Impervious Surfaces on Campus

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Restoration Design Project
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### Table of Contents

1.0 **Introduction** ......................................................................................................................... 2  
2.0 **Site Analysis** ......................................................................................................................... 2  
   2.1 Location  
   2.2 Geography/Site Description  
   2.3 Culture and History  
   2.4 Problem Identification  
3.0 **Policy, Goals and Objectives** .............................................................................................. 8  
4.0 **Plan Design** .......................................................................................................................... 9  
   4.1 Restoration Focus Plan  
   4.2 Runoff Reduction Plan  
   4.3 Permeable Alternatives Plan  
5.0 **Implementation and Management** ..................................................................................... 18  
   5.1 Qualitative Factors  
   5.2 Quantitative Factors  
6.0 **Monitoring and Evaluation** .................................................................................................. 23  
   6.1 Monitoring the Restoration Focus Plan  
   6.2 Reducing the Amount of Runoff into Bowker Creek  
   6.3 Monitoring Alternative Permeable Parking Lots  
   6.4 Evaluation  
   6.5 Monitoring Checklist  
7.0 **Conclusion** ........................................................................................................................... 29  
**References** .................................................................................................................................. 31  

Who did what: Casey did some preliminary planning. Zoey and Kelsey worked together on sections 1.0, 2.0 and 5.0. Casey and Megan worked together on sections 3.0 and 4.0. Yang worked on section 6.0. Kelsey also did section 7.0. Zoey did the final editing with help from Kelsey, Casey and Megan. Zoey also put together everybody’s contributions and organized the layout of the project document.
1.0 Introduction

Impervious surfaces are a big part of life today, it is what we spend the majority of our day on, but do we ever stop to consider the impacts these surfaces have? Not just for us directly, but also for the ecosystem within which it was constructed. Our project was initiated knowing that impervious surfaces can have detrimental side effects on an ecosystem. Some of these side effects include storm drain run off (both quantity and quality), heat island effects, as well as a lack of habitat for animals and plants. The task of this project was to find ways to address the issue of impervious surfaces and its effects on the environment and to try and find solutions to mitigate them. As a group we decided to narrow our focus towards stormwater runoff from UVic and Bowker Creek, a river that has its headwaters start on the campus of the University of Victoria (UVic). With the use of survey information, reference to the UVic Integrated Stormwater Management Plan coupled with in-site measurements, this report will provide a layout of costs, benefits and priorities to decide on what impervious surfaces our project will primarily focus on.

2.0 Site Analysis

2.1 Location

UVic is located at the southern tip of Vancouver Island off the southern coast of mainland BC. It is on the far east part of the Southern tip. The Northern half of UVic is in the Municipality of Saanich, whereas the Southern half is in the District of Oak Bay (Appendix B - Glossary 2006). Bowker Creek is an extensive stream that commences at a wetland situated on the UVic campus. The water from this wetland enters a culvert, which is situated under Gordon Head Road. Water then proceeds to enter a stream drain network located underground starting on Gordon Head road, running through the municipalities of Saanich, Victoria and Oak Bay, finally discharging into the ocean near the Glenlyon-Norfolk school in Oak Bay (CRD 2013a).
2.2 Geography/Site Description

2.2.1 Hydrology
Based on Gonzales weather station historical data from 1971-2000, Victoria on average receives just over 600 mm of precipitation and just under 2200 hours of bright sunshine per year (Canadian Climate Normals 1971-2000 n.d.). Presently, 23.5% of campus is impervious area; some examples include sidewalks, rooftops and parking lots. Due to this increase in impervious surface area it had resulted in twice the amount of ‘normal’ amount of runoff into Bowker Creek and Hobbs Creek (Integrated Stormwater Management Plan 2004). 50% of the watershed of Bowker Creek is estimated to be composed of impervious surfaces (CRD 2013a).

2.2.2 Physical Geography
Bowker Creek’s main channel is approximately 8 km long, with a watershed that has a total drainage area of 1028 hectares. Before water from Bowker Creek is discharged into Oak Bay, the water flows through open channels, drains and culverts. The ground slopes of Bowker Creek are relatively flat (slopes are less than 5%). However, there a few areas that have slopes that are much steeper, for example, Mount Tolmie. The Geological Survey of Canada (GCS) reports that underlying soils are predominantly clay, with areas of gravel and sand (Bowker Creek Master Drainage Plan, 2007).

2.2.3 Ecology
UVic is situated in the Coastal Douglas Fir biogeoclimatic zone, this zone is ‘home to a unique and sensitive group of ecosystems known collectively as Saanich, meaning “place of fertile soil” in the language of the local aboriginal people’ (Egan 1999, 2). It has a Mediterranean-like climate with sunny summers and mild winters. Bowker Creek goes through several ecosystems starting at the headwaters and ending at the ocean: terrestrial, freshwater, riparian and marine.
2.2.3.1 Terrestrial Ecosystem
Bowker Creek is now classified by urban areas yet it still contains nature. Wildlife and natural vegetation can be found along Bowker Creek. Bowker Creek is a watershed that is located in the Coastal Douglas Fir (CDF) geoclimate zone. Both native and exotic plants are located in Bowker Creek, however while some exotic species are harmless some are invasive, such as Scotch Broom (*Cytisus scoparius*) and English Ivy (*Hedera helix*) (CRD 2013a).

