations and colonizers of this “new world” (Bryce, 2013).

Garry Oak Ecosystems are culturally significant to the indigenous people of this region. The University campus lies in the traditional territory of the Lekwungen (Songhees) Nation. An important aspect of these peoples life was to burn selected woodlands and meadows to maintain open conditions and promote the growth of berries, nuts and root vegetables such as camas. These ecosystems were so important, the Victoria area was originally known as Camosun, which means “place to gather camas”(Erickson).

For Centuries Douglas Fir Ecosystems have been used by indigenous people for food, medicines, and tools. The Songhees used the wood from Douglas Fir trees to make spears, harpoons, caskets and fish hooks (Flynn, 1999).

2.4 Site Description

2.4.1 Ecology

Currently, the University of Victoria bus loop is home to many species both native and exotic. Big-leaved maple, western white pine, Garry oak and non-native grasses currently inhabit the area.

Big-leaved maple trees are the largest maple trees in Canada reaching 36 m in height. The leaves are 5 lobed with teeth and turn colors in fall. It normally blooms greenish-yellow flowers in spring and has fruit that consists of two winged seeds that are joined at the base. These trees are native to the area being restricted to the southwest corner of British Columbia at low to mid elevations (Parish, 109-112).

Western White Pine trees can grow to be 60 meters high and are normally distinguished by their long, 5 to 10 cm, needles. These trees have cones that are cylindrical when closed and bark that turns greyer and grooved with age. They thrive in environments that are rich in nutrients and well drained (Parish, 45-48).

Gary Oak Trees have unique bark that is greyish-black, thick, and scaly. It grows to be only about 20 m tall and has leaves and acorns. These trees are also native to the island and extremely threatened by urban development. With the management of indigenous tribes, these trees have survived in meadows and woodlands (Parish 133-136)

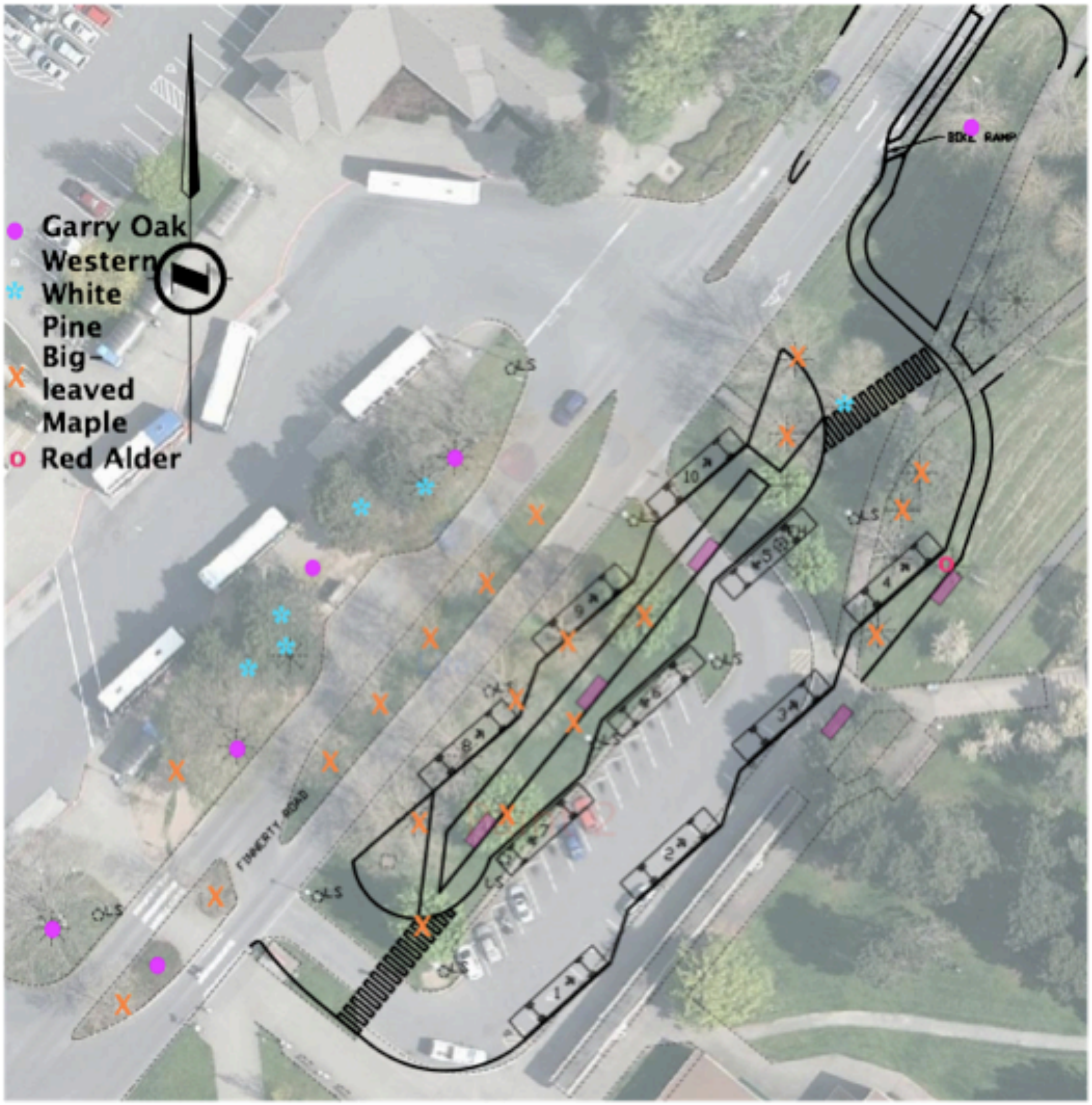


Figure 1: Species of Trees in The University Bus Loop

2.4.2 Climate

Victoria, B.C. has some of the mildest weather in Canada and the lowest amount of rainfall in British Columbia's entire western coast. This sub marine climate means that temperatures rarely rise above 30 ºC or fall below 0 ºC (Climate and Weather). Vegetation blooms early and for a long time in these climates, having received on average of 2,183 hours of sunshine yearly, and an eight-month frost free season (City of Victoria).

2.4.3 Hydrology

Being that the average monthly rainfall for Victoria's winters and summers is respectively 5 cm and 2.5 cm, over a monthly period the paved bus loop will collect on average 25.4m^3 of water per month in winter and 12.7m^3 of water per month in summer (City of Victoria). This mass amount of water flows into the sewer system to drain into streams and eventually the ocean. Several sewage grates are located around the bus loop to help with this process. Currently the pavement also slants towards these grates to aid water drainage patterns.

2.5 2014 Transit Expansion Project

By the end of fall 2014, 10 new terminals will be built to increase the capacity of the transit area as well as decrease congestion and alleviate some pressure on the existing infrastructure. Currently, the bus loop at the university has eleven terminals with only seven of these used for passenger pick up and drop off. Plans for the new bus loop involve its expansion into the parking lot at northwest side of the university's Student Union Building. The lot has a parking capacity of 14 cars as well as a large drop off/pick up zone for traffic coming from the pharmacy, Cinecenta, and many other businesses in the SUB. The eastern side of the parking lot also contains a useful hub for bikers looking for pressurized air, tools and racks to lock their bikes (BC Transit, 2013).

In order to increase the number of terminals and respect BC Transits requirements, the old parking lot will be expanded into the existing field in front of the Halpern Center for Graduate Students.

2.6 Engage Partners, Stakeholders and Public

Stakeholder's interests need to be taken into account in every step of a restoration process. This is to ensure that the goals and objectives of individuals be met to the greatest degree. Furthermore, by engaging partners, stakeholders and public, one can insure that ecological and cultural heritage is respected to minimize future conflict (Parks Canada and the Canadian Parks Council). The stakeholders' involvement will also mandate correct policy use.

A principal stakeholder is the University Board and Facility Management as they are involved in any work completed on campus. A current issue of interest to the university is resolving the trampled vegetation caused by people cutting across natural areas. Another concern expressed by the university is the need of increased paved areas for students waiting for transportation. The latter will involve the removal of some trees on site, which invokes considering the University Policies. The Universities maintains a policy to plant three trees for every one removed to insure that trees will continue to be abundant on campus. BC transit is also a key stakeholder in this operation. The construction plans used in this restoration project belong to BC transit and are designed as per their regulations. As the purpose of the area is for BC transit's use, their input is also valuable as they may have specific requirements for a functional operation. The input of the public users of the bus loop, which are mainly the students and faculty members of the university will be valuable in creating a functional area. The municipal government may also need to be incorporated in the plans, as permits for safety and location management may be required.

2.8 Problem Identification

The bus loop at the University of Victoria is constructed in such a way that it is harming surrounding environments, decreasing biodiversity and poorly expressing university culture and principles.

One of the main problems associated with the bus loop is water drainage. As large volumes of water travel across impervious surfaces such as pavement and concrete, salt, dirt, dust, rubber and metal deposits from tire wear, antifreeze and engine oil are picked up. Nitrates, sulfates, and heavy metals are just a few of the many toxic chemicals that have been found in increased concentrations in the soils and water around bus terminals. These contaminants accumulate into high concentrations during dry spells and are flush out all at once during rainfall, carried to the sewer system and are shed into streams and eventually large water basins like the ocean. The contaminated water has negative impacts on all aquatic life by changing the chemistry of the water, specifically salt (sodium chloride), which in high concentration has shown to be fatal to fish (United States Environmental Protection Agency). The change in chemistry also has negative impacts on food sources.

According to the government of British Columbia's Ministry of Environment, the amount of impervious surface greatly increases the volume of water entering the drainage system. As seen in Figure 2, both the volume and speed of flow greatly increase post development. The negative effects pertaining to the increase flow volume and rate include erosion of stream banks during heavy storms due to high volumes of water that is not able to absorb into the ground. This causes habitat destruction and the introduction of excess sediment into the water.

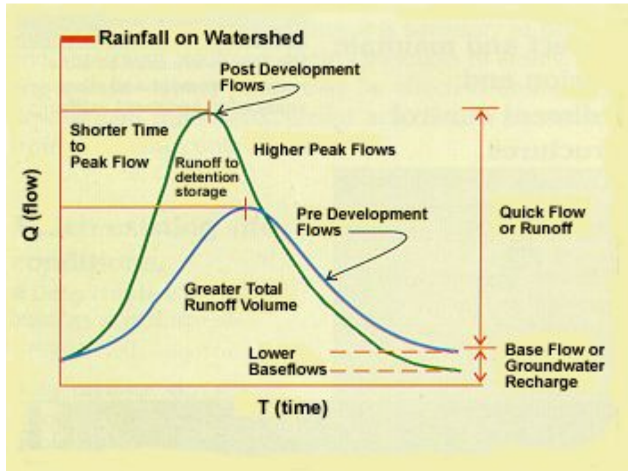


Figure 2. The Demonstration of Water flow volume pre and post development.

