# Countywide Transit Corridors Functional Master Plan

Appendix 14
Stormwater Management

PARSONS BRINCKERHOFF

*Tower 1, 10th Floor*
*100 S. Charles Street*
*Baltimore, MD 21201-2727*
*(410) 727-5050*

***Memorandum***

**To:** Larry Cole, M-NCPPC

**From:** Monique Ellis, Nimish Desai

**CC:** Mike Flood

**Date:** April 6, 2012

**Subject:** Stormwater Management for BRT Corridors in Montgomery County: Response to Comments

The PB study team has reviewed the feedback received from M-NCPPC Planning staff on our memorandum on possible stormwater management (SWM) options using environmental site design (ESD) along BRT corridors. We should clarify that the intent of our memorandum was to provide an overview of possible SWM ESD options and understand the minimum right-of-way needs for typical sections developed for the Functional Plan. Many of the planning efforts for the BRT network are still preliminary and site-specific conditions affecting SWM along each corridor remain unknowns until individual corridor analyses refine the physical needs for BRT service implementation. With this in mind—and working within the scope of this project—our memorandum provides information to facilitate dialogue of right-of-way needs and neither makes recommendations on nor precludes any SWM option from future consideration.

The following section provides direct responses to feedback received from Planning staff on our initial memorandum, which has been modified as appropriate based on the feedback and within the context of our scope of work. Based on the information provided in the memorandum, it is recommended that the planting strips for all typical sections be widened to eight feet to provide the minimum right-of-way for ESD treatment of SWM quality and quantity.

We thank you for insights on experience with ESD treatments within the County and welcome additional dialogue that will aid in refining the rights-of-ways along the BRT corridors.

**Green Street**

Disadvantages:

- Not a standard MDE approved practice (sand filters): May require additional testing.
  - M-NCPPC Response: MDE has not rejected "Green Streets". A Green Street is a street with any stormwater treatment. MDE will approve a 'Green Street' if the treatment facility(s) (whichever ones they are) are sized correctly.

    *PB Response: Comment noted. To avoid confusion with any SWM treatment that can be accommodated within the streetscape, we have renamed the phrase "green street" to "water quality filter strip," to accurately reflect the treatment being described. Although MDE has not rejected the idea of water quality filter strips, the feasibility and viability of the same is still being tested in several cities in US. Maryland Transit Administration is currently studying the concept for the Red Line project. The key to the concept of the water quality filter stripis that vegetation be maintained in the filter strips and that the filter media should allow free draining of runoff and not creating ponding. Also, further design guidance will need to be coordinated with the designers, Montgomery County and MDE.*

  - M-NCPPC Response: A Green Street does not have to be or have a sand filter; it can have any approved stormwater treatment facility/device.

    *PB Response: Agreed. The water quality filter strip can be of any material and does not necessary have to be a sand layer. The key to the concept of the green street is that vegetation be maintained in the filter strips and that the filter media should allow free draining of runoff and not creating ponding and create a traffic hazard. There are very limited choices of the approved ESD stormwater management treatment facilities that will qualify for this application.*

- Requires plant establishment which is difficult due to free-draining layer of sand
  - M-NCPPC Response: As noted above, a Green Street does not have to be a sand filter and thus planting does not have to be limited.

    *PB Response: Please see response stated above.*

**Permeable Pavements**

- Permeable pavement is recommended only in areas where the soils types are sandy or silty having hydrologic soil groups of A, B or C.
    - M-NCPPC Response: Soil types C and D drain slowly or not at all. These soil types are often found in compacted urban soils. In these situations soil types C and D does not preclude the use of permeable pavements. A routine practice is the use of an underdrain to which allow for water catchment, containment, and the slow release of water into the stormdrain system.

      *PB Response: Comment noted. Chapter 5 of the MDE manual (Page 5.48 –Supplement 1)) states that permeable pavements should not be installed in HSG D or on areas of compacted fill. The MDE manual also recommends using perforated pipes in non-HSG D areas as an additional measure to ensure that the runoff is intercepted and conveyed to the storm drain system.*

- The subsurface water table will help determine the stone reservoir thickness used.
    - M-NCPPC Response: The stone reservoir depth is determined by the storage treatment volume goals. However, if there is a high water table (not likely along the BRT line), then there would be a shallow reservoir or none at all.

      *PB Response: Agreed. The stone reservoir depth is determined by the storage treatment volume goals as well as the ground water table. This will be determined during final design.*

Disadvantages:

- Maintenance is a major issue. Typically permeable pavements require regular vacuuming (usually every 6-8 weeks) to prevent sediments from clogging within the voids of the pavement.
    - M-NCPPC Response: Permeable pavements have come a long way. The void spaces are quite large now and many manufacturers recommend vacuuming once or twice a year. Some have even gone so far as to say no vacuuming is necessary (Flexi-pave).

      *PB Response: Comment noted. Permeable pavements need periodic maintenance depending on its type and application. The type of permeable pavements to be used will be determined during final design and maintained as per the manufacturer's approved specifications.*

- Cannot be used in areas having poorly drained soils or where the ground water table is high.
  - M-NCPPC Response: See response above pertaining to soil groups.

