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July 31, 2003

Lando and Associates, Landscape Architecture
Environmental Education Grant #921693

Metro Regional Greenspaces Project Report: Eco-Roof Plus

1.0 Project description

Eco-Roof *plus* is a storm water management project, specifically designed to reduce runoff and improve water quality in the Lower Willamette River. The project is located on the rooftop of the B & O Commerce Center, an industrial warehouse centrally located on the east bank of the Willamette River.

Depending on the type of storm, planted rooftops reduce total annual runoff volume and peak runoff rates. For small rainfall event characteristics within the Portland area, little runoff will occur and most of the precipitation will eventually return to the atmosphere by evapotranspiration. For larger storms, vegetated rooftops can significantly delay and attenuate the discharge of runoff from roofs. In addition to stormwater benefits, the planted roof provides urban heat reduction, wildlife habitat and increased energy efficiency for regulating the building temperature.

The design of the project is a series of eight test plots with varying configurations of growth media and drainage. Each plot measures 12.5 ft. x 38 ft. and slopes to a central drain point on the northern boundary of the plot. The design allows for drainage and stormwater runoff monitoring. The plots are delineated with 1x12 inch cedar boards set on top of 4 mm reinforced EPDM rubber. The engineered system within each plot consists of three primary layers:

- Plant material
- Growth media and principal root zone
- Drain Layer

Plant Material

A mix of native and nonnative *Sedum spp.* for Eco-Roof *plus* was selected based on the following criteria:

- Survivability
- Zero plant maintenance and replacement standards
- A non-aggressive root systems with a shallow (3 ½"–5 ½") rooting zone
- Easily propagated plant material through a hydro-seeding process
- Emphasis in native plant material
- Evapotranspiration potential
- Long term sustainability based upon a "plant community" approach

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Five (5) pounds of the *Sedum* mix (see Attachment 'A') were distributed by hand across each plot. In addition to the *Sedum* spp., straw blankets were installed and sterile annual rye was broadcast on each plot to secure the growth media and minimize wind erosion.

Growth media

Each test plot was constructed from a lightweight soil or rock substrate designed to support the principal root zone, to facilitate absorption and to slow the release of storm water in the following ways:

- Capture and hold precipitation in the growth medium and plant material
- Evapotranspire water through leaves
- Slow the velocity of direct runoff as it infiltrates through the layers of vegetated cover

Drain Layer

In 5 of the 8 plots ½ inch *Delta* drain mats were installed to test their performance and necessity in roof top plantings. The drain mats were placed directly on top of the EPDM rubber and beneath the growth media.

1.1 Site Design

In total the test plots covered 5,000 ft^2 and were monitored for storm water absorption, filtration and plant performance. Using a thin, bio-engineered layer of absorbent substrate, plant material, and geo-textiles, the transformed industrial rooftop serves as a working laboratory for the development of alternatives to storm water run-off reduction and water quality improvements.

Each plot was designed as an exact replicate of the other plots except for the growth media/drain layer. By modifying only one factor per plot we could reliably attribute changes in performance to the change in growth media/drain layer. Substrate depths range from 2.5 to 6.5 inches, each rated at 10 pounds/ft^2. The growth media of each plot is outlined as follows:

AREA	SUBSTRATE NAME	DESCRIPTION
A	Pro-Grow 3.2(no drain)	Classic rooftop / planter light weight soil mix
B	Pro-Grow 3.2	Classic rooftop / planter light weight soil mix with a drain layer
C	Pro-grow 2.1	Highly organic light weight soil mix with a drain layer
D	Lando 1.1(no drain)	Custom light weight soil with minimal organics
E	Lando 1.1	Custom light weight soil with minimal organics with a drain layer
F	Geo-Soil 1.1	Geo-textile mat with organic compost mix
G	Rock Wool 1.1	4" bat rock (loose) rock wool insulation with drain layer
H	Cinder Rock 1.1	Local red cinder rock with drain layer

Once each plot was constructed, filled with the growth media and planted, site maintenance consisted of watering for the first summer season. A temporary irrigation system was constructed out of PVC tubing with pop up spray heads and a programmable timer. Once the *Sedum* spp. are established, irrigation should not be required.

1.2 Monitoring

Monitoring of Eco-Roof *plus* included the following:

- Comparative documentation of plant growth for each plot
- Chemical and physical analysis of each growth medium
- Testing of water holding capacity for each plot

In addition to the specific monitoring techniques listed above, Eco-Roof *plus* provides critical design, construction and performance information for future planted rooftops. The site was selected because conditions at the B & O Commerce Center typify commercial and industrial buildings along Portland's east bank of the Willamette River. The information obtained as a result of this project is being made publicly available (see below) so that others may benefit.

