An Investigation into the Feasibility of Rain Gardens as a Stormwater Management Solution

Lam, Alfred; Tam, Raymond; Young, Robert; Woo, Sangpil

University of British Columbia, Applied Science 262 Technology and Society Sustainability Report, March 31, 2011

Science translation by Cindy Elliser, PhD 2022

Abstract

Stormwater pollution is an increasing problem in urban areas, like Vancouver, British Columbia, Canada. Rain gardens are thought to reduce the amount of pollutants entering waterways and may be a good way to reduce stormwater pollution. This study looks at whether the benefits of building rain gardens on the University of British Columbia campus outweigh the costs. Comparing costs, rain gardens were similar or cost less than regular gardens. The presence of rain gardens raises awareness about stormwater pollution and people enjoy how they look. Rain gardens can also filter out up to 90% of chemicals and up to 80% of solids from stormwater runoff, making them better for the environment than regular gardens. Rain gardens are a cost-effective way to filter stormwater while also making the campus more beautiful and providing educational opportunities.

Figure 1| Raingarden and Musqueam story pole on the University of British Columbia's campus. Water enters a drain system below ground after it is filtered by these wetland plants. (Image from student.ubc.ca is not associated with original article)

Introduction

In cities, the construction of buildings, homes and roads is needed as more and more people live in smaller areas. This changes the nature of the land and creates impervious surfaces like cement and pavement that do not allow water to drain as it would in soil. If water doesn't drain, it washes into the waterways, carrying whatever chemicals or other pollutants that are present.

Research has shown that pollutants such as poop, copper, lead, tire dust, and hydrocarbons (oil/gas) were present in very high amounts in streams that reach the Salish Sea. Heavy storms mean that more stormwater flows into the Salish Sea, and carries more pollutants into the water. Vancouver has a high amount of rain and snowfall, about 1200mm (47 inches) per year. They also have a large amount of impervious surfaces. Stormwater pollution is a big concern for the environment in this area.

Raingardens

Rain gardens are areas with lots of plants that allow stormwater runoff to be absorbed into filtering soils before it gets to the sewer pipes, most of which lead directly to the Salish Sea, but some lead to sewage treatment plants. When there is too much stormwater runoff, it can't be treated in normal sewage treatment plants, and instead is released directly into the Salish Sea.

Rain gardens provide an important step where the water can be filtered and reduce the amount of pollution. The University of British Columbia (UBC) is doing new construction and would like to reduce the amount of runoff that would be produced by adding rain gardens. Two rain gardens will be made around the new building that will help shape the landscape and increase how much rain water can be filtered before reaching the sewers.

There are two parts to raingarden design: the plants (vegetation) and drainage paths (Figure 2). The plants should be native to the area as they are well-adapted to the climate in the area. Microorganisms in the soil work together with the plants as filters, removing chemicals and waste from the rainwater. Below the garden is a thick layer of drain rocks to allow a space for the water to flow into. The drainage paths are made with rocks around the gardens and work to direct the stormwater to the gardens.

This study looks at raingarden design: what plants will be used and how they will be planted together, what the cost will be compared to a regular garden, and what environmental and social benefits may occur.

