VIRGINIA DCR STORMWATER DESIGN SPECIFICATION No. 12

FILTERING PRACTICES

VERSION 2.0
January 1, 2013

Photo: Compost Filter; courtesy Stormwater Management Inc.

SECTION 1: DESCRIPTION

Stormwater filters are a useful practice to treat stormwater runoff from small, highly impervious sites. Stormwater filters capture, temporarily store, and treat stormwater runoff by passing it through an engineered filter media, collecting the filtered water in an underdrain, and then returning it back to the storm drainage system. The filter consists of two chambers: the first is devoted to settling, and the second serves as a filter bed consisting of a sand or other filter media.

Stormwater filters are a versatile option because they consume very little surface land and have few site restrictions.

SECTION 2: PERFORMANCE

Stormwater filters provide moderate pollutant removal performance and provide no runoff volume reduction credit, so designers should consider using up-gradient runoff reduction practices to decrease the Treatment Volume (*Tv*) and the required size of the filtering practice. Certain filtering practices can be the least expensive and most effective option for treating designated hotspot runoff, especially vehicle storage and maintenance areas. In this way, stormwater filters can provide essential hotspot pre-treatment upstream of volume reduction practices and serve to minimize the potential maintenance costs (similar to the forebay on a basin). For a list of potential stormwater hotspots that merit treatment by filtering practices, consult the Stormwater Design Specification No. 8 (Infiltration).

While most filters tend to be subsurface or engineered to fit particular site conditions, there are variations of surface filters that function very similar to bioretention or dry swales (**Figure 12.1**). Increasing the depth and content of the media, adding vegetation, and other design variations can easily upgrade some filter applications to a runoff reduction practice. In general, stormwater filters depend on physical treatment mechanisms to remove pollutants from stormwater runoff: gravitational settling in the sedimentation chamber, straining at the top of the filter bed, and filtration and adsorption onto the filter media. In addition, microbial films may form on the surface of the filter bed, which can enhance biological pollutant removal processes. Filters are usually designed only for water quality treatment.

Table 12.1. Summary of Stormwater Functions Provided by Filtering Practices

Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	0%	0%
Total Phosphorus (TP) EMC Reduction[1] by BMP Treatment Process	60%	65%
Total Phosphorus (TP) Mass Load Removal	60%	65%
Total Nitrogen (TN) EMC Reduction[1] by BMP Treatment Process	30%	45%
Total Nitrogen (TN) Mass Load Removal	30%	45%
Channel Protection	Limited – Runoff diverted off-line into a storage facility for treatment can be supplemented with an outlet control to provide peak rate control.	
Flood Mitigation	None. Most filtering practices are off-line and do not materially change peak discharges.	
[1] Change in the event mean concentration (EMC) through the practice..		

Sources: CWP and CSN (2008), CWP, 2007

Leadership in Energy and Environmental Design (LEED®). The LEED® point credit system designed by the U.S. Green Building Council (USGBC) and implemented by the Green Building Certification Institute (GBCI) awards points related to site design and stormwater management. Several categories of points are potentially available for new development and redevelopment projects. **Chapter 6** of the 2013 *Virginia Stormwater Management Handbook* (2nd Edition) provides a more thorough discussion of the site planning process and design considerations as related to Environmental Site Design and potential LEED credits. However, VDCR is not affiliated with the USGBC or GBCI and any information on applicable points provided here is based only on basic compatibility. **Designers should research and verify scoring criteria and applicability of points as related to the specific project being considered through USGBC LEED resources.**

Table 12.2. Potential LEED® Credits for Filtering Practices[1]

Credit Category	Credit No.	Credit Description
Sustainable Sites	SS6.2	Stormwater Design: Quality Control

[1] Actual site design and/or BMP configuration may not qualify for the credits listed. Alternatively, the project may actually qualify for credits not listed here. Designers should consult with a qualified individual (LEED AP) to verify credit applicability.

SECTION 3: DESIGN TABLE

The major design goal is to maximize nutrient removal. To this end, designers may choose to go with the baseline design (Level 1) or choose an enhanced Level 2 design that maximizes nutrient removal. **Table 12.2**.

Table 12.3. Filtering Practice Design Guidance

Level 1 Design (RR:0; TP:60; TN:30)	Level 2 Design (RR:0 [1]; TP:65; TN:45)
Tv = [(1.0)(Rv)(A)] / 12 – the volume reduced by an upstream BMP	Tv = [(1.25)(Rv)(A)] / 12 – the volume reduced by an upstream BMP
One cell design[2]	Two cell design[2]
Sand media	Sand media with an organic layer
Contributing Drainage Area (CDA) contains pervious area	CDA is nearly 100% impervious

[1] May be increased if the 2nd cell is utilized for infiltration in accordance with Stormwater Design Specification No. 8 (Infiltration) or Stormwater Design Specification No. 9 (Bioretention). The Runoff Reduction (RR) credit should be proportional to the fraction of the Tv designed to be infiltrated.

[2] A pretreatment sedimentation chamber or forebay is not considered a separate cell

SECTION 4: TYPICAL DETAILS

Figures 12.1 and 12.2 provide typical schematics for a surface sand filter and organic filter, respectively. **Figure 12.3** provides a schematic for an underground sand filter, and **Figure 12.4** provides a schematic of a perimeter sand filter.