2.0 Benefits and Future Directions of this project

The environmental benefits of Eco-Roof *plus* are motivated by federal, state and regional regulatory directives to restore water quality and fish habitat. In 1989, the U.S. Environmental Protection Agency (EPA) adopted a Combined Sewer Overflow Strategy designed to reduced and eliminate combined sewer overflows nationwide. In an effort to

protect human health and the environment, states were required to develop strategies to reduce pollution from combined sewers and bring dischargers into compliance with the federal Clean Water Act (CWA). In Oregon, the Department of Environmental Quality (DEQ) has made significant progress towards achieving the EPA mandate. As of 1995, Portland, Corvallis and Astoria are the only remaining cities in the state of Oregon with combined sewer systems. When Portland's wastewater discharge permit was renewed, DEQ required the city to correct its combined sewer overflow problem by the year 2011.

In addition to CWA-related efforts, recent Endangered Species listings have stimulated an increasing awareness of fish issues on the need for improved water quality conditions. On March 16th, 1999 the National Marine Fisheries Service (NMFS) listed nine new populations of salmon and steelhead in Washington and Oregon. The listings include upper Willamette River steelhead and Chinook salmon, which will bring the Endangered Species Act to Oregon's most heavily populated region. With over 70% of the state's population living in the Willamette Valley, urban impacts to water quality are at the forefront of fish protection efforts.

Numerous scientific studies have linked reduced water quality to adverse impacts on aquatic organisms such as salmonids. As a result of regulatory pressure and scientific evidence, numerous regional programs, plans, and funding sources have been developed to address this imminent natural resource threat (i.e. The Willamette River Basin Task, The Oregon Plan, and Metro's Salmonid Education and Enhancement Grant). Although it is widely recognized that Portland's overtaxed sewer system is a major contributor to poor water quality, full-scale conversion of the system is cost prohibitive. Therefore, widespread residential and industrial programs have been implemented to promote alternative measures of reducing storm water runoff.

Together these organizations have produced a staggering amount of information including the Oregon Plan, the Regional Framework Plan, habitat protection plans, water quality studies, fish and wildlife studies and much more. In reviewing these resources, two outstanding issues are repeatedly identified - the need to improve water quality and fish habitat. Portland has no alternative but to explore innovative means of achieving these urgent environmental goals.

Eco-Roof *plus* is an innovative restoration and stormwater management project. If properly constructed, planted rooftop can measurably reduce the quantity and rate of runoff, while simultaneously filtering and retaining particulate matter in the soil substrate. Experience strongly suggests that education, community support, and the widespread construction of planted rooftops within the urban infrastructure will provide significant benefits to salmonid populations in the Lower Willamette Basin. This tutorial pilot program documents project design, construction, and monitoring details for such

projects. Convenient public access, detailed on-site interpretive signs, and extensive community outreach efforts will be used to promote Eco-Roof *plus* in the future. In addition, an informative web page dedicated to Eco-Roof *plus* will be developed. It will include project background, current efforts, site-specific data, relevant statistical analyses, and links to other relevant storm water efforts.

In addition to providing technical design, construction and performance information, Eco-Roof *plus* has raised and will continue to raise awareness regarding the need for clean water and healthy fish habitat. Projects such as Eco-Roof *plus* are specifically designed to provide alternative strategies to current environmental problems. The potential long-term impact of roof top gardens is directly linked to public awareness and support. The more roof top gardens, the greater the impact will be on storm water runoff, clean air, and wildlife habitat. Our project is designed to provide critical supporting data, to serve as a test site for the development of similar rooftop gardens, and to educate the public. The successful completion of this project will entail additional on-site monitoring, performance documentation and public involvement.

3.0 Public Awareness

Eco-Roof *plus* has already received considerable attention through the following avenues:

- Volunteer participation in the project installation
- Publication in the Daily Journal of Commerce
- Site tours by the Northwest Eco Building Guild
- Site monitoring by Portland State University students

Additional public venues include:

- Presentation at the 2004 International Eco-Roof conference
- Launch of the Eco-Roof *plus* website – Fall 2003
- Eco-Roof *plus* "Grand Opening" - Fall 2003
- Continued site tours by public interest groups
- Continued monitoring by Lando and Associates and Portland State University

Site signage will be installed in Fall 2003. The signage will increase public understanding of the project and it's components.

4.0 Work Tasks and Timeline

The project has been subject to countless schedule changes and an array of obstacles to overcome from the conception of the project. With determination the project is now competed and awaiting research and evaluation. The following is a brief summary of the project's timeline

12/1998 Project conception – The project was formulated as we completed the construction of Portland's first eco-roof.

