

4.4.1 Organic Filter

Limited Application
Stormwater BMP



Description: The organic filter is a design variation of the surface sand filter that uses organic media to filter stormwater, as opposed to sand. An organic filter has two chambers. The first chamber is used for settling of heavy pollutant particles. The second chamber is filled with organic media and used to filter out fine particles.

KEY CONSIDERATIONS

DESIGN GUIDELINES:

- Maximum drainage area of 10 acres.
- Minimum head requirement of 5 to 8 feet.
- Requires the use of a peat/sand mixture as the filter media.
- Runoff discharges to an underdrain system.
- Intended for hotspot or space-limited applications, or for areas requiring enhanced pollutant removal capability.

ADVANTAGES / BENEFITS:

- Useful for treatment of small drainage areas and highly impervious areas.
- Good retrofit capability.

DISADVANTAGES / LIMITATIONS:

- High maintenance burden.
- Not recommended for areas that have high sediment content in stormwater or clay/silt runoff areas.
- Relatively costly to install and maintain.
- Possible odor problems.
- Cannot be installed until site construction is complete.

MAINTENANCE REQUIREMENTS:

- Inspect for clogging.
- Remove sediment from forebay/chamber.
- Replace filter media as needed.
- Stabilize, clean and maintain upstream drainage areas.

STORMWATER MANAGEMENT SUITABILITY

- Water Quality**
- Channel/Flood Protection**
- Overbank Flood Protection**
- Extreme Flood Protection**

* in certain situations

Accepts runoff from SPAP land uses: Yes

FEASIBILITY CONSIDERATIONS

- L Land Requirement**
- H Capital Cost**
- H Maintenance Burden**

Residential/Subdivision Use: No

High Density/Ultra-Urban: Yes

Drainage Area: 10 acres maximum

Soils: Not recommended for clay/silt drainage areas that are not stabilized.

POLLUTANT REMOVAL

- H Total Suspended Solids**
- M Nutrients:** Total Phosphorus / Total Nitrogen
- M-H Metals:** Cadmium, Copper, Lead, and Zinc
- M Pathogens:** Coliform, Streptococci, E.Coli

L=Low M=Moderate H=High

4.4.1.1 General Description

The organic filter is a design variant of the surface sand filter with the unique characteristic of using organic materials such as leaf compost or a peat/sand mixture as the filter media. The organic material enhances pollutant removal by providing adsorption of contaminants such as soluble metals, hydrocarbons, and other organic chemicals.

As with the surface sand filter, an organic filter consists of a pretreatment chamber, and one or more filter cells. Each filter bed contains a layer of leaf compost or the peat/sand mixture, followed by filter fabric and a gravel/perforated pipe underdrain system. The filter bed and subsoils can be separated by an impermeable polyliner or concrete structure to prevent movement into groundwater.

Organic filters are typically used in high-density applications, or for areas requiring enhanced pollutant removal ability. Maintenance is typically higher than the surface sand filter facility due to the need to reduce the potential for debris and sediment clogging the organic filter. In addition, organic filter systems have a higher head requirement than sand filters.

4.4.1.2 Stormwater Management Suitability

Organic filter systems are designed primarily as off-line systems for treatment of the water quality volume and will typically need to be used in conjunction with another structural BMP that can provide downstream channel protection, overbank flood protection, and extreme flood protection. However, under certain circumstances, organic filters can provide limited runoff quantity control, particularly for smaller storm events.

Water Quality (WQv)

In organic filter systems, stormwater pollutants are removed through a combination of gravitational settling, filtration and adsorption. The filtration process effectively removes suspended solids and particulates, biochemical oxygen demand (BOD), fecal coliform bacteria, and other pollutants. Organic filters with a grass cover have additional opportunities for bacterial decomposition as well as vegetation uptake of pollutants, particularly nutrients.

Channel Protection (CPv)

For smaller sites, an organic filter may be designed to capture the entire channel protection volume (CPv) in either an off- or on-line configuration. Given that an organic filter system is typically designed to completely drain over 40 hours, the channel protection design requirement for extended detention of the 1-year, 24-hour storm runoff volume can be met. For larger sites or where only the WQv is diverted to the organic filter facility, another structural control must be used to provide extended detention of the CPv.

