University of Victoria and the School of Environmental Studies

Impervious Surface Restoration:
Bio-swales for Bowker Creek

University of Victoria
Environmental Studies 341 – Ecological Restoration
Spring 2014
By Claire Buchanan, Chris Zielonka, Maria Chiarella and Melanie Bryant
“A river seems a magic thing. A magic, moving, living part of the very earth itself.”

- Laura Gilpin – “The Rio Grande” 1949
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1.0 Introduction

“High quality water is more than the dream of the conservationists, more than a political slogan; high quality water, in the right quantity at the right place at the right time, is essential to health, recreation, and economic growth. Of all our planet's activities--geological movements, the reproduction and decay of biota, and even the disruptive propensities of certain species (elephants and humans come to mind) -- no force is greater than the hydrologic cycle.”


In a world of increasing urbanization, we are faced with many ecological and social challenges. Development of our urban jungles alters many natural processes and systems (species ranges, distribution, and habitats, nutrient cycles, microclimates, vegetative patterns, etc.), as well as the human relationships with those processes and systems. One of the systems most dramatically affected by urbanization is the hydrological cycle. Consequences of urbanization on hydrological systems include: changing river/stream flow patterns (Booth, 2005), deterioration of stream and ground water quality, loss of wetlands, lower groundwater levels (Higgs, 2003), and decreased aquatic and riparian health and biodiversity. When approaching creek and river restoration, it is essential to note “local actions cannot reverse the consequences of broadly degraded urban catchments” (Booth, 2005). Localized actions, such as restoring riparian vegetation, can only go so far when directed channeling, increase impervious surfaces, and unrestricted storm-water runoff degrade the structural integrity of the waterways. However, localized efforts should not be underestimated in their abilities to address factors such as water quality and biodiversity. In the absence of feasible hydrologic mitigation, efforts to reduce point source pollution and sustainably manage storm-water runoff are essential.

The focus of this project is to address the above issues in relation to the Bowker Creek watershed, with the goals of reducing storm-water runoff rates and volumes, while mitigating point source pollution. The project design includes installing a bioswale at the storm-water exit point on Parking Lot #8 at the University of Victoria (UVic). Pollutants on parking lots pose a serious threat to the watersheds and creeks that have their headwaters at the UVic campus. The Bowker Creek Initiative, an organization of municipal and community stakeholders, has been working to restore and manage the health of the Bowker Creek Watershed by implementing the 2004 Bowker Creek Watershed Management Plan.
One of their main goals is to achieve and maintain acceptable water quality in the watershed, which will require removing pollutants from storm-water (Bowker Creek Watershed Management Plan, 2003). Another is to manage flows effectively by “encouraging onsite retention and infiltration of storm-water” (Bowker Creek Watershed Management Plan, 2003), which can be achieved through bioswale and raingarden systems.

Effective monitoring and creating public awareness are vital to the success of this project. Restoring the social and cultural relationships to our watersheds is a task that needs to be seriously and creatively addressed though restoration projects such as this. Linking monitoring activities to public engagement is a good way to bring a sense of connection and responsibility to the issues that motivate the restoration project in the first place. The hope is that these efforts result in more sustainable behavior when it comes to personal water use and institutional water management.

2.0 Site Analysis

2.1 Site Location/General Information

The site we are focusing on is located at the northwest corner of the University of Victoria campus, and is part of the Bowker Creek headwaters. The Bowker Creek watershed provides drainage for an area of 1028 hectares within the municipalities of Saanich, Victoria, and Oak Bay. The vast majority of Bowker Creek has been directed underground via culverts to accommodate for urban development, leaving only 2.9 km of the original 7.9 km of the creek above ground (CRD Watershed Info n.d.). Bowker Creek flows north passing under McKenzie Ave. and Shelbourne St. before flowing southeast through the Shelbourne valley and into Oak Bay before entering the sea near Willows Beach and Glenlyon-Norfolk School (CRD Watershed Info, n.d.).
The site of the project is UVic Parking lot #8 (Figure 1.1) at the northwest corner of the UVic campus. The parking lot is roughly 300 x 270 feet with a westward slope. The current system used for storm-water runoff (as recommended by UVic’s 2004 Integrated Storm-water Management plan), is a series of curb cuts along the west side of the parking lot leading into the adjacent woods. The storm-water currently floods into this area, which acts as a filter for the water that eventually seeps into Bowker Creek. One of the curb cuts leads into an open man-made channel at northwestern corner of the parking lot that leads into Bowker Creek. The water that floods through the curb cuts into the thicket or open channel is not filtered in any way, bringing with it the oil, chemicals, and sediment sitting on the parking lot.
2.2 Geography

The Bowker Creek watershed is located in the Coastal Douglas Fir biogeoclimatic zone, and has historically been characterized by Garry Oak meadow ecosystems. A complex of seaside parkland, dry forest, rock outcrops, and wetland habitats characterizes the region. The climate is ‘Mediterranean-like’ with long, warm, and sunny summers, and mild, wet winters (Egan, 1999).

