RaG

Bioretention Basin (Rain Garden)

Description

Bioretention Basins or Rain Gardens are basins containing landscaping features adapted to provide on-site treatment of storm water runoff. They are commonly located in parking lot islands, along roadways, or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, stormwater runoff is collected and then percolates through the plant, mulch, and soil layers of this system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. Typically, the filtered runoff is collected in a perforated underdrain and returned to the storm drain system. This facility consists of seven components: The grass buffer strip, the ponding area, the surface mulch and planting soil, the sand bed, the organic layer, the plant material, and the infiltration chambers. Bioretention basins are planting areas installed in shallow basins, where stormwater runoff is filtered through the various layers mentioned above. Bioretention basins enhance stormwater quality through adsorption, filtration, volitization, ion exchange, microbial soil processes, evapotranspiration, nutrient uptake in plants, and decomposition prior to exfiltration into the surrounding soil mass. Such basins also enhance infiltration and groundwater recharge, thus reducing the volume of stormwater runoff.

Selection Criteria

The primary use of this BMP is for water quality control, although it provides some detention. Bioretention basins are suitable for use at any site where the subsoil provides reasonable infiltration, and the water table is sufficiently lower than the design depth of the basin. Each basin is usually designed for drainage (impervious) areas of less than one acre.

This BMP will not function properly in sites subjected to continuous or frequent flows, as the sand filter will not have time to dry and aerate. In addition, areas with mature tree or slopes greater than 20% would need further consideration.

Rain gardens can be located in the following areas: stormwater runoff area, landscaping islands, roof drain discharge areas, as well as highly impervious areas, such as parking lots and roadways runoff.

Properly designed rain gardens replicate a dense forest floor, through the use of certain plants, mulches, and nutrient-rich soils. Since rain gardens often have aesthetic value,

it is recommended that the designer has working knowledge and design skills of indigenous horticultural practices, or partnering with landscape architect or horticulturist.

The size of the structure is based on the amount of impervious surface in the drainage area. For example, for structures treating the first 0.75 inches of runoff from the impervious areas in the catchment, the surface area of the rain garden is typically small, but should be a minimum of 3.75% of the treated impervious area.

Rain gardens will typically need to be used in conjunction with another structural control to provide channel protection as well as overbank flood protection. It is important to ensure that a rain garden area safely bypasses higher flows.

Other design elements are as follows:

- The minimum width and length of the rain garden is 10 feet by 15 feet. Minimum depth requirement may vary between 1 to 4 feet with a maximum recommended ponding depth of 6 inches.
- Maximum contributing drainage area is 5 acres. 0.5 to 2 acres are preferred. Multiple rain gardens can be used for larger drainage areas.
- The site slope should be no more than 6%.
- The bottom of the structure should be 2 feet or more above the seasonally high water table.
- Rain gardens required sufficient hydraulic head (difference elevation between the inflow and outflow) to function properly. Five (5) feet of minimum head is common.
- The rain garden should be designed to completely drain within 48 hours. It should not be used on sites with a continuous flow from groundwater, sump pumps, or other sources. Rain garden area locations should be integrated into the site planning process, and aesthetic considerations should be taken into account in their sizing and design. They should be sited at least 10 feet from a house or other building.
- Elevations must be carefully worked out to ensure that the desired runoff flow enters the structure with no more than the maximum design depth.

Structure Components

Grass Filter Strip

The grass filter strip pre-treats the runoff. It filters particles from the stormwater runoff by trapping particles and reducing runoff speed. Often, the filter strip is enhanced with a pea gravel ribbon, to spread the runoff and increase infiltration through the strip. Pea gravel may be placed in some areas around the filter strip to enhance filtration.

Sand Bed

The sand bed further slows the runoff, and spreads the runoff over the entire basin. As the water infiltrates into the sand, the water is filtered. Drainage must be designed to flow away from the sand bed, in order to guard against anaerobic conditions in the planting area, and provide exfiltration from the basin. The sand bed should be 12 to 18 inches thick. Sand should be clean and have less than 15% silt or clay content.

Ponding Area

The ponding area detains runoff waiting to be treated. It also allows for pre-settling of particulates in the stormwater runoff. The ponding area should be constructed in accordance with design consideration in accordance with Section 7 - Permanent Basins in this manual. The pond should be equipped with an overflow structure, with its invert elevation 0.5 feet above the organic layer.