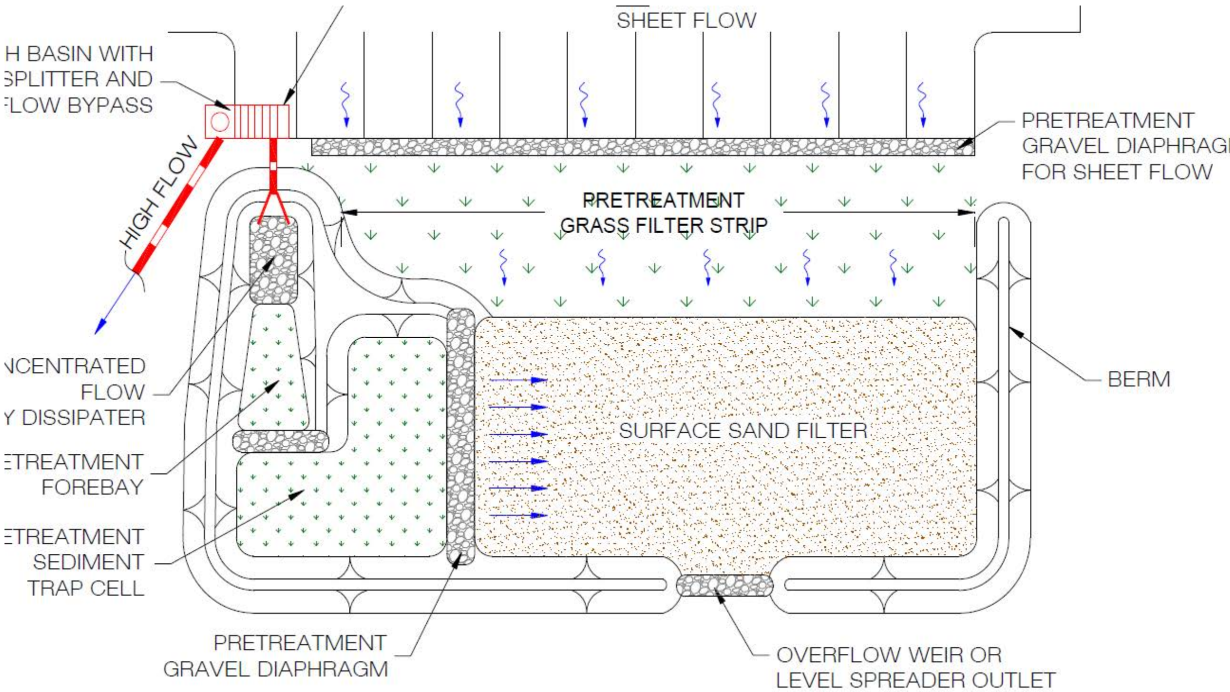

Figure 12.1. Schematic of a Surface Sand Filter

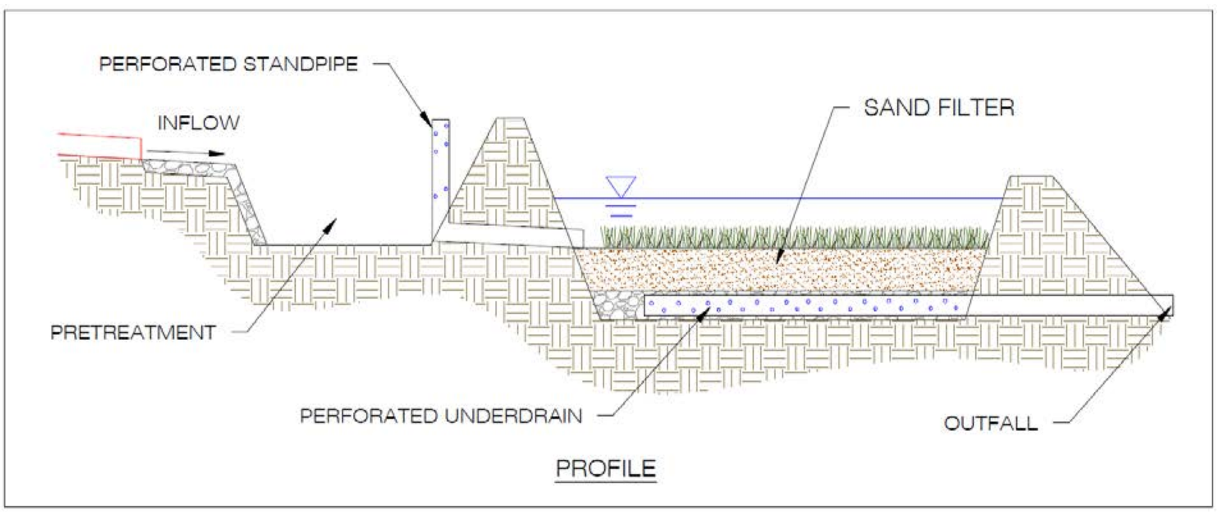

Figure 12.2. Profile of an Organic Filter

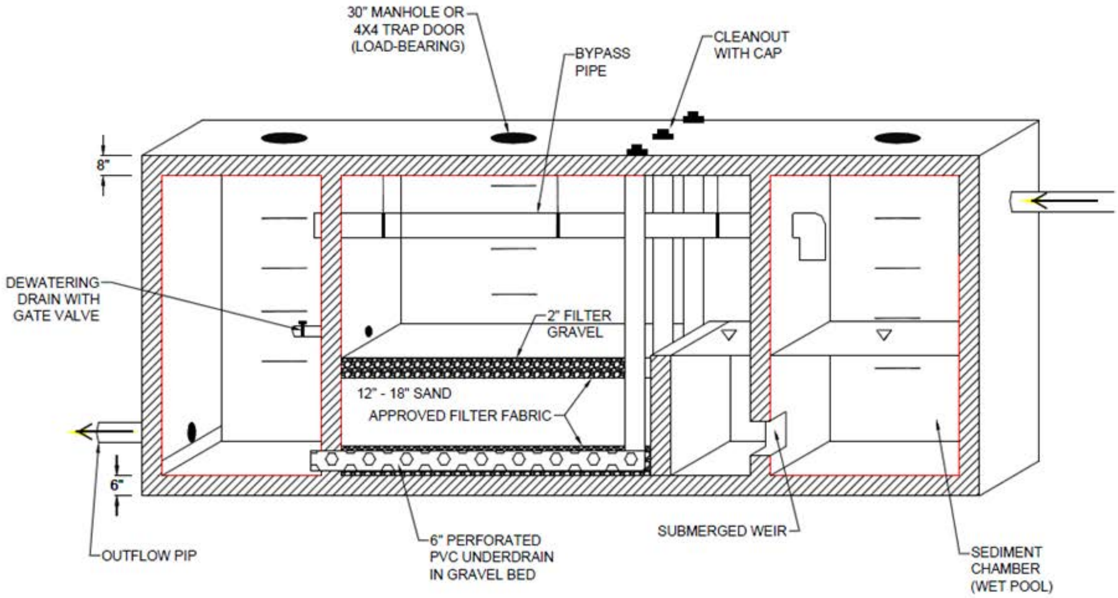

Figure 12.3. Underground Filter Schematic

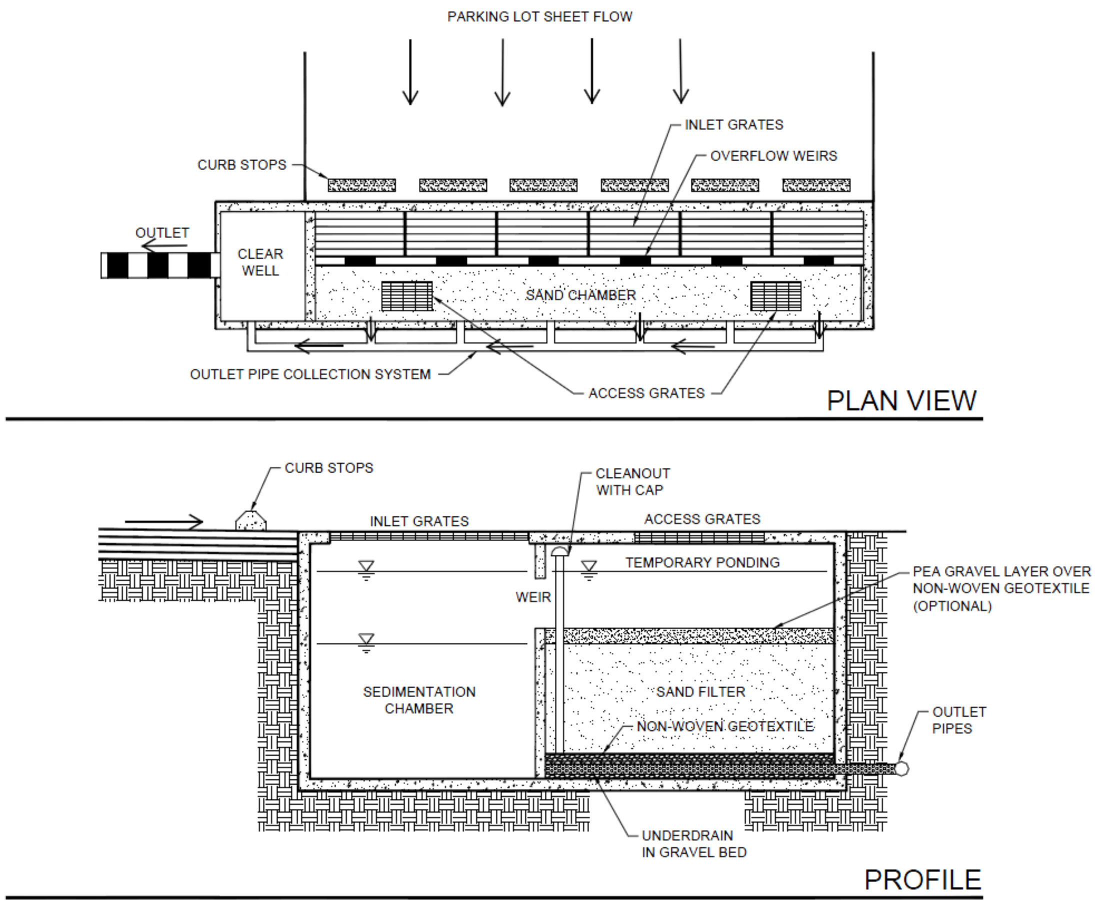

Figure 12.4. Perimeter Filter Plan and Profile Schematic

SECTION 5: PHYSICAL FEASIBILITY & DESIGN APPLICATIONS

Stormwater filters can be applied to most types of urban land. They are not always cost-effective, given their high unit cost and small area served, but there are situations where they are clearly the best option (e.g., hotspot runoff treatment, small high-traffic parking lots, ultra-urban areas etc.). The following is a list of design constraints for filtering practices.

Available Hydraulic Head. The principal design constraint for stormwater filters is available hydraulic head, which is defined as the vertical distance between the runoff ponding depth above the filter surface and the bottom elevation of the existing stormwater conveyance system that receives its discharge. The head required for stormwater filters ranges from 2 to 10 feet, depending on the design variant, making them difficult to employ in extremely flat terrain. The only exception is the Perimeter Sand Filter (**Figure 12.4**), which can be applied at sites with as little as 2 feet of head.

Depth to Water Table and Bedrock. The designer must assure a standard separation distance of at least 2 feet between the seasonally high groundwater table and/or bedrock layer and the bottom invert of the filtering practice.

Contributing Drainage Area. Stormwater filters are best applied on small sites where the contributing drainage (CDA) area is as close to 100% impervious as possible to minimize the sediment and organic solids load to the filter. A maximum CDA of 5 acres is recommended for surface sand filters, and a maximum CDA of 2 acres is recommended for perimeter or underground filters. Filters can be designed to treat runoff from larger areas; however, the increased hydraulic loading will contribute to greater frequency of media surface clogging and/or maintenance costs.

Space Required. The amount of space required for a filter practice depends on the design variant selected. Both sand and organic surface filters typically consume about 2% to 3% of the CDA, while perimeter sand filters typically consume less than 1%. Underground stormwater filters can be placed under parking or open space and generally consume no surface area. This makes stormwater filters well suited to treat runoff from redevelopment of commercial sites or stormwater hotspots.