4/1999 Salmonid Education and Enhancement Grant Awarded

5/1999 Project undergoes a "historical landmark" review.

7/1999 The 5000 ft^2 testing area is designed and engineered

5/2000 The project is permitted for 5000 ft^2 of eco-roof

5/2000 Construction is halted due to weather, short time line to coordinate in-kind donations from venders (long material ship dates). Plans to begin construction are rescheduled to the fall.

8/2000 A new construction timeline is established.

2/2001 Construction is halted due to announcement of BES 's "Stormwater Management Grant". Project is placed on hold in order to participate in this grant program.

10/2001 Awarded grant from BES, re-engineering the project to a net 20,000 ft2 of eco-roof.

2/2002 Permitting of eco-roof fails. Project has exceeded the allowable increase in weight load to the roof without a formal seismic / structural analysis. Coordinate with BES begins for funding of additional engineering services.

x/xxxx Canceling participation in B.E.S. stormwater management program due to engineering fees and preliminary construction cost estimates for seismic retrofitting. BES never completes their funding research / participation.
A new construction timeline is established.

3/2002 Construction is halted due to building owner's request. Leaking has occurred from an upper roof area. Roofing repairs are made. Contractual agreement are re-established.

5/2002 A new construction timeline is established

9/2002 Construction is halted. Company is dissolving and ownership of grant and office location is established. Grant is transferred from Total Work of Art, inc. to Lando and Associates, Landscape Architecture.

10/2002 A new construction timeline is established

2/2003 Construction begins on 5000ft^2 test plots

2/2003 Project advertised in Daily Journal of Commerce.

3/2003 Construction is completed. Portland State / Lando and Associates begin first round of testing and research. Slight design modification are made

4/2003 An automatic irrigation system is installed and is incorporated into project

Overall the project was a success. Although it was reduced in size from the original proposal, the integrity and function of the test plots remained intact. The project is currently in the plant establishment phase with a positive outlook for the data collection phase of the project.

Construction: The construction of the eco-roof was relatively simple and without incident. The test areas are equal in size and (relative) slope. The materials were easily obtained and assembled with little difficulty. A more difficult items has recently been observed. It seems as if two of the areas are not entirely separated from each other and so water can migrate from one are to another. In addition the original design called for an open gutter or runnel to be attached to the lowest end of each test area. This caused a problem early on. First of all the runnels were too shallow n pitch and too much to short in height off of the roofing surface to allow for traditional monitoring equipment to be installed. Moreover the original price quotes for monitoring of the test area was not accurate and prove to be off in excess of $9,000.

Plant establishment: The plant establishment period underwent a very warm, dry spring and subsequentually we are predicting a high plant mortality rate. Our ability to irrigate the eco-roof was greatly reduced do to time constraints and equipment. An automated system has been installed and we are seeing a great improvement in the plant material. We are estimating that an "over seed" with a sedum mix will have to be performed this fall in order to create an adequate plant distribution.

Data Collection: The data collection component of the project has begun, however, it is still in its infancy. Initial testing has occurred through cooperation with Portland State University and Lando and Associates, Landscape Architecture and can be fond under Attachment 'B'. Additional summary and documentation of ongoing data collection will be presented at the 2004 green roof conference.

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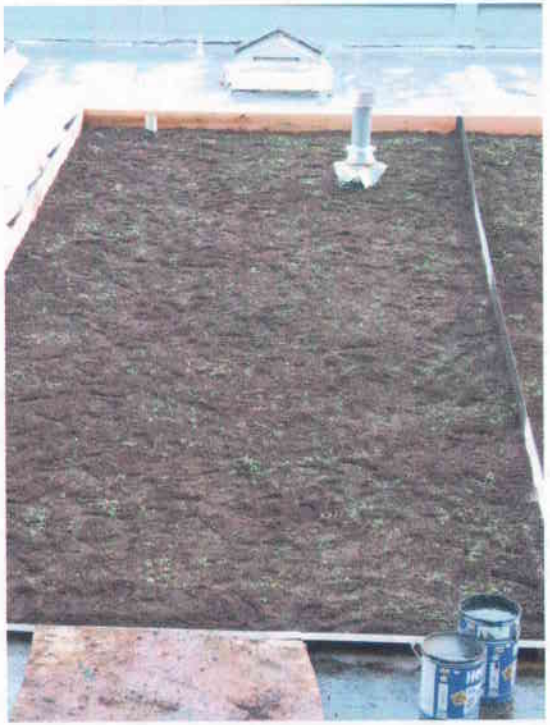
1.0 Photo Documentation

Test Area 'A'



2 / 2003
Newly Planted

4 / 2003
Cover Crop is doing very well

6 / 2003
Cover crop - dead, Sedum - good

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Test Area 'B'

