User Manual:

Surrey Rain Garden Project

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Executive Summary

The goal of the Rain Garden Design Guide is to provide steps on how to build a rain garden in Surrey, BC. Any risks of endangerment in building and maintaining the rain garden will be outlined under safety considerations. The technical specifications will explain considerations for choosing a site, sizing a garden, and calculating infiltration rate, layer composition, and layer depth.

For a full-size rain garden, one can choose to build a water sampling mechanism for quantifying the rain garden's performance. Details on how to construct the water sampling mechanism will be included in the technical specifications as well. How to use the water sampling mechanism is discussed within the user manual for users who wish to collect data from the rain garden's performance.

To construct the rain garden, materials, equipment, and services will need to be utilized. Ongoing maintenance materials and tasks are also defined such that the user is well-equipped to oversee the growth of the rain garden over time. A list of appropriate plants has been selected by FloRA for their climate resilience and aesthetics. These plants are outlined in the technical specifications for users to choose from.

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1. Building a Rain Garden

1.1. Rain Garden Safety Considerations

The rain garden users' safety is dependent on both design and location. FloRA is determined to ensure that for any location, risks are mitigated accordingly to keep the public and users of the rain garden safe. Before the construction of the rain garden, checking for utilities is done to ensure that no obstructions are beneath the garden's planned site. The depth of the garden is greatly dependent on the existing soil conditions, though garden depth will not be a significant hazard as the area will be cordoned off with caution tape when digging is taking place. Once the rain garden is filled, it will not be a significant tripping hazard for the public due to the very low slope of the garden.

The potential of pooling in the rain garden is also a risk, however, signage, and the shallow depth of the rain garden's ponding layer should minimize risk. In the recommended plants for a rain garden, some plants have edible berries; it is important not to eat any of the plants or berries from the rain garden as the soil can be contaminated from the water runoff it is filtering. Minimal allergens are present in the selected plants and plants with edible berries are not common berry types that would attract people to eat the plants (such as blueberries).

In the construction phase of the rain garden, have a group of individuals help with lifting heavy soil and rocks. The use of a wheelbarrow and rotating responsibilities is recommended to avoid overexertion and/or strain.

1.2. Rain Garden Technical Specifications

1.2.1: Site Location

When choosing a site for the rain garden, there are certain features of a site to look for and ones to avoid.

Good Site Features

- Flat, unused areas of lawn
- Areas with good drainage
- Areas downslope of a paved surface or roof downspout
- In front of homes or areas where the garden will approve the appearance

Features to avoid

- Within 10ft of a building foundation
- Near steep slopes (over 10%)
- Low areas with poor drainage
- Near or over utilities such as electrical boxes or septic tanks
- Underneath large trees
- Areas with existing healthy native vegetation
- Areas with a water table above 1.3m

Be sure to check with the appropriate municipality for any bylaws applying to rain garden location and construction. In Metro Vancouver, it is required to use the BC 1 Call service prior to excavating the rain garden site to ensure there are no utilities in the excavation site.

1.2.2: Sizing

Depending on the site, different specifications will be needed. To determine what is best for the site, an infiltration test and sizing calculations must be done. The procedure for the infiltration test consists of digging a circular hole of a known diameter, digging 12 inches deep with a flat bottom. Using a 12-inch deep hole will give a better idea of the soil's water retention. Then, fill the hole with water and use a ruler to indicate the starting and endpoint over time. Calculate the volume of water before and after, then divide over the amount of elapsed time. This will give the infiltration rate. An example is given in Equation 1. Figure 1 shows an example of an infiltration test being conducted as well as an example of a hole dug for infiltration testing.

$$K_s = \frac{(h_f - h_i) \times \pi \times r^2}{T_{in}} \qquad (1)$$

Where:
K_S = Infiltration rate (mm/hr)
h_f = Final water height (mm)
h_i = Initial water height (mm)
r = Radius of the hole (mm)
T_{in}= Infiltration time (hr)

Figure 1: Onsite Infiltration Testing

To size the rain garden, the user must know the area of impervious cover that will feed the runoff to the rain garden, as well as the anticipated rain garden area. FloRA defines impervious cover

areas as areas of impervious surface that water will flow from, and into the adjacent rain garden. Figure 2 shows an image of previous areas and impervious surfaces where one may want to collect water. The ratio of impervious cover to the garden area, I/P, is found by Equation 2.

