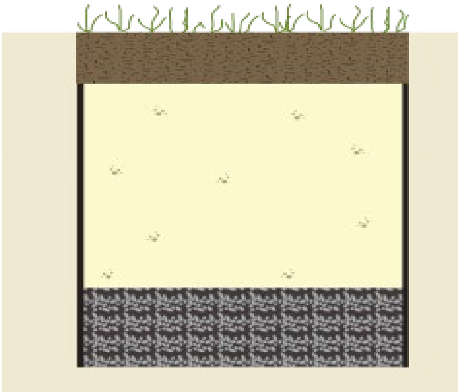
9.9 SMALL-SCALE SAND FILTERS (GI)



Small-scale sand filters are stormwater management systems designed to maximize the removal of pollutants from stormwater runoff. A small-scale sand filter consists of a pre-treatment zone and a treatment zone, which includes the sand bed as the filter media and its underlying materials. Pollutants are treated through settling, filtration and adsorption by the sand bed prior to discharging stormwater runoff by infiltration into the subsoil. The total suspended solids (TSS) removal rate is 80%.

N.J.A.C. 7:8 Stormwater Management Rules – Applicable Design and Performance Standards		
	Green Infrastructure	Yes
	Stormwater Runoff Quantity	Yes, when designed as an on-line system
	Groundwater Recharge	Yes
	Stormwater Runoff Quality	80% TSS

Stormwater Runoff Quality Mechanisms and Corresponding Criteria	
Settling	
Storage Volume	Entire Water Quality Design Storm Volume
Filtration	
Maximum Contributory Drainage Area	2.5 acres
Maximum Design Storm Drain Time	72 hours, using slowest design permeability rate
Sand bed minimum thickness	18 inches
Maximum storage above sand bed	24 inches
Maximum design permeability rate of sand bed	2 inches/hour
Minimum topsoil permeability rate, if using optional vegetative cover	2x the permeability of the subsoil

Introduction

A small-scale sand filter is a stormwater management facility that uses sand to filter particles and particle-bound constituents from stormwater runoff. Pollutant removal occurs in the sand bed. Although there are two types of small-scale sand filter systems: infiltration sand filters and underdrained sand filters, **the underdrained type does not meet the definition of green infrastructure, i.e., treating stormwater runoff through infiltration into the subsoil, treating stormwater runoff through filtration by vegetation or soil or storing stormwater runoff for reuse, and is not included in this chapter**. Stormwater runoff entering the small-scale sand filter is first conveyed through the pretreatment zone where trash, debris and coarse sediment are removed. It then passes through the treatment zone and out of the system through the subsoil via infiltration. Pollutants in stormwater runoff are treated in small-scale sand filters through the processes of settling, filtration and adsorption.

Due to the potential for groundwater contamination, the use of small-scale sand filters designed to infiltrate into the subsoil, and all stormwater infiltration best management practices (BMP), is prohibited in areas where high pollutant or sediment loading is anticipated. For more information regarding areas where stormwater runoff infiltration is prohibited, refer to N.J.A.C. 7:8-5.4(b)3.

Small-scale sand filters are better suited for impervious drainage areas with high TSS, heavy metals and hydrocarbon loadings such as roads, driveways, drive-up lanes, parking lots and urban areas. They are not recommended for use in pervious drainage areas where high sediment loads and organic material can clog the sand bed; where such loadings cannot be avoided, pretreatment is recommended.

Small-scale sand filters function similarly to larger sand filters; however, because small-scale sand filters are smaller and may vary widely in shape, they are more easily incorporated into the design of sites with limited space. This flexibility allows small-scale sand filters to be used in various locations. Because small-scale sand filters are intended to treat stormwater runoff close to its source, the maximum contributory inflow drainage area is 2.5 acres.

Small-scale sand filters must have a maintenance plan and must be reflected in a deed notice recorded in the county clerk's office to prevent alteration or removal.

Applications

Pursuant to N.J.A.C. 7:8-5.2(a)(2), the minimum design and performance standards for groundwater recharge, stormwater runoff quality and stormwater runoff quantity at N.J.A.C. 7:8-5.4, 5.5 and 5.6 shall be met by incorporating green infrastructure in accordance with N.J.A.C. 7:8-5.3.

Small-scale sand filters may be designed to convey storm events larger than the Water Quality Design Storm (WQDS); however, regardless of the design storm chosen, all small-scale sand filters must be designed for stability and capacity in accordance with the *Standards for Soil Erosion and Sediment Control in New Jersey*, as required by N.J.A.C. 7:8 Stormwater Management rules.

Small-scale sand filter systems, since they must be designed to infiltrate into the subsoil, may be used to meet the groundwater recharge requirements. For more information on computing ground water recharge, see *Chapter 6: Groundwater Recharge.*

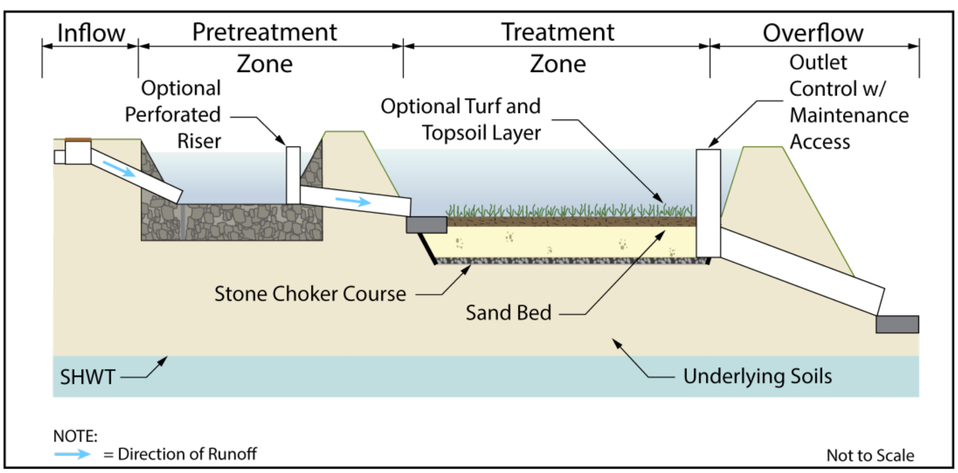
To merit the approved TSS removal rate of 80%, small-scale sand filters must be designed to treat the WQDS and in accordance with all of the following criteria.

