



Description

Vegetated buffer strips (grassed buffer strips, vegetated filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by reducing runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide moderate pollutant removal and are often incorporated as pretreatment in more effective treatment control practices such as bioretention areas or permeable pavement.

California Experience

Caltrans constructed and monitored three vegetated buffer strips in southern California. These strips were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the sites. The gophers created mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- Buffers require minimal maintenance activity (generally erosion prevention and mowing).
- When properly designed and operated, buffer strips can provide reliable water quality benefits in conjunction with high aesthetic appeal.
- Flow characteristics and vegetation type and density can be closely controlled to maximize BMP effectiveness.

Design Considerations

- Tributary Area
- Slope
- Water Availability
- Aesthetics

Targeted Constituents	Removal
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Sediment	High
Nutrients	Low
Trash	Med
Metals	Med
Bacteria	Low
Oil and Grease	Med
Organics	Med
Flow Control	Low



Limitations

- Not appropriate for areas with concentrated runoff (i.e., locations where spills may occur).
- A thick, properly maintained vegetative cover is needed to function properly.
- Provides limited treatment for dissolved constituents (except when infiltrated into the soil).
- Does not provide significant attenuation of the increased volume and flow rate of runoff.

Performance

Vegetated buffer strips provide similar treatment of stormwater runoff as vegetated swales but have fewer tendencies for channelization or erosion. Table 2 documents the pollutant removal vegetated filter strip from a variety of references.

Table 1. Typical pollutant removal for constituents and removal processes

Pollutant	Typical Removal	Median Effluent Concentration ¹	Removal Processes	References
Sediment	High (-195% to 91%)	<u>19</u> mg/L	Sedimentation and filtration.	Geosyntec Consultants and Wright Water Engineering 2012; Knight et al. 2013; Winston et al. 2011; Scholes 2007
Metals	Medium	TAs: 0.88 μ g/L, TCd: 0.18 μ g/L, TCr: 2.63 μ g/L, TCu: 7.19 μ g/L, TFe: 616 μ g/L, TPb: 1.88 μ g/L, TNi: 2.95 μ g/L, TZn: 24.3 μ g/L	Removal with sediment.	Knight et al. 2013; Geosyntec Consultants and Wright Water Engineering 2012
Total phosphorus	Low (-126% to 40%)	0.173 mg/L	Settling with sediment, can be a net source or sink via breakdown or uptake of plant material	Geosyntec Consultants and Wright Water Engineering 2012; Knight et al. 2013; Winston et al. 2011;
Total nitrogen	Low TN: -17 to 40% TKN: -18 to 39%, NO _{2,3} -N: -18 to 43%	TN: 1.13 mg/L, TKN: 1.10 mg/L, NO _{2,3} -N: 0.19 mg/L	Settling, sedimentation (TKN) and plant uptake.	Geosyntec Consultants and Wright Water Engineering 2012; Knight et al. 2013; Winston et al. 2011;
Bacteria	Low (likely exports pathogens)	N/A	Limited sedimentation, desiccation, predation, and photolysis at surface.	US EPA 2012

¹ Underlined effluent concentrations were (statistically) significantly lower than influent concentrations, as determined by statistical hypothesis testing on the available sampled data. Effluent concentrations displayed in *italics* were (statistically) significantly higher than influent concentrations.

Filter strips also exhibit good removal of litter and other floatables because the water depth in these systems is below the vegetation height and consequently these materials are not easily transported through them. Unfortunately little attenuation of peak runoff rates and volumes (particularly for larger events) is normally observed, depending on the soil properties. Therefore it may be prudent to follow the strips with another practice than can reduce flooding and channel erosion downstream.

Some treatment practices (e.g., wet ponds) can warm stormwater substantially, filter strips do not increase stormwater temperatures. Thus, they are good practices for protection of cold-water streams.

Suitability and Design

Filter strips require minimal design because they are essentially a grassed slope. Both the top and toe of the slope should be as flat as possible to encourage sheet flow and prevent erosion. They are best suited to treat runoff from roads and highways, roof downspouts, and small parking lots. They are also ideal components of the "outer zone" of a stream buffer or as pretreatment to a downstream BMP.