2.2.3.2 Freshwater Ecosystem
Bowker Creek is limited to invertebrate species, which includes larvae and worms; fish can be found in small numbers by the mouth of the channel. Water quality for aquatic life in Bowker Creek has been listed as “acceptable”, but is believed to be one of the major factors in limiting fish habitat. The current condition of the channel is a threat to the current fish populations as well as organic life more generally, mainly due to the underground storm drains. Certain areas of the creek are open but unsheltered and therefore not ideal for supporting life. The flow of the water is very destructive, primarily due to impervious surfaces, which causes erosion of the banks due to the high velocity of the water entering Bowker Creek. This is contrary to normal, stable streams which have rocks, fallen trees and bends to slow down the flow of water, thereby making it less destructive (CRD 2013a).

2.2.3.3 Riparian Ecosystem
Riparian zones are defined as being the transition zone between aquatic and terrestrial ecosystems. The soil in Riparian ecosystems absorbs water from floods/storms, which aids in reducing downstream damage and filters out contaminants from the water. Overall, riparian ecosystems lead to a highly productive environment due to the specialized plants and microbes that flourish in saturated soils. Few Riparian areas are situated around Bowker Creek, one part of a riparian ecosystem is found at the headwaters at the University of Victoria. The riparian zones that used to be present around Bowker Creek were transformed into dry terrestrial ecosystems due to falling water levels in the creek (CRD 2013a).
2.2.3.4 Marine Ecosystem
Water from Bowker Creek is eventually discharged into Oak Bay. This area of the ocean is home to many different species, including harbour seals and even further out, orcas. Therefore water quality is an important factor to consider here, as it can affect the marine diversity negatively or positively (CRD 2013a).

2.2.4 Species Present
Bowker Creek contains numerous species of trees, shrubs and herbaceous plants. Trees include the ‘Douglas fir (Pseudotsuga menziesii), western flowering dogwood (Cornus nutallii), black cottonwood (Populus balsamifera), western redcedar (Thuja plicata), bigleaf maple (Acer macrophyllum) and arbutus (Arbutus menziesii)’ (CRD 2013a). The shrubs include ‘Nootka rose (Rosa nutkana), common snowberry (Symphoricarpos albus), salal (Gaultheria shallon), Oregon grape (Mahonia sp.), willows (Salix sp.), red-osier dogwood (Cornus stolonifera), Kinickinnic (Arctostaphylos uva-ursi) and Indian plum (Oemleria cerasiformis)’ (CRD 2013a).

2.3 Culture and History
UVic is currently (academic year 2012-2013) celebrating 50 years since receiving its degree status in 1963. Its predecessor goes back to 1903, when it was known as Victoria College, and the three martlets on UVic’s shield come from a time when Victoria College was affiliated with Victoria College (Facts and Reports n.d). UVic strives to be sustainable (Sustainability n.d.).

Where UVic is currently located, used to be an army camp. In 1959, due to pressure from increasing enrolment (Turner & Lovell 1999), UVic bought ‘the Gordon Head Army Camp and adjoining property from the Federal Government for $115,500 and 141 acres from the Hudson's Bay Company in Oak Bay for $438,235’ (Icons and Landmarks n.d.). In 1963 UVic (as it was no longer Victoria College) held classes in two places (as the new location was still under construction), its current location and the Victoria College’s old location on Lansdowne. By 1966, all students attended the new location. In 2011-2012 there were over 20,000 students attending UVic, as well (in March 2012) there were approximately 4500 employees (Icons and Landmarks n.d.). Due
to the presence of so many people, it does not come as a surprise that there is a high impact of impervious surfaces; high pollutions on the roads and parking lots from many cars. Trampled grass is a problem from many thousands of feet trying to find the shortest route around campus, and many kilometers of paved sidewalks in order to prevent the trampling of grass.

Historically, Bowker Creek consisted of low gradient streams with several small tributaries. Bowker Creek was rich in biodiversity, as fish and wildlife were commonly found around the area. Collectively, the First Nations had a cultural connection with the Creek as they collected food from the streams, including salmon, as well as freshwater. Bowker Creek was predominantly the major source of nutrient transportation to the ocean in Oak Bay and significantly assisted in contributing to a healthy marine ecosystem (CRD 2013a).

In terms of the history of impervious surfaces that reside on campus, UVic originally had minimal impervious surfaces. Historically, UVic was predominantly upland fir forest and water runoff was not of huge concern for three reasons: the forest canopy was extensive as it contained rich, organic soils, which absorbed the majority of the water and therefore largely eliminated runoff. The topography of UVic at this time was not subjected to runoff (See Figure 3, below). When the military base was propagated, extensive deforestation occurred which resulted in water being shed instead of being absorbed (Integrated Stormwater Management Plan 2004) (See Figure 1 and 2).

Figure 1: Aerial View of UVic Campus, 1965 (UVic 1965)  Figure 2: Aerial View of UVic Campus, 1980 (UVic 1980)
2.4 Problem Identification

The site analysis consisted of an assessment of which areas of the University of Victoria campus had the greatest priority/need for restoration in terms of dealing with impermeable surfaces. The assessment showed that there were several: such as parking lots, rooftops, sidewalks, roads, the bus terminal, trampled grass and the storm drains that lead into Bowker Creek. Each is of great importance, but due to the limited timeframe and resources for this project we have chosen to focus on limiting the quantity and improving the quality of stormwater exiting UVic and entering Bowker Creek.

