Greenville County Technical Specification for:

WQ-24 GREEN ROOF

1.0 Green Roof

1.1 Description

A Green Roof or Rooftop Garden is a vegetative layer grown on a building rooftop. Green roofs provide shade and remove heat from the air through evapotranspiration, reducing temperature of the roof surface. Green roofs help conventional roofs last longer and reduces energy cost with natural insulation.

The type of Green Roof used for a project is determined by the load that the building can support and approved building codes. A licensed professional structural engineer or architect will determine which system is best suited for any building based on the structural analysis of the building. Typically, Green Roofs are identified as either an extensive green roof or an intensive green roof.

- Extensive Green Roof – Much lighter loads than intensive green roof. Soil depth is typically 1-6 inches and the weight load is 15-50 pounds per square foot. Plants such as sedums and prairie flowers are utilized on extensive green roofs because they are low to the ground, will not be destroyed by nesting birds, require less maintenance, and can tolerate widely varying weather conditions.

- Intensive Green Roof – More complex and heavier loads than extensive green roof. Soil depth is typically 6-24+ inches and the weight load is 80-150 pounds per square foot. Intensive green roofs use a greater variety of plants including hardy perennials, native flowers, shrubs, and small trees.

1.2 Roof Components and Materials

The applicability of Green Roofs is limited by site specific characteristics. At a minimum, Green Roof installations include the following design components:

- Waterproofing Membrane
- Root Barrier
- Insulation
- Drainage and Flashing
- Growing Medium
- Vegetation
- Vegetation Free Zones
- Irrigation

Follow specific design requirements for each component listed above as directed in this specification or by the Green Roof product manufacturer recommendations.

1.2.1 Waterproofing Membrane

The most critical component of a Green Roof, or any roof, is its ability to prevent water from entering the building. The waterproofing membrane prohibits water from penetrating the building while also facilitating run-off. It is comprised of a material able to withstand hydrostatic pressure (ponding water) for extended periods of time. The membrane needs to be installed by a professional experienced in Green Roof applications as this layer is essential to the success of the system. The warranty of the product and the installation, restrictions, and obligations are understood by all parties at the design and/or specification stage.

1.2.2 Root Barrier

The root barrier protects the integrity of the waterproofing membrane by preventing unwanted plant roots from reaching the layer and the supporting structure.

Types of root barriers include the following:

- High density polyethylene (HDPE)
- Impregnated copper hydroxide
- Impervious concrete
- PVC
- TPO

Make every effort to overcompensate in the root barrier. The root barrier is carried into flashings. Roots, if given enough time and a place to grow, will seek moisture and nutrients beyond the growing medium.

1.2.3 Insulation

Insulation is required by code in the building industry and conserves energy through reduced heat loss or gain. The effectiveness of insulation is measured in its R-value and is a measure for how well a certain material resists thermal influence of heat or cold. In winter, insulation can prevent heat loss and help maintain a consistent soil temperature, as well as reducing the demand for air conditioning in the summer.

Most commonly used types of insulation include the following:

- Polyurethane foam
- Polystyrene foam (Expanded and Extruded)
- Fiberglass

Insulation material such as expanded or extruded polystyrene foam is often used to create lightweight landforms on Green Roofs where the creation of large volumes of growing medium or other fill material would otherwise have been needed. Using polystyrene products is an alternative that is lightweight, easy to handle, easy to cut and shape on site, inexpensive and readily available. It is necessary to ensure the insulation has drainage grooves (chamfers) and/or is installed with a pitch or tapered toward the drainage outlets to avoid ponding of water on the insulation layer.

1.2.4 Drainage

The drainage layer is a network of boards, pipes and drains intended to remove additional water from the waterproofing layer. It allows enough moisture to remain and sustain plant life. Additional functions may be to act as an additional layer to the root barrier or membrane and augment the compressive strength and thermal capacity of the insulation layer.

Keep all components of the drainage system free of debris and plant material in order to properly convey drainage.

Flashing is necessary to seal the waterproofing membrane at points of interruption, penetration or termination, such as walls, drains or features. Base flashings cover the edges of the membrane; counter-flashing seals the upper edges of the base flashing. Flashing are made from corrosive resistant materials such as stainless steel. The root barrier is also carried into the flashings.

The majority of leaks in a Green Roof (as with any roof) are not found in the membrane field, but in points of interruption, such as flashing, drainage and anchors. It is vital that these places of weakness be properly designed, installed and maintained.