Overbank Flood Protection (up to Qp25) and Extreme Flood Protection (Qp100)

Organic filters are not useful for flood protection. Another structural control, such as a conventional detention pond must be used in conjunction with an organic filter system to control stormwater peak discharges. Further, organic filter facilities must provide flow diversion and/or be designed to safely pass extreme storm flows and protect the filter bed and facility.

4.4.1.3 Pollutant Removal Capabilities

Peat/sand filter systems provide good removal of bacteria and organic waste metals. The following design pollutant removal rates are conservative average pollutant reduction percentages for design purposes derived from sampling data, modeling and professional judgment.

- Total Suspended Solids – 80%
- Total Phosphorus – 60%
- Total Nitrogen – 40%
- Heavy Metals – 75%
- Pathogens – 50%

For additional information and data on pollutant removal capabilities for organic filters, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the International Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

4.4.1.4 Application and Site Feasibility Criteria

Organic filter systems are well-suited for highly impervious areas where land available for structural BMPs is limited. Organic filters should primarily be considered for new construction or retrofit opportunities for commercial, industrial, and institutional areas where the sediment load is relatively low, such as: parking lots, driveways, loading docks, gas stations, garages, airport runways/taxiways, and storage yards. Organic filters may also be feasible and appropriate in some multi-family residential developments where maintenance is performed by a landscaping (or other suitably capable) company.

To avoid rapid clogging and failure of the filter media, the use of organic filters should be avoided in areas with less than 50% impervious cover, or high sediment yield sites with clay/silt soils.

The following basic criteria should be evaluated to ensure the suitability of an organic filter facility for meeting stormwater management objectives on a site or development.

General Feasibility

- Not generally suitable for use in a residential subdivision.
- Suitable for use in high density/ultra urban areas.
- Not suitable for use as a regional stormwater control. On-site applications are typically most feasible.

Physical Feasibility - Physical Constraints at Project Site

- Drainage Area – Ten (10) acres maximum
- Space Required – Function of available head at site
- Minimum Head – The surface slope across the filter location should be no greater than 6%. The elevation difference needed at a site from the inflow to the outflow is 5 to 8 feet.
- Minimum Depth to Water Table – If used on a site with an underlying water supply aquifer, a separation distance of 2 feet required between the bottom of the organic filter and the elevation of the seasonally high water table to prevent groundwater contamination.
- Soils – Not recommended for drainage areas with exposed soil. Karst areas may require a liner.

Other Constraints / Considerations

- Aquifer Protection – Do not allow infiltration of filtered hotspot runoff into groundwater

4.4.1.5 Planning and Design Standards

The following standards shall be considered **minimum** design standards for the design of organic filters. Organic filters that are not designed to these standards will not be approved. The Director of Engineering and Public Works (the Director) shall have the authority to require additional design conditions if deemed necessary.

A. CONSTRUCTION SEQUENCING

- Care shall be taken during construction to minimize the risk of premature failure of the organic filter due to deposition of sediments from disturbed, unstabilized areas. This can be minimized or avoided by proper construction sequencing.
- Ideally, the construction of an organic filter shall take place **after** the construction site has been stabilized. In the event that the organic filter is not constructed after site stabilization, diversion of site runoff around the organic filter and installation and maintenance of appropriate erosion prevention and sediment controls prior to site stabilization is required.

- Diversion berms shall be maintained around an organic filter during all phases of construction. No runoff shall enter the organic filter area prior to completion of construction and the complete stabilization of construction areas. Erosion prevention and sediment controls shall be maintained around the organic filter to prevent runoff and sediment from entering the organic filter during construction.
- Organic filters shall not be used as a temporary sediment trap for construction activities.
- During and after excavation of the organic filter, all excavated materials shall be placed downstream, away from the organic filters, to prevent redeposit of the material during runoff events.

B. LOCATION AND SITING

- Organic filters shall have a contributing drainage area of 10 acres or less.
- Organic filter systems are generally applied to land uses with a high percentage of impervious surfaces. Organic filters shall not be utilized for sites that have less than 50% impervious cover. Pretreatment must be provided as described in part E below, due to the potential for high clay/silt sediment loads that could result in clogging and failure of the filter bed. Any disturbed or denuded areas located within the area draining to and treated by the organic filter shall be stabilized prior to construction and use of the organic filter. The organic filter shall only be constructed after the construction site is stabilized.
- It is preferred that organic filters only be used in an off-line configuration where the WQv (and CPv if used for this purpose) is diverted to the filter facility through the use of a flow diversion structure and flow splitter. Stormwater flows greater than the WQv (and CPv if used for this purpose) are then diverted to other controls or downstream using a diversion structure or flow splitter.
- Organic filter systems shall be designed for intermittent flow and must be allowed to drain and re-aerate between rainfall events. They shall not be used on sites with a continuous flow from groundwater, sump pumps, or other sources.

