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PROPOSED

LAFAYETTE COLLEGE

CEERC

Civil & Environmental Engineering Research Center

-

Report 3

Sustainable Design Elements

Site
Former Hummel Lumber Supply at 900 Bushkill Drive

City of Easton, Northampton County, Pennsylvania

Sustainability Analysis Table of Contents

SECTION I: GENERAL PROJECT DESCRIPTION

One of the goals outlined in Lafayette College's master plan "is to encourage sustainability at the 'Campus Scale' by addressing four broad categories: ecology and hydrology, energy, built environments, and human capital." The design for the new Civil and Environmental Engineering Research Center (CEERC) incorporates these categories. The plan addresses energy by providing an alternative source and implementing photovoltaic panels (PV Panels) on the existing structure. The design includes local and reusable material in order to incorporate a sustainable built environment. Various stormwater strategies were configured in order to maintain the site's hydrology and ecology. The plan aims to design a site that will set a standard for future buildings constructed on Lafayette's campus.

SECTION II: ENERGY

II.1: Photovoltaic Panels

The roof of the CEERC will be divided into two parts composing of a green roof in order to collect and treat runoff, as well as PV panels to capture and use solar energy. The space will act as a learning tool for students to further understand different methods of alternative energy. This is in accordance with the College's master plan which states, "By generating as much energy as possible onsite, the College will decrease its carbon footprint while creating 'living laboratories and classrooms' where students will experience sustainable technologies first-hand."

The CEERC has about 75 m^2 of space allocated for PV panels. Allentown's yearly minimum solar isolation of 5.4 kWh/meters squared/day was used in order to calculate the amount of energy generated by the PV panels. Table II.1 shows the average solar isolation per year in Allentown, Pennsylvania. The average solar isolation varies based on location in the United States. In Arizona the average solar isolation is about 6 kWh/meters-squared/day, whereas in Vermont it is around 4kWh/meters-squared/day.

Table II.1 Solar Radiation for 1 Axis Tracking Flat-Plate collectors (kWh/m^2/day)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YEAR
Avg.	3.6	4.6	5.5	6.3	6.7	7.1	7.1	6.8	6.0	5.0	3.4	2.9	5.4
Min	2.7	3.7	4.6	4.8	5.4	5.5	5.9	5.8	4.6	4.0	2.2	1.7	5.0
Max	4.5	6.3	6.7	7.9	8.3	8.5	8.3	8.0	7.1	6.6	4.7	3.6	5.9

Using a solar isolation of 5.4 kWh/meters squared/day and assuming 21% efficiency panels, the total electricity generated is 85 kWh/day**,** this total can be seen in Table II.2**.**

21% efficiency is a high value for PV panels to capture light, and was selected assuming the College could afford the newest technology in the market. Most solar panels have an efficiency of about 12-18%, but the technology continues to improve over the years.

Table II.2 Total Daily Electricity Generated

Surface Area (m^2)	Efficiency (%)	Total Electricity (kWh/day)
75	21	85

The average household utilizes about 30 kWh/day; therefore, the energy from the solar panels will provide a substantial source of power for the research facility. The PV panels will act as both a useful alternative energy source as well as a way for students to have more opportunities for hands-on learning.

SECTION III: MATERIALS

III.1: Existing Building

The current building's existing structure is designed to be retrofitted, and not demolished. This reduces the amount of materials used if constructing a new building. The amount of waste generated also decreases because there will be less debris.

III.2: Local Materials

In addition to maintaining the existing structure, any further materials will be outsourced from as many local manufacturers as possible. The closer resources are to the site, the less energy will be consumed from transportation.

The geologic composition of the Lehigh Valley provides an abundance source of limestone. Much of this limestone is mined and heated and combined with other materials, the result is cement. There are several different mining facilities near the College. Table III.2 provides a description as well as their distance from site. Each facility mines limestone and would be able to provide cement in a sustainable manner.

