Cramer Hall Eco-Roof Project

Project Summary for City of Portland Bureau of Environmental Services

Engineers Without Borders, Portland State University Student Chapter

ABSTRACT

This document outlines details of the Cramer Hall Eco-Roof Project (CHERP). The system was designed and installed by students of Portland State University with guidance from faculty and local professionals. CHERP will serve as a living laboratory for undergraduate courses and be a platform for sustainably oriented research.

Table of Contents

We gratefully acknowledge the overwhelming support of all those involved in the project. Without the enduring efforts of all parties the ecoroof on Cramer Hall would not exist. The EWB-PSU student chapter would like to extend gratitude to Alice Coker and Tom Lipton at the Bureau of Environmental Services; Francis McBride and Ernest Tipton with Facilities and Planning; Tom Szymoniak from the Engineers Without Borders Portland Professionals chapter; and Jerry Abdie with KPFF. Students also would like to acknowledge the financial support of The Flora Foundation, BES, and the Student Fees Committee at Portland state University. Collaboration among these different groups embodies the purpose of this project.
Thank you.

Project objective

The purpose of the Cramer Hall Eco-Roof Project (CHERP) is to support sustainable stormwater management while fostering eco-conscious education and green technology research. The two primary criteria by which the success of CHERP will be measured are the level of student involvement, and the amount of quality insight gained through monitoring. Partnerships with the University Studies Department (UNST) and the Maseeh College of Engineering and Computer Science (MCECS) will facilitate the pursuit of the first criteria. Monitoring will be conducted with efforts to support Bureau of Environmental Services (BES) objectives, and progress reports will be generated for their use throughout the project's life cycle.

Project Description

Concept

CHERP is composed of 20 individual 8' x 12' planter boxes (total area, 1920 ft^2). Among the boxes there are 7 different soil types at varying depths (3" to 7"). Each box was planted with a collection of either native or non-native plant species. This configuration (see Box Layout) allows for direct comparison of the performance of different soil/plant combinations.

Location

The site of CHERP was chosen for its accessibility and geographic significance. The system is located on the roof of Cramer Hall (1721 SW Broadway, Portland Oregon 97201). This building houses the office of UNST. Proximity of this department with the project will facilitate student engagement. The building also resides on the developing Montgomery Green Street in the University District.

Figure 1, Site location in downtown Portland with existing conditions. CHERP was installed in the northeast quadrant of the roof.

Existing Site Conditions

The existing roof consists of ~1' x 2' concrete pavers on top of an EPDM membrane. The west side of the roof is partially shaded in the afternoon whereas the east side has full sun exposure throughout the day. This allows students to analyze how shade affects eco-roof performance.

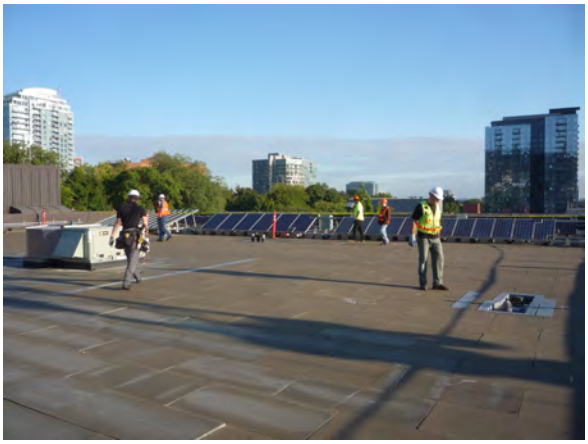


Figure 2, site the morning of installation

Photovoltaic arrays were installed north of the proposed CHERP site prior to ecoroof construction. The configuration consists of 5 different panel designs. Their performance is being monitored to meet goals analogous to those of CHERP. Together the PV's and CHERP comprise the living laboratory of Cramer Hall.

System Design

The ecoroof is composed of wooden frames that sit on top of a composite of ACF West Amergreen 50 geonet and fabric (see Appendix). The plastic geonet material was chosen for its low weight and ability to provide adequate drainage for the soil. The product also includes a synthetic fabric, which acts as a root barrier. The geonet sits on top of a Firestone EPDM membrane, which will help collect water for monitoring (Figure 3).