Design Criteria

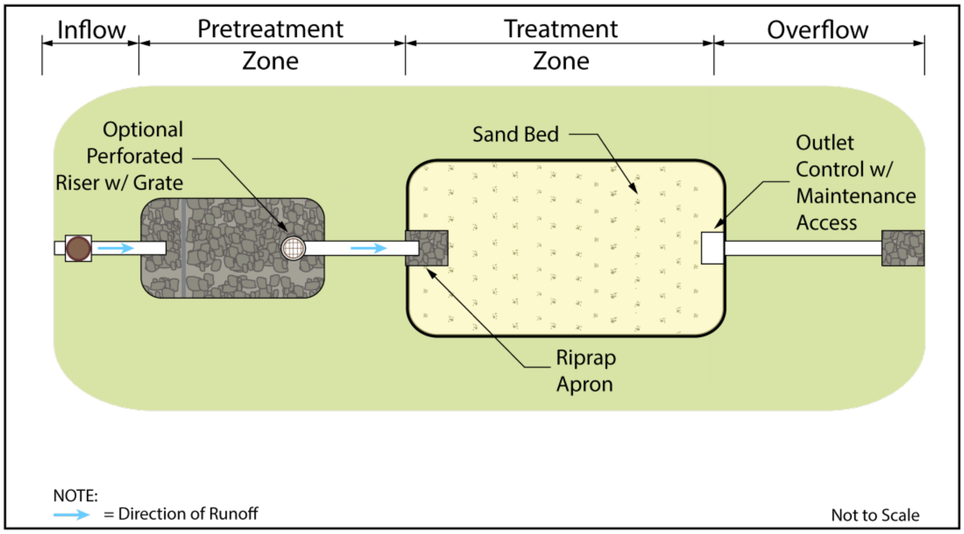
Basic Requirements

The following illustrations depict the basic components and the various zones through which stormwater runoff travels.

Profile View – Small-Scale Sand Filter Basics



Plan View – Small-Scale Sand Filter Basics



The following design criteria must all be met in order to receive the 80% TSS removal rate for this BMP. It is critical that all small-scale sand filters are designed in accordance with these criteria in order to ensure proper operation, to maximize the functional life of the system and to ensure public safety.

Contributory Drainage Area

- Pursuant to N.J.A.C. 7:8-5.3(b), the maximum contributory drainage area to a small-scale sand filter is 2.5 acres.
- The entire contributory drainage area must be completely stabilized prior to use of the small-scale sand filter.

Pretreatment

Pretreatment is required for all small-scale sand filters to extend the functional life and increase the pollutant removal capability of a small-scale sand filter by reducing incoming velocities and capturing coarser sediments.

- Pretreatment is a requirement for all small-scale sand filters.
- Any roof runoff may be pretreated by leaf screens, first flush diverters or roof washers. For details of these pretreatment measures, see Pages 5 and 6 of *Chapter 9.1: Cisterns.*
    - This pretreatment requirement for roof runoff can be waived by the review agency if the building in question has no potential for debris and other vegetative material to be present in the roof runoff. For example, a building that is significantly taller than any surrounding trees and does not have vegetative roof should not need the pretreatment. However, in making this determination, the review agency must consider the mature height of any surrounding trees.
- Pretreatment may consist of a forebay or any of the BMPs found in *Chapters 9 or 11.*

- There is no adopted TSS removal rate associated with forebays; therefore, their inclusion in any design should be solely for the purpose of facilitating maintenance. Forebays can be earthen, constructed of riprap, or made of concrete, and must comply with the following requirements:
    - The forebay must be designed to prevent scour of the receiving basin by outflow from the forebay.
    - The forebay should provide a minimum storage volume of 10% of the Water Quality Design Storm (WQDS) and be sized to hold the sediment volume expected between clean-outs.
    - It should fully drain within nine hours in order to facilitate maintenance and to prevent mosquito issues. Under no circumstances should there be any standing water in the forebay 72 hours after a precipitation event.
    - Surface forebays must meet or exceed the sizing for preformed scour holes in the *Standard for Conduit Outlet Protection* in the *Standards for Soil Erosion and Sediment Control in New Jersey* for a surface forebay.
    - If a concrete forebay is utilized, it must have at least two weep holes to facilitate low level drainage.
    - The recommended Minimum surface area (sf) = 59 X Inflow (cfs).

- When using another BMP for pretreatment, it must be designed in accordance with the design requirements outlined in the respective chapter. For additional information on the design requirements of each BMP, refer to the appropriate chapter in this manual.

Inflow

- All inflow must be stable and non-erosive and must be consistent with the applicable subchapters of the *Standards for Soil Erosion and Sediment Control in New Jersey,* such as the *Standard for Conduit Outlet Protection*.

Geometry

- Small-scale sand filters may not be constructed in areas where the surrounding slopes are 15% or greater.

- The area of the sand filter intended for infiltration must be as level as possible in order to uniformly distribute runoff infiltration over the subsoil.

- The system must have a sufficient surface area to prevent the accumulated volume of stormwater runoff exceeding the maximum depth requirement.

- The seasonal high water table (SHWT) or bedrock must be at least 2 feet below the bottom of the sand layer.