2 / 2003
Newly Planted

4 / 2003
Cover Crop is doing very well

6 / 2003
Cover crop - dead, Sedum - good

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Test Area 'C'

2 / 2003
Newly Planted

4 / 2003
Cover Crop is doing very well

6 / 2003
Cover crop - dead, Sedum - good

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Test Area 'D'

2 / 2003
Newly Planted

4 / 2003
Cover Crop is doing very well

6 / 2003
Cover crop - dead, Sedum - good

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Test Area 'E'

2 / 2003
Newly Planted

4 / 2003
Cover Crop is doing very well

6 / 2003
Cover crop - dead, Sedum - good

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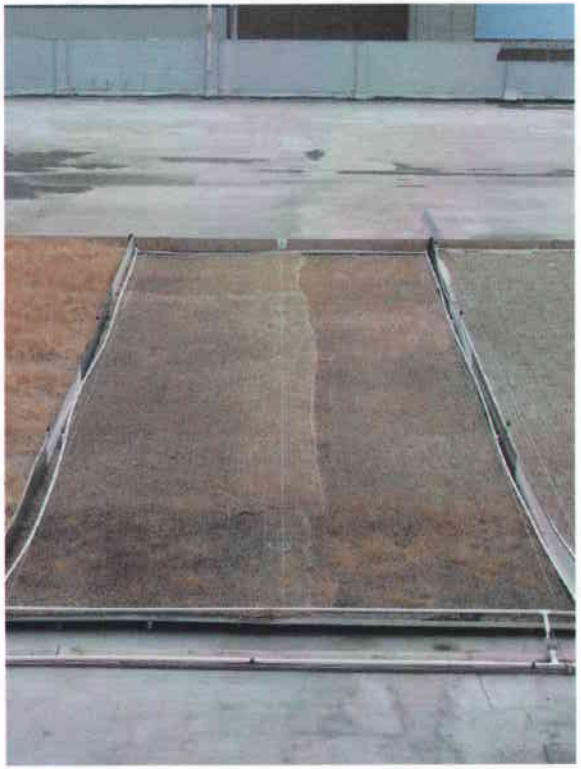
Test Area 'F'

2 / 2003
Newly Planted

4 / 2003
Cover Crop grows best at low point



6 / 2003
cover crop - dead and Sedum - marginal

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Test Area 'G'

2 / 2003
Newly Planted

4 / 2003
Cover crop and sedum don't survive

6 / 2003
Cannot sustain Sedum

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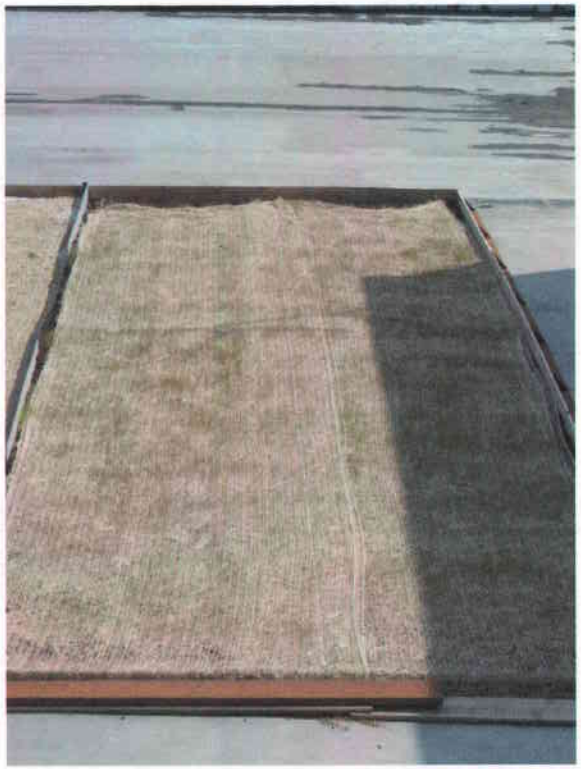
Test Area 'H'

2 / 2003
Newly Planted



4 / 2003
Cover Crop does not 'take' in cinder

6 / 2003
Sedum is still surviving

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Attachment 'A': Plant Schedule

SCIENTIFIC NAME	Percent overage
SEDUM MORANENSE	12.50%
SEDUM TSCHERNOKOLERVIS	15.00%
SEDUM ACRE	17.50%
SEDUM ALBUM LACONICUM	15.00%
SEDUM ALBUM BELLA D'INVERNO	16.25%
SEDUM ALBUM BALTICUM	10.00%
SEDUM SPATH. CARNEA	3.75%
SEMPRIVIRUM SP. (ASSORTED)	10.00%

Attachment 'B': Data Collection