

# F.9 Green Roofs

### F.9.1 Green Roof Plan Standards

1. Verify that the plans include an appropriate sequence of construction that is specific to the construction of the green roof. Refer to Section 4.3.5 for guidance. [Section 2.3.1]
2. Verify that the plans include an appropriate cross-sectional detail for the green roof. [Section 2.3.1]
3. Verify that a roof drainage plan is provided and that the roof drainage is consistent with the green roof design. [Appendix E, Table E-7]

### F.9.2 Green Roof Design Standards

1. Verify that runoff from impervious roof area onto the green roof is dispersed evenly across the green roof surface and passes through the growing medium either by sheet flow or a level spreading device. [Section 4.3.3, 1]
2. Verify that the flow path of runoff across the green roof surface is greater than or equal to the contributing DCIA length. [Section 4.3.3, 2]
3. Verify that structural loading is considered for the green roof design, and that the green roof design is coordinated with a licensed structural engineer for both new building construction and retrofits to existing structures. [Section 4.3.3, 3a]
4. If runoff estimation calculations are required, verify that the correct curve number for the proposed green roof is used in the calculations. Refer to Table 3.4-2 of the Manual. [Section 4.3.3, 4a]
5. If flow routing is required, verify that the rational coefficient used is 0.40. [Section 4.3.3, 4b]
6. If flow routing is required, verify that the time of concentration used is six minutes. [Section 4.3.3, 4c]
7. Verify that the total amount of impervious surfaces within the designated boundary of the green roof footprint does not exceed 1/3 of the combined area. [Section 4.3.3, 5]
8. If runoff is conveyed via piping, verify that a distribution piping manifold embedded in a gravel strip, along with an appropriate detail, is provided on the plans to dissipate energy and promote uniform flow. [Section 4.3.3, 7]
9. For green roofs that receive direct (1:1) rainfall only, verify the following:
  - a. The minimum allowable thickness of the green roof growing medium is three inches. This can include both an upper finer-grained medium and a basal foundation growth media (lightweight drainage aggregate). The minimum allowable thickness of the foundation growth media is one inch. [Section 4.3.3, 9a]
  - b. Green roofs that meet minimum growing medium thickness requirements are permitted a DCIA reduction equal to the entire area of the green roof. [Section 4.3.3, 9b]

10. For green roofs that receive runoff from contributing impervious roof catchments, verify the following:
  - a. Impervious roof areas that direct runoff onto the green roof cannot exceed 50% of the green roof area, which is equivalent to a maximum hydraulic impervious runoff loading ratio of 0.5:1. [Section 4.3.3, 10a]
  - b. The minimum thickness of the green roof growing medium must be calculated as follows, where the “impervious roof area to green roof area” ratio is less than or equal to 0.50: [Section 4.3.3, 10b]  
$$\text{Minimum thickness (in inches) of green roof growing medium} = 3 \text{ inches} + \left[ 3 * \left( \frac{\text{Impervious roof area}}{\text{Green roof area}} \right) \right]$$
  - c. Green roofs that meet minimum growing medium thickness requirements are permitted a DCIA reduction equal to the entire area of the green roof. Impervious roof areas that drain to these green roofs can be also considered as disconnected impervious cover, and, thus, included in the green roof’s DCIA reduction. [Section 4.3.3, 10c]
  - d. In areas that will receive tributary discharge, verify that the plans include specifications that demonstrate that the drainage layer is not a high-transmissivity drainage layer, defined as a layer with a transmissivity of 0.005 m<sup>2</sup>/s or greater (ASTM D4716). In general, this will exclude peg-style or egg-carton-style geosynthetic sheets. High-transmissivity drainage layers will allow runoff to effectively flow under the green roof, minimizing contact with medium and plant roots. Typical granular aggregate, or coarse granular green roof medium, with a grain-size distribution complying with ASTM gradation No. 7 will satisfy the requirement, as will also a variety of mats and composite drainage layer assemblies. [Section 4.3.3, 10d]
  - e. Verify that any deck built atop a green roof that does not allow for sheet flow runoff is slotted, and that the minimum thickness of growing medium required for the green roof is maintained under the entire extent of the deck. [Section 4.3.3, 10e]
11. Verify that the plans indicate that the saturated permeability of the growing medium, in its compacted state [ASTM E2399], is not less than six inches per hour. [Section 4.3.3, 11]
12. Verify that a drainage layer is provided and that it prevents ponding of runoff in the growing medium during the ten-minute maximum rainfall rate associated with the one-year, 24-hour storm event. [Section 4.3.3, 13]
13. Verify that the contributing area of rooftop to each disconnected discharge point is equal to, or less than, 500 square feet. [Section 4.3.3, 15]
14. Verify that details are provided on the plans that demonstrate that all drains and scuppers are covered and protected by an enclosure, typically a square or round chamber with a locking lid. These chambers are designed to prevent clogging of the drains by debris. [Section 4.3.3, 17]
15. Verify that the roof drainage system and the remainder of the site drainage system safely convey roof runoff to the storm sewer, combined sewer, or receiving water. [Section 4.3.3, 18]
16. Verify that the green roof is designed to allow for safe access and working conditions for green roof inspection and maintenance personnel. This access must be a permanent feature of the building, such as a pilot house, roof hatch, or exterior stairs to the green roof. Retractable, unsecured ladders should not be required for routine maintenance and inspections. The design may include other permanent personal safety measures. For green roofs, designers must specifically assess applicability to Occupational Safety and Health Administration (OSHA) Fall Protection Safety Standards and the American National Standards Institute (ANSI) and American Society of Safety Engineers (ASSE) consensus-based fall protection standards. [Section 4.3.3, 20]