Placement of Riprap

- The use of riprap in these systems should be limited to the area directly under the inflow. The use of riprap is to dissipate energy from the inflow of stormwater and thereby prevent scouring of the receiving sand.

Sand Bed

The thickness and character of the bed must provide adequate pollutant removal.

- Minimum thickness: 18 inches.
- Maximum depth of runoff generated by the WQDS above the sand bed: 24 inches.
- The sand must meet the specifications for clean, medium-aggregate concrete sand in accordance with AASHTO M-6 or ASTM C-33, as certified by a professional engineer licensed in the State of New Jersey.
- Filter fabric is required along the sides of the sand bed to prevent the migration of fines from the surrounding soil into the sand bed. However, filter fabric may not be used between the sand bed and the stone choker course, described below, because it may cause a layer of fines to collect resulting in a loss of permeability.
- The maximum design permeability rate of the sand bed is 2 inches/hour and must be verified prior to installation.
- When using the 2 in/hr design permeability rate, a design drain time of 36 hours must be used.

Stone Choker Course

- This layer must be between 1 and 2 inches.
- The stone in this layer must meet the specifications for clean, coarse aggregate in accordance with AASHTO No. 57.

Storage Volume

- The system must have sufficient storage volume to contain the WQDS runoff volume without overflow.
- Small-scale sand filters are generally constructed as off-line systems, in which most or all of the stormwater runoff from storms larger than the WQDS bypass the filter media through an upstream diversion; this reduces the size of the required storage volume, the sand's long-term pollutant loading, associated maintenance and the threat of erosion and scour caused by larger storm inflows. Small-scale sand filters, however, may also be constructed as on-line systems. On-line small-scale sand filters receive upstream stormwater runoff from all storm events; they provide treatment for the WQDS, and they convey the runoff from larger storms through an overflow. These on-line systems store and attenuate the larger storm events and provide runoff quantity control; in such systems, the invert of the lowest quantity control outlet is set at or above the maximum water surface elevation of the WQDS.
- Small-scale sand filters must contain only the WQDS or smaller storm events below the first outlet control structure.
- Exfiltration can be used in the design of a small-scale sand filter, provided all of the conditions regarding the use of exfiltration in stormwater runoff calculations, as published in *Chapter 5: Stormwater Management Quantity and Quality Standards and Computations* are met. This

information is published in the section beginning on Page 8 of *Chapter 5*, entitled "*Conditions Regarding the Use of Exfiltration in Stormwater Runoff Calculations*."

- Small-scale sand filters are intended to be free of standing water between storm events in order to allow for sufficient storage for the next rain event; therefore, the drain time for standing water present on the surface of the bottom or in the overflow structure must not exceed 72 hours after any rain event. Storage times in excess of 72 hours may render a small-scale sand filter ineffective and may result in anaerobic conditions, odor, and both water quality and mosquito breeding issues. If the small-scale sand filter is installed in an area subject to pedestrian traffic, such as sidewalk or pedestrian accessible area in parking lot, the drain time should be reduced to 24 hours.

Permeability

The following specifications apply to the permeability rates of the sand bed, the stone choker course, the subsoil and the topsoil in systems designed with the optional vegetative cover.

- The testing of all permeability rates must be consistent with *Chapter 12: Soil Testing Criteria* in this manual.
- The permeability rate of the topsoil, if using the optional vegetated surface, must be twice the design permeability rate of the subsoil.

Routing of Larger Storms through a Small-Scale Sand Filter

While the storage volume cannot be calculated using the 10- or 100-year storm, the routings for the stormwater runoff quantity standard can utilize the exfiltration from a small-scale sand filter, provided all of the conditions regarding the use of exfiltration in stormwater runoff calculations, as published in *Chapter 5,* are met. This information is published in the section beginning on Page 8 of *Chapter 5*. The pretreatment requirements outlined under *Pretreatment*, which begins on Page 4, must be followed.

Groundwater Mounding Impacts

- As with any infiltration BMP, groundwater mounding impacts must be assessed, as required by N.J.A.C. 7:8-5.2(h). This includes an analysis of the reduction in permeability rate when groundwater mounding is present.
- Exfiltration shall be used in the groundwater mounding analysis. The design soil permeability rate, also referred to herein as the design vertical hydraulic conductivity, of the most hydraulically restrictive soil horizon below an infiltration type BMP, may be used as the exfiltration rate in the routing calculations only when the soil is tested strictly in accordance with *Chapter 12*.
    - Additional trials may be required, including using a reduced recharge rate in accordance with the method published in *Chapter 5: Stormwater Management Quantity and Quality Standards and Computations*, should the calculations demonstrate an adverse impact is produced. Refer to the information labeled "*Steps to Follow When an Adverse Impact is Encountered*" found on Page 56 of *Chapter 5*.

- □ Where the mounding analysis identifies adverse impacts, the small-scale sand filter must be redesigned, the routing run again and another groundwater mounding analysis performed for the redesign. The mounding analysis must provide details and supporting documentation on the methods used and assumptions made, including values used in calculations. For further information on the required groundwater mounding assessment, *see Chapter 13: Groundwater Table Hydraulic Impact Assessments for Infiltration BMPs*.