    *PB Response: Comment noted. Chapter 5 of the MDE manual (Page 5.48 –Supplement 1) states that permeable pavements should not be installed in HSG D or on areas of compacted fill. The MDE manual suggests using perforated pipes to ensure that the runoff is intercepted and conveyed to the storm drain system.*

- During winter, there is a possibility of ice being formed in the voids of the pavement which can cause damage.
  - M-NCPPC Response: Multiple years of installation and testing has not shown this statement to be true.

    *PB Response: Comment has been removed. Chapter 5 of the MDE manual states that all permeable pavements shall be designed to ensure that water surface elevations for the 10-year storm do not rise into the pavement to prevent freeze/thraw damage to the surface. This should be confirmed with the manufacturer when selecting the surface during final design.*

**Bioinfiltration**

Disadvantages:

- Require annual inspections to assess vegetative heath, etc…
  - M-NCPPC Response: Annual maintenance is required for all stormwater management systems.
- If the water does not drain within 48 hours, the bottom soil should be tilled and relegated:
  - M-NCPPC Response: Prior to the construction of any bioinfiltration system, percolation tests must be done to determine soil type and rate of infiltration. If there is no infiltration, the uses of amended soil and/or underdrains are used (biofiltration). If the system clogs many years later, as with any stormwater treatment, the media is replaced.

    *PB Response: Comment agreed. The detail provided in the memo does include an underdrain. The memo has been revised to indicate the that existing soil layer may need to be replaced or an underdrain be provided if the infiltration test determine the soils to be infeasible. This is a final design issue.*

**PARSONS BRINCKERHOFF**

**Manufactured Low Impact Development Practices**

Description Paragraph: "This bioretention device is not an approved MDE device and may require additional coordination with the manufacturer to receive MDE approval. "

- o M-NCPPC Response: A recent conversation with Brian Clevenger (MDE, Stormwater and Sediment Control) has stated that Filterra systems are an approved MDE stormwater treatment device.

  *PB Response: Filterra is an approved MDE device to treat 1" of runoff. However, during a presentation with Filterra in during late 2010, Filterra was still trying to work with MDE and get an approval so that their products could be used for ESD. The ESD guidelines suggest that the target rainfall may need to be as high as 2.6" and a minimum of 1" of runoff needs to be treated through ESD to MEP. If the entire target rainfall ($P_E$) runoff cannot be treated, supplemental facilities will need to be provided. PB is working on getting a response from Filterra as to their current status with MDE on the ESD criteria.*

Disadvantages:

- Maintenance needs to be provided by the manufacturer on a semi-annual basis.
  - o M-NCPPC Response: Annual maintenance is required.

    *PB Response: Comment agreed. This will be confirmed during our coordination with Filterra.*

- Not a standard MDE approved practice.
  - o M-NCPPC Response: See above comment pertaining to MDE approval.

    *PB Response: Comment noted. Filterra is manufactured device and not a traditional standard SWM device.*

**Swales**

- o Wet swales are not appropriate for the BRT line as the water table is not likely to be high enough in most areas and insects could be a nuisance.

  *PB Response: SWM facilities will be selected during final design depending upon the location of the alignment. The memo presents the different ESD options that can potentially be used along a BRT corridor.*

PARSONS BRINCKERHOFF

*Tower 1, 10th Floor*
*100 S. Charles Street*
*Baltimore, MD 21201-2727*
*(410) 727-5050*

***Memorandum***

**To:** Larry Cole, M-NCPPC

**From:** Nimish Desai

**CC:** Michael Flood

**Date:** April 6, 2012

**Subject:** Stormwater Management for BRT Corridors in Montgomery County - Updated (DRAFT)

One of the tasks of the Functional Plan is to identify the types of stormwater management (SWM) facilities that can be provided within the BRT system's proposed rights-of-way. Current SWM requirements administered by Montgomery County and the Maryland Department of Environment (MDE) require consideration for water quality and quantity management. The primary goal of Maryland's stormwater management program is to maintain the same level of storm water management after a project is completed as was in place prior to construction and development of an area through environmental site design (ESD). The Stormwater Management Act of 2007 requires providing SWM ESD practices to the maximum extent practicable. In ESD, water quality and quantity management is provided using small-scale SWM practices. In Montgomery County, quantity management requires providing channel protection control for the one-year event[1] through 24-hour extended detention.[2] Quantity peak management for the 10-year event[3] may be required where there are downstream flooding/drainage issues. Quality management requires control for the water quality volume and recharge volume for the first 'flush' or one-inch of rainfall.

Maryland's SWM guidelines for State and federal projects (as of April 2010) require treating 1.0 to 2.6 inches of rainfall depending on the design and site conditions from new and redeveloped impervious areas. ESD must be used to treat runoff from one inch of rainfall for a minimum level of compliance. When the entire target rainfall is treated using ESD, the channel protection volume requirements, in addition to the water quality volume and recharge volume, is satisfied. When site constraints limit the use of ESD practices, traditional SWM practices including detention ponds, infiltration trenches and basins, and bio-retention facilities can be provided. However, prior to proposing the standard practices, it must be demonstrated through calculations,

---

[1] A heavy rainfall that typically occurs once a year
[2] A stormwater management facility that will hold a one-year storm volume and drain within 24 hours
[3] A heavy rainfall that typically occurs once every 10 years

reports and drawings that it is impracticable to provide ESD practices at the particular location.

The following sections describe several different SWM options using ESD practices, as well as each option's advantages and disadvantages, that could be applicable to the BRT corridors under study and aid in identifying the right-of-way needs for SWM treatment. As such, this memorandum is for informational purposes only and does not recommend a particular SWM option for use along future BRT corridors.

