C-6. Sand Filter

Design Objective

A sand filter is a surface or subsurface device that percolates stormwater down through a sand media where pollutants are filtered out. Sand filter effluent is usually discharged. Sand filters are capable of removing a wide variety of pollutant concentrations in stormwater via settling, filtering, and adsorption processes. Sand filters have been a proven technology for drinking water treatment for many years and now have been demonstrated to be effective in removing urban stormwater pollutants including TSS, BOD, fecal coliform, hydrocarbons and metals. Since sand filters can be located underground, they can also be used in areas with limited surface space.

Design Volume

Sand filters, as explained below, are designed to treat 0.75 times the design volume. This "discount" in their sizing is allowed because the water drains through the sand media so quickly that the stormwater is being treated by the sand filter concurrently with the storm event.

Important Links

Rule 15A NCAC 2H .1056. MDC for Sand Filters

SCM Credit Document, C-6. Credit for Sand Filters

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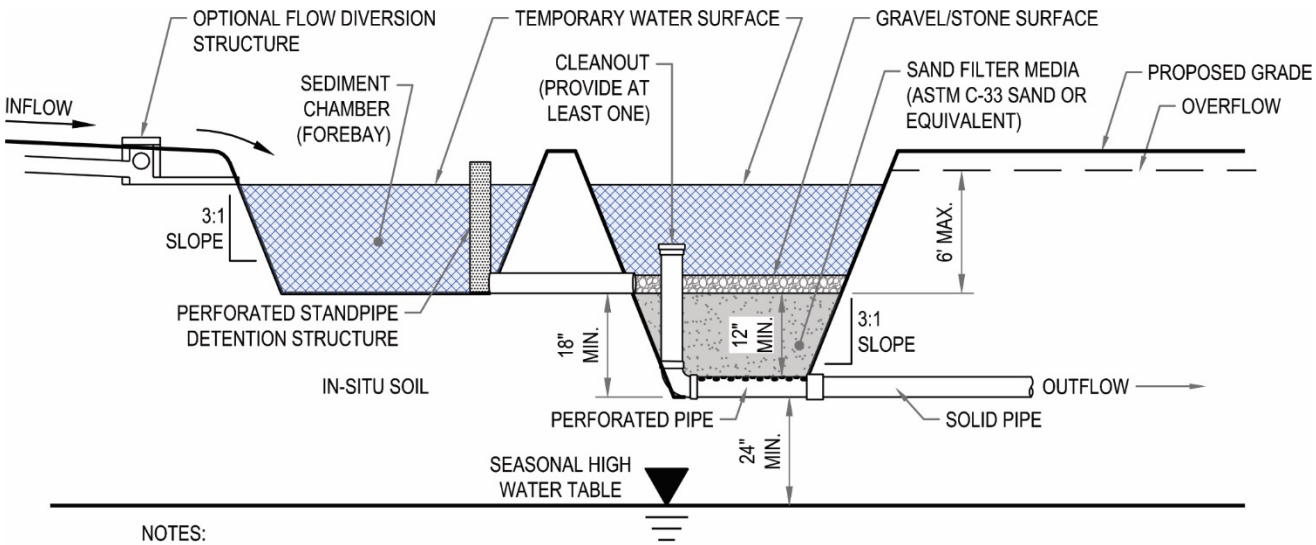
Figure 1: Open Bottom Sand Filter Example: Cross-Section



NOTES:
THE MINIMUM COMBINED VOLUME OF SEDIMENT CHAMBER AND STORAGE ABOVE SAND FILTER MEDIA IS 0.75 TIMES THE TREATMENT VOLUME.

MAINTAIN SAND FILTER MEDIA SUCH THAT THE INFILTRATION RATE IS GREATER THAN OR EQUAL TO 2 INCHES PER HOUR (2"/HR).