Focusing on stormwater is important because there are many impervious surfaces present at UVic that negatively affect the water (both qualitatively and quantitatively) consequently affecting the organisms that live in-stream and the users of the water downstream. The high percentage of impervious surfaces results in more water being channelled into the stream, on top of that higher concentration of pollutants are involved with impervious surfaces. As well, an increased quantity of water reaching the stream quickly/directly (as it is no longer slowly progressing through the soil to the stream) also impacts the ecosystem as it causes the stream channel to erode, thereby making the stream water cloudy and destroys habitat, which are both negative impacts on the users of water (CRD 2013a).
3.0 Policy, Goals and Objectives

Bowker Creek is an extensive stream that commences at a wetland situated on the University of Victoria campus, and discharges into the ocean near the Glenlyon-Norfolk school in Oak Bay (CRD 2013a). The watershed flowing into it is located adjacent to an urban area comprised of influential impervious surfaces. Stormwater runoff generated by these surfaces has a negative impact on Bowker Creek through stream degradation and pollutant input. Community members, UVic students, municipal governments, and hobby restorationists have engaged in many projects associated in solving these problems. Our group will work toward creating relationships with these groups, and achieving their common goals.

During the development of this restoration project, our group determined that the urbanization of the areas adjacent to Bowker Creek has eliminated the possibility of restoration to a historical trajectory. Heavy modification of surfaces through the installation of asphalt and concrete cannot be completely reversed without the deconstruction of a large amount of university infrastructure. Despite this, the condition of Bowker Creek can be improved with the proper application of restoration efforts by our project.

This section will state the policy, goals, and objectives of our project. Additionally it will provide a description of how goals and objectives are connected to our policy.

**Policy:** To ensure the establishment and preservation of ecological integrity of Bowker Creek.

**Goal:** To reduce the impacts of impervious surfaces on water quality and quantity in Bowker Creek.

- Impervious surfaces will be assessed and altered according to their impact in order to establish and preserve ecological integrity of Bowker Creek.
Objectives:
1. Identify impervious surfaces on campus, quantify their need for restoration, and select areas of highest priority to focus restoration efforts.
   ➢ This will ensure the efforts of our restoration project are successful in establishing and preserving the ecological integrity of Bowker Creek.

2. Reduce the amount of runoff into parking lot storm drains that lead directly to Bowker creek by installing curb cuts on the edges of parking lots, and constructing rain gardens adjacent to them.
   ➢ This will establish and preserve the ecological integrity of Bowker Creek by reducing the degrading effects of stormwater runoff, in addition to reducing pollutants in the stormwater entering the creek.

3. Create a plan for installing alternative permeable parking lots when existing lots require repaving and when new lots are constructed.
   ➢ This will provide the continuing establishment and preservation of ecological integrity in Bowker Creek, by reducing the impacts of impervious parking lot surfaces.

4.0 Plan Design
Permeable surfaces have undergone an increase with the development of infrastructure on the UVic campus. The increase in these surfaces bring with them greater rates of stormwater runoff, Figure 3 indicates this increase.

The development of objectives to reduce impacts of these impervious surfaces on water quality and quantity in Bowker creek will be addressed by the following 3 plans:
1. A Restoration Focus Plan
2. A Runoff Reduction Plan
3. A Permeable Alternatives Plan
This section of the restoration design project is a description of these plans and what each one entails. More specifically it outlines the maps, surveying, and references used to choose our restoration focus. Additionally it includes the size, structure, and function of the rain gardens and permeable surfaces we propose to install.

4.1 Restoration Focus Plan
The Restoration Focus Plan is the first step towards accomplishing the restoration of ecological integrity in Bowker creek by reducing the impacts of impervious surfaces on water quality and quantity. This plan incorporates the use of in-site measurements coupled with previously conducted studies to determine what impervious surfaces require restorative efforts. Using survey information and reference to the UVic Integrated Stormwater Management Plan (ISMP), the cost, benefit, and priority for restoration can be determined, and decisions on what impervious surfaces to restore can be made.

4.1.1 Preliminary Analysis and the ISMP
The identification of impervious surfaces on campus will occur in both field and laboratory settings; before field measurements can be taken to determine the locations of restoration focus, a preliminary analysis must be done in order to narrow the scope of our restoration. A site analysis, carried out by reviewing campus maps or aerial photos, will identify impervious surfaces close to Bowker Creek. See Figure 4 below for a campus map indicating the location of parking lots and buildings, both of which are impervious surfaces. The map allows us to focus our attention on parking lots 4, 6, 8, 9, 10, and the Fraser, Visual Arts, and Phoenix buildings.

Although possible sites for restoration have now been determined; due to the limited timeframe and resources for this project we must narrow the scope of our restoration. To do this we will combine our preliminary site analysis with results of the ISMP, a ‘plan commissioned to provide a series of recommendations to reduce the quantity and improve the quality of stormwater leaving the Gordon Head campus’ (Lloyd 2004). The ISMP uses computer modeling to simulate the hydrology of the UVic campus and adjacent areas; the Personal Computer Stormwater Management Model (PCSWMM),
has the capability to generate hourly runoff hydrographs using daily rainfall (Smith, Li & Banting 2006). Below is the model output created by the ISMP (Figure 4).

![ISMP Hydrologic Simulation Model](image)

**Figure 4: ISMP hydrologic simulation model outlining catchment boundaries (Lloyd 2004)**

The ISMP used simulated model outputs of stormwater runoff depths across UVic to quantify the cost, benefit, and priority of restoration for each impervious area; by correlating this quantification with our preliminary analysis, we can determine the final scope of our restoration.

