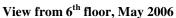
# Metro Regional Government Headquarters Ecoroof 600 NE Grand Avenue, Portland, Oregon

## **PROJECT SUMMARY**

<b>Project Type:</b>	Roof replacement with ecoroof—demonstration project			
Technologies:	Ecoroof			
Major Benefits:	<ul> <li>The ecoroof will prevent more than 25,000 gallons of rainwater annually from discharging to the combined sewer system.</li> <li>The ecoroof provides additional green space and enhances the outdoor terrace for building occupants.</li> <li>The ecoroof helps cool the building.</li> <li>The project demonstrates environmentally beneficial building practices that can improve urban livability.</li> <li>The ecoroof will reduce peak stormwater runoff by more than 80%.</li> </ul>			
Cost:	• \$105,975 total. The total cost includes monitoring and maintenance for two years. Funding included \$40,000 from an EPA Innovative Wet Weather Projects (IWWP) grant and additional matching grants from Metro's Sustainability and Solid Waste programs. Note: planting, soil and irrigation cost \$20,000 of the total.			
Constructed:	August 2005			







View from 4<sup>th</sup> floor, May 2006

## **Overview of the Stormwater System**

Metro is the regional government that provides integrated resource management for the 25 cities and unincorporated areas in the Portland, Oregon, metropolitan area. In May 2003, the Metro Council adopted a resolution to endorse a sustainable business model for internal business operations. In 2005, Metro elected to replace a section of damaged roof on its central office building with an ecoroof. This project not only meets the Council's resolution,

but also demonstrates an environmental building design that manages stormwater and helps reduce energy consumption.

- The 2,500-square-foot ecoroof portion accounts for about 6 percent of the building's entire roof area.
- The ecoroof is intended to manage all of the rain that falls on it.
- The design introduces an innovative conveyance system, using drainage channels that convey overflow to the roof drain. The drainage channels are filled with cinder rock. This method saves costs compared with more expensive drainage systems and gives the roof an artistic quality.
- Monitoring equipment was installed to compare stormwater retention from the ecoroof with retention from a similarly sized portion of the roof that remains in conventional rock ballast.
- Based on the success of this project, additional ecoroof could be installed when the remaining 38,000 square feet of the roof needs to be replaced.







Metro Ecoroof Monitoring Equipment at the Roof Drain

### STORMWATER CAPACITY AND SYSTEM COMPONENTS

## **Stormwater Management Goal**

The overall stormwater management goal was to reduce peak runoff and volume that would otherwise contribute to combined sewer overflow (CSO) events in the Willamette River. BES staff estimates that the ecoroof will reduce stormwater runoff by approximately 50 percent, although the ecoroof's performance will vary, depending on a number of factors—e.g., storm size, soil moisture content, and temperature. Although the project did not trigger the

requirements of the City's *Stormwater Management Manual*, it meets general standards for ecoroofs.

## **System Components**

### **Ecoroof Components**

- **Structural roof support:** A structural analysis concluded that the existing roof would support a 12-pound-per-square-foot ecoroof.
- **Fiberglass and asphalt layer:** This layer is an integral part of any built-up (or modified bitumen) roofing system. In this instance, it was used as an adhesive for attaching the foam core insulation board to the existing concrete roof.
- **Foam core tapered insulation board**: This layer provides a positive drainage slope of <sup>1</sup>/<sub>4</sub> inch per foot, with a minimum 1-inch thickness at the overflow drain.
- **Protection board:** A <sup>1</sup>/<sub>4</sub>-inch protection board was laid on top of the insulation board for increased compressive strength to protect the insulation board.
- **Waterproof membrane:** A single-ply, 60-millimeter EPDM membrane was fully attached to the insulation and up the parapet wall, under the flashing.
- **Root barrier:** The root barrier is an impervious IS 24-millimeter, scrim-reinforced HDPE (high-density polyethylene) membrane coated with LDPE (low-density polyethylene).
- **Filter fabric:** This is a non-woven, geotextile fabric that allows excess runoff to filter through the soil, to the roof drain, without transporting soil sediment.
- **Soil:** Approximately 10 tons of soil was imported and spread over the root barrier to a depth of 3 inches. The soil comprises 10 percent recycled paper fiber waste, 20 percent compost, and 70 percent pumice.
- **Drainage channels:** Red cinder rock drainage channels were placed on top of the root barrier and nestled within the layer of soil and vegetation to the same 3 inch depth as the soil. The artistically arranged drainage channels provide efficient conveyance of rainfall that is not absorbed. The drainage channels also appear to support sedum growth.
- **Vegetation:** See the Landscaping section.
- **Irrigation system:** See the Irrigation section.
- **Gravel ballast:** Rock from the original rock ballast roof was reused and placed around the roof perimeter and drains. It is a typical component for ecoroof systems.

