Introduction
Multnomah County considered a number of options in 2000 when it became clear the leaky roof on the Multnomah Building was in need of replacement. With the encouragement of Portland’s Bureau of Environment Services (BES), the County evaluated the potential for an ecoroof and ultimately decided to cover most of the west-facing roof with a vegetated system.

The County Commissioners endorsed the project because of the longevity of the green roof, the predicted cost-effectiveness over the long term, and the environmental benefits. They also supported the project because it offered a unique opportunity to promote the technology. The 12,000 sq. ft. ecoroof is accessible and open to the public and is visible from many nearby offices.

The project’s demonstration value led to strong financial support from outside parties: the Department of Environmental Quality (DEQ) contributed $75,000 of Federal funds for non-point source pollution control, and BES contributed $50,000 from the Willamette Stormwater Control Program\(^1\). Tremco Roofing provided certain components at no cost, and BES and Portland State University committed resources for monitoring the performance of the roof.

The project goal was to create a landmark demonstration ecoroof with amenities such as a stone terrace and educational signage. The focus of this report is limited to the design, construction, and cost of the vegetated ecoroof.

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\(^1\) Portland’s Bureau of Environmental Services implemented the Willamette Stormwater Control Program in 2001. The Program offered financial grants and technical support for a series of projects to retrofit existing commercial properties with stormwater controls incorporating green technologies. The Program recruited these demonstration projects in order to research the feasibility, cost and performance of commercial stormwater retrofits in the area served by the combined sewer.
Overview of the Stormwater System
The roof absorbs rainfall that falls directly on it. The roof also receives runoff from a flagstone terrace (1,660 sq. ft.) and pavers along the perimeter of the roof (1,780 sq. ft.). The average depth of the growing medium (soil) is 6 in. Although the performance of the roof will vary depending on a number of factors - storm size, soil moisture content, and temperature - researchers hope to confirm that the roof retains more than 50% of the total annual runoff.

Stormwater Capacity and System Components

Stormwater Management Goal
The overall stormwater management goal was to reduce the peak runoff and volume that would otherwise contribute to combined sewer overflow (CSO) events in the adjacent Willamette River. Although the project did not trigger the requirements of the City’s Stormwater Management Manual (SWMM), it meets the general standards for ecoroofs.

System Components

Planted Roof portion
(See Planting Plan for more details, pg. 10)
- The footprint of the vegetated portion of the ecoroof is approximately 11,900 sq. ft. The catchment is 15,420 sq. ft., including the planted area, stone terrace, and the pavers along the roof’s perimeter.
- Overflow drains to internal downspouts that are connected to the combined sewer system.

Figure 1. Diagram of the ecoroof system components
Refer to Figure 1 for the following description:

a. **Structural roof support** (previously existed)

b. **5-ply roofing system** (previously existed): A built-up roof (3-ply polyester and 2-ply fiberglass membrane) set in hot asphalt atop three inches of polyisocyanurate and fiberboard insulation.

c. **¼ in. protection board over existing roof**: laid on top of the existing roof, provides roof protection during construction as well as additional root barrier protection.

d. **½ in. drainage mat with root barrier**: A hollow core layer of TremCo GR with a top layer of fabric that allows water to pass through while restricting the movement of soil. The fabric is treated with copper hydroxide to restrict root penetration.

e. **Stainless steel edging**: Retains the soil around the perimeter of the roof and prevents it from entering the drains.

f. **6 in. growth medium (soil)**: see “Landscaping” section

g. **Green roof vegetation**: see “Landscaping” section

h. **Drip irrigation system**: see “Irrigation” section

i. **Gravel ballast**: Surrounds the roof drains. Secures the drainage mat and allows free movement of runoff around the roof drains.

j. **Roof drain**: Provides overflow drainage for runoff that is not absorbed, evaporated, or evapotranspired.

k. **Monitoring equipment**: Measures the rate and volume of runoff.

l. **Concrete pavers**: Provides access for maintenance personnel.