Figure 2: Closed Bottom Sand Filter Example: Cross-Section

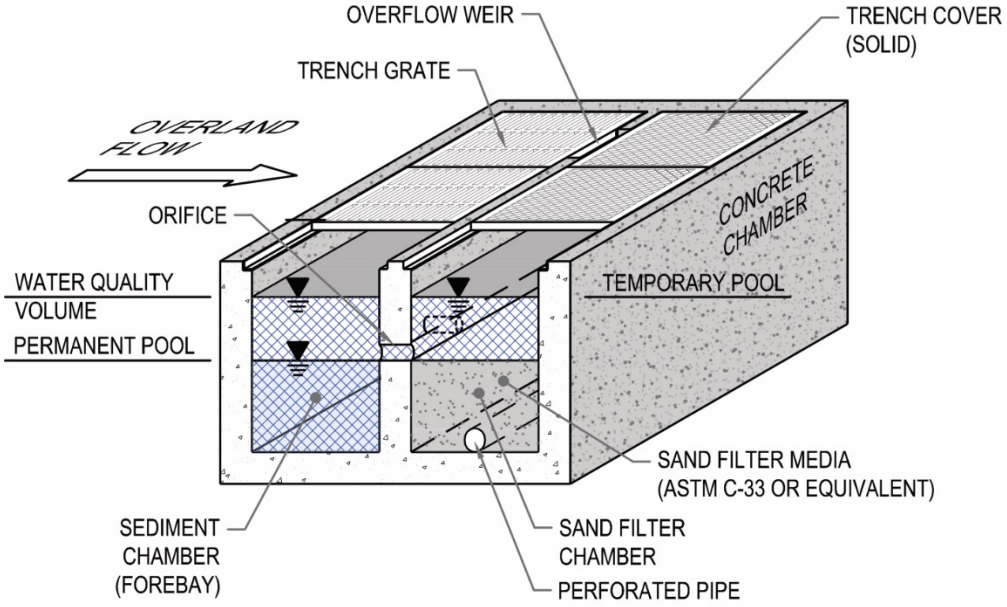


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Figure 2: Closed Bottom Sand Filter Example: Plan and Cross-Section

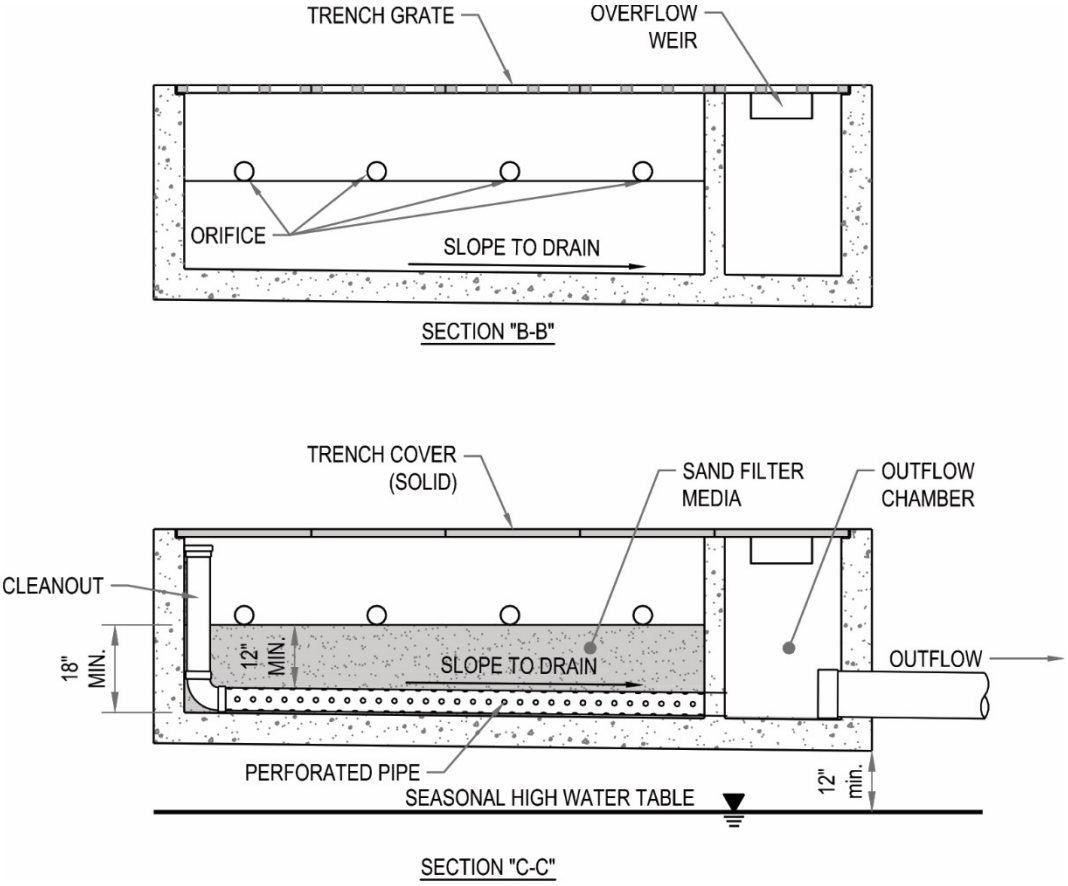
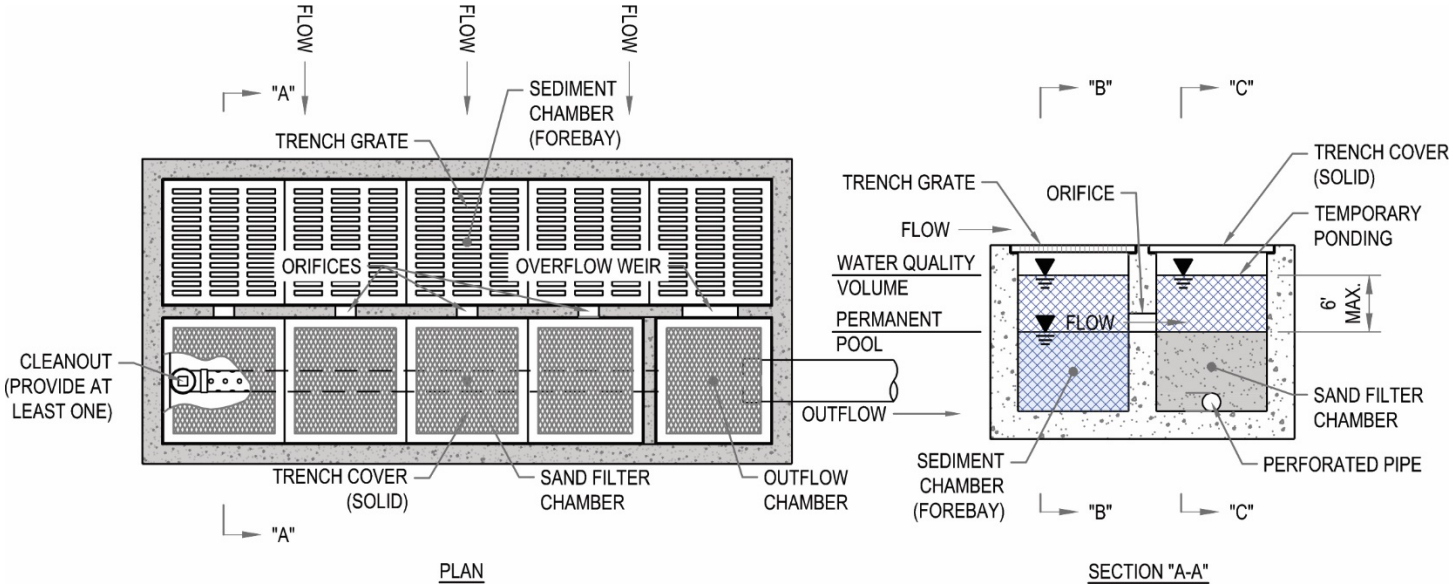