1.2.5 Growing Medium

When designing a Green Roof, special consideration needs to be paid to the formula of the growing medium as it will play a major role in the success or failure of the vegetation. Growing medium is typically a combination of inorganic matter, organic matter, air and water.

The growing medium is specifically formulated to meet the requirements of the vegetation it is intended for as well as be compositionally satisfactory for the intended structural, slope, drainage and climatic conditions. The growing medium anchors the vegetation, giving it nutrients for growth and sustenance. Unlike soils at grade, the Green Roof growing medium is engineered to meet specific functions of drainage and weight. The medium is specifically developed for a certain application and varies according to the roof's condition. When considering highly specialized applications, it may be necessary to consult a soil scientist. Green Roofs typically require a lightweight growing medium with several features. These features are carefully balanced to provide healthy support systems for plant success.

The growing medium:

- Retains necessary amounts of air and water for plant roots
- Allows water to permeate through planting media
- Provides root stability and plant support
- Resists compaction and maintain integrity
- Drains well enough so that roots are not consistently saturated.
- Is able to resist and stay in place during wind gusts.

1.2.6 Vegetation

The plant selection is the most distinctive component of a Green Roof. Designs vary widely to incorporate different plant species and aesthetic functions, but the vegetative layer must be carefully considered for the conditions and the projected goals. In many cases, that means considering plants that are native to South Carolina or from a region with a similar climate.

Many Green Roofs have a shallow and light weight growing medium layer. This results in a composition that is unable to provide stability for larger shrubs and trees. Furthermore, this can be exacerbated as plants grow and wind loads increase. Deadmen, or other custom guying systems may be needed in these circumstances.

Plant selection objectives are dependent upon the design goals of the roof, whether the goals are related to function, performance, education or aesthetics. Horticulturists or Landscape Architects might recommend hardy and adaptable perennial plants with rather shallow, spreading and fibrous root systems. If the Green Roof is located in an urban setting, these plants must be able to withstand excess heat and dryness.

1.2.7 Vegetation Free Zones

Creating vegetation-free zones around the perimeter of a Green Roof, around drainage zones, flashing areas and other penetration areas are highly recommended. This zone helps with fire prevention, creates passage in case of a fire, creates accessibility for maintenance and helps prevent roots from reaching and damaging the membrane and flashings at these locations. Wind turbulence at roof edges can displace light weight growing medium and is another reason for providing vegetation free zones. The vegetation free zone can be created by materials such as concrete pavers, crushed gravel, pebbles or pavers. For very large Green Roof areas, vegetation free zones are also recommended to divide the roof into smaller zones in case of a leak or system failure.

1.2.8 Irrigation

All Green Roofs require an irrigation system. Typically the Green Roof installation contractor or a licensed irrigation specialist will design and install the appropriate irrigation system based on the roof design, climate, and vegetation type.

1.3 Maintenance

Establish a maintenance plan prior to the completion of all new Green Roofs. Both plant maintenance and inspection of membrane flashing points and various roof structural elements are required regularly. Green Roof installations require a maintenance contract for routine Green Roof maintenance needs.

Green Roof plants require regular attention and care including irrigation, weeding, fertilizing, pruning and replanting. Some maintenance procedures are scheduled after events (such as floods and storms) while others can be scheduled according to seasonal events (such as germination period, season for certain invasive and unwanted species and in the fall after leaf fall).

The waterproofing roof membrane is the most vital aspect of Green Roof longevity and success. There are areas where regular inspections are required at least three times per year. These include all joints, borders or other features penetrating the roof, such as all abutting vertical walls, roof vent pipes, outlets, air conditioning units and perimeter areas.

Plants are susceptible to insufficient drainage in the soil. If too much water is present and unable to drain, the plants will drown or rot. Perform regular inspections of drains three times per year, with additional inspections after major weather events.

Ensure all drains remain free of vegetation and foreign objects. Inspection of drainage flow paths is crucial because of the severe consequences of drainage back-ups. In order to allow for regular inspections and maintenance, ensure every Green roof drain remains permanently accessible. Ensure all roof outlets, drains, interior gutters, and emergency overflows are kept free from obstruction by either providing a drainage barrier (e.g., a gravel barrier between the green roof and the emergency overflows) or equip them with an inspection shaft.

