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Overview for iron enhanced sand filter

Iron-enhanced sand filters (https://stormwater.pca.state.mn.us/index.php?title=Iron_enhanced_sand_filter_(Minnesota_Filter)) are **filtration** (https://stormwater.pca.state.mn.us/index.php?title=Filtration) **best management practices** (BMPs) that incorporate filtration **engineered media** (https://stormwater.pca.state.mn.us/index.php?title=Design_criteria_for_bioretention#Materials_specifications_-_filter_media) mixed with iron. The iron removes several dissolved constituents, including phosphate (**dissolved phosphorus**), from stormwater. Iron-enhanced sand filters may be particularly useful for achieving low phosphorus levels needed to improve nutrient **impaired waters** (https://stormwater.pca.state.mn.us/index.php?title=Special_Waters_and_Impaired_Waters). Iron-enhanced sand filters could potentially include a wide range of filtration BMPs with the addition of iron; however, iron is not appropriate for all filtration practices due to the potential for iron loss or plugging in low oxygen or persistently inundated filtration practices. Here iron-enhanced filtration is limited to two types:

- Iron-enhanced sand filter basin (analogous to surface sand or media filters)
- Iron-enhanced sand bench in wet ponds

Iron enhanced sand filter basin, Maplewood, MN. Photo courtesy of Ramsey-Washington Watershed District.

Iron-enhanced sand filters may be applied in the same manner as other filtration practices and are more suited to urban land use with high imperviousness and moderate solids loads. Iron-enhanced sand filters are more suitable to conditions with minimal groundwater intrusion or tailwater effects. Because the primary treatment mechanisms are filtration and chemical binding and not volume reduction, vegetating the filter is not needed and may impair the filter function. All of the iron-enhanced sand filters require **underdrains** that serve to convey filtered and treated stormwater and to aerate the filter bed between storms. The exit drain from the iron-enhanced sand filter should be exposed to the atmosphere and above downstream high water levels in order to keep the filter bed aerated.

Iron enhanced sand bench, Prior Lake, MN. Photo courtesy of Ross Bintner.

Iron-enhanced sand filters may be used in a treatment sequence, as a stand-alone BMP, or as a retrofit. If an iron-enhanced sand filter basin is used as a stand-alone BMP, an overflow diversion is recommended to control the volume of water, or more specifically, the inundation period in the BMP. As with all filters, it is important to have inflow be relatively free of solids or to have a **pretreatment** (https://stormwater.pca.state.mn.us/index.php?title=Pretreatment) practice in sequence.

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Function within stormwater treatment sequence

The iron-enhanced sand filter basin may be used in conjunction with other structural controls. The iron-enhanced sand filter bench is constructed along the perimeter of a pond that provides pretreatment. Placement of a plunge pool or some sort of pretreatment upstream of an iron-enhanced sand filter basin is recommended to extend the lifespan of the filter.

MPCA permit applicabilty

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 the **infiltration** (https://stormwater.pca.state.mn.us/index.php?title=Stormwater_infiltration_Best_Management_Practices) / filtration category described in the permit (http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/construction-stormwater/index.html). 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 Permit (https://stormwater.pca.state.mn.us/index.php?title=Construction_stormwater_program) (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 permit.

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 an infiltration 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 infiltration facility, depending on where it is situated both jurisdictionally and within the surrounding landscape.

Benefits

- Removal of several colloidal and dissolved constituents, including color and phosphates
- High pollutant removal rates
- Use as a retrofit for existing ponds and other stormwater BMPs
- Good for nutrient impaired water
- Could be used at sites with certain types of restrictions where infiltration is not appropriate or feasible

Limitations

- New technology with somewhat limited phosphorus removal performance history
- Best for urban watersheds or runoff with moderate sediment loads
- Lifespan of iron-enhanced filtration practice potentially reduced by clogging or iron loss
- Head required for treatment and draw down of filter between storms
- Tailwater effects may restrict siting of filters
- Vegetation should not be allowed to grow over the iron enhanced media. Decomposed vegetation may reduce oxygen in the filter media and cause a chemical change in the iron resulting in filter media fouling.
- Lifespan of the filter potentially limited by repeated clogging and cleaning cycles
- Disposal of the iron-sand bed material will be required when the iron is consumed
- Iron-sand filtration offers limited water quantity control
- Accumulation of senesced and decomposed plant material in the filter bed (e.g., due to leaf litter accumulation or if vegetation is allowed to grow on the filter bed) may cause low oxygen conditions and iron loss or fouling over time