Two topography types characterize the region: moist deep-soil forest and dry shallow-soil rocky outcrops. The moist deep-soil areas were historically are dominated by Douglas fir (Pseudotsuga menziesii), while the dry rocky outcrops are dominated by Garry oak (Quercus garryana) and Arbutus (Arbutus menziesii).
The local First Nations, however, historically managed a unique system of Garry oak meadows in the deep-soil regions, of which only 1.5% of the original deep-soil sites remain (GOERT, 2014).

Native species prevalent in the vicinity of the site include snowberry (*Symphoricarpos albus*), Nootka rose (*Rosa nutkana*), red-osier dogwood (*Cornus stolonifera*), Douglas fir (*Pseudotsuga menziesii*), and black cotton wood (*Populus balsamifera*). There are also a few invasive species present in the site, most notably Himalayan blackberry (*Rubus armeniacus*), but also a small amount of English Ivy (*Hedera helix*). Other invasive species known to be more sporadically present in the area are English hawthorn (*Crataegus laevigata*), Daphne (*Daphne odora*), and English holly (*Ilex aquifolium*). Himalayan blackberry is particularly pervasive in the area, particularly along the stream transporting water from the parking lot to the main Bowker Creek channel (Integrated Storm Water Management Plan, 2004).

2.3 Hydrology

The current UVic campus is a local topographic high point and formed the headwater area for Bowker, Hobbs, and Finnerty Creeks prior to intensive development. The historical topography and vegetation of the area allowed for adequate run-off retention, as did the rich topsoil of surrounding areas, allowing rainwater to charge the water table (Integrated Storm Water Management Plan, 2004). In fact, only one third of the annual precipitation would have been received by the streams found on campus on an average year (Integrated Storm Water Management Plan, 2004). The subsurface permeability of the area is quite low because it consists primarily of Quadra deposit, Vashon till, and Victoria marine clay (Integrated Storm Water Management Plan, 2004). This means that water movement must be slow enough to allow absorption and retention.

Historically, Bowker Creek would have had the adequate riparian vegetation, micro-invertebrates, and microbes to filter pollutants from the creek water. Because a majority of the creek has been channeled through culverts, there is less natural filtration and sequestration, resulting in increased concentrations of pollutants and sediments.
2.4 Culture and History

Bowker Creek was historically a “meandering, low gradient stream with numerous small tributaries and wetland areas” (CRD Watershed Info, n.d.) The Bowker Creek headwaters are located in an area once known as the Cedar Plain; a flat and open grassland that was “part of the 100-acre Rosebank Farm established by Scottish settlers John and Jessie Irvine in 1857” (Mjolsness, 2003:11; CRD History, n.d.).

The creek also has a secondary source originating under the Cedar Hill Golf Course (CRD Watershed Info, n.d.). Bowker creek has had many names after European settlement, including “Tod’s Stream”, “Thomas River”, and “The Thames” (Mjolsness, 2003; CRD Watershed Info, n.d.). Pre settlement, the creek was used by the Straits Coast Salish peoples as a source of drinking water, as a salmon run (Mjolsness, 2003), and most likely as a trade/transportation rout.

Since European settlement in the 1800s, “the watershed has been increasingly developed, first for agriculture, and later for residential, commercial, industrial, and urban uses” (CRD Watershed Info, n.d.). After the start of Second World War, the Canadian Government established the Gordon Head army camp on the north end of what is now the University of Victoria. The army camp was completed in 1940, and in 1959 Victoria College purchased the army base and the adjacent 141-acre parcel of land. By 1967, approximately 780,000 square feet of the purchased land had been developed (Lovell and Turner, 1999). The Bowker Creek watershed is now largely urbanized, with 70% of the original channel confined to culverts, and supporting three municipal storm-water drainage systems (CRD Watershed Info, n.d.).

Today, residents admire the creek as a beautiful water feature meandering through Saanich and Oak Bay. The creek provides a wonderful place for people to bird-watch, and is the site of “Bowker Creek Brush Up” – an annual art show hosting over 40 artists along the creek between Oak Bay High School and Hampshire Road (Bowker Creek Brush-Up, n.d.).

2.5 Problem Identification

Prior to 1956, the terrestrial area associated with the Bowker Creek watershed consisted of 91.2 hectares of pervious area, and 1.7 hectares of impervious area. Due to urban development, the drainage area has expanded from 92.9 hectares to
100.4 hectares between 1956 and 2003. Another result of urban development is that the area of impervious surfaces has drastically increased from 1.6 hectares in 1956 to 51 hectares in 2003 (Integrated Storm Water Management Plan, 2004). The unfortunate outcome of this development and increase in impervious surfaces has been the decrease in surface water absorption and the increase in runoff rates and volumes. The storm water runoff volume into Bowker creek has doubled between 1956 and 2003, while the runoff rate has increased significantly due to lack of retention and absorption (Table 1.1).