**4.1.2 ISMP Correlation and Field Surveying**

After preliminary site analysis has been completed, correlation with ISMP’s quantification of cost, benefit, and priority of restoration for each impervious area can be
carried out. The ISMP’s modeling of the UVic campus determined that parking lots had a
greater surface area than building roofs and therefore produced greater stormwater runoff.
The ISMP classified none of the buildings surrounding Bowker Creek as high priority
restorations yielding high benefits, while all of the surrounding parking lots that drain
into Bowker Creek were identified as high priority restorations yielding high benefits.
Table 1, as seen below, is taken from the ISMP and illustrates their rankings for
impervious surfaces on campus in the Bowker creek catchment area.

Table 1: Potential locations for stormwater drainage improvements, taken from UVic's Integrated Stormwater
Management Plan. Priority, cost and benefits are ranked by high, medium and low. (Lloyd 2004).

<table>
<thead>
<tr>
<th>Impervious Surface</th>
<th>Priority</th>
<th>Cost</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraser Building</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Visual Arts Building</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Phoenix Building</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Parking Lot 4</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Parking Lot 6</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Parking Lot 8</td>
<td>High</td>
<td>High</td>
<td>High</td>
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<tr>
<td>Parking Lot 9</td>
<td>High</td>
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</tr>
<tr>
<td>Parking Lot 10</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

In conjunction with ISMP rankings, we have chosen to focus our project on
parking lots 4, 6, 8, 9 and 10, as their priority, cost and benefit are ranked as high and
their runoff drains directly enter Bowker Creek (Lloyd 2004). Now that the scope of our
restoration project has been defined, in-site measurements can be carried out to determine
the locations within the parking lots that will receive restoration.

To determine the location of rain garden installation, we will work in cooperation
with the UVic Geography Department to survey our selected parking lots. The University
of Victoria offers classes in Field Surveying; Geog 325 is an introduction to fundamental concepts of surveying and fieldwork. This is an instrument-based course covering differential levelling, traversing, tachometry, GPS, and their applications to field work (‘UVic course: Geog’ 2012). We will establish a volunteer program in which geography students can build surveying experience by using their skills learned in class. With supervision from teachers and teaching assistants, volunteers can use school equipment to survey our selected parking lots for 6 of the lowest points in each lot. These six locations are where the majority of surface runoff will flow to, and therefore will be the sites of curb cut and rain garden installation.

4.2 Runoff Reduction Plan
The Runoff Reduction Plan includes the methodology behind the installation of features that will reduce the impacts of impervious surfaces on water quality and quantity, accomplishing the restoration of ecological integrity in Bowker creek. Using the outcome of our Preliminary Restoration Plan, the decisions of where to focus our restoration efforts and the installation of permeable features can be carried out. This plan is a description of the installation, dimensions, structure, and function of rain gardens and their adjacent curb cuts.

4.2.1 Curb Cut Installation
Parking lots are traditionally paved with asphalt, which is 95% impermeable, and because the water has nowhere else to go, it runs straight into storm drains (Lloyd 2004). In parking lots 4, 6, 8, 9 and 10, the area of our study, these storm drains lead straight to Bowker Creek. Curb cuts will be created every meter along the curb at the lowest points of the parking lots, as determined by the field surveying done by future geography students. In conjunction with these curb cuts, rain gardens will be installed, so that instead of stormwater flowing directly down the storm drain, it is redirected into the rain gardens, reducing the amount of stormwater runoff that flows into Bowker creek from these lots.
4.2.2 Rain Garden Installation

Rain gardens are a ‘planted depression that slows and filters rainwater runoff from impervious surfaces such as building roofs and parking lots’ (‘Rain gardens’ 2011), see Figure 5 for a representation of a rain garden schematic. The installation of rain gardens provides three restorative purposes to our design project; the reduction of stormwater runoff, pollutants and suspended sediments. Studies indicate that rain gardens are very efficient at trapping particular pollutants; Environmental Protection Agency studies have shown up to an 88% reduction in total suspended solids and silt, that is retained in the soil rather than washed into storm drains due to the implementation of rain gardens (Santisi 2011). In addition to trapping sediments, rain gardens capture 99% of imputed runoff, as well as 99% of the pollutant load contained by the captured runoff (Emery 2006).

![Figure 5: Cross section of a rain garden showing plant placement, depth, and soil zones. (Rain Gardens 2013).](image)

The 15 parking lots on the UVic campus cover a total area 1,458,854 square feet (Lloyd 2004); our restoration project deals with 5 of these lots so we must construct rain gardens to receive stormwater runoff from impermeable surfaces of 486,284 square feet. The area of a rain garden should be 7% of the size of the impermeable area flowing into it (Pounders 2007). Taking this into account, we have chosen to construct 8 rain gardens per parking lot that will each be approximately 850 square feet. Rain gardens will be 2 feet deep and cut into the ground at a lower level than the existing parking lot to prevent backflow of water. The depressions will be filled with permeable soil, the RainScapes program advises the use of soil that is 50% sand, making it very absorbent (Rain Gardens 2013).
Plant selection and placement within the rain garden is important to ensure vegetation health and longevity; in particular, only native plants can be used to prevent the introduction of exotic species into the disturbed ecosystem. Plants with a high tolerance to chemicals must be placed where water first enters the rain garden because water at this point has not yet experienced pollutant filtration. The use of drought resistant and water loving plants depending on the distance from the center of the rain garden is important; Figure 6 (to the left) shows the moisture zones of a rain garden.

RainScapes also suggests to put drought-tolerant plants with taproots around the garden's perimeter, since that will be the driest area (Rain Gardens 2013). Possible native species with these characteristics include Low oregon-grape (Mahonia nervosa) and Pacific sanicle (Sanicula crassicaulis). RainScapes also advises the use of plants with fibrous root systems in the center of the garden, because it is the wettest zone (Rain Gardens 2013). Examples of possible native species are Common rush (Juncus effuses) and False lily of the valley (Maianthemum dilatatum).

