

## Green Roofs

# Inspection and Maintenance of Stormwater Best Management Practices

Key components of green roofs to pay close attention to are the overflow outlets. Accumulations of sediment, debris and vegetation in these locations must be removed regularly to ensure water exceeding the retention capacity of the green roof can flow freely out of the practice.

Green roofs are specially engineered rooftops designed to support the growth of vegetation while protecting the structural integrity of the roof. They can also be referred to as vegetated roofs, rooftop gardens or eco-roofs. A green roof acts like a lawn, meadow or garden by intercepting and absorbing a portion of the rainwater or snowmelt that falls on it. The typical layers of a green roof (in ascending order from the roof surface) include a water-proofing membrane, drainage layer, lightweight growing media layer and the vegetation. Excess water that is not absorbed by the growing media or vegetation is collected by the underlying drainage layer, directed to outlet structures and conveyed via the roof drainage system to another BMP or the municipal storm sewer system. A portion of the water absorbed by green roofs is returned to the atmosphere by evaporation and transpiration by plants. Green roofs are typically designed to retain precipitation from small to medium-sized (e.g., 5 to 25 mm rainfall depth) storm events. Overflow outlets are necessary to safely convey flows from major storm events. Key components of green roofs for inspection and maintenance are described in Figure 1 and Table 1.

## RELATED TERMS

**Intensive green roofs** contain greater than 15 cm depth of growing media, can be planted with deeply rooted plants (e.g., shrubs and trees) and can be designed to handle pedestrian traffic.

**Extensive green roofs** consist of a thinner growing media layer (15 cm depth or less) and are typically planted with





## BENEFITS

- Reduce the quantity of pollutants and runoff being discharged to municipal storm sewers and receiving waters (i.e., rivers, lakes and wetlands);
- Growing media and plants retain pollutants deposited from the atmosphere and reduce metals and other pollutants from conventional roof materials transported by runoff;
- Improve the energy efficiency of the building due to their insulating properties;
- Reduce the urban heat island effect;
- Can provide food and shelter for pollinators;
- Can provide aesthetic value as attractive landscaped features.

## TIPS TO HELP PRESERVE BMP FUNCTION

- To avoid over-compaction of the filter media, any maintenance tasks involving foot traffic on the filter bed should not be performed during wet weather;
- Pavers or walkways should be placed at roof access locations and along primary paths to facilitate access and avoid walking on planted portions during inspection and maintenance work;
- To perform installation, maintenance or repair work, do not use sharp tools, lawn staples and stakes which can damage the drainage layer, root barrier and water-proofing membrane. All sharp pieces of metal and fasteners should be removed from the media area with care;
- For green roofs with succulents (e.g., sedum) as vegetation cover, trim off top stems annually in the spring during the first two years of establishment and leave on the growing media surface to encourage colonization or purchase and spread fresh cuttings;
- Transplant vegetation that is established in the vegetation-free perimeter areas to supplement plantings on the filter bed if species are appropriate;
- Pruning of mature trees should be performed under the guidance of a Certified Arborist;
- Establish procedures and timing for irrigation system start-up and winterization to avoid damage to system components from freezing;
- Routinely check that the irrigation system is free of damage and delivering water evenly to vegetated areas;
- For green roofs with automated irrigation systems using municipal/drinking water, schedule watering to occur at night or early in the morning to minimize the loss of water to evaporation;
- For green roofs with automated irrigation systems using cistern water, irrigating during the day when evaporation rate is high will make greater use of stored rainwater, thereby freeing up more storage in the system for the next rain storm and helping to reduce site runoff volume.

## KEY COMPONENTS AND INSPECTION AND MAINTENANCE TASKS

Figure 1. Generalized plan and cross-section view of a green roof showing key components

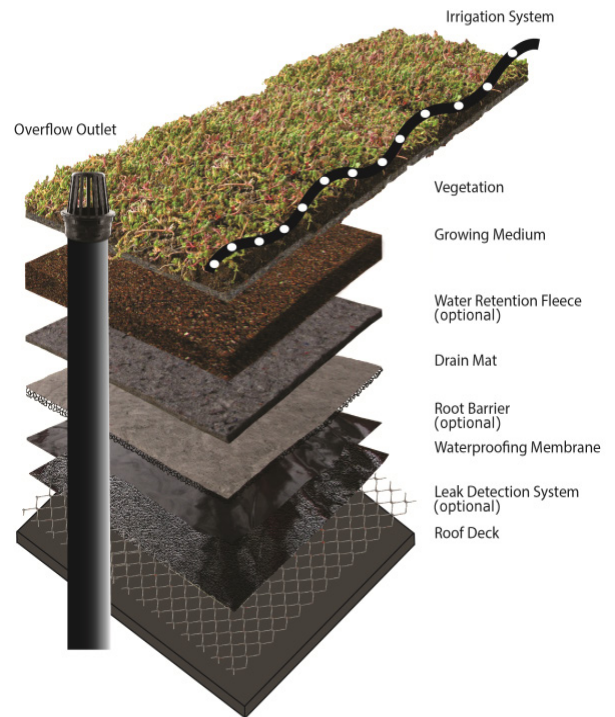


Figure 2. Green roof parkette area



Table 1. Key components, descriptions and routine inspection and maintenance tasks.