Surface Sand Filters are normally designed to be off-line facilities in order to economize the size of the filter components and reduce maintenance costs. However, in some cases they can be installed as a treatment component within the bottom of a Dry Extended Detention (ED) Pond that has a shallow total ponding depth (see **Figure 12.5** and Stormwater Design Specification No. 15).

There are several design variations of the basic sand filter that enable designers to use filters at challenging sites or to improve pollutant removal rates. The most common design variants include the following:

- ***Surface Sand Filter.*** The surface sand filter is applied to sites less than 2 acres in size, and is essentially the same as a Bioretention Basin (see Stormwater Design Specification No. 9), with the following exceptions:
  - The bottom is lined with an impermeable filter fabric and always has an underdrain.
  - The surface cover is sand, turf or pea gravel.
  - The filter media is 100% sand.

- The filter surface is not planted with trees, shrubs or herbaceous materials.
- The filter has two cells, with a dry or wet sedimentation chamber preceding the sand filter bed.

The surface sand filter is designed with both the filter bed and pretreatment settling chamber or forebay located at ground level. Both chambers can be constructed with earthen components (**Figure 12.5**) or pre-cast or cast-in-place concrete (Austin sand filter **– Figure 12.6**)..

Figure 12.5. Hybrid Sand filter in a Detention Basin

Figure 12.6. Austin Surface Sand Filter

- ***Underground Sand Filter.*** The underground sand filter is modified to install the filtering components underground and is often designed with an internal flow splitter or overflow device that bypasses runoff from larger stormwater events around the filter. Underground sand filters are typically expensive to construct, but they consume very little space and are well suited to ultra-urban areas.

- ***Perimeter Sand Filter.*** The Perimeter Sand Filter also includes the basic design elements of a sediment chamber and a filter bed in a linear configuration allowing the overall system to be relatively small and shallow (**Figure 12.7**). However, this also serves to limit the contributing drainage area since treating a large area becomes very challenging with the linear configuration (designers will recognize the value of shifting to a traditional underground sand filter or proprietary filter on large drainage areas). Flow enters the system as sheet flow through linear grates, usually at the edge of a small parking lot. The perimeter sand filter is usually designed as an **on-line practice** (i.e., all flows enter the system), but larger events bypass treatment by overflowing the internal treatment chamber weir. One major advantage of the perimeter sand filter design is that the smaller scale of the design reduces the required hydraulic head and is therefore a good option for sites with low topographic relief.

Figure 12.7. Perimeter Sand Filter

- ***Organic Media Filter.*** Organic media filters are a design variant for the filtering systems described above with an organic filter medium replacing the sand. Two notable examples are the peat/sand filter and the compost filter system. Organic filters achieve higher pollutant removal for metals and hydrocarbons due to the increased cation exchange capacity of the organic media, and are therefore useful for targeting specific hotspot pollutants.

- ***Proprietary Filters.*** Proprietary filters use various filter media and system configurations to achieve filtration within a packaged structure. In some cases, these systems can provide excellent targeting of specific pollutants. However, designers must verify that the particular product has been reviewed and accepted by the Virginia BMP Clearinghouse (http://www.vwrrc.vt.edu/swc/) for use in Virginia.

SECTION 6: DESIGN CRITERIA

6.1. Overall Sizing

Filtering devices are sized to accommodate a specified *Tv*. The volume to be treated by the device is a function of the storage depth above the filter and the surface area of the filter. The storage volume is the volume of ponding above the filter. For a given *Tv*, **Equation 12.1** is used to determine the required filter surface area:

Equation 12.1. Minimum Filter Surface Area for Filtering Practices

$$A_f = \frac{(Tv)(d_f)}{(K)(h_f + d_f)(t_f)}$$

Where:

A_f = area of the filter surface (sq. ft.)
Tv = Treatment Volume[1], volume of storage (cu. ft.)
d_f = Filter media depth (thickness) = minimum 1 ft. (ft.)
K = Coefficient of permeability – partially clogged sand (ft./day) = 3.5 ft./day
h_f = Average height of water above the filter bed (ft.), with a maximum of 5 ft.= $h_{max}/2$
t_f = Allowable drawdown time = 1.67 days

[1]Stormwater filters are typically the only practice in a drainage area, or in some cases pre-treatment, however where runoff reduction practices are upstream of the filter, the design *Tv* is reduced by the upstream runoff reduction, or Tv_{BMP}.

The coefficient of permeability (ft./day) is intended to reflect the worst case situation (i.e., the condition of the sand media at the point in its operational life where it is in need of replacement or maintenance). Filtering practices are therefore sized to function within the desired constraints at the end of the media's operational life cycle.

A storage volume of a least 75% of the design *Tv* – including the volume over the top of the filter media and the volume in the pretreatment chamber(s), as well as any additional storage – is required in order to capture the volume from high-intensity storms prior to filtration and avoid premature bypass. The reduced volume of storage (75% of *Tv*) takes into account the varying filtration rate of the water through the media, as a function of a gradually declining hydraulic head.

Equation 12.2. Required Treatment Volume Storage for Filtering Practices

$$V_s = 0.75(Tv)$$

Where:

V_s = Volume of storage (cu. ft.)
Tv = Treatment Volume (cu. ft.)

6.2. Soil Testing Requirements

At least one soil boring must be taken at a low point within the footprint of the proposed filtering practice to establish the water table and bedrock elevations, and evaluate soil suitability for the proposed structure.