* Table 2.1: Bowker Creek peak flow, total volume, and impervious surfaces at UVic

<table>
<thead>
<tr>
<th></th>
<th>Total Volume (m$^3$)</th>
<th>Peak Flow (m/s)</th>
<th>% impervious surfaces of watershed</th>
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<tr>
<td>Pre-development</td>
<td>15,520</td>
<td>0.40</td>
<td>n/a</td>
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<tr>
<td>1956</td>
<td>20,950</td>
<td>0.55</td>
<td>1.6</td>
</tr>
<tr>
<td>2003 “As-is”</td>
<td>46,180</td>
<td>1.92</td>
<td>51</td>
</tr>
</tbody>
</table>

(Integrated Storm water Management Plan, 2004)

A major cause of such dramatic increases in total volume and peak flow rates into Bowker Creek is the massive increase of impervious surfaces in the watershed and its headwaters due to development. According to the Bowker Creek Watershed Management Plan “[a]proximately 87 percent of the watershed has been developed for commercial, industrial, office, institutional, and residential uses” (2003), with an estimated 45% of the total watershed now impervious due to urbanization. As noted in Table 1.1, impervious surfaces of campus lands have surpassed 50%.

A major form impervious surface on campus is the parking lots. The Bowker Creek headwaters on campus receives storm water run-off from three parking lots (Parking lots 8, 9, and 10). Parking lot 8 was chosen because of its large size and thus its potential for polluting storm-water. As mentioned above, the water that floods through the curb cuts into the thicket or into the open channel at the northwest corner is not filtered in any way, bringing with it the oil, chemicals, and sediments that sit on the parking lot.

The vegetation running along the west side of the parking lot acts as a barrier and filter to the water that manages to seep through the curb cuts, but the curb cuts are usually blocked and ineffective at allowing drainage. This results in most of the
water being channeled to the northwest corner of the parking lot where a culvert (Figures 2.2) channels the polluted storm-water to a stream and eventually to Bowker Creek. This is further problematic because of decreased filtration from riparian vegetation, micro-invertebrates, and microbes throughout the entirety of Bowker Creek. Pollution in Bowker Creek is detrimental to both biodiversity and public health.

* Figure 2.3 -- Parking lot #8 - northwest culvert. (Integrated Storm water Management Plan 2014)

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Section B – Goals and Objectives

1.0 Vision Statement

Our overall vision is to have a university that is a leader in wise storm-water management, that prioritizes maintaining the health and integrity of the watersheds they call home, and educates and engages the student body and broader community in understanding our integral relationship with our watersheds.

Through this project we hope to enhance the health of The Bowker Creek Watershed, educating the community in wise-water management, and instil healthy and holistic relationships between the University of Victoria and Bowker Creek.

2.0 Goals and Objectives

To be successful and efficient with any projects requires a set of well thought out goals and objectives. These goals have been articulated based upon the vision that we presented above and seek to create guidance for future work with impervious surfaces on and off the university campus. The goals that we wish to achieve through this project are:
• Goal 1: Eliminate pollutants and sediments from storm-water runoff on parking lot #8.
• Goal 2: Reduce the rate of storm-water runoff exiting parking lot #8.
• Goal 3: Reduce the volume of water entering the runoff stream leading to Bowker Creek without causing flooding on the parking lot.
• Goal 4: Create awareness about the Bowker Creek initiative and the importance of wise water management.

Goal #1 - Eliminate pollutants and sediments from storm-water runoff on parking lot #8:
Chemical pollutants and sediments on the parking lot are picked up by storm-water and washed into Bowker Creek. This threatens biodiversity and public health throughout the watershed.
• Objective 1: Create a bio-swale along the western side and northwest corner of the parking lot. Plants within the bio-swale will act to filter pollutants from storm-water, while the materials capture sediments that would otherwise end up in the creek.

Goal 2: Reduce the rate of storm-water runoff exiting parking lot #8.
Increased runoff rates can cause erosion throughout the Bowker Creek Watershed and threaten its hydrological and biological integrity.
• Objective 1: Create a bio-swale along the western side and northwest corner of the lot. The bio-swale will act as an abiotic barrier between the parking lot and the creek, effectively slowing the runoff rate.

Goal 3: Reduce the volume of water entering the runoff stream leading to Bowker Creek without causing flooding on the parking lot.
The large impervious surface, as well as ineffective curb cuts, restricts water absorption resulting in larger volumes of water exiting the northwest corner of the parking lot.
• Objective 1: Design the bio-swale to act as a sink that regulates the release of water into the creek and allows absorption into surrounding soils.

Goal 4: Create awareness about the Bowker Creek initiative and the importance of wise water management.
Creating awareness about the project and educating the public is vital to ensuring the sustainability of these sorts of projects, and helps instill positive and respectful relationships between people and their watersheds.
• Objective 1: Create and erect educational and informative signage on site that explains: a) what bio-swales are and how they function; b) who is involved, and; c) the need for the
bio-swale and the importance of implementing wise-water management at the Bowker Creek headwaters. Because the site is located beside a high traffic pathway intersection at the northwest corner of campus, we expect a large number of people to be exposed to the bio-swale, and hope that curiosity will lead people to read the strategically placed signs. Potential signage to include in the future would outline the geographical and cultural history of the Bowker Creek Watershed, and what native plants are in the swale and what their functions are.