C. GENERAL DESIGN

- An organic filter facility shall consist of a two-chamber open-air structure, which is located at ground-level. The first chamber is the sediment forebay (commonly referred to as the sedimentation chamber) while the second chamber houses the filtration chamber (organic filter bed). Flow enters the sedimentation chamber where settling of larger sediment particles occurs. Runoff is then discharged from the sedimentation chamber through a perforated standpipe into the filtration chamber. After passing through the filter bed, runoff is collected by a perforated pipe and gravel underdrain system. Figure 4-56 provides a plan view and profile schematic of an organic filter.
- Organic filters can utilize a variety of organic materials as the filtering media. Two typical media bed configurations are the peat/sand filter and compost filter (see Figure 4-56). The peat filter includes an 18-inch 50/50 peat/sand mix over a 6-inch sand layer and can be optionally covered by 3 inches of topsoil and vegetation. The compost filter has an 18-inch compost layer.
- The type of peat used in a peat/sand filter is critically important. Fibric peat in which undecomposed fibrous organic material is readily identifiable is the preferred type. Hemic peat containing more decomposed material may also be used. Sapric peat made up of largely decomposed matter should *not* be used in an organic filter.

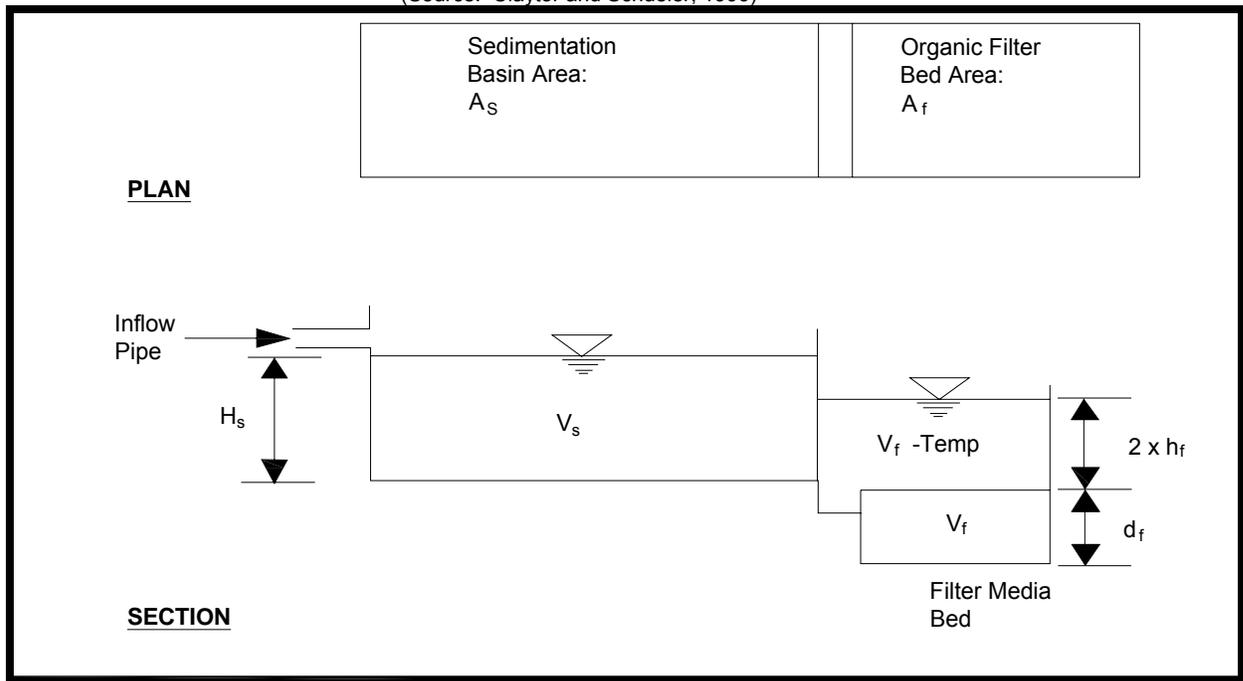
D. PHYSICAL SPECIFICATIONS / GEOMETRY

- The entire organic filter treatment system (including the sedimentation chamber) shall be designed to temporarily hold at least 75% of the WQv prior to filtration. Figure 4-56 illustrates the distribution of the treatment volume (0.75 WQv) among the various components of the surface sand filter, including:
 - V_s – volume within the sedimentation basin
 - V_f – volume within the voids in the filter bed
 - V_{f-temp} – temporary volume stored above the filter bed