Table III.3 Cement Facilities

Facility	**Description**	**Location**	**Distance**

Eastern Ind. Inc	Produce crushed limestone and other stones. Extracted for a variety of uses.	3285 Martins Creek Belvidere H Bangor, PA 18013	9.4 mi
Essroc Cement Corp.	Cement plant and masonry warehouse.	3251 Bath Pike, Nazareth PA	11.3 mi
Hercules Cement Corp.	Manufacturer of cement and cement products. Clients are construction and contracting companies	401 W Prospect St, Nazareth Pa	8.6 mi

SECTION IV: STORMWATER MANAGEMENT STRATEGY

IV.1: Vegetation and Impervious Areas

One of the main purposes of the stormwater management strategy for the CEERC is to treat runoff before it enters the neighboring Bushkill Creek. Areas of vegetation have been implemented throughout the property such as a green roof, rain garden, courtyard, and various vegetated areas in order to infiltrate and treat water through natural methods. The different methods can be seen in Figure IV.1.

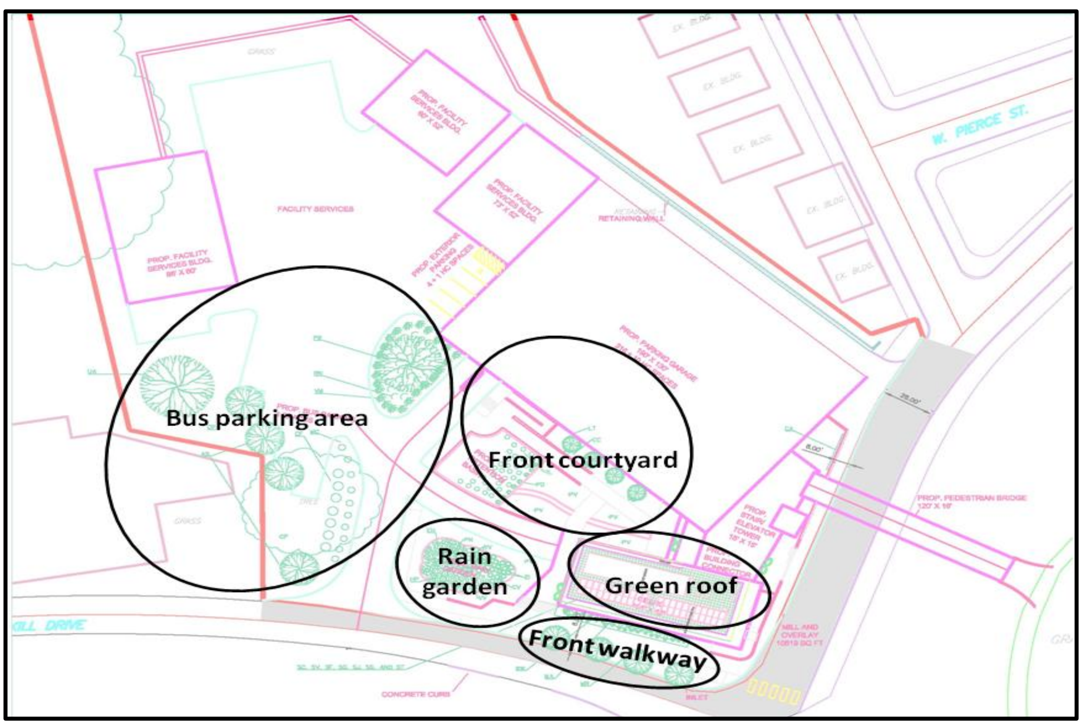

Figure IV.1 Vegetated Areas

About 1000 additional sq meters of vegetation have been designed for the CEERC. Table IV.1 shows the different areas that make up this total.

Table IV.1 Total Vegetated Space

Vegetated Space	Area (ft^2)	Area (m^2)
Greenroof	2992	278
Rain Garden	1440	134
Front Walkway	475	44
Front Courtyard	1596	148
Bus Parking Area	5270	490
Total	11773	1094

Removing the amount of impervious surface on the site improves the water quality of the runoff. The plants and soils outlined in the design have the ability to decrease the amount of pollutants in the water such as the level of Total Dissolved Solids (TDS), Organic Biological Oxygen Demand (BOD), sedimentation, and certain Pathogens.

