

3.4 GREEN ROOFS

General Description

A Green Roof is a vegetated roofing system that typically consists of a number of layers: a waterproofing membrane, a drainage system, root protection, growing media (soil) and vegetation. Green Roofs provide numerous environmental benefits and offer a valuable tool for integrated storm water management.



Photo: Jonathan Feldman

Figure 3-31: Green roof on Carmel Valley, CA residence.



Photo: www.infrastructures.com

Figure 3-32: Green roof on a commercial office building.

Green Roofs have been a popular sustainable building practice to improve urban environments in Europe since the 1970s. However, it is still an immature market and evolving practice in the United States¹. Many terms may be used to describe Green Roof systems. The list below describes some of the related terms:

- *Ecoroof* is used to describe lightweight vegetated roof systems, implemented as a sustainable building technique that limits impacts on the natural environment.
- *Roof garden* is a term generally describes a useable garden space that includes some vegetation. This type of roof system typically requires extra structural support and consequently, costs more to build.
- *Vegetated roof* is a general term that may describe a number of Green Roof objectives.
- *Living roof* is a general term that may describe a number of Green Roof objectives.

¹ Rozenzweig, C. et al., and Green Roofs for Healthy Cities

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Structurally, there are two types of Green Roofs: intensive and extensive. Extensive Green Roofs are lightweight vegetated roofs consisting of 4-8 inches of growth media (or soil), planted with hardy, drought-tolerant species to minimize additional irrigation, maintenance, cost and weight². They typically require supplemental irrigation to support growth during extended dry periods.



Photo: Rana Creek

Figure 3-33: Extensive green roof Big Sur, California.



Photo: Rana Creek

Figure 3-34: Extensive green roof at Post Ranch Inn, Big Sur, CA.

Alternatively, *intensive* Green Roofs can be designed to support lawns, trees, and create a useable outdoor garden space; often referred to as *roof gardens*. While these amenities do not preclude environmental benefits of Green Roofs, they do require extra structural support, cost, and have functional goals in addition to sustainable building objectives. They also typically require supplemental irrigation systems.



Photo: Rana Creek



Photo: Rana Creek

Figure 3-35: Intensive Green Roof on a parking structure at Stanford University, Palo Alto, California.

² Rozenzweig, C. et al. and City of Portland, Bureau of Environmental Services

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Storm water management

As a storm water management strategy, Green Roofs can help meet the following Low Impact Development (LID) objectives:

- Absorbs rainfall
- Reduces urban runoff at its source
- Increases evapotranspiration
- Reduces heat island effect

Green Roofs provide small-scale decentralized controls that collect, absorb, and increase the evapotranspiration rates of rainfall. Additionally, Green Roofs are effective in reducing the heat island effect of urbanized areas containing large impervious surfaces. By reducing the temperatures of the runoff, the thermal impacts of urban runoff on local waterways are reduced.

Benefits

Green Roofs provide numerous environmental, economic and social benefits listed below.

- **Absorbs rainfall at the source.** 10-100% of roof runoff is absorbed and utilized by the vegetation³. Peak storm water flow rates are also reduced.
- **Improves building insulation.** This reduces heating and cooling costs and energy consumption.⁴
- **Reduces heat island effect** and the associated effects on waterway temperatures.
- **Increases wildlife habitat** for birds and insects that is often scarce in urban areas.
- **Absorbs noise pollution** through soils, plants, and trapped layers of air.
- **Reduces glare** that affects adjacent buildings and habitat.
- **Increases life-span of roof** by protecting the roof's structural elements from UV rays, wind and temperature fluctuations. Green Roofs typically last twice as long as conventional roofs.⁵
- **Improves air quality** by reducing air temperatures, filtering smog, binding dust particles, and converting carbon dioxide to oxygen through photosynthesis.
- **Provides an attractive roof.** In urbanized areas, Green Roofs integrate living systems into the built environment. In less urbanized areas, Green Roofs can help blend a structure into the surrounding landscape.

³ City of Portland, Bureau of Environmental Services. Note: estimates vary depending on the climate, depth of growing media, and plant materials.

⁴ Rozenzweig, C. et al.

⁵ Green Roofs for Healthy Cities, City of Portland, Bureau of Environmental Services, and Rozenzweig, C. et al.

