7.3 Vegetated Filter Strips and Soil Amendment Areas

7.3.1 BMP Overview

Vegetated filter strips (a.k.a. buffer strips and grassed filter strips) are gently sloping, densely vegetated areas that treat runoff as sheet flow from adjacent impervious areas. Similarly, soil amendment areas are any landscaped area where the topsoil has been amended to enhance its water holding capacity. Typical types of soil amendments include application or restoration of 20 to 30 cm of uncompacted topsoil, rather than the standard 10 to 15 cm, and incorporation of compost to achieve between 5 and 15% organic matter content by dry weight. It is a good practice to implement such soil amendments on vegetated filter strips. Soil amendment areas that serve as SWM BMPs may receive runoff from adjacent impervious areas either by sheet flow or from a pipe (e.g., roof downspout) with a splash block or gravel diaphragm to help spread out and slow the flow of water onto the landscaped area.

In both of these types of LID BMPs vegetation slows the flow of water to enhance sedimentation, filtration/infiltration through the soil and root zones of plants and evaporation back to the atmosphere. Vegetation may be comprised of grass or a variety of trees, shrubs and native plants to add aesthetic value. Water not absorbed/infiltrated by, or evaporated from the filter bed is conveyed to an adjacent drainage system (e.g., municipal storm sewer or other BMP) at the lowest downstream point by an outlet structure (e.g., swale and ditch inlet catchbasin) or sheet flow onto an adjacent impervious surface. Key components of vegetated filter strips and soil amendment areas for inspection and maintenance are described in Table 7.13 and Figure 7.3.

Properly functioning vegetated filter strips and soil amendment areas reduce the quantity of pollutants and runoff being discharged to municipal storm sewers and receiving waters (i.e., rivers, lakes and wetlands). In addition to their SWM benefits, they provide aesthetic value as attractive landscaped features.

7.3.2 Inspection and Testing Framework

Table 7.14 describes what visual and testing indicators should be used during each type of inspection for vegetated filter strips and soil amendment areas and provides a basis for planning field work. Numbers in the first column refer to the section of Section 8.0 and Appendix C that provides detailed guidance on standard protocols and test methods for assessing the respective indicator.

Table 7.13: *Key components of vegetated filter strips and soil amendment areas for inspection and maintenance.*

Component	Description
Contributing Drainage Area	The area from which runoff directed to the BMP originates. CDAs include impervious and pervious areas draining to the BMP and the BMP itself. CDAs should be free of point sources of pollutants (e.g., leaking waste containers, spills, failing ESCs). Trash, sediment and debris should be removed regularly from pavements and other stormwater conveyances (e.g., gutters, eavestroughs) draining to the BMP.
Inlets	Inlets can be pavement edges (for BMPs receiving sheet flow) or pipes (e.g., roof downspouts). Inlets must remain unobstructed to ensure that stormwater enters the BMP as designed. Flow spreading devices (e.g., splash blocks, gravel diaphragms) are needed for pipe inlets to promote sheet flow and prevent filter bed erosion.
Perimeter	Inspection is done to confirm the dimensions and footprint area of the BMP are acceptable. For soil amendment areas, inspection involves confirming that topsoil depth and degree of compaction are acceptable in the specified areas.
Filter bed	A gently sloping (between 0.5 and 3%) vegetated area that receives runoff from adjacent impervious surfaces and is composed of a 0.2 to 0.3 metre deep uncompacted topsoil layer containing 5 to 15% organic matter by dry weight where filtration and evaporation of runoff occurs. Vegetated filter strips and soil amendment areas should not pond water on the surface during storm events. Areas should be routinely checked for presence of standing water. Trash should be removed from the filter bed regularly. Repair of animal burrows, sunken areas, erosion rills or damage from vehicle or foot traffic may also be needed to prevent surface ponding.
Vegetation	Healthy vegetation cover (i.e., grasses, herbs, shrubs, and trees) is relied upon to intercept, uptake and evapotranspire stormwater and to provide habitat for soil organisms that break down pollutants. Plant roots also help to maintain soil structure and permeability. Routine maintenance of vegetation is the same as a conventional lawn or planting bed (i.e., weeding, mowing, irrigation during droughts). In the first 2 months of establishment, plantings need to be irrigated frequently (e.g., bi-weekly). Where topsoil has been amended with compost, periodic top dressing with compost should be all that is needed to maintain healthy vegetation cover (i.e., application of chemical fertilizers should not be a part of routine maintenance).

