Alternative Stormwater Management Practice
RAIN GARDENS

Description

The rain garden is a stormwater management practice to manage and treat small volumes of stormwater runoff using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression. They are most commonly used in residential land use settings. The method is a variation on bioretention and combines physical filtering and adsorption with bio-geochemical processes to remove pollutants. Rain gardens are typically smaller than bioretention and are generally designed as a more passive filter system without an underdrain connected to the stormdrain system, although a gravel filter bed is recommended. Rainwater is directed into the garden from residential roof drains, driveways and other hard surfaces. The runoff temporarily ponds in the garden and seeps into the soil over several days. The system consists of an inflow component, a shallow ponding area over a planted soil bed, a mulch layer, a gravel filter chamber, plant materials consisting of attractive shrubs, grasses and flowers, and an overflow mechanism to convey larger rain events to the storm drain system (see Figure 1) or receiving waters.

Recommended Application of the Practice

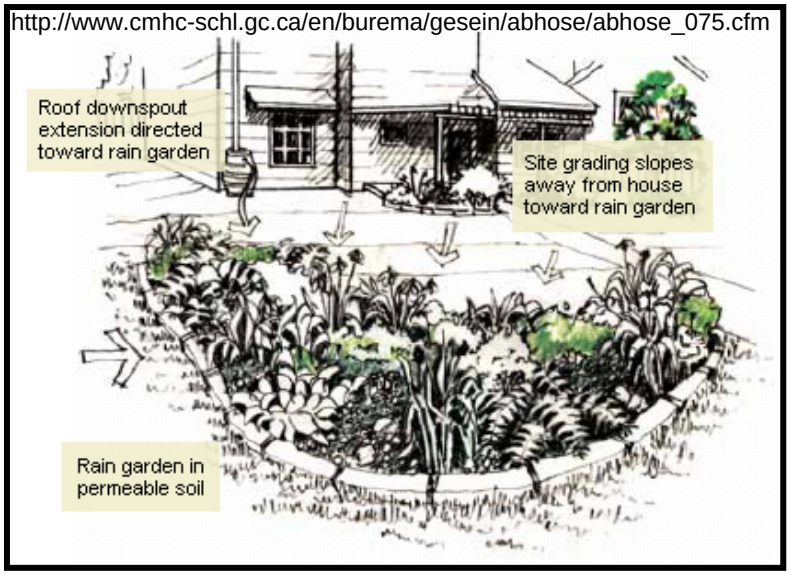

Figure 1: Layout of a typical rain garden

The rain garden is suitable for townhouse and single family residential applications where it is used to treat small storm runoff from residential rooftops, driveways, and sidewalks. Rain gardens can be utilized in residential redevelopment projects, including townhouse projects, and in some institutional settings such as schoolyard projects. Since rain gardens do not need to be tied directly into the stormdrain system, they can be used to treat areas that may be difficult to otherwise address due to inadequate head or other grading issues. Rain gardens are designed as an "exfilter," allowing rainwater to slowly seep through the soil. They have a prepared soil mix and should be designed with a deeper gravel chamber to improve treatment volume, and to compensate for clays and fines washing into the area. They are typically 150 - 300 square feet for a residential area. Rain gardens can be integrated into a site with a high degree of flexibility and work well in combination with other structural management systems, including porous pavement, infiltration trenches, and swales.

Benefits

Rain gardens can have many benefits when applied to redevelopment and infill projects in urban settings. The most notable include:

- Effective pollutant treatment for residential rooftops and driveways, including solids, metals, nutrients and hydrocarbons
- Groundwater recharge augmentation
- Micro-scale habitat
- Aesthetic improvement to turfgrass or otherwise hard urban surfaces (Figure 2)
- Ease of maintenance, coupling routine landscaping maintenance with effective stormwater management control
- Promotion of watershed education and stewardship

Figure 2: Rain gardens also have aesthetic value.

Feasibility/Limitations

Rain gardens have some limitations, similar to bioretention, that restrict their application. The most notable of these include:

- Steep slopes. Rain gardens require relatively flat slopes to be able to accommodate runoff filtering through the system. Some design modifications can address this

constraint through the use of berms and timber or block retaining walls on moderate slopes.

- Compacted and clay soils. Soils compacted by construction and heavy clay soils need more augmentation than sandy soils, though all soils should be prepared to specification. In compacted soils and clay, additional excavation is necessary, along with a gravel bed and, under some circumstances, an underdrain system.