- A_s – the surface area of the sedimentation basin
- A_f – surface area of the filter media
- h_s – height of water in the sedimentation basin
- h_f – average height of water above the filter media
- d_f – depth of filter media

Figure 4-56. Organic Filter Volumes

(Source: Claytor and Schueler, 1996)



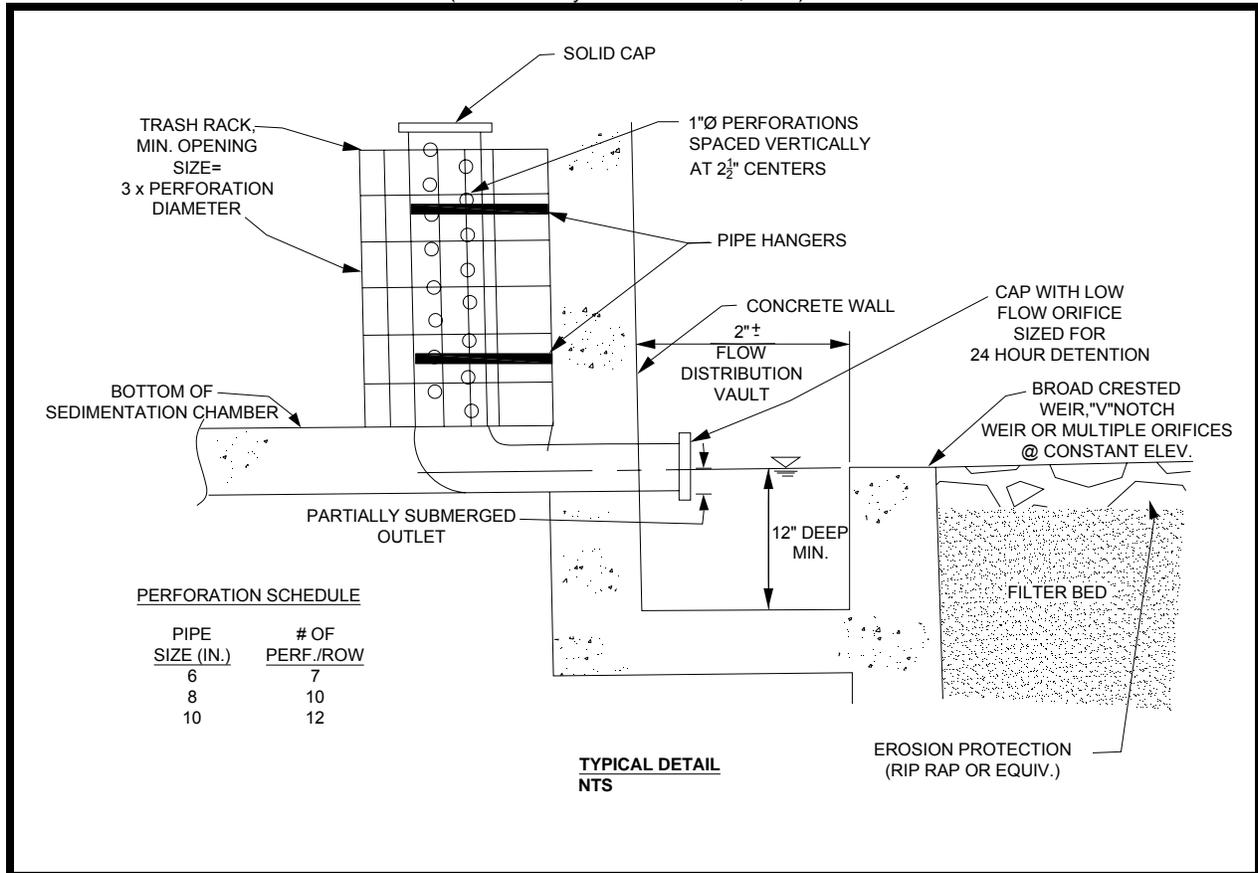
- The sedimentation chamber shall be sized to hold at least 25% of the computed WQv and have a length-to-width ratio of at least 2:1. Inlet and outlet structures should be located at opposite ends of the chamber.
- The filter area shall be sized based on the principles of Darcy's Law. A coefficient of permeability (k) of 3.5 ft/day for sand, 2.0 ft/day for peat and 8.7 ft/day for leaf compost shall be used. The filter bed shall be designed to completely drain in 40 hours or less.
- The filter media for an organic filter shall consist of either an 18" layer of peat/sand mixture on top of a 6" sand layer or an 18" layer of leaf compost. Both types of media are placed on top of the underdrain system. Three inches of topsoil shall be placed over the sand bed. Permeable filter fabric shall be placed both above and below the filter bed to prevent clogging of the filter media and the underdrain system. Figure 4-56 illustrates a typical media cross section.
- The filter bed shall be equipped with a 6-inch perforated pipe underdrain (PVC AASHTO M 252, HDPE, or other suitable pipe material) in a gravel layer (see figure 4-58). The underdrain shall have a minimum grade of 1/8-inch per foot (1% slope). Holes shall be 3/8-inch diameter and spaced approximately 6 inches on center. Gravel shall be clean-washed aggregate with a maximum diameter of 3.5 inches and a minimum diameter of 1.5 inches with a void space of about 40%. Aggregate contaminated with soil shall not be used.
- The structure of the organic filter may be constructed of impermeable media such as concrete, or through the use of excavations and earthen embankments. When constructed with earthen walls/embankments, filter fabric shall be used to line the bottom and side slopes of the structures before installation of the underdrain system and filter media.