Organic/Mulch Layer

The organic or mulch layer filters the pollutants in the runoff, protects the soil from eroding, and provides an environment for microbes to degrade pollutants, such as petroleum-based solvents. The mulch layer may consist of hardwood mulch and should be applied uniformly at a depth of 2-3 inches.

Planting Soil Layer

This layer stores water and nutrients for the plants. Clay particles in the layer adsorb heavy metals, hydrocarbons, and other pollutants. The planting soil bed must be at least 10 inches depth. Planting soils should be sandy loam, loamy sand, or loam texture. Planting media may consist of top soil and/or compost

Plant Material

The plant species should be selected with great care, depending on their ability to treat pollutants through their interaction with other plants, soil, and the organic layer. Other factors to consider when choosing vegetation include climate of the site, shape, growth rates, maintenance requirements, size, hardiness, and type of root system. A variety of plants should be selected, in order to combat insects and disease, and increase envirotranspiration and aesthetic beauty. It is best to use native, non-invasive species that are resistant to the stress from both brief periods of pooling as well as dry periods between rainfall events. A variety of plants with large root structures will make the rain garden more effective and less susceptible to disease. It is also better to use plants with a developed root structure instead of starting plants by seed. Seeds will have a hard time establishing in the conditions of a rain garden and will also leave the soil exposed and prone to erosion. See Section 11.1 – Landscaping with Native Plants.

Infiltration Chambers

For large-scale rain gardens (bigger than 300 square foot), vented infiltration chambers provide exfiltration through open-bottomed cavities, decrease ponding time above the basin, and aerate the filter media between storms through the cavities and vents to the surface. By providing a valve equipped drawdown drain to daylight, the basin can be converted into a soil media filter should exfiltration surface failures occur.

Underdrain Collection System

For large-scale rain gardens (bigger than 300 square foot), an underdrain collection system consisting of filter fabric, gravel and perforated PVC pipes is recommended. The collection system is equipped with a 6-inch perforated PVC pipe (AASHTO M 252) in an 8-inch gravel layer. The pipe(s) should have 3/8-inch perforations, spaced at 6-inch centers, with a minimum of 4 holes per row. The piping system is spaced at a maximum of 10 feet on center and a minimum grade of 0.5% must be maintained. A permeable filter fabric is placed between the gravel layer and the planting soil bed.

Inflow and Outflow Structures

In addition to the above mentioned structure components, rain garden should have inflow structure for runoff flow diversion and outflow structure for overflow. Refer to Detention Pond section for guidelines for such structures.

Construction & Inspection Considerations

Sediment must be controlled during and after construction of the rain garden. Since infiltration is a key component of the rain garden, rain gardens are not recommended as the site of sediment detention basins during construction, as sediments tend to clog underlying soil strata. The rain garden will function more efficiently if the entire system is fully stabilized with vegetative and structural practices. Use relatively light, tracked equipment during construction, to avoid compaction of the basin floor.

Procedure and Solution

Step 1: Determine the percentage of each land cover occurring on site.

Step 2: Calculate the custom composite Curve Number for pre and post condition.

Step 3: Calculate CN based on connectivity of the site imperviousness. For example, adjust that curve number to account for the disconnected imperviousness. One of the assumptions when using uniformly distributed bioretention facilities is that there is essentially 100% disconnected impervious surfaces.

Note: For bioretention, *R* (the ratio of disconnectivity) will always equal *1.0* because once the water is intercepted, that portion of the drainage area is disconnected. This is true for any BMP that intercepts runoff from impervious areas before the runoff enters a stream channel directly.

Step 4: Determination of Design Storm:
Determine the amount of rainfall (*P*) needed to initiate direct runoff.

Step 5: Account for variation in land cover: Multiply *P* by a correction factor.

Step 6: Determine storage volume required to maintain Predevelopment Runoff Volume using retention storage.

Step 7: Determine Volume for Water Quality Control:
Minimum requirement for water quality control is equivalent to the first 3/4 inch of runoff from impervious surfaces.

Step 8: Determine storage volume required to maintain predevelopment peak runoff rate using 100% retention.

