

DRAFT SAND FILTERS

Definition

A sand filter consists of a forebay and sand bed. Runoff entering the sand filter is conveyed first through the forebay, which removes trash, debris, and coarse sediment, and then through the sand bed to an outlet pipe. Sand filters use solids settling, filtering, and adsorption processes to reduce pollutant concentrations in stormwater.

The TSS removal rate for sand filters is 80 percent provided they are designed and maintained as specified below.

Purpose

Sand filters are normally used to remove relatively large amounts of sediments, metals, hydrocarbons, and floatables from stormwater runoff.

Conditions Where Practice Applies

Sand filters are normally used in highly impervious areas with relatively high TSS, heavy metal, and hydrocarbon loadings such as roads, driveways, drive-up lanes, parking lots, and urban areas. However, due to their relatively high sediment removal capabilities, sand filters are not generally recommended in pervious drainage areas where high coarse sediment loads and organic material such as leaves can quickly clog the sand bed. Where such loadings cannot be avoided, pretreatment is recommended. Since sand filters can be located underground, they can also be used in areas with limited surface space.

A sand filter must not be placed into operation until the contributing drainage area is completely stabilized. Therefore, system construction must either be delayed or upstream runoff diverted around the system until such stabilization is achieved. Such diversions must continue until stabilization is achieved. Additional information is provided in the Recommendations section below.

The elevation of the Seasonal High Water Table (SHWT) relative to the bottom of a sand filter system is critical to ensure proper functioning of the system. The SHWT shall be at least 1 foot below the bottom of a sand filter's underdrain system. For sand filters without underdrains, the SHWT shall be at least 2 foot below the bottom of the soil planting bed. In addition, it is important that the permeability of the existing subsoil below such bioretention systems is sufficient to convey the runoff passing through

the soil planting bed. See 6.6 *Infiltration Basins* for more information on the requirements and design of this type of sand filter.

A sand filter must have a maintenance plan and, if privately owned, should be protected by easement, deed restriction, ordinance, or other legal measures that prevent its neglect, adverse alteration, and removal.

Design Criteria

The basic design parameters for sand filters are its storage volume, the thickness, character, and permeability rate of the sand, and either the hydraulic capacity of its underdrain or the permeability of its subsoil (whichever is applicable). Sand filters can be designed as surface or subsurface sand filters. Subsurface sand filters must provide access points to the sediment forebay and to the sand layer for maintenance.

The system must have sufficient storage volume to contain the design storm runoff volume without overflow. The thickness and character of the bed itself must provide adequate pollutant removal, while the bed's permeability rate must be sufficient to drain the stored runoff within 72 hours. In addition, depending upon the type of sand filter system, either the capacity of the underdrain or the permeability of the existing subsoil must also be sufficient to allow the system to drain within 72 hours.

The surface of a sand filter may consist of the surface sand bed, vegetated, or armored above the sand. However, additional material above the sand bed must maintain the field permeability rate necessary for sand filter draindown time.

Details of these and other design parameters are presented below. The components of a typical sand filters are shown in Figure 6.9-1 and 6.9-2.

A. Storage Volume, Depth and Duration

Sand filters must be designed to treat the runoff volume generated by the stormwater quality design storm with a maximum elevation above the sand bed of two feet. Techniques to compute this volume are discussed in [Chapter XX: Computing Stormwater Runoff Rates and Volumes](#). The maximum time required to fully drain the stormwater quality design storm runoff volume is 72 hours. A design drain time of 36 hours must be used when designing the sand bed with a permeability rate of 2 inches per hour.