**Additional Information**:
- The saturated soil weight is approximately 28 pounds per sq. ft.
- The planted area is gently mounded in the center due to the roofing structure. The slightly western aspect adds visual interest.

**Landscaping**
- The growth medium (soil) is a proprietary aggregate from a local company. The 6-in. deep soil is comprised of pumice, perlite, digested fiber, and paper pulp (reclaimed); it has a higher proportion of mineral content than organic content. The composition meets the structural requirements of the roof, and is free draining to promote plant growth.
- A seed mix was broadcast by hand. The mix includes various wildflower species and fescue grass.
- The vegetated portion directly adjacent to the building was densely planted with plugs and containers of sedum species, perennials, bulbs, and ornamental grasses.
- The project designers selected the plants with advice from a green roof consultant from Toronto, Canada. The selection criteria included adaptability to roof conditions, ecological function, local availability, drought tolerance, seasonal interest, aesthetics, and maintenance requirements.

**Irrigation**
Portland’s extensive summer dry periods made an irrigation system a requirement. The system includes:
- A permanent drip irrigation system, approximately 3 in. below the soil surface, that delivers water directly to the plant roots.
- Soil moisture sensors to control the drip irrigation system, delivering water only when needed.
A temporary above-ground, spray irrigation system, to ensure that the new seeds received sufficient water for germination. The system also helped the new plantings survive the establishment period while their roots were still fairly shallow. The temporary system was removed in late spring 2004.

**Stone Terrace Planter**
- The footprint of the terrace planter is approximately 200 sq. ft. It is filled to a depth of 6 in. with the same proprietary soil mix used on the roof.
- The raised planter, featuring a built-in bench seat, is incorporated into the patio hardscape.
- The planter receives precipitation and some supplemental water from a drip irrigation system.
- It is planted with perennial flower species and varieties of sedum.

**Budget**

The final budget for construction of the Multnomah County building ecoroof was $179,807. This cost covers all of the construction activities for the vegetated ecoroof; it does not include any design activities or costs associated with construction of the terrace.

Over $125,000 in grant funds and in-kind donations of materials and services were provided by interested professionals, businesses, and agencies. BES contributed $50,000. The in-kind costs are included in the costs summarized below.

<table>
<thead>
<tr>
<th>Item</th>
<th>Item Cost or Value</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction:</strong></td>
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<td></td>
</tr>
<tr>
<td>Protection board (material &amp; labor)</td>
<td>$ 8,644.00</td>
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<tr>
<td>Ecoroof components (drain mat, root barrier, filter fabric, soil)</td>
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<tr>
<td>Ecoroof installation (labor)</td>
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<td>*Mobilization/demolition/cleaning</td>
<td>$ 4,800.00</td>
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<tr>
<td>*Crane</td>
<td>$ 12,480.00</td>
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<tr>
<td>*Miscellaneous supplies</td>
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<tr>
<td>Rock removal (labor)</td>
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<td><strong>Landscaping (11,900 s.f.)</strong></td>
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<td>$ 44,418.00</td>
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<td>Plant /seed material</td>
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<td>Installation (labor)</td>
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<tr>
<td><strong>Irrigation:</strong></td>
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<tr>
<td>Permanent drip</td>
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<tr>
<td>Temporary overhead spray</td>
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<tr>
<td><strong>Permitting</strong></td>
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<tr>
<td>Construction bonds/permits</td>
<td>$ 3,927.00</td>
<td>$ 3,927.00</td>
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<td><strong>TOTAL</strong></td>
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<td>$ 179,807.00</td>
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</table>

* Mobilization costs for the ecoroof were estimated by pro-rating the mobilization costs for the entire roof project (including the terrace). Eighty-percent of the costs were attributed to the vegetated portion of the ecoroof because it occupies 80% of the roof area.
I. Budget Elements

Non-Construction Activities
The cost for management, design, and permitting was not fully documented and therefore is not included in the budget.

