5.3.8 Green Roofs

Description

A green roof (also referred to as a vegetated roof or living roof) consists of vegetated roof cover used to mimic the hydrologic performance of surface vegetation rather than the impervious surface cover of a flat or pitched roof. Green roofs are effective in reducing the volume of runoff from a roof as well as the rate at which runoff leaves a rooftop. Green roofs help to minimize thermal impacts to downstream receiving waters. Green roofs may be designed to accommodate functions ranging from simple rainfall management to more complex systems that integrate rainfall management with livable/usable space.

Green roofs may be designed to meet a variety of goals and conditions. Green roofs may be **extensive** systems, designed to be very simple, light systems with a relatively thin (2- to 4-inch) layer of engineered media installed with a variety of drought-resistant vegetative species. Extensive green roofs are lightweight, low cost, and low maintenance. More complex green roof designs, referred to as **intensive** systems, incorporate deeper soils to promote and sustain larger planting structures and integrate human occupancy of roof space (see Figures 5.8-1and 5.8-2). Regardless of the complexity of the system, green roofs may be designed and constructed to meet stormwater management requirements.

Green roof plant species, especially for extensive green roofs, generally have shallow root systems, good regenerative qualities, and resistance to direct solar radiation, drought, frost, and wind.

Green roofs always include one or more drainage layers, separation fabrics (which may include a root barrier), and a waterproofing system, which is one of the more important components of a green roof. Designs and specifics vary with different manufacturers and designers.

In addition to stormwater benefits, green roofs provide direct benefits in terms of increased longevity of the roofing system (by protecting the roof from temperature extremes) and insulation benefits that may reduce heating or air-conditioning energy costs.

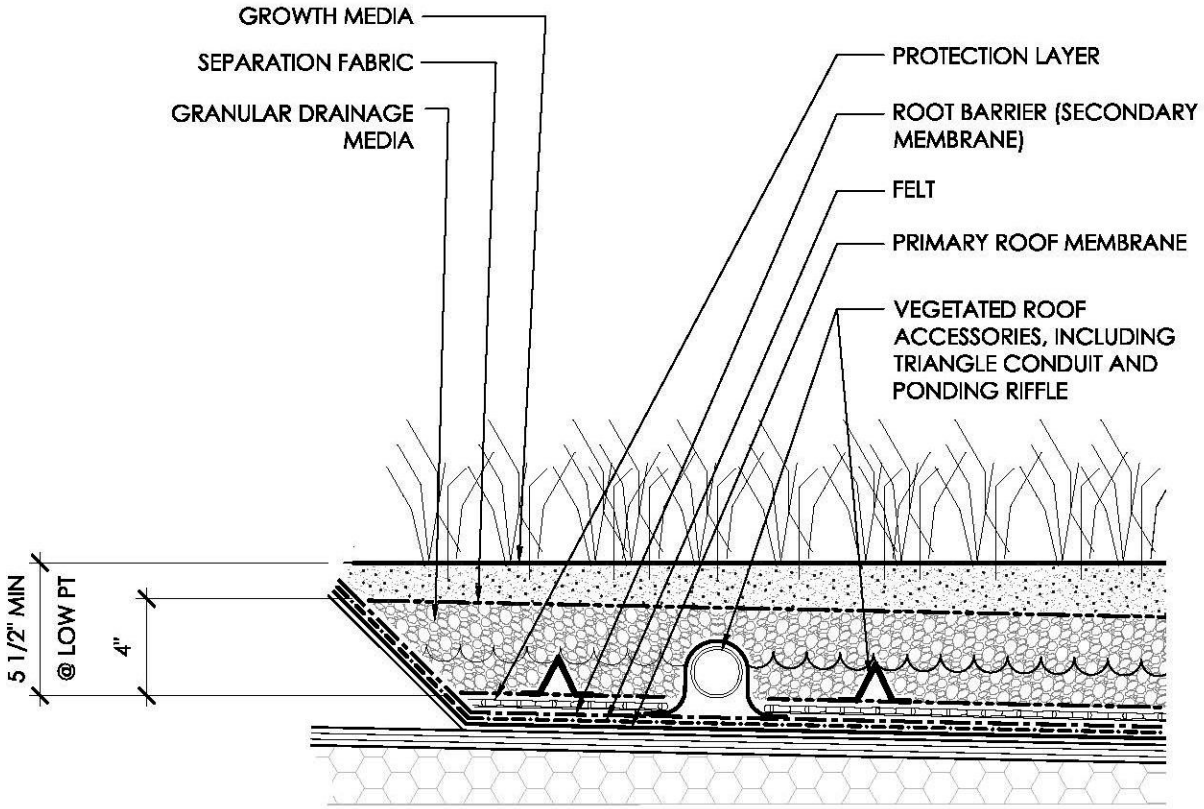

Figure 5.3.8-1. Example of extensive green roof cross-section.