The bottom of a sand filter with an underdrain must be a minimum of 1 foot above the seasonal high groundwater table (SHWT). This includes the underdrain piping and gravel underdrain layer. For a sand filters without underdrains, the SHWT must be at least 2 foot below the bottom of the sand bed. All flows to the sand bed must be designed to prevent the scouring of the receiving sand

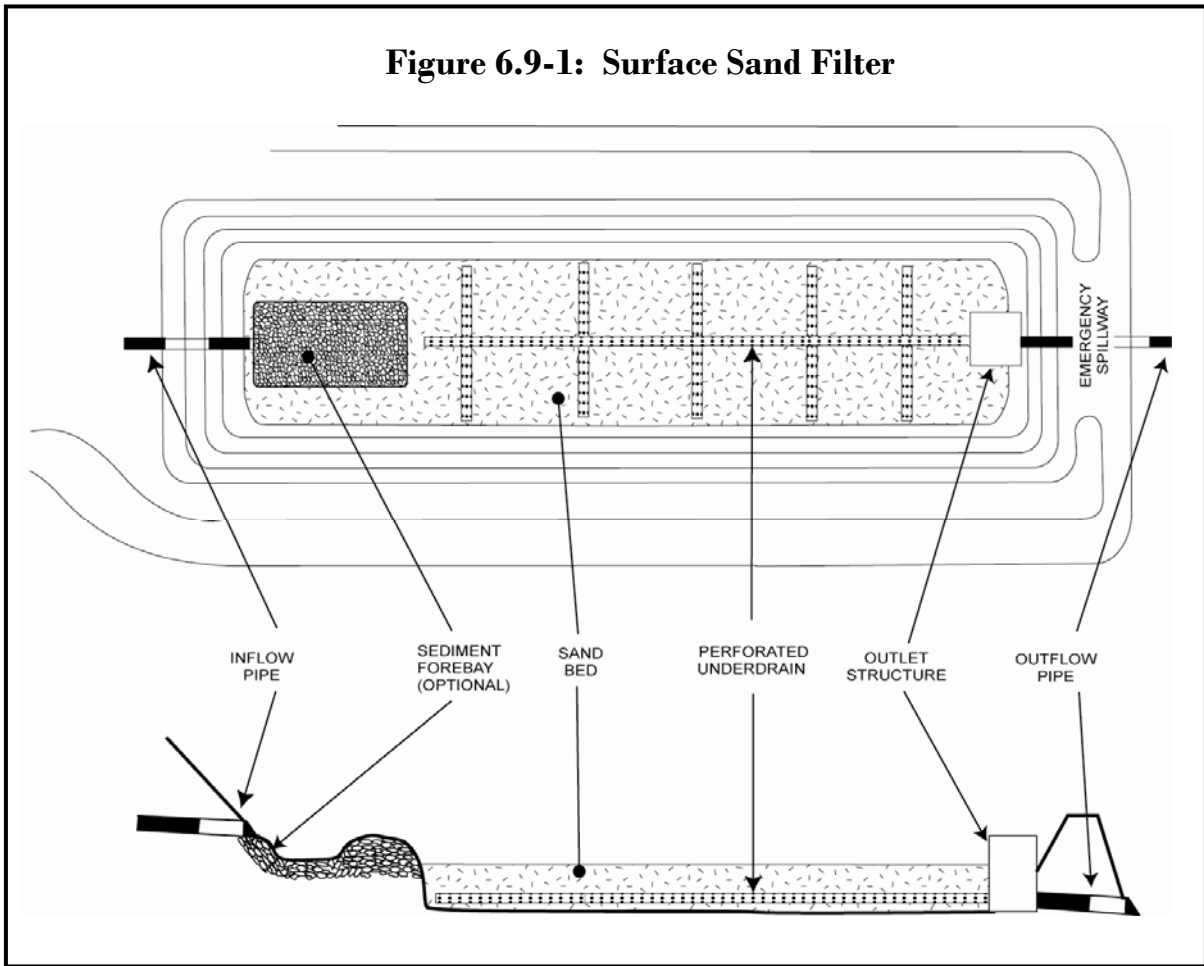
Note: While subsurface sand filters are recognized in this chapter for their ability to effectively remove TSS, such sand filters must incorporate access points for the maintenance of these devices. Maintenance plans must specify any specific training required for maintenance personnel to address specific tasks, and must include the method of sand replacement when there is a significant loss of permeability rate in the sand filters.

