Overview of UVA's Research Strategy for All Three Case Studies [1]

Introduction: The UVA research team's case studies focus on landscape projects that manage water in the form of a stream restoration and stormwater conveyance. The goal of this research is to examine the performative features of the three built landscape projects. The UVA research team used a variety of methods to examine the design features and analyze the performative aspects of these projects. Using the Landscape Performance Series (LPS) formatting, each case study presents an overview, performance benefits, sustainable features, challenges/solutions, cost comparisons, lessons learned, and the role of the landscape architect. The research is led by the Case Study Investigation (CSI) program and funded by the Landscape Architecture Foundation (LAF).

Data Collection and Analysis: The research process began with collecting all available information from the firms and clients. All data was carefully examined to develop the appropriate benefit statements and sustainable feature descriptions to provide the most accurate and detailed case studies. In accordance with the LPS format, our goal was to provide a well-rounded case study that included environmental, economic, social (and cultural heritage) benefit statements. LAF designed this program to be a close collaboration between firms and university research teams; therefore firms were prepared to provide necessary data and were able to include other members of the design team to provide additional insight. The benefits first address the primary impacts of the site, then reach into the broader community and environmental system to address secondary impacts of the project. The detailed methodology below explains how the research team used a variety of methods to examine the data and extract each benefit statement.

Secondary Data Collection: Beyond data collected from the project firms, the exploration continued by reaching out to secondary stakeholders and public records to enrich the depth of the research. Others involved included: engineers, neighbors, faculty, staff, and maintenance crews. Collaboration and cooperation from the design teams (engineers and architects) and site users (visitors and students) was essential in accomplishing a well-rounded case study. The project engineers were essential in understanding stormwater measurements, irrigation methods and stream monitoring.

Drawings: To better understand the projects and to learn about the design features, the researchers closely examined the drawing sets. This information helped to identify plant palettes, quantify site measurements and evaluate the design intent as compared to the built work.

Site Observations: The research team used passive observation, photography, site measurements, traffic counts and activity mapping to gain a better understanding of the site and to collect primary data to contribute to the case study. The researchers acquired necessary permissions from site owners and managers to access the site; when possible, site staff escorted the research team to limited access areas such as green roofs. Observational methods aimed to not disrupt the user experience on each site. As a result of the limited timeframe for site observations, and the summer climate conditions during our research, some observations were not representative of the typical site usage patterns, especially at the JMU Biosciences academic building where the summer course load is significantly smaller than the use during the academic year.

Survey: To best understand the social benefits of these built projects that are open to the public, we conducted surveys to attain primary source data about the perceptions of the site users, particularly focusing on how the site was perceived before and after the landscape installation. The surveys start by asking the user if the changes in the landscape have made a positive or negative impact on their experience of the site. The questions become increasingly detailed in asking which features the user finds the most important, how often the respondent uses the site, how much time they spend there, and what activities they use the site for. The remaining questions ask the respondent to rate the quality of different aspects of the site from before and after the landscape installation. Respondents are also given a chance to write in responses to explain the best aspects of the project from before and after the changes. Finally, demographic information is collected to best understand the pool of respondents.

[1] This white paper can be cited as: Cho, Leena, and Margaret Graham. "James Madison University College of Integrated Science and Technology Case Study Methodology." *Landscape Architecture Foundation*. 2014.

JMU College of Integrated Science and Technology Landscape

Methodology for Landscape Performance Benefits
Case Study Investigation 2014
University of Virginia

Research Fellow:
Leena Cho
Lecturer in Landscape Architecture
School of Architecture, University of Virginia

Research Assistant:
Margaret Graham, MLA Candidate
School of Architecture, University of Virginia

Firm Liaison: Rhodeside & Harwell
Elliot Rhodeside, Principal, Landscape Architect
Kurt Parker, Associate Principal, Landscape Architect

The James Madison University College of Integrated Science and Technology building and landscape represents the interest of the University to combine environmental stewardship with educational opportunities. The $1.2 million project completed in 2012 encompasses the 128,066 square feet of outdoor space around the academic building. The case study, therefore, evaluates the stormwater conveyance features, the green roof, and the outdoor spaces scattered between the rain gardens and swales. The challenge of this case study was observing the site during the summer season, when the academic year is on recess and the building is used at its minimum capacity. Additionally, because the landscape is still young, the shade trees have not reached their maturity, giving little space for summer students to retreat to in the outdoor spaces.

Figure 1. College of Integrated Science and Technology site plan

Environmental Performance Benefits:

- ***Estimated to remove 65% of total phosphorus with 2 rain gardens that treat 0.86 acres of impervious area.***

Method: Information was obtained from the engineer's stormwater narrative document for the project. The engineers used a technology-based approach to calculate what features were necessary to mitigate the on-site runoff.

Data: According to the engineer's documents, the post-development condition results in a site that is 45% impervious; therefore the technology-based approach calls for a BMP that is at least 50% effective in removing Total Phosphorus. The rain gardens are designed to remove 65%. Rain garden 1 treats .6 acres of impervious area and rain garden 2 treats .264 acres of impervious area. The rain gardens are sized to treat the first 1" of rainfall over the impervious area within their drainage area.

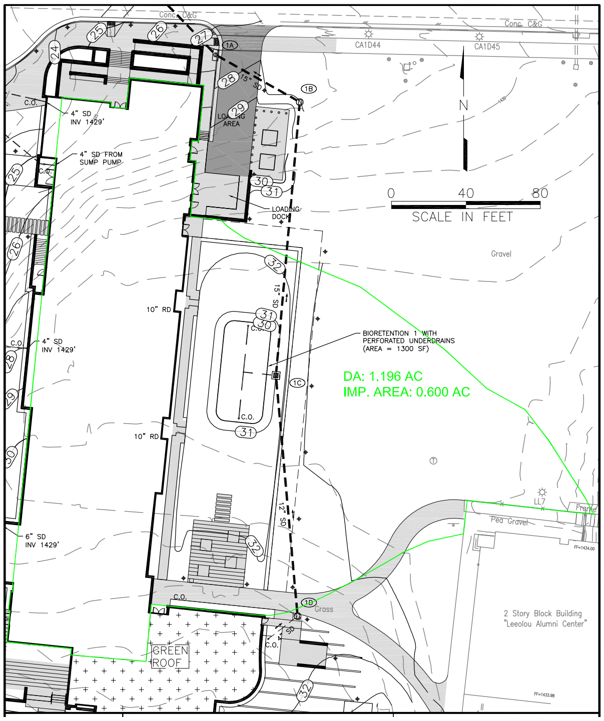

Figure 2. Rain garden 1 drainage area
Source: Anderson & Associates Engineers