Section C – Design of the Project

1.0 Introduction

The design for our restoration project consists of storm water management, a bioswale, and lastly, a drainage ditch. We really wanted to incorporate native plants into our restoration project because we found native plants have strong root resistance, and implementing native plants would also diminish the strength of invasive species in the area. Finally, we decided these three implementations justified our four goals: Eliminate pollutants from the storm-water runoff from parking lot #8, reduce the rate of storm-water runoff exiting parking lot #8, reduce the volume of water entering the runoff stream leading to Bowker Creek without causing flooding on the parking lot, and lastly, create awareness about the Bowker Creek initiative and the importance of wise water management and native plant species.

2.0 Storm Water Management

We want to ensure the rainwater that falls on school grounds can be deviated from running off into Bowker Creek. This is important because the rainwater that falls on the impermeable surfaces in Parking lot 8 mixes with pollutants like gasoline, motor oil, and cigarette butts which is hazardous to the living species of the creek. In response we want to create a bioswale and a ditch that will move the water from the uneven parking lot to the bioswale in the north west end of the Alumni Chip trail. Furthermore, we also want to implement a drainage ditch, on the farthest parking spots on the West, perpendicular to our bioswale. We hope the drainage ditch will act as a mechanism to maneuver rainwater that collects in the uneven parking lot, to facilitate it to the bioswale

3.0 Bioswale Design

A bioswale is the perfect implementation design for numerous reasons. The function of a bioswale is to act as a "biological filtration canal" that is used to deter runoff water from polluting nearby water sources (American Society of Landscape Architects, 2008), in this...
case, Bowker Creek. By designing a bioswale in close proximity to Bowker Creek we can reinforce solutions such as water pollution, create vegetation, and decreasing flooding. The optimum design for the bioswale will encompass of three major components: soil, compost mixture, and on the top layer vegetation which will include native species from Vancouver Island, as well as plants that will offer premium ecosystem functions, like food. We will explain all these different components in detail to ensure the design and implementation work cohesively.

The optimum design for the bioswale will encompass of three major components: soil, compost mixture, and on the top layer vegetation which will include native species from Vancouver Island, as well as plants that will offer premium ecosystem functions, like food.

![Diagram of typical bioswale](image)

Figure 2. Diagram of typical bioswale (adapted from UDFCD 1999)

Figure 3.0 -- Yocum, D. (2005) Design Manual: Biological Filtration Canal (Bioswale).

3.1 Site

The site we believed was the best possible location for the bioswale will be in the North West corner of Parking lot #8. This parking is one of the biggest and busiest parking lots, which also mean pollution and rainwater collect steadily during the rainy season. The best location for the drainage ditch will be perpendicular to the bioswale, on the western side of the parking lot. We determined the drainage ditch would run along the perimeter, eventually connecting, and flowing into the bioswale.

*Bio-swales for Bowker Creek*

By: Claire Buchanan, Chris Zielonka, Maria Chiarella, an Melanie Bryant
3.2 Design

Bioswale: The design of the bioswale for this particular restoration project will be a trapezoid shape because it is the most effective bioswale at removing pollutants (Jurries, 2003). The trapezoid shape also is simple to construct. According to the Department of Environmental Quality, the optimal slope is between 1-2% incline, this is crucial for limiting erosion of the slope (Jurries, 2003). We will ensure the bottom width of the bioswale is a wide, flat bottom because it will maximize treatment area and pollutant removal, which is one of our main priorities. Geotextiles, such as jutte matting, compost, and straw mulching is necessary in the building of the slope as it provides physical protection for the slope.

Our mission is to take out two parking spots in parking lot #8; according to our calculations, around 2.15mX2.04m. The amount of impervious surface taken out for the creation of the bioswale will allow for a more robust and well-functioning bioswale, which will also increase the filtering of the rainwater.
3.2.1 Soil
The bioswale can successfully be built in most soil types. The best type of soil for this specific bioswale will be mixed with compost and sand. This type of soil will promote good root development and also be better at retaining water for dry periods, and finally provide filtering (Jurries, 2003.)

3.2.2 Vegetation
The selected vegetation will be in accordance with the pollutants we would like to be removed. We also want to only plant native plants because they offer various ecosystem functions, have stronger roots, and will do better in this type of ecosystem. We will plant woody plant material on the side of the slope for support, and on the lower canopy we will plant flowering plants. We decided to use only native plants for our bioswale because native plants resist local pests and diseases, have low maintenance and have better roots (USDA 2007).

3.3 Materials
- Non-Woven Fabric Geotextile
- Compost and Sand
- Driwater
3.4 Native Plants

- **Nodding Onion**: We chose it because it is a native plant, it is aesthetically attractive, and would do well in a sunny location.

![Nodding Onion](image.jpg)

Figure 3.4 - Fine Gardening: Nodding Onion, 2014

- **Orange Honeysuckle**: It attracts hummingbirds and butterflies. However, deer are not attracted to it. It produces red berries, which is enjoyed by a variety of birds.