The vegetation of the area should be reflective of the University of Victoria Sustainability practices, which include increasing ecological integrity, social awareness about the ecological restoration initiatives and honoring the social, cultural and ecological history of the university's campus land. Currently non-native grasses grow around the bus loop, and the little vegetation that is present does not reflect Vancouver Island's natural ecosystems. Furthermore invasive English Ivy has begun to climb up several pine trees. This is a problem because invasive species tend to produce monocultures, which reduces diversity. Ideally this site would reflect the vegetation that existed at this spot pre colonization.

3. Goals & Objectives

Project goals are defined based on the interests of stakeholders and on the interests of community members. The following goals aim to outline a restoration project that is not only effective, efficient and engaging, but also realistic in the context of future disturbances such as global change (Parks Canada and the Canadian Parks Council). Objectives are also explained in this section, which describe the actions needed to enable the success of this project.

3.1 Goal 1:

To acquire a water drainage system that promotes healthy ecosystem function

The dynamic nature of climate makes future weather patterns difficult to predict. In addition, climate change has also contributed to this unpredictability. To account for this, areas with large magnitudes of pavement need to be adapted to support unseasonably high amounts of precipitation. Where pavement is present, water cannot percolate the land, resulting in large amounts of water that flows at accelerated rates. This results in problems concerning stream bank erosion, which proves detrimental to stream side habitat and introduces large amounts of sediment into waterways.

3.1.1 Goal 1 Objectives

- Use approximately 500 square meters of permeable concrete to replace sidewalks around the existing transit island
- Install approximately 750 square meters of permeable concrete into the new median for the transit expansion island

- Install two native rain gardens to slow and control bus loop water runoff as it transitions from UVic drainage systems to those of greater Victoria
    - One is located is the central median of the bus loop and the other located at the corner of Finnerty Road and Mackenzie Avenue
    - The design of the rain gardens will be 25% greater than required to account for unpredicted heavy rainfall
- To establish plants which are proficient in the uptake of water from soils, while being drought resistant and also able to thrive in wet conditions like Red Twig Dogwood *(Cornus sericea)*

3.2 Goal 2:

To reduce the amount of pollutants entering adjacent waterways and ecosystems

When contaminants are found in substantial amounts in the surrounding ecosystems of an urbanized area, the first step is to find the source of the pollutants. As large areas of impervious surface contribute to contaminated water entering the sewer system, it is crucial that these pollutants be reduced to trace amounts before entering the system.

3.2.1 Goal 2 Objectives

- To install pervious concrete which reduce the total suspended solids a minimum of 85 percent, total phosphorus by 65 percent, total nitrogen by 80 percent, nitrate by 30 percent, and metals by 98 percent (Transportation Synthesis Report, 2012)
- To install appropriate native plants in the two rain gardens such as Slough sedge *(Carex obnupta)* which have shown to filter contaminants from the water.

3.3 Goal 3:

To increase biodiversity of flora within the parameters of the bus loop

The restoration of biodiversity within the bus loop green spaces, will be enabled by the recovery of native ecosystems. Self-proficiency and the resilience of an ecosystem is dependent on the complexity of the flora and fauna. It is recognized that not all animals will be able to contribute to ecosystem function, due to high traffic of the area, and thus biodiversity will never become as complex as that of a wild system. Nonetheless, the ecosystem will still function accordingly by providing ecological services such as promotion of biodiversity and contributing to the nutrient and water cycle.

3.3.1 Goal 3 Objectives

- To create seven gardens, which are representative of Ecosystems that are native to Vancouver Island. Five Garry Oak Garden Ecosystems will be created containing native plants like Great Camus (Camassia *leichtlinii),* Chocolate Lilly (Fritillaria *affinis),* and Tall Oregon-grape (Mahonia *aquifolium)* Two Douglas Fir Garden Ecosystems will also be designed with native plant species like - Salal (*Gaultheria shallon),*Nootka Rose (*Rosa nutkana) and* Western Sword Fern (*Polystichum munitum)*. Three of these Garry Oak Garden Ecosystems would be on the Existing Transit Island and the remaining two would be on the Southern Island Crosswalk. The two Douglas Fir Garden Ecosystems are located on the Transit Expansion Island

- Control and removal of invasive English Ivy and exotic grass species that are encroaching upon the area
- To plant native and diverse species within the rain gardens like Red Twig Dogwood *(Cornus sericea)* , Common Camas *(Camassia quamash)*, Nodding Onion *(Allium cernuum)* , and Slough sedge *(Carex obnupta)* amongst others
- Create a 1 meter tall fence surrounding the native garden ecosystems and rain gardens so that humans do not degrade biodiversity by trample the plants. A 1 meter tall fence is enough to keep out people while maintain the aesthetics of the gardens

3.4 Goal 4:

To increase the social engagement to place around the bus loop

The bus loop is the main entrance and exit point for students and staff attending the university. For this reason, individuals tend to spend a lot of time waiting for the buses to arrive and depart. Educating the public is effective in areas such as this, because people idly waiting for a bus are more inclined to seek out means of entertainment. Spreading ecological knowledge is one way to promote a connection to place and an awareness of ecological processes. Furthermore by involving the community in the restoration of healthy ecosystem function, this project will further reinforce this connection to place, and generate personal responsibility among those involved. ERPG describes the importance of community involvement by stating that "Engaging restoration contributes to re-establishment of an ecologically healthy relationship between nature and culture."

3.4.1 Goal 4 Objectives

- Install educational at the corner rain garden and at the native ecosystem gardens (one concerning Douglas fir ecosystems and one concerning Garry oak ecosystems) and one sign at the major pedestrian zone (concerning permeable pavements) including information on the cultural importance of the area through its history (including cultural value) and educate the public about the importance of healthy ecological systems, the benefits of restoration and innovative environmental management
- Use native plants with an abundance of color to attract the public towards the gardens, subsequently increasing the amount of individuals reading the educational signs
- Use of aesthetically pleasing native plants to create a welcoming environment to the public
- One open houses will be held to inform the public on the ecological and community significance to the area
- Volunteer workshops for planting native crops will be held prior to the sites development

4. Design and Implementation

The implementation portion of this project is designed to be adaptable to account for the occurrence of unforeseen obstacles and events. The restoration project will therefore continuously monitor the results of each stage, so that implementation and design strategies can be adapted to be the most effective, efficient and engaging (Parks Canada and the Canadian Parks Council).

The designs for the UVic bus exchange restoration project works in unison with BC Transits design of an expansion, which is scheduled to be completed in the fall of 2014 (BC Transit, 2013). Rain gardens are incorporated into the restoration design, which function to control rainwater runoff and reduce contaminants entering the drainage system. Porous concretes is another factor helping to restore ecosystem function. It will work in conjunction with the current ground layout of the bus expansion while filtering contaminants from water and diminish large quantities of fast moving water. The native gardens around the bus loop will help restore the area to its original state and along with the rain gardens, use only native plants thereby increasing the biodiversity of the area.

4.1 Rain Gardens Design

The restoration of the bus loop, will include the installation of two rain gardens in order to account for the large amounts of rain water. As seen in Figure 8 in Appendix A the first rain garden will be situated on the centre median of Finnerty Road and the second will be on the corner of Mackenzie Avenue and Finnerty Road.

Plants

Both rain gardens will consist of 100% native plants. Native plants were grown in the gardens for numerous reasons. As the bus loop is an entrance and exit point for many individuals attending the university, it should be welcoming, environmentally conscious and colorful. For this reason, native plants of various colors, heights and structures were chosen to create an attractive garden. Plants that are colorful and interesting are more alluring and tend to spark the interest of passing traffic. By growing these plants, the public may become more interested rain gardens and more inclined to read the educational signs to learn more about restoration in the area.

Biodiversity

The areas chosen for the construction of both rain gardens are currently composed of very few species of plants, some being exotic such as the grass sod. As explained in the SER primer (2004), by increasing the biodiversity of the area, species composition and redundancy will also be increase. Species redundancy will be accomplished by growing 2-3 species of plants that are able to withstand similar moisture levels to provide a safety net of ecosystem resilience and maintain the function of the rain gardens. The diversity of plants contained in the rain gardens will therefore maintain the services that the rain gardens provide by filtering contaminants from water.

Pollution

The UVic bus exchange area is a highly populated area being that is used by pedestrians, personal vehicles and buses. The frequency of the coming and going traffic causes large amounts of pollutants to accumulate. Hazardous contaminants mix with water during rainfall events and flow into the rainwater drainage system of Victoria, and eventually into the Strait of Juan de Fuca. Contaminants include, dirt and dust, rubber and metal deposits from tire wear, antifreeze and engine oil that has dripped onto the pavement, pesticides and fertilizers. Other contaminants include garbage debris such as discarded cups, plastic bags, cigarette butts and pet waste (EPA, Office of Water, 1995). Rain gardens have been shown to remove 92-99% of copper, lead, and zinc, over 91% total suspended solids, and over 98% of oil and grease from runoff.(LID Fact Sheet - Rain Gardens)

Plant Placement

All plants used in the rain gardens are drought tolerant, however due to moisture tolerance, they are designated to be placed in different zones depending on their moisture tolerance. According to the inflow of water, 3 zones are designated within the rain garden (Hinman. & WSU Extension Faculty, 2007). Zone 1 consists of the innermost layer, which contains plants that are able to persist in wet conditions and seasonal flooding. The plants in zone 1 will consist of Red Twig Dogwood (Cornus sericea), Slough sedge (Carex obnupta), and Douglas spirea Steeplebush(Spiraea douglasii). Zone 2 is the mid section with plants that withstand wet conditions, include periods of standing water. Zone 2 will consist of Western columbine (Aquilegia formosa), Douglas aster (Aster subspicatus), Common camas (Camassia quamash) and Tall Oregon Grape (Mahonia aquifolium) Zone 3 is adjacent to the mulch layer that will be comprised of ground cover plants that will be exposed to drier conditions. The plants included in zone 3 will be creeping oregon grape (Mahonia repens), nodding onion (Allium cernuum), ocean spray (Holodiscus discolor).

Size

The size of the rain gardens was decided based on the amount of impervious surfaces in the area, which is approximately 1233m^2. As suggested by Hinman & WSU Extension Faculty (2007), for the rain garden to filter 90-100% of the rainwater, it must be approximately 20% the size of the impervious surface. For the bus loop area, the required size of rain garden is 1233m^{2}x 0.20 = 247m^2. The rain gardens were broken down into the Corner Finnerty rain garden, which is 150m^2, and the Median rain garden, which is 180m^2, a total area of 330m. This is approximately 25% bigger than needed, which was done purposefully in accordance to goal # 1, and prepare for unpredicted weather events.