### F.9.3 Green Roof Material Standards

1. Verify that the green roof growing medium is specified on the plans to be a lightweight mineral material with a minimum of organic material that meets the following specifications: [Section 4.3.4, 2]
  - a. Moisture content at maximum water holding capacity (ASTM E2399 or FLL): 40% to 60% (vol)
  - b. Porosity at maximum water holding capacity (ASTM E2399 or FLL): 10% to 15%
  - c. Density at maximum water holding capacity (ASTM E2399 or FLL):  $\leq 85$  lb/ft<sup>3</sup>
  - d. Total organic matter (MSA): 6% to 10% (dry weight)
  - e. pH (MSA): 6.5 to 7.8
  - f. Soluble salts (DPTA saturated media extraction):  $\leq 2$  mmhos/cm
  - g. Water permeability (ASTM E2399 or FLL): 0.25 in/min to 1.25 in/min
  - h. Grain-size distribution consisting of  $\leq 4.5\%$  passing for clay (0.002 mm) and 5% to 15% passing for silt (0.05 mm)
  - i. The nutrients must be initially incorporated in the formulation of a suitable mix for the support of the specified plant materials.
  - j. The medium must withstand freeze/thaw cycles.
2. Verify that the foundation growth media (lightweight drainage aggregate) is specified on the plans to be composed of blended media that meets the following specifications: [Section 4.3.4, 3]
  - a. Density at maximum water capacity (ASTM E2399-05):  $\leq 65$  lbs/ft<sup>3</sup>
  - b. Maximum water holding capacity: 15% to 25%
  - c. Water permeability (ASTM E2396-05):  $\geq 25$  in/min
  - d. Total organic matter by loss on ignition (ASTM F1647):  $\leq 1\%$
  - e. Porosity (ASTM C29): 20% to 65%
  - f. Grain-size distribution (ASTM C136) consisting of the following gradations:
    - i. Pct. Passing US#18 sieve (1.0 mm):  $\leq 5\%$
    - ii. Pct. Passing  $\frac{1}{4}$ -inch sieve:  $\leq 30\%$
    - iii. Pct. Passing  $\frac{3}{8}$ -inch sieve (9.5 mm):  $\geq 75\%$
    - iv. Pct. Passing  $\frac{1}{2}$ -inch sieve (12 mm): 100%
3. Verify that geotextile is specified on the plans to consist of polypropylene fibers and to meet the following specifications (AASHTO Class 1 or Class 2 geotextile is recommended): [Section 4.3.4, 4]
  - a. Grab Tensile Strength (ASTM-D4632):  $\leq 120$  lbs
  - b. Mullen Burst Strength (ASTM-D3786):  $\geq 225$  psi
  - c. Flow Rate (ASTM-D4491):  $\geq 95$  gal/min/ft<sup>2</sup>
  - d. UV Resistance after 500 hrs (ASTM-D4355):  $\geq 70\%$
  - e. Heat-set or heat-calendared fabrics are not permitted

4. For vegetated cover assemblies with an overall thickness of five inches or greater, verify that the drainage layer is specified on the plans to meet the following specifications: [Section 4.3.4, 5b]
  - a. Abrasion resistance (ASTM-C131-96):  $\leq 25\%$  loss
  - b. Soundness (ASTM-C88):  $\leq 5\%$  loss
  - c. Porosity (ASTM-C29):  $\geq 25\%$
  - d. Percent of particles passing 1/2-inch sieve (ASTM-C136):  $\geq 75\%$
  - e. The minimum thickness of the granular layer must be two inches. The granular layer may be installed in conjunction with a synthetic reservoir sheet.
5. Verify that all waterproof membranes meet appropriate ASTM specifications. PVC membranes must meet ASTM D4434 requirements, EPDM membranes must meet ASTM D4637 requirements, and TPO membranes must meet ASTM D6878 requirements. [Section 4.3.4, 6b]
6. Verify that all waterproofing membranes are fully waterproof with properly sealed seams, corners, and protrusions to prevent any intrusion of standing water above the membrane. [Section 4.3.4, 6c]
7. Verify that roofing membranes meet all building code requirements and guidelines of the City of Philadelphia. [Section 4.3.4, 6d]
8. Verify that the proposed green roof plantings are indicated on the plans and that the proposed plantings and are non-invasive. Refer to **Appendix I** [water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/](http://water.phila.gov/development/stormwater-plan-review/manual/appendices/i-plant-lists/) for plant lists. [Section 4.3.4, 7]
9. Verify that sedum sarmentosum, also known as star sedum, gold moss, stringy stonecrop, or graveyard moss, is not proposed. [Section 4.3.4, 10]