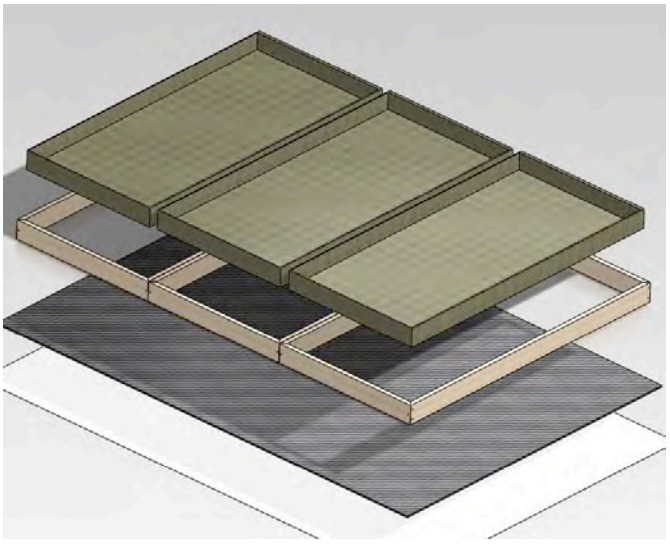


Figure 3, Planter box components. The green shells represent soil media, and the black sheet represents the geonet composite

The simple modular design allowed for quick installation. In addition, all the boxes are independent so they can be easily replaced if damaged/worn. Future expansion of the system would not affect existing boxes.

Figure 4, Geonet (top) and fabric (bottom) composite. Courtesy of ACF West

Planter Boxes

Boxes measure 8'x12' and are composed of three 4'x8' sections (see Appendix). The wood frames were constructed on campus by students and Facilities and Planning (FAP) staff prior to installation. The smaller sections facilitated transportation and lifting during the day of construction. The frames are made of 2"x6" Douglas fir and painted with water-based white primer. All joints were connected using 2 or 3 1/4" x 3" lag screws.

Growing Media

Phillips Soil provided the seven different soil types distributed among the boxes. Each box holds roughly 1.5 yd^3 of soil (5" soil depth). The collection consists of a variety of intensive, extensive, and non-conventional green roof media. Each mixture has distinct composition and is priced differently. By monitoring the different boxes we hope to illuminate possible reasons for the discrepancy and determine if the extra cost of more expensive soils is worth future investment. Table 1 outlines the types and quantities of each soil:

Table 1, Growing media

Soil Media	Quantity (yd^3)
Extensive C	7.5
Intensive B4	6
Intensive B4 Plus	1.5
Intensive A3	3
Extensive E	4.5
Biomax Mat	1.5
Potting Soil on top of Pumice	6

Phillips Soil has provided data sheets for some of these mixes. PSU students will work towards having data for the remaining soils within the first year of completion. This information will be provided in a progress report submitted to BES.

Plants

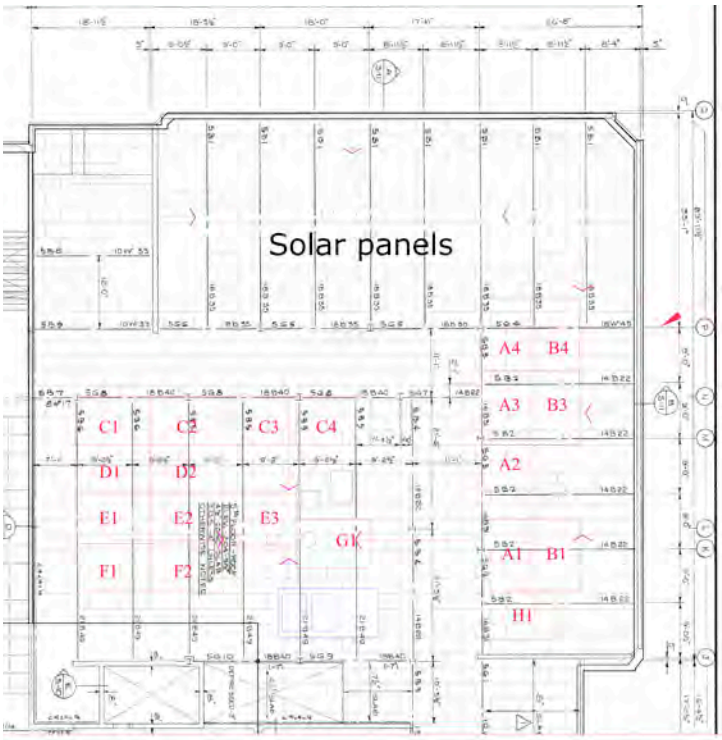
Plants were ordered from Koenig, Bosky Dell, and Northwest Horticulture. The project consists of mostly sedums with dispersed grasses/rushes, and wild strawberry and thyme. The price for native sedums was roughly three times higher than their non-native counterpart. Funding has been allocated to replace dead plants if needed. Table 2 summarizes the plant selection. Detailed species locations will be provided in a progress report submitted to BES.