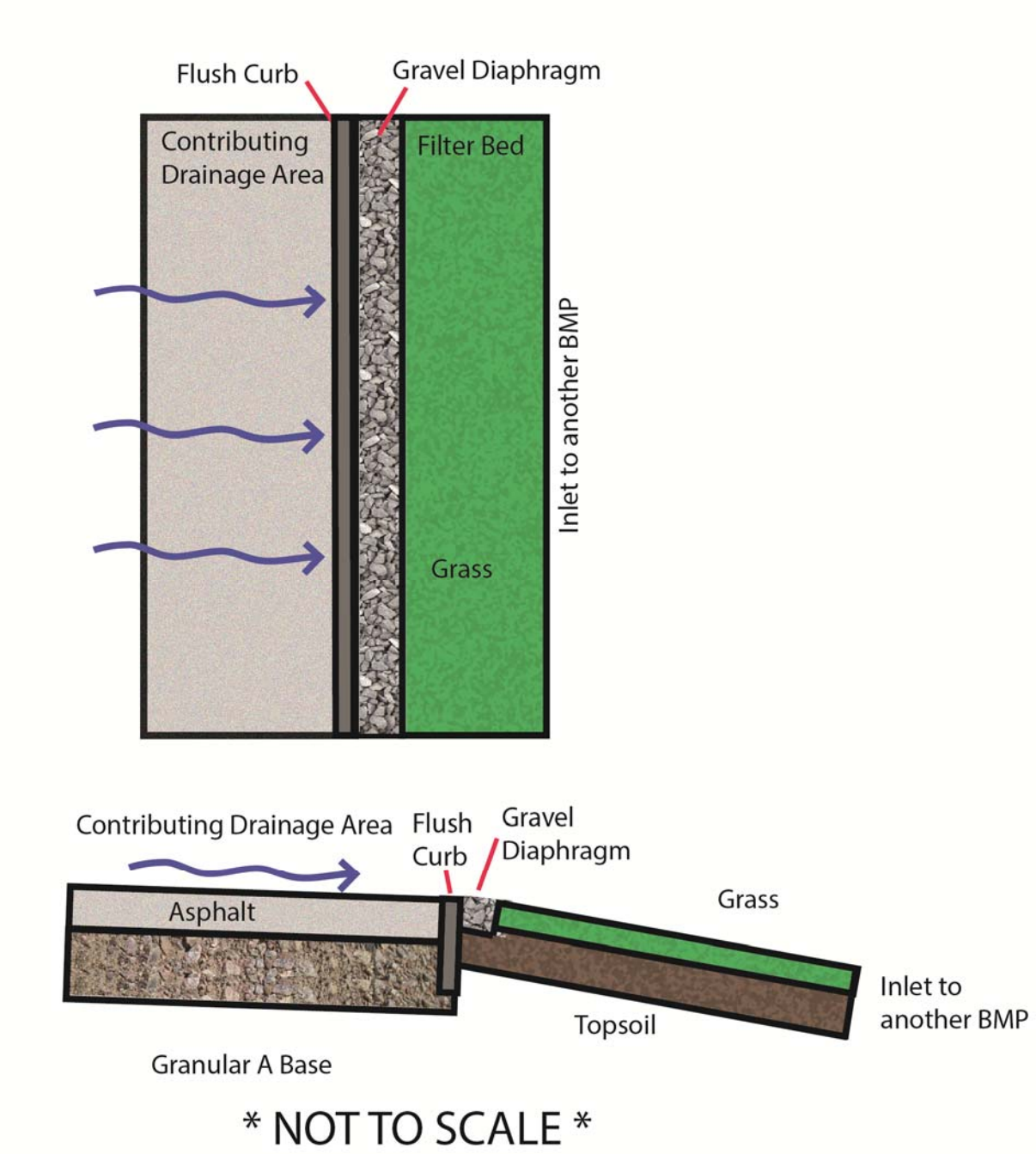

Figure 7.3: *Generalized plan and cross-section views of a vegetated filter strip showing key components.*

Table 7.14: *Inspection and testing indicators framework for vegetated filter strips and soil amendment areas.*

INSPECTION AND TESTING FRAMEWORK					
VEGETATED FILTER STRIPS & SOIL AMENDMENT AREAS		**Inspection Type**			
Section	**Indicator**	**Construction**	**Assumption**	**Routine Operation**	**Verification**
Visual indicators					
C.1	CDA condition	x	x	x	x
C.2	Inlet//Flow spreader structural integrity		x	x	x
C.3	Inlet/Flow spreader obstruction	x	x	x	x
C.6	BMP dimensions	x	x		x
C.9	Standing water		x	x	x
C.10	Trash		x	x	
C.11	Filter bed erosion		x	x	
C.15	Filter bed surface sinking		x	x	x
C.17	Vegetation cover	x	x	x	x
C.18	Vegetation condition		x	x	
C.19	Vegetation composition	x	x	x	
Testing indicators					
8.2	Soil characterization testing	x	x		(x)
8.4	Surface infiltration rate testing		x		(x)