If an under-drain system is used, provide a clean-out for both inspection and maintenance. There is potential over the long term for the roof under-drain system to become clogged and the ability to access the under drain system for clean-out is imperative.

Ensure surrounds are installed with consideration for the structural integrity of the roof membrane and for water drainage. Drainage outlets may be installed at the foot of the surrounds, depending on layout of the roof regarding paved and vegetated areas.

Ensure that vertical components rising from the main structure such as walls, vents, HVAC systems and electrical boxes do not generate pressure on any part of the roof membrane, which could potentially over time compromise the membrane and cause water ponding or leaks. Perform regular inspections around these vertical components to keep them clear of debris. These inspections may be scheduled at the same time as drain inspections.

Care of the Green Roof plants requires the most attention during the critical establishment phase, which lasts approximately 18-24 months (unless the Green Roof is pre-grown and close to being established upon installation, as in the case of some modular systems). New Green Roofs will succeed with proper plant selection and care. A horticultural professional can assist with individuals caring for the Green Roof to organize schedules and routines for the following essential garden tasks:

- Hand weeding - necessary throughout life of the roof.

- Watering - necessary especially during establishment phase and might be necessary throughout the life of the roof and/or especially during droughts.
- Thinning - necessary after the establishment phase to promote plant health.
- Pruning - necessary after the establishment phase to promote plant health.
- Fertilizing - may be used during establishment phase to promote plant health - organic products are recommended. Perform fertilization thoughtfully, keeping in mind that Green Roofs are confined planting areas. Excess fertilizer is carried in stormwater runoff and is likely to end up in waterways.
- Replacing planting and in-fill in areas where plants have died off might be necessary for adequate surface coverage.

Watering and weeding is especially important during the first two years of the Green Roof. The roof requires careful weeding before weed seeds are produced. Sterile plant medium may also contain weed seeds. A certain amount of weed growth is inevitable, as seeds arrive on the roof via wind, birds and shoes. For overall health of the Green Roof, weeds should be identified and removed early and often.

The irrigation system needs to be flushed out completely before the first winter freeze. It is recommended to check emitters and spray heads at spring start-up and throughout the season.

1.4 IDEAL Modeling

The table below shows how to represent this BMP and BMPs similar to this one in the IDEAL model. It lists the parameters needed to successfully run the model and the parameters that affect the trapping efficiency of the BMP.

<table>
<tr><th colspan="3">Green Roof Modeling in IDEAL</th></tr>
<tr><td>What to Model as in IDEAL</td><td colspan="2">Bioretention Cell</td></tr>
<tr><td rowspan="5">Similar BMPs</td><td colspan="2">Stormwater Alley</td></tr>
<tr><td colspan="2">Planter Box</td></tr>
<tr><td colspan="2">Rain Gardens</td></tr>
<tr><td colspan="2">Natural Infiltration Area/ Basins</td></tr>
<tr><td colspan="2">Bioretention Areas/Swales/Basins</td></tr>
<tr><td rowspan="6">Specifications Needed for IDEAL</td><td colspan="2">Cell area and number of layers within the cell.</td></tr>
<tr><td colspan="2">Uunderdrain details such as:
- Subgrade soil texture must be set as Clay and degree of saturation must be 0.99 (to closely mimic the impervious roof below the media).
- Underdrain orifice diameter.</td></tr>
<tr><td colspan="2">Type of media and depth of each layer of the cell.</td></tr>
<tr><td colspan="2">Shape and dimensions of the riser.</td></tr>
<tr><td colspan="2">Dimensions, slope, manning's roughness coefficient, and entrance loss coefficient of the barrel.</td></tr>
<tr><td colspan="2">Type, shape, and dimensions of the emergency spillway if applicable.</td></tr>
<tr><td rowspan="3">Parameters that Drive Performance</td><td colspan="2">Direct loading of bacteria that will be entering the cell.</td></tr>
<tr><td>Feature</td><td>How Value Affects Sediment Trapping Efficiency (TE)</td></tr>
<tr><td>Area</td><td>Increasing area increases TE.</td></tr>
<tr><td>Amount of Clay in Media</td><td>More clay increases TE but decreases infiltration rate.</td></tr>
</table>

1.5 References

City of Santa Barbara Stormwater BMP Guidance Manual. June 2008.

South Burlington Stormwater Utility Low Impact Development Guidance Manual. May 2009.

Hydrotech Garden Roof Assembly. 2011