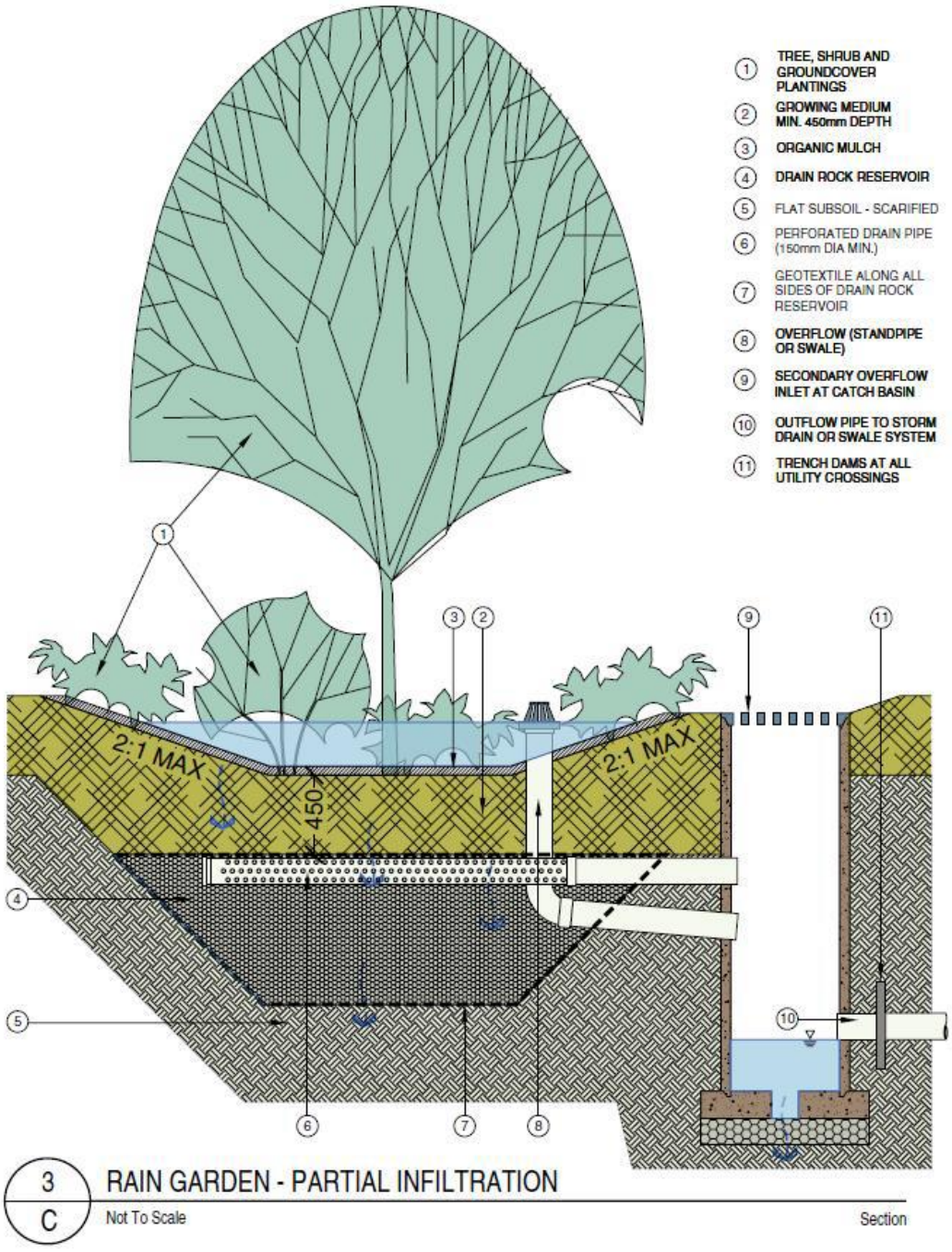

Figure 2| Cross section showing the typical components of a rain garden including the soil, the drainage rockbed, and the overflow and drainage plumbing (Metro Vancouver, 2005).

Economic factors – cost

The first expense is building the garden, called the capital cost. The area for the two gardens was determined (117.81m^2 and 94.25m^2). The cost for the project was calculated from a handbook about building rain gardens in Washington State, which has identical weather conditions so should be a good estimate for the cost in Vancouver (Table 1).

The cost was estimated to be $12,866. Another estimate was made based on the cost for each item needed to complete the project (like vegetation, excavators, gardeners, etc). This total cost was similar at $16,707.40. This price would not be significantly more expensive than a regular garden because the extra items needed to make the raingarden (drain rocks, pipes and certain plants) do not add much to the price of the project.

The second cost is garden maintenance. The UBC plant operations' landscape manager estimated that it would require a medium level of maintenance, including weed control, tree trimming and minor repairs, and estimated $2500 cost per year. However, native raingarden plants are adapted to the climate and soil, which means they may need less maintenance (unlike regular gardens that often use nonnative plants) and the cost may be lower than the estimate given. *Note: that the dollar amounts in Table 1 are from 2011 and may be higher now.*

Table 1 - Expected costs for materials and equipment necessary to implement a typical rain garden based on the Washington State University guide for rain gardens (Hinman, 2007).

Excavator	**$2,000/ 2 weeks (EZ equipment, 2011) = $3,150** ***Western Washington's rain garden required 2 days of use with the excavator and UBC's rain gardens are approximately 9x their size; hence assuming it takes 18 days to construct, or approximately 2 weeks**
Excavator Delivery	2 trips @ $25/trip (EZ equipment, 2011) = $50
Compost	127.24m^3 @ $10/$m^3$ (Engineering Services Solid Waste, 2011) = $1,272.40 *Assuming the garden is at max, 0.6 meters deep; hence the total volume of the garden is (212.06m^2) * 0.6m =127.24m^3 in volume
Compost Pick Up	Free
Drain Rocks	1 ton @ $55/tonne (Sharecost Rentals & Sales, 2011) = $55
Overflow and bulk drainage plumbing	27 meters @ $40/3 meters (The Home Depot, 2011) = $360 *Assuming the pipes needed are approximately the combined lengths of the garden: 15m+12m = 27 meters
Vegetation Costs *The plant list is provided by the 100% Schematic Report *Quantity is estimated based on the size of the Rain Gardens *Prices are market value estimates retrieved from plant companies around the world	
Beaked Sedge	$30/oz of seeds (Prairie Moon Nursery, 2011) = $30
Saw Beak Sedge	$15/oz of seeds (Western Native Seed Home, 2011) = $15
Red-Stemmed dogwood	10 pots @ $8/pot (Las Pilitas Nursery, 2011) = $80
Common Rush	$40/oz of seeds (Prairie Moon Nursery, 2011) = $40
'Nana' Dwarf Purple Willow	10 pots @ $6/pot (Planfor, 2011) = $60
Arrowhead	$15/oz of seeds (Prairie Moon Nursery, 2011) = $15
Miniature Cattail	10 pots @ $6/pot (The Grass Emporium, 2011) = $60
Labor Cost:	*The plant list is provided by the 100% Schematic Report *Quantity is estimated based on the size of the Rain Gardens *Prices are market value estimates retrieved from plant companies around the world
1 Excavator operator	8 hour/day @ $16/hour @ 18 days = $2,304
4 Gardeners	8 hour/day @ $16/hour @ 18 days = $9,216
Total Cost	$16,707.40

