Vegetated Filter Strips

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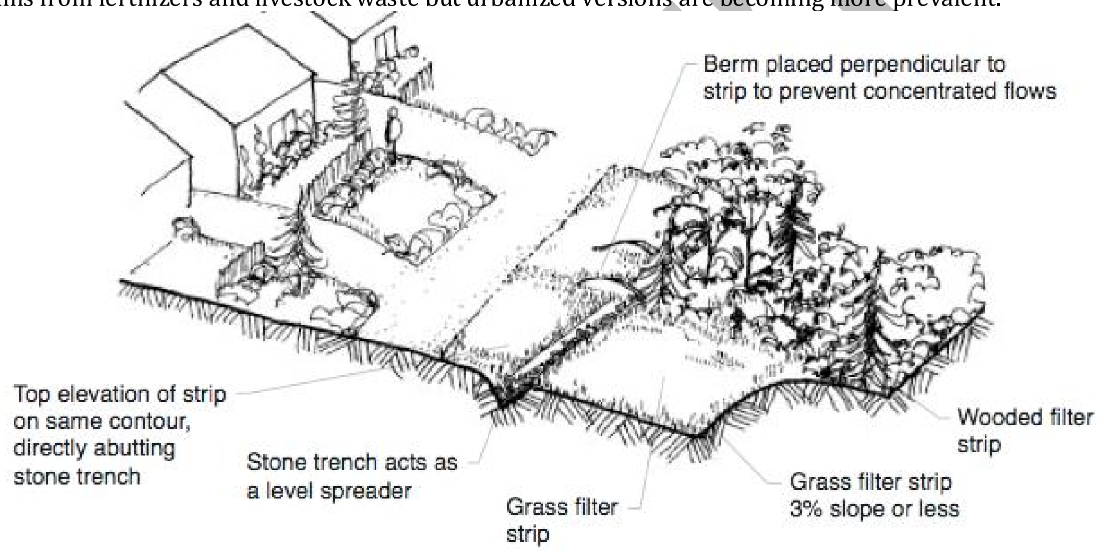
A vegetated filter strip (VFS) is a sloping area covered in vegetation (grass and/or plants) receiving sheet flow runoff from pervious and impervious surfaces. Generally, vegetated filter strips minimize flow velocities, filter pollutants and collect sediment before passing the remaining runoff volume to a secondary facility such as a swale or bioretention practice, but they can also be designed like rain gardens with amended soils to store and infiltrate runoff volumes. VFS manage smaller volumes of runoff, generally less than 5 acres (Arnold 1991, Field 2007). Because VFSs require sheet flow runoff, a level spreader is required where runoff has become concentrated, such as from downspouts. Traditionally, they have been used in agricultural settings to protect streams from fertilizers and livestock waste but urbanized versions are becoming more prevalent.



Vegetated Filter Strip Design (NRCS 2008)
**Note: slope design may vary from site to site*

Design

Vegetated filter strips are like flattened swales and are typically designed to convey, treat, and capture the stormwater runoff from surfaces draining to the garden during 80 to 90 percent of annual storm events, on average. In Oregon, this is usually a 1 inch 24-hour design storm. In some cases, cities may require VFSs to infiltrate larger storm events, especially where local soils drain well.

In other cases, where pollutant loading is low, a more simple facility to remove total suspended solids may be all that is needed. As with other conveyance treatment facilities such as swales, the minimum retention time in the facility should be 9 minutes. In the case of a facility that has replaced slow draining native soils with amended planting soils with infiltration rates between 2 and 12 inches per hour, this minimum retention time will likely be very easy to achieve and water quality treatment will be more effective than simply passing it over the surface. *Check with your local planning department for specific design requirements for your area.*

SIZING

Generally, high infiltrating soils and lower slopes will result in a shorter VFS and many guidelines include a 10-15 foot minimum length (length specified as the dimension normal to flow). Stream buffers are often designed as vegetated filter strips and 50 to 200 feet. Generally, 100 foot stream buffers seem to be a reasonable balance between restricting land use and providing water quality benefits [1]. Ultimately, though, the length of the filter strip that should be used in these circumstances depends on pollutants levels, as well stream sensitivity. When inflow to the facility is overland, ideally, the width of the facility should span the entire impervious area width from which the facility is receiving runoff (Barr 2001, Field 2007); however, there are many examples of filter strips receiving inflow from concentrated flows that may be more narrow.