### 4.3 Permeable Alternatives Plan

In the coming decade the University of Victoria intends to acquire additional land for increased development and strengthen its image as a destination university by increasing the population of international students on campus (Planning and Priorities Committee 2012). With this intention of continued growth will come the creation of new facilities and parking lots, increasing impervious surfaces on campus. Increasing impervious surfaces will potentially negatively impact Bowker Creek through increased runoff. One of the best ways to reduce the impacts of impervious surfaces is through the use of permeable pavement types. Permeable pavement is any paved surface designed to reduce runoff through allowing infiltration (Bean, Hunt & Bidelspach 2007). By repaving existing campus parking lots with a higher permeability than asphalt we can reduce the
amount of runoff from impermeable surfaces going into Bowker Creek. Not only can porous pavements reduce quantity of stormwater running into streams through reduction of runoff, they also significantly improve stormwater quality through reducing pollutant loads (Bean, Hunt & Bidelspach 2007).

Naturally it would be unfeasible to replace all parking lots within a short time frame, it would be more cost-efficient to replace the asphalt parking lots when they need repaving, which is every 8-15 years (ISMP 2003). The University is expecting to expand, and so new parking lots should be installed with permeable pavement to avoid further impacting stream flow in Bowker Creek. Potential pavement alternatives will now be assessed, after which, a recommendation will be made for which type is best suited for the University of Victoria parking lots 4, 6, 8, 9 and 10. While there are many permeable pavement options available, this plan will assess the suitability of three. The first is porous asphalt, the second is porous concrete pavers, and the third is grass/gravel pave parking systems.

4.3.1.1 Porous Asphalt
Porous asphalt parking lots are composed of four layers. Starting from the bottom layer there is the undisturbed soil that is covered by a filter fabric to prevent migration of soil, then there is a 1.5-2.5 inch thick stone mix with 40% void space to allow for storage of stormwater, next is the filter course, made of crushed stone it provides filtration and stability. The final layer is the porous asphalt itself, consisting of open-grade asphalt concrete (Faulkner 2005). Porous concrete is about 35% more permeable than standard asphalt, and is similar in cost. While the initial installation for porous asphalt may be slightly more expensive, as it typically consists of two additional layers, this cost difference is offset by the significant reduction of stormwater pipes and inlets (Hansen
2006). The downside to porous concrete is that it requires regular maintenance. It must be vacuum swept four times a year and further inspections after large storm events in order to prevent clogging, which can reduce permeability (ISMP 2003).

4.3.1.2 Porous Concrete Pavers
Porous concrete pavers consist of interlocking blocks that contain voids between them, and generally the larger the voids the greater the permeability. Pavers are considered an aesthetically pleasing alternative to standard asphalt and are increasingly being made more permeable. This pavement type also contributes to reducing runoff quantity by allowing infiltration into the underlying soil, as well as filtering out pollutants in stormwater (ISMP 2003). Pavers are also less prone to clogging than porous asphalt. The downside to porous concrete pavers is that they are more expensive than both standard asphalt and porous asphalt. They also require inspection four times per year.

4.3.1.3 Grass/Gravel Pave
The installation of the recycled plastic grids in grass/gravel pave parking lots is comparable to the installation of standard asphalt parking lots when the entire cost of parking is considered (ISMP 2003). This considers the cost of maintenance and repairs, over a fifteen year period: the cost of grass/gravel pave maintenance and repairs is 60-90% the cost of maintaining and repairing standard asphalt. The grass/asphalt pave lot has a lifespan of 30 years, while standard asphalt must
be resealed every 2-4 years and resurfacing every 8-15 years (ISMP 2003). This pavement is 92% permeable and filters out 95% of pollutants. The downside to grass/gravel pave is that it requires seeding, irrigation and mowing, though the costs and efforts associated with this maintenance can be reduced with the use of native grasses.

### 4.3.2 Recommended permeable pavement solution

While each of these permeable pavements provides benefits of reducing runoff quantity and improving water quality, it is the grass/gravel pave that provides the greatest benefits in relation to its costs. It is recommended that future parking lots at the University of Victoria be designed using this alternative to standard asphalt, as well as installing them instead of resurfacing the existing lots when the time comes for each lot to be resurfaced. Grass/gravel paved parking lots result in the greatest decrease in stormwater runoff and filter out the most pollutants. They also last longer than asphalt parking lots and when the entire lifespan is considered they are similar in price.

### 5.0 Implementation and Management

In terms of our proposal, it is crucial to incorporate implementation parameters in order for a successful outcome. This includes a plan that involves qualitative factors such as who will be involved in the implementation in our project and how we will recruit these individuals. Quantitative factors will also be presented which includes budgeting and timelines (Society for Ecological Restoration 2004). The premise behind implementation is to draw an outline of what is needed for the project and to provide a broad overview of how the project is going to progress in a successful manner.

#### 5.1 Qualitative Factors

Incorporating qualitative factors is crucial as it involves the recruitment of help from students and volunteers, which are all a necessity in the implementation process of this project.
5.1.1. Acquiring Volunteers for the following tasks:
There are several tasks with which we had planned to use volunteers and students from certain classes: field observations and surveying, planning of the curb cuts and planting of the rain gardens.