Figure 4: Closed Bottom Sand Filter Example: Plan and Cross-Section



Guidance on the MDC

SAND FILTER MDC 1. SHWT SEPARATION.
The minimum separation between the lowest point of the sand filter system and the SHWT shall be:

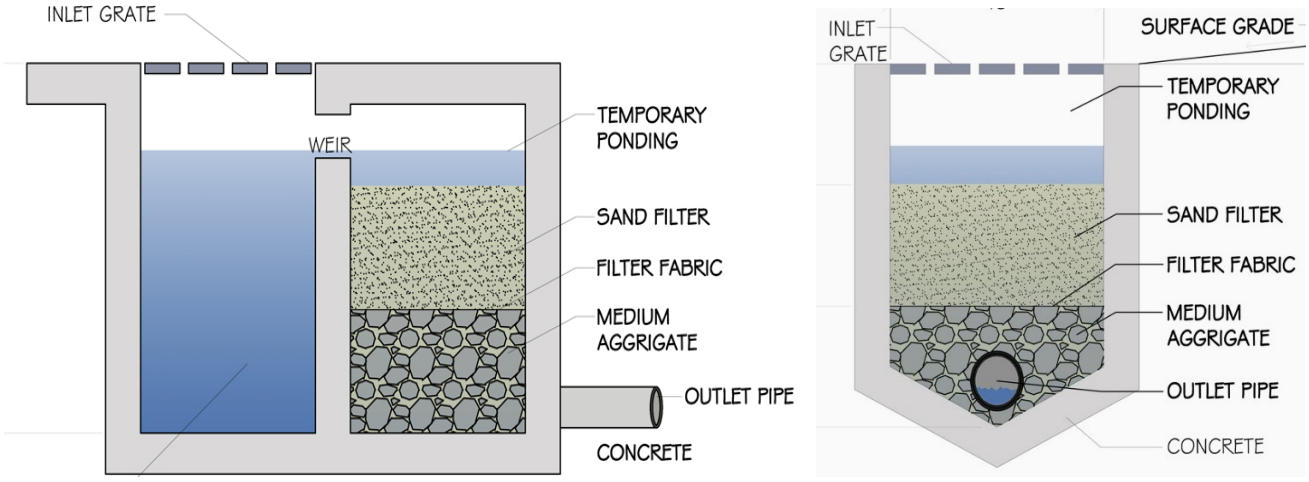
(a) two feet for open-bottom designs; and
(b) one foot for closed bottom designs. Exceptions to the one-foot SHWT separation may be made if the applicant provides documentation that the design will neither float nor drain the water table.