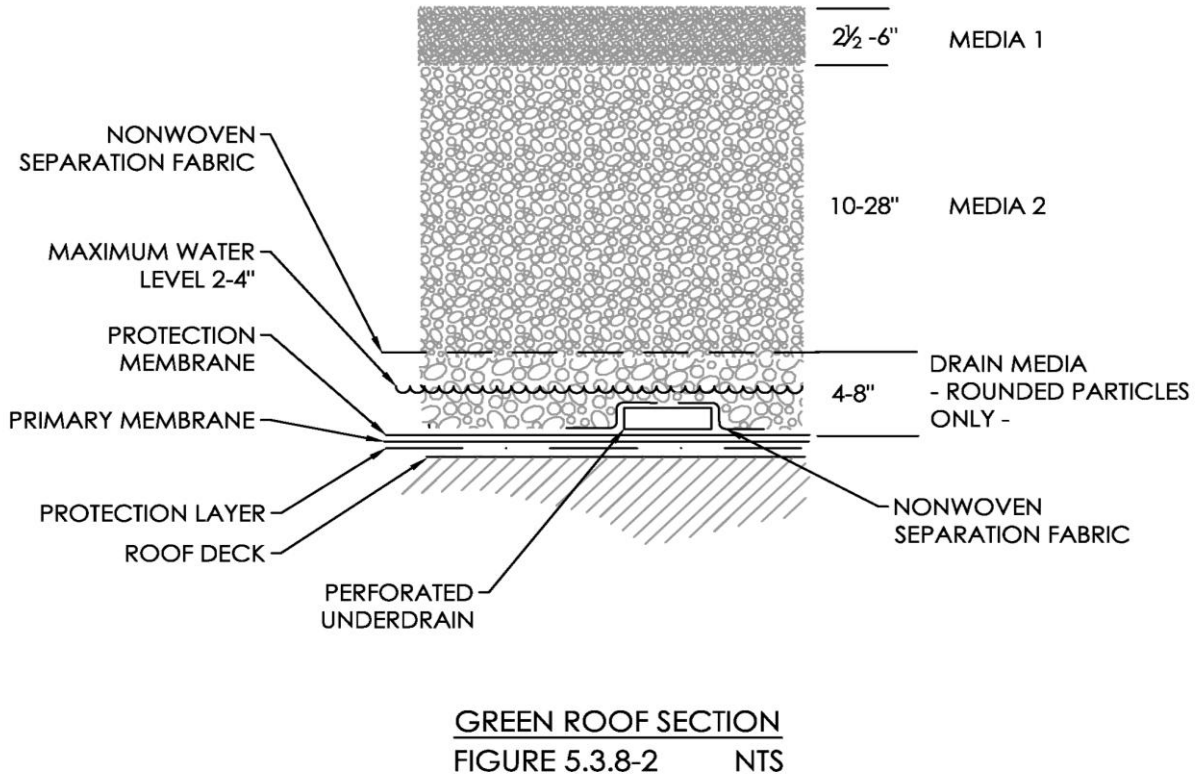

Figure 5.3.8-2. Example of intensive green roof cross-section.

BMP Functions Table

BMP	Applicability	Volume Reduction	Water Quality	Peak Rate Reduction	Recharge	Runoff Temperature Mitigation	Heat Island	Habitat Creation	Maintenance Burden*	Cost**
Green Roof	U/S/R	M	H	H	L	H	H	M	L/M	M/H

KEY: U = Urban; S = Suburban; R = Rural; H = High; M = Medium; L = Low

*Maintenance burden depends on design.

**Initial cost may be relatively high, but low over the long-term.

Key Design Features

- 2 to 6 inches of engineered growing media with high mineral content; assemblies that are 4 inches and deeper may include more than one type of engineered media.
- One or more drainage layers.
- Engineered media for extensive vegetated roof covers is typically 85 percent to 97 percent non-organic (wet combustion or loss on ignition methods).
- Vegetated roof covers intended to achieve water quality benefits should not be fertilized.
- Internal building drainage, including provisions to cover and protect deck drains or scuppers, must anticipate the need to manage large rainfall events without inundating the cover.
- Assemblies planned for roofs with pitches steeper than 2:12 must incorporate supplemental measures to ensure stability against sliding.
- May include a wind erosion stabilization system.