IV.2: Green Roof

Plants were selected for hardiness and various shade and drought tolerance based on location in the site. Plants were selected and placed such that some would be most attractive in each season: blooming flowers in spring, dense leaf cover in summer, red and orange foliage in autumn, and evergreen and ornamental grasses for visual cover and aesthetics in winter. Height variation was also considered, to maximize aesthetic value. Larger, taller plants were placed towards the outer edge of the pedestrian view point with smaller flowers being closer. The plants selected can be seen in Table IV.2. Green roof species were selected for their ability to absorb water well. Wetland species were selected based on obligate wetland status and the ability to improve water quality. The layers of the green roof are shown in Figure IV.2.

Table IV.2 Plant Selection

Scientific Name	Common Name	Quantity
Acer Saccharinum	Silver Maple	4
Clematis Alpina	Alpine Clematis	3
Crocus 'Pickwick'	Purple Striped Crocus	20
Calamagrostis Acutiflora	Feather Reed Grass Karl Forester'	7
Coreopsis Verticillata	Threadleaf Coreopsis	5
Elymus Hystrix	Bottlebrush Grass	7
Hypericum Perforatum	St. John's Wort	5
Ilex Decidua	Possumaw	2
Muscari Armeniacum	White Grape Hyancinths	4
Malus X 'Red Jewel'	Red Jewel Crabapple	9
Picea Breweriana	Brewer's Weeping Spruce	10
Physocarpus Opulifolius	Ninebark	4
Polygonatum Odoratum Var. Pluriflorum 'Variegatum'	Variegated Solomon's Seal	1
Panicum Virgatum	Switchgrass	1
Rhododendron Nova Zembla	Rhododendron	9
Rhododendron Viscosum	Swamp Azela	--
Sedum Cauticola	Sedum Cauticola	3
Sedum 'Frosty Morn'	Sedum 'Frosty Morn'	4
Sedum Grisebachil	Sedum Grisbachil	--
Sedum Spathulifolium	Sedum Spathulifolium	--
Sedum Spurium 'Tricolor'	Sedum Spurium 'Tricolor'	--
Sedum 'Vera Jameson'	Sedum 'Vera Jameson'	--
Scilla Siberica	Wood Squill	--
Typha Latifolia	Cattail	30
Ulmus Americana	American Elm	1
Vinca Major	Vinca	--
Veronicastrum Virginicum	Culver's Root	5