6.3. Pre-treatment

Adequate pre-treatment is needed to distribute flow across the filter surface and capture coarse sediment to ensure filter media longevity. Pre-treatment devices or sedimentation chambers are subject to the following criteria:

- Sedimentation chambers may be wet or dry but must sized to accommodate at least 25% of the total design *Tv* (inclusive).
- All pretreatment devices, including sediment chambers should be designed as level spreaders such that inflows to the filter bed have near zero velocity and spread runoff evenly across the surface.
- Surface sand filters may use alternative pre-treatment measures, such as a compost amended grass filter flow path, forebay, gravel diaphragm, check dam, level spreader, or combination, as follows:
  - Filter strips must be a minimum length of 15 feet, and have a slope of 3% or less;.
  - Check dams used to create a forebay may be wooden or concrete and must be installed so that the crest extends a maximum of 2 inches above the filter media surface with a gravel diaphragm energy dissipator (see Grass Channel Design Specification No. 3 for guidance on check dams). The forebay is sized to accommodate at least 25% of the total *Tv* (inclusive). Other forms of a forebay should contain a non-erosive spillway that distributes the flow evenly over the filter surface.
- If proprietary devices are used for pre-treatment, designers must confirm through the Virginia BMP Clearinghouse that the practice has been evaluated and approved for use and the design flow rate.

6.4. Conveyance and Overflow

Filtering practices should be designed as off-line systems with either an internal or external bypass to divert larger flows around the filter to an outlet chamber. Claytor and Schueler (1996) and ARC (2001) provide design guidance for flow splitters for filtering practices.

Underground filtering practices with an internal bypass must include design information to indicate how the device will safely pass the full range of design storms (e.g., 10 year event) without resuspending or flushing previously trapped material.

All stormwater filters should be designed to drain or dewater within 40 hours (1.67 days) after a storm event to reduce the potential for nuisance conditions.

Stormwater filters are normally designed with an impermeable liner and underdrain system that meet the criteria provided in **Table 12.4** below.

6.5. Filter Media and Surface Cover

Type of Media. The traditional sand filter media consists of clean, washed concrete sand with individual grains between 0.02 and 0.04 inches in diameter. Alternatively, organic media can be used, such as a peat/sand mixture or a leaf compost mixture. The decision to use organic media in a stormwater filter depends on which stormwater pollutants are targeted for removal. Organic media may enhance pollutant removal performance with respect to metals and hydrocarbons

(Claytor and Schueler, 1996). ***However, some organic media can actually leach soluble nitrate and phosphorus back into the discharge water, making it a poor choice when nutrients are the pollutant of concern***. Designers must provide documentation that the selected media has been tested and verified for use as a stormwater filtering media.

Type of Filter. The choice of which sand filter design to apply depends on available space and hydraulic head and the level of pollutant removal desired. In ultra-urban situations where surface space is at a premium, underground sand filters are often the only design that can be used. Surface and perimeter filters are often a more economical choice when adequate surface area is available.

Surface Cover. The surface cover for surface sand filters should consist of a 3-inch layer of topsoil (refer to Bioretention Media specification in BMP Design Specification No. 9) on top of a non-woven filter fabric laid above the sand layer. The surface may also have pea gravel inlets in the topsoil layer to promote filtration. The pea gravel may be located where sheet flow enters the filter, around the margins of the filter bed, or at locations in the middle of the filter bed.

Underground sand filters may utilize a mono-filament filter fabric with a high flow rate and a thin layer of pea gravel ballast on top of The pea-gravel helps to prevent bio-fouling or blinding of the sand surface. The fabric serves to facilitate removing the gravel during maintenance operations.

Depth of Media. The depth of the filter media plays a role in how quickly stormwater moves through the filter bed and how well it removes pollutants. Recent design guidance recommends a minimum filter bed depth ranging from 12 to 18 inches. Greater depths can be used in order to facilitate the removal of 1 to 3 inches of sand during maintenance without having to necessarily replace the sand upon each scheduled maintenance.

Impervious Drainage Area. The contributing drainage area should be as close to 100% impervious as possible in order to reduce the risk that eroded sediments will clog the filter.

6.6. Maintenance Reduction Features

The following maintenance issues should be addressed during filter design to reduce future maintenance problems:

- ***Observation Wells and Cleanouts.*** Surface filters should include an observation well consisting of a 6-inch diameter non-perforated PVC pipe fitted with a lockable cap. It should be installed flush with the ground surface to facilitate periodic inspection and maintenance. In most cases, a cleanout pipe will be tied into the end of all underdrain pipe runs. The portion of the cleanout pipe/observation well in the underdrain layer should be perforated. At least one cleanout pipe must be provided for every 2000 square feet of filter surface area.
- ***Access.*** Good maintenance access is needed to allow crews to perform regular inspections and maintenance activities. "Sufficient access" is operationally defined as the ability to get a vacuum truck or similar equipment close enough to the sedimentation chamber and filter to enable cleanouts.
- ***Manhole Access (for Underground Filters).*** Access to the headbox and clearwell of underground filters must be provided by manholes at least 30 inches in diameter, along with steps to the areas where maintenance will occur.

- ***Visibility.*** Stormwater filters should be clearly visible at the site so inspectors and maintenance crews can easily find them. Adequate signs or markings should be provided at manhole access points for Underground Filters.
- ***Monofilament fabric and Pea Gravel Ballast.*** The use of the fabric and ballast should simplify the maintenance of the filter media surface for both underground and surface filters.
- ***Confined Space Issues.*** Underground Filters are often classified as an *underground confined space*. Consequently, special OSHA rules and training are needed to protect the workers that access them. These procedures often involve training about confined space entry, venting, and the use of gas probes.

6.7. Filtering Material Specifications

The basic material specifications for filtering practices are outlined in **Table 12.4**.