5.1.1.1 Collecting Field Observations/Surveying
➢ Visiting Environmental Studies (ES) classes, in particular ES classes that include a three-hour field lab excursion (such as ES 200) as well as Geography students to both recruit them as volunteers and have them help us as part of their class work. Subdivide field information (diameter, slope, etc) amongst all students and have them collect information and compile all data when completed. Having students participate in this will:
   o Provide students with field work knowledge and gain valuable skills.
   o Provides us with a cheap alternative to paid workers, allowing us to focus our resources on constructing a well designed rain garden and curb cut.

5.1.1.2 Curb Cutting
➢ Visiting the Engineering department to see if they can help (as a project for a class or student) with the planning on our proposed curb cut and perhaps create the most effective (and cost effective) design.

5.1.1.3 Rain Gardens
➢ Speak to ethnobotany or biology courses (or professors) on campus to determine the best plant species to incorporate in the rain gardens. In particular, which plant species will be the most effective in absorbing water, while not being detrimental to the plant. And which plants can survive off relatively little water.
➢ Incorporate volunteers to help with the planting in the rain gardens.
➢ Incorporating a volunteer who has ample experience on rain gardens, perhaps a knowledgeable professor who has an extensive background on gardening. This could also be a botanist, ethnobotanist, etc and can also be the overseer of the restoration project.
5.1.2 Recruiting volunteers

- Provide volunteers with snacks and refreshments
- Provide individuals an explanation on the severity of impervious surfaces and the huge implications that arise after storms
- Provide an explanation of the processes that occur in the implementation of rain gardens.
- Select an individual to be in charge of organizing the volunteers. This includes emailing or calling the volunteers with details (time, place, instructions/outcomes of project or given task for the day) and provide the volunteers with snacks and refreshments.

5.1.3 Getting Permission

- Approach Facilities Management to get permission: Facilities Management at UVic involves a diverse team of professionals that strive towards promoting good quality research and community services at the University. The department has a large range of qualifications ranging from trades persons to engineers. The responsibilities of Facilities Management are to develop new buildings, maintain, construct grounds and utility systems and support sustainability proposals across campus (UVic Facilities Management 2013).
- Contact the UVic Grounds Maintenance Department to get permission to have this facility be a monitoring aspect of our project. Precisely focusing on the reduction of weed growth. The primary motivations for the Grounds Maintenance Department is to keep UVic looking visually appealing. This is done through mowing lawns, cleaning pavement surfaces and parking lot maintenance (UVic Facilities Management 2013), as the aim is to provide a good first impression to newcomers or visitors to the campus.

5.2 Quantitative Factors

This section involves the budget and the timeline for the implementation of our proposed rain garden. Two potential sources of funding include grants from the University of
Victoria Sustainability Project. (UVSP) and funding from the Capital Regional District (CRD).

The UVSP is a student-run program based out of UVic with their primary goal to engage campus community while also incorporating the remainder of the community. It is an organization where people can learn about environmental degradation and is a way to initiate projects throughout the campus. Through the UVSP’s ‘Sustainable Grants Program’ it encourages students, groups and staff to create a sustainable project and will be funded by UVSP through the means of a grant (UVSP 2013).

The CRD of Victoria is another means of funding. The CRD offers project grants for non-profit organization and must complete a Project Grant Application (CRD 2013b).

### 5.2.1 Budget

**Table 2: Cost of food and drinks for volunteers**

<table>
<thead>
<tr>
<th>Food and Drink</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>584g of Folgers Coffee</td>
<td>$10</td>
</tr>
<tr>
<td>1 pound of Earl Grey Black Tea</td>
<td>$13</td>
</tr>
<tr>
<td>Trail Mix (2 bags)</td>
<td>$25</td>
</tr>
<tr>
<td>Fruit (Apples and Bananas)</td>
<td>$30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$78</strong></td>
</tr>
</tbody>
</table>

**Table 3: Implementation of Rain Garden. (Rain Gardens 101; Equipment Rentals in BC 2013)**

<table>
<thead>
<tr>
<th>What</th>
<th>Per unit</th>
<th>Per 850 sq ft rain garden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants and soil amendments</td>
<td>$4 per square foot (on average)</td>
<td>$4*850 sq ft=$3400</td>
</tr>
<tr>
<td>Average size of rain garden</td>
<td>850 square feet</td>
<td>850 square feet</td>
</tr>
<tr>
<td>Renting excavator &amp; operator</td>
<td>$ 225 per day</td>
<td>$225*1 day=$225</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$3625</strong></td>
</tr>
</tbody>
</table>

We will be working in cooperation with the local municipalities, especially in bringing the dirt to UVic via dump truck. The municipalities may possibly also assist with the providing of an excavator and its operator. The excavator will both dig out the area that will be the rain garden, as well as make the curb cuts. Furthermore, we will
collaborate with UVic Grounds Maintenance to ensure the gardens are maintained by ensuring, especially in the first few years, that the gardens remain free of weeds. The costs for installing grass/gravel pave in future parking lots will be $28.00/m² (BODPAVE 85 for Grass n.d). This comes out to $2.60 per square foot.

5.2.2 Timeline
In terms of time, our goal is to complete the rain garden within a year, but have the majority of the construction occur in the summer. A detailed timeline follows:

5.2.2.1 April-June
Acquire and recruit our volunteers, particularly students at UVic, to use their help in collecting data and doing fieldwork. April to June is the best time of year to do this, due to reasonable weather and many of the students are either not studying or only taking a few summer classes, therefore have more time to contribute.

5.2.2.2 July-September
Construction and landscaping of rain garden. Aim to have construction at this time due to optimal weather conditions, and because there will be less people on campus (especially who are driving).

5.2.2.3 October-March
Due to this being the rainy and stormy season in Victoria, this would be an ideal period of time to do monitoring to view the success of the newly established rain garden and curb cut. This is also a time for maintenance.