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Siting Criteria

Regional Criteria:

As a storm water management strategy, Green Roofs are best utilized in highly urbanized areas where there is little pervious ground surface to infiltrate and manage storm water or on buildings with significant roof areas such as industrial facilities, warehouses, shopping centers, and office buildings. Though environmental benefits still pertain in less urbanized areas, the initial cost of Green Roof implementation may preclude their use as a storm water management strategy in these areas because more cost effective solutions that utilize open spaces or landscaped areas may be available. Green Roofs can also be utilized to blend structures into the scenic landscapes and protect native plant species.

The arid climate of the Truckee Meadows is amenable to succulents, grasses, and native perennials that are recommended for Green Roofs. Short bursts of supplemental irrigation may be necessary to maintain a green appearance and for fire protection during the dry season. The roofs of large warehouses provide potential locations for green roofs that can substantially reduce runoff and associated conventional storm drain infrastructure.



Photo: Jonathan Feldman

Figure 3-36: Residential green roof, Carmel Valley, CA.



Photo: Rana Creek

Figure 3-37: Green roof at GAP Corporate Campus, San Bruno, CA.

Limitations

- **Initial costs** can be prohibitive, especially for re-roofing a standard roof. However, it should be noted that extensive Green Roofs can be competitive on a life cycle basis.
- **Specific maintenance**, such as irrigation and cleaning out drainage features will need to be factored into the long-term building care.
- **Untraditional** design and installation may stall the permitting process. Green Roof systems are still an evolving market and practice that needs perfecting in North America.
- **Immature market and government policies.** Not yet widely understood, regional and local governments may not yet be providing economic or policy incentives to implement Green Roofs.

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Figure 3-38: Comparison of green vs. conventional roofing costs.

(Source: City of Portland, OR)

	Ecoroof (cost per square foot)	Conventional Roof (cost per square foot)
New construction (including structural support)	\$10 to \$15	\$3 to \$9
Re-roofing	\$15 to \$25	\$5 to \$20

Source: Bureau of Environmental Services estimates based on City of Portland demonstration projects, and information obtained from roof contractors.

As shown in the comparison of roofing costs above, it is important to note that there is a wide range of costs depending on many factors. Since Green Roofs typically last twice as long as conventional roofs, the life cycle costs are competitive with conventional roofs.



Photo: Rana Creek

PROGRESSIVE POLICIES AND INCENTIVES

Numerous economic benefits can help to offset initial costs of Green Roofs including: reduced energy costs, extended roof life, increased property values. Some jurisdictions are promoting their implementation through various incentive programs such as:

- Lowered storm water utility fees
- Increased floor to area ratios and/or density bonuses
- Faster permitting for new projects
- Energy tax credits
- Grants and subsidies for Green Roofs and energy efficient building
- LEED credits from the U.S. Green Building Council

Design and Construction

Green Roofs can be placed on flat or pitched roof structures at slopes up to 40 percent (or 5 in 12 pitch).⁶ Green Roofs can be incorporated into new construction or to re-roof existing buildings. Though several site factors will need to be considered, such as the aspect of the roof, the microclimate of the site, prevailing winds and the building's functions – most factors can be accommodated into a successful Green Roof design.

Extensive Green Roof systems are composed of several layers. The roof systems may be modular interlocking components or each layer may be installed separately. Either way an

⁶ City of Portland, Bureau of Environmental Services.

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extensive Green Roof is constructed with the following basic layers (starting at the bottom): structural support, a waterproof roofing membrane (including flashing), a root barrier, drainage, a filter fabric (for fine soils), growing medium (soil) and plant materials and mulch. Other elements shown in the diagram below may be optional or required depending upon the conditions of the roof design.