Source original image: http://www.uvic.ca/campusplanning/assets/docs/UVIC%20Transit%20-%20R11R%20-%20REDUCED%20SET.pdf

4.1.1 Median Rain Garden Design

The rain garden design makes use of the entire median, which is 180 m^2 in size. One obstacle that currently exists is the lack of drainage within the median; there are currently no rainwater drainage systems connected to the median, but they do exist near by. With the construction of the new bus exchange, there will be excavation occurring in the immediate area. This problem can be solved by creating a drainage system within in the garden that connects to the existing rainwater pipes, during construction on damaged roads entering the campus. Another obstacle to contend with is the removal of 5 maple trees from the central median. These trees will be removed with the other trees being taken out for the bus loop expansion. To mitigate this obstacle, these 5 maple trees will be included in the tree replanting process listed under section

The median rain garden will have a depth of approximately 30 inches to 42 inches and be filled with a layer of loose gravel and proper piping in the deepest section, and an equally thick layer of sand filling the remaining under layer; these expenses will be covered in the detailed budget layout. After being topped with a layer of mulch, plants such as Slough sedge, Western Columbine, Nodding Onion and Common Camas will be planted in order to achieve an under layer design as shown in figure 3. Being that the median rain garden is situated between two roads, a focus mostly on lower grass/small hedge plants is ideal, so not to disrupt traffic view. The plant selection, amount used and their prices are detailed under budget.

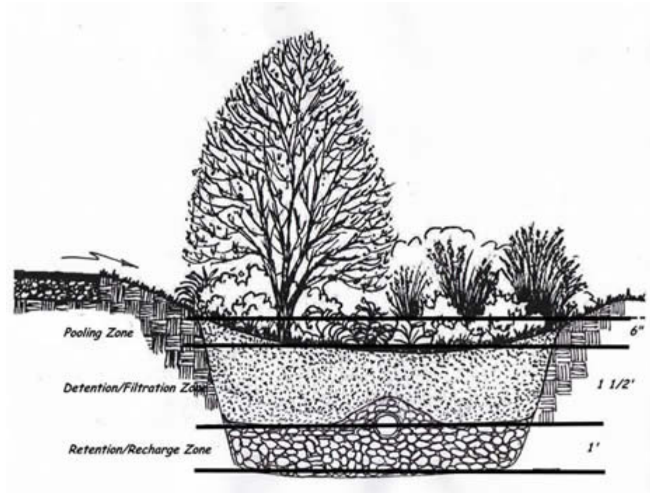
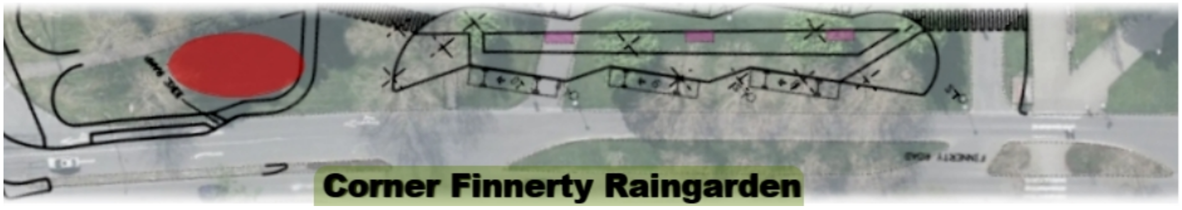


Figure 3: Underlayer design for Raingarden

Source: http://www.ecohusky.uconn.edu/raingardens.htm



4.1.1 The Corner Rain Garden Design

The Corner Finnerty rain garden will be approximately 150m^2. It is located near the corner of Finnerty road and McKenzie avenue, and its purpose is to filter contaminated rainwater from the Southern half of the bus exchange and Finnerty road, as well as from pedestrian pathways. As the rain garden is to be located in a site that is mostly surrounded by sidewalks and a pathway, this inhibits the water from accessing the rain garden. To overcome this obstacle, the FRENO pilot project, whose rain garden was also hindered by sidewalks, will be used as a reference site. The project used gutters in the sidewalks to provide a pathway for water to travel to the rain garden. As in Figure 4, the construction company installing the gutters will follow a similar strategy by laying 3 gutters between the sidewalk squares during the laying of concrete for the new sidewalk seen in figure 4. There also will be a path of stones leading from the gutters to the main section of the rain garden. The stone path gives the storm water from the bus loop a path to access the main section of the rain garden and slow the inflow of water. The other source of inflow of water will be from the adjacent pathways and grass area. To account for overflow of water, a gravel path on the opposite side of the gutters will be installed for times of heavy rainfall, allowing water to disperse to nearby sewers.

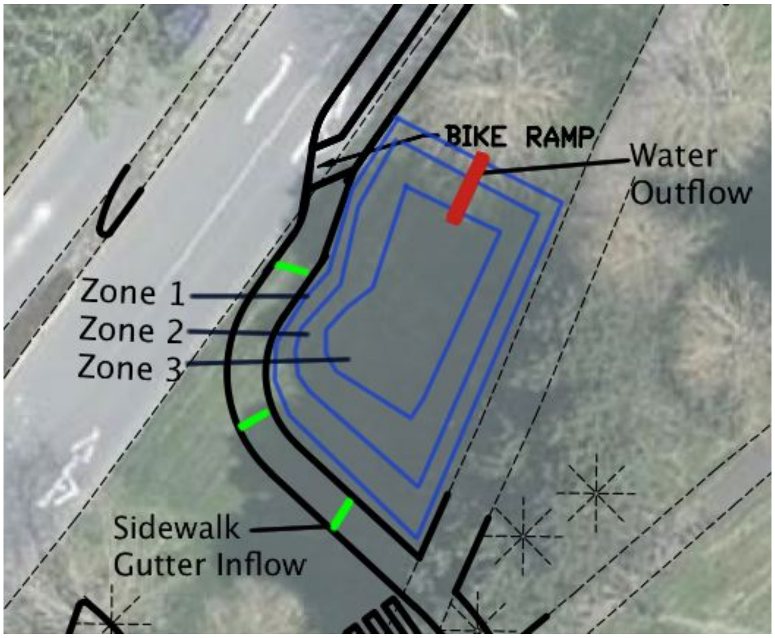


Figure 4: Corner rain garden design

The materials used for the corner rain garden are similar to that of the central median rain garden. Mulch consists of hardwood or softwood and is placed on the sides of the rain garden, while compost lies in the middle (Hinman. & WSU Extension Faculty, 2007). The purpose of laying mulch on the perimeter of the rain garden is to prevent erosion, control weeds, replenish the organic material in the soil and improve infiltration.

4.2 Rain Garden Implementation

Procedure

Both the central median rain garden and the corner rain garden would fit directly into the current timeline in place to build the new transit exchange. According to the *Transit Exchange Expansion Project* information guide, the project is expected to be completed by the fall of 2014[4], thus the completion of the rain gardens should fall before that date. For the purposed bus exchange expansion to occur, Finnerty Road will have to be temporarily closed. This creates an opportune time to construct the rain garden without traffic hazards. Before beginning the construction of the gardens, a soil drainage test to determine the filtration rate will take place, based on the following procedure:

Soil Drainage Test

The depth of the rain garden depends on the drainage ability of the underlying soil. A soil drainage test is performed to determine the rate of filtration. The soil drainage test will follow the steps as recommended by Hinman. & WSU Extension Faculty (2007). It will occur in February since the soil is the wettest during the winter**,** which gives the best indication of drainage in the wet months.

<u>Steps:</u>

1) Dig a small hole 2ft deep and 1-2ft in diameter

2) Note soil characteristics: sandy with a gritty feel drains well, sticky clay will drain slower, smooth but not sticky will drain moderately to poorly.

3) Fill the hole with 8-12in of water, then time the water drainage (for precision perform the test 3 times)

<u>Interpretations to determine depth:</u>

1) Poor draining soil: If the hole drains less than 0.5in per hour, the soil drains poorly. For poorly draining soils, it is necessary to increase depth to 30in (fill 24in with soil and leave 6in for ponding).

2) Fast draining soil: If the hole drains more than 0.5in per hour, the soil drains well. For good draining soils the hole should be filled with 12in of soil and the remaining 6in left for ponding

Interpretations to determine soil composition:

1) Mostly clay soil: The gardens will be filled with 60% screened sand and 40% compost. 2) Lacking clay soil: The gardens will be filled with 65% excavated soil and 35% compost.

Gravel and sand can also be added to improve the drainage of the soil. Within the bottom gravel and sand layer, a pipe or multiple pipes will be fitted. The pipes will have holes drilled throughout their length to let water in, and will be covered with a mesh fiber to keep out debris and soil.

The rate of filtration will determine the depth of each rain garden, which should insure that at least 6in is left at the top for pooling water. To begin the construction of the rain gardens, the site will be excavated to the depth determined by the soil drainage test. The area will be dug by hand to avoid heavily packing the underlying soil, which would hinder filtration. To insure that rainwater is evenly dispersed once it enters the gardens, the bottom will be leveled. A level or a plank of wood can be used for this purpose. At this point, the composition of soil and compost determined by the composition of underlying soil will be set in place. For the corner rain garden, the rock paths will be set from the gutters to the midsection of the rain garden. Following this step, the plants will be installed. The layout of native plants will be set according to their appropriate zones, however their arrangement will be left to volunteers. The arrangement of the plants is left up to the volunteers to create a fun and creative aspect to the project to further promote engagement. Once the gardens are in place, the fence will be installed along the perimeters of each garden and the educational signs and plaque installed on the fence.

People involved

The construction of the rain garden and surrounding fence will be done by 15-20 volunteers acquired by advertisements on the University of Victoria Campus and on the University of Victoria Environmental Restoration website. The University of Victoria grounds crew will be responsible for the maintenance of the rain garden as they currently maintain the other rain gardens on campus. As a construction company will be hired to install the new sidewalks, the contract will also include implementing gutters between sidewalk paths. Lastly, the contractors who are in charge of the tree removal for the exchange expansion will also remove the 5 maple trees in the Finnerty road median.

Equipment

The University of Victoria grounds crew will provide the equipment needed to construct the rain gardens. These tools consist of wood stakes, hammers, measuring tape, shovels, rakes, gardening gloves, a level and/or plank of wood. The construction crew would provide their own tools to construct the gutters underneath the sidewalks. The materials for the garden will be all purchased from local businesses.

4.3 Porous Concrete Design

An important factor to keep in mind throughout the design of this project is the preservation of native Garry oak and Douglas Fir ecosystems wherever possible. The expansion of the pedestrian idell zones at the existing bus loop is designed around the preservation of current Garry Oak trees and the creation of small ecosystems in an effort to create an area to replicate what the landscape used to look like. Porous concrete will assist the growth of the Garry Oak trees and Douglas Fir trees by better allowing percolation of water and oxygen into soils and limiting the runoff of nutrients from the bus terminal.

Unlike alternative concretes, permeable pavements require several base layers to allow for adequate drainage and to ensure even settling of the finished concrete occurs. Typically the subgrade depth is 18 to 36 inches; its thickness depends on rainfall and substrate composition. A second base is then laid with smaller rocks (3/4 to 3/16 inch) to a depth of 3 to 4 inches (Yang et al., 2005). The layer of pervious concrete of around 6 inches is then installed on the surface and allowed to set (Illustrated void percentage shown in Image 1.) These layers combine to form a very efficient drainage system and allow for the slow percolation and dispersal of storm water, as well as the collection of harmful pollutants. It is important for professionals to lay pervious concrete because it will lead to a longer lasting and more effective surface while reducing maintenance and repair costs (Charger Enterprises).