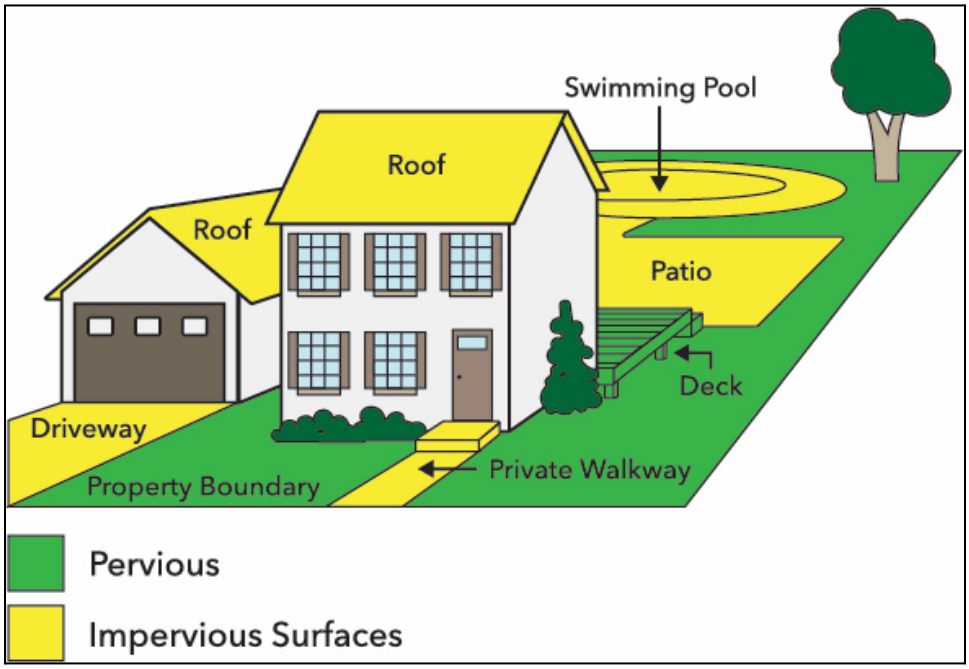

Figure 2: Examples of impervious and pervious cover [1].

$$I/P = \frac{IA}{GA} \quad (2)$$

Where:

I/P = Ratio of impervious cover to rain garden area
IA = Impervious cover area
GA = Rain garden area

Using this ratio, the required depth for the bioretention layer can be found. Equation 3 shows how the bioretention layer thickness is sized. Rainfall capture depth, R, is a regional measure of how much precipitation one plans on designing for with their rain garden.

$$D_S = \frac{R \times (I/P + 1) - K_s \times 24}{0.2} \quad (3)$$

Where:

D_S = Required soil depth (thickness) of the bioretention layer (mm)
R = Rainfall capture depth (mm)
I/P = Ratio of impervious cover to rain garden area
K_S = Infiltration rate (mm/hr)

To allow for temporary water storage, the drain rock layer thickness will need to be sized as well. An example of drain rock can be seen in Figure 3. To avoid a situation where undrained water becomes a breeding ground for mosquitoes, 3 days are recommended as the allowable drain time, T_d. Depending on the drain rock used, porosity, n, is variable, though a porosity of n = 0.4 is common for most drain rock [2].

Figure 3: Example drain rock [3].

$$D_R = \frac{K_s \times T \times 24}{n} \quad (4)$$

Where:

D_R = Maximum depth (thickness) of rock reservoir (mm)
K_S = Infiltration rate (mm/hr)
T_d = Allowable drain time (days)
n = porosity of drain rock in reservoir

In most rain gardens, the drain rock layer will be one of the most costly portions of the project. The Metro Vancouver 2012 Stormwater Source Control Guidelines 2012 (SCG) highlights that the minimum depth of the drainage layer should be 0.3m. As long as the depth of drain rock in one's garden is between 0.3m and D_R, it is up to the user to decide how thick they wish the drainage layer to be. A thicker drain rock layer will lead to a deeper garden and greater potential for temporary water storage.

1.2.3: Bioretention and Drainage Layers

FloRA's rain garden consists of multiple layers that allow for better water retention within the garden. Using literature values from the Massachusetts Clean Water Toolkit, the bio-retention layer can be broken down into a mixture of topsoil (30%), (40%), and compost (30%) [4]. Below is a

list of layer descriptions and functions. In Figure 4, a diagram is presented that shows the different layers concerning each other.