- Flow depth should not exceed 2/3 the height of the vegetation.
- Width should be the same as the tributary area.
- Flow length should allow a 10 minute hydraulic residence time.
- Maximum design storm velocity of 1 foot per second to minimize erosion.
- Use of low growing, drought tolerant, native vegetation.
- Irrigation must be available to support the vegetation.
- Sheet flow conditions must exist entering the strip.

Table 2 details a number of core construction components and corresponding design considerations.

Table 2. Cost of design components and associated considerations

Component	Cost	Design Consideration
Fine Grading	\$0.24/ft ²	Limited to gently sloping areas where shallow flow characteristics are possible. 1% to 6% overall slope (1% to 2% optimum).
Vegetation		
Sod (buffalo)	\$0.67/ft ²	Filter strips must be thickly vegetated. Turf grasses (not bunch grasses) should be maintained on the surface to prevent erosion and improve treatment. Water and spot fertilize during first year
Seeding	\$0.15-\$0.22/ft ²	

Vegetation

It is best to install filter strips at the time of the year when there is a reasonable chance of successful establishment without irrigation. When seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season. If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the swale or strip. Use a roller on the sod to ensure that no air pockets form between the sod and the soil.

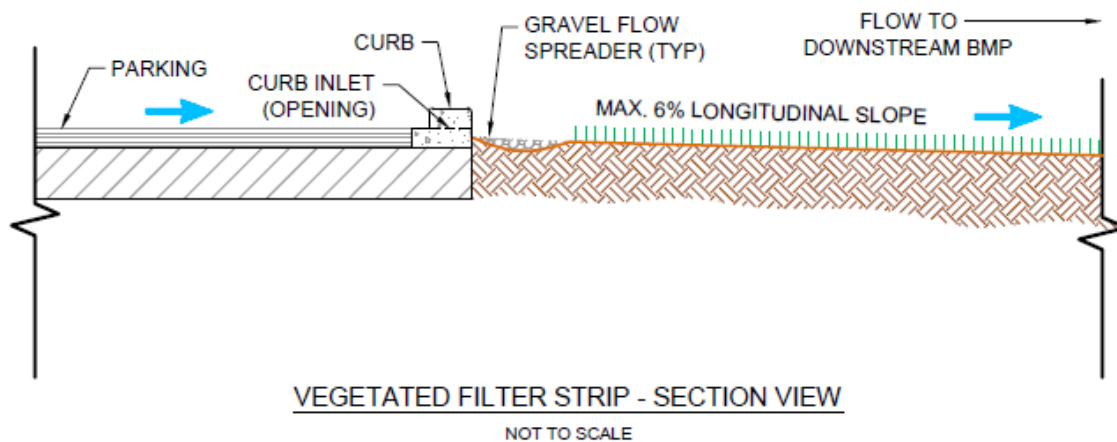
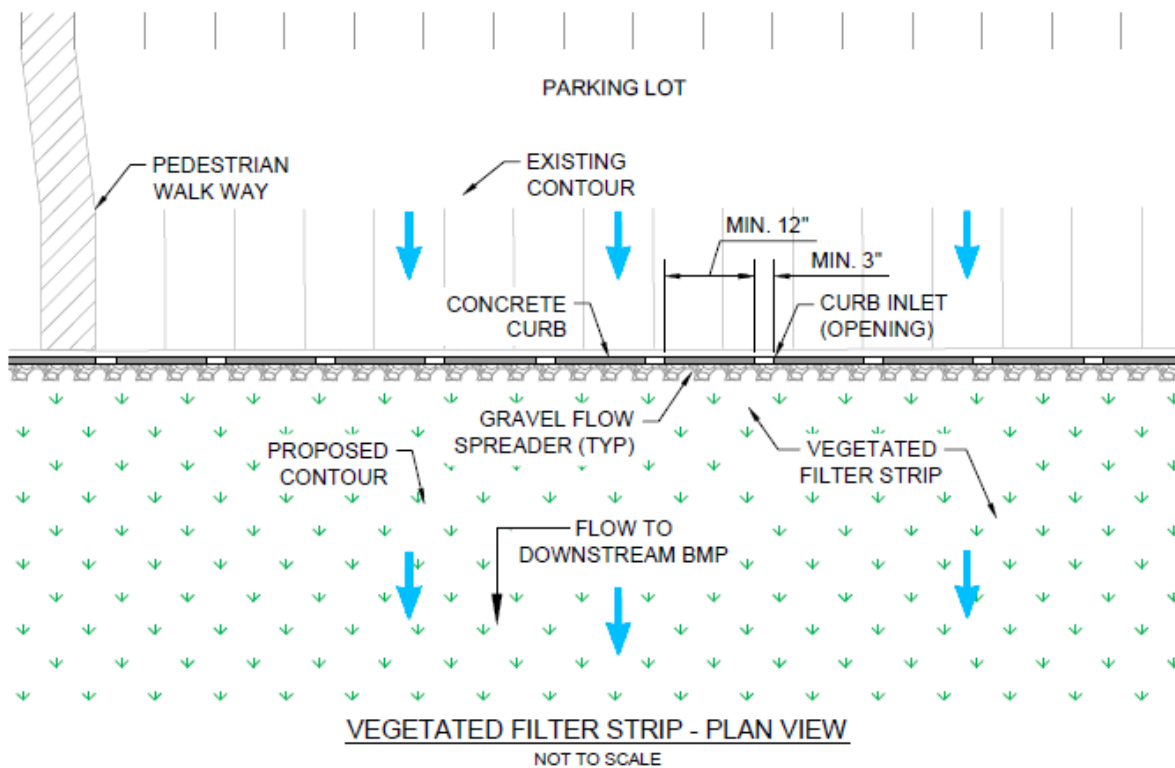
Maintenance