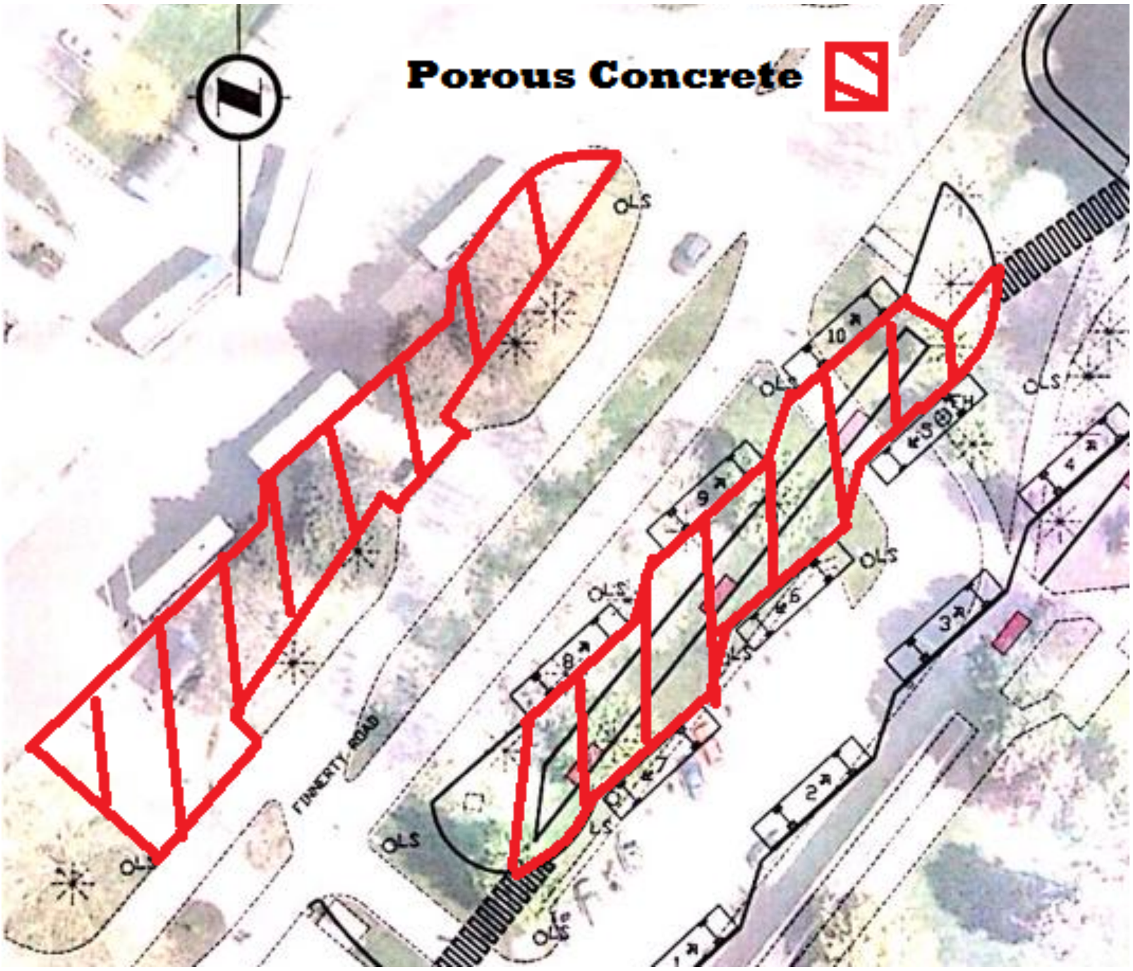


Figure 5: Porous Concrete layout

4.4 Pervious Concrete Implementation

Site Preparation

1. Clear existing material and dig to required depth and dimension
2. Grade and pitch are set with steel pins and a laser
3. Bankrun Gravel sub-base laid to a depth of 4”
4. Geotextile layer cut and prepared for porous concrete pouring (Finishing Edge)

Pour and Shape Concrete

1. Pervious concrete is poured on top of geotextile layer
2. Concrete is leveled with come-alongs and rakes
3. Compaction completed with vibratory screed and compaction rollers
4. Mist porous concrete with water to aid in curing process
5. Install gutters within the new sidewalk (Finishing Edge)

Stabilizing Concrete

1. During curing process surface must be kept moist with hoses, sprinklers, or water trapping curing compounds.
2. After 5 to 10 days concrete is cured and suitable for non-vehicular traffic (Finishing Edge)

4.5 Native Garden Ecosystem Design

4.5.1 Garden Placement

The gardens are placed in such a way to control the movement of pedestrians. Trampled grass contributes minimally to ecosystem function. Furthermore organisms who reside here are in constant harm of damage, and as such only the resilient monocultures can exist. One can increase the biodiversity of the area by creating “no walk” zones which function also to control human traffic. The gardens placement was designed based on pedestrian movement and scarce vegetation growth. The following diagram shows the location of the garden ecosystem, which will be installed following the development of the western bus loop. The upgraded pavement will be laid according to the garden placement.

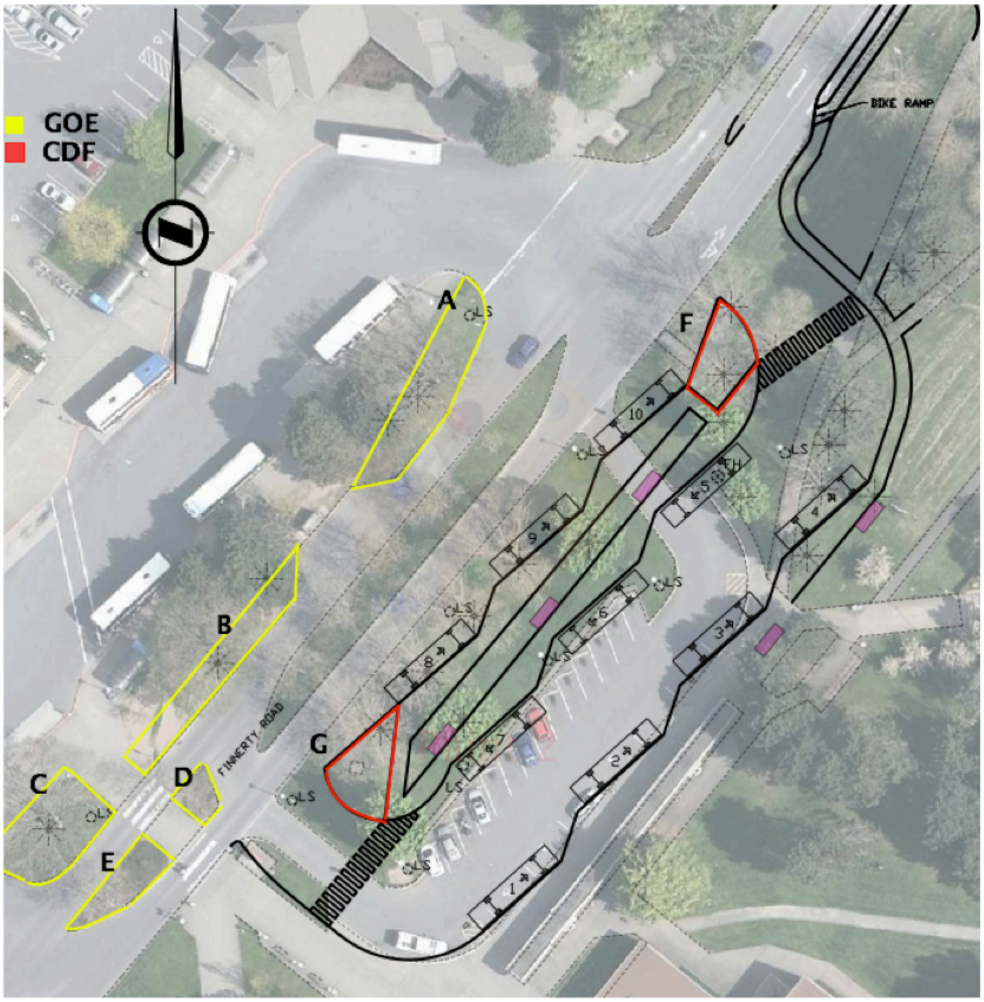


Figure 6: Placement of Native Garden Ecosystems

Table 1: Garden quantitative measurements

Garden	Average Length (m)	Average Width (m)	Average Area (m^2)
A	25.4	6.20	158
B	28.5	3.72	106
C	14.3	7.44	106
D	4.96	4.96	24.6
E	12.4	3.72	46.1
F	12.4	9.92	61.5
G	9.30	7.13	66.3
Total			569

4.5.2 Reference Ecosystem Selection and Planting Strategies

The University of Victoria bus loop should be representative of local pre colonial ecosystems. Seven native plant gardens will exist on the bus loop. Both Garry Oak and Coastal Douglas-Fir ecosystems will be embodied in these gardens. The nature of the fragmented gardens insures that a fully functional, intact, and healthy CDF ecosystem can never truly exist in the bus loop. However by establishing these ecosystems will improve the biodiversity of the area, utilize plants in pollution removal, and encourage education in one of the most travelled areas on campus.

<u>Garden A, B, C, D, E:</u>

A Garry Oak Ecosystem was chosen as the reference ecosystem for these gardens. The Garry Oaks that currently stands within these areas, will act as starting points for the development of these Ecosystem. More trees, wildflowers, shrubs and grasses will be transplanted and grown in an attempt to increase the biodiversity of the gardens. These segmented gardens are more exposed to the sun and pollutants than natural ecosystems existing away from human development. Because of this, resilient plants were chosen for the gardens. GOERT Gardening Handbook provides the following guidelines for planting a Garry Oak Woodland Ecosystem:

Table 2: Planting Garry Oak Woodland Ecosystems

Structure	Technique	Possible plants
Grass	Plant three dominant bunch grass per square meter (10sq ft)	- California oatgrass (Danthonia *californica)* - Blue Wildrye (Elymus *glaucus)* - Idaho Fescue (Festuca idahoensis)
Herbaceous plants	For every square metre (10sq ft), plant six herbaceous perennials in random clumps between the grasses.	- Great Camus (Camassia *leichtlinii)* - Chocolate Lilly (Fritillaria *affinis)* - Two-colored lupin (*Lupinus bicolor)* - Nodding Onion (*Allium cernuum)* - Menzies' larkspur (Delphinium *menziesii)*
Shrub	For every five square metres (50sq ft), plant a shrub	- Oceanspray (Holodiscus *discolor)* - licorice fern (*Polypodium glycyrrhiza)* - Tall Oregon-grape (Mahonia *aquifolium)* - Baldhip rose (Rosa *gymnocarpa)*
Tree	For every 50 square metres (1000sq ft), plant a tree.	- Arbutus (Arbutus *menziesii)* - Garry oak (Quercus *garrryana)*

Table 3: Number of each type of plants required in gardens

Garden		Grass	Herbaceous	Shrub	Tree
A	158	474	790	32	3
B	106	318	530	21	2
C	106	318	530	21	2
D	24.6	74	123	5	0
E	46.1	138	231	9	1
Total	441	1322	2204	88	9

Gardens F and G

Garden F and G will be restored to represent a Douglas Fir Ecosystem. Like Garry Oak ecosystems, Douglas Fir Ecosystems have many functions including water uptake, filtration of contaminated water, and air purification. These ecosystems are aesthetically beautiful and hold cultural significance for first nation people. In order to have a functional Douglas Fir Ecosystem the following 4 structures must exist: big trees, decomposing trees, multi layered canopy (small trees, shrubs, herbaceous plants) and lichens (Franklin, Cromack, Denison et al.). The plants that make up these structures should be resilient, efficient at water uptake, and filter pollution from air, groundwater and soil. According to Franklin Cromack and Denison, a functional Coastal Douglas Fir Ecosystem requires different structures to have varying plant coverage over the area.