1. **Ponding**: Space for water to pool prior to infiltration into the soil.
2. **Mulch and Top rock**: Hold moisture, provide microorganisms into the soil and allow for large alien objects to be caught.
3. **Bioretention**: Compost/Topsoil combination with sand underneath to increase infiltration rates and act as a "powerhouse" to filter out the bulks of the hydrocarbons, metals, bacteria, and suspended solids [5].
4. **Drain Rock**: Store water within voids and filter.
5. **Scarified Soil**: Soil is tilled into parallel sections beneath the bottom layer of gravel to increase infiltration and increase stabilization in the garden.
6. **Geotextile lining** (woven): the sloped perimeter: low permeability layer to aid water diversion, contain the garden, and help structurally support its sloped walls.

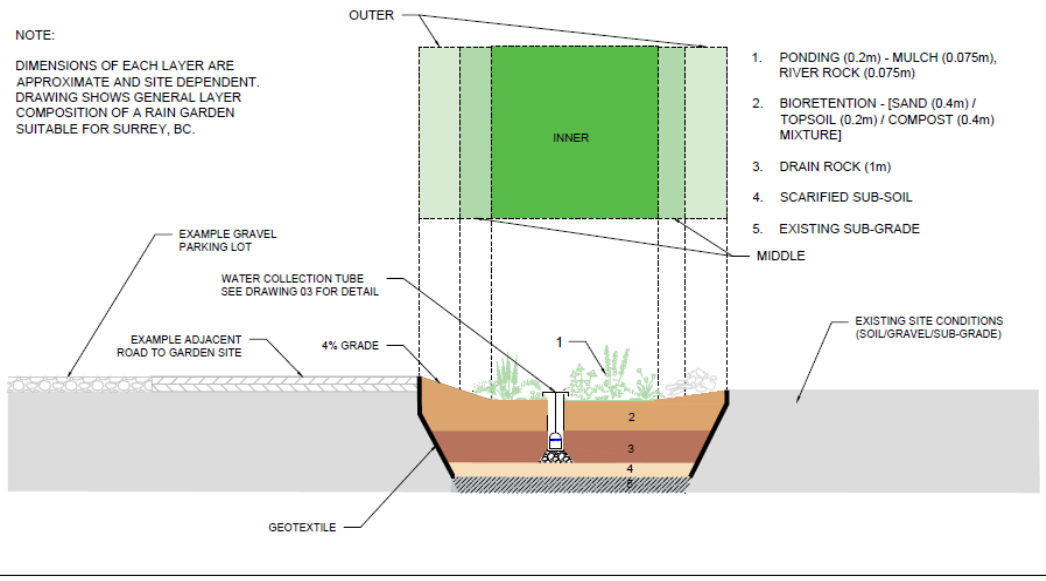

Figure 4: Cross-sectional view of rain garden

1.2.4: Plant Planning and Selection

FloRA has created a list of plants that would be appropriate for a rain garden in the Metro Vancouver area. In Table 1, the appropriate plants are zoned and notes are provided about their size, maintenance, and fruit/flowers.

Table 1. Plant species chosen for the rain garden categorized into garden zones

Garden Zone	*Species* / Common Name * *indigenous species*	Type	Mature Size	Notes
Inner (Wet zone)	* *Cornus sericea* / Red-oseri dogwood	Deciduous Shrub	6-12 feet	Will require pruning. Small white flowers in clusters, red branches.
	* *Cornus sericea* 'Kelseyi' / Dwarf red-twig dogwood	Deciduous Shrub	1.5 feet	Small white flowers, low-growing.
	* *Vaccinium ovatum* 'Thunderbird' / Evergreen huckleberry	Evergreen Shrub	3-6 feet	May require pruning. White-pink flowers, small black berries.
	Carex muskingumensis / Palm Sedge	Grass	2-3 feet	
	Carex Squarrosa / Squarrose Sedge	Grass	2-3 feet	Small tufts on grass ends.
	Chelone / Turtlehead	Perennial	2-3 feet	Pink flowers.
Middle (Moist zone)	* *Adiantum pedatum*/ Maindenhair fern	Perennial	1-2 feet	Prefers a moist environment. Leafy green.
	* *Blechnum spicant* / Deer fern	Perennial	1-2 feet	Prefers a moist environment. Leafy green.
	* *Mahonia aquifolium* / Oregon grape	Evergreen Shrub	6-8 feet	May require pruning. Yellow flowers.
	Carex Squarrosa / Squarrose Sedge	Grass	2-3 feet	Small tufts on grass ends.
	* *Tiarella trifoliata* / Foamflower	Perennial	1-2 feet	White-pink flowers.
	* *Gaultheria shallon* / Salal	Evergreen Shrub	1-6 feet	May require pruning. White flowers, dark berries.
	Chelone / Turtlehead	Perennial	2-3 feet	Pink flowers.
Outer (Dry zone)	**Symphyotrichum subspicatum* / Douglas Aster	Perennial Wildflower	1-3 feet	White-pink flowers.
	* *Blechnum spicant* / Deer fern	Perennial	1-2 feet	Prefers a moist environment. Leafy green.
	* *Tiarella trifoliata* / Foamflower	Perennial	1-2 feet	Prefers a moist environment. Leafy green.
	* *Gaultheria shallon* / Salal	Evergreen Shrub	1-6 feet	May require pruning. White flowers, dark berries.
	* *Arctostaphylos uva-ursi* / Kinnikinnick	Evergreen Shrub	1 foot	Dry or occasionally moist areas. White-pink flowers, red berries.
	* *Cornus sericea* 'Kelseyi' / Dwarf red-twig dogwood	Deciduous Shrub	1.5 feet	Small white flowers, low-growing.
	Carex muskingumensis / Palm Sedge	Grass	2-3 feet	