Slope: Ideal slopes are 5% or less with up to 15% acceptable, but not encouraged (Arnold 1993, Field 2007). Steeper slopes do not allow time for infiltration and pollutant removal, however, different vegetation types can aid in infiltration affecting the percent slope suitable for a specific site. As mentioned above, greater slopes generally require larger facilities (LIDMM 2008). Lateral slope should not exceed 1% (LIDMM 2008).

		Maximum Filter Strip Slope (Percent)	
Filter Strip Soil Type	**Hydrologic Soil Group**	**Turf Grass, Native Grasses and Meadows**	**Planted and Indigenous Woods**
Sand	A	7	5
Sandy Loam	B	8	7
Loam, Silt Loam	B	8	8
Sandy Clay Loam	C	8	8
Clay Loam, Silty Clay, Clay	D	8	8

Slope percents based on soil and vegetation types (LIDMM 2008)

Vegetated Filter Strip, Portland, OR (lcrep 2008)

FLOW VELOCITIES

VFS are not designed to handle high velocities of runoff (Field 2007). Overland flow and spreader facilities help to keep the velocities below erosive velocities, but this should be confirmed in the design. Dense plantings will also play a significant role in slowing flows.

SOILS AND MEDIUM

[1] http://www.co.chatham.nc.us/dept/planning/planning_dept/watershed_review_board/supporting_documents/cases/cecc_request_05-05/Scientific_Lit_Excerpt.pdf

Vegetated filter strips should have amended planting soil or amended native soils with infiltration rates that are not too low, so that at least small storms pass through the soil column for treatment, but not so high that stormwater doesn't has enough "retention time" in the soil. The ideal infiltration rate is between 1/2 inch/hour and 12 inches/hour[2]. The top 18 inches of soil is typically amended with organic compost and soil mixtures to create a sandy loam soil. In some cases, the existing topsoil is replaced with a soil mix, as specified by the local jurisdiction. In addition to infiltration rates, other key considerations for robust plant establishment and stormwater treatment by plants and soil include soil pH (between 5.5 and 7.5[3]), cation exchange capacity (>5 millequivalents/100grams, and the resulting soil mix should be 60% sandy loam and 40% compost. Be sure that imported soil and compost is free of weed seeds.

Native soils should always be tested in the proposed filter strip location to determine the infiltration rate of the native undisturbed soils below the amended topsoil. The infiltration rate should be at least ½ inch per hour when using an infiltration facility that receives runoff from elsewhere; some jurisdictions require higher rates. Since stormwater has already passed through the middle amended soil layer and received treatment, there is no recommended maximum infiltration rate for the native soils. If infiltration rates are so low that the plants will have wet feet for too long, you may consider building a smaller VFS with an under drain pipe that will allow the water to leave the bottom of the facility.

VEGETATION

The interaction of soil, plants, and the beneficial microbes that concentrate on plant roots is what ultimately provides the filtration benefit of vegetated filter strips-- the more plants, the more treatment. A vegetated filter strip that won't infiltrate the water quality storm will still provide some reduction of total suspended solids; plant density is even more important in this case, since the above ground structure of the plants is what slows runoff and allows sediments to settle out.

A variety of trees, shrubs, grasses, and ground covers are acceptable for filter strips in both sun and shade conditions. The VFS should be densely vegetated for maximum runoff treatment and to control weeds. Local jurisdictions often provide specifications for density, size, and types of vegetation to use. Vegetation should be selected based on its tolerance to flooding and its ability to survive in the local climate conditions with no fertilizers, and no herbicides or insecticides, and minimum to no watering after establishment. Vegetation such as perennial flowers, ornamental grasses, and shrubs can add significant appeal to the facility. Filter strips can also be designed to attract beneficial insects and wildlife. Contact your local OSU Extension Service office or planning department for a list of plants appropriate for your area. Because downstream seed dispersal during flooding and spreading by birds is well documented in natural wetlands, take special care to avoid noxious weeds (aks invasive plant species). A list of noxious weeds is available on the Oregon Department of Agriculture's Web site at http://www.oregon.gov/ODA/PLANT/WEEDS/.