Applications

- Residential
- Institutional
- Commercial
- Industrial
- Roadside (i.e., atop bus shelter)

Advantages

- Appropriately designed green roofs can manage quantity, improve quality, and reduce the rate of stormwater runoff.
- Green roofs provide energy savings by providing an insulating layer to buildings, which also provides sound-absorbing benefits to the building and surroundings.
- Green roofs mitigate urban heat island effects and reduce atmospheric levels of greenhouse gases.
- Green roofs provide habitat for birds, butterflies, and other animals that may be displaced due to building development.

Disadvantages

- Green roofs are not recommended in areas where groundwater recharge is desired.
- Green roofs may be more expensive to design and construct than other BMPs, particularly when retrofitting an existing building if structural modifications are required for the additional roof load.

- Maintenance for green roofs may require weeding and watering to be done by hand, especially during establishment.

Figure 5.3.8-3. Green roof at the Kresge Foundation in Troy, Michigan.

Roadside Green Roof

Figure 5.3.8-4. Green roof on a bus shelter (http://inhabitat.com/philadelphia-plants-its-very-first-bus-stop-green-roof/philly-bus-green-roof-7/?extend=1).

Hotel Green Roofs

Figure 5.3.8-5. Chattanooga green roof at the Crash Pad.

Institutional Green Roofs

Figure 5.3.8-6. Extensive green roof plaza atop a parking garage at UNC Chapel Hill.

Commercial Green Roofs

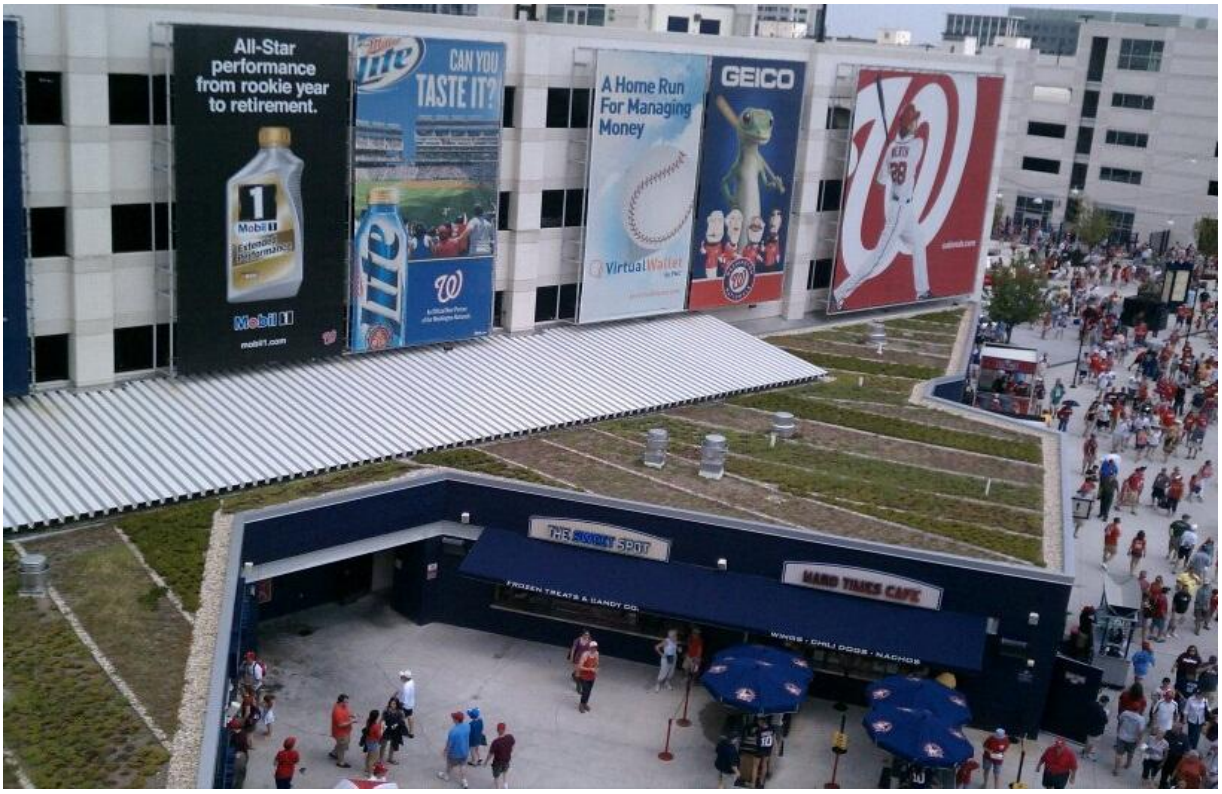

Figure 5.3.8-7. Green roof at a Washington Nationals Stadium.