In order to reduce the surface area of the bioretention areas, the storage within soil layers in the bioretention facilities is calculated. The additional volume is derived based on the following assumptions:

1. The soil medium is comprised chiefly of minimally compacted sand/leaf compost mixture and the void ratio is 30%.
2. The depth of soil medium available below the underdrain is 2 ft. This volume is used for recharge and extended detention.

Step 9: Determine bioretention basin sizing needed to accommodate volume requirements. Use 6” maximum surface ponding depth.

Maintenance

The structure and vegetation of the rain garden should be inspected and maintained frequently to assure proper function.

- Debris and sediment shall be removed regularly.
- This BMP requires extensive landscaping. Rain gardens are not recommended for areas with steep slopes.
- Pests and weeds should be extracted from the facility.

- Avoid using pesticides and herbicides and reduce fertilizers use.

Limitations

Knowledge of engineering and horticulture is required for the successful implementation of this BMP. Maintenance and frequent inspections are also necessary.

Photo 1
Rain Garden for Roadway Runoff

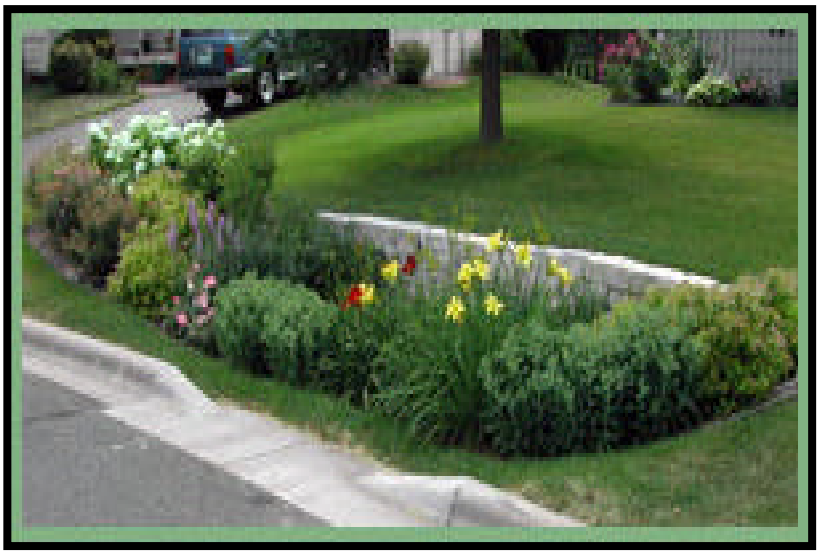
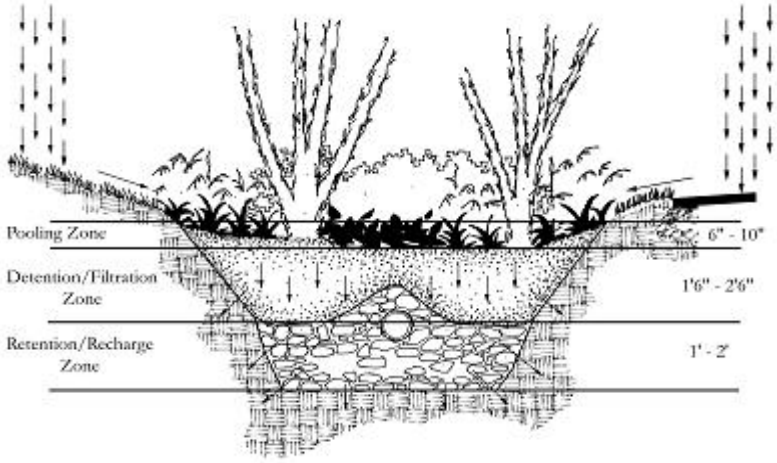


Photo 2
Rain Garden for Commercial Building & Parking Lot

Figure 1
Rain Garden Components



Functional Components

Filter Strip:	Reduces incoming runoff velocity
Ponding Area:	Provides temporary storage prior to evaporation, infiltration or uptake
Mulch Layer:	Supports micro-organisms that degrade hydrocarbon/organic materials
Planting Soil:	Provides filtration and supports plant growth (Clay in soil also absorbs pollutants)
Woody & Herbaceous Plants:	Provide vegetative uptake of runoff and pollutants while stabilizing soil
Sand / Gravel Bedding:	Promotes positive drainage and aerobic soil conditions