Drain Time

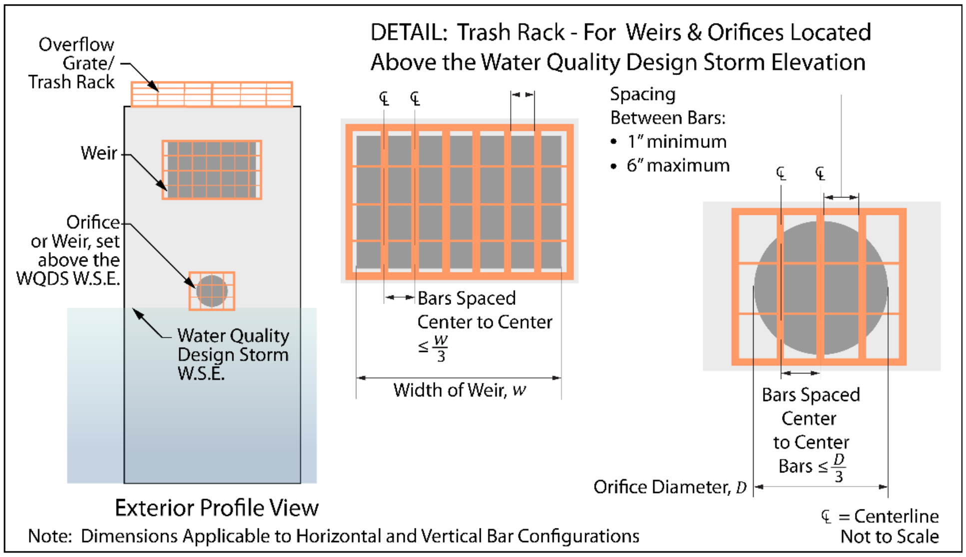
- The drain time is determined by the permeability of the sand bed, the permeability of any additional materials above it and the hydraulic conductivity of the most restrictive layer in the subsoil.
- However, when sizing an infiltration small-scale sand filter, both the permeability of the subsoil and the permeability of the sand bed must be considered, and the more restrictive permeability rate of the two layers must be used in sizing calculations.

Safety

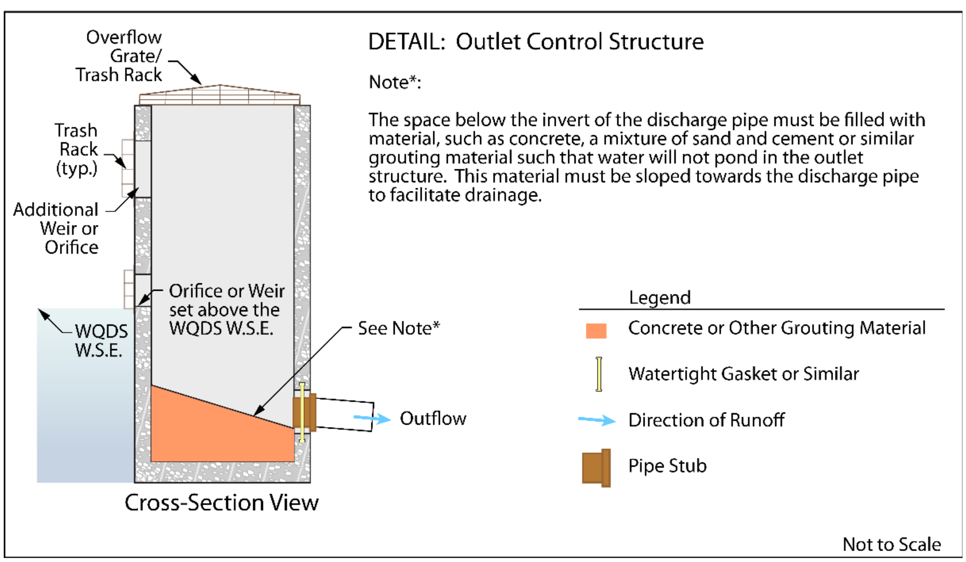
- All small-scale sand filters must be designed to safely convey overflows to down-gradient drainage systems. The design of the overflow structure must be sufficient to provide safe, stable discharge of stormwater runoff in the event of an overflow. Safe and stable discharge minimizes the possibility of erosion and flooding in down-gradient areas. Therefore, discharge in the event of an overflow must be consistent with the current version of *Standards for Off-Site Stability* found in the *Standards for Soil Erosion and Sediment Control in New Jersey,* as required by N.J.A.C. 7:8. Small scale sand filters that are classified as dams under the NJDEP Dam Safety Standards at N.J.A.C. 7:20 must meet the overflow requirements under these regulations. Overflow capacity can be provided by a hydraulic structure, such as a weir or orifice, or a surface feature, such as a swale or open channel as site conditions allow.

Outlet Structure

- For systems designed with an outlet structure, trash racks must be installed at the intake to the outlet structure. They must also be designed to avoid acting as the hydraulic control for the system. They must meet the following criteria, as required by N.J.A.C. 7:8-5.2(i)2 and 6.2(a) and the detail on the following page illustrates these requirements:
  - □ Parallel bars spaced at 1-inch intervals, up to the elevation of the WQDS;
  - □ Minimum bar spacing: 1 inch, for elevations in excess of the WQDS;
  - □ Maximum bar spacing: 1/3 the diameter of the orifice or 1/3 the width of weir, with a maximum spacing of 6 inches, for elevations in excess of the WQDS;
  - □ Maximum average velocity of flow through clean rack: 2.5 feet/second, under full range of stage and discharge, computed on the basis of the net area of opening through rack;
  - □ Constructed of rigid, durable and corrosion-resistant material; and
  - □ Designed to withstand a perpendicular live loading of 300 lbs./sf.



- An overflow grate is designed to prevent obstruction of the overflow structure. If an outlet structure has an overflow grate, the grate must comply with the following requirements:
  - The overflow grate must be secured to the outlet structure but removable for emergencies and maintenance;
  - The overflow grate spacing must be no greater than 2 inches across the smallest dimension; and
  - The overflow grate must be constructed of rigid, durable and corrosion resistant material and designed to withstand a perpendicular live loading of 300 lbs./sf.
- The space below the invert of the discharge pipe must be filled with material, such as concrete, a mixture of sand and cement, or similar grouting material, such that water will not pond in the outlet structure. This material must be sloped towards the discharge pipe to facilitate drainage, as shown in the detail below.