- A single rain garden system should be designed to receive sheet flow runoff or shallow concentrated flow from an impervious area or from a roof drain downspout with a drainage area equal to or less than 1,000 square feet. Because the system works by filtration through a planting media, runoff must enter at the surface.

- The rain garden must be sited in a location that allows overflow from the area to sheet flow or be otherwise safely conveyed to the formal drainage system. Rain gardens should be located downgradient and at least 10 feet from basement foundations.

- Rain gardens require a modest land area to effectively capture and treat residential runoff from storms up to approximately the 1-inch precipitation event.

- Rain gardens should not be located in areas with heavy tree cover, as the root systems will make installation difficult and may be damaged by the excavation.

Sizing and Design Guidance

Stormwater quantity reduction in rain gardens occurs via evaporation, transpiration, and infiltration, though only the infiltration capacity of the soil and drainage system is considered for water quality sizing. The storage volume of a rain garden is achieved within the gravel bed, soil medium and ponding area above the bed. The size should be determined using the water quality volume (WQv), where the site area is the impervious area draining to the rain garden. The following sizing criteria should be followed to arrive at the surface area of the rain garden, based on the required WQv:

$$WQv \leq V_{SM} + V_{DL} + (D_P \times A_{RG})$$

$$V_{SM} = A_{RG} \times D_{SM} \times n_{SM}$$

$$V_{DL} \text{ (optional)} = A_{RG} \times D_{DL} \times n_{DL}$$

where:
V_{SM} = volume of the soil media [cubic feet]
V_{DL} = volume of the drainage layer [cubic feet]
A_{RG} = rain garden surface area [square feet]
D_{SM} = depth of the soil media, typically 1.0 to 1.5 feet [feet]
D_{DL} = depth of the drainage layer, typically .05 to 1.0 feet [feet]
D_P = depth of ponding above surface, maximum 0.5 feet [feet]

n_{SM} = porosity of the soil media (≥20%)
n_{DL} = porosity of the drainage layer (≥40%)
WQv = Water Quality Volume [cubic feet], as defined in Chapter 4 of the New York Stormwater Management Design Manual

A simple example for sizing rain gardens based upon WQv is presented in Table 1.

Table 1: Rain Garden Simple Sizing Example

Given a 1,000 square foot impervious drainage area (e.g., rooftop), a rain garden design has been proposed with a 200 square foot surface area, a soil layer depth of 12 inches, a drainage layer depth of 6 inches, and an allowable ponding depth of 3 inches. Evaluate if the proposed rain garden design satisfies site WQv requirements

Step 1: Calculate water quality volume using the following equation:

$$WQv = \frac{(P)\,(Rv)\,(A)}{12}$$

where:

P = 90% rainfall number = 0.9 in

Rv = 0.05+0.009 (I) = 0.05+0.009(100) = 0.95

I = Percentage impervious area draining to site = 100%

A = Area draining to practice (treatment area) = 1,000 ft^2

$$WQv = \frac{(0.9)(0.95)(1{,}000)}{12} \qquad WQv = 71.25\ ft^3$$

Step 2: Solve for drainage layer and soil media storage volume:

$V_{SM} = A_{RG} \times D_{SM} \times P_{SM}$

$V_{DL} = A_{RG} \times D_{DL} \times P_{DL}$

where:

A_{RG} = proposed rain garden surface area = 200 ft^2

D_{SM} = depth soil media = 12 inches = 1.0 ft

D_{DL} = depth drainage layer = 6 inches = 0.5 ft

P_{SM} = porosity of soil media = 0.20

P_{DL} = porosity of drainage layer = 0.40

V_{SM} = 200 ft^2 x 1.0 ft x 0.20 = 40 ft^3

V_{DL} = 200 ft^2 x 0.5 ft x 0.40 = 40 ft^3

D_P = ponding depth = 3 inches = 0.25 ft

$WQv \leq V_{SM}+V_{DL}+(D_P \times A_{RG})$ = 40 ft^3 + 40 ft^3 + (0.25 ft x 200 ft^2)

WQv = 71.25 ft^3 ≤ 130.0 ft^3, OK

Therefore, the proposed design for treating an area of 1,000 ft^2 satisfies the WQv requirements .

Siting Rain gardens should be located within approximately 30 feet of the downspout or impervious area treated. Rooftop conveyance to the rain garden is through roof leaders directed to the area, with stone or splash blocks placed at the point of discharge into the rain garden to prevent erosion. Runoff from driveways and other paved surfaces should be directed to the rain garden at a non-erosive rate through shallow swales, or allowed to sheet flow across short distances (Figure 3).