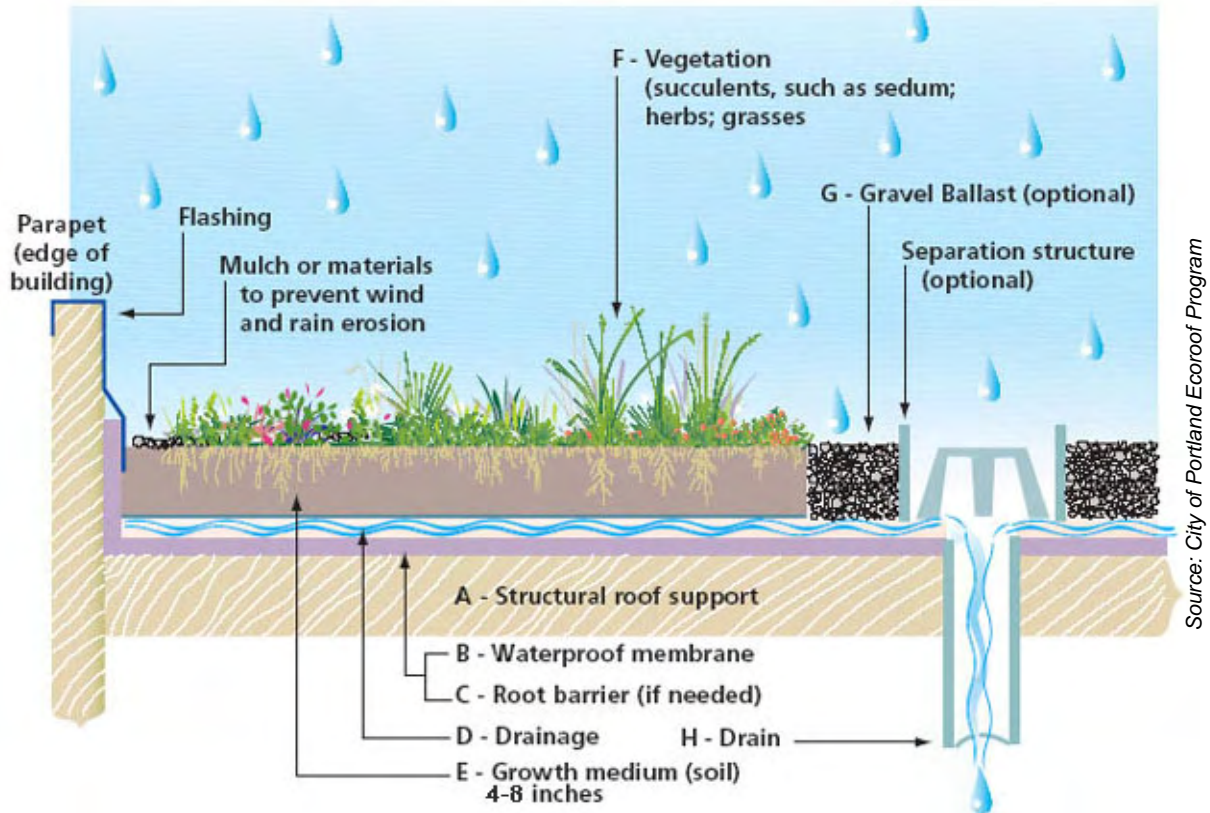


Figure 3-39: Green roof construction detail schematic.

Generally, a building's structure must be able to support an additional 10-25 pounds per square foot of saturated weight, depending on the growth media and vegetation used. For New construction, the load requirement of the Green Roof can be addressed as part of the building's design process. Additional structural support may be necessary for a re-roofing project; however, many existing buildings are structurally sound enough to accommodate a Green Roof.⁷

Green Roofs can be designed by architects, landscape architects, and building contractors. Since Green Roof systems include materials not found on convention roofs, it is recommended that qualified roofing contractor with Green Roof experience is chosen to install the design.⁸

Green Roofs may require maintenance beyond standard roof care, though such care is likely similar in cost. Long term management should be factored into appropriate siting of Green Roofs.

⁷ City of Portland, Bureau of Environmental Services.

⁸ Green Roofs for Healthy Cities

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Inspection and Maintenance

- Upon installation, the Green Roof system should be inspected monthly for the first year and after each large storm event for erosion, plant survival, proper drainage and water proofing.
- Inspections can be reduced to a quarterly schedule once the Green Roof system has proven to work properly and vegetation is established.
- If necessary, irrigate in short bursts only (3-5 minutes) to prevent runoff. Irrigation frequencies should be established by the designer using an automated system.
- Clean out drain inlets as needed.
- Weeding and mulching may be necessary during the establishment period, depending on the planting design.
- Replace or fill in vegetation as needed.
- Inspect soil levels semi-annually to ensure plant survival and rainfall absorption.
- If the vegetation used is flammable during the dry season, it should be mowed or watered as needed to prevent fire.

References

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Photograph Sources

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