In most cases, native plants are preferred not just because non-native seeds and rhizomes can greatly impact the habitat potential of our natural land and drainageways, but also because native plants will provide more food for native insects and birds. Even when native insects and birds find non-native plants appealing, non-native plants don't provide as much nutrition. Finally, native plants support native microbes and other native soil life, while non-natives have been found to negatively impact the composition of the soil life.

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[2] http://www.psparchives.com/publications/our_work/stormwater/BSMResults-Guidelines%20Final.pdf

[3] Low Impact Development Center specifications: http://www.lowimpactdevelopment.org/epa03/biospec_left.htm

Vegetated Filter Strip along Highway (WDOT 2009) Vegetated Filter Strip, Portland, OR (lcrep 2008)

ROUTING: Runoff must enter a VFS as sheet, not concentrated, flow. This can be achieved with a level spreaders. Level spreaders can be a stone filled gravel trench with or without a perforated pipe, concrete weir, runnel, or curb (Arnold 1993). The most appropriate level spreader for a downspout delivering roof runoff is a gravel trench (LIDMM 2008). Regardless of type, the spreader should be continuous and level (Barr 2001 and Field 2007). Field 2007 has more information regarding these devices. If a level spreader is not used, Arnold 1993 suggests the use of dams or berms at the top of the facility and every 50-100ft (Arnold 1993).

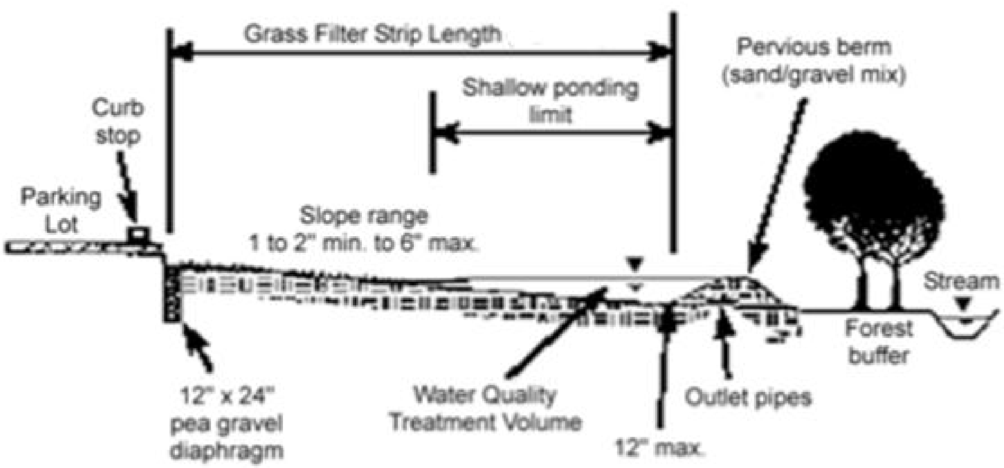

Figure 1 Vegetated Filter Strip Design (Barr 2001)

Like many low impact development facilities, a bypass system is required for high flows during storms exceeding the design capacity (Barr 2001).

To enhance storage capacity, a berm at the bottom of the facility will allow ponding, but the effectiveness of this measure is dependent on the slope of the facility and the height of the berm. Field 2007). Alternatives include an underdrain and overflow weir (Field 2007).

Setbacks

Lined vegetated strips aren't typical but could be designed for water quality only and would have no setback requirements. Setbacks for infiltration facilities vary by jurisdiction. The City of Portland (PSMM 2008) setback requirements are at least 10 feet from building foundations and 5 feet from property lines. Along with this is a minimum landscape requirement in their zoning codes that bans building walls within 5 feet of the property line, thereby ensuring the 10 feet of building setback. They should also be set back a minimum of 100 feet from down-gradient slopes of 10 percent. Add 5 feet of setback for each additional percent up to 30 percent, and avoid installing an infiltration rain garden where the down-gradient slope exceeds 30 percent. The Oregon DEQ requires a minimum soil depth from the bottom of the rain garden to the seasonal high groundwater table of 3 feet.