(x) denotes indicators to be used for Performance Verification inspections only (i.e., not for Maintenance Verification inspections)

7.3.3 Critical Timing of Construction Inspections

Construction inspections take place during several points in the construction sequence, specific to the type of LID BMP, but at a minimum should be done weekly and include the following:

1. During site preparation, prior to BMP grading to ensure the CDA is stabilized or that adequate ESCs or flow diversion devices are in place and confirm that construction materials meet design specifications;
2. At completion of grading, prior to planting to ensure slopes and elevations are acceptable;
3. Prior to hand-off points in the construction sequence when the contractor responsible for the work changes (i.e., hand-offs between the storm sewer servicing, paving, building and landscaping contractors);
4. After every large storm event (e.g., 15 mm rainfall depth or greater) to ensure ESCs and pretreatment or flow diversion devices are functioning and adequately maintained.

Table 7.15 describes critical points during the construction sequence when inspections should be performed prior to proceeding further. Table 7.15 can also be used as a checklist during Construction inspections, in addition to the Inspection Field Data Forms provided in Appendix C.

Table 7.15: *Critical timing of construction inspections - vegetated filter strips and soil amendment areas.*

Construction Sequence Step and Timing	Inspection Item	Observations [1]
Site Preparation – after site clearing and grading, prior to BMP grading	Natural heritage system and tree protection areas remain fenced off	
	ESCs protecting BMP layout area are installed properly	
	CDA is stabilized or runoff is diverted around BMP layout area	
	BMP layout area has been cleared and is staked/delineated	
	Benchmark elevation(s) are established nearby	
	Construction materials have been confirmed to meet design specifications	
BMP Grading - prior to landscaping	Excavation depth, footprint and slope are acceptable	
	Excavated soil is stockpiled outside the CDA	
Landscaping – after final grading, prior to planting	Topsoil depth, degree of compaction and surface elevations at inlets and outlets are acceptable	
	Area is free of ruts, local depressions	
	Planting material meets approved planting plan specifications (plant types and quantities)	

Notes:

1. S = Satisfactory; U= Unsatisfactory; NA = Not Applicable

7.3.4 Inspection Field Data Forms

Template forms for recording inspection observations, measurements, sampling location details and follow-up actions have been prepared for each LID BMP type and can be found in Appendix C.

7.3.5 Routine Maintenance

Table 7.16 describes routine maintenance tasks for vegetated filter strips and soil amendment areas, organized by BMP component, along with recommended minimum frequencies. It also suggests higher frequencies for certain tasks that may be warranted for BMPs located in highly visible locations or those receiving flow from large or high traffic (vehicle or pedestrian) drainage areas. Tasks involving removal of trash, debris and sediment and weeding/trimming of vegetation for BMPs in such contexts may need to be done more frequently (i.e., higher standards may be warranted).

Individuals conducting vegetation maintenance and in particular, weeding (i.e., removal of undesirable vegetation), should be familiar with the species of plants specified in the planting plan and experienced in plant identification and methods of removing/controlling noxious weeds. Key resources on these topics are provided below:

- Agriculture and Agri-food Canada's WeedInfo database, http://www.weedinfo.ca/en/
- Ontario Ministry of Agriculture, Food and Rural Affairs' Ontario Weed Gallery, http://www.omafra.gov.on.ca/english/crops/facts/ontweeds/weedgal.htm
- Ontario Ministry of Agriculture, Food and Rural Affairs' Noxious Weeds In Ontario list, http://www.omafra.gov.on.ca/english/crops/facts/noxious_weeds.htm
- Ontario Invasive Plant Council's Quick Reference Guide to Invasive Plant Species, http://www.ontarioinvasiveplants.ca/files/Invasives_booklet_2.pdf
- Plants of Southern Ontario (book), 2014, by Richard Dickinson and France Royer, Lone Pine Publishing, 528 pgs.
- Weeds of North America (book), 2014, by Richard Dickinson and France Royer, University of Chicago Press, 656 pgs.