E. PRETREATMENT / INLETS

- Pretreatment of runoff in an organic filter system shall be by a sedimentation chamber, designed in accordance with the criteria stated above.
- Energy dissipators shall be used at the inlets to organic filters. Figure 4-57 shows a typical inlet pipe from the sedimentation basin to the filter media basin.
- The organic filter shall be designed such that runoff exits the sedimentation chamber at a non-erosive velocity.

Figure 4-57. Surface Sand Filter Perforated Stand-Pipe

(Source: Claytor and Schueler, 1996)



F. OUTLET STRUCTURES

- An outlet pipe shall be provided from the underdrain system to the facility discharge. Due to the slow rate of filtration, outlet protection is generally unnecessary (except for emergency overflows and spillways). However, the design shall ensure that the discharges from the underdrain system occur in a non-erosive manner.

G. EMERGENCY SPILLWAY

- An emergency or bypass spillway must be included in the organic filter design to safely pass flows that exceed the WQv (and CPv if the filter is utilized for channel protection purposes). The spillway prevents filter water levels from overtopping the embankment and causing structural damage. The emergency spillway shall be located so that embankments, downstream buildings and structures will not be impacted by spillway discharges.

H. MAINTENANCE ACCESS

- A minimum 20' wide maintenance right-of-way or drainage easement shall be provided for the organic filter from a driveway, public or private road. The maintenance access easement shall have a maximum slope of no more than 15% and shall have a minimum unobstructed drive path having a width of 12 feet, appropriately stabilized to withstand maintenance equipment and vehicles. Adequate access must be provided to the filter bed. Facility designs must enable maintenance personnel to easily remove and replace upper layers of the filter media.

I. SAFETY FEATURES

- Where necessary, surface organic filter facilities can be fenced to prevent access.
- Inlets and outlets shall be designed and maintained so as not to permit access by children.

J. LANDSCAPING

- Organic filters can be designed with a grass cover to aid in pollutant removal and prevent clogging. The grass should be capable of withstanding frequent periods of inundation and drought.

K. ADDITIONAL SITE-SPECIFIC DESIGN CRITERIA AND ISSUES

Physiographic Factors - Local terrain design constraints

- Low Relief – Use of an organic filter may be limited by low head
- High Relief – Filter bed surface must be level
- Karst – Use liner or impermeable membrane to seal bottom earthen surface of the organic filter or use watertight structure

Special Downstream Watershed Considerations

- Wellhead Protection – Reduce potential groundwater contamination (in required wellhead protection areas) by preventing infiltration of hotspot runoff. May require liner for type “A” and “B” soils; Pretreat hotspots; provide 2 to 4 foot separation distance from water table.

4.4.1.6 Design Procedures

Step 1. Compute runoff control volumes

Calculate WQ_v , CP_v , in accordance with the guidance presented in Volume 2, Chapter 3.