Depending on what plants one chooses for their rain garden, different maintenance needs may occur. It is up to the user to decide which plants they want to include in their rain garden.

1.2.5: Water Sampling Mechanism & Testing

For users who wish to obtain data from the rain garden's performance, a water sampling mechanism can be constructed. Figure 5 shows the design of a water collection tube that individuals can use to procure water samples which can then be qualitatively or chemically analyzed.

Qualities to look for or test from the water collected include:

- Turbidity
- pH
- Presence of toxic compounds (ex. 6PPD-quinone)

Other tests that can be conducted include soil moisture which simply requires the user to take a soil sample, weigh it, dry it in an oven, and re-weigh it. The difference in weight indicates how much water was retained in the soil. Though this test can only be reasonably conducted on the top layer of the garden, it can still serve as a useful learning tool throughout the year to demonstrate how soil characteristics change over the seasons with precipitation changes.

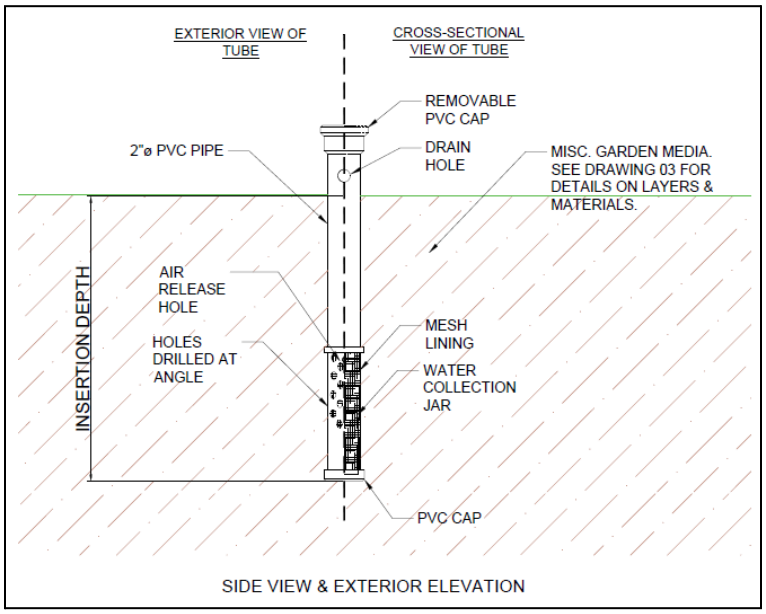

Figure 5: Water collection tube.

1.3. Construction Process

1.3.1: Rain Garden Construction

The construction of the rain garden has been broken down into multiple steps:

1. Coordinate with the site owners and suppliers for the delivery of the materials.
2. Begin excavation of the determined hole size.

3. Scarify the bottom layer of the original soil.
4. Add the drain rock throughout the hole until the required depth.
5. Install the fabric along the outside walls of the given hole.
6. If a water collection tube is included, position it in the garden before continuing to step 6.
7. Add the bioretention layers and spread them evenly throughout the hole.
8. Spray the soil with a mild mist of water until reaching saturation. The garden can then be left alone to dry and utilize natural compaction.
9. If desired, invite volunteer participants to assist with planting, and adding the mulch and top rock.
10. Engage with volunteers/students about the various elements of the garden.
11. Remove any alien debris from the top layers and ponding section left from construction.

