Page Content

Overview for filtration

Filtering practices include media filters (surface, underground, perimeter), **vegetated filters** (https://stormwater.pca.state.mn.us/index.php?title=Overview_for_pretreatment_vegetated_filter_strips) (filter strips, grass channels), and combination media/vegetative filters (**dry swales** (https://stormwater.pca.state.mn.us/index.php?title=Dry_swale_(Grass_swale))). Media and media/vegetative filters operate similarly and provide comparable water quality capabilities as bioretention. Vegetative filters are generally more suitable as **pretreatment** (https://stormwater.pca.state.mn.us/index.php?title=Pretreatment) practices, but in some situations can be used on a stand alone basis.

Download pdf (https://stormwater.pca.state.mn.us/index.php?title=File:Design_criteria_for_bioretention_-_Minnesota_Stormwater_Manual_feb_2021.pdf)

Filtering practices have widespread applicability and are suitable for all land uses, as long as the **contributing drainage areas (https://stormwater.pca.state.mn.us/index.php?title=Contributing_drainage_area_to_stormwater_BMPs)** are limited (e.g., typically less than 5 acres). Media filters are not as aesthetically appealing as **bioretention**, which makes them more appropriate for commercial or light industrial land uses or in locations that will not receive significant public exposure. Media filters are particularly well suited for sites with high percentages of impervious cover (e.g., greater than 50 percent). Media filters can be designed with an **underdrain**, which makes them a good option for treating potential **stormwater hotspots (https://stormwater.pca.state.mn.us/index.php?title=Potential_stormwater_hotspots)** (PSHs). They can also be installed underground to prevent the consumption of valuable land space (often an important retrofit or redevelopment consideration). Vegetative filters can be incorporated into landscaped areas, providing dual functionality.

Contents

Iron enhanced sand filter basin, Maplewood, MN. Photo courtesy of Barr Engineering.

Function within stormwater treatment train

Media filtration systems are designed primarily as **offline** systems for stormwater quality and typically are used in conjunction with other structural controls in the stormwater **treatment train** (https://stormwater.pca.state.mn.us/index.php?title=Using_the_treatment_train_approach_to_BMP_selection). Vegetative filters, designed as grass channels or **swales** (https://stormwater.pca.state.mn.us/index.php?title=Dry_swale_(Grass_swale)), may be the main form of conveyance between or out of BMPs, as well as providing treatment for stormwater runoff.

Vegetated filter strips filter solids and debris from stormwater runoff before the runoff enters the treatment practice. In this image, the filter strip is treating runoff prior to the runoff entering a detention pond. Source: StormwaterPartners (http://www.stormwaterpartners.com/facilities/detention.html)

MPCA permit applicability

One of the goals of this Manual is to facilitate understanding of and compliance with the MPCA Construction General Permit (CGP) (https://stormwater.pca.state.mn.us/index.php?title=Construction_stormwater_program), which includes design and performance standards for permanent stormwater management systems. These standards must be applied in all projects in which at least 1 acre of new impervious area is being created, and the permit stipulates certain standards for various categories of stormwater management practices.

For regulatory purposes, **filtration** (https://stormwater.pca.state.mn.us/index.php?title=Filtration) practices fall under Filtration systems of the MPCA CGP. If used in combination with other practices, credit for combined stormwater treatment can be given. Due to the statewide prevalence of the MPCA permit, design guidance in this section is presented with the assumption that the permit does apply. Also, although it is expected that in many cases the filtration practice will be used in combination with other practices, standards are described for the case in which it is a stand-alone practice.

The following terms are thus used in the text to distinguish various levels of filtration practice design guidance:

- **REQUIRED**:Indicates design standards stipulated by the MPCA CGP (or other consistently applicable regulations).
- **HIGHLY RECOMMENDED**: Indicates design guidance that is extremely beneficial or necessary for proper functioning of the filtration practice, but not specifically required by the MPCA CGP.
- **RECOMMENDED**: Indicates design guidance that is helpful for filtration practice performance but not critical to the design.