## Micro-Bioretention

Micro-bioretention practices capture and treat runoff from impervious areas by passing it thourgh a filter bed mixture of sand, soil and organic matter. Filtered stormwater is either returned to the conveyance system or partially infiltrated into the soil. Stormwater runoff is stored temporarily and filtered in landscaped facilities shaped to collect runoff from impervious areas. Micro-bioretention provides water quality treatment, aesthetic value and could be applied as linear roadway or median filters and ultra-urban planter boxes.

Micro-bioretention facilities (see Figure 1) are proposed in areas where slopes of contributing areas and filter beds are gradual (i.e., less than 5 percent). If slopes within micro-bioretention are too steep, then a series of check dams may be required to maintain sheetflow internally. There should also be an elevation difference between inflow and outflow of a micro-bioretention practice to allow flow through the filter bed (2 to 4-ft deep). This diffence is critical when deisgning downstream conveyance systems like storm drains and grass ditches. Subsurface water table conditions and required volume storage will help determine the thickness of the filter beds to be used. The probability of practice failure increases if the filter bed intercepts ground water. Therefore, it is recommended that the micro-bioretention practice inverts should be above ground water tables. An underdrain may be used to prevent water from ponding if the underlying soils do not meet the infiltration requirements.

The surface area of a typical micro-bioretention filter is dependent on  the area of the contributing imperviousness. The size and distribution of open areas within a project (such as landscaped areas or roadway medians) must be considered early during a project's planning and design. MDE recommends the maximum drainage area to a micro-bioretention facility to be limited to 0.5 acres. If the drainage area exceeds 0.5 acres to a single micro-bioretention facility, the practice effectiveness weakens and larger systems may be designed according to Chapter 3 of the MDE Manual or several bio-retention facilities in series should be considered depending on the site constraints.

The advantages of using micro-bioretention are as follows:

- Aesthetically pleasing due to the plants and vegetation in the facility, especially in an urban setting
- Standard practice approved by MDE

The disadvantages of micro-bioretention are as follows:

- Not recommended where the contributing drainage areas have slopes greater than 5 percent. If the slopes of the adjacent areas are too steep additional measures like level-spreaders may be required to redistribuite flow prior to filtering which may require additional right-of-way
- Requires the top few inches of the filter media be removed and replaced if water ponds for more than 48 hours
- Occasional pruning and replacement of dead vegetation is necessary. If specific plants are not surviving, more appropriate species should be used. Watering may be required during prolonged dry periods
- Underground conflicting utilities may require relocation due to the presence of 2-4 ft of planting media