Step 2. Determine if the development site and conditions are appropriate for the use of organic filter.

Consider the Application and Site Feasibility Criteria, and the Additional Site Specific Design Criteria and Issues noted above. Check with Knox County Engineering and other agencies as appropriate to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

Step 3. Compute WQ_v peak discharge (Q_{wq})

The peak rate of discharge for water quality design storm is needed for sizing of off-line diversion structures (see Volume 2, Chapter 3 for more information on this calculation).

- Using WQ_v , compute CN
- Compute time of concentration using TR-55 method
- Determine appropriate unit peak discharge from time of concentration
- Compute Q_{wq} (in inches) from unit peak discharge, drainage area, and WQ_v

Step 4. Size flow diversion structure, if needed

A flow regulator (or flow splitter diversion structure) should be supplied to divert the WQv to the organic filter facility. Size low flow orifice, weir, or other device to pass Q_{wq} .

Step 5. Size filtration basin chamber

The filter area is sized using the following equation (based on Darcy's Law):

$$A_f = (WQv) (d_f) / [(k) (h_f + d_f) (t_f)]$$

where:

- WQv = water quality volume (ft³)
- A_f = surface area of filter bed (ft²)
- d_f = filter bed depth
(at least 1.5 feet, no more than 2 feet)
- k = coefficient of permeability of filter media (ft/day)
(use 3.5 ft/day for sand)
(use 2.0 ft/day for peat)
(use 8.7 ft/day for leaf compost)
- h_f = average height of water above filter bed (ft)
(1/2 h_{max}, which varies based on site but h_{max} is typically ≤ 6 feet)
- t_f = design filter bed drain time (days)
(1.67 days or 40 hours is required maximum time)

Set preliminary dimensions of filtration basin chamber.

Step 6. Size sedimentation chamber

The sedimentation chamber shall be sized to at least 25% of the computed WQv and have a length-to-width ratio of 2:1. The Camp-Hazen equation is used to compute the required surface area:

$$A_s = - (Q_o/w) * \ln (1-E)$$

where:

- A_s = sedimentation basin surface area (ft²)
- Q_o = rate of outflow = the WQv (ft³) / 86400 seconds
- w = particle settling velocity (ft/sec)
- E = trap efficiency

Assuming:

- E = 90% sediment trap efficiency (0.9)
- w = particle settling velocity (ft/sec) = 0.0033 ft/sec for imperviousness (I) ≥ 75%
- w = particle settling velocity (ft/sec) = 0.0004 ft/sec for imperviousness (I) < 75%
- average of 24 hour holding period

Then:

$$A_s = (0.0081) (WQv) \text{ ft}^2 \text{ for } I \geq 75\%$$

$$A_s = (0.066) (WQv) \text{ ft}^2 \text{ for } I < 75\%$$

Set preliminary dimensions of sedimentation chamber.

Step 7. Compute V_{min}

$$V_{min} = 0.75 * WQv$$

Step 8. Compute storage volumes within entire facility and sedimentation chamber orifice size

Use the following equation:

$$\text{Vol}_{\text{min}} = 0.75 \text{ WQv} = V_s + V_f + V_{f\text{-temp}}$$

- (1) Compute V_f = water volume within filter bed/gravel/pipe = $A_f * d_f * n$
Where: n = porosity = 0.4 for most applications
- (2) Compute $V_{f\text{-temp}}$ = temporary storage volume above the filter bed = $2 * h_f * A_f$
- (3) Compute V_s = volume within sediment chamber = $\text{Vol}_{\text{min}} - V_f - V_{f\text{-temp}}$
- (4) Compute h_s = height in sedimentation chamber = V_s/A_s
- (5) Ensure h_s and h_f fit available head and other dimensions still fit – change as necessary in design iterations until all site dimensions fit.
- (6) Size orifice from sediment chamber to filter chamber to release V_s within 24-hours at average release rate with $0.5 h_s$ as average head.
- (7) Design outlet structure with perforations allowing for a safety factor of 10.
- (8) Size distribution chamber to spread flow over filtration media – level spreader weir.

Step 9. Design inlets, pretreatment facilities, underdrain system, and outlet structures

See design criteria above for more details.