Of course, there are situations, particularly retrofit projects, in which a filtration facility is constructed without being subject to the conditions of the MPCA permit. While compliance with the permit is not required in these cases, the standards it establishes can provide valuable design guidance to the user. It is also important to note that additional and potentially more stringent design requirements may apply for a particular filtration facility, depending on where it is situated both jurisdictionally and within the surrounding landscape.

Retrofit suitability

The use of filters as a retrofit practice primarily depends on existing infrastructure and the compatibility of existing storm drain inverts that need to connect to the filter underdrain outflow. In general, four to six feet of elevation above the existing collection system invert is needed for **media** (https://stormwater.pca.state.mn.us/index.php?title=Design_criteria_for_bioretention#Materials_specifications_-_filter_media) filter retrofits (2 to 3 feet is needed for perimeter filters). Underground media filters are excellent for **highly urban and ultra-urban environments** where space is at a premium.

Special receiving waters suitability

The following table provides guidance regarding the use of filtration practices in areas upstream of special receiving waters.

Infiltration and filtration bmp[1] design restrictions for special waters and watersheds.
Link to this table

BMP Group			receiving water		
	A Lakes	B Trout Waters	C Drinking Water[2]	D Wetlands	E Impaired Waters
Infiltration	RECOMMENDED	RECOMMENDED	NOT RECOMMENDED if potential stormwater pollution sources evident	RECOMMENDED	RECOMMENDED unless target TMDL pollutant is a soluble nutrient or chloride
Filtration	Some variations NOT RECOMMENDED due to poor phosphorus removal, combined with other treatments	RECOMMENDED	RECOMMENDED	ACCEPTABLE	RECOMMENDED for non-nutrient impairments

[1]Filtration practices include green roofs, bmps with an underdrain, or other practices that do not infiltrate water and rely primarily on filtration for treatment.

[2] Applies to groundwater drinking water source areas only; use the lakes category to define BMP design restrictions for surface water drinking supplies

Cold climate suitability

Various options for use of filtration are available for treating snowmelt runoff. Some of the installations are built below the frost line (trenches, sub-grade proprietary chambers) and do not need further adaptation for the cold. However, some special consideration is *HIGHLY RECOMMENDED* for surface systems.

The problem with filtration in cold weather is the ice that forms both over the top of the facility and within the soil interstices. To avoid these problems to the extent possible, it is *HIGHLY RECOMMENDED* that the facility be actively managed to keep it dry before it freezes in the late fall. This can be done by various methods, including limiting inflow, under-drainage, and surface disking.

Proprietary, sub-grade filtration systems provide an alternative to standard surface based systems. Essentially, these systems provide an insulated location for pre-treated snowmelt to be stored and slowly filtered, or simply filtered and drained away if ground water sensitivity is an issue. The insulating value of these systems adds to their appeal as low land consumption alternatives to ponds and surface infiltration basins.

Water quantity treatment

Filters are not typically a primary practice for providing water quantity control. They are normally either designed offline using a flow diversion or configured to safely pass large storm flows while still protecting the filter bed. In limited cases, filters may be able to accommodate the channel protection volume, V_{cp}, in either an off- or online configuration, and in general they do provide some (albeit limited) storage volume. Vegetative filters, in particular, can help reduce detention requirements for a site by providing elongated flow paths, longer times of concentration, and volumetric losses from infiltration and **evapotranspiration**. Generally, however, to meet site water quantity or peak discharge criteria, it is *HIGHLY RECOMMENDED* that another structural control (e.g., detention) be used in conjunction with a filter.

It is *HIGHLY RECOMMENDED* that vegetative filters have a maximum slope of 5 percent and a minimum slope of 1 percent.