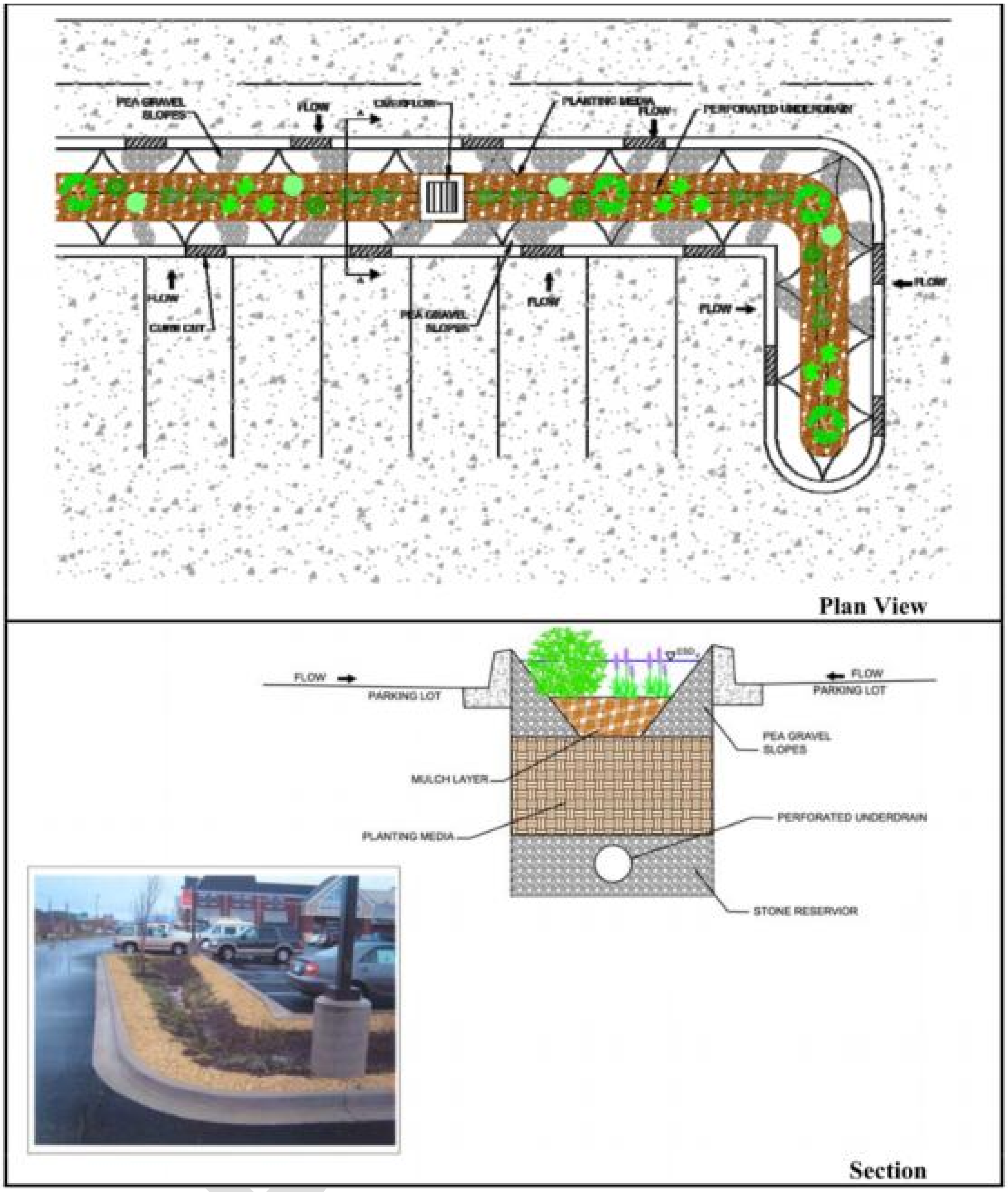


**Figure 1: Illustration of Micro-bioretention**
*Source: MDE SWM Manual*

## Swales

Swales are channels that provide conveyance, water quality treatment and flow reduction of stormwater runoff. Swales provide pollutant removal through vegetative filtering, sedimentation, biological uptake and infiltration into the underlying soil media. Three types of swales have been covered under this topic. Implementation of each type of swale is dependent upon the site soils, topography and drainage constraints. The maximum drainage area to a swale should be limited to one acre. The following swale geometry needs to be considered while designing any type of swale:

- Swales shall have a bottom width of two to eight feet
- The longitudinal slope of the channel should not be more than 4 percent
- Channel side slopes shall be 3:1 or flatter
- Swales shall be safely designed to convey the 10-year, 24-hour storm with at least six inches of freeboard.[4]

### *Grass Swales*

Figure 2: Example of Grass Swale

Grass swales (see Figure 2) are flat bottom swales and are typically recommended for linear applications and shall be as long as the treated surface. The surface area of the swale bottom should be at least 2 percent of the contributing drainage area. The maximum flow depth should be four inches and the channel should have a roughness coefficient of 0.15. This can be accomplished by either maintaining vegetation height equal to the flow depth or using check dams.

Based on the design guidelines, the minimum width of the grass swale that will be required (assuming 2-ft. flat bottom and 1-ft. deep swale), is eight feet.

[4] The clearance from the top of the swale embankment to the top of the water contained in the swale

The advantages of using grass swales are as follows:

- Easy to maintain compared to other practices
- Standard practice approved by MDE
- Cheaper to construct

The disadvantages of grass swales are as follows:

- Cannot be used on slopes greater than 4 percent, especially in hilly areas
- Aesthetically not pleasing, especially in urban areas
- Maintenance may be an issue if check dams are provided
- Swales along roadways can be damaged due to off-street parking

***Bio-Swales***

Bio-swales (see Figure 3 and Figure 4) are flat bottom vegetated swales and are typically recommended for linear applications. The surface area of the swale bottom should be at least 2 percent of the contributing drainage area. Bio-swales shall be designed to temporarily store at least 75 percent of the ESD volume. A two to four-foot deep layer of filter media shall be provided in the swale bottom. Selected plants and vegetation can be grown in the bio-swale.

**Figure 3: Example of Bio-swale**
*Source: City of Wilsonville, OR*

Based on the design guidelines, the minimum width of the bio-swale that will be required (assuming 2-ft flat bottom and 1-ft deep swale), is 8-ft.

If the water does not drain within 48 hours, the bottom soil should be tilled and relegated. If infiltration tests determine the existing soil type or rate of infiltration to be unsuitable, a certain layer of the existing soil type will need to be replaced with more favorable infiltrating soils or an underdrain can be provided.

The advantages of using bio-swales are as follows:

- Aesthetically pleasing due to the plants and vegetation in the swale, especially in an urban setting
- Standard practice approved by MDE

The disadvantages of bio-swales are as follows:

- Cannot be used on slopes greater than 4 percent especially in hilly areas
- Requires regular inspections to assess vegetative health, soil stability, ensure that water infiltrates through the planting media layer and does not create ponding
- Underground conflicting utilities may require relocation due to the presence of 2-4 ft of planting media