Table 4: Planting Douglas Fir Ecosystems

Structures	Abundance	Possible plants
Big Trees (>3m tall)	71%	- Douglas Fir (*Pseudotsuga menziesii)*
Dead Trees	Occur naturally	Fallen Standing
Smaller Tree (<3m tall)	11%	- Young Douglas Fir (*Pseudotsuga menziesii)*
Shrubs	Tall (>51cm) 20%	- Salal (*Gaultheria shallon)* - Oregon Grape (*Mahonia nervosa)* - Ocean – spray (*Holodiscus discolor)* - Nootka Rose (*Rosa nutkana)*
	Short (<51cm) 29%	- Trailing Snowberry (*Symphoricarpos mollis)* - White Fawn Lily (*Erythronium oreganum)*
Forbs	18%	- Western sword Fern (*Polystichum munitum)* - Vanilla leaf (*Achlys triphylla)* - Kinnikinnick (*Arctostaphylos uva-ursi)*
Lichens	Occurs naturally	

Table 5: Number of plants required for Douglas Fir Gardens

Garden	Area	Ground cover plants	Low Shrubs	High Shrubs	Small Trees	Big Trees
F	62	80	15	11	3	1
G	66	85	17	13	4	2
Total Ground Cover	128	165	32	26	7	3

4.5.3 Soil

Soils of different ecosystems vary. This is due to a number of factors including type of vegetation producing litter, climate, and decomposers and wildlife occupying the site. In order to have a functioning ecosystem, some work will have to be done to prepare the soils for plant growth. Garry Oak Ecosystems have richly organic upper layers (dark soils) created through the combined effort of vegetation and dry climate (GOERT: Garry Oak Ecosystems Recovery Team). Douglas Fir Ecosystems tend to have moderately dry soil with minimal nutrient (Capital Region District). According to Demarchi, Nuszdorfer, and Klinka the soil of Douglas Fir Ecosystems usually belong to the Dystric Brunisol soil great group with a Moders humus form.

4.5.4 Tree Re-plantation plan

According to the campuses on going sustainability goals, for every one tree removed, three trees have to be planted (University of Victoria). Our proposed project involves the removal of about twenty-one trees, meaning that ideally 63 trees will be replanted on campus. The vegetation plan involves planting 19 new trees in the respective gardens. This leaves 44 trees that need to be replanted. BC transit, has expressed an interest in a “buffer zone” in between the Halpern center and the SUB, where trees will be planted to lessen noise and pollution from bus loop.

4.6 Native Gardens Ecosystem Implementation

4.6.1 Stakeholders

In order to achieve our goals, a collaborative group of individuals must be involved. Stakeholders' interests need to be taken into account when designing vegetation for the site. As the university has expressed the need to increase paved areas for students waiting for transportation, trees will have to be removed from the site. The Universities initiative to plant three trees for every one removed, insures that trees will continue to be abundant on campus. Another concern expressed by the school is the trampled vegetation caused by people cutting across natural areas. Students and community members under the advisements of a specialist (biologist or ecologist) will participate in the vegetation removal, introduction and management.

4.6.2 Involvement

By engaging the community in the replanting process, the gardens would not only be more economically efficient, but would also create a connecting to place for those involved. This connection is important as it spreads interest in ecological processes and promotes others to care for unique ecosystems, like the ones residing in the bus loop. Under the advisement of a specialist in biology or ecology, an informative workshop will be held to inform participants of the goals and objectives associated with building these representative ecosystems. Each volunteer will be assigned to a particular native plant and provided information regarding its significance, appearance, and how it is to be planted. As a group, the volunteers will work together to prepare soil and plant the native vegetation.

4.6.3 Removal and control of invasive species

English Ivy is climbing several Western White Pines outside of the Student Union Building. Its success here, indicates a chance for future inhabitation. Student and community members under the advisement of a biologist or ecologist can be involved in its removal and prevention. In an effort to increase education regarding removal of invasive, an education workshop will be held prior to an Ivy pull. The following topics will be discussed in a collaborative workshop, and volunteers will be fed juice and cookies.

<u>Safety:</u>

- proper clothing should be worn (long sleeves, long pants, gloves and sturdy shoes)
- ivy should not be pulled from trees above your head as it could cause material to fall on your head or bod

<u>Reasons for pulling:</u>

- English Ivy mats forest floor, preventing indigenous plants from getting enough light to photosynthesis nutrients.
- trees around campus die due to the ivy, which climb up their trunks, increasing the wind resistance until the trees fall down.

<u>Process:</u>

- begin the removal process by pulling the Ivy from trees
- follow this by working outwards from the base of the tree, pulling the ivy to at least six feet from the base

<u>Tools</u>

- work gloves
- pruning shears
- lopping shear
- pruning saw

The removals of invasive species will address Goal 3 by encourage an increase in biodiversity of the area. According to Daniell Simberloffs article *The Threat to Biodiversity and What Can be Done* “Compared to other threats to biodiversity, invasive introduced species rank second only to habitat destruction, such as forest clearing”. Their existence is a major threat to the environment because they have the ability to change an entire ecosystem by crowding out native species. Furthermore, invasive species are usually free to thrive as there are rarely predators to control the invasive population.

4.6.4 Removal of non indigenous grasses

Non-indigenous grass species make up the majority of the undergrowth. In order to promote the growth of native ecosystems, all alien species must first be removed. Due to timing constrictions, grass will be removed from site by using a sod cutter. This method avoids unnecessary loss of topsoil by only removing the grass (including the roots) and the top 1 to 2 inches of soil. On average 2 people can remove and haul away up to 300-square feet in an hour (Yardcare). Four volunteers would be able to remove all the grass from the designated gardens sites within approximately one hour.

When should removal occur: after heavy rainfall

<u>Process:</u>

- insure no rocks are on removal site
- follow instructions on manual
- cutting involves lowering the blade, pushing the cutter forward a few feet, and checking the depth of cut periodically
- at the end of each row, raise the handles of the cutter in order to push the blade down and make a cut that severs your strip from the rest of the lawn
- repeat as needed until you've cut the sod from the entire area.

4.6.5 Soils

Being that both GOE and DFE soils tend to have nutrient-poor soils, one should refrain from fertilizing. The vegetated ground is currently raised so soil will have to be removed to level it out with the surrounding pavement. This will also help prevent unwanted weeds in the garden. By stripping off the top 5 –10cm overlying rich soil can be completely removed making the soil ideal for both Garry Oak and Douglas Fir garden ecosystems (GOERT: Garry Oak Ecosystems Recovery Team).

4.6.6 Planting the ecosystems

After grass has been completely removed, the soil should be dug to loosen it up, and any remaining roots removed. At this point table 2 and table 4 should be consulted so that shrubs, plants, grasses and trees are planted in proper proportions in the new garden beds. For Garry Oak Ecosystems, remaining open areas should be covered with at least 15cm (6”) Garry oak leaf mulch (GOERT: Garry Oak Ecosystems Recovery Team). The mulch will break down over a few months, preventing weed growth and retaining moisture. Specific planting requirements, may also be present in Appendix C.

4.7 Fence Design and Implementation

The rain gardens and garden ecosystems are located in an area of high traffic. Fences will be installation to protect the native plants within the gardens from being trampled or eaten by deer. Like the fence of the Garry Oak ecosystem outside Elliot building, it will be constructed from interlocking logs to be about 1 meter high (4 logs widths). This height was chosen as it will still deter pedestrian traffic, but it will also minimize the amount of wood required, reduce construction costs, and make the garden more visually appealing. Lastly, the wood from the trees that had been removed from the bus exchange area will be given to a local lumber company to be used as wood for our fence construction.

Figure 7: Fence Design

4.8 Signs for Education

There will be four educational signs installed in the area. One will pertain to each of the ecosystems restored in the native ecosystem gardens and will be attached to the fence surrounding the two of the gardens. These two signs will provide information concerning the history of the area, it's cultural values and protection importance. Another sign will be installed to the fence surrounding the corner rain garden facing the bus loop. This sign will contain information concerning both rain gardens installed, and commemorate the volunteers who participated in the construction of the gardens. Information such as the impacts a large transit such as this has on the environment and the details into how the rain gardens help to mitigate these effects to restore the ecosystems that have been degraded in the surrounding area. The final sign will be installed in the new centre island of the bus exchange. This sign will contain information of the new pervious concrete installed to the site. By the use of educational signs in the area will spread the knowledge of innovative environmental initiatives. They will promote historical knowledge of the area, provide insight into the benefits of a successful restoration effort.

5. Timeline

In order to gain adequate donor funding and volunteer participation, an open house will be held three months before the start of construction. Additionally an open house should be held annually to maintain support interest for the project and report how it has reduced pollution in nearby ecosystems. Construction will begin in May 2014 with the installation of permeable concretes and drainage systems to each garden. Approximately a week after being laid, the concrete will be strong enough to support workers so volunteers will be able to start creating the native garden ecosystems and rain gardens. Once all gardens are installed by end of August, the construction of fences can begin using recycled wood from trees removed in the construction of the new bus loop. Therefore we expect the entire project to be completed by September 1st 2014.

5.1 Construction Timeline of Rain Gardens

Table 6: Timeline of construction, instillation and monitoring of rain gardens

February 2014	Volunteers conduct soil drainage tests
May/August 2014	Construction Crew install drainage systems
February 2014	Advertise for volunteers and investors
August 2014	Volunteers install rain gardens
August 2014	Volunteers install fencing and signage
2-3 Years Following Installation	University of Victoria Grounds Crew to follow monitoring plan
The duration the rain garden is in place	University of Victoria Grounds Crew to follow monitoring plan

5.2 Detailed Timeline of Porous Concrete Installation

Table 7: Timeline of construction and curing process of porous concrete (Yaday et al., 2013)

Day	Installation Process
1-4	- Clear existing material, grade and pitch set - Prepare sub-base and lay Geotextile layer
5-6	Pour pervious concrete
6-13	Curing process
28	Maximum strength reached

5.3 Detailed Timeline for Native Garden Ecosystems

After pavement construction the following steps will be taken to create native garden ecosystems on campus.