Applicable Protocols and Specifications

The following protocols and specifications (see Appendices A through F) are applicable to green roofs and must be addressed:

- Protocol 5 Planting and Mulching
- Stormwater System Specifications
  - Impervious Liners and Waterproofing

Manufacturer specifications and design criteria must also be addressed.

Design Considerations for Green Roofs

All green roofs are designed with four primary component layers (from bottom to top): a waterproofing layer, an insulating layer, a stormwater storage layer, and a growth (vegetated) layer. Green roofs may be designed to meet a variety of stormwater and development program goals, when carefully designed using the following considerations:

1. Location and Capture Area

Green roofs are typically designed to manage the rainfall that falls onto the vegetated area. They also may be sized to manage runoff from other roof areas where vegetation may not be established (e.g., areas of steeply pitched roofs, air conditioning units).

2. Entrance/Flow Conditions

For green roofs situated atop roofs with slopes greater than 1.5 percent, battens should be incorporated to hold drainage layers in place and temporary erosion control measures should be implemented to minimize erosion while vegetation is established.

Green roofs that receive drainage from more steeply sloped roof areas should include an area for velocity dissipation (i.e., cobbles) prior to runoff flowing onto the vegetated area.

3. Management of Sediment, Trash, and Debris

Green roofs designed to integrate human occupancy of roof space should have a maintenance program that includes frequent inspection and removal of accumulated trash and debris.

4. Storage and Stay-on-Volume

Green roofs may be designed to manage SOV or a portion of SOV. To be excluded from the SOV area, the green roof must be designed with a minimum media depth of 2½ inches.

For green roofs intended to manage runoff from non-vegetated roof areas, supporting calculations must be provided showing that the roof design has capacity to receive additional runoff.

5. Surface Area and Dimensions

The size and surface area of a green roof are a function of the building program and architectural preferences. Depth of growing media, drainage media, and other components vary based on manufacturer or design criteria.

6. Overflow and Peak Rate

All green roofs must provide a safe way for water to exit the system when large storms generate more stormwater runoff than the media can hold. The inclusion of a positive overflow route ensures that flooding risks, which can cause overloading of the structural capacity of the building and related property damage, are minimized.

The positive overflow route is most often via the downspouts and roof gutters normally provided in the building design.

Careful consideration must be provided to maintenance of downspouts and roof gutters, particularly with regard to accumulation of debris from plants during seasonal changes.

Figure 5.3.8-8. Green roof drainage box (image courtesy of Roofmeadow).

Peak Rate Control Credit

For the purposes of site peak rate control, the designer may use a Curve Number of 75 for green roof areas.

7. Underdrain

Green roofs that include additional storage capacity (i.e., those managing other non-vegetated areas) may be designed with an underdrain to allow for positive outflow of larger design storms. Underdrains may be designed as perforated pipes connected to roof gutters or manufactured products that promote positive drainage.

Non-vegetated areas managed by underdrained green roof systems may not be excluded from SOV area calculations.

Figure 5.3.8-9. Installation of drainage layer beneath intensive green roof.

8. Waterproofing

All vegetated roof covers require a premium waterproofing system. Depending on the waterproofing materials selected, a supplemental root-fast layer may be required to protect the primary waterproofing membrane from plant roots.

Insulation, if included in the roof covering system, may be installed either above or below the primary waterproofing membrane. Most vegetated roof cover systems can be adapted to either roofing configuration.

Figure 5.3.8-10. Geotextile and root protection.

Construction Considerations

- Install waterproof membranes carefully to ensure that the structural integrity of the roof and building are maintained.
- It is strongly recommended to test for water tightness prior to installation beyond the waterproof layer.
- Implement temporary erosion controls, including control measures for dust suppression, during construction until vegetation has been suitably established.
- Follow specific manufacturer or designer construction requirements.

Operations and Maintenance

All green roofs require regular maintenance to ensure proper function.

- Green roof area should be weeded at least twice per year.
- Detritus and other debris should be removed regularly from gutters, downspouts, and other screens and filters to prevent system clogging.
- Waterproof layers (and roof substructure) should be inspected regularly for signs of water below the vegetated cover.