Table 12.4. Filtering Practice Material Specifications

Material	Specification
Sand	Clean silica based coarse sand (AASHTO M-6/ASTM C-33).
Organic Layer	The compost shall conform to the requirements contained in Stormwater Design Specification No. 4 (Soil Compost Amendments) Section 6.5.
Underdrain	Use 4 to 6 inch (as needed based on drainage area) rigid perforated pipe. meeting ASTM F758 or ASTM F949 with maximum perforation dimensions of 3/8 inch and a minimum perforation inlet area of 1.76 square inches per linear foot of pipe. Underdrain pipe supplied with precision-machined slots provides greater intake capacity and superior clog-resistant drainage of fluids, as compared to standard round-hole perforated pipe. Slotted underdrain reduces entrance velocity into the pipe, thereby reducing the possibility that solids will be carried into the system. Slot rows can generally be positioned symmetrically or asymmetrically around the pipe circumference, depending upon the application.
Filter Fabric	For use under the turf or stone surface cover of a surface sand filter and underground filters: an appropriate material for the application based on AASHTO M288-06. Fabric should have a flow rate of > 125 gpm/sq. ft. (ASTM D4491), and an Apparent Opening Size (AOS) equivalent to a US # 70 or # 80 sieve (ASTM D4751). The geotextile AOS selection is based on the percent passing the No. 200 sieve in "A" Soil subgrade, using FHWA or AASHTO selection criteria.
Stone Jacket for Underdrain	Use clean washed gravel that meets VDOT #57 stone specifications or the ASTM equivalent (1 inch maximum).

SECTION 7: REGIONAL & SPECIAL CASE DESIGN ADAPTATIONS

7.1. Karst Terrain

Stormwater filters are a good option in karst areas, since they are not connected to groundwater and therefore minimize the risk of sinkhole formation and groundwater contamination. Construction inspection should certify that the filters are indeed water tight and that excavation will not extend into a karst layer.

7.2. Coastal Plain

The flat terrain, low head and high water table of the coastal plain make several filter designs difficult to implement. However, the perimeter sand filter generally has a low head requirement and can work effectively at many small coastal plain sites, subject to the following criteria:

- The combined depth of the underdrain and sand filter bed can be reduced to 18" inches.
- The designer may wish to maximize the length of the stormwater filter or provide treatment in multiple connected cells.
- The minimum depth to the seasonally high groundwater table may be relaxed to 1 foot, as long as the filter is equipped with a large diameter underdrain (e.g., 6 inches) that is only partially efficient at dewatering the filter bed.
- The depth to the seasonally high groundwater can be reduced further if the filter is entirely self-contained to prevent untreated stormwater from entering the groundwater. A geotechnical or structural engineer must verify sufficient support and anchoring to counteract any uplift from hydrostatic pressure.
- It is important to maintain at least a 0.5% slope of the underdrain to ensure drainage and to tie it into the receiving ditch or conveyance system.

7.3. Steep Terrain

The gradient of slopes contributing runoff to sand filters can be increased to 15% in areas of steep terrain, as long as a two cell, terraced design is used to dissipate erosive energy prior to filtering. The drop in elevation between cells should be limited to 1 foot and the slope should be armored with river stone or a suitable equivalent.

7.4. Cold Climate and Winter Performance

Surface or perimeter filters may not always be effective during the winter months. The main problem is ice that forms over and within the filter bed. Ice formation may briefly cause nuisance flooding if the filter bed is still frozen when spring melt occurs. To avoid these problems, filters should be inspected before the onset of winter (prior to the first freeze) to dewater wet chambers and scarify the filter surface. Other measures to improve winter performance include the following:

- Place a weir between the pre-treatment chamber and filter bed to reduce ice formation; the weir is a more effective substitute than a traditional standpipe orifice.
- Extend the filter bed below the frost line to prevent freezing within the filter bed.
- Oversize the underdrain to encourage more rapid drainage and to minimize freezing of the filter bed.

- Expand the sediment chamber to account for road sand. Pre-treatment chambers should be sized to accommodate up to 40% of the *Tv*.

7.5. Linear Highway Sites

Linear stormwater filters are a preferred practice for constrained highway rights-of-way when designed as a series of individual on-line or off-line cells. In these situations, the final design closely resembles that of Dry Swales with vegetated filter strip pretreatment. Salt-tolerant grass species should be selected if the contributing roadway will be salted in the winter.

SECTION 8: CONSTRUCTION

8.1. Construction Sequence

The following is the typical construction sequence to properly install a structural stormwater filter. This sequence can be modified to reflect different filter designs, site conditions, and the size, complexity and configuration of the proposed filtering application.

Step 1: Use of Filtering Practices as an E&S Control. The future location of a filtering practice may be used as the site of a temporary sediment basin or trap during site construction, as long as design elevations are set with final cleanout and conversion in mind. The bottom elevation of the filtering practice should be lower than the bottom elevation of the temporary sediment basin. Appropriate procedures should be implemented to prevent discharge of turbid waters when the temporary basin is converted to a filtering practice.

Step 2: Stabilize Drainage Area. Filtering practices should only be constructed or opened to runoff after the contributing drainage area to the facility is completely stabilized, so sediment from the CDA does not flow into and clog the filter. If the proposed filtering area is used as a sediment trap or basin during the construction phase, the construction notes should clearly specify that, after site construction is complete, the sediment control facility is to be dewatered, dredged and regraded to design dimensions for the post-construction filter.

Step 3: Install E&S Controls for the Filtering Practice. Stormwater should be diverted around filtering practices as they are being constructed. This is usually not difficult to accomplish for off-line filtering practices. It is extremely important to keep runoff and eroded sediments away from the filter throughout the construction process. Silt fence or other sediment controls should be installed around the perimeter of the filter, and erosion control fabric may be needed during construction on exposed side-slopes with gradients exceeding 4H:1V. Exposed soils in the vicinity of the filtering practice should be rapidly stabilized by hydro-seed, sod, mulch or other locally approved method of soil stabilization.

Step 4: Assemble Construction Materials on-site, make sure they meet design specifications, and prepare any staging areas.

Step 5: Excavate/Grade until the appropriate design elevations are achieved for the bottom and side slopes of the filtering practice.