Construction Activities
The total construction cost was $179,807. The activities include general construction, landscaping, the value of in-kind materials and labor, and the cost of the permits.

Construction
The core construction activities include removal of the existing rock ballast, mobilization and demobilization of a crane to transfer the rock and import soil, and installation of the ecoroof components. The cost of these activities was $131,462, which is approximately 73% of the overall construction budget.

Mobilization costs for the ecoroof were estimated by pro-rating the mobilization costs for the entire roof project (including the terrace). Eighty-percent of the costs were attributed to the green roof because it occupies 80% of the roof area. Permit costs for mobilization, including contract bonds, total $3,927.

Landscaping
The cost of the landscaping, excluding the soil matrix but including irrigation, was $44,418. The associated unit cost was approximately $3.73 per sq. ft. Landscaping costs comprised approximately 25% of the total construction budget (excluding soil matrix). The costs for the soil matrix are included in “ecoroof components” under construction activities.

The irrigation system was valued at $18,231, including both the permanent drip system and the temporary overhead spray system.

II. Cost Components

Construction – Mobilization and installation of the structural components comprised approximately 75% of the total construction budget; landscaping costs were about 25% of the total budget (excluding soil matrix).

Labor vs. Materials – Labor accounted for approximately half the total construction budget.
Irrigation – The County simply expanded the existing irrigation systems, which included valves, a backflow preventer, and a controller. Construction of a new system would have been substantially more expensive.

Pavers – The County saved money by re-using the pavers from the previous roof. The pavers were placed around the perimeter to provide access for maintenance staff.

### III. Cost Comparisons

Construction costs for the eco-roof project may be low, relative to other similar projects, for retrofitting existing roofs with ecoroofs. Although mobilization costs to raise materials to the 5th floor were substantial, the project saved on other activities that sometimes account for higher costs on similar retrofit projects. For example, the roof was sound and required no structural alterations - its load bearing capacity had been previously certified; the existing 5-ply roof was in good condition and did not necessitate removal or replacement.

### Maintenance and Monitoring

Multnomah County owns the facility and is responsible for all maintenance activities.

BES, the County, and PSU, are jointly funding hydraulic monitoring. Led by PSU, the team will intensively monitor the performance of the ecoroof facility for at least five years, and perhaps longer. BES will also regularly evaluate the level of effort required to maintain the facility, the success and viability of the planting regime (which may change over time), and any comments received.

A detailed Operations and Maintenance Manual includes site plans, operation and performance requirements for vegetative care, natural pest/weed reduction, safety precautions to protect workers and visitors, erosion & litter control measures, and a detailed schedule and timeline for maintenance of the irrigation system.
Successes and Lessons Learned

Multiple Benefits - The project is a great example of how an ecoroof can be a central feature in the urban environment, with multiple benefits:

- Many nearby offices enjoy views of the green roof and it provides an appealing picnic spot. It should continue to attract visitors interested in ecoroofs.
- The roof will provide ongoing benefits for the County and the City in terms of stormwater management and moderating temperatures on the roof (including reductions in heating and cooling costs for the building).
- The roof provides habitat for urban life – birds, butterflies, etc.

Roof Longevity and Cost Effectiveness – In 2000 the County conducted a life cycle cost analysis comparing a conventional roof with an ecoroof. The study concluded the ecoroof would be more cost-effective than a standard roof over a 60-year period. The analysis assumed that the ecoroof would double the life of the impermeable seal on the roof (a common assumption in the industry). More information about the study is available from Multnomah County or Allen Lee at allenl@quantecllc.com.

Construction Schedule - The project confirmed the crucial influence of seasonal weather on installation schedules: in Portland planting should occur in early spring or early fall when the temperatures are cool and precipitation is most likely to assist with plant establishment. Seeds are especially vulnerable to prolonged dry periods.