- Any flow control device, such as an orifice, weir, grate or perforated pipe, at the outlet of the stormwater management measures shall be designed to prevent the clogging of the flow control device while achieving the design and performance standards at N.J.A.C. 7:8-5.4, 5.5 and 5.6.

- Blind connections to down-gradient facilities are prohibited. Any connection to down-gradient stormwater management facilities must include access points such as inspections ports and manholes, for visual inspection and maintenance, as appropriate, to prevent blockage of flow and ensure operation as intended. All entrance points must adhere to all State, County and municipal safety standards such as those for confined space entry.

- In instances where the lowest invert in the outlet or overflow structure is below the flood hazard area design flood or tide elevation in a down-gradient waterway or stormwater collection system, the effects of tailwater on the hydraulic design of the overflow systems, as well as any stormwater quantity control outlets must be analyzed. Two methods to analyze tailwater are:

  - A simple method entails inputting flood elevations for the 2-, 10- and 100-year events as static tailwater during routing calculations for each storm event. These flood elevations are either obtained from a Department flood hazard area delineation or a FEMA flood hazard area delineation that includes the 100-year flood elevation or derived using a combination of NRCS hydrologic methodology and a standard step backwater analysis or level pool routing, where applicable. In areas where the 2-year or 10-year flood elevation does not exist in a FEMA or Department delineation, it may be interpolated or extrapolated from the existing data. If this method demonstrates that the requirements of the regulations are met with the tailwater effect, then the design is acceptable. If the analysis shows that the requirements are not met with the tailwater effects, the detailed method below can be used or the BMP must be redesigned.
  - A detailed method entails the calculation of hydrographs for the watercourse during the 2-, 10-, and 100-year events using NRCS hydrologic methodology. These hydrographs are input into a computer program to calculate rating curves for each event. Those rating curves are then input as a dynamic tailwater during the routing calculations for each of the 2-, 10- and 100-year events. This method may be used in all circumstances; however, it may require more advanced computer programs. If this method demonstrates that the requirements of the regulations are met with the tailwater effect, then the design is acceptable. If the analysis shows that the requirements are not met with the tailwater effects, the BMP must be redesigned.

Construction Requirements

- The use of the small-scale sand filter system for sediment control during construction is discouraged; however, when unavoidable, excavation for the sediment basin should be at least 2 feet above the final design elevation of the basin bottom.

- Basin excavation and sand placement should be performed with equipment placed outside of the basin bottom whenever possible. However, in circumstances where this is unavoidable, light earth moving equipment with oversized tires or tracks should be utilized.

- The excavation for the small-scale sand filter bottom should only occur after all construction within its contributory drainage area is completed and the contributory drainage area is stabilized. If construction of the small-scale sand filter cannot be delayed, berms should be placed around the perimeter of the sand filter during all phases of construction, diverting all flows away from the filter. The berms should not be removed until all construction within the contributory drainage area is completed and the area is stabilized.

- Once the excavation is completed, the floor of the small-scale sand filter must be deeply tilled with a rotary tiller or disc harrow and smoothed over with a leveling drag, or equivalent grading equipment.

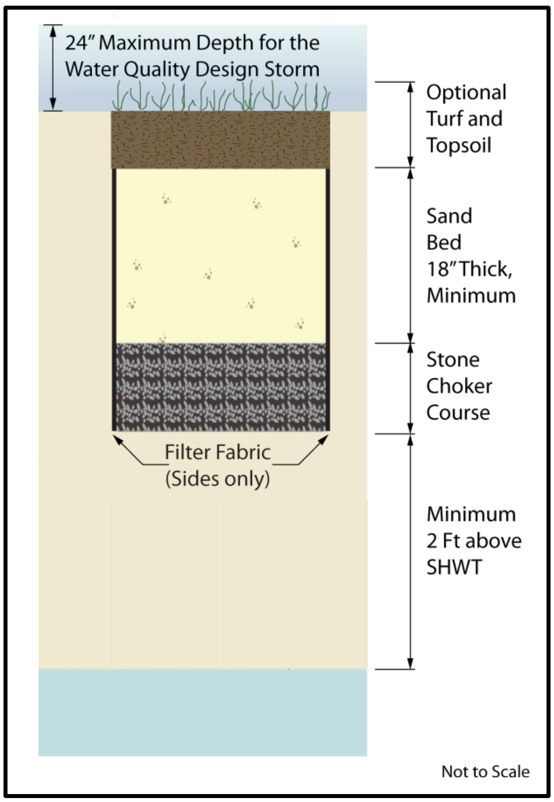
- Once both the small-scale sand filter and its contributory drainage area are stabilized, the infiltration rate of the sand bed must be retested to ensure that the design permeability rate is the same as the as-built permeability rate.

- Post-construction testing of the system must be performed on the as-built small-scale sand filter in accordance with the *Construction and Post-Construction Oversight and Soil Permeability Testing* section in *Chapter 12* of this manual.

- Once construction is complete, the permeability rate of the subsoil below the small-scale sand filter must be retested to ensure that the subsoil was not compacted during construction.

The following cross-section view provides another view of a small-scale sand filter.

Cross Section View – Small-Scale Sand Filter



Requirements for the Detention Option

A small-scale sand filter may be constructed as part of an on-line, combination system to provide detention for larger storms. Such a system could include a level-graded infiltration zone such as that defined by a smaller contour, oval or other discrete area within the basin bottom. Runoff up to the WQDS water surface elevation is temporarily stored and exits the system through infiltration into the subsoil. Runoff in excess of this elevation exits the system through various quantity control devices in the outlet structure. Keep in mind that too small of an infiltration zone is likely to experience groundwater mounding impacts, as discussed in *Chapter 13*.