Step 10. Compute overflow weir sizes

1. Size overflow weir at elevation h_s in sedimentation chamber (above perforated stand pipe) to handle surcharge of flow through filter system from 25-year storm.
2. Plan inlet protection for overflow from sedimentation chamber and size overflow weir at elevation h_f in filtration chamber (above perforated stand pipe) to handle surcharge of flow through filter system from 25-year storm (see example).



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4.4.1.7 Maintenance Requirements and Inspection Checklist

Note: Section 4.4.1.7 must be included in the Operations and Maintenance Plan that is recorded with the deed.

Regular inspection and maintenance is critical to the effective operation of an organic filter as designed. It is the responsibility of the property owner to maintain all stormwater BMPs in accordance with the minimum design standards and other guidance provided in this manual. The Director has the authority to impose additional maintenance requirements where deemed necessary.

This page provides guidance on maintenance activities that are typically required for organic filters, along with a suggested frequency for each activity. Individual organic filters may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes or redevelopment in the upstream land use. Each property owner shall perform the activities identified below at the frequency needed to maintain the organic filter in proper operating condition at all times.

Inspection Activities	Suggested Schedule
<ul style="list-style-type: none"> A record should be kept of the dewatering time (i.e., the time required to drain the filter bed completely after a storm event) for an organic filter to determine if maintenance is necessary. The filter bed should drain completely in about 40 hours after the end of the rainfall. Check to ensure that the filter surface does not clog after storm events. 	After Rain Events
<ul style="list-style-type: none"> Check the contributing drainage area, facility, inlets and outlets for debris. Check to ensure that the filter surface is not clogging. 	Monthly
<ul style="list-style-type: none"> Check to see that the filter bed is clean of sediment, and the sediment chamber is not more than 50% full of sediment or the sediment accumulation is not more than 6 inches, whichever is less sediment. Remove sediment as necessary. Make sure that there is no evidence of deterioration, spalling, bulging, or cracking of concrete. Inspect inlets, outlets and overflow spillway to ensure good condition and no evidence of erosion. Check to see if stormwater flow is bypassing the facility. Ensure that no noticeable odors are detected outside the facility. 	Annually
Maintenance Activities	Suggested Schedule
<ul style="list-style-type: none"> Mow and stabilize (prevent erosion, vegetate denuded areas) the area draining to the organic filter. Collect and remove grass clippings. Remove trash and debris. Ensure that activities in the drainage area minimize oil/grease and sediment entry to the system. 	Monthly
<ul style="list-style-type: none"> Check to see that the filter bed is clean of sediment, and the sediment chamber is not more than 50% full of sediment or the sediment accumulation is not more than 6 inches, whichever is less sediment. Remove sediment as necessary. Repair or replace any damaged structural parts. Stabilize any eroded areas. 	Annually
<ul style="list-style-type: none"> If filter bed is clogged or partially clogged, manual manipulation of the surface layer of filter media may be required. Remove the top few inches of filter media, roto-till or otherwise cultivate the surface, and replace with media meeting the design specifications. Replace any filter fabric that has become clogged. 	As needed

Knox County encourages the use of the inspection checklist that is presented on the next page to guide the property owner in the inspection and maintenance of organic filters. The Director can require the use of this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the organic filter. Questions regarding stormwater facility inspection and maintenance should be referred to the Knox County Department of Engineering and Public Works, Stormwater Management Division.



**INSPECTION CHECKLIST AND MAINTENANCE GUIDANCE (continued)
ORGANIC FILTER INSPECTION CHECKLIST**

Location: _____ Owner Change since last inspection? Y N
 Owner Name, Address, Phone: _____
 Date: _____ Time: _____ Site conditions: _____

Inspection Items	Satisfactory (S) or Unsatisfactory (U)	Comments/Corrective Action
Organic Filter Inspection List		
Complete drainage of the filter in about 40 hours after a rain event?		
Clogging of filter surface?		
Clogging of inlet/outlet structures?		
Clogging of filter fabric?		
Filter clear of debris and functional?		
Leaks or seeps in filter?		
Obstructions of spillway(s)?		
Animal burrows in filter?		
Sediment accumulation in filter bed (less than 50% is acceptable)?		
Cracking, spalling, bulging or deterioration of concrete?		
Erosion in area draining to organic filter?		
Erosion around inlets, filter bed, or outlets?		
Pipes and other structures in good condition?		
Undesirable vegetation growth?		
Other (describe)?		
Hazards		
Have there been complaints from residents?		
Public hazards noted?		