Step 6: Install the Filter Structure and check all design elevations (e.g. concrete vault pipe cut-out holes, bottom of excavation for surface filters, etc.).

Step 7: Ensure Watertight Storage and Filter Structure. Upon completion of the filter structure shell, the inlets and outlets should be temporarily plugged and the structure filled with water to the brim to demonstrate watertightness. Maximum allowable leakage is 5% of the water volume in a 24-hour period. If the structure fails the test, repairs must be performed to make the structure watertight before any filter media is placed into it.

Step 8: Install Underdrain, and Gravel and Choker Stone Layers.

Step 9: Spread Filter Media Across the Filter Bed in 1 foot lifts up to the design elevation. Backhoes or other equipment should deliver the media from outside the filter structure. Sand should be manually raked.

Step 10: Consolidate the Filter Media. Fill the sedimentation and filter media chamber with clean water and allow to drain, hydraulically compacting the sand layers. Verify the depth of filter media meets the design minimum.

Step 11: Surface Filters - Install the Permeable Filter Fabric (if specified) over the sand, add a 3-inch topsoil layer with pea gravel inlets diaphragms located with stakes, and immediately seed with the permanent grass species. The grass should be watered, and the facility should not be switched on-line until a vigorous grass cover has become established.

Step 11: Underground Filters – Install the permeable fabric and thin layer of pea gravel ballast (if specified) over the filter media.

Step 11: Stabilize Exposed Soils on the perimeter of the structure with temporary seed mixtures appropriate for a buffer. All areas above the ponding area should be permanently stabilized by hydroseeding or seed and straw mulch.

Step 12. Conduct the final construction inspection (see **Section 8.2**). Remove excess straw and any unwanted vegetation.

8.2. Construction Inspection

Multiple construction inspections during and immediately after construction are critical to ensure that stormwater filters are properly constructed. The following interim verification inspections are recommended during critical stages of construction:

- Pre-construction meeting.
- Excavation/grading to design dimensions and elevations.
- Installation of the filter structure, including the watertightness test.
- Installation of the underdrain and sand filter bed.
- Check off that turf cover is vigorous enough to switch the facility on-line.

- Final Inspection (after a rainfall event to ensure that it drains properly. Develop a punch list for facility acceptance.
- Log the filtering practice's GPS coordinates and submit them for entry into the VSMP Authority's BMP maintenance tracking database.

A construction inspection form for stormwater filtering practices can be accessed at the end of this specification.

SECTION 9: MAINTENANCE

9.1. Maintenance Agreements

The Virginia Stormwater Management regulations (4 VAC 50-60) specify the circumstances under which a maintenance agreement must be executed between the owner and the VSMP authority, and sets forth inspection requirements, compliance procedures if maintenance is neglected, notification of the local program upon transfer of ownership, and right-of-entry for local program personnel.

- All stormwater filtering practices must include a long term maintenance agreements consistent with the provisions of the VSMP regulations, and must include the recommended maintenance tasks and a copy of an annual inspection checklist.
- When stormwater filters are applied on private residential lots, homeowners should be educated regarding their routine maintenance needs by being provided a simple document that explains their purpose and routine maintenance needs. .
- A deed restriction, drainage easement or other mechanism enforceable by the VSMP authority must be in place to help ensure that stormwater filters are maintained and not converted or disturbed, as well as to pass the knowledge along to any subsequent owners.
- The mechanism should, if possible, grant authority for the VSMP authority to access the property for inspection or corrective action.

9.2. Maintenance Inspections

Regular inspections are critical to schedule sediment removal operations, replace filter media, and relieve any surface clogging. Frequent inspections are especially needed for underground and perimeter filters since an organic mat can quickly clog the filter surface. Depending on the level of traffic or the particular land use, a filter system may become clogged within a few months of normal rainfall. Frequent maintenance can quickly establish a routine frequency acclimated to the land use. Maintenance inspections should be conducted within 24 hours following a storm that exceeds 1/2 inch of rainfall in order to evaluate the condition and performance of the filtering practice, including checking for the following:

- Check to see if sediment accumulation in the sedimentation chamber has exceeded 6 inches. If so, schedule a cleanout.
- Check to see if inlets and flow splitters are clear of debris and are operating properly.
- Check the dry sediment chamber and sand filter bed for any evidence of standing water or ponding more than 48 hours after a storm, and take necessary corrective action to restore permeability.

- Dig a small test pit in the sand filter bed to determine whether the first 3 inches of sand are visibly discolored and need replacement.
- Inspect whether the contributing drainage area to the filter is stable and not a source of sediment.
- Check whether turf on the filter bed and buffer is more than 12 inches high, and schedule necessary mowing operations.
- Check the integrity of observation wells and cleanout pipes.
- Check concrete structures and outlets for any evidence of spalling, joint failure, leakage, corrosion, etc.
- Ensure that the filter bed is level and remove trash and debris from the filter bed. Sand or gravel covers should be raked to a depth of 3 inches. Filters with a turf cover should have 95% vegetative cover.

The results of the inspection will then determine the level of maintenance required (routine or major – see **Table 12.5**) Example maintenance inspection checklists for Filtering Practices can be accessed in Appendix C of Chapter 9 of the *Virginia Stormwater Management Handbook* (2010) or at CWP website at:

http://www.cwp.org/Resource_Library/Controlling_Runoff_and_Discharges/sm.htm
(scroll to Tool6: Plan Review, BMP Construction, and Maintenance Checklists)

9.3. Routine Maintenance Tasks

A cleanup should be scheduled at least once a year to remove trash and floatables that accumulate in the pretreatment cells and filter bed. Sediment cleanouts in the dry and wet sedimentation chambers should be performed as needed in order to maintain the function and performance of the filter. If the filter treats runoff from a stormwater hotspot, crews may need to test the filter bed media before disposing of the media and trapped pollutants. Testing is not needed if the filter does not receive runoff from a designated stormwater hotspot, in which case the media can be safely disposed by either land application or land filling.