Table 2, Plant species and types

Native		Non-Native	
Evergreen Sedums	Sedum oreganum	Evergreen Sedums	Sedum album (coral carpet)
	Sedum stenopetalum (worm-leaved)		Sedum acre
	Sedum spathulifolium 'Cape Blanco'		Sedum acre gold carpet
	Sedum spathulifolium 'Rogue River'		Sedum nevii Silver Frost
Deciduous Sedums	Sedum oregonense		Sedum spurium (Dragon's Blood)
	Sedum oblanceolatum	Deciduous Sedums	Sedum kamtschaticum (variegatum)
Grasses	Festuca idahoensis		Sedum rupestre (Angelina)
	Camassia Quamash		Sedum 'John Creech'
	Allium cernuum		Sedum ewersii
Accent Plants	Campanula rotundifolia	Grasses	Festuca glauca Elijah blue
	Eriophyllum lanatum (Oregon Sunshine)		Festuca glauca blue
	Wild strawberry	Accent Plants	Sempervivum tectorum (hens and chicks)
			Delosperma (cooperii pink)
			Herb thyme fragrantissimus

Box Layout

The total area of CHERP is 1,920 ft². Planter Boxes are separated into two sections (Figure 5), which differ in the amount of sunlight they receive. The sections contain boxes with either native and non-native plant species in each of the seven soils. A map of the boxes with their plant and soil composition is provided below:



Box ID	Soil type	Plant type
H1	Pumice/potting soil	Non-native
A1	Pumice/potting soil	Native
B1	Extensive E	Native
A2	Extensive E	Non-native
A3	Extensive C	Non-native
B3	Extensive C	Native
A4	Intensive A3	Non-native
B4	Intensive A3	Native
C4	Intensive B4	Native
C3	3" Extensive C	Mix (2 non-native, 1 native)
C2	Extensive C	Native
C1	Extensive C	Non-native
D1	3" Extensive C	Mix (2 non-native, 1 native)
D2	Biomax mat	Mix (1 non-native, 1 native, 1 edible)
E1	Intensive B4	Non-native
E2	Extensive E	Mix (1 non-native, 2 native)
E3	Potting soil	Mix (2 non-native, 1 native)
F1	Intensive B4	Non-native
F2	Intensive B4	Native
G1	Intensive B4+	Mix (1 non-native, 2 native)

*Mix means that native and non-native plants will both be used in a completed box in separate sections. Each completed box has three sections inside. The edible section contains wild strawberry and thyme.

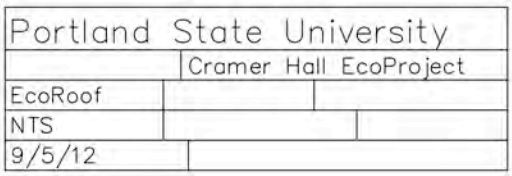


Figure 5, Planter box layout with soil and plant specifications.

Itemized Budget

During the design of CHERP students strived to maintain a budget within the amount allotted by BES ($5/ft²). The final cost of the project ($8.25/ft²) was substantially reduced through in-kind donations and student volunteer labor. Table 3 outlines the itemized budget for the project. Table 4 shows the additional costs that would have been included without donated materials and labor. These tables illustrate that the cost was reduced by 31% through the donations.

Table 3, Itemized budget with donations

ITEM	PRICE
Planter Boxes	$1,711.03
Soil Media	$2,150.25
ACF West Geonet	$2422.00
Plants	$2,441.09
Staff Labor	$1,902.53
Crane and traffic control	$5,220.00
Total with donations	$15,846.90
Price per square foot	$8.25

Table 4, Budget excluding donations***

ITEM	PRICE
Student Labor*	$2,400
Roof Membrane**	$4,800
Total with donations	$15,846.90
Total without donations	$23,046.90
Price per square foot	$12.00

*30 students for 8 hours at $10/hr
**Assumed at $2.5/ft^2
***This table does not include billable hours for KPFF.