![Orange Honeysuckle](image.jpg)

Figure 3.5 - Washington Native Plant Society: Orange Honey Suckle, 2014

- **Common Harebell**: We chose it because the plants are edible raw or cooked (perfect for hungry students!)
Bio-swales for Bowker Creek

By: Claire Buchanan, Chris Zielonka, Maria Chiarella, and Melanie Bryant

Figure 3.6 - Portfolios Chukhaney, Common Harebell, 2014

- Parsley Fern: Perfect for a parking lot area

Figure 3.7 - Cedar Rim Nursery, Parsley Fern, 2013

- Red osier Dogwood: This native shrub is a perfect home for mice and birds

Figure 3.9 - Saint Nicolas Nursery, Red osier Dogwood, 2014
4.0 Drainage Ditch Design

The design for the drainage ditch will have positive benefits, and low costs. The drainage ditch will be built behind the curb on the farthest western parking spots. We will make a ditch about one meter wide. We decided the depth of the ditch had to accommodate the slant of the parking lot. Right now the parking lot is inclined, which means rainwater is accumulated rather quickly at the bottom western end of the parking lot. This is problematic because it over floods Bowker Creek. We hope by making the ditch even, it can slow down the flow of rainwater into the Bowker Creek, and allow for filtering. The benefit of creating the drainage ditch is the low costs associated with its implementation, for example not having to remove any parking lots, and there being only two required materials: weeping tile and drain rock.

4.1 Site

The site for the drainage ditch will be implemented behind the curb of the farthest parking spots on the West side, perpendicular to our bioswale. We decided this would be the optimal spot for our drainage ditch because the slant of parking lot #8 causes the overflow of Bowker Creek. By setting the ditch in this particular area, we are decreasing the overflowing of the creek, while also acting as a rainwater filter.

Figure 4.0 - University of Victoria, Parking lot #8. Google Maps
4.2 Design
The ditch will be one meter in width; we decided this width would be ideal for its purpose as a sink. The depth will be dependent on the inclination. We hope at its fullest, the depth will be 5 degrees parallel to the most level ground on the parking lot. This would allow the rainwater to be easily facilitated into the bioswale.

4.3 Materials
The materials associated with this ditch are weeping tile, and drain rock. The benefits of using weeping tile is that it allows for rainwater to enter the pipe, however, the small holes in the weeping tile acts as a filter to the pollutants in the parking lot. After digging the ditch we hope to put drain rock on the very bottom. This will not only maintain the durability of the ditch, but also decrease sedimentation. On top of the drain rock we will align the ditch with weeping tile (a pipe), which will filter the rainwater. Finally, we will cover the pipe with drain rock. This will help with filtering out larger pollutants, and decrease the flow into Bowker Creek. We hope the implementation of the bioswale, and the drainage ditch will help us achieve our goals and objectives. We realize the importance of Bowker Creek and want to ensure its health.

Section D – Implementation

1.0 Introduction
Restoration projects require detailed implementation plans to be able to succeed in establishment (Keenleyside, Dudley, Cairns, Hall & Stolton, 2012). At the core of a good implementation plan is the budget and timeline for the restoration project (Keenleyside et al, 2012). In addition to the budget and timeline other implementation plans such as, education plans, allow the project to be implemented with ease and success. In the case of the Bowker Creek Parking Lot restoration plan, four major implementation plans are required for this project to be a success. The four main plans are as follows:

1. Budget Plan
2. Timeline Plan
3. Education Plan
4. Future Monitoring Plan

The nature of the Bowker Creek Parking Lot restoration project requires extensive implementation planning due to the location, on the University of Victoria campus in a high
traffic parking lot, and the goals of community education about impervious surfaces. In this implementation section, each implementation plan will be outlined and the rationales and objectives behind each plan will be explained.

2.0 Budget Plan

2.1 Introduction
The Budget Plan for the Bowker Creek Parking Lot restoration plan details the numerous factors that have a cost associated to them in the project design. Each factor has been researched to ensure that the budget numbers put forward are accurate. The source of our budget will be coming from the University of Victoria.

2.2 Rational and Objectives of the Budget Plan
The Budget Plan has been prepared for the Bowker Creek Parking Lot restoration project to ensure its efficiency. Efficiency is a key component of a restoration plan (Keenleyside et al, 2012). Efficiency in a restoration plan refers to the projects ability to maximize the benefits but minimize the cost and effort needed to implement the project (Keenleyside et al, 2012). In the case of this plan the decisions was made to create detailed plans to ensure the cost and efforts were minimized but the benefits of the project where maximized.
2.3 Budget Plan

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<th>Materials</th>
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<td>Educational Sign (post construction – permanent sign)</td>
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<td>Soft Rush (x50)</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Flat Redosier Dogwood (x1)</td>
<td>$8.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$290.00</strong></td>
<td><strong>Total</strong></td>
<td><strong>$560.00</strong></td>
</tr>
</tbody>
</table>

**Total Cost = $9,896.65**

Table 2.0 – Budget Table
3.0 Timeline Plan

3.1 Introduction
The Timeline Plan created for the Bowker Creek Parking Lot Restoration Project is a guiding plan to ensure that the project stays within its timeline goals. The Timeline Plan has been developed to

3.2 Rational and Objectives of the Time Plan
The rationale for the Timeline Plan is to ensure that the project stays on track and is completed in the appropriate amount of time. The objective of the Timeline Plan is to ensure that the implementation of the project is efficient. As explain above in section 2.2 of the Budget Plan, efficiency refers to minimizing the cost and maximizing the benefits (Keenleyside et al, 2012). In the case of this project it is necessary to maintain the Timeline Plan because the location of the project site is in a high traffic area, and the establishment of the bioswales restoration project will cause a disruption to the area.