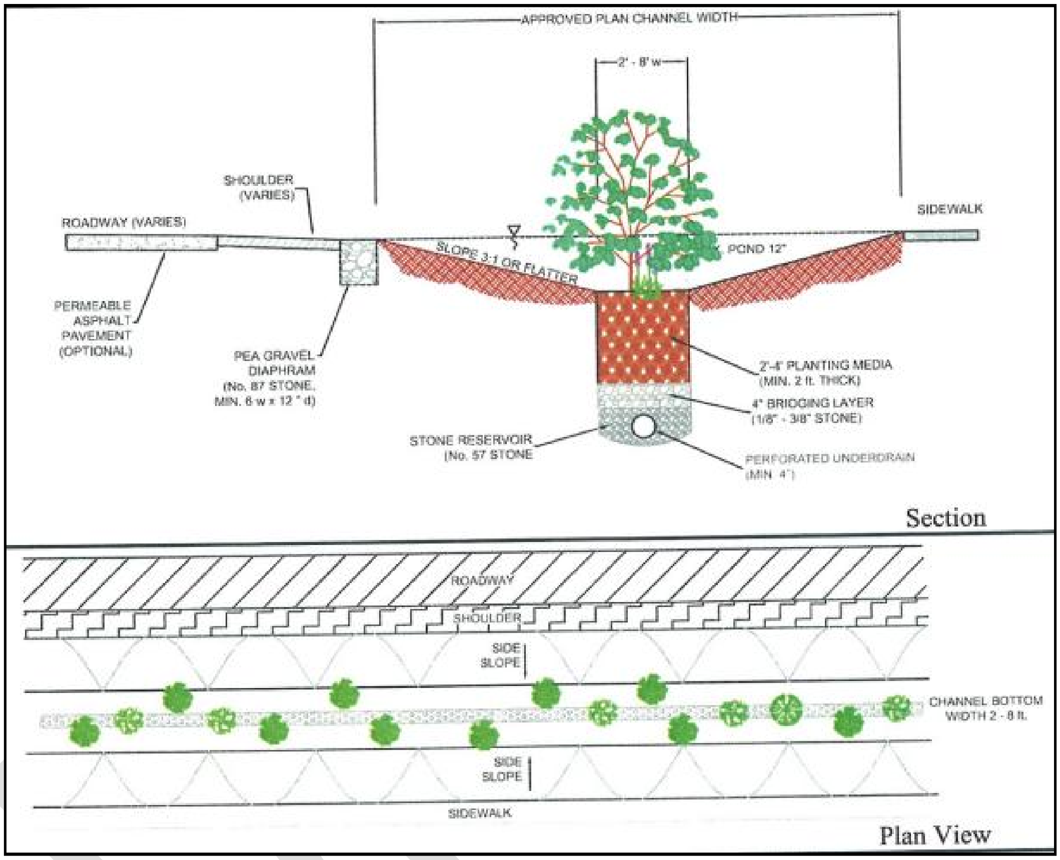


**Figure 4: Illustration of Bio-swale**

*Source: MDE SWM Manual*

***Wet Swales***


Figure 5: Example of Wet Swale

Wet swales (see Figure 5 and Figure 6) are flat bottom swales and are typically recommended for linear applications in areas with poorly drained soils (hydrologic soil groups C or D) or areas with high ground water table. Wet swales shall be designed to temporarily store at least 75 percent of the ESD volume. It is recommended to provide check dams to enhance storage of filter media shall be provided in the swale bottom. Selected wetland plants and vegetation can be grown.

Based on the design guidelines, the minimum width of the wet swale that will be required (assuming 2-ft flat bottom and 1.5-ft deep swale), is 11-ft.

The advantages of using wet swales are as follows:

- Recommended in areas having high ground water table and poorly drained soils
- Regular mowing is not required especially if wetland plans are provided
- Standard practice approved by MDE

The disadvantages of wet swales are as follows:

- If constructed in residential areas, the presence of ponded water can potentially create a breeding ground for mosquitoes and other insects and can be a nuisance
- Cannot be used on slopes greater than 4 percent especially in hilly areas
- Presence of check dams make the wetlands harder to maintain than the other swales
- This is not a desireable SWM option in ultra-urban environments.