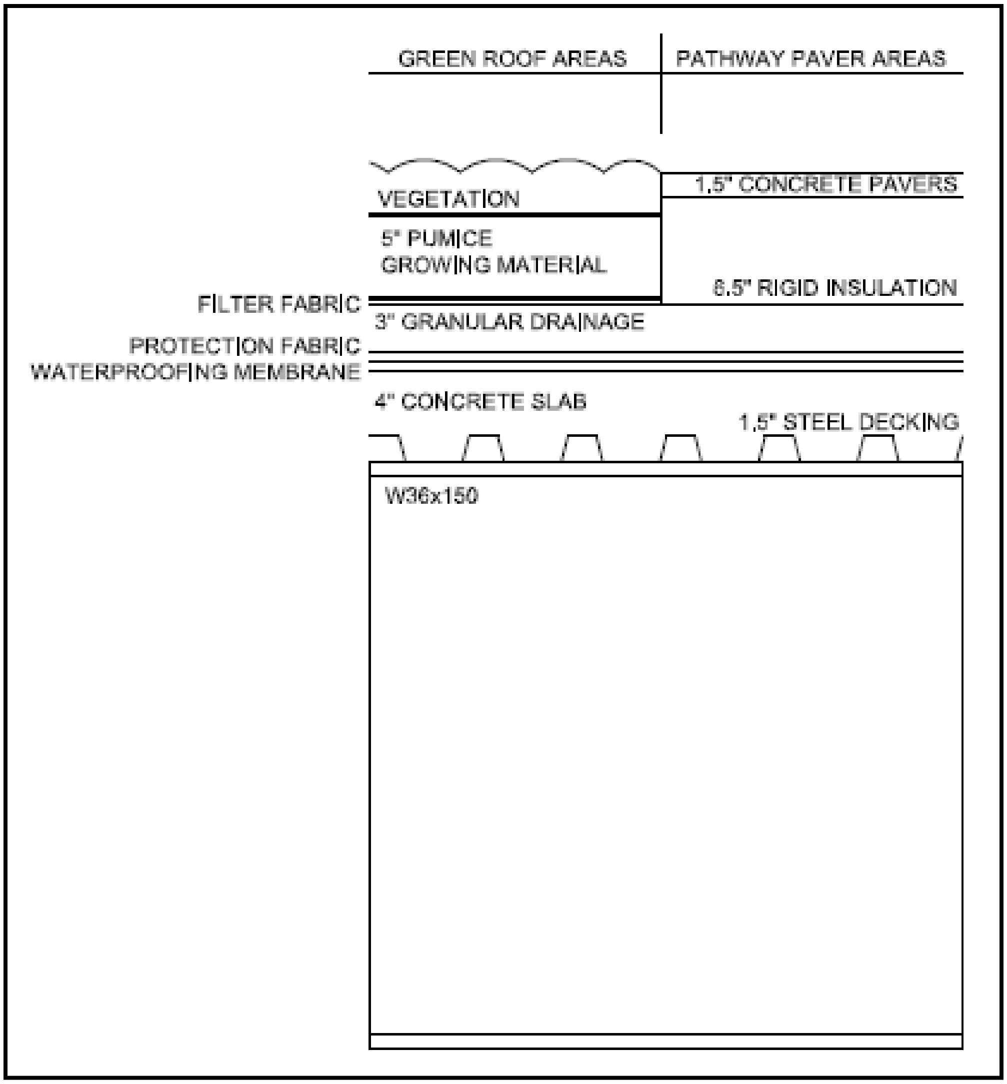

Figure IV.2 Green roof Layers

IV.3: Pavement and Pavers

As discussed in Section III.2, cement is an abundant regional resource that can be used as a component of concrete. Concrete is commonly used for foundations, structures, and pedestrian pathways. Recently, concrete has been used as pavement on roads and parking lots in order to decrease the level of thermal impact on stormwater. Concrete has high levels of albedo and reflective emittance, which are two factors that contribute to the amount of the heat absorbed. Conventional asphalt can reach temperatures of 120-150 ºF. It also has an albedo, which is the amount of solar reflectance, of 5 – 40% which means it absorbs 95 – 60% of energy. Light-colored pavements, such as concrete, can have a solar reflectance greater than 75%.

IV.3.1: Properties of Concrete Pavement

The concrete mixture is a conventional concrete pavement composed of Portland cement, water, and aggregate that is cured until strong enough to carry traffic. In order to increase the strength of the concrete, slag ash can be added. Slag ash is a byproduct of processing iron ore that can be ground to produce cement, which is an excellent way to reuse the byproduct and not waste material. The slag ash lightens the color tone and increases the reflectivity from 35% to 60%. White cement can also be used which can raise the solar reflectance from 40% to 70%.

IV.3.2: Issues and considerations

The solar reflectance may start at 70% but it can decrease to 25% over 5 years. This can occur by traffic that can pollute the concrete and wear the surface away and can be seen in Figure IV.3: Typical Solar Reflectance of Asphalt and Concrete Pavements over Time.