B. Permeability Rates

The water quality design storm runoff volume must fully drain through he sand bed, the gravel layer (and the for the existing subsoil below the sand bed for sand filters without underdrains) within 72 hours, based on the design permeability rate. For sand filter, a maximum design permeability rate of 2 inches

per hour shall be used for the sand bed. The permeability rate of the sand must be verified prior to installation. Since the actual permeability rate may vary from test results and may also decrease over time due to soil bed consolidation or the accumulation of sediments removed from the treated stormwater, a factor of safety of two shall be applied to the tested permeability rate to determine the design permeability rate. Therefore, if the tested permeability rate of the subsoil is 4 inches/hour, the design rate would be 2 inches/hour (i.e., 4 inches per hour/2). This design rate would then be used to compute the system’s stormwater quality design storm drain time.

Testing of all permeability rates must be performed in accordance with *Appendix E*. Post-construction testing must be performed on the as-built sand filter in accordance with *Appendix E. 4. Construction and Post-Construction Oversight and Soil Permeability Testing*. **The maximum allowable design permeability shall be 10 inches/hour for any permeability at 20 inches/hour or greater.**

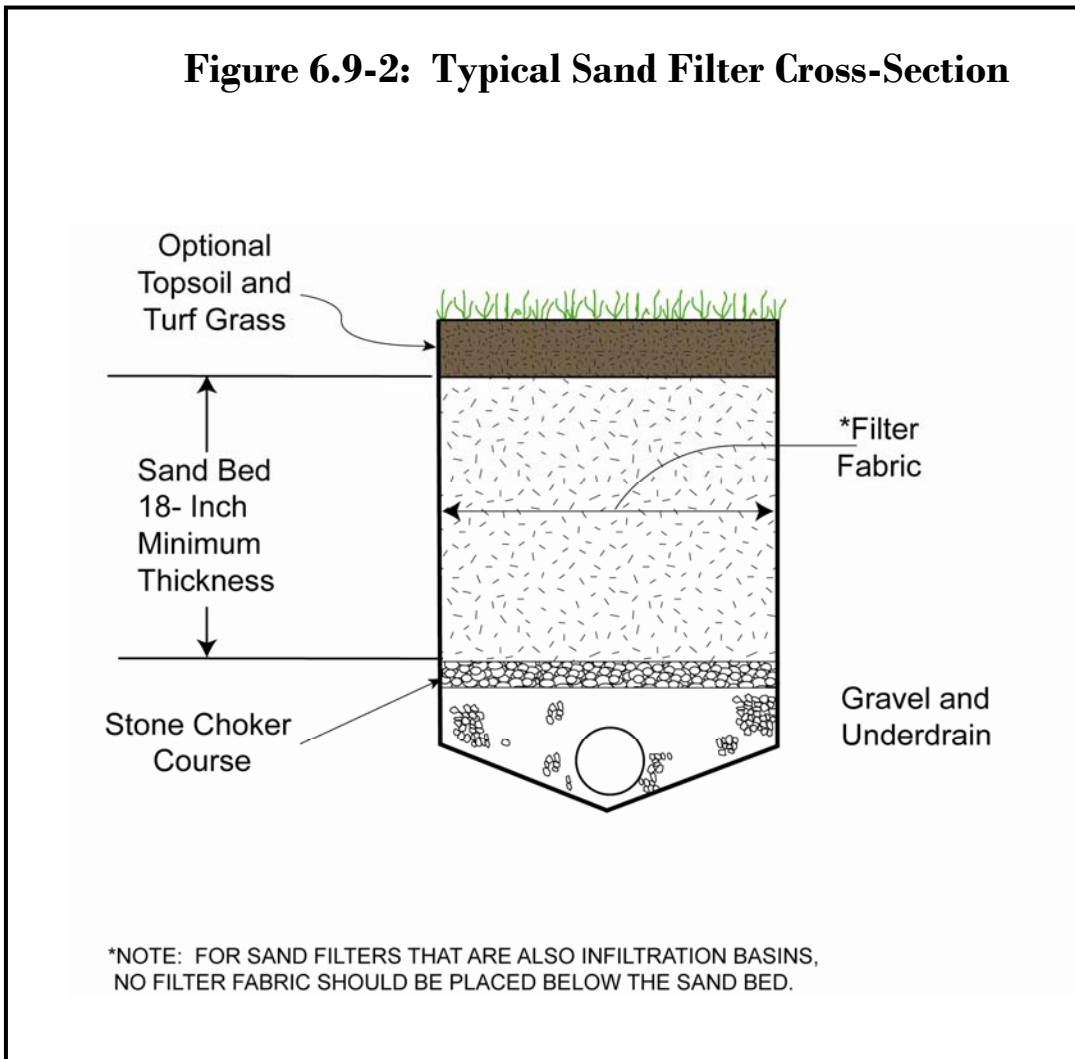


B. Sediment Forebay

Forebays are beneficial for all sand filters. All subsurface sand filters are required to have a sediment forebay to capture the gross pollutants and to reduce the maintenance frequency. Sediment forebay volumes must be a minimum of 10% of the total water quality volume. The minimum surface area of the forebay in square feet is provided by the following:

$$\text{Min Surface Area (sf)} = 59 * \text{Inflow in cfs}$$

The forebay must also be designed to allow all the forebay to drain within 9 hours from the end of the water quality design storm to facilitate sediment removal. 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.



C. Filter Bed Sand and Underdrain

A sand bed consisting of 18 inches of sand is required for all sand filters, as shown in Figure 6-9.2. The sand used in the sand bed must meet the specifications for clean medium aggregate concrete sand in accordance with AASHTO M-6 or ASTM C-33. This must be certified by a professional engineer licensed in the State of New Jersey. The area of the sand must be sufficient to fully drain the stormwater quality design storm runoff volume within 72 hours at maximum assumed field permeability rate of 4 inches/hour.