- Small-scale sand filters with the detention option may be designed to treat and temporarily store stormwater runoff produced by both small storms, such as the WQDS, and larger storms such as the 2-, 10- and 100-year design storms.
- Exfiltration can be used in the design of a small-scale sand filter designed to provide detention for stormwater runoff quantity control, provided all of the conditions regarding the use of exfiltration in stormwater runoff calculations published in *Chapter 5* are met. This information is published in the section beginning on Page 8 of *Chapter 5*, entitled "*Conditions Regarding the Use of Exfiltration in Stormwater Runoff Calculations*."

Designing A Small-Scale Sand Filter

The example below illustrates how to design a small-scale sand filter to treat the stormwater runoff generated by the WQDS. The following parameters apply:

Area =	1 acre
CN Value =	98 (100% Impervious)
Calculated WQDS Runoff Volume =	3,755 cf
Forebay Primary Outflow:	Perforated Riser Pipe
Forebay Secondary Outflow:	Broad-crested Weir
Sand Bed Permeability Rate =	2 inches/hour
Subsoil Permeability Rate =	8 inches/hour
Forebay Surface Elevation =	1.10 ft
Sand Bed Surface Elevation =	0.00 ft
Assumed Depth of Stormwater Runoff to be infiltrated =	1 ft above the small-scale sand filter surface

Step 1: Forebay Sizing

The forebay must be sized to hold 10% of the WQDS volume. Assuming the depth of stormwater runoff in the forebay is equal to the depth of the WQDS in the surface of the small-scale sand filter system, which is assumed to be 1 ft, a rectangular forebay with a width of 20 ft and a length of 20 ft will provide adequate storage volume. However, in order to facilitate drainage, the water surface elevation in the forebay must be greater than the water surface elevation in the small-scale sand filter; in addition, the perforations in the riser pipe must be designed to ensure that the forebay will drain within 9 hours.

In this example, the WQDS water surface elevation (W.S.E.) in the forebay is 2.15 ft; this translates to a depth of 1.05 ft, with the additional 0.05 ft of depth resulting from head loss in the riser pipe. Based on the above elevations, the top of the riser pipe is set at an elevation of 2.20 ft. A grate or trash rack must be installed on the top of the riser to keep floatables from entering the riser pipe during large storm events.

Step 2: Small-Scale Sand Filter Sizing

When designing a small-scale sand filter, the permeability of the subsoil can affect the design permeability of the entire system; as previously stated, the maximum design permeability of any small-scale sand filter system is 10 in/hr and the maximum permeability of the sand bed, for the purpose of calculations, is 2 in/hr. In this example, the tested subsoil permeability rate is 8 in/hr and the design subsoil permeability rate is therefore 4 in/hr. The design subsoil permeability rate is used as the exfiltration rate in the routing calculation. By trial and error, the sand bed area is 1,520 sf and the highest depth of stormwater runoff collected in the system during the WQDS is 1.98 ft. The invert of the orifice of the riser can be set at 1.98 ft above the sand bed. A summary report and routing table excerpt from modelling software is provided below and on the following page.

Summary Report:

Inflow Area = 43,560 sf,100.00% Impervious, Inflow Depth = 1.03"
Inflow = 2.90 cfs @ 1.09 hrs, Volume= 3,755 cf
Outflow = 0.14 cfs @ 1.89 hrs, Volume= 3,755 cf, Atten= 95%, Lag= 47.6 min
Discarded = 0.14 cfs @ 0.70 hrs, Volume= 3,755 cf
Primary = 0.00 cfs @ 1.89 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 1.98' @ 1.88 hrs Surf.Area= 1,520 sf Storage= 3,013 cf

Plug-Flow detention time= 186.7 min calculated for 3,755 cf (100% of inflow)
Center-of-Mass det. time= 186.6 min (256.9 - 70.3)

Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	6,080 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
0.00	1,520	0	0
4.00	1,520	6,080	6,080

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**4.00 in/hr Exfiltration over Surface area**
#2	Primary	1.98'	**4.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.14 cfs @ 0.70 hrs HW=0.04' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.14 cfs)

Primary OutFlow Max=0.00 cfs @ 1.89 hrs HW=1.98' (Free Discharge)
└**2=Orifice/Grate** (Weir Controls 0.00 cfs @ 0.13 fps)

Source: HydroCAD® Summary Report; HydroCAD is a register trademark of HydroCAD Software Solutions LLC. Used with permission.

WQDS Routing Table Excerpt:

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)	Discarded (cfs)	Primary (cfs)
0.00	0.00	0	0.00	0.00	0.00	0.00
0.10	0.00	0	0.00	0.00	0.00	0.00
0.20	0.00	0	0.00	0.00	0.00	0.00
0.30	0.00	0	0.00	0.00	0.00	0.00
0.40	0.02	1	0.00	0.00	0.00	0.00
0.50	0.07	12	0.01	0.03	0.03	0.00
0.60	0.15	33	0.02	0.08	0.08	0.00
0.70	0.22	62	0.04	0.14	**0.14**	0.00
0.80	0.30	102	0.07	0.14	0.14	0.00
0.90	0.63	211	0.14	0.14	0.14	0.00
1.00	1.84	558	0.37	0.14	0.14	0.00
1.10	**2.89**	1,403	0.92	0.14	0.14	0.00
1.20	1.60	2,197	1.45	0.14	0.14	0.00
1.30	0.76	2,552	1.68	0.14	0.14	0.00
1.40	0.44	2,705	1.78	0.14	0.14	0.00
1.50	0.39	2,801	1.84	0.14	0.14	0.00
1.60	0.33	2,883	1.90	0.14	0.14	0.00
1.70	0.30	2,944	1.94	0.14	0.14	0.00
1.80	0.26	2,997	1.97	0.14	0.14	0.00
1.90	0.12	**3,012**	**1.98**	**0.14**	0.14	**0.00**
2.00	0.10	3,000	1.97	0.14	0.14	0.00
2.10	0.04	2,977	1.96	0.14	0.14	0.00
2.20	0.00	2,931	1.93	0.14	0.14	0.00
2.30	0.00	2,881	1.90	0.14	0.14	0.00
2.40	0.00	2,830	1.86	0.14	0.14	0.00

Source: HydroCAD® Output; HydroCAD is a registered trademark of HydroCAD Soft-ware Solutions LLC. Used with permission.