In order to demonstrate that a closed system did not require a one-foot separation from the SHWT, the designer will typically provide flotation calculations and specify an enclosure that will not allow seepage from the groundwater into the sand filter system.

SAND FILTER MDC 2. TWO CHAMBER SYSTEM.
The sand filter shall include a sediment chamber and a sand chamber. Storage volume in each chamber shall be equivalent.

The term “sand filter” is used to refer to the entire SCM, which comprises a sediment chamber and a sand chamber. The sediment chamber serves as a forebay for the sand chamber, which is the main treatment area of the sand filter system. The sediment chamber may be designed to have a permanent pool of water or with orifices that allow it to drain between storm events. If the sediment chamber has a permanent pool, then the volume contained by the permanent pool shall not be considered to be storage volume. The sediment chamber can be oversized to provide detention when peak flow mitigation is required for a site. The sand chamber will typically be equipped with an underdrain surrounded by aggregate to drain the sand chamber between storm events.

Figure 5: Two Cross-Sections of Closed-Bottom Sediment and Sand Chambers



SAND FILTER MDC 3. SEDIMENT/SAND CHAMBER SIZING.
The volume of water that can be stored in the sediment chamber and the sand chamber above the sand surface combined shall be 0.75 times the treatment volume. The elevation of bypass devices shall be set above the ponding depth associated with this volume. The bypass device may be designed to attenuate peak flows.

The area required for a sand filter device is calculated similarly to many other SCMs:

1. Calculate the design volume.
2. Multiply the design volume by 0.75, a "discount" that is allowed because stormwater infiltrates so rapidly through the sand media that the stormwater is treated throughout the storm event. By the end of the storm, the runoff from the beginning of the storm has already been treated and has exited the sand filter.
3. Divide the discounted design volume by the ponding depth, this will be the minimum surface area of the sand filter.
4. If the sand filter is designed to attenuate peak flows, additional surface area may be added in the sediment chamber only. The sand filter must be designed so that 50% of the treatment volume can be stored in the sand chamber below the first bypass device.

There are no MDC related to the shape of the sand filter. One of the biggest advantages of sand filters is how easily they can be fit to the site. Open-bottom sand filters can be rectangular, square, circular or irregular. Closed bottom sand filters are usually rectangular.

SAND FILTER MDC 4. MAXIMUM PONDING DEPTH.
The maximum ponding depth from the top of the sand to the bypass device shall be six feet.

The ponding depth is limited to six feet in order to avoid overloading the sand chamber. The designer is allowed to design the sand filter for peak flow attenuation as long as the six-foot ponding depth is not exceeded.

SAND FILTER MDC 5. FLOW DISTRIBUTION.
Incoming stormwater shall be evenly distributed over the surface of the sand chamber.

Stormwater flow may be distributed over the surface of the sand chamber via a level spreader, a pipe distribution system, or a series of weirs.

SAND FILTER MDC 6. SAND MEDIA SPECIFICATION.
Sand media shall meet ASTM C33 or the equivalent.

The media in the sand filter shall be cleaned, washed, course masonry sand such as ASTM C33 or the equivalent. The sand particles shall be less than 2 mm average diameter. The entire surface area of the sand chamber must contain sand.

SAND FILTER MDC 7. MEDIA DEPTH.
The filter bed shall have a minimum depth of 18 inches. The minimum depth of sand above the underdrain pipe shall be 12 inches.

The filter bed shall have a minimum depth of 18 inches, with a minimum depth of sand above the drainage pipe of 12 inches.

SAND FILTER MDC 8. MAINTENANCE OF MEDIA.
The sand filter shall be maintained in a manner that results in a drawdown of at least two inches per hour at the sand surface.

The easiest way to determine if the sand media is infiltrating adequately is to divide the depth of sand by two inches per hour (the minimum allowed infiltration rate) to determine the maximum number of hours that stormwater should take to drain through the sand chamber. For example, if the sand is 18 inches deep, the sand chamber should drain in 9 hours or less. When the filtering capacity has diminished below this level, then remedial actions shall be taken. The first step is to remove the top few inches of media replace it with fresh media. The removed sediments should be disposed of in an acceptable manner (e.g., landfill). If the problem still persists, then all of the sand media may need to be replaced.