6.0 Monitoring and Evaluation
Environmental monitoring and evaluation are essential for assessing whether the objectives and goals have been achieved (SER 2004). Information gathered through monitoring and evaluation can help decide the quality of an ecological restoration plan,
and managers can further make adjustments to the strategies that do not achieve the goal. This section will first monitor the objectives of the plan, including the strategies of restoration focus, runoff reduction plan and permeable alternatives. Detailed monitoring strategies, such as data collection, frequency of monitoring, timing and location, are different in each objective. The following section will use the SWOT analysis to evaluate the strengths, weaknesses, opportunities and threats faced by the process of ecological restoration when considering these strategies. The last section will generate a checklist to summarize all the important indicators of monitoring.

6.1 Monitoring the Restoration Focus Plan
Monitoring the focus plan will primarily look at the impacts of other impervious surfaces near Bowker Creek on water runoff into the storm drain. Due to the likelihood of UVic expanding, it is predicted that within the next decade more impervious surfaces will be paved at UVic. The computer modeling system that simulates the hydrology of the UVic campus is used to determine which impervious surfaces will need to be monitored in terms of their impact on water runoff. For each area, a land manager should note whether the water entering Bowker Creek is entering directly or indirectly. This monitoring will help determine if more intensive monitoring is needed during the rainy season.

6.2 Reducing the Amount of Runoff into Bowker Creek
6.2.1 Monitoring Curb Cuts
Although parking lots 4, 6, 8, 9 and 10 already have curb cuts, collectively they do not direct water flow away from Bowker Creek because leaves usually block the curb cuts. Figure 10 and 11 show that leaves heavily block the curb cuts in parking lot 8, thereby not permitting the rainwater runoff to flow to the adjacent bushes. Figure 12 illustrates that the rainwater eventually flows to a storm drain that leads straight to Bowker Creek. Therefore, in order to ensure the curb cuts’ effectiveness of directing water flow into the rain garden, land managers should monitor and prevent the leaves from blocking the curb cuts before the rainy season.
Increasing the number of curb cuts by creating them every meter along the curb at the lowest points of the parking lots can greatly improve the effectiveness of discharging water runoff to the adjacent rain gardens. However, creating a curb cut may exert negative impacts on the surrounding vegetation species. It is important to note that there
are various ways to create curb cuts. Figure 13, below, shows that a curb-cutting machine uses a blade to cut the existing curb; however, the blade may also cut the plant behind the curb, which can be detrimental to the plant. Therefore, the process of creating curb cuts should be monitored.

![Curb cutting machine](CSDA Member Hits the Curbs 2002)

When creating a curb cut there are two questions to be kept in mind: where is the curb cut going to be placed along the curb? and is the curb cut going to be effective? It is possible that the curb cut may not direct water to permeable surfaces. If this is the case then we encourage the project undertaker to experimentally make one or two cuts along the curb in order to examine its effectiveness. The best monitoring period will be during the rainy and stormy season from October to January.

### 6.2.2 Monitoring Rain Gardens on Perimeter of Parking Lots

Monitoring the performance of rain gardens depends on two approaches: visual inspection and infiltration rate testing. The visual inspection is the first level approach that involves the observation of vegetation and soils, for example observing the condition of vegetation after a storm event. Observation also requires profound knowledge of the vegetation and soils pertaining to rain gardens. The second level approach is infiltration rate testing that examines the ability of soil pores to become saturated with water, this is represented as $K_{\text{sat}}$. Several devices, including Double-Ring Infiltrometer, Guelph Permeameter, and Modified Philip-Dunne (MPD) Infiltrometer, can determine the $K_{\text{sat}}$ of
soil. The $K_{\text{sat}}$ is helpful in predicting the drain time of a rain garden and helps identify low infiltration rate areas that are in need of specific maintenance. Furthermore, this approach is able to calculate the reduction of water runoff volume in a rain garden (Asleson et al. 2009). For monitoring the performance of rain gardens accurately, it is recommended to combine both the visual inspection and the infiltration rate testing.

Our project proposes the construction of 8 rain gardens in each parking lot, where each rain garden is 850 square feet and 2 feet deep. The first step is to observe for obvious drainage problems, including ‘sediment accumulation in the basin from the drainage area, clogged inlet or outlet structures, and excessive erosion within the rain garden’ (Asleson et al. 2009, 1022). Then examining the species of plants, favoured growing season and growth requirements of the vegetation used in the rain gardens. We recommend taking photographs of each site every month to observe whether invasive species are growing in rain gardens. Rain gardens that have ‘ponded water, the presence of hydric soils, wetland plants and a lack of plant growth on compacted soil’ fail to meet the first level approach, and will need rehabilitation (Asleson et al. 2009, 1022). Moreover, at each rain garden we will sample soil and use the MPD Infiltrometer in order to determine the infiltration rate. Furthermore, drain time and storage capacity of water can be measured by filling rain gardens with water at the highest level and then use a stopwatch to record the draining time. Rain gardens that have low storage capacity and long draining times will need to be supplemented with new soil or vegetation cover (Asleson et al. 2009).

6.3 Monitoring alternative permeable parking lots

- Monitoring the impact of porous asphalt on water quality we will sample a small amount of water after a storm event and then analyze PH, dissolved oxygen, polycyclic aromatic hydrocarbons (PAHs) and heavy metals levels.
- Removing snow and ice to maintain porous asphalt or porous concrete pavers. Snow-melting agents, such as salt, is not recommended, and abrasives cannot be applied on porous pavement surfaces (Roseen et al. 2012).
- Monitoring clogging of pavement surfaces. Pavement should be vacuumed at specific time periods.
Monitoring the deterioration of the porous pavement surfaces and if need be, patching with porous to ensure maximum performance.