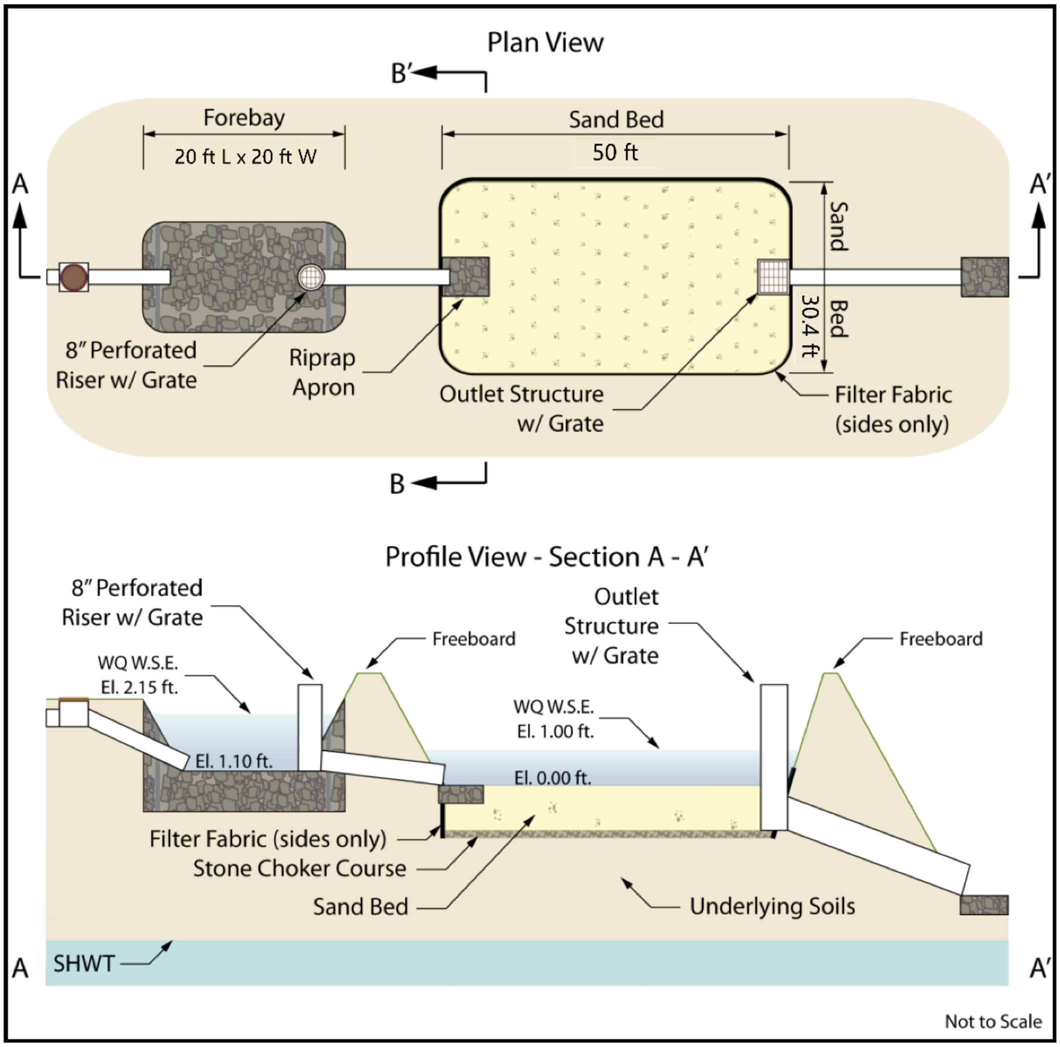
Step 3: Check the drain time

$$Drain\ Time = \frac{WQDS\ Runoff\ Volume}{System\ Infiltration\ Area\ x\ Subsoil\ Design\ Permeability\ Rate}$$

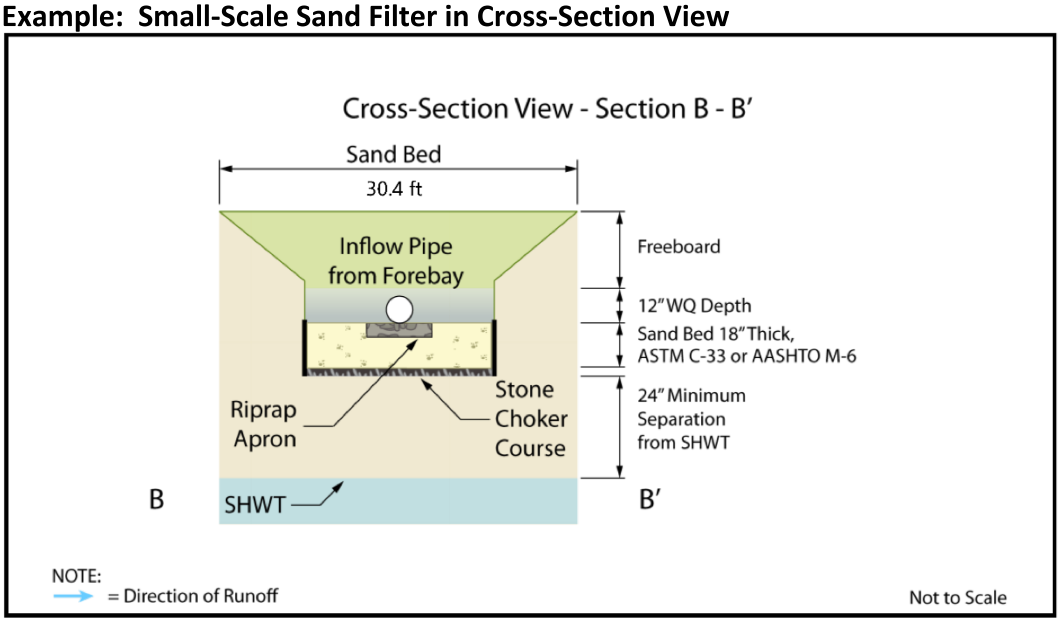
$$= \frac{3{,}755\ cf}{(1{,}520\ sf\ x\ 4\ in/hr\ x\ 1\ ft/12\ in)} = 7.41\text{ hr}$$