Warning: It is REQUIRED that volume reduction practices, such as infiltration basins, are considered before filtration practices

Water quality treatment

Filters can be an excellent stormwater treatment practice with the primary pollutant removal mechanism being filtering and settling. Less significant processes can include evaporation, infiltration, transpiration, biological and microbiological uptake, and soil adsorption. Pollutant removal data for select parameters are provided for filtration BMPs in the table below. “Performance” can also be defined as the quality of the water flowing out of a treatment BMP. These outflow concentrations can be used to assess how well a BMP is performing and what its benefit to a down-gradient receiving water will be. The Pollutant concentrations for filtration BMPs table below contains information on typical expectations for outflow concentration.

Pollutant removal percentages for filtration BMPs.
Link to this table

Practice	TSS Low-Med-High	TP Low-Med-High	TN[4]	Metals[3] (average of Zn and Cu)	Bacteria[3]	Hydrocarbons[3]
Media Filter[1]	75-85-90	30-50-55	35	80	50	80

Practice	TSS Low-Med-High	TP Low-Med-High	TN[4]	Metals[3] (average of Zn and Cu)	Bacteria[3]	Hydrocarbons[3]
Vegetative Filter[2]	see here	see here	35	80	0	80

[1] For example, sand, mixed sand/peat and other geologic media

[2] Grass filter/swale

[3] Not enough information given in databases to differentiate type of filter so both combined for this entry

Typical pollutant effluent concentrations, in milligrams per liter, for filtration BMPs.
Link to this table

Practice	TSS Low-Med-High[4]	TP Low-Med-High[4]	TN	Cu	Zn
Media Filter[2]	5-11-16	0.06-0.10-0.19	1.1	0.008	0.060
Vegetative Filter[3]	13-20-44	0.15-0.24-0.36	1.1	0.008	0.060

[1] All concentration values in mg/L which equals parts per million

[2] For example, sand, mixed sand/peat and other geologic media

[3] Grass filter/swale

[4] Not enough information given in databases to differentiate type of filter so both combined for this entry

While it is possible to design media filters to discharge a portion of the effluent to the groundwater, they are typically designed as enclosed systems (i.e., no “infiltration”). Vegetative filters, on the other hand, can readily be designed as an effective infiltration/recharge practice, particularly when parent soils have good permeability (> ~ 0.5 inch per hour). Consult the **credit (stormwater credit)** (https://stormwater.pca.state.mn.us/index.php?title=Overview_of_stormwater_credits) section for more guidance on how to use filters to meet water quality and recharge criteria. Note that the vegetative filters might not meet the 80 percent TSS removal required by the Construction permit.

The benefits associated with filtration BMPs should only be accrued based on the amount of water actually passing through the BMP. Excess runoff beyond that designed for the BMP should not be routed through the system because of the potential for hydraulic and particulate over-loading, both of which will adversely impact the life and operation of the BMP.

For example, a filtration device designed to treat the first 0.5 inch of runoff from a fully impervious surface will catch about 30 percent of the volume of runoff in the Twin Cities. This means that 70 percent of the runoff volume should be routed around the filtration system and will not be subject to the removals reflected in the above tables. Attributing removal to all runoff just because a BMP is in place in a drainage system is not a legitimate claim.

Limitations

The following general limitations should be recognized when considering installation of a filtration practice.

- **Nitrification** of water in media filters may occur where aerobic conditions exist.
- Filtration offers limited water quantity control.
- The potential to create odors exists

It is *HIGHLY RECOMMENDED* that media filters be equipped with a minimum 8 inches diameter underdrain in a 1 foot gravel bed.

Related pages

- Overview for filtration
- Types of filtration
- Design criteria for filtration
- Construction specifications for filtration
- Assessing the performance of swales
- Assessing the performance of sand filters
- Operation and maintenance of filtration
- Calculating credits for sand filter
- Calculating credits for swale
- Cost-benefit considerations for filtration
- References for filtration