Table 12.5. Suggested Annual Maintenance Activities for Filtering Practices

Maintenance Tasks	Frequency
• Mow grass filter strips and perimeter turf.	At least four times a year
• Remove blockages and obstructions from inflows • Relieve clogging • Stabilize contributing drainage area and side-slopes to prevent erosion	As needed
• Inspection and cleanup	Annually
• Cleanout wet sedimentation chambers • Remove sediments from dry sedimentation chamber	Once every 2 to 3 years or as needed
• Replace top sand layer • Till or aerate surface to improve infiltration/grass cover	Every 5 years

SECTION 10: COMMUNITY & ENVIRONMENTAL CONCERNS

Surface stormwater filters have few community and environmental concerns. Their main drawback is their appearance – the surface of the media is either pea gravel or turf that may not be sustained during the dry summer months. Designers should focus on aesthetics to make sure filtering practices are integrated aesthetically into the landscape. Underground filters can avoid aesthetic issues, however they can accumulate a lot of trash in commercial land use applications and be difficult and possibly costly to maintain. Also, there is a small risk that underground and perimeter filters may create a potential habitat for mosquitoes to breed. If this is a community concern, designers should shift to dry sedimentation chambers rather than wet chambers.

Sample Construction Inspection Checklist for Filtering Practices: The following checklist provides a basic outline of the anticipated items for the construction inspection of filtering practices. The users of this information may wish to incorporate these items into a VSMP Authority Construction Checklist format consistent with the format used for erosion and sediment control and BMP construction inspections.

☐ **Certification of Pre-Construction Meeting:** Pre-construction meeting with the contractor designated to install the filtering practice has been conducted.

☐ Subsurface investigation and soils report supports the placement of a surface or an underground filtering practice in the proposed location.

☐ Impervious cover has been constructed/installed and area is free of construction equipment, vehicles, material storage), etc.

☐ All pervious areas of the contributing drainage areas have been adequately stabilized with a thick layer of vegetation and erosion control measures have been removed.

☐ Stormwater has been diverted around the area of the filtering practice and perimeter erosion control measures to protect the facility during construction have been installed.

Surface Filter

☐ Excavation of the filtering practice has achieved proper grades and the required geometry for the filter media placement.

☐ No groundwater seepage or standing water is present. Any standing water is dewatered to an acceptable dewatering device.

☐ Installation of the impermeable liner (if required). Liner meets project specifications and is placed in accordance with manufacturers specifications.

☐ All aggregates, including the reservoir layer around the underdrain, the choker stone layer, and the filter media (sand) conform to specifications as certified by quarry.

☐ Underdrain size and perforations meet the specifications.

☐ Placement of the underdrain, observation wells, and underdrain fittings (45 degree wyes, cap at upstream end, etc.) are in accordance with the approved plans.

☐ **Certification of Excavation and Placement of Liner and Underdrains**: Inspector certifies the successful completion of the previous steps for a surface filter.

☐ Placement of the stone aggregate, spread (not dumped) around the underdrain, and placement of the layer of the choker stone in accordance with the approved plans.

☐ Placement of the sand filter media in one-foot lifts.

☐ Verify proper depth of filter media

☐ Verify surface treatment (vegetation, pea gravel, etc., in accordance with the approved plans.

Underground Structural Filter

☐ Excavation of the filtering practice has achieved proper grades and the required geometry for the underground structural housing – typically a vault or container made of concrete of other approved material.

☐ No groundwater seepage or standing water is present. Any standing water is dewatered to an acceptable dewatering device.

☐ Installation of fabric (if needed) and gravel bedding.

☐ Placement of the structural housing and verification of internal and external plumbing invert elevations.

☐ **Certification of Water-Tightness Test Inspection**: Inspector certifies the successful completion of the water-tightness test completed and signed off by contractor or vault supplier.

☐ Installation of perforated pipes and other piping as required, and filter media to the required depth.

☐ Connection of inlet and outlet pipes to the site drainage system.

All Filters

☐ **Certification of Opening of Stormwater Inflow to the Filter Inspection**: Inspector certifies that the contributing drainage areas are stabilized and erosion and sediment control practices have been removed.

☐ Follow-up inspection and as-built survey/certification has been scheduled.

☐ GPS coordinates have been documented for all filtering practices on the parcel.

SECTION 11: REFERENCES

Atlanta Regional Commission (ARC). 2001. *Georgia Stormwater Management Manual, First Edition*. Available online at: http://www.georgiastormwater.com

Claytor, R. and T. Schueler. 1996. *Design of Stormwater Filtering Systems*. Chesapeake Research Consortium and the Center for Watershed Protection. Ellicott City, MD. http://www.cwp.org/PublicationStore/special.htm

CWP. 2007. *National Pollutant Removal Performance Database Version 3.0*. Center for Watershed Protection, Ellicott City, MD.

District of Columbia Stormwater Management Guidebook. Available online at: http://dchealth.dc.gov/DOH/site/default.asp?dohNav=|33110|

Maryland Department of Environment. *Maryland Stormwater Design Manual.* Available online: http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

Minnesota Stormwater Steering Committee (MSSC). 2005. *The Minnesota Stormwater Manual*. http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html

Northern Virginia Regional Commission. 2007. *Low Impact Development Supplement to the Northern Virginia BMP Handbook.* Fairfax, Virginia.

Schueler et al. 2007. *Urban Stormwater Retrofit Practices*. Manual 3 in the Urban Subwatershed Restoration Manual Series. Center for Watershed Protection. Ellicott City, MD.

Schueler, T. 2008. Technical Support for the Baywide Runoff Reduction Method. Chesapeake Stormwater Network. Baltimore, MD. www.chesapeakestormwater.net