#### Additional Information

- Walkway pads (30 inches by 30 inches) were placed to protect the membrane in areas designated for foot traffic (e.g., for access to monitoring equipment).
- Perforated metal edging was used at the main roof drain; this element is optional. No edging
  was used to separate the rock ballast perimeter or the drainage channels from the vegetated
  roof portion.
- A test of the saturated weight of the soil was required to determine the soil depth at 12 pounds per square foot.

## Landscaping

- A mix of various wildflower species was broadcast over the soil in late September 2005 to provide interest and color through the growing season. The mix included *Castilleja exserta*, *Eschscholzia maritima*, *Gaillardia aristata*, *Lupinus nanus*, *Sisyrinchium bellum*, *Linaria reticulata*, *Gilia tricolor*, and *Chrysanthemum multicaule*. A reseeding of another 50% of the original mix was added in April 2006.
- Following the seeding, a slow release fertilizer consisting of nitrogen-phosphorus-potassium (14-14-14) was applied at 9.4 lbs. /1000 square feet and broadcast over the ecoroof section in late 2005. Fertilizer was used only for plant establishment.
- The following sedum sprigs were planted:
  - Blue: Sedum rupestre erectum, S. anacampseros
  - Green: S. album balticum, S. oreganum, S. spurium 'Dr John Creech'
  - Gold: *S. kamtschaticum variegatum* (small form)
  - Red: S. spurium 'Red Carpet', S. album 'Hillebrandtii' (broadcast over the top of the soil as the final layer in August 2005)
- In April 2006, a final broadcast planting of sedum consisted of:
  - Blue: S. anopetalum glauca, S. ochroleuceum, S. lanceolatum
  - Gold: S. acre 'Krajinae'. S. sexangulare, S. apoliepon
  - Red: S. spurium 'Bronze Carpet'. S. spurium 'Elizabeth'. S. album 'Murale'

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Flowers: Gilia tricolor next to perforated metal edging at roof drain

Sedum grows into a carpet

## Irrigation

- An overhead spray irrigation system of schedule 40 PVC piping was installed for plant establishment and minimal summer irrigation. The piping system is buried beneath the soil.
- Aluminum sleeves were placed around 6-inch pop-up risers to protect them from ultraviolet light and accidental damage. Drain rock was placed around the base of each riser for added stability.
- The irrigation system is connected to an automated control that is programmed to deliver, on average, no more than 75 gallons of water over the ecoroof area in a 24-hour period. A rain sensor will override the irrigation system if the roof receives rainfall.

## **BUDGET**

The total project cost was \$105,975. An EPA Innovative Wet Weather Projects (IWWP) grant to the Bureau of Environmental Services (BES) paid for \$40,000 of the total project. Additional matching grants from Metro's Sustainability and Solid Waste programs also funded the project.

As shown in the table below, project expenditures can be broken down as follows:

Cost Summary for Ecoroof Construction				
Item	Conventional Roof Expenditure <sup>1</sup>	Ecoroof Expenditure <sup>2</sup>	Total Expenditure	
Design:				
Engineering analysis of roof load		\$4,890	\$4,890	
Scope of work for roof replacement				
and ecoroof	\$6,056	\$6,056	\$12,112	
Construction:				
Mobilization (includes permit)	\$4,000		\$4,000	
Demolition (rock removal)	\$6,000		\$6,000	
New EPDM roof (includes				
insulation, flashing)	\$46,240		\$46,240	
Eco roof construction and irrigation				
(materials, labor, 2-year guarantee)		\$18,425	\$18,425	
Miscellaneous		\$672	\$672	
SUB TOTALS	\$62,296	\$30,043	\$92,339	
Monitoring:				
(Ancillary cost to ecoroof project)				
Materials		\$5,961	\$5,961	
Installation		\$7,675	\$7,675	
TOTALS	\$62,296	\$43,679	\$105,975	

## **Budget Elements**

## Design and Structural Analysis

Non-construction activities cost \$17,002, or approximately 16 percent of the total project cost. These activities included an engineering analysis of roof load (attributed to the ecoroof portion only) and EPDM roof membrane replacement and the new ecoroof (split between the conventional roof portion and ecoroof portion). Additional activities include: soil specifications, planting design, irrigation design, construction specifications, and the Operations and Maintenance (O&M) Plan.

#### Construction of EPDM Roof

Construction of the EPDM roof cost \$56,240, or approximately 53 percent of the overall project cost. The core construction activities included removal of the existing rock ballast; demolition of the existing roof; and installation of the insulation, flashing, and waterproof membrane. (All of these activities would be required for a conventional roof and are therefore attributed to the conventional roof portion.)