If any of the above inspection items are **UNSATISFACTORY**, list corrective actions and the corresponding completion dates below:

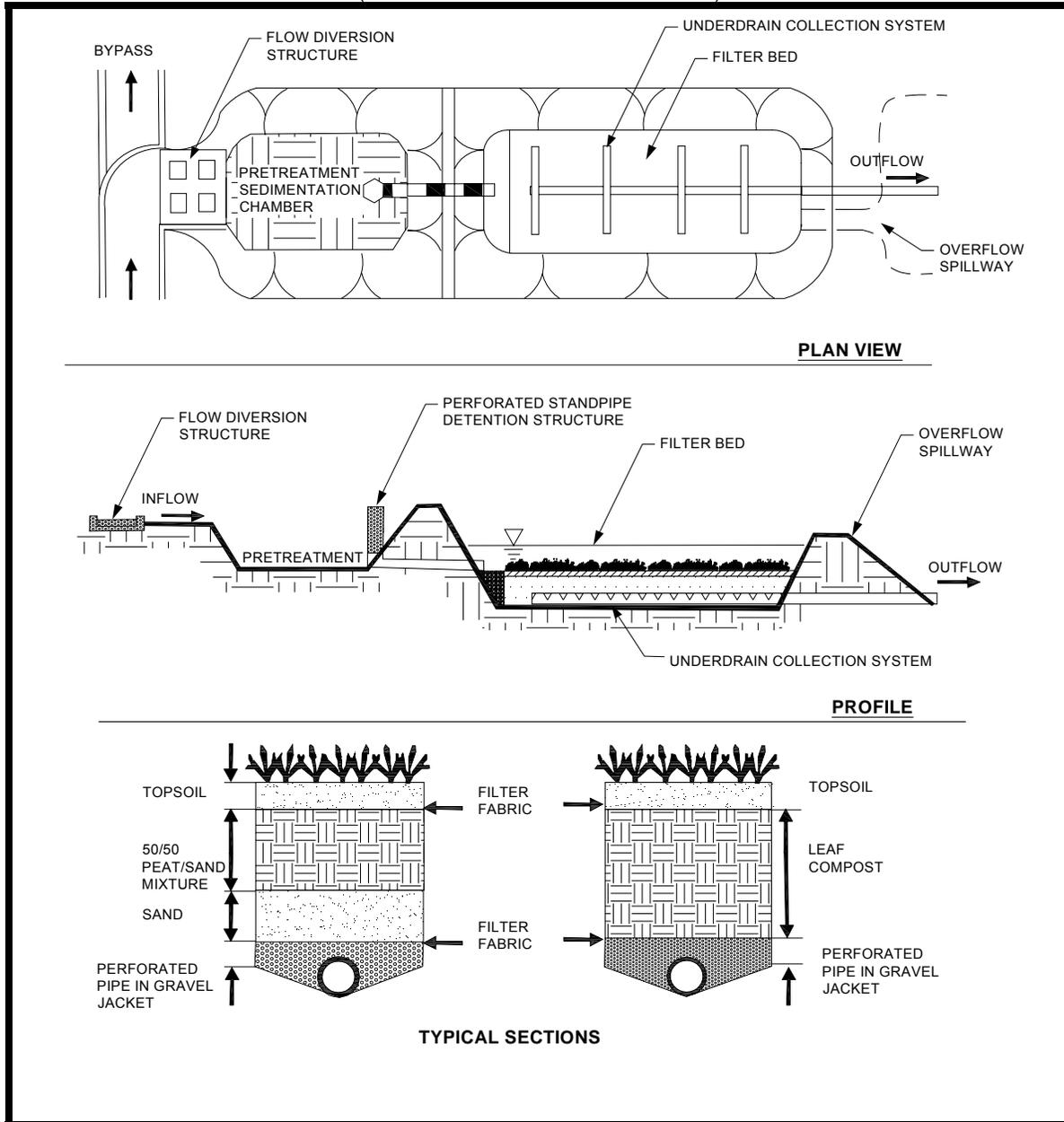
Corrective Action Needed	Due Date

Inspector Signature: _____ Inspector Name (printed) _____

4.4.1.8 Example Schematic

Figure 4-58. Schematic of an Organic Filter

(Source: Center for Watershed Protection)



4.4.1.9 References

AMEC. *Metropolitan Nashville and Davidson County Stormwater Management Manual, Volume 4 Best Management Practices*. 2006.

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4.4.1.10 Suggested Reading

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