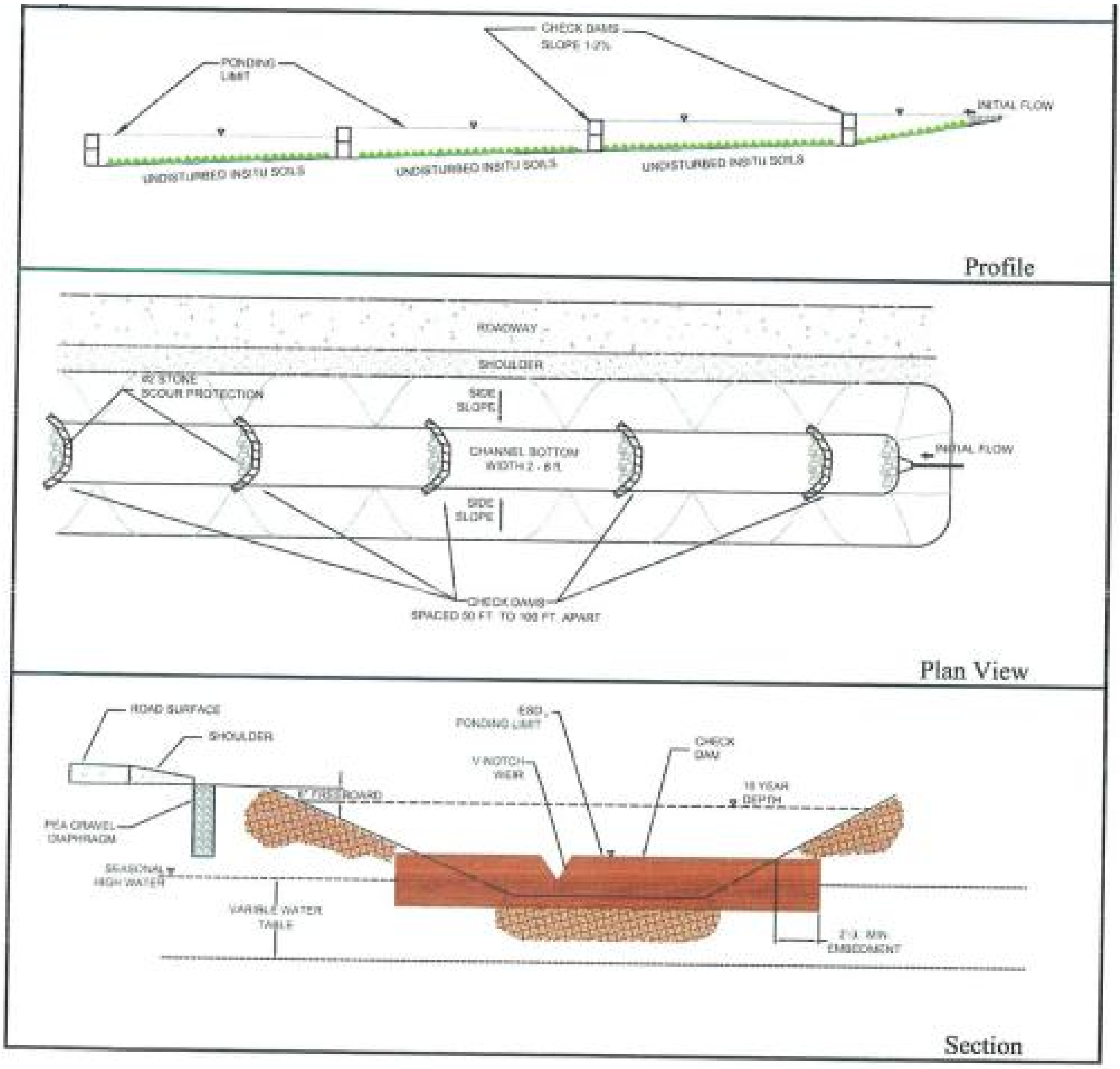


**Figure 6: Illustration of Wet Swale**
*Source: MDE SWM Manual*

## Water Quality Filter Strip

An innovative approach for stormwater management could be through the use of water quality filter strips as implemented for the BRT system in the City of Eugene (see Figure 7). In some portions of the BRT corridor where right-of-way was limited, the design incorporated water quality strips between track-like ribbons of concrete, as shown in the figure below. These water quality filter strips incorporate into roadway designs low-impact features that manage stormwater as close as possible to the source of runoff. The treatment system provided water quality treatment via filtering before the flow was concentrated.

The design consisted of providing a sand filter layer underneath the surface of the water quality filter strip. Runoff from the roadway sheet flowed into the green strip and percolated into the sand filter layers. This practice requires the vegetated filter strip to be present throughout the year and is not included in the standard MDE approved practices. Since it was difficult to maintain vegation in the sand filter layers, other typies of filter media/soil mix are currently being tested. Since the vegetated filter strip is in the middle of the transitway, the filter media to be used should drain as soon as possible to prevent water from ponding in the layer. Some of the traditional ESD practices mentioned in the MDE manual may fit into the concept of water quality filter strips, however further discussion with the MDE is required regarding the design and its viability.


**Figure 7: Example of Water Quality Filter Strips**
*Source: The EmX Franklin Corridor BRT Project Evaluation – FTAFL-26-7109.2009.2*

The <u>advantages</u> of using water quality filter strips are as follows:

- Can be implemented within the existing right-of-way
- SWM facility is not dependent on the type of existing soils
- Aesthetically pleasing

The <u>disadvantages</u> of green strips are as follows:

- Not a standard MDE approved practice. May require additional testing (NOTE: Maryland Transit Administration is currently performing "green track" testing along the Central Light Rail in Baltimore for possible implementation on the Red and Purple Line projects. The pilot did not include maintenance of grass or plant matter, resulting in poor establishment of grass and plant matter due to the climatic conditions, specifically the hot dry summer period.)

- Requires plant establishment which is difficult due to the free-draining layer of sand or other soil media. May need to experiment with some other engineered soil mixes instead of sand that are friendly to plant establishments.
- Maintenance may be an issue as the transit way may need periodic closure due to grass mowing, replacing sand, etc.
- In winter during a snow event, snow ploughs may damage the grass strip and the underlying sand layer/soil mix.

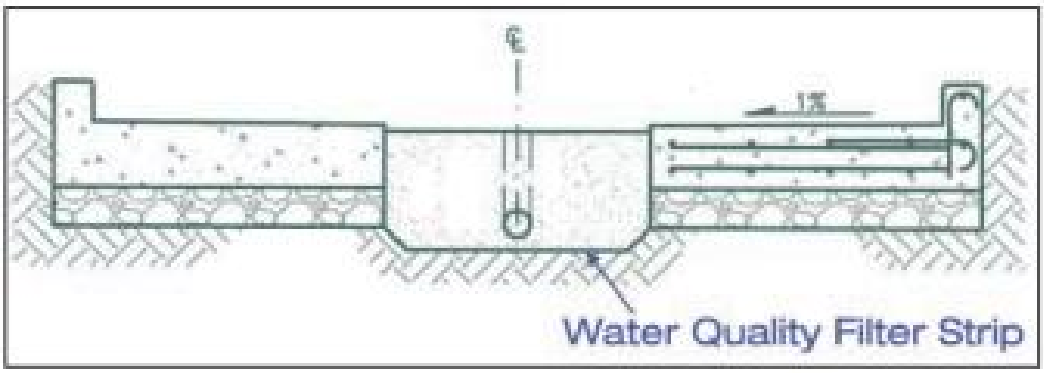


**Figure 8: SWM Typical Section using Water Quality Filter Strip**
*Source: PBNetwork, May 2009*

## Permeable Pavements

Permeable pavements (see Figure 9) are alternatives that may be used to reduce imperviousness. While there are many different materials commercially available, permeable pavements may be divided into three basic types: porous bituminous asphalt, pervious concrete, and permeable interlocking concrete pavements. Permeable pavements typically consist of a porous surface course and open graded stone base/subbase or sand drainage system. Stormwater drains through the surface course, is captured in the drainage system, and infiltrates into the surrounding soils.