Social factors – what benefits will the raingarden bring?

The design of a unique rainwater collection feature will be eye catching and get student's attention. This is important because based on a small survey, even though many knew about the issue surrounding stormwater, most had never heard of a raingarden before or knew that it could help. In addition, the site can be used by teachers to teach students about stormwater issues and what can be done to help.

Studies have shown that nature has positive effects on the body and mind (Kaplan 1989 and 2001). Studies have shown that students who used green spaces on campus felt happier with their peers (friends) and felt better about themselves at school (McFarland et al., 2008). Many studies have shown that being in nature, or even seeing nature (through a window for example), can help relieve stress. Rain gardens can have positive impacts on student mental health. Rain gardens will also help with flooding that can make it difficult for students to get to different parts of the campus, making life on campus a little easier.

The rain gardens can have many positive social effects on students at UBC. It can provide a place for people to interact, relieve stress levels, and be an educational site for stormwater issues.

Environmental factors – how good is it for the environment?

Rainwater picks up pollutants from the land as it flows along to the storm drain. This makes up 70% of water pollution. The soil, plants and root systems in a rain garden soak up and filter the water, taking out up to 90% of the chemicals and up to 80% of the sediment (dirt/solids). The roots allow the water to infiltrate (get into) the soil and give it structure. Plants with roots that go side to side (horizontal) are best because they spread out and stabilize the soil. This also allows water to more easily soak into the soil. Native plants also help preserve (save) other native plants, attract wildlife and give oxygen to the environment. The plant species used should be able to survive the cool and wet climate, be good at treating waste water, and fit into a university campus environment. Native plants don't need fertilizers, can withstand harsher weather and require less maintenance compared to a traditional garden.

Having wildlife in the garden adds to the beauty that benefits people, but also provides habitat, protection from predators and food for small mammals and birds. However, some animals may not be wanted on the campus, so the wildlife benefits of each plant (what animals they attract) should be looked at when choosing the plants. Another possible negative effect is extra rain may create standing water during the summer months that attracts mosquitos. Mosquitos can pass on diseases like West Nile Virus, and are a human health concern, but they need around 3 days to lay and hatch eggs.

Rain gardens are known to greatly reduce the amount of pollution entering waterways. However, this means that chemicals are left in the soil that may be toxic to plants. Replacing the soil and mulching (covering the soil with things like wood chips) can help breakdown these chemicals over time.

The benefits to the environment are clear, with very few negative effects. Issues with soil toxicity and mosquitoes can be easily managed with regular soil maintenance and good design of the drainage system that will limit standing water.

Monitoring – how is it working?

It is important to monitor how well a raingarden is working. The American Water Resources Association has three methods to determine if rain gardens are working: visual inspection (is the garden overflowing with water), measuring how much water can get into the soil, and flooding the garden on purpose to see how well it drains. These methods should be used to make sure the raingarden is working effectively.

Conclusion

There are clear social and environmental benefits to installing rain gardens at UBC. Compared to regular gardens, only a few small changes are needed, but these changes create an environment that filters out the majority of pollutants in stormwater runoff. The rain garden also adds beauty to the campus and provides educational opportunities for students to learn about stormwater runoff issues and what can be done to stop them. The cost is not much more than a traditional garden. Rain gardens are a cost effective way to add beauty to the campus and reduce pollution in stormwater runoff. Monitoring methods should be used throughout the life of the garden to be sure the rain gardens are working as intended.

Figure 1 - Cross section showing the typical components of a rain garden including the planting medium, the drainage rockbed, and the overflow and drainage plumbing (Metro Vancouver, 2005).

References cited

Kaplan, R. (2001). The nature of the view from home: Psychological benefits. *Environment & Behavior*, 33, 507-542

Kaplan, R., & Kaplan, S. (1989). *The Experience of Nature: A Psychological Perspective*. Cambridge University Press, Cambridge, New York.

McFarland, A. L., Waliczek, T. M., & Zajicek, J. M. (2008). The Relationship Between Student Use of Campus Green Spaces and Perceptions of Quality of Life. *HortTechnology,* 18, 232-238