The gravel layer serves as bedding material and conveyance medium for the underdrain pipes. The underdrain piping must connect to a downstream location which is readily accessible for inspection and maintenance. To ensure proper system operation, the gravel layer and perforated underdrain piping must have infiltration rates and conveyance rates at least twice as fast as the design flows from the sand bed.

As with any vegetated BMP that relies on filtration through a media, the permeability rates of both the top soil must be a minimum of twice the design permeability rate for the infiltration basin.

F. Overflows

All sand filters must be able to safely convey overflows to downstream drainage systems. The capacity of the overflow must be consistent with the remainder of the site’s drainage system and sufficient to provide safe, stable discharge of stormwater in the event of an overflow. Sand filters that are classified as dams under the NJDEP Dam Safety Standards at N.J.A.C. 7:20 must also meet the overflow requirements of these Standards. 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 filter location and site conditions allow.

G. Tailwater

The hydraulic design of the underdrain and overflow systems, as well as any stormwater quantity control outlets, must consider any significant tailwater effects of downstream waterways or facilities. This includes instances where the lowest invert in the outlet or overflow structure is below the flood hazard area design flood or tide elevation in a downstream waterway or storm sewer system.

H. On-line and Off-line Systems

In general, most sand filters are constructed off-line. In off-line sand filters, most or all of the runoff from storms larger than the stormwater quality design storm bypass the filter through an upstream diversion. This not only reduces the size of the required filter overflow, but also reduces the filter’s long-term pollutant loading and associated maintenance and the threat of erosion and scour caused by larger storm inflows. However, sand filters may also be constructed on-line. On-line filters receive upstream runoff from all storms, providing runoff treatment for the stormwater quality design storm and conveying the runoff from larger storms through an overflow. Multi-purpose on-line filters also store and attenuate these larger storms to provide runoff quantity control. In such filters, the invert of the lowest quantity control outlet is set at or above the maximum water surface of the water quality design storm.

Maintenance

Effective sand filter performance requires regular and effective maintenance. **Chapter 8: Maintenance and Retrofit of Stormwater Management Practices** provides information and requirements for preparing a maintenance plan for stormwater management facilities, including sand filters. Specific maintenance requirements for sand filters are presented below. These requirements must be included in the filter’s maintenance plan.