Component	Description	Inspection and Maintenance Tasks
Perimeter	Separates the green roof from the roof edges and other structures; kept clear of vegetation and natural debris as a fire prevention measure. Parapets or other wind break structures may also be present around the perimeter to help prevent wind scour of growing media.	<ul style="list-style-type: none"> <li>• Check for damage or vegetation;</li> <li>• Remove any vegetation or natural debris annually to biannually.</li> </ul>
Growing medium/filter bed	Flat or gently sloping area covered by growing medium and a mixture of plants. Growing medium varies according to the green roof system or product but is generally designed to be porous and lightweight with adequate fertility and moisture retention to support plant growth while maintaining drainage of excess water within a few hours after a storm or snowmelt event. May be covered by matting/other erosion control product to prevent rain/wind scour while plantings are becoming established.	<ul style="list-style-type: none"> <li>• Check for standing water, animal burrows or damage from foot traffic, rain or wind scour;</li> <li>• Replace erosion/scour protection where missing or uplifted;</li> <li>• Remove trash and natural debris annually to biannually.</li> </ul>
Vegetation	Plants should be tolerant of the harsh conditions prevalent on rooftops. Use of a wide variety of plants may improve resilience but complicates maintenance and may require staff or contractors trained in horticulture.	<ul style="list-style-type: none"> <li>• Maintenance is similar to a conventional perennial planting bed;</li> <li>• Water bi-weekly in the absence of rain during first two months and as needed for the remainder of the first growing season;</li> <li>• Remove undesirable vegetation biannually to quarterly;</li> <li>• Prune shrubs and trees annually, and replace dead plants to maintain a minimum of 80% cover by the third growing season.</li> </ul>
Overflow outlets	Flows exceeding the storage capacity of the BMP are conveyed to an adjacent drainage system via an overflow outlet structure and the roof drainage system.	<ul style="list-style-type: none"> <li>• Remove trash, natural debris and clippings biannually to quarterly;</li> <li>• Flush with hose or pressure washer annually to biannually.</li> </ul>
Irrigation system	Most green roofs will require watering over their operating life cycle, especially during the first 2 months. Systems can range from simple hose bibs, garden hoses and sprinklers to intelligent automated systems that schedule watering based on weather forecasts and cistern water levels.	<ul style="list-style-type: none"> <li>• In the spring, reconnect all parts to the water supply, flush lines to clear out any debris or sediment and test to confirm that the system is undamaged and functioning well;</li> <li>• In the late fall/early winter, disconnect the system from the water supply, connect it to an air compressor and blow air through it to remove water and ensure the lines and parts are dry, shut off water supply to the roof, and drain all hose bibs;</li> <li>• Remove any debris/sediment accumulated on filters biannually.</li> </ul>
Protective layers	May be one or two layers; designed to protect the roof deck from water damage, including a water-proofing membrane, a root barrier that protects the water-proofing membrane from root penetration and degradation by microbial activity.	<ul style="list-style-type: none"> <li>• Repair isolated leaks in the water-proofing membrane through deconstruction of a small portion of the green roof, patching with new material, and reconstruction.</li> </ul>



Figure 4. Urban green roofs



REHABILITATION

Table 2. Key components, typical problems and rehabilitation tasks.

Component	Problem	Rehabilitation Tasks
Growing media	Eroded growing media area $\geq 30$ cm in length or other damage is present	Restore growing media to required depth with material that meets design specifications, replant and irrigate bi-weekly or as needed until plantings are established. If problems persist, consider covering with matting or other erosion control measure until plantings are established or adding parapets or other wind break structures.
	Surface ponding remains for $> 3$ hours after the end of a storm event because water does not infiltrate through the growing media	Aerate (i.e., rake) or replace growing media in problem areas taking care not to damage the drainage or protective layers.
	Surface ponding remains for $> 3$ hours after the end of a storm event because the drainage layer is clogged	Consult with green roof designer or product manufacturer/vendor to determine corrective actions.
Vegetation	Plants are not thriving AND growing medium is low in organic matter ( $< 3\%$ ) or available phosphorus ( $< 2.2$ mg/kg)	Amendment or fertilizer application should be prescribed by the medium manufacturer or product vendor.
Overflow outlets	Surface ponding remains for $> 3$ hours after the end of a storm event because overflow outlet is obstructed	Remove the obstruction which may require the use of a pressure washer or drain-snaking service.
Irrigation system	Distribution line, fitting or sprinkler nozzle is leaking, damaged or misaligned.	Identify the location of the damaged system component through testing (i.e., running the system in each zone while making observations). Turn off the system and schedule the repair work.
Protective layers	Water-proofing membrane has reached 40 years of age and is due for replacement.	Deconstruct the green roof, replace the water-proofing membrane with new material, and reconstruct with materials that meet design or product specifications.