Installation

CHERP was installed September 22nd, 2012. Construction began at 8AM and lasted 8 hours. Thirty student volunteers were present to help with box layout and assembly, traffic control, soil distribution, and planting.

Campbell Crane lifted all materials to the roof. First the membrane and geonet composite were brought up, followed by the box frames, soil, and plants. Soil was carried in 1.5 yd^3 bags and dumped directly into the boxes (Figure 6).

Figure 6, Intensive A-3 mixture being dumped into box B-4 (first three sections).

Monitoring and Maintenance

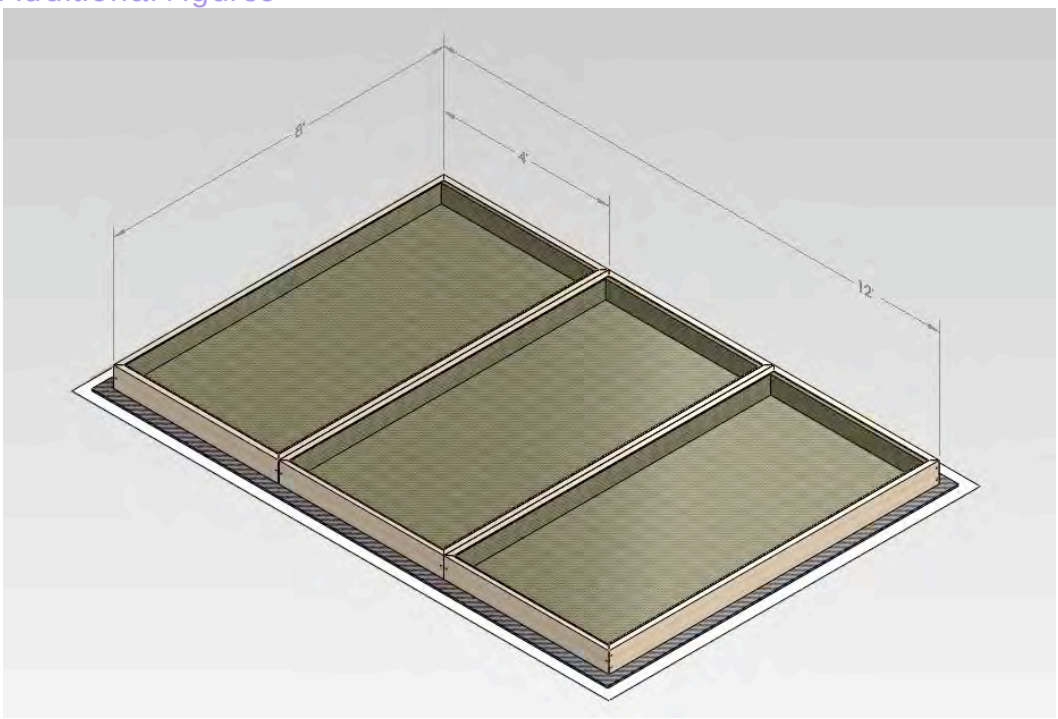
One objective of CHERP is to analyze the performance of different extensive ecoroof systems. Individual boxes will be monitored and compared throughout the design life cycle (7 years). At the initial stage the criteria that will quantify performance are storm water management behavior (water quality, retention, etc.) and plant health (growth, diversity, health). Data quality objectives will be discussed following construction to more explicitly define these criteria.

Students are highly dedicated to quantifying the behavior of the different planter box systems. Monitoring and data analysis will be carried out as part of course curriculum and student group activities at Portland State University. Two students have already begun working on research projects involving water quality and quantity monitoring as part of the Undergraduate Research and Mentorship Program.

EWB-PSU and FAP will jointly oversee maintenance of the system. The maintenance plan will follow that outlined in Chapter 3 of the COP Stormwater Management Manual for ecoroofs. At this time the roof has no irrigation systems.