Table 7.16: *Routine maintenance tasks for vegetated filter strips and soil amendment areas.*

Component	Routine Maintenance Task	Frequency[1]	
		Minimum[2]	High[3]
Contributing Drainage Area	◖ Remove trash, natural debris, clippings and sediment	BA	Q
	◖ Re-plant or seed bare soil areas	A	BA
Inlets and Outlets	◖ Remove trash, natural debris and clippings	BA	Q
	◖ Reconfigure splash block if displaced	BA	Q
	◖ Remove accumulated sediment	A	BA
Filter bed	◖ Remove trash	BA	Q
	◖ Core aerate	Every 5 years	Every 3 years
	◖ Remove accumulated sediment when ≥ 5 cm depth ◖ Re-grade and restore cover over any animal burrows, sunken areas when ≥ 10 cm in depth and erosion rills when ≥ 30 cm in length	AN	AN
	◖ Add stone cover to maintain 5 to 10 cm depth where specified in the planting plan	AN	AN
Vegetation	◖ Watering during first two months after planting	BW	BW
	◖ Watering for the remainder of the first two (2) growing seasons (i.e., May to September) after planting or until vegetation is established	AN	AN
	◖ Watering for the remainder of the BMP lifespan	D	AN
	◖ Mow grass to maintain height between 5 to 10 cm	M	BM
	◖ Remove undesirable vegetation (e.g., tree seedlings, invasives/weeds)	BA	Q
	◖ Replace dead/diseased plants to maintain a minimum of 80% vegetation cover[4]	A	BA
	◖ Prune shrubs and trees ◖ Cut back spent plants ◖ Divide or thin out overcrowded plants	A	A

Notes:

1. A = Annually; AN = As needed based on Routine Operation inspections; BA = Bi-annually or twice per year, ideally in the spring and late fall/early winter; BM = Bi-monthly; BW = Bi-weekly or twice per week; M = Monthly; D = During drought conditions classified by Agriculture and Agri-Food Canada's Canadian Drought Monitor as severe (D2) or higher (AAC, 2015); Q = Quarterly or four times per year, ideally in the spring, summer, early fall and late fall/early winter; W = Weekly.
2. These frequencies are recommended as the minimum necessary to ensure the BMP functions adequately over its expected lifespan.
3. High priority BMPs such as or those draining to a sensitive receiving waterbody, those receiving drainage from high traffic areas, or those designed with larger than recommended impervious drainage area to pervious BMP footprint area ratios (i.e., I:P ratios), may warrant a

higher frequency of routine maintenance tasks involving removal of trash/debris/sediment and mowing/weeding/trimming of vegetation.

4. Aim to achieve 80% vegetation cover in planting areas by the end of the establishment/warranty period for the original plantings (e.g., two years after planting).

Tips to help preserve BMP function

- Because the risk of compaction is higher when topsoil is saturated, any maintenance tasks involving vehicle (e.g., ride mower) or foot traffic on the filter bed should not be performed during wet weather;
- Use push mower to maintain grass cover or the lightest ride mower equipment available to minimize compaction of the topsoil;
- Use a mulching mower to maintain grass cover or leave clippings on the surface to help replenish organic matter and nutrients in the topsoil;
- Pruning of mature trees should be performed under the guidance of a Certified Arborist;
- Woody vegetation should not be planted or allowed to become established where snow will be piled/stored during winter; and
- Removal of sediment accumulated on the filter bed surface should be performed by hand with rake and shovel, or vacuum equipment where feasible. If a small excavator is the chosen method, keep the excavator off the BMP footprint to avoid rutting and compaction of the topsoil.

7.3.6 Rehabilitation and Repair

Table 7.17 provides guidance on rehabilitation and repair work specific to vegetated filter strips and soil amendment areas organized according to BMP component.

Table 7.17: *Rehabilitation and repair guidance for vegetated filter strips and soil amendments.*

BMP Component	Problem	Task
Inlets	Inlet or flow spreading device is producing concentrated flow and causing filter bed erosion	Add flow spreading device or regrade existing device back to level to promote sheet flow to the filter bed. Regrade damaged portion of the filter bed and replant. If problem persists, consider adding turf reinforcement devices or replace filter bed vegetation cover with stone at inlets.
Filter bed	Topsoil is overly compacted	Core aerate; or remove stone, mulch and vegetation cover and till topsoil to a depth of 20 cm; or remove and replace with uncompacted topsoil that meets design specifications. Replace stone, mulch and vegetation cover (re-use/transplant where possible).

