Bioretention

Bioretention practices capture and treat runoff from impervious areas by passing it through a filter bed mixture of sand, soil, and organic matter. Filtered stormwater is either returned to a conveyance system or infiltrated into the soil. Bioretention is a multi-functional practice that can be easily adapted for new and redevelopment applications in commercial and industrial projects. Stormwater runoff is stored temporarily and filtered in landscaped facilities shaped to take runoff from various sized impervious areas. Bioretention provides water quality treatment, aesthetic value, and can be applied as concave parking lot islands, linear roadway or median filters, terraced slope facilities, residential cul-de-sac islands, and ultra-urban planter boxes.

Constraints

The following constraints are important when considering the use of bioretention practices to capture and treat stormwater runoff.

- **Space:** The surface area of a typical bioretention practice depends on the area of the contributing imperviousness. Generally, the bioretention surface area will be 3-6% of the contributing drainage area. The size and distribution of open areas within a project (e.g., parking lot islands, landscaped areas) must be considered early during a project's planning and design if these practices are considered.

- **Topography:** Slopes of contributing areas and filter beds should be gradual (< 5%). If slopes are too steep, then level-spreading devices may be needed to redistribute flow prior to filtering. If slopes within bioretention practice are too steep, then a series of check dams, terraces, or berms may be needed to maintain sheetflow internally. There should also be an elevation difference between the inflow and outflow of a bioretention practice to allow flow through the filter.

- **Soils:** Soil conditions are a crucial determining factor for bioretention and determine whether an underdrain is needed. When located in sandier soils, these practices may be used to promote recharge. If heavier soils are encountered, an underdrain system may be needed. Also, elevated groundwater (water table) may limit filter bed thickness and excavated applications; bioretention should always be sited to ensure that groundwater does not intersect the filter bed. On-site soil investigation is a key element of practice design.

- **Drainage Area:** Bioretention works best with small to moderate contributing drainage areas, where it is easier to achieve flow distribution over the filter bed. Typical drainage area size range from 0.1 to 2.5 acres and consist of up to 100% impervious cover (or up to 5 acres if the impervious cover is less than 50%). Several cells may be designed adjacent to each other to accommodate larger areas.

- **Hotspot Runoff:** Bioretention practices that are designed to promote infiltration of runoff should not be used to treat hotspots that generate higher concentrations of hydrocarbons, trace metals, or toxicants than are typically found in stormwater runoff and may contaminate groundwater. In such locations, an impermeable bottom liner and an underdrain should be employed.

- **Other Considerations:** The location of existing and proposed buildings and utilities will influence the design and construction of bioretention. In general, bioretention practices should be located at least 50 feet from any water supply well and 35 feet from septic system leachfields (VA DCR 2012). Landscape designers should also consider overhead lines; any trees planted in bioretention practices shall be located to avoid future problems with overhead electrical and telecommunication lines. Bioretention areas can be used for snow storage as long as overflow is provided and they are planted with salt-tolerant, non-woody plant species.

Design Guidance

The following conditions shall be considered in designing bioretention practices:

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- The most important design factor to consider in using bioretention is the scale at which it will be applied. ***Micro-Bioretention or Rain Gardens*** are small, distributed practices designed to treat runoff from small areas such as individual rooftops and driveways. ***Bioretention Basins*** are often used to treat parking lots in commercial or institutional areas. And ***Urban Bioretention*** structures are often incorporated or retrofitted into tree pits, curb extensions, and foundation planters (VA DCR 2013).

- Bioretention systems should be designed off-line whenever possible. A flow splitter should be used to divert excess high flows away from the filter media to a stable, downstream conveyance system. If bypassing a bioretention practice is impractical, an internal overflow device (e.g., elevated yard inlet) may be used (MDE 2009).

- Runoff shall enter, flow through, and exit bioretention practices in a safe and non-erosive manner. Flows entering a bioretention facility should be less than 1.0 foot per second to minimize erosion potential. Inflow may be through depressed curbs or curb cuts, or conveyed directly using downspouts, covered drains, or catch basins (VA DCR 2013).

- An underdrain system may be necessary to discharge treated stormwater safely downstream. In order to remove the underdrain requirement, a minimum infiltration rate of 0.5in/hour must be demonstrated (Nashville 2012). Underdrains may be interconnected to other practices as part of a treatment system or directly to the storm drain (SPU 2009; MDE 2009).

- The surface area of the bioretention practice shall be at least 2% of the contributing drainage area (MDE 2009).

- Filter beds shall be between 18 and 60 inches deep, depending on the application (MDE 2009; Nashville 2012).

- Filter beds shall not intercept groundwater. If designed as infiltration practices, filter bed inverts shall be separated at least two feet vertically from the seasonal high water table (VA DCR 2013).

- Maximum ponding depth should be no more than 12 inches above the surface of the filter bed; ponding depths greater than 6 inches will require a specific planting plan to ensure appropriate plant selection (VA DCR 2013).

- The surface pool drawdown time shall be a maximum of 24 hours (SPU 2009).

- The maximum planted side slope shall be 2.5H:1V. If total cell depth exceeds 3 feet, the maximum planted side slope is 3H:1V. If steeper sides are necessary, rockery, concrete walls, or steeper soil wraps may be used (SPU 2009).

- Bioretention practices should be located down gradient of and set back between 10 and 25 feet from structures depending on the treatment volume. Micro-bioretention variants (e.g., planter boxes) that must be located adjacent to structures should include an impermeable liner (MDE 2009; VA DCR 2013).

- Bioretention areas shall be designed with a hardwood mulch layer or a dense groundcover (except for turf-vegetated cells, which should be mulch-mowed). Research indicates that most attenuation of heavy metals in bioretention cells occurs in the first 1 to 2 inches of the mulch layer. That layer can be easily removed or added to as part of a standard and periodic landscape maintenance procedure (SPU 2009).

- Landscaping plans shall be provided for each bioretention area. Vegetation is critical to the function and appearance of any micro-bioretention system. Native and adapted plants are preferred, hardier, and usually require minimal nutrient or pesticide application. Also, aesthetically pleasing landscape designs generally enhance property value and community acceptance (MDE 2009).

- Pre-treatment of runoff entering bioretention areas is necessary to trap coarse sediment particles and organic debris from reaching and clogging the filter bed (VA DCR 2013). Adequate pre-treatment should incorporate grass filter strip, gravel diaphragm, gravel flow spreader or another approved pre-treatment structure (Nashville 2012; VT DEC 2002).

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Performance and Credit

Bioretention is credited based on the treatment volume provided. The treatment volume (T_v) will be calculated as follows:

T_v,= (SA) (V_r) (D), where:

SA = surface area of the bioretention practice
V_r = void ratio
D = media depth in feet

The accepted void ratios are:

- Soil Media V_r = 0.25
- Gravel V_r = 0.40
- Surface Storage Vr = 1.0

For bioretention practices employing an underdrain (e.g., any site unable to demonstrate a minimum infiltration rate of 0.5 in/hour), the treatment volume will need to be reduced by a factor of 0.6 (ISBD 2011):

$T_{v(under)} = 0.6(T_v)$

For More Information

All information regarding the Vermont Stormwater Management Manual Update process is available at: http://www.vtwaterquality.org/stormwater/htm/sw_manualrevision.htm.

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