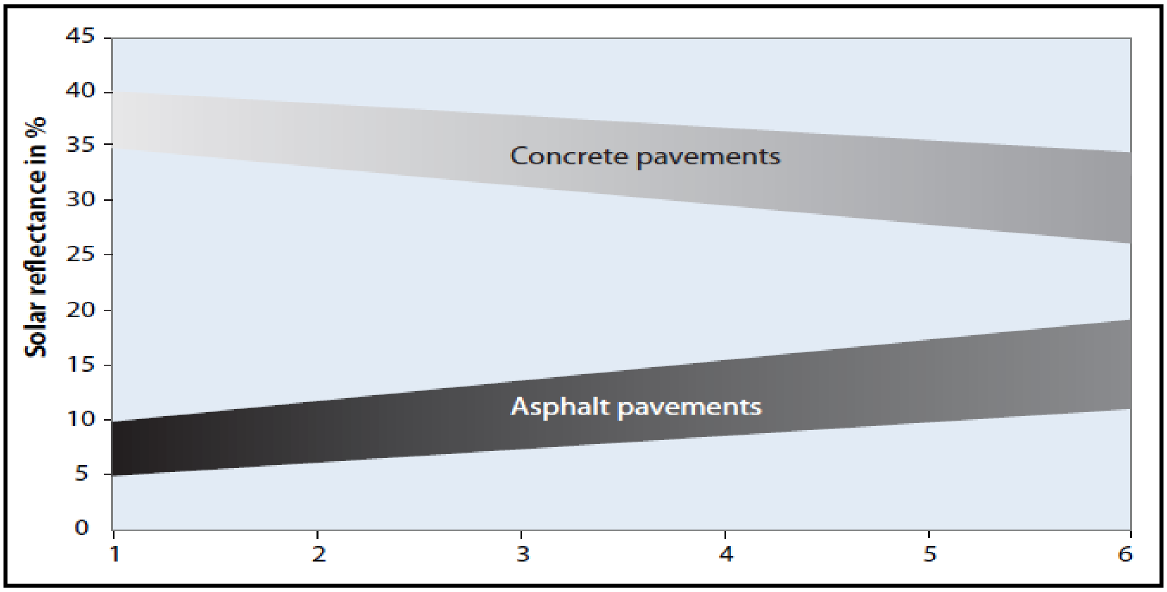

Figure IV.3 Typical Solar Reflectance of Asphalt and Concrete Pavements over Time

IV.3.3: Benefits

There are, however, many benefits to using concrete instead of asphalt pavement. The concrete would lower the surface temperature would also lower the temperature of stormwater, which would also lower the ameliorating thermal shock to aquatic life. In addition to reducing the temperature of stormwater the overall air temperature would also decrease. In general, if a city increases the amount pavement reflectance from 10 to 35% the temperature would reduce 1 ºF. This would lower the amount of energy used in the summer to cool cities.

IV.4: Additional Information

To learn more about the stormwater management plan in greater detail please refer to the Report 4: Post-Construction Stormwater Management Plan.

SECTION V: WATER CAPTURE AND REUSE

V.1: Rainwater Volume Generated

Two plant operations buildings that are to the west of the parking garage and research facility were designed to capture rainwater. In total, the site captures over 133,000 gallons per year. The rainwater will be collected from the roofs, through a gutter system, which will then be stored in aboveground storage tanks.

Table V.1 Total Rainfall Volume Capture

Building	Roof Area (ft^2)	Annual Precipitation (in.)	Volume Captured ($gal/ft^2/in$)	Efficiency	Annual Rainfall Potential Capture (gal/year)
Plant Operations 1	5148	32.54	0.62	0.80	83088
Plant Operations 2	3120	32.54	0.62	0.80	50356
TOTAL					133444

V.2: Rainwater Volume Consumed

The rainwater harvested is best used towards irrigation. The water quality standards are less stringent than the regulations for water usage indoors. The volume of water required to irrigate the subject property, however, is much more than the water be collected. The best option is to still use the water for irrigation but in smaller quantities. The water will be collected from the above ground storage tanks through plant operations trucks, which will then transport the water to treat plants on Lafayette’s campus.