The resulting surface area could be achieved with a 50 ft by 30.4 ft sand bed. Illustrations for this example are shown on the following page.

Example: Small-Scale Sand Filter in Plan and Profile Views



Example: Small-Scale Sand Filter in Cross-Section View



Considerations

When planning a small-scale sand filter, consideration should be given to soil characteristics, depth to the groundwater table, sensitivity of the region and inflow water quality. It is also important to note that the use of small-scale sand filters is recommended in this manual only where the WQDS or smaller storm events are contained below the first outlet control structure. Use of these basins to store larger volumes below the first outlet control structure should only be considered when another applicable rule or regulation requires the infiltration of a larger storm event. In such a case, the small-scale sand filter should be designed to store the minimum storm event required to address that rule or regulation, below the first outlet control structure.

In addition to the prohibition of recharge in the areas with high pollutant loading or with runoff exposed to source material as defined in N.J.A.C. 7:8-5.4(b)3, the utilization of small-scale sand filters should consider the impact of infiltration on subsurface sewage disposal systems, water supply wells, groundwater recharge areas protected under the Ground Water Quality Standards rules at N.J.A.C 7:9C, streams under antidegradation protection by the Surface Water Quality Standards rules at N.J.A.C. 7:9B, or similar facilities or areas geologically and ecologically sensitive to pollutants or hydrological changes. Furthermore, the location and minimum distance of the small-scale sand filter from other facilities or systems shall also comply with all applicable laws and rules adopted by Federal, State and local government entities.

Optional Vegetative Cover

- Vegetation may only be turf grass.
- The permeability rate of the topsoil, if using the optional vegetated surface, must be twice the design permeability rate of the subsoil.

Maintenance

Regular and effective maintenance is crucial to ensure effective small-scale sand filter performance; in addition, maintenance plans are required for all stormwater management facilities associated with a major development. There are a number of required elements in all maintenance plans, pursuant to N.J.A.C. 7:8-5.8; these are discussed in more detail in *Chapter 8: Maintenance of Stormwater Management Measures*. Furthermore, maintenance activities are required through various regulations, including the New Jersey Pollutant Discharge Elimination System (NJPDES) Rules, N.J.A.C. 7:14A. Specific maintenance requirements for small-scale sand filter systems are presented below; these requirements must be included in the small-scale sand filter's maintenance plan. Detailed inspection and maintenance logs must be maintained.

General Maintenance

- All structural components must be inspected, at least once annually, for cracking, subsidence, spalling, erosion and deterioration.
- Components expected to receive and/or trap debris and sediment must be inspected for clogging at least twice annually, as well as after every storm exceeding 1 inch of rainfall.
- Sediment removal should take place when all stormwater runoff has drained from the sand bed and the sand bed is dry.
- Disposal of debris, trash, sediment and other waste material must be done at suitable disposal/recycling sites and in compliance with all applicable local, state and federal waste regulations.
- A detailed, written log of all preventative and corrective maintenance performed on the small-scale sand filter, including a record of all inspections and copies of maintenance-related work orders. Additional maintenance guidance can be found at:

  https://dep.nj.gov/stormwater/maintenance-guidance/.
- Access points for maintenance are required on all enclosed areas within small-scale sand filter; these access points must be clearly identified in the maintenance plan. In addition, any special training required for maintenance personnel to perform specific tasks, e.g., confined space entry, must be included in the plan.
- Stormwater BMPs may not be used for stockpiling of plowed snow and ice, compost, or any other material.

Vegetated Areas

- In small-scale sand filter systems with vegetated surfaces, bi-weekly inspections are required when establishing/restoring vegetation.
- A minimum of one inspection during the growing season and one inspection during the non-growing season is required to ensure the health, density and diversity of the vegetation.

- Mowing/trimming of vegetation must be performed on a regular schedule based on specific site conditions; perimeter grass must be mowed at least once a month during growing season.
- Vegetative cover must be maintained at 85%; damage must be addressed through replanting in accordance with the original specifications.
- Vegetated areas must be inspected at least once annually for erosion, scour and unwanted growth; any unwanted growth must be removed with minimum disruption to the remaining vegetation.
- All use of fertilizers, pesticides, mechanical treatments and other means to ensure optimum vegetation health must not compromise the intended purpose of the small-scale sand filter.

Drain Time

- The sand bed must be inspected at least twice annually to determine if the permeability of the bed has decreased.
- The approximate drain time for the maximum design stormwater runoff volume below the top of the sand bed must be indicated in the maintenance manual.
- If the actual drain time is significantly different from the design drain time, the components that could provide hydraulic control must be evaluated and appropriate measures taken to return the small-scale sand filter to minimum and maximum drain time requirements.
- If the small-scale sand filter fails to drain the WQDS within 72 hours, corrective action must be taken, up to and including the replacement of the upper layers of the sand bed. In addition, the anticipated frequency of this replacement must be indicated in the maintenance manual.

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