Appendix

Additional Figures



Planter box configuration

ACF West Geonet Composite

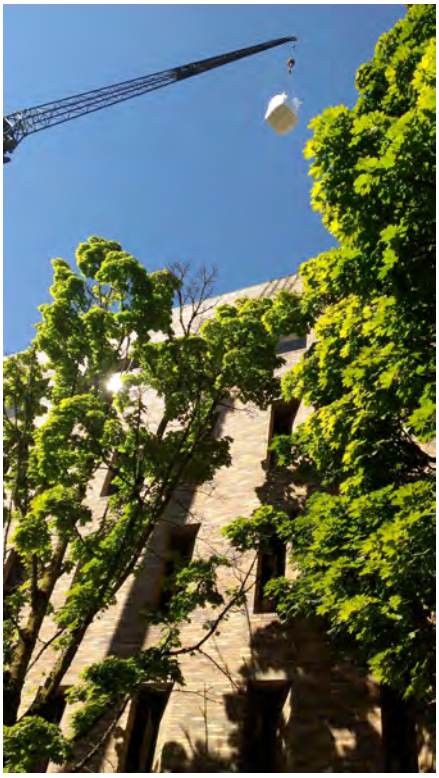
TECHNICAL DATA			50	100
Physical Properties	ASTM Test Method	US Value	Typical Value	Typical Value
FILTER FABRIC - Growing Medium Retention, Root Barrier				
Fabric Type			Spunbonded, Nonwoven	Spunbonded, Nonwoven
Material			Polypropylene	Polypropylene
Water Flow Rate	D-4491	gpm / ft²	80	80
		Lpm / m²	3,260	3,260
Grab Tensile Strength	D-4632	lbs	145	145
		N	645	645
UV Resistance	D-4355	% / 500 Hrs	70	70
DRAIN CORE - Drainage, Water Storage, Aeration				
Material			High Impact Polystyrene	High Impact Polystyrene
Thickness	D-1777	in	0.44	1.0
		mm	11.0	25.4
Compressive Strength	D-1621	psf	15,000	9,000
		kPa	718	431
Horizontal Flow Rate [1] Gradient = 1.0	D-4716	gpm/ft	16	80
		Lpm/m	200	933
Horizontal Flow Rate [1] Gradient = 0.1	D-4716	gpm/ft	6	21
		Lpm/m	75	260
Water Storage Capacity		g/ft²	.06	0.11
		L/m²	2.4	4.5
Perforation Open Area		in²/ft²	3.9	8.7
		mm²/m²	27,080	60,400
PROTECTION FABRIC-Waterproofing Protection				
Fabric Type			Needle-Punched, Nonwoven	Needle-Punched, Nonwoven
Material			Polypropylene	Polypropylene
ROLL SIZE			4' x 50'	3' x 50'
RECYCLED CONTENT			57 %	68 %

1 - In-plane flow rate measured at 3,600 psf (172 kPa) compressive load and referenced hydraulic gradient.

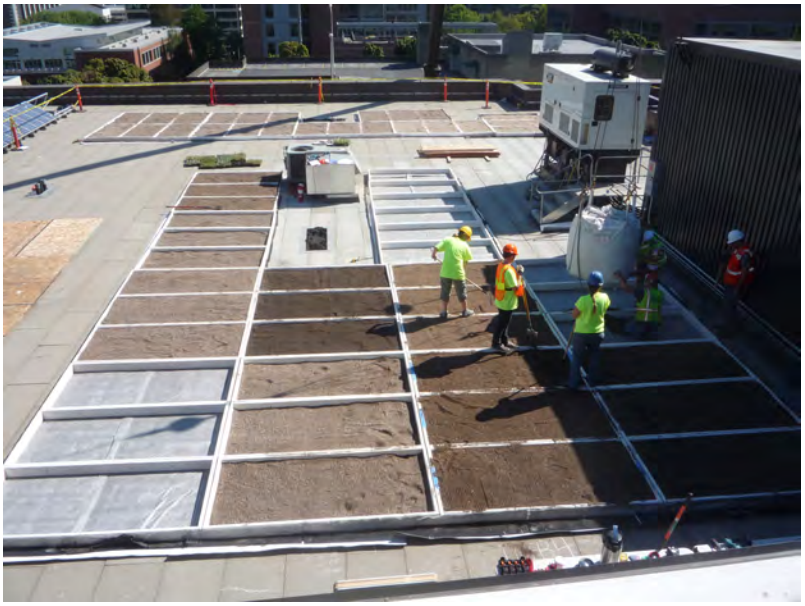
*Table courtesy of ACF West

Ecoroof Photos

Panorama of roof construction. Rows A and B are to the right.



Crane lifting soil from Broadway Avenue



Birds eye view, looking east

Wild Strawberries in Biomax soil, Box D2

Initial Planting Stage