Filter strips require mainly vegetation management; therefore little special training is needed for maintenance crews. Typical maintenance activities and frequencies are included in Table 3.

Table 3. Typical maintenance activities and associated costs and frequency

Frequency	Cost	Activity
Routine Maintenance (required monthly to every 2 years)		
Routine (small)	\$3.73/ft ²	Remove excess sediment, trash, and debris across the surface, inlet, and outlet. Check for sediment accumulation and erosion. Mow once or twice seasonally. Inspect for ponding water to mitigate vector breeding. Repair holes created by rodents.
Routine (medium)	\$1.40/ft ²	
Routine (large)	\$1.01/ft ²	
End of Life Replacement (service life of 20 years)		
Replacement (small)	\$4.17/ft ²	Excavate to the depth of soil media. Test soil for excessive soil contamination of common stormwater pollutants (e.g. metals, nutrients). Continue to remove underlying soil if pollutants exceed standard for contaminated soil. Replace with clean soil.
Replacement (medium)	\$2.33/ft ²	
Replacement (large)	\$2.02/ft ²	
Note: Small System = 500 ft ² ; Medium System = 2000 ft ² ; Large System = 4000 ft ²		

Schematic



VEGETATED FILTER STRIP NOTES

1. GRAVEL FLOW SPREADER: 6-IN. DEEP ASTM NO. 57 STONE
2. SIGNAGE SHOULD IDENTIFY FILTER STRIP AS A STORMWATER PRETREATMENT PRACTICE AND PROHIBIT FOOT TRAFFIC OR OTHER ACTIVITIES THAT COULD COMPACT OR RUT FILTER STRIP SOILS. SIGNAGE SHOULD INSTRUCT MAINTENANCE PERSONNEL TO MOW GRASS TO MOW GRASS NO SHORTER THAN 4-IN. AND MOW PERPENDICULAR TO FLOW PATH (FOLLOWING THE CONTOURS).
3. FLOW DEPTH SHOULD NOT EXCEED 2/3 THE HEIGHT OF THE VEGETATION
4. FLOW LENGTH SHOULD ALLOW A 10 MINUTE HYDRAULIC RESIDENCE TIME
5. VEGETATION: SEE VEGETATION NOTES

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