Permeable pavements are effective for reducing imperviousness in pedestrian pavements (sidewalks and cross walks), parking lots and access roads. Permeable pavements are not recommended on roadways having slopes that are greater than 5 percent. Permeable pavements are recommended only in areas where the soil types are sandy or silty having hydrologic soil groups of A, B or C. The subsurface water table and the storage volume requirements will help determine the stone reservoir thickness used. Permeable pavements should not be used in areas with high ground water table.[5] Chapter 5 design guidelines of the MDE manual state that the invert of the subbase reservoir be at least four feet above the seasonal high water table (two feet on the Eastern Shore).

[5] *2000 Maryland Stormwater Design Manual* (Revised May 2009)

This does not mean that permeable pavements cannot be used in areas having poorly drained soil types. If permeable pavements are being proposed in areas having poorly drained soil types, an underdrain may need to be provided to allow the runoff from the pavement be intercepted and relase it slowing into the storm drain system.

The advantages of using permeable pavements are as follows:

- Does not require additional right-of-way. Can be installed instead of concrete/asphalt
- Areas covered by permeable pavements will have runoff characteristics more closely resembling vegetated areas.

The disadvantages of permeable pavements are as follows:

- Trees and shrubs should not be located adjacent to asphalt and concrete permeable pavements as the tree roots may penetrate through and damage the surface. Also, clogging from the leaves is a major concern
- Typically permeable pavements require periodic maintenance with special equipment to prevent sediments from clogging within the voids of the pavement
- MDE ESD criteria does not recommend permeable pavements in areas with Soil types D or compacted fill areas.[6]
- Expensive to construct compared to the regular paving material such as concrete or asphalt
- If an underdrain is used, regular inspection and cleaning of the underdrain pipes is requied to ensure that the underdrain system is not clogged



[6] Ibid.