	Topsoil organic matter or phosphorus content too low AND vegetation not thriving	Top dress with compost
	Topsoil pH is out of specification range (6.0 to 7.8) AND vegetation not thriving	If soil pH is lower than 6.0, amend with ground limestone to raise the pH back to neutrality. If soil pH is higher than 7.8, amend with compost or sulphur to lower the pH back to neutrality.
	Topsoil soluble salts content exceeds 2.0 mS/cm	Flush the affected area with fresh water.
	Surface ponding remains for > 24 hours or surface infiltration rate is out of acceptable range	Remove any accumulated sediment and core aerate. If problem persists, remove vegetation, till the topsoil to a depth of 20 cm to reduce compaction, or remove and replace the uppermost 15 cm of material with topsoil that meets design specifications. Replace vegetation cover (transplant where possible).
	Damage to filter bed is present (e.g., erosion rills, animal burrows, local sinking, ruts)	Re-grade damaged portion and restore vegetation cover. Animal burrows, local sinking and compacted areas should be tilled to 20 cm depth prior to re-grading and planting.

7.3.7 Life Cycle Costs of Inspection and Maintenance

Estimates of the life cycle costs of inspection and maintenance have been produced using the latest version of the LID Life Cycle Costing Tool (STEP, 2016; TRCA & U of T, 2013b) to assist stormwater infrastructure planners, designers and asset managers with planning and preparing budgetsFor more details of the tool's assumptions, see Section 7.1.7 and refer to the project report, TRCA and U of T (2013a).

For vegetated filter strips and soil amendment areas, life cycle cost estimates have been calculated for two level-of-service scenarios: the minimum recommended frequency of inspection and maintenance tasks (i.e., Table 7.14 and Table 7.16 "Minimum Frequency" column), and a high frequency scenario (i.e., Table 7.14 and Table 7.16 "High Frequency" column) to provide an indication of the potential range. Version 1.1 of the tool does not include the an option for generating life cycle cost estimates for vegetated filter strips and soil amendment areas, but Version 2.0 does, with assumptions based on an impervious to pervious area (I:P) ratio of 2.5:1 and inspection and maintenance recommendations for enhanced swales, for relevant components.

The annual average maintenance cost represents an average of routine maintenance tasks, as outlined in Table 7.10. All cost value estimates represent the NPV as the calculation takes into account average annual interest (2%) and discount (3%) rates over the evaluation time periods.

The CDA has been defined as 2,000 m^2 of impermeable pavement (e.g., road or parking area) which drains by sheet flow to a vegetated filter strip that is approximately 800 m^2 in area (I:P ratio of 2.5:1), 70 m long, 11.4 m wide and situated along the long edge of the paved area. The side slope is defined as

12.5:1 (8%). Water enters the BMP as sheet flow from a gravel diaphragm flow spreading device along the edge adjacent to the pavement. The BMP surface is planted with grass and does not include check dams, nor any pipes or culverts.

The life cycle cost estimates for vegetated filter strips and soil amendments are presented in Table 7.18. No design variations scenarios were examined, therefore the Minimum Recommended and High Frequency maintenance scenarios (Table 7.16) are the only two scenarios examined for this BMP. It is assumed that no rehabilitation work will be needed to maintain acceptable drainage performance over a 50 year time period.

Estimates of the life cycle costs of vegetated filter strips and soil amendment areas in Canadian dollars per unit CDA ($/m^2) are presented in Table 7.18. The LID Life Cycle Costing Tool allows users to select what BMP type and design variation applies, and to use the default assumptions to generate planning level cost estimates. Users can also input their own values relating to a site or area, design, unit costs, and inspection and maintenance task frequencies to generate customized cost estimates, specific to a certain project, context or stormwater infrastructure program.

Table 7.18: *Life cycle costs for vegetated filter strips and soil amendment areas.*

Vegetated Filter Strips and Soil Amendment Areas	Minimum Frequency	High Frequency
Construction Costs	$8.18	$8.18
Rehabilitation Costs	$0.00	$0.00
Rehabilitation Period	n/a	n/a
50 YEAR EVALUATION PERIOD		
Average Annual Maintenance	$1.00	$1.57
Maintenance and Rehabilitation	$50.36	$78.32
25 YEAR EVALUATION PERIOD		
Average Annual Maintenance	$1.14	$1.79
Maintenance and Rehabilitation	$28.82	$44.32

Notes:

1. Estimated life cycle costs represent NPV of associated costs in Canadian dollars per square metre of contributing drainage area ($/m2).
2. Average annual maintenance cost estimates represent NPV of all costs incurred over the time period and do not include rehabilitation costs.
3. It is assumed that no rehabilitation is needed to maintain acceptable drainage performance over a 50 year evaluation period.
4. Maintenance costs over a 25 year time period are estimated to be between 3.52 to 5.42 times the original construction cost for the Minimum Recommended and High Frequency maintenance scenarios respectively.
5. Maintenance costs over a 50 year time period are estimated to be between 6.16 and 9.57 times the original construction cost for the Minimum Recommended and High Frequency maintenance scenarios respectively.