<sup>&</sup>lt;sup>1</sup>Conventional Roof Expenditure: The cost incurred to address the damaged roof section without addition of the ecoroof components.

<sup>&</sup>lt;sup>2</sup> Ecoroof Expenditures: The cost for the ecoroof components.

*Note*: it was discovered that a collar around a post was not installed correctly and led to a leak; The leak went away upon correction of the collar. Problem.

#### Construction of Ecoroof

Construction of the ecoroof cost \$19,097, or 18 percent of the total project cost. The construction activities included the soil matrix, irrigation system, landscaping (with a 2-year maintenance guarantee), and irrigation system.

### Monitoring

The cost of the monitoring system for both the ecoroof section and a similar ballasted roof section (as a control) was \$13,636, or 13 percent of the total project cost.

## **Cost Comparisons and Savings**

- The structural analysis concluded that the capacity of the existing roof section could support a 12-pound–per-square-foot ecoroof without additional structural reinforcement. This represented a cost savings compared with similar retrofit projects that may need additional reinforcement.
- Cost savings were achieved by reusing 2 of the 18 cubic yards of existing rock ballast roof to place around the ecoroof perimeter.
- The innovative cinder rock drainage channels were less expensive than a manufactured drainage mat component. The drainage channels also eliminate the possibility of a warm air layer under the soil that can occur with traditional drainage mats and desiccate plant roots.
- The low organic content of the soil matrix (30 percent) reduced cost, weight, and potential pollutants in the excess runoff.
- The sedum cuttings were broadcast over the soil matrix instead of using the more time-consuming and costly method of transplanting containerized plants. In addition, workers spent less time walking on the soil matrix with a broadcasting method, resulting in less soil compaction.

## **MONITORING AND MAINTENANCE**

## Monitoring

Metro will monitor the performance of the ecoroof for at least 2 years after the ecoroof is fully established. Metro installed two V-notch weirs and water level instruments at the drain on both the ecoroof section and the rock ballast roof test section. The weir dams the water to create a measurement pool, and the pool raises a float off the ground before the water reaches the bottom

of the V-notch. A rain gauge (Unidata, 6506B) was located near the data collection site on the conventional roof, and a flow transducer was installed to measure the irrigation used on the ecoroof during the dry months while the plants are being established. A data logger gathers the information and downloads it. The entire monitoring system is powered by a solar photovoltaic cell.

The following information was collected from the first phase of the ecoroof monitoring project. Once the plants are more established and more data are available, these initial results will be reviewed and augmented.

- The ecoroof retains an average of approximately 55 percent of the rainfall that falls on it, compared with from 16 to 25 percent retention on the conventional rock ballast roof.
- The ecoroof attenuates approximately 25 percent more of the peak flows than the rock ballast roof section.
- The estimated runoff volume from the conventional roof is less than expected, possibly as a result of some retention in the surface fines and surface evaporation.

The monitoring data will help Metro design an effective ecoroof for the building's remaining roof section that will need replacing (approximately 6 to 8 years from the time of this ecoroof project).

Metro used the HELP model, a hydrologic model developed by EPA for landfills, to estimate the performance of an ecoroof with a thin soil layer. The purpose was solely for planning purposes to better estimate expected flows of stormwater. Metro did not calibrate the model; however, the modeling results will be compared with the observed data to determine if the predictions of stormwater diversion were accurate in comparing the ecoroof to the rock ballast roof.

### **Maintenance**

Metro is responsible for all maintenance activities, including weeding, watering, and replanting as needed to maintain the full performance of the ecoroof.

### SUCCESSES AND LESSONS LEARNED

- Improve local reuse and recycling opportunities for roofing materials: A lack of options for recycling or reusing the replaced EPDM roofing material and polystyrene insulation captured the attention of Metro. Although there continues to be a need for such a service, the industry is continuing to research opportunities and methods to arrive at a solution. Insulation installed within the building, as opposed to installing it on the rooftop, can increase longevity of the insulation and reduce the need for discarding the material when replacing a roof.
- Determine the building's hydraulic pressure when designing the irrigation system: The irrigation system was initially designed to operate with static pressure of about 30 pounds per square inch. The contractors discovered, however, that the pressure on the building's

fourth floor was insufficient, so a second control valve and irrigation line was added for a cost of \$700.

• **Verify all roof dimensions**: Metro discovered that the drain was incorrectly located on the original contract drawings. This resulted in a slight project delay because the installation plan for the tapered insulation had to be redrawn.