## TYPES OF INSPECTIONS

**Routine Operation:** Regular inspections (annually, at a minimum) done as part of routine maintenance tasks over the operating phase of the BMP life cycle to determine if maintenance task frequencies are adequate and determine when rehabilitation or further investigations into BMP function are warranted.

**Maintenance and Performance Verification:** Periodic inspections done every 5 years (Maintenance Verifications) and every 15 years (Performance Verifications) post-construction over the operating phase of the BMP life cycle to ensure compliance with maintenance agreement (e.g., Environmental Compliance Approval permit) conditions, evaluate functional performance and determine when rehabilitation or replacement is warranted.

## INSPECTION TIME COMMITMENTS AND COSTS

Estimates are based on an extensive green roof with 15 cm of growing medium, irrigation and water-proofing membrane with leak detection system; estimates for other combinations of these variables are described in the Low Impact Development (LID) Stormwater Management Practice Inspection and Maintenance Guide available at <https://sustainabletechnologies.ca>.

Figure 5. Overflow outlets



Table 3. Time commitments and costs for inspection of a green roof

Green Roofs	Routine Operation	Maintenance Verification	Performance Verification
Tasks to complete	8	5	5
Visits (per year)	2	1 every 5 years	1 every 15 years
Time (hours per m <sup>2</sup> BMP area)	0.001	0.0004	0.0004
Cost	\$0.03	\$0.02	\$0.34
<b>Performance Verification Options (\$ per m<sup>2</sup> BMP area)</b>			
Irrigation system testing: \$0.05			
Leak detection system testing: \$1.50			

Table 4. Task cost estimates for maintenance and rehabilitation of a green roof

Green Roofs	Costs per m <sup>2</sup> of BMP area	
Tasks	Min.	High
Watering - first year only	\$0.89-\$0	\$0.89-\$0
Watering - second year only	\$0.30-\$0	\$0.37-\$0
Annual watering - Starts in year 3	\$0.09-\$0	\$0.18-\$0
Drought watering	\$0.05-\$0	\$0.05-\$0
Weeding	\$1.09	\$2.18
Remove litter	\$0.33	\$0.63
Test membrane	\$1.50	\$1.50
Repair membrane, small leak	\$0.38	\$0.76
Plant replacement - starts year 2	\$0.98	\$1.95
Green roof irrigation test	\$0-\$0.05	\$0-\$0.05
Rehabilitation	\$112.91-\$234.76	\$112.91-\$234.76

Figure 5. Maintenance being performed on a green roof





“Minimum” and “High” life cycle costs estimates are based on two different types of extensive green roof systems; a low cost 10 cm deep without irrigation and water-proofing membrane design and a higher cost 15 cm deep with irrigation and membrane design. For a detailed description of construction, inspection, maintenance and rehabilitation cost assumptions see section 7.1.7 of the LID Stormwater Management Practice Inspection and Maintenance Guide. To generate BMP-specific cost estimates use the LID Life Cycle Costing Tool available at <https://sustainabletechnologies.ca>.

Table 2. Construction and life cycle cost estimates

Green Roofs	Costs per m <sup>2</sup> of BMP area + CDA	
	Minimum	High
Construction	\$126.40-\$244.75	
LIFE CYCLE COSTS		
25 year evaluation period		
Average annual maintenance	\$2.80 - \$2.85	\$5.15
Maintenance and rehabilitation	\$69.55 - \$71.85	\$128.70 - \$129.05
50 year evaluation period		
Average annual maintenance	\$2.50 - \$2.60	\$4.65
Maintenance and rehabilitation	\$257.55 - \$362.45	\$363.00 - \$464.25

Figure 6. Green roof with seating area



Figure 7. Goose nest on a green roof



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For more detailed information on inspection, testing and maintenance of green roofs and a field data form (checklist) to use for collecting and recording inspection results, please refer to Appendix D of the Low Impact Development Stormwater Management Practice Inspection and Maintenance Guide, available at <https://sustainabletechnologies.ca>.

For more information about STEP and other resources and studies related to stormwater management, visit our website or email us at [STEP@trca.on.ca](mailto:STEP@trca.on.ca).