Physical Setting

Due to a VFS's need for space, they may not be ideal for retrofitting (Barr 2001) (unless space is adequate), but can help meet open space requirements in new developments (UDFCD 2008). Ideal locations for VFSs are roads, highways and roof downspouts as well as small parking lots and pervious surfaces (Barr 2001, Field 2007). An alternative location is the center of a driveway, usually 3 foot wide which two 3 foot aisles of paved driveway. The paved portions should be slightly sloped toward the center filter strip (PSMM 2008). They can also be located along a stream as the outer zone of a stream buffer (Field 2007).

When placing a facility, potential for groundwater contamination should be considered, especially if the facility is located in urban areas or other areas with high pollutant levels in runoff (Barr 2001, Field 2007).

Pollutant Removal

A properly designed and well functioning filtration VFS can remove about 35-60% of total suspended solids and 40% nutrients in an urban setting (Arnold 1993, Barr 2001), varying from site to site depending on soils, vegetation and contact time (Field 2007). Based on published research, the Center for Watershed Protection estimates event mean concentration phosphorus removal rates to be 60 to 65% and nitrogen removal rates to be 30 to 45% (CWP 2008)[4]. Runoff reduction was estimated at 25-50% as well (CWP&CSN 2008). Pollutant removal is mainly performed through straining rather than bioretention (UDFCD 2008), yet there is some evidence that in forested VFS, bioretention is more prevalent than VFS constructed with grasses (Arnold 1993, NRCS 2008).

For vegetated filter strips designed to substantially infiltrate runoff, pollutant removal rates could be expected to mirror those for rain gardens.

Construction

Like all stormwater management facilities, care must be taken to properly construct a filter strip. If the facility will be for infiltration, the proposed VFS location should be fenced off to prevent vehicular and foot traffic that will compact soils and reduce the infiltration rate of the native soils. Construction techniques such as using track equipment and/or excavating from the sides of the infiltration area should be used to protect the soils during excavation. If the soils are exposed to rain, fine soil particles will be picked up and moved around and may clog the native subgrade soils. Rake the surface to loosen soil before proceeding. Raking will also be needed if the rain garden is dug by hand since foot traffic in the facility area is probably unavoidable.
If the facility is for filtration only, then protecting the native soils in the facility area from compaction isn't as important, but any infiltration that can be achieved would be beneficial as long as appropriate setbacks exist. In

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[4] The Center for Watershed Protection published event mean concentrations for "Filters", which is approximately an equivalent term for vegetated filter strips.

addition, vegetation is difficult to establish in compacted soils, so, for this reason, we recommend that the same care be taken In construction either variation of VFS.

Maintenance

Because vegetated filter strips look very similar to a regular garden, in residential applications, where owner turnover rates tend to be high compared to other land uses, some sort of permanent demarcation to prevent long term compaction might be helpful. Common maintenance tasks include mowing and trimming grasses (when dry) to appropriate lengths (Barr 2001);inspecting for excess sediment that may affect vegetation growth (dispose in approved location, check with local jurisdiction);replacing of vegetation as needed;repairing eroded areas where channels have formed;and maintaining the level spreader(Barr 2001). Consistent maintenance ensures longevity and effectiveness of the facility and tasks are less than other vegetated BMPs (LIDMM 2008).

Cost: These facilities are relatively low cost to install, may lack extensive grading and vegetation establishment (Arnold 1993) and maintenance tasks are similar to those of open space practices (UDFCD 2008).

Permits

Consult your local planning and building department. Ask about applicable permits, plumbing codes, and piping requirements. Find out if there are any maps, as-built drawings, or site specific constraints. In many cases, if building a planter on a non-residential site, a commercial building permit is required and a clearing, grading, and erosion control permit may be required if ground disturbance is large enough.

UIC PERMITTING

An Underground Injection Control (UIC) is a system designed "for the subsurface placement of fluids" and is regulated through the Oregon Department of Environmental Quality's UIC program. This program protects groundwater resources from injection of pollutants directly underground and depending on the potential of various pollutants to be on-site, may be rule authorized or require a more formal permitting process.

A vegetated filter strip designed and installed per the details shown is not considered a UIC; however, changes to the detail that might allow runoff to shortcut infiltration through the top of the facility could turn the facility into a UIC.

A lined vegetated filter strip is also not considered a UIC, because by design, it doesn't infiltrate.

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