Retrofit suitability

All of the iron-enhanced sand filters covered here are suitable as retrofits and may be best employed downstream or in conjunction with existing wet ponds or other settling basins. The iron-enhanced sand filter basin should not be placed downstream of a pond or wetland that delivers an unabated flow of stormwater to the filter. If the filter bed is not allowed to drain dry to promote bed aeration, it is possible that the bed may become anaerobic and cause filtration bed fouling or iron loss.

Special receiving waters suitability

The following table provides guidance regarding the use of filtration practices in areas upstream of special **receiving waters**. The corresponding information about other BMPs is presented in the respective sections of this Manual.

Infiltration and filtration bmp[1] design restrictions for special waters and watersheds. See also Special waters and other sensitive receiving waters.
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

The iron-enhanced sand filter basin and the iron-enhanced sand filter bench in wet ponds are both suitable for cold climates.

Water quantity treatment

Iron-enhanced sand filters do not provide water quantity control. (Currently, no volume reduction **credit (stormwater credit)** (https://stormwater.pca.state.mn.us/index.php?title=Overview_of_stormwater_credits) is given for iron-enhanced sand filtering systems. Volume losses through **evapotranspiration** and infiltration below an underdrain are being investigated for all BMPs and will be applied if it is deemed appropriate.)

Water quality treatment

Although iron-enhanced sand filters can remove solids, the primary water quality benefit of iron-filters is the removal of dissolved constituents. Limited solids and phosphorus removal data are available for full scale treatment systems. Available data are provided below for an iron-enhanced sand bench that was constructed for a **wet pond** (https://stormwater.pca.state.mn.us/index.php?title=Stormwater_ponds) in Prior Lake, Minnesota and an iron-enhanced sand filter basin constructed in Maplewood, Minnesota. The outflow concentrations can be used to assess how well a BMP is performing and the potential benefits to down-gradient receiving waters.

Iron-enhanced sand filters are not designed to discharge a part of the effluent to groundwater nor are they designed to treat all runoff events. The water quality benefit of the iron-enhanced sand filter should only be accrued based on the volume of water that is treated by the BMP.

Pollutant concentrations and removals for iron enhanced filters.
Link to this table

Practice	TSS Out (mg/L)	TSS removal (%)	TP Out (mg/L)	TP removal (%)	Phosphate Out (mg/L)	Phosphate removal (%)
I-E SFB[1]	ND[3]	ND	ND	ND	0.015	70
I-E SB[2]	2	92	0.025	71	0.010	50

[1] Parallel iron-enhanced sand filter benches in a wet pond. Values are from an average of two parallel 7.2% and 10.7% iron by weight iron-enhanced sand benches reported by Erickson et al. (2010, 2012). Averages are from a total of five storms monitored from July through September 2010. Values reported as below the detection limit were set equal to one-half the detection limit when calculating average phosphorus at the outlet and percent removals.

[2] Iron-enhanced sand filter basin. Values are from an average of 19, 19, and 11 (for TP, TSS, and phosphate, respectively) storm events monitored from April through September 2010. For phosphate, only storms with above detection limit data at the inlet were used to calculate removals. Phosphate data below detection limits at the outlet were set equal to one-half the detection limit (0.01 mg/L) when calculating an average and removal rates. Data were collected by the Ramsey-Washington Metro Watershed District and reported by Barr Engineering Company, December, 2010.

[3] ND is "not determined"

Related pages

- Overview for iron enhanced sand filter
- Types of iron enhanced sand filter
- Design criteria for iron enhanced sand filter
- Operation and maintenance of iron enhanced sand filter
- Calculating credits for iron enhanced sand filter
- References for iron enhanced sand filter
- Supporting material for iron enhanced sand filter