A. General Maintenance

All sand filter components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least twice annually and as needed to ensure proper operation of the sand filter. Such components may include inlets and diversion structures, forebays, sand beds, and overflows.

Sediment removal should take place when all runoff has drained from the sand bed and the sand is reasonably dry. In addition, runoff should be drained or pumped from forebays with permanent pools before removing sediment. 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.

B. Vegetated Areas

In surface sand filters with turf grass bottom surfaces, mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass should be mowed at least once a month during the growing season. Vegetated areas must also be inspected at least annually for erosion and scour. The filter bottom must be inspected for unwanted underbrush and tree growth at least once a year.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density, and diversity should be performed during both the growing and non-growing season at least twice annually. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

All use of fertilizers, mechanical treatments, pesticides and other means to assure optimum vegetation health must not compromise the intended purpose of the sand filter. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

C. Structural Components

All structural components must be inspected for cracking, subsidence, spalling, erosion, and deterioration at least annually.

D. Other Maintenance Criteria

The maintenance plan must indicate the approximate time it would normally take to drain the maximum design storm runoff volume below the top of the filter’s sand bed and the anticipated frequency of the replacement of the upper layers of the sand bed. The normal drain time must be used to evaluate the filter’s actual performance. If significant increases or decreases in the normal drain time are observed, the filter’s sand bed, underdrain system, and tailwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the filter.

The sand bed must be inspected at least twice annually. The infiltration rate of the sand bed material may also be retested. If the water fails to infiltrate 72 hours after the end of the stormwater quality design storm, corrective measures must be taken. Additional training, such as confined space training, may be necessary for the standard maintenance of subsurface sand filters. Such training must be specified in the maintenance manual.

Note: The Considerations section below is provided to assist the designer in enhancement of sand filters. However, consistency with these recommendations is not required in order to receive the TSS removal rate for this BMP.

Recommendations

A. Construction

During basin construction, precautions must be taken to prevent infiltration soil bed compaction by construction equipment and sediment contamination by runoff. Basin excavation and planting soil placement should be performed with equipment placed outside the basin bottom whenever possible. Light earth moving equipment with oversized tires or tracks should be utilized when the basin must be entered.

Sand Filters are susceptible to clogging and subsequent failure if significant sediment loads are allowed to enter the structure. Therefore, using a sand filter system for construction sediment control is discouraged. When unavoidable, excavation for the sediment basin should be a minimum of 2 feet above the final design elevation of the basin bottom. Sediment can then accumulate and be removed during site construction without disturbing the final basin bottom, which should be established only after all other construction within its drainage area is completed and the drainage area stabilized. If basin construction cannot be delayed until then and the basin will not be used for sediment control, diversion berms should be placed around the basin’s perimeter during all phases of construction to divert all sediment and runoff completely away from the basin. These berms should not be removed until all construction within the basin’s drainage area is completed and the area stabilized.

To prevent compaction of the soil below the basin that will reduce its infiltration capacity, sand filter basins should be excavated with light earth moving equipment, preferably with tracks or over-sized tires located outside the basin bottom. Once the basin’s final construction phase is reached, the floor of the basin must be deeply tilled with a rotary tiller or disc harrow and smoothed over with a leveling drag or equivalent grading equipment.

Upon stabilization of the sand filter bioretention systems and its drainage area, the infiltration rate of the planting soil bed must be retested to ensure that the rate assumed in the computations is provided at the basin. The permeability rate of the subsoil below the basin must also be retested after construction at sand filters that utilize infiltration rather than an underdrain system.

B. Pretreatment

As with all other best management practices, pretreatment can extend the functional life and increase the pollutant removal capability of a sand filter. Pretreatment can reduce incoming velocities and capture coarser sediments, which will extend the life of the system. This is usually accomplished through such means as a vegetative filters and/or a manufactured treatment device. Information on vegetative filters and manufactured treatment devices is presented in Chapters XXXX, respectively.

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