Figure 3: This rain garden treats road and driveway runoff.

Sizing The following considerations should be given to design of the rain garden (after PA Stormwater Design Manual, Bannerman 2003 and LID Center):

- Ponding depth above the rain garden bed should not exceed 6 inches. The recommended maximum ponding depth of 6 inches provides surface storage of stormwater runoff, but is not too deep to affect plant health, safety, or create an environment of stagnant conditions. On perfectly flat sites, this depth is achieved through excavation of the rain garden and backfilling to the appropriate level; on sloping sites, this depth can be achieved with the use of a berm on the downslope edge, and excavation/backfill to the required level.

- Surface area is dependent upon storage volume requirements but should not exceed a maximum loading ratio of 5:1 (drainage area to infiltration area, where drainage area is assumed to be 100% impervious; to the extent that the drainage area is not 100% impervious, the loading ratio may be modified)

- A length to width ratio of 2:1, with the long axis perpendicular to the slope and flow path is recommended.

Soil The composition of the soil media should consist of 50% sand, 20-30% topsoil with less than 5% clay content, and 20-30% leaf compost. The depth of the amended soil should be approximately 4 inches below the bottom of the deepest root ball.

Construction Rain gardens should initially be dug out to a 24" depth, then backfilled with a 6 - 10 inch layer of clean washed gravel (approximately 1.5-2.0 inch diameter rock), and filled back to the rain garden bed depth with a certified soil mix.

Environmental/Landscaping Elements

The rain garden system relies on a successful native plant community to stabilize the ponding area, promote infiltration, and uptake pollutants (Figure 2). To do that, plant species need to be selected that are adaptable to the wet/dry conditions that will be present. The goal of planting the

rain garden is to establish an attractive planting bed with a mix of upland and wetland native shrubs, grasses and herbaceous plant material arranged in a natural configuration starting from the more upland species at the outer most zone of the system to more wetland species at the inner most zone. Plants should be container grown with a well established root system, planted on one foot centers. Table 2 provides a representative list of possible plant selections. Rain gardens should not be seeded as this takes too long to establish the desired root system, and seed may be floated out with rain events. The same limitation is true for plugs. Shredded hardwood mulch should be applied up to 2" to help keep soil in place.

Table 2: Suggested Plant List

Shrubs	Herbaceous Plants
Witch Hazel *Hamemelis virginiana*	Cinnamon Fern *Osmunda cinnamomea*
Winterberry *Ilex verticillata*	Cutleaf Coneflower *Rudbeckia laciniata*
Arrowwood *Viburnum dentatum*	Woolgrass *Scirpus cyperinus*
Brook-side Alder *Alnus serrulata*	New England Aster *Aster novae-angliae*
Red-Osier Dogwood *Cornus stolonifera*	Fox Sedge *Carex vulpinoidea*
Sweet Pepperbush *Clethra alnifolia*	Spotted Joe-Pye Weed *Eupatorium maculatum*
	Switch Grass *Panicum virgatum*
	Great Blue Lobelia *Lobelia siphatica*
	Wild Bergamot *Monarda fistulosa*
	Red Milkweed *Asclepias incarnata*
Adapted from NYSDM Bioretention Specifications, Bannerman, Brooklyn Botanic Garden.	

Maintenance

Rain gardens are intended to be relatively low maintenance. Weeding and watering are essential the first year, and can be minimized with the use of a weed free mulch layer. Rain gardens should be treated as a component of the landscaping, with routine maintenance provided by the homeowner or homeowners' association, including the occasional replacement of plants, mulching, weeding and thinning to maintain the desired appearance. Homeowners and

landscapers should be educated regarding the purpose of the rain garden, so the desirable aspects of ponded water are recognized and maintained.

Cost

The cost of a rain garden is typically $10-$12 dollars per square foot of surface area (Bannerman 2003).

References

Bannerman, Roger. 2003. Rain Gardens, A How-to Manual for Homeowners. University of Wisconsin. PUB-WT-776.

Brooklyn Botanic Garden. 2004.Using Spectacular Wetland Plantings to Reduce Runoff.

Low Impact Development Center, Inc. (LID)
http://www.lid-stormwater.net/intro/sitemap.htm#permpavers

Pennsylvania Stormwater Best Management Practices Manual. Draft 2005.