Table 8: Hours required by a two person crew to complete the job at each garden location

Project	Hours required
Removal and control of invasive species	6 hours
Removal of non-indigenous grasses	6 hours
Soils	4 hours
Planting the ecosystems	12 hours
Fence Construction	16 hours

5.4 Detailed Timeline Summary

Table 9: Summary of Timeline with dates

Item	Time	Stages	Days
Preparation	February 2014	Soil Drainage Test	1
Volunteer	February 2014	Advertise for Involvement	1
		Advertise for investors	1
		Order Education Signs	1
Porous Concrete	May- August 2014	(Step 1) Site Preparation	4
		(Step 2) Pour and shape Concrete	2
		(Step 3) Stabilizing Concrete	7
		(Step 4) Maximum strength reached	15
Rain Garden	August 13-22, 2014	Excavate area	1
		Level Area	1
		Soils	1
		Rock Paths	1
		Native Plants	2
		Fence Construction	2
Native Garden Ecosystems	August 22-29, 2014	Removal and control of invasive species	1
		Removal of non-indigenous grasses	1
		Soils	1
		Planting the ecosystems	2
		Fence Construction	2
Education	August 30, 2014	Signage Installment	1
Construction Completed	September 1st, 2014		
Management by UVic Grounds Crew	2-3 years following construction	Follow short term management and monitoring plan	
	Each year	Follow long-term management and monitoring plan	

6. Budget

The existing budget for the University's transit expansion is between $750,000 and $1,000,000(Bell, Times Colonist). The construction of the rain gardens and Native Garden Ecosystems can happen in two ways; a landscaping company can be brought in to do all the work or we can reach out the UVic community for volunteers to help with the construction of the rain garden, which would be the ideal and cheaper route. The preparation and installation of porous concrete must be done by a qualified contractor with previous experience working with pervious surfaces. Although the equipment and crews required to install these porous concrete surfaces can be expensive, it is necessary for the longevity and efficiency of the product. A correct installation of porous concrete should last for more than 25 years, some companies also offer a 10 year limited warranty.

6.1 Median Rain Garden Budget

The central median rain garden is 180 m^2 in size, it is estimated that hiring a landscaping and construction company to do all the work, design, materials needed and installation would cost $10-$12 per square foot, but if we were to have volunteers that cost would decrease substantially. Given the above estimate, if the central median rain garden were to be completed entirely with construction and landscaping companies, it would entail a cost between $20,000 - $24,000. By taking the approach to build the garden with the help of volunteers the above cost could be cut approximately in half. By holding an information session on the rain garden proposal we can have a signup sheet for volunteers who wish to contribute to participate in the construction of the rain garden. To commemorate the community involvement the names of those volunteers can be listed as a special thanks on informational signage educating about the UVic bus exchange restoration project. A budget design put forward by the *North Carolina State University Biological and Agricultural Engineering Stormwater Team*, gives a more specific rain garden budget layout which will be used as the backbone for the following table.

Table 9: Budget for Median Rain Garden

<table>
<tr><th>Construction Element</th><th>Unit Cost</th><th>Total Cost</th></tr>
<tr><td>Excavation (including labour and Rental Equipment)</td><td>$9.50/Cubic Yard (Includes excavation for pipe trench) [8]

*NCSU estimates 374 yards^3 excavated per 2000feet^2 garden</td><td>$3,550</td></tr>
<tr><td>Hauling soils and debris</td><td colspan="2">Included in price above</td></tr>
<tr><td rowspan="2">Importing rock and sand</td><td>$0.40/cubic foot [8]

*Rain garden depth of 2.5ft required 5000 feet^3</td><td>$2000</td></tr>
<tr><td colspan="2">* This cost can be reduced if the existing soil is of sufficient quality for a rain garden, less sand needs to be used.</td></tr>
<tr><td>Piping and filter fabric</td><td>$2/linear foot [8] × 600ft estimate</td><td>$1200</td></tr>
<tr><td>Mulch</td><td>$0.30/square foot [8] × 2000 feet^2</td><td>$600</td></tr>
<tr><td rowspan="2">Vegetation</td><td>$0.30/square foot [8] (young plants and transplants*) × 2000 feet^2</td><td>$600- $800 estimate**</td></tr>
<tr><td colspan="2">Individual Plants for Median Rain Garden:<table><tr><th>Plant</th><th>Cost</th></tr><tr><td>Red Twig Dogwood</td><td>15 (1 gallon plants) x $10.00 = $150.00</td></tr><tr><td>Slough sedge</td><td>20 (1 gallon plants) x $4.75 = $95.00</td></tr><tr><td>Western</td><td>10 (9cm plants, 18 per flat) x $2.75 =</td></tr></table></td></tr>
</table>

	Columbine	$27.50
	Common camas	20 (9cm plants, 18 per flat) x $4.95 = $99.00
	Nodding Onion	8 (9cm plants, 18 per flat) x $2.75 = $22.00
	Total	$393.50 - 450* * Left room for expansion
Total estimated cost	$7743 - $7800	
Estimated cost per foot^2	$3.875 - $3.900per square foot	

6.2 Corner Rain Garden Budget

6.2.1 Material and Construction Cost

To account for the cost of both the corner and median rain garden, it will be advertised to be purchased and named according to the buyers wish. The amount to be advertised is the total cost for both rain gardens construction. The buyers name will then be installed on a plaque and fastened to the corner rain garden's fence. The cost of the plaque is approximated by Buy The Yard. (2013).

To approximate cost of the labour cost for the installation of the gutters was calculated according the Homewyse (2013) estimates. The price of the gutters was obtained from The Aberdeen Group. The Compost, mulch and soil cost estimate was calculated from the Buy the Yard website. The plants cost for both rain gardens was obtained from two local native plant nurseries: Fraser's Thimble Farms and Streamside Native Plants.

Table 10: Cost of Materials and Construction of Large Rain Garden

Object	Cost
Compost/Screened Sand	Total Volume varies on soil type: <u>Option 1</u> Compost: 59.8yards x 40% = 24yards 24 yards x $49.00 = $1,172.07 Screened sand: 59.8yards x 60% = 35.88 yards 35.88yards x 32.00 = $1,148.16
	<u>Option 2:</u> Compost: 59.8 yards x 35%= 20.93 yards 21 yards x $49.00 = $1,029 Excavated Soil: 59.8 yards x 65% = 38.87 yards 38.87 yards x $0 = Free
Mulch	Volume (50m long, 1m wide, 3in deep): 5 yards 5 yards x $32.50 = $162.50
Gravel	4 gravel paths: 0.5 yards 0.5 yard x $22.00 + $2.00 = $13.00
Fencing	Perimeter: Corner rain garden = 50m, Median rain garden = 125m Native Garden Ecosystem = 245m 140- 3 foot pieces of rebar x $ 0.31/ foot = $140 (ihlCanada) Labor and shaping of wood = 64 hours x $50/hour = $3,200
Plants total	$290.10
Plaque	Approximately (varies with inscription) = $1,800
Construction crew	Metal gutter: $5.00 x 3 = $15.00 Labour: 5 hours x $51.82 = $260
Volunteers Snacks	Juice, fruit and granola bars = $60
Maintenance and Monitor	Approximately= $100
	Total: $6.969.60- $7,212.67

Table 11: Cost of Individual Plants for Corner Rain Garden

Plant	Cost
Red Twig Dogwood	10 (1gallon plants) x $10.00 = $100.00
Douglas spirea Steeplebush	5 (1gallon plants) x $10.00 = $50.00
Slough sedge	10 (1gallon plants) x $4.75 = $47.5
Western columbine	3 (9cm plants, 18 per flat) x $2.75 = $8.25
Douglas aster	3 (9cm plants, 18 per flat) x $2.75 = $8.25
Common camas	3 (9cm plants, 18 per flat) x $4.95 = $14.85
Creeping Oregon grape	10 (1gallon plants) x $5.50 = $55.00
Nodding Onion	3 (9cm plants, 18 per flat) x $2.75 = $8.25
	Total: $292.10

Table 12: Total Cost of Corner Rain Garden

Item	Cost
Materials and Construction	$7,769.60- $8,012.67
Cost of plants	$292.10
Total	$8,062.60 - $8,304.77

6.3 Porous Concrete Budget

The cost breakdown of porous concrete materials and their installation at the University of Victoria bus loop are based on the cost structure of a similar project in Olympia, Washington (McFadden, 2005). In Olympia a major project to install 51,000 square yards of pervious concrete sidewalks was proposed and its cost was compared to the impervious alternative. In total, traditional impervious concretes including maintenance (less installation costs) were estimated to cost $101.16 per square yard, almost double the projected cost of permeable concretes at an estimated $54.16 per square yard (McFadden, 2005). The costs of materials and labour were scaled to the size of the bus loops and the detailed breakdown can be seen in Table 8. The total cost of $169,248 is around 20% higher than that of regular concretes but the savings occur when the drainage costs are considered (McFadden, 2005). McFadden suggests that since the sidewalk and other impervious surfaces are considered to pollution generating, the runoff must be treated before it can be diverted into a collection structure. McFadden discusses the extreme costs involved in creating an area to deal with this highly contaminated runoff, up to $100,000 scaled to the area of the bus terminals (McFadden, 2005).

Table 13: Porous Concrete Material and Installation Costs Breakdown (Stormwater Solutions)

Item	Cost	Quantity	Total Cost
Bankrun gravel	$20/cubic yard	1464 $yards^2$ at 6" thick = 81 $yards^3$	$1,620
Geotextile layer	$4.50/square yard	1464 $yards^2$	$6,588
Pervious Concrete	$60/square yard	1464 $yards^2$	$87,840
Labour and Equipment	$50/square yard	1464 $yards^2$	$73,200
Total			$169,248

6.4 Native Garden Ecosystem Budget

6.4.1 Equipment

Table 14: Equipment cost for Native Gardens and Garry Oak Ecosystems

Equipment	Price
Work gloves	Free – can borrow from grounds crew
Pruning shears	Free – can borrow from grounds crew
Lopping shear	Free – can borrow from grounds crew
Pruning saw	Free – can borrow from grounds crew
Sod cutter	Rental for $50/day = $50
Shovels	Free – can borrow from grounds crew
Garry Oak Leaf Mulch	Collected by leaf blowing machines on campus
Total	$50

6.4.2 Plants

Plants purchased from Fraser's Thimble Farms will be indicated by a star (*), and plants purchased from Streamside Nursery will be indicated with an apostrophe (‘).