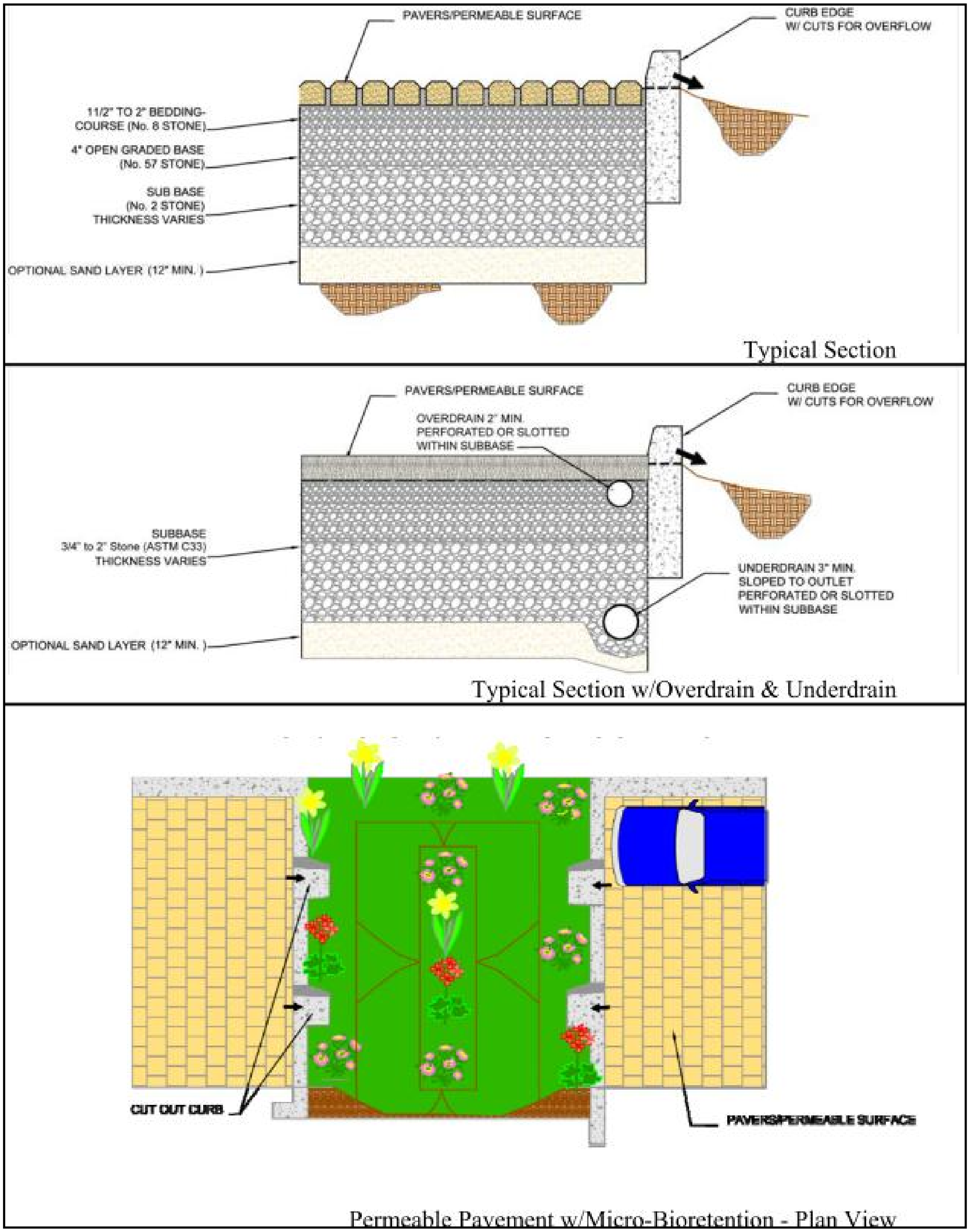


**Figure 9: Illustration of Permeable Pavements**
*Source: MDE SWM Manual*

## Manufactured Low-Impact Development Practices

There are several non-standard manufactured stormwater management practices available in the market depending on the type of application. One of the manufactured stormwater management devices that can be used in an urban setting is Filterra Bioretention Systems. One of the recommended products is the Filterra Sump-Curb Inlet. The sump-curb inlet consists of an inlet box structure containing a special engineered media (bioretention mix). A small tree/shrub is usually planted above the inlet box. Runoff from the roadway enters the inlets and gets filtered through the bioretention mix layers before entering the storm drain system. The sump-curb inlet system, illustrated in Figure 10, incorporates a curb inlet with bioretention treatment and internal high flow bypass chamber into one single structure. This device is ideal for an ultra urban setting where right-of-way is extremely limited and is aesthetically pleasing. Typically the maximum drainage area that can flow to a Filterra inlet is 0.25 acres. This bioretnetion deveice is an approved MDE device to treat one inch of runoff. However, for ESD requiring management of $P_E$ > 1", a continued dialoge between the designers, Montgomery County, MDE and the manufacturer may be requried.

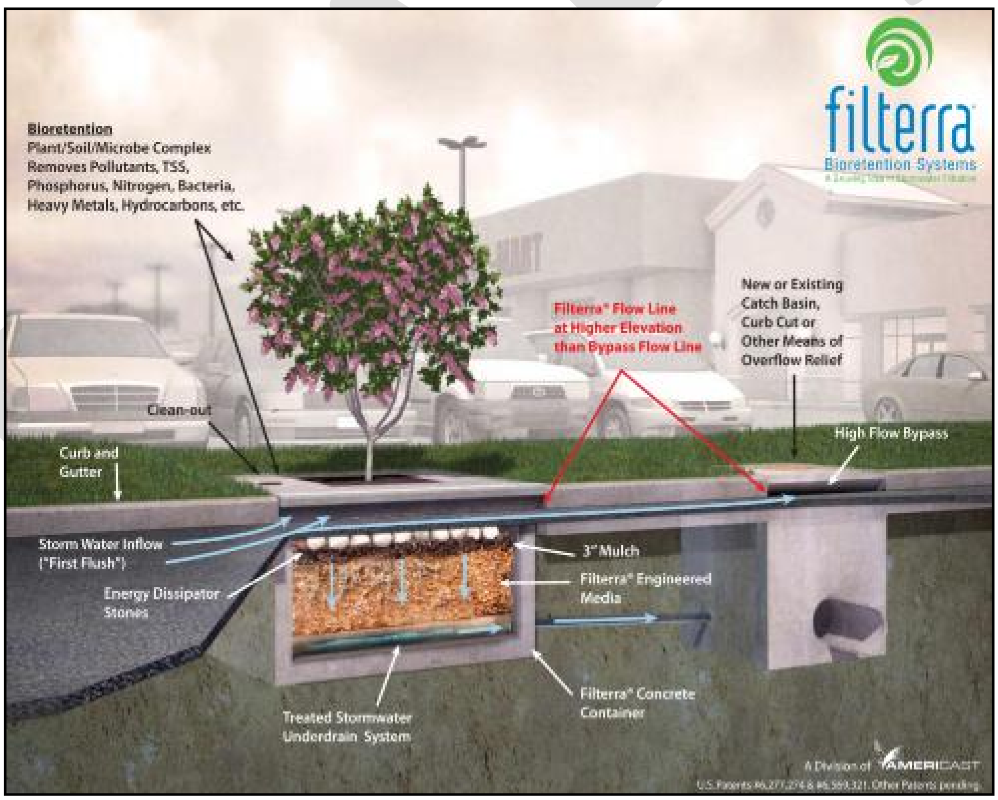


**Figure 10: Illustration of Filterra Bioretention System**
*Source: http://www.filterra.com/*

The advantages of Filterra inlets are as follows:

- Can be used in areas where right-of-way is not available
- Aesthetically pleasing

The disadvantages of Filterra inlets are as follows:

- Maintenance needs to be provided by the manufacturer on an annual basis and is expensive
- Since the drainage area to a Filterra inlet is limited to approximately 0.25 acres, several Filterra inlets will be required to provide stormwater management
- Higher operating costs compared to standard MDE approved facilities
- Not a traditional SWM device

**Figure 11: Examples of Filetrra Inlets**
*Source: http://www.filterra.com/*