V.3: Storage Tank Dimensions and Maintenance

In order to determine the size of each storage tank several factors were considered. The total volume of water collected each month was calculated and then subtracted by the volume utilized by plant operations for irrigation purposes. During the winter months such as January, February, November, and December, no rainwater will be harvested because the vegetation will be covered. Instead, any runoff accumulated will be drained from the system immediately. Every October the tanks will be emptied in order to prepare for the winter months and prevent any freezing and expansion. The amount consumed in March and April will be less, to prevent wells from emptying in future months

The larger plant operation building has a surface area of 5148 ft^2. Using the average monthly rainfalls from the National Weather Service, a gutter efficiency of 85%, and a typical water removal of 350 gallons per day, the maximum storage volume was calculated. This facility has the largest maximum volume of 5148 gallons, so the storage tank is designed for 5871 gallons, this can be seen in Table V.2. The storage tank has a radius and height of 10 ft.

Table V.2 Total Rainfall Collection

Month	Monthly Rainfall (inches)	Collected (gallons)	Consumed (gallons)	End of month Inventory (gallons)
Jan	3.03	8265	-	-
Feb	2.8	7637	-	-
Mar	3.39	9247	8370	877
Apr	3.56	9710	10500	87
May	4.14	11292	10850	529
Jun	4.31	11756	10500	1785
Jul	4.95	13502	10850	4437
Aug	3.69	10065	10850	3652
Sep	4.62	12601	10500	5753
Oct	3.88	10583	10850	5486
Nov	3.5	9547	-	-
Dec	3.58	9765	-	-

The other plant operations facility has a surface area of 3120 ft^2. Using the average monthly rainfalls from the National Weather Service, a gutter efficiency of 85%, and a typical water removal of 200 gallons per day, the maximum storage volume was calculated. This facility has a maximum storage tank volume of 5502 gallons, so the storage tank is designed for 5871 gallons, this can be seen in Table V.3. The storage tank has a radius and height of 10 ft.

Table V.3 Total Rainfall Collection

Month	Monthly Rainfall (inches)	Collected (gallons)	Consumed (gallons)	End of month Inventory (gallons)
Jan	3.03	5009	-	-
Feb	2.8	4629	-	-
Mar	3.39	5604	5425	179
Apr	3.56	5885	5400	664
May	4.14	6844	6200	1308
Jun	4.31	7125	6200	2233
Jul	4.95	8183	6200	4216
Aug	3.69	6100	6200	4116
Sep	4.62	7637	6200	5553
Oct	3.88	6414	6200	5767
Nov	3.5	5786	-	-
Dec	3.58	5918	-	-

V.4: Water Quality Standards

Few states and local municipalities have regulations and water quality standards for harvested rainwater. The Uniform Plumbing Code (UPC) and the International Plumbing Code (IPC) both do not address rainwater-harvesting regulations in their potable or stormwater sections.

In October 2012 the EPA published a document addressing different types of indoor and outdoor water use. There is a section *Onsite Alternative Water Sources*, which discusses modifications that can be done to make a sites water system more efficient. Tables V.4 and V.5 show water quality requirements harvested rainwater. The Total Dissolved Solids (TDS), Organic Biological Oxygen Demand (BOD), and any Pathogens are all considered a low level of concern. The amount of sediment in the rainwater will be of medium level of concern will need additional treatment in order to be used for the Water Resources Lab Tank. The rainwater does not need to be treated when used for irrigation.

Table V.4 Water Quality Standards for Rainwater Harvesting

Possible Source	Sediment	Total Dissolved Solids (TDS)	Hardness	Organic Biological Oxygen Demand (BOD)	Pathogens	Other Considerations
Rainwater	Low/ Medium	Low	Low	Low	Low	None

Table V.5 Available Treatments Based on Water End Use

Possible Source	Filtration	Sedimentation	Disinfection	Biological Treatment	Other Treatment Considerations
Rainwater	Depends	Depends	Depends	No	May be used for irrigation without additional treatment

SECTION VI: REFERENCES

Lafayette College. *Lafayette 2009 Master Plan Executive Summary*. Master Plan. N.p.: n.p., 2009. Print.

US Environmental Protectional Agency. *WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities*. Rep. 2012.

USA Environmental Protection Agency: Climate Protection Partnership Division. *Reducing Urban Heat Islands: Compendium of Strategies*. Rep. 2005.

WBAN NO. 14737. Solar Radiation for Flat-Plate Collectors. 1990. Raw data. Allentown,