Resealing asphalt every 2 to 4 years and resurfacing every 8 to 15 years to ensure effective performance on reducing runoff.

Monitoring seeding, irrigation and mowing on grass and gravel pavement.

6.4 Evaluation

The analytical tool for assessing our objectives is the SWOT analysis. It is used as a structured planning method to evaluate the strengths, weaknesses, opportunities and threats. SWOT analysis is one of the most popular tools in the decision making process because of its simplicity and clarity. SWOT helps decision makers choose their preferred strategy by ‘[scrutinizing] internal strengths and weaknesses [that] is followed by [an] analysis of external opportunities and threats’ (Coman & Ronen 2009, 5678). The following sections will evaluate our strategies in terms of strengths, weaknesses, opportunities and threats.

6.4.1 Strengths

- The strategies of creating curb cuts, installing rain gardens, and paving permeable surfaces can greatly reduce the impacts of impervious surfaces on water quality and quantity in Bowker Creek. By reducing the water runoff from the parking lots, Bowker Creek will have less chance of being polluted.
- Rain gardens improve water quality and reduce erosion on parking lot surfaces by filtering polluted runoff. Moreover, rain gardens are able to create potential habitats for birds and insects, thereby increasing plant diversity and enhancing sidewalk appeal. Their ability to tolerate drought makes them require less maintenance.
- Permeable paving surfaces are effective in reducing runoff from paved surfaces and reducing the concentration of suspended pollutants, which results in less erosion of and pollution in Bowker Creek.
- Implementing rain gardens may reduce the need to create permeable pavements or vise versa.
6.4.2 Weaknesses

- Permeable pavements require frequent maintenance in order to prevent pollutants from clogging the pores. If we do not vacuum them on a regular basis, porous pavements can function like impervious surfaces.
- Snow-melting agents and abrasives cannot be used to melt snow and ice because they may block the pores and reduce the infiltration rate.
- When the surface is frozen, the effectiveness of porous pavements may be decreased (Barrett & Shaw 2007).
- Porous pavements can be damaged by the spillage of gasoline that breaks down the asphalt binder (Barrett & Shaw 2007).
- Leaves can block curb cuts that prevent runoff from flowing into rain gardens.

6.4.3 Opportunities

- Installing rain gardens may reduce the need for creating permeable pavements, which reduces construction costs.
- Decreased runoff pollutants that flow into Bowker Creek can improve water quality, which benefits the aquatic ecosystem, which then reduces the cost of managing water pollution in the future.
- Rain gardens may attract wildlife species, such as, deer, butterflies and raccoons, which increases the local species diversity.

6.4.4 Threats

- Climate change is one of the most important threats that impact the performance of these strategies. In the future, annual mean temperatures in Victoria will increase by 0.9 to 1.7 °C, and summer rainfall will decrease by 32% (City of Victoria 2012). Hotter and drier summers may be detrimental to the vegetation in rain gardens. With potential winter precipitation increasing by about 14%, rain gardens may flood (City of Victoria 2012). Furthermore, increased frequency of storm events may exceed the maximum infiltration rate of permeable pavements and water storage capacity of rain gardens.
6.5 Monitoring Checklist

<table>
<thead>
<tr>
<th>Monitoring Indicators</th>
<th>Met</th>
<th>Not Met</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restoration Focus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Constructed Impervious Surfaces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curb Cuts &amp; Rain Gardens</td>
<td>Leaves Block Curb Cuts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Death of Plants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of Plant Growth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ponded Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Storage Capacity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long Drain Time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permeable Pavements</td>
<td>Improved Water Quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snow-melting Agency/Abrasive on Surfaces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vacuuming at a regular basis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deterioration of Surfaces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spillage of Gasoline on Surfaces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frozen Surfaces</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.0 Conclusion

This restoration project was collaborated in aims of addressing the issue of impervious surfaces on the University of Victoria Campus that directly affects Bowker Creek. Our primary goal of this project focused on reducing the impacts of impervious surfaces on water quality and quantity in Bowker Creek with the hopes of restoring ecological integrity. Three precise outcomes emerged through our goal to implement our proposal. First was to identify the impervious surfaces, then reduce the amount of runoff from parking lots into the storm drain that consequently is directed to Bowker Creek and finally, to create a plan for installing alternative permeable surfaces for parking lots. Collectively these are all described in greater detail in our plan design.

Through our extensive implementation and management plan, help from UVic students and staff will allow for our project to be successful and efficient. Not only will this project assist with impervious surfaces around UVic and Bowker Creek but it will
engage individuals. It will provide awareness and provide helpful and useful restoration knowledge. A budget plan and timeline is another important factor of this project, to represent that our proposed plan is achievable and can be accomplished in reasonable weather conditions. Although, rain gardens and curb cuts are expensive to implement, the end results will outweigh the costs.

Monitoring and Evaluation is another key portion of our project, as it is important to track and make changes that may be needed because restoration typically has a mind of its own and never goes exactly the way it was originally planned.

Group collaboration from various fields is a strong factor in successfully completing a restoration project and keeping in mind it is also a timely process. These factors need to be clearly understood by all before embarking on this task. Despite these complications, the real implementation of this project would lead to positive outcomes with regard to UVic’s impervious surfaces and would consequently lead to a stronger and healthier ecosystem at Bowker Creek.
References