Table 15: Cost of Plants Garry Oak Gardens

Structure	Total amount needed	Possible plants	Cost per plant	Average Cost per plant	Total cost
Grass	1322 bunches	- California oatgrass (Danthonia *californica)*	$0.14’	$0.14	$185
		- Blue Wildrye (Elymus *glaucus)*	$0.14’		
		- Idaho Fescue (Festuca idahoensis)	$0.14’		
Forbs	2204	- Great Camus (Camassia *leichtlinii)*	$0.46 *	$0.37	$815
		- Chocolate Lilly (Fritillaria *affinis)*	$0.63 *		
		- Two-colored lupin (*Lupinus bicolor)*	$0.15*		
		- Nodding Onion (*Allium cernuum)*	$0.15*		

		- Menzies' larkspur (Delphinium *menziesii)*	$0.46*		
Shrub	88	- Oceanspray (Holodiscus *discolor)*	$4.75*	$4.94	$434
		- licorice fern (*Polypodium glycyrrhiza)*	$4.75*		
		- Tall Oregon-grape (Mahonia *aquifolium)*	$5.50*		
		- Baldhip rose (Rosa *gymnocarpa)*	$4.75*		
Tree	9	- Arbutus (Arbutus *menziesii)*	$10.00*	$7.38	$66
		- Garry oak (Quercus *garrryana)*	$4.75*		
Total					$1330

Table 15: Cost of Plants for Douglas Fir Garden

Structure	**Total amount needed**	**Possible plants**	**Cost per plant**	**Average Cost**	**Total Cost**
Big Trees	3	- Douglas Fir (*Pseudotsuga menziesii)*	$8.50 *	$8.50	$25.5
Small Trees	7	- Young Douglas Fir	$4.50*	$4.50	$31.5
Tall Shrubs	26	- Salal (*Gaultheria shallon)*	$0.13*	$3.78	$98.3
		- Oregon Grape (*Mahonia nervosa)*	$5.50*		
		- Ocean – spray (*Holodiscus discolor)*	$4.75*		
		- Nootka Rose (*Rosa nutkana)*	$4.75*		
Short Shrubs	32	Trailing Snowberry (*Symphoricarpos mollis)*	$4.75*	$2.68	$85.7
		- white Fawn Lily (*Erythronium oreganum)*	$0.60 *		
Forbs	165	- western sword Fern (*Polystichum munitum)*	$4.75*	$1.67	$276
		- vanilla leaf (*Achlys triphylla)*	$0.13*		
		- Kinnikinnick (*Arctostaphylos uva-ursi)*	$0.13*		
Total					$517

6.4.3 Labor

Table 15: Labor Costs for Specialist and Volunteer Snacks

Specialist (biologist or ecologist)	$50/hr * 3	$150
Juice and cookie cost		$40

6.4.4 Total

Table 16: Total Budget for Native Garden Ecosystem

Section	Cost
Equipment	$50
Plants (Douglas Fir and Garry Oak ecosystems)	$1,847
Labor	$190
Total Cost	$2,087

6.5 Bus Loop Restoration Cost

Table 16: Summary Table of Restoration Cost

Section	Cost
Median Rain Garden	$7743 - $7800
Large Rain Garden	$6.969.60- $7,212.67
Porous Concrete	$169,248
Garry Oak and Native Gardens	$2,087
Educational Signs	4 signs @ $200 each = $800.00
Total Cost	$187,140.70 – $187,349.77.

7. Management and Monitoring

Management and monitoring is necessary to insure the success of restoration projects, being that it consists of continuous cycles of assessment and upkeep. A successful restoration effort is perceived with the goals and objectives being continuously met. For this reason, it is crucial that the management plan be adapted when faced with unforeseen changes in restored areas. As IUCN's Ecological Restoration for Protected Areas (2004) explains, in order to make the correct adaptations, an effective management plan sets out clear protocols for those to follow in order to ensure detailed and consistent results are recorded. A precise recording of results will entail that the correct adjustments are made to the project.

To continually engage the stakeholders, the public will be kept up-to-date through continuous postings on the University of Victoria restoration webpage, which will also encourage comments and suggestions for improvements to be made. In addition, an annual open house will be held, detailing the changes made according to the results. This will also provide a chance to receive suggestions for current and future adjustments.

The grounds crew of the University of Victoria will provide the basic monitoring procedures of the site. These procedures include the maintenance and contributing to the evaluation of the project's goals and objectives being met. The success of the educational signs will be analyzed by the amount of people observed reading the signs. This observation will be noted by the grounds crew as they perform their management duties to the pavements, rain gardens and native ecosystem gardens. The success of the signs will be rated as in one day: more than five people in one day being very good, one to five being moderately successful and none being ineffective. Based on the results obtained, adjustments may include putting the signs in a different location, changing the information on the sign or installing more signs.

The grounds crew will also note as they perform the necessary maintenance to the site any damage incurred on the fence, to the plants or to the pavements that may require immediate or future attention. The assessment for damage such as trampling or abuse to the site will provide insight into the effectiveness of the fence. From this data, adjustments such as raising the height of the fence or other parameters can be proposed. Two simple observation tables are provided in the appendix for the grounds crew to use to record their data.

7.1 Pervious Concretes

The management plan specifically for the pervious concrete will be done by the University of Victoria grounds crew, as it entails simple cleaning procedures. As suggested by McFadden, the plan involves maintenance procedures that will persist over a 10-year period (McFadden, 2005). This management plan includes vacuuming the area bi-annually in order to maintain adequate storm water management and pollution trapping. Additionally, every 5 years, a thorough pressure washing of the pavement will take place to fully dislodge any contaminants that may be present deep within the porous concretes (NPDES).

The success of the permeable pavement will be assessed based on repair costs, and the data collected by students measuring for contaminants. To measure for these contaminants, an evaluation plan will consist of testing for the reduction of chemicals in the storm water by analyzing samples of water and soil at major headwaters in the surrounding areas where it is known the water from the bus loop travels. This will determine the scale to which the permeable concretes have reduce pollutant runoff. Tests will be conducted once a month for 2-3 years in order to gain an accurate range of data. The testing will also be completed in the soils beside the bus loops before and after the installation to determine the immediate effects of the pavements on soil quality. It may take time for the effects of the permeable concretes to be noticed because water samples take a while to percolate through soils and make their way to the headwater.

7.2 Rain gardens

Rain gardens require detailed monitoring plans to ensure they are effective, efficient, and engaging. The first few years following the creation of a rain garden are the most vulnerable in insuring the gardens success, and will therefore require more human involvement. Following heavy rainfall events, it will be necessary to check the rain gardens for uprooted small shrubs, since they will not have fully established their root system (DiNardo). To encourage the establishment of stable and strong root systems, irrigation will be required for the first 2-3 years. Over the first year, shrubs will require 3-5 gallons, once every 1-2 weeks and ground cover plants will require 1-2 gallons, 1-2 times per week. For the second year, shrubs require 3-5 gallons every 2-4 weeks and ground-covering plants require 1-2 gallons every 2-4 weeks (Hinman. C, & WSU Extension Faculty, 2007).

Native plants were chosen since they require less long term maintenance. Each garden will however still require maintenance based on the observational data recorded by the grounds crew. It is estimated that annual addition or replacement of the mulch layer will be necessary to maintain a healthy 2-3 inch thick layer (Hinman. C, & WSU Extension Faculty, 2007). Monthly procedures may include weeding, pruning, and checking for soil erosion, exposed soil and plant coverage. Weed management will consist of removing any weeds present in the rain gardens. The gardens will still function if weeds are present, however they will restrict native plant growth and deduct from garden aesthetics. Monthly pruning, and checking for soil erosion and exposure will control garden growth to the designated areas and maintain a healthy plant coverage. Specifically, as the central median rain garden is located so close to multiple deciduous trees, it will be necessary to remove leaf clutter, as it will reduce water drainage. The costs of substance replacements can only be approximated, given it is dependent on time, weather conditions and plant survival.

The long term monitoring plan for the two rain gardens will ensure that the goals and objectives are constantly met to ensure the success of the rain gardens. The success of both rain gardens will be assessed on an annual basis. Since the location of the site is at a university, students in environmental studies will perform the monitoring procedures for the rain gardens. These procedures will consist of soil and infiltration testing and creating a photo journal of the gardens progress. Soil testing will sustain the pH at a proper acidic level which will be between 5.2 and 7.0, as recommended by the Rutgers Rain Garden maintenance guide(DiNardo). As the infiltration rate will be determined prior to the rain gardens construction, the comparison of pre and post construction infiltration rates, will deduce the success of each garden. The post construction test will be done by following the same procedure as the initial filtration test, however instead of a hole, a small amount of water on the surface of each rain garden will be tested. The infiltration rate should remain similar throughout the years that the rain gardens are present. These tests will allow us to evaluate the effectiveness of the rain gardens. A photo journal will be used to track the progress of the plants and be able to check for any slow degradation of soil over time(DiNardo). The results from the soil testing, infiltration and the photo journal will be made public and feedback will be encouraged so that adaptations can be made and the rain gardens can reach their full potential.

7.3 Native Garden Ecosystem

In order to monitor ecosystem success by plant propagation, upper level environmental studies or biology students will be involved. After the gardens have been planted, the students will document species composition/abundance. Over the first year of growth, students will make observations on a bimonthly basis recording species response to changes to site and the development of the plants. After the first year the gardens will be monitored annually. In June, when plant species bloom and are easily identifiable, composition/abundance should be again recorded. Depending on the experience of the student, it may be beneficial to return again in late April, when bulb plants are blooming.

Lastly, if students record English Ivy or other invasive species, it should be removed immediately to insure that its effect on the ecosystems is kept to a minimal.

In order to assess the success of the ecosystems, all researched will be compiled into a database and compared to composition of intact Gary Oak and Douglas Fir ecosystems. Furthermore key principle of island biogeography can be examined by comparing these isolated ecosystems against their wild equivalences. If the ecosystem is observed to develop uniquely in comparison to surrounding ecosystems, one will be able to observe a basic form of island biogeography.

The amount of management needed in the individual gardens will be determined by the results collected through monitoring of ecosystems. Unsuccessful plant growth or exotic species invasion are a few examples of times when implementation strategies will have to be revisited by experts or innovative students in biology or environmental studies. Since the plants found in Garry Oak and Douglas Fir Ecosystems are native to Vancouver Island, little maintenance will be required from UVic faculty management. It is well known that Garry Oak Ecosystems have been maintained by indigenous populations by careful burning of the vegetation. Being that the restored ecosystems are in high traffic areas, this will not be possible, since pedestrian safety may is a primary concern. Both gardens should be pruned and weeded on a monthly basis for aesthetic purposes.