Figure 2
Examples of Rain Garden Application

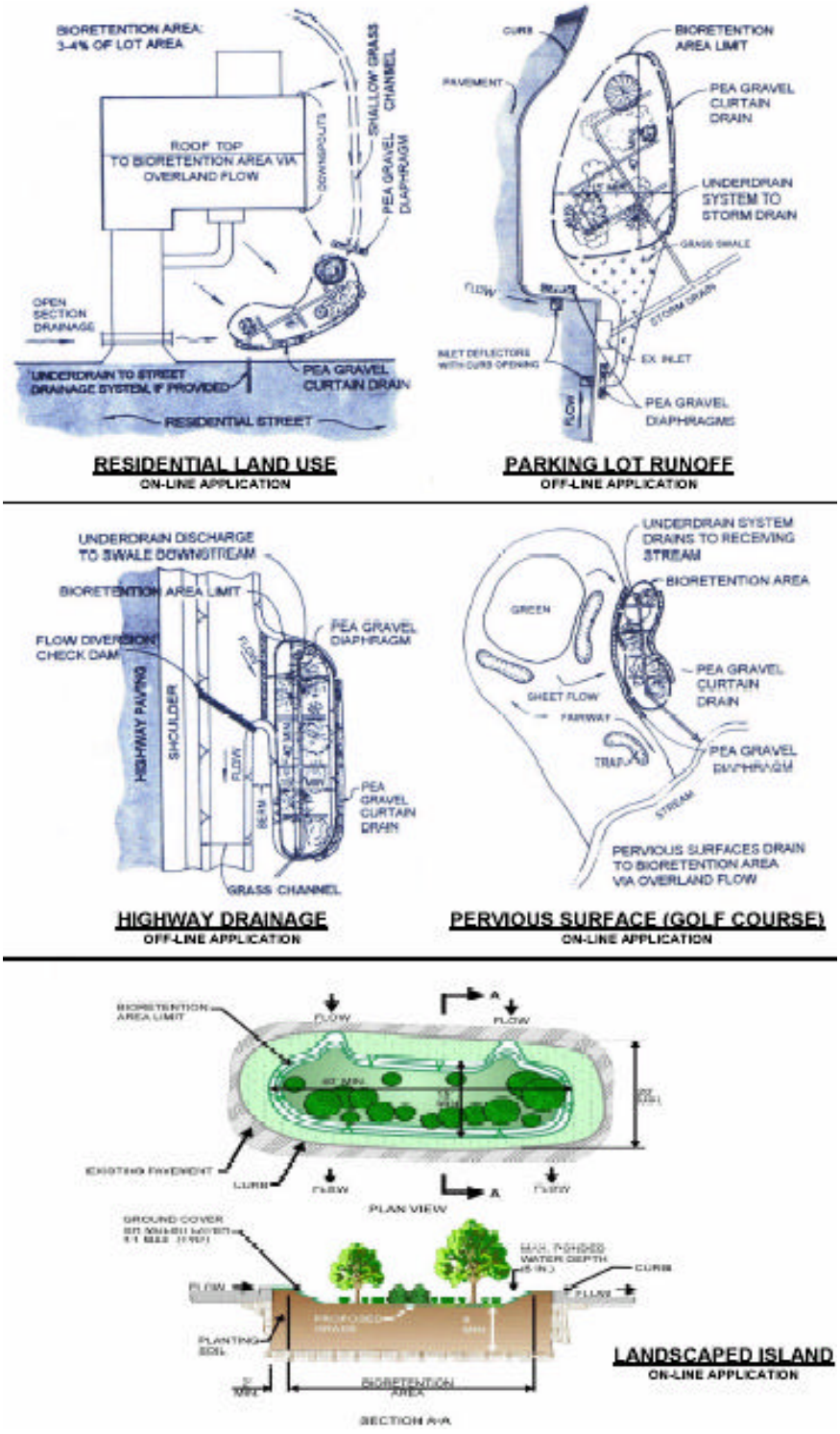


Figure 3
Typical Inlet Deflector

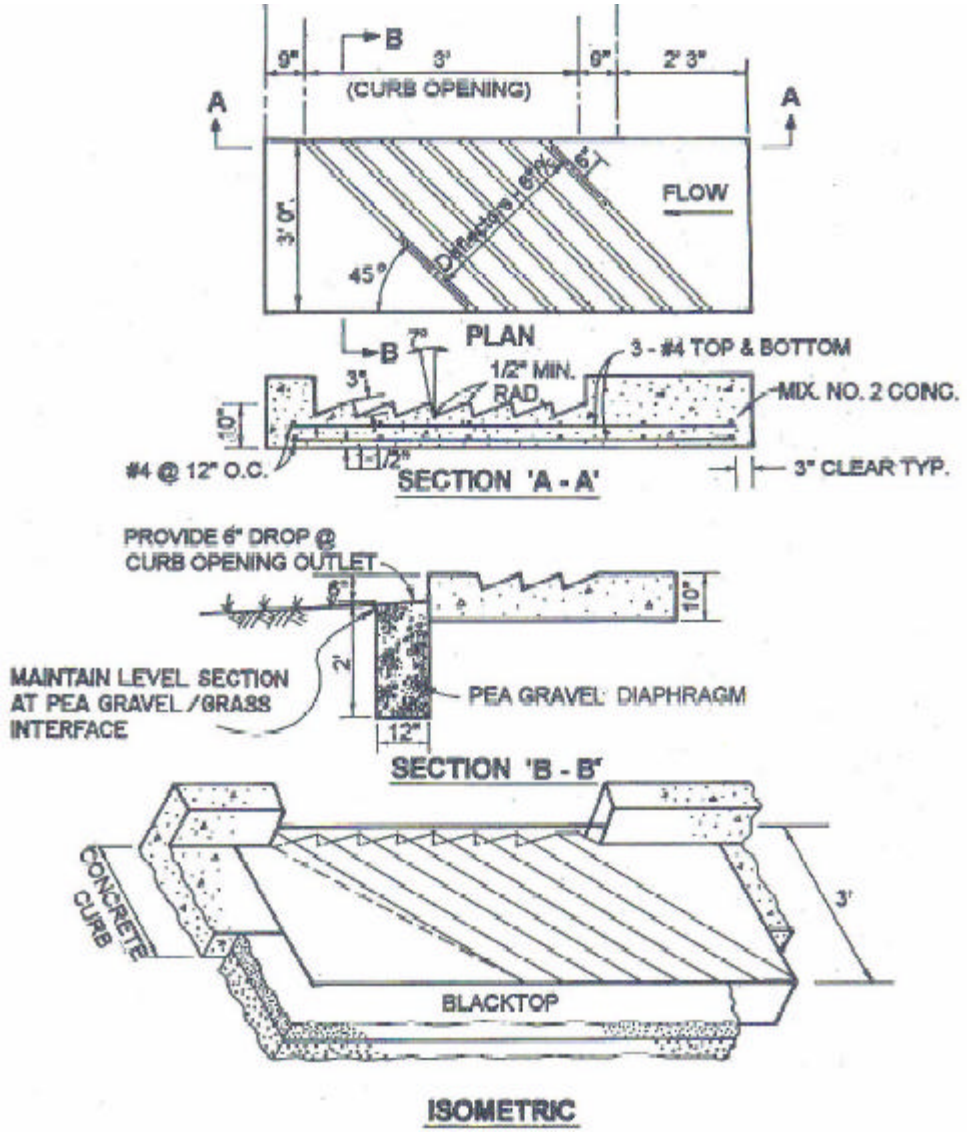
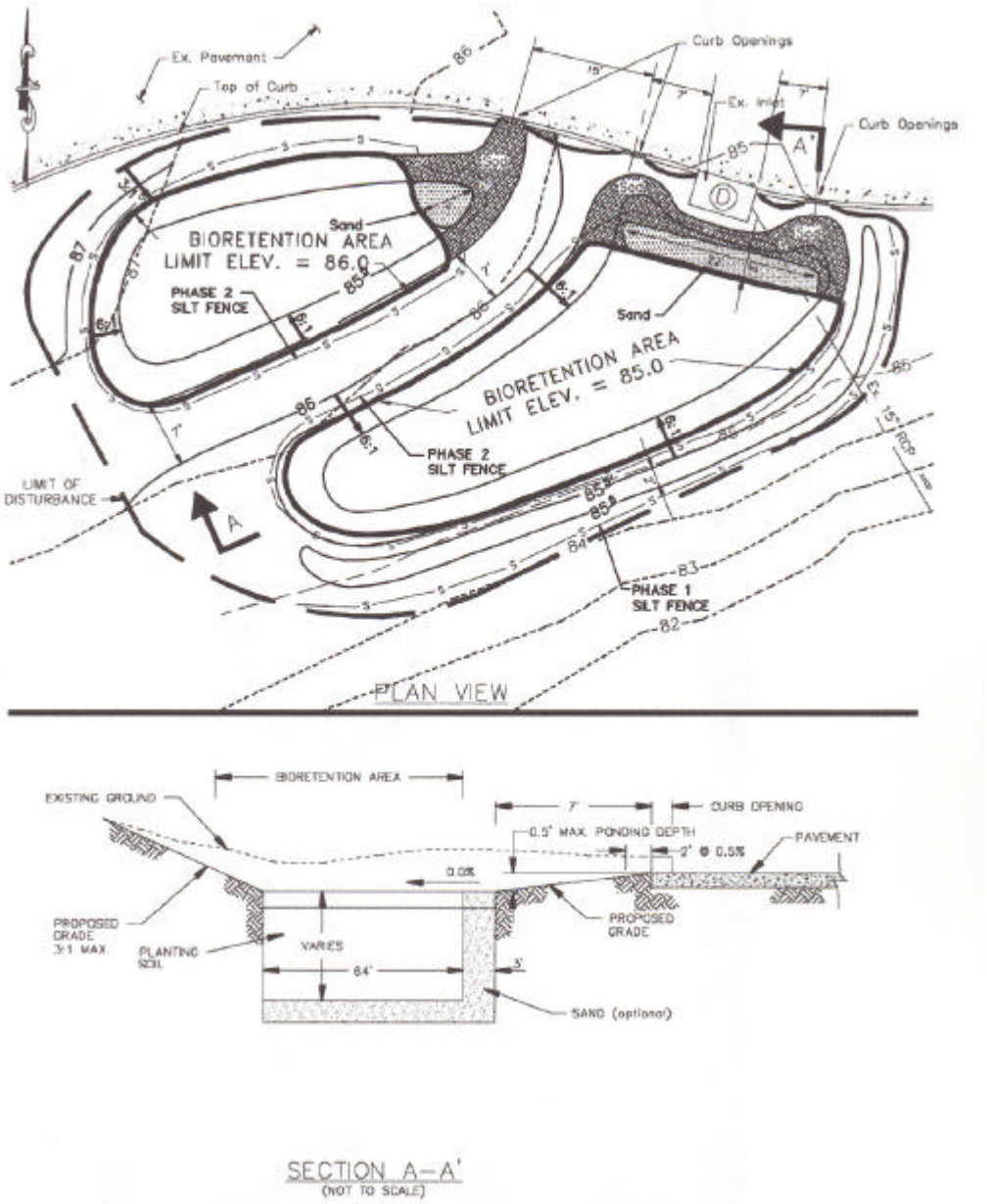


Figure 4
Plan View and Grading Plan for Typical Rain Garden



References

City of Maplewood, Minnesota.
http://www.maplewoodmn.govoffice.com/index.asp?Type=B_BASIC&SEC={F2C03470-D6B5-4572-98F0-F79819643C2A}

Georgia Clean Water Campaign.
http://www.cleanwatercampaign.com/what_can_i_do/raingardenworkshop.html

Kansas City Water Services Department.
http://www.rainkc.com/HOME/

North Carolina State University Cooperative Extension.
http://www.bae.ncsu.edu/cont_ed/bioretention/index.htm

Prince Georges County, MD.
http://www.goprincegeorgescounty.com/Government/AgencyIndex/DER/ESD/Bioretention/bioretention.asp?nivel=foldmenu(7)

University of Rhode Island Cooperative Extension.
http://www.uri.edu/ce/healthylandscapes/raingarden.htm#

University of Wisconsin Extension.
http://clean-water.uwex.edu/pubs/raingarden/

Water Environment Research Foundation (WERF).
http://www.werf.org/livablecommunities/