SAND FILTER MDC 9. CLEAN-OUT PIPES.
At least one clean-out pipe shall be provided at the low point of each underdrain line. Clean out pipes shall be capped.

For the clean-out, it is recommended to specify a PVC pipe that has glued clean-out fittings with screw type caps. It is crucial that the cap be secure so that the stormwater will not leave the sand filter via the pipe rather than passing through the sand media as intended. In addition, the ends of each underdrain pipe should be capped to prevent clogging of the underdrain system.

Recommendations

SAND FILTER RECOMMENDATION 1. DRAINAGE AREA.
It is recommended to grade pervious areas to drain away from sand filters and to limit the drainage area of a sand filter to five acres or less.

Sand filters will function much better when the drainage area is highly built-upon because this will greatly reduce the amount of fines that reach the sand filter and potentially cause clogging. It is particularly important to grade pervious surfaces to drain away from the sand filter in areas with C and D soils. There is no maximum drainage area for sand filters; however, sand filters with smaller drainage areas (less than five acres) usually have fewer maintenance issues. Multiple sand filters can be used throughout a development to provide treatment for larger sites.

SAND FILTER RECOMMENDATION 2. ACCESS TO UNDERGROUND SAND FILTERS. It is recommended to provide access to underground sand filters that applies with OSHA regulations.

If a sand filter is to be located underground, safe access must be provided to facilitate cleaning and maintenance. It is recommended to consult OSHA standards for confined space entry.

Maintenance

Sand filters shall be inspected at least once a quarter and shall be maintained as needed to remove surface sediment accumulation, trash, debris, and leaf litter to prevent the filter from clogging. Sediment should be cleaned out of the forebay/sedimentation chamber when it accumulates to a depth of more than 6 inches. During inspection, structures such as outlets and flow diversions should be checked at least annually for damage or degradation. Figure 6 shows an example of a sand filter that is overdue for maintenance.

Figure 6: Sand Filter Overdue for Maintenance

Clogged Sediment Chamber

Clogged Sand Chamber

Important maintenance procedures for a sand filter include:

1. Manage the drainage area to reduce the sediment load to the sand filter.
2. Clean out the sedimentation chamber or forebay whenever sediment depth exceeds six inches.
3. At least once a year, skim the sand media.
4. Replace the sand filter media whenever it fails to function properly after maintenance.

5. Inspect the sand filter at least quarterly. Any problems that are found shall be repaired immediately.

Maintain operation and maintenance records in a known set location. Operation and maintenance records will be available upon request.

Table 1: Sample Operation and Maintenance Provisions for Sand Filters

SCM element:	Potential problems:	How to remediate the problem:
Entire sand filter	Trash/debris is present.	Remove the trash/debris.
Adjacent pavement (if applicable)	Sediment is present on the pavement surface.	Sweep or vacuum the sediment as soon as possible.
Perimeter of sand filter	Areas of bare soil and/or erosive gullies have formed.	Regrade soil if necessary to remove the gully, plant ground cover and water until it is established. Provide lime and a one-time fertilizer application.
	Vegetation is too short or too long.	Maintain vegetation at an appropriate height.
The flow diversion structure (if applicable)	The structure is clogged.	Unclog the sructure and dispose of sediment in a location where it will not cause impacts to streams or the SCM.
	The structure is damaged.	Make any necessary repairs or replace if damage is too much for repair.
Sediment chamber (forebay)	Sediment has accumulated to a depth of greater than six inches.	Search for the source of the sediment and remedy the problem if possible. Remove the sediment and dispose of it in a location where it will not cause impacts to streams or the SCM.
	Erosion has occurred.	Provide additional erosion protection such as reinforced turf matting or riprap if needed to prevent future erosion problems.

	Weeds are present.	Remove the weeds, preferably by hand. If a pesticide is used, wipe it on the plants rather than spraying.
Sand chamber and underdrain collection system	Water is ponding on the surface for more than 24 hours after a storm.	Check to see if the collector system is clogged and flush if necessary. If water still ponds, remove the top few inches of filter bed media and replace. If water still ponds, then consult an appropriate professional.
Outlet device	Clogging has occurred.	Clean out the outlet device. Dispose of the sediment offsite.
	The outlet device is damaged	Repair or replace the outlet device.
Receiving water	Erosion or other signs of damage have occurred at the outlet.	Repair the damage and improve the flow dissipation structure.
	Discharges from the sand filter are causing erosion or sedimentation in the receiving water.	Contact the local NCDEQ Regional Office.