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9. Appendix

9.1 Appendix A

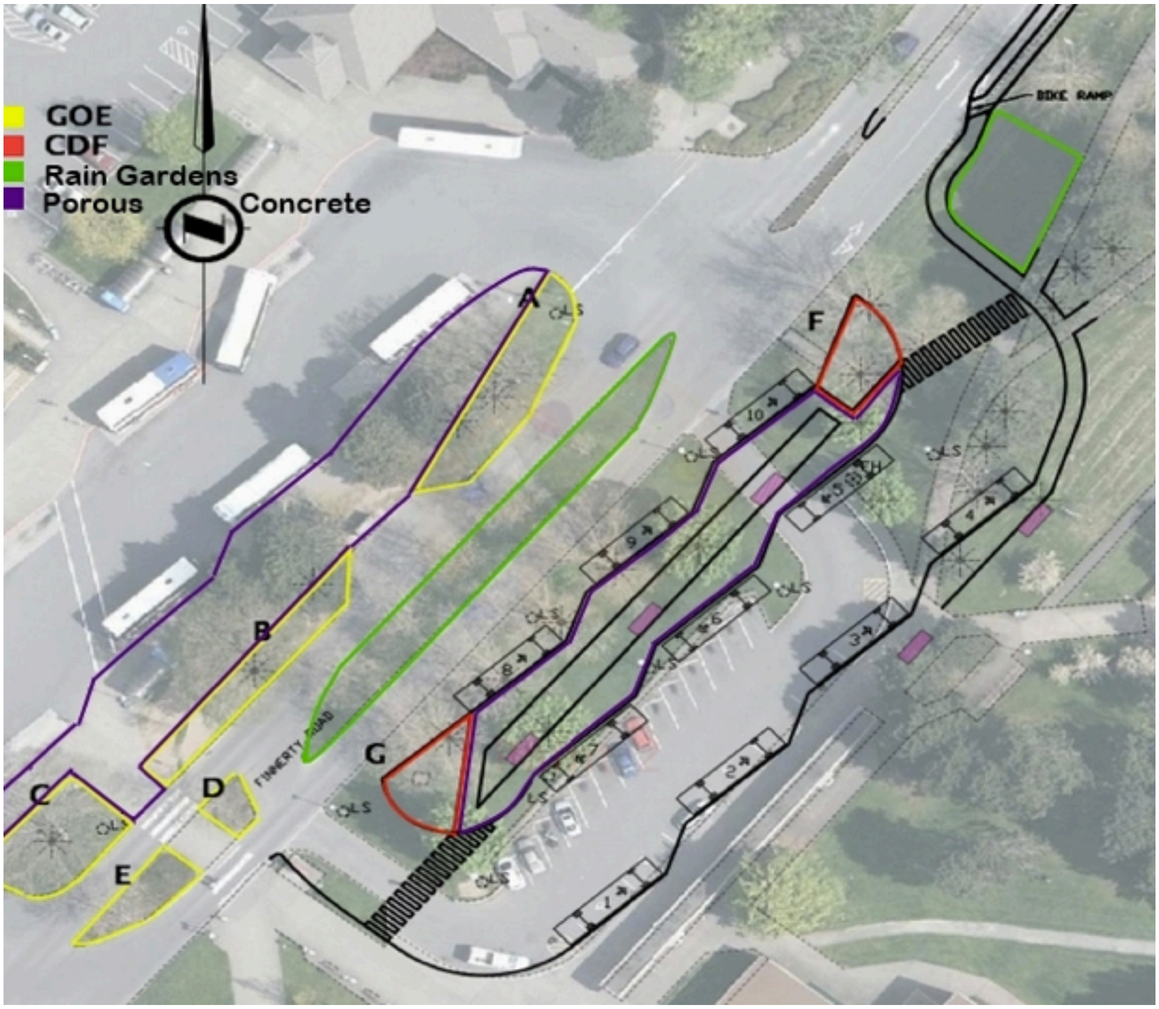


Figure 8: Restoration Project Layout

9.2 Appendix B

Maintenance and Success Evaluation

Table 17: Grounds Crew Monthly Educational Signs Observations

Educational Sign	People Observed	Comments
Corner Rain Garden		
Garry Oak Native Ecosystem		
Douglas Fir Native Ecosystem		
Pervious Concrete		

Table 18: Grounds Crew Monthly Maintenance Observations

Site	Status (Good / Adequate / Needs repair)
Corner Rain Garden	
Native Garden Ecosystem (indicate each)	
Median Rain Garden	
Pervious Concrete	

9.3 Appendix C

Table 19: Native Plant Description

Plant	Image
Red Twig Dogwood *(Cornus sericea)* - Sun/partial sun - Grows to 15ft. - Blooms May & June - Grows in wet-moist, rich soil, tolerates seasonal flooding - Small white flowers in clusters, berrylike bluish-white fruits	 * **http://www.monrovia.com**
Slough sedge *(Carex obnupta)* - Sun/partial shade - Grows 1-5ft. - Grows in moist to seasonally saturated soils - Shiny foliage - Excellent soil binder	 * **http://nativeplantgarden.org**
Douglas spirea Steeplebush *(Spiraea douglasii)* - Sun/partial shade - Grows 4-7ft - Grows in moist or dry to seasonally inundated soils - Spikes of small pink flower clusters; may spread in wet soils	 **www.ourhabitatgarden.org**
Western columbine (*Aquilegia formosa)* - Sun/partial shade. - Grows 1-3ft. - Tolerates soils of varying quality - Tolerant of seasonal flooding - Red and yellow flowers attracts hummingbirds and butterflies	 **www.fs.fed.us**

Douglas aster *(Aster subspicatus)*

- Sun
- Grows 6”-2.5ft.
- Blooms June-September
- Grows in moist soils, blue to purple flowers

www.nwplants.com

Common camas (*Camassia quamash)*

- Sun/partial shade
- Grows to 1.5ft.
- Blooms May-June
- Moist to dry soils
- Loose clusters of deep blue flowers

en.wikipedia.org

Tall Oregon Grape *(Mahonia aquifolium)*

- Sun or shade
- Grows 3-6ft, up to 5ft wide
- Blooms March – April
- Black berries after bloom
- Valued for its striking foliage and flowers

www.reed.edu

Creeping Oregon grape (*Mahonia repens)*

- Sun
- Dull green leaves in 7-21 serrated leaflets
- Yellow flower clusters
- Bloom April-June
- Blue berries
- Well-drained soil

science.halleyhosting.com

Nodding Onion *(Allium cernuum)*

- Pink-purple flowers
- Grows to 18in
- Blooms in July-August

www.ofnc.ca

Ocean Spray *(Holodiscus discolor)*

- Shrub with several main stems to 4 m height
- Leaves alternate, deciduous, slightly hairy, and oval to triangular in shape
- Flowers small, white to cream in color
- Prefers well-drained soils in sun or partial shade.

http://shrubstudy2.blogspot.ca

California oatgrass (Danthonia *californica)*

- 30-130 cm tall
- Leaves are smooth or soft hairy sheaths
- Seems to prefer some moisture until established; plant in sun to light shade

http://www.goert.ca

Blue Wildrye (Elymus *glaucus)*

- Stems 30-180 cm tall
- Leaves are smooth to rough sheaths, with white hair close to the base and often purplish

http://www.goert.ca

Idaho Fescue (Festuca idahoensis)

- Densely clumped perennial with stem 30-80 cm
- Has stiff and short rolling leaves
- Hairy spicules that produce awned fruit

www.laspilitas.com

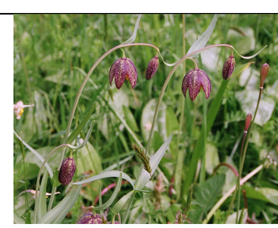
Great Camas (Camassia *leichtlinii)*

- Grow from a deep, egg-shaped bulb (2-4 cm long)
- Flowering stems 20-100 cm tall, smooth
- Flowers pale to deep blue of six similar, distinct, petal-like segments
- Plant bulbs fairly deep and space 6-12" to form a drift in sun in dry to moist but well-drained soil

http://www.goert.ca

Chocolate Lily (Fritillaria *affinis)*

- Perennial herb (80 cm tall)
- Grow from a scaly bulb with numerous rice-like bulblets.
- Flowers dark purple mottled with greenish-yellow, bell-shape (4 cm long)
- Plant in well-drained, sandy soils, rich in humus. Space plants 15 to 30 cm for best effects



http://www.goert.ca

Two-colored lupin (*Lupinus bicolor)* - Brown-hairy herb, 10-45 cm tall - 5-8 leaflets, to 4 cm long - Flowers blue and white, pea-like, small	 http://www.goert.ca
Licorice Fern (*Polypodium glycyrrhiza)* - Small to medium sized evergreen fern - Licorice - flavored - Blades to 50 cm long, with leaflets with pointed tips and finely toothed margins. - Sow in high densities on the surface of a humus rich, sterilized soil	 http://www.goert.ca
Baldhip Rose (Rosa *gymnocarpa)* - Spindly shrub, to 1.5 m tall, with slender stems - Thorns and alternating deciduous leaves - Flowers small and pale-pink with five petals, numerous stamens, usually solitary - Open sun to partial shade. Moist to dry sites.	 http://www.goert.ca
Arbutus (Arbutus *menziesii)* - Broadleaf tree, 6-30 cm tall, often with many stems from the base - Bark ages to a deep brownish-red and peeling off - Leaves are evergreen, leathery, egg-shaped to elliptic	 http://www.goert.ca
Garry Oak (Quercus *garrryana)* - Grow 12 to 35 m tall - Bark is light grey, with thick furrows and ridges. - Leaves are alternate and deciduous with round-lobes - Acorn bearing	 http://www.goert.ca
Douglas Fir (*Pseudotsuga menziesii)* - Large, tall (70-90 m) coniferous tree - Needles spirally arranges, flat, yellow-green, 2-3 cm long, - Bark very thick, ridged, rough and greyish-brown. - Select sunny, open, roomy conditions in neutral to slightly acid, well drained, moist soils.	 http://www.goert.ca

Salal (*Gaultheria shallon)* - Evergreen shrub with average height of 5 ft - Thick and tough egg – shaped leaves - Partial shade/sun - Spring flowers look like little white bells and are slightly sticky and hairy	 https://green.kingcounty.gov
Nootka Rose (*Rosa nutkana)* - Medium to tall shrub (0.5-3 m) - Leaves are alternating and deciduous - flower is single with five pink pedals - Prefers rich, moist soil but will tolerate drier mineral soils. Sun to partial shade.	 http://www.goert.ca
Trailing Snowberry (*Symphoricarpos mollis)* - Deciduous Groundcover that grows to 3 ft - Tends to grow low and spread - White berries and small white to pink flowers	 https://green.kingcounty.gov
Vanilla Leaf (*Achlys triphylla)* - Perennial Groundcover - Attractive white spike of flowers rising from leaves - Partial shade/shade	 https://green.kingcounty.gov
Kinnikinnick (*Arctostaphylos uva-ursi)* - Leaves: Alternate, evergreen, leathery, egg- to spoon-shaped - Flowers are pinkish-white and urn-shaped - Sun to partial shade; tolerates poor, dry, infertile soil	 http://www.goert.ca

9.4 Appendix D

Project Breakdown:

The project was divided into four sections (pervious concrete, corner rain garden, median rain garden, and native garden ecosystems), and it was the job of each member to research and design every element for their respective section (design, implementation, timeline, budget and management). Each person was then assigned to major components of restoration projects, and formatted and edited the initial four sections into this second component (collaboration).

<u>Bryana Matthews:</u>

Research and Design: Corner Rain Garden

Collaboration: Monitor & Management, Goals & Objectives, Key Editor

<u>Ryan Glenn:</u>

Research and Design: Central Median Rain garden

Collaboration: Design and Implementation, Editing, Title page and graphic banners

<u>Sydney Flowerday</u>

Research and Design: Native Garden Ecosystems

Collaboration: Introduction, Site Analysis, Goals and Objectives, Key Editor, Formatting

<u>Alex Fraser:</u>

Research and Design: Porous concretes and Pollution Runoff

Collaboration: Budget and Timeline, Editing