1.3.2: Water Sampling Tube Construction

To build a water sampling mechanism, follow the following steps:

1. Obtain a 2" PVC pipe long enough for your garden's depth, two 2" pipe caps, a small jar without a lid, wire, tape, or non-toxic glue, and stainless steel mesh.
2. Drill holes around the lower third of the pipe at an angle and one hole near the top of the pipe (above the garden). Line the lower holes with mesh and use tape or non-toxic glue to affix the mesh onto the inner walls of the PVC pipe.
3. Create a wire basket around the jar to pull the jar out of the tube for testing.
4. Attach the bottom pipe cap and place the jar with a wire basket inside the pipe.
5. When assembling the garden, place the collection tube in the desired area.

1.4. Rain Garden Maintenance

Bioretention Layers and Mulch
The surface layer of the rain garden requires regular maintenance to ensure the rain garden is functioning optimally. As large volumes of rainwater run through the garden, the surface layer of mulch can experience erosion in addition to biodegrading over time. Keeping the ground wood mulch layer at 50-75mm in thickness by replenishing the mulch annually can inhibit weeds while protecting the bioretention soil layers from erosion. There will still be some weeds that require removal during the spring and summer months to keep the rain garden looking clean. For rain gardens collecting pollutants from road runoff, the pollution accumulation in the bioretention layers requires that the layers eventually be fully replaced and disposed of accordingly after 10-20 years, depending on the site conditions.

Irrigation
The garden will require watering for approximately 2-3 years after planting, with the most important watering stage being the first summer after planting. Follow local watering restrictions

during the summer months. After 2-3 years, the plant's root systems should be established enough that the rain garden no longer requires watering.

Plant Maintenance

Plants need regular maintenance such as pruning and replacement. All dead plants should be replaced. Remove dead plant material from the mulch surface. Perform weeding and pruning according to the maintenance schedule in Table 2.

Erosion Control

The inlets and outlets of the rain garden should be inspected periodically for the buildup of plant material. Inspect any garden slopes or berms for signs of erosion. Repair any eroded areas and re-assess the area during rainfall events. River rock can be a useful material to prevent further erosion of mulch layers.

Table 2. Rain garden maintenance schedule. Adapted from District of Saanich maintenance recommendations [6].

Maintenance Practices												
	Schedule (Month)											
Procedure	**J**	**F**	**M**	**A**	**M**	**J**	**A**	**S**	**O**	**N**	**D**	**Frequency**
Replenish Mulch				/				/				Annually
Replace Perished Plants				*	*							As required
Water				*	**	**	**	**	*			As required
Prune		*								*		As required
Remove Weeds				*	*	*	*	*	*			As required
Barrier/Slope Repair				/					/			As required
Collection Tube Sediment Removal				/								Annually or as required
Clean Inlets/Outlets	**	**	*	*	*	*	*	*	*	**	**	As required
General Debris Cleaning			*					*				As required
/ denotes regular maintenance procedures			* denotes maintenance as required					** denotes extra important maintenance during specific months				

2. References

[1]"Savage, MN," *Impervious Surface*. [Online]. Available: https://www.cityofsavage.com/government/departments-divisions/impervious-surface. [Accessed: 28-Mar-2023].

[2] "Assets.ads-pipe.com." [Online]. Available: https://assets.ads-pipe.com/m/68ef3093e0ede856/original/TN-6-30-Porosity-of-Structure-Backfill.pdf. [Accessed: Nov-2022].

[3] "Drain Rock," Super Soil. [Online]. Available: https://supersoil.ca/product/drainrock/. [Accessed: Nov-2022].

[4] "Bioretention Areas & Rain Gardens," megamanual.geosyntec.com. [Online]. Available: https://megamanual.geosyntec.com/npsmanual/bioretentionareasandraingardens.aspx. [Accessed: Nov-2022].

[5] NJDEP New Jersey Department of Environmental Protection. [Online]. Available: https://www.nj.gov/dep/stormwater/bmp_manual2.htm. [Accessed: Oct-2022].

[6] "Rain gardens - saanich.ca." [Online]. Available: https://www.saanich.ca/assets/Community/Documents/Rain%20Garden.pdf. [Accessed: Nov-2022].