3.3 Timeline Plan
Length of Project
The construction timeline of this project is approximately two weeks or fourteen days. In addition to the two weeks of actual construction there will be associated time to organize all elements of the project. We consulted with Facilities Management at the University of Victoria to get an understanding of how long a project like this would take.

When
The project will be conducted in either June or early July. This time has been determined to be the best time because of the lower amounts of rainfall in the area. Due to the nature of developing bioswales that capture and slow rainwater, it is best to implement these features when there are lower levels of rainwater flowing in the area.

Timeline
March – May
- Contact local nurseries to order plants needed for project
- Ensure educational signage is ready

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- Inform facilities management and the university of the project and ensure that all requirements have been met for the implementation of the project
- Order all materials
- Organize what workers will be doing the project – brief workers on the project
- Begin organizing and ordering work force and educational signage to ensure it is ordered and ready by the start date

_June - July_
- Depending on weather and staffing abilities – implement project during two weeks in either June or July
- Construction should be done in two consecutive weeks to decrease disturbance to the parking lot use
- Set up educational sign number one during the construction phase

_August – December_
- Implement monitoring of the project success
- Install permanent education sign

4.0 Education Plan

4.1 Introduction
The Education Plan for the Bowker Creek Parking Lot restoration project has been developed to ensure that proper community education is available to raise awareness about impervious surfaces and the effects that they have on the Bowker Creek watershed. Due to the large number of individuals on university campus, we have determined that signs at the bioswale location will be the best way to implement the Education Plan.

4.2 Rational and Objectives of the Education Plan
Bowker Creek runs directly through a highly populated area, and raising awareness about this is necessary for restoration projects to be successful. We feel that this project will only truly succeed if the general community becomes educated about what the project is doing and how they can help ensure the success of the project. The objective of the Education Plan is to create easy to read signage that will inform individuals about the project, during implementation and after, and sources to more information.

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4.3 Education Plan

The Education Plan will consist of two signs. One that will be erected during the construction stage to inform people about what is happening, and another sign that will be erected after the construction is complete to inform people about the bioswale and its objectives. Sample signs below:

Pre/During Construction Sign:

WHAT IS HAPPENING HERE?

The University of Victoria, in partnership with the Capital Regional District and Friends of Bowker Creek, have teamed up to implement a restoration project for this parking lot. The rainwater that falls onto this parking lot flows directly into Bowker Creek. Due to the slope of the parking lot, large amounts of water flow directly into Bowker Creek. The restoration project being established here is to slow down the runoff into Bowker Creek to help maintain the health of the creek for future generations. Large amounts of runoff can overwhelm the creek ecosystem and cause damage to the species that are found within the creek.

HOW WE ARE DOING IT

We are creating bioswales to slow down and capture the rainwater and allow it flow into Bowker Creek. Take a look at the diagram below to see what a bioswale is!

LEARN MORE

Want to learn more about this project and other projects like it. Check out the following organizations for more information.

5.0 Monitoring Plan

This restoration project will require future monitoring to ensure that the project will be successful and fulfill its goals and objectives. The monitoring plan is quite extensive, and thus has been developed into its own section in this report. Please refer to Section E.

Section E – Monitoring

1.0 Introduction and Monitoring Goals and Objectives

Monitoring is an important component of any ecological restoration project. It provides a way to measure the progress towards the project objectives. The IUCN guide to best practices for ecological restoration outlines what should be involved in effective monitoring. Effective monitoring should be incorporated into the project from the beginning. It is necessary to first decide on indicators and monitoring methods, which will help determine the progress towards reaching the objectives. Even once objectives have been met it is important to continue monitoring for possible changes (Keenleyside, Dudley, Cairns, Hall, and Stolton, 2012).

There are some other important aspects to consider when planning the monitoring phase of a project. Monitoring should try and involve a variety of stakeholders, including, restoration specialists, local experts, and community groups. This varied involvement increases the accuracy of monitoring results. Ensuring transparency in the results of the monitoring process...
should be a priority, as it will help ensure confidence in the overall process and project. Choosing the right indicators and monitoring methods, which are cost effective and clear, make the continuation of monitoring viable over the long term. There will inevitably be changes in monitoring staff; so creating clear protocols for monitoring is useful (Keenleyside, Dudley, Cairns, Hall, and Stolton, 2012).

In our design project, we aim to monitor the effectiveness of our four main goals:

**Goal 1** - Eliminate pollutants and sediments from the storm-water runoff from parking lot #8.

**Goal 2** - Reduce the rate of storm-water runoff exiting parking lot #8.

**Goal 3** - Reduce the volume of water entering the runoff stream leading to Bowker Creek without causing flooding on the parking lot.

**Goal 4** - Create awareness about the Bowker Creek initiative and the importance of wise water management and native plant species.

2.0 Monitoring of Water Runoff and Volume

Monitoring water volume will be important for ensuring the proper functioning of the bioswale. One or two months before the implementation of the bioswale, depth measurements of the run-off stream should begin. These should be undertaken during storm events/heavy rains using meter stick. If the bioswale is working properly and increasing the water infiltration into the ground then we should see a decline in water depth. This data should be recorded in a spreadsheet and any trends can be assessed. Measuring the depth of the water contained in the swale itself will also be useful. This can be measured using a PVC pipe that has been secured to the bottom of the bioswale.

There are many ways to assess the success of reducing run-off. Current meters, calibrated or rated channel cross-sections, flumes or standardized wiers are all tools, which can be used to measure run-off. However for our purposes we suggest that measuring the water level of the run-off stream, during storm events, will be sufficient to get a general idea of run-off amounts (Jurries, 2003). Ideally, it would be good to have stream depth data for every month before the bioswale is put in, so a comparison can be made. Although even still there are limitations to this, because monthly precipitation data will vary.
3.0 Monitoring of Water Pollution

To monitor the changes in pollutants entering the stream (near parking lot 8) which runs into Bowker creek, a variety of tests can be done. Firstly, an easy test of water turbidity can be done. Turbidity is a measure of water clarity. In other words, it tells us how much suspended material is in the water. High turbidity means there is a lot of suspended material in the water, which prevents light from passing through it. Suspended material can include sediments (clay, sand, silt), algae, plankton, and microbes. High turbidity can be an indicator of soil erosion, waste discharge and urban runoff. Turbidity often increases during heavy rains, particularly in developed areas with many impervious surfaces (United States Environmental Protection Agency, 2012).

![Figure 3.0 - Water Turbidity](http://www.fondriest.com/news/turbiditymeasurement.htm)

High turbidity is an issue for all watersheds, including Bowker Creek, because it increases water temperatures. This results in decreases the amount of oxygen (warmer water holds less dissolved oxygen) in the stream. Reduced light penetration results in reduced photosynthesis. Both of these factors can greatly influence the health of a watershed. Suspended particles in water can affect fish species by directly clogging gills, reducing disease resistance, and affecting egg and larval development (United States Environmental Protection Agency, 2012). To ensure consistency and accuracy of monitoring procedures there are a few things to keep in mind. Turbidity measurements...
should be done at the same location with the same water flow, because it is closely related to stream velocity and flow. For our project, Facilities Management can do the turbidity monitoring.

There are multiple methods for assessing turbidity. Using a turbidity meter would produce the most accurate results. Although, this is also the most expensive method. Meters can cost up to $800 dollars each. We recommend using transparency tubes. These tubes can be purchased from a scientific supply house for $35 to $60. This method gives us a less costly, qualitative assessment of water clarity. The procedure is simple and can be carried out by volunteers. The procedure is as follows:

1. Collect a sample of water in a bottle or bucket.
2. Place the transparency tube on a white surface in an open but shaded environment. Avoid taking readings in direct sunlight.
3. Look vertically down the tube and observe the black and white pattern on the bottom.
4. Stir the water sample. Try to avoid creating air bubbles (these would scatter light and affect the reading).
5. Slowly pour the water sample you have collected into the tube. Intermittently stop to check if the pattern on the bottom has disappeared.
6. Once you can no longer see the pattern read the ruler on the side of the tube. Record the number on the weekly checklist. The water column will be higher in the tube when the water is clearer (ie there is less suspended material in the water).

*This sampling should be done in the same two locations. Location #1: in the culvert before the water reaches the bioswale. Location #2: the bioswale exit to the stream (United States Environmental Protection Agency, 2006).

Before implementation, turbidity tests upstream and downstream from the bioswale location can be done. A month after the bioswale is completed these tests should be done again monthly for at least a year.

When taking water samples these guidelines should be followed:

-If the water depth is less than 0.5 meters, one should collect samples at a depth equal to 1/3 of the water depth

-If the water depth is greater than 0.5 meters, one should collect samples at a depth of 0.3 meters below the surface.
To assess the success of our bioswale at removing pollutants from the runoff there must be analysis of water samples. Students in the Uvic chemistry department can do these tests. Partnering with Uvic in this manner will reduce monitoring costs. Water samples from the entrance and exit of the swale can be sent in for testing every month for 1 to 2 years. This will help us assess the effectiveness of the vegetation at filtering pollutants. The chemical constituents in storm run-off that can be tested for include nutrients like Nitrogen, ammonia (NH4), nitrate (NO3), and Phosphorus (P), metals (zinc (Zn), copper (Cu), iron (Fe), chromium (Cr), lead (Pb), nickel (Ni), mercury (Hg), and cadmium (Cd)), Total Organic Carbon (TOC), Dissolved organic carbon (DOC), and Total Petroleum Hydrocarbons (TPH). These are the primary concern in run-off water (Xiao and McPherson 2009). Tests should be done a few times during storm events before implementation of the bioswale, so an assessment of the success of pollutant reduction can be made. If results are not as we had hoped there is an opportunity for adaptive management (ex. Planting different vegetation etc).

4.0 Monitoring of Native Vegetation

Monitoring native vegetation in the bioswale can be done two ways. Firstly, volunteers can assess plant health during the weekly monitoring checklist. Notes can be made on the list if there are any concerns about plants. Photographs of the bioswale should be taken at least once a month to ensure longer term monitoring. Facilities Management should keep a log of these photographs for a historical record. Any dead vegetation should be removed as it is noticed. This will help by removing some of the accumulated pollutants from the bioswale (Jurries, 2003). This part of the monitoring should be done for at least a year.

4.0 Public Awareness

One of our goals was to increase public awareness of the Bowker Creek Initiative, and the importance of wise water management and native plants. To assess the success of this goal, we will conduct surveys before and after the implementation of our bioswale and signs. Before the implementation, at least 100 faculty members and students will be asked a series of questions pertaining to the project. Two months after the bioswale is completed and the signage is in place, the same questions will be asked of 100 more people. The questions will be as follows:

1. Can you name three native plants?
2. What is a bioswale? Why are they important?
3. Have you heard of the Bowker Creek Initiative?
To continue cultivating awareness and knowledge, the signage should be well maintained. Staff can assist in this process by cleaning signs weekly to ensure legibility. Any damage to the signs should be reported immediately to Facilities Management Grounds and Environmental Services Manager.

6.0 Monitoring Checklist

<table>
<thead>
<tr>
<th>Task</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observe native plant health: If it is the first week of the month</td>
<td>Take a photo of the bioswale and associated plants (send photos to <a href="mailto:bsly@uvic.ca">bsly@uvic.ca</a>)</td>
</tr>
<tr>
<td>Check signage: wipe off/check for damage. Report damage to Facilities</td>
<td>Manager.</td>
</tr>
<tr>
<td>Perform turbidity tests</td>
<td>Upstream of bioswale: Downstream:</td>
</tr>
<tr>
<td>Pick up any visible garbage</td>
<td>Entrance to bioswale: Exit:</td>
</tr>
<tr>
<td>Pull out weeds in bioswale</td>
<td></td>
</tr>
<tr>
<td>Check drainage ditch for blockages</td>
<td></td>
</tr>
<tr>
<td>Remove any dead vegetation (record removed species)</td>
<td></td>
</tr>
<tr>
<td>Qualitatively assess parking lot runoff: Is there water building</td>
<td></td>
</tr>
<tr>
<td>Collect two samples (entrance and exit of bioswale) to be sent to</td>
<td>upstream anywhere?</td>
</tr>
<tr>
<td>the chemistry department for analysis of pollutants</td>
<td></td>
</tr>
<tr>
<td>Measure run-off stream depth</td>
<td></td>
</tr>
<tr>
<td>Measure water level in bioswale (using PVC pipe)</td>
<td></td>
</tr>
</tbody>
</table>

7.0 Future Monitoring Opportunities

Facilities management may wish to involve the Friends of Bowker Creek Society in the monitoring process. If this is the case, the detailed checklist for staff monitoring activities (provided above) can also be supplied to the volunteers. This report can also be provided for further details of testing procedures. To ensure monitoring consistency amongst...
volunteers, one member of facilities management should be designated to show new volunteers the monitoring procedures. This staff member should also be the one volunteers report to and send their collected data.

We also hope that our project site and associated monitoring activities will be incorporated into future ES 341 classes. Viewing the site or participating in monitoring procedures would serve as a valuable education opportunity, provide students with practical experience, and generate interest and knowledge about the importance of storm-water management and impervious surfaces.

Section F – Acknowledgements

We would like to thank Bently Sly and Facilities Management at the University of Victoria for their guidance and . We would also like to thank Rita Fromholt and Matt Greeno from the Office of Campus Planning and Sustainability for their help. We would also thank Heike Lettrari for your support and encouragement through the development process of this project design.
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*Bio-swales for Bowker Creek*

By: Claire Buchanan, Chris Zielonka, Maria Chiarella, an Melanie Bryant
Group Work Division

Our group decided to break up the sections of the report into 4 different main parts. The first being Site Analysis and Goals and Objectives, the second being project design, the third being implementation, and the fourth being monitoring. Each member of the group was responsible for doing background research about their section and writing up the associated portion for our project. The break down of who did what section is as follows:

Site Analysis/Goals and Objectives – Chris

Project Design – Maria

Implementation – Claire

Monitoring – Melanie

In addition to our individual sections, our group met a number of times to ensure that the document flowed and each section was written using the same style. We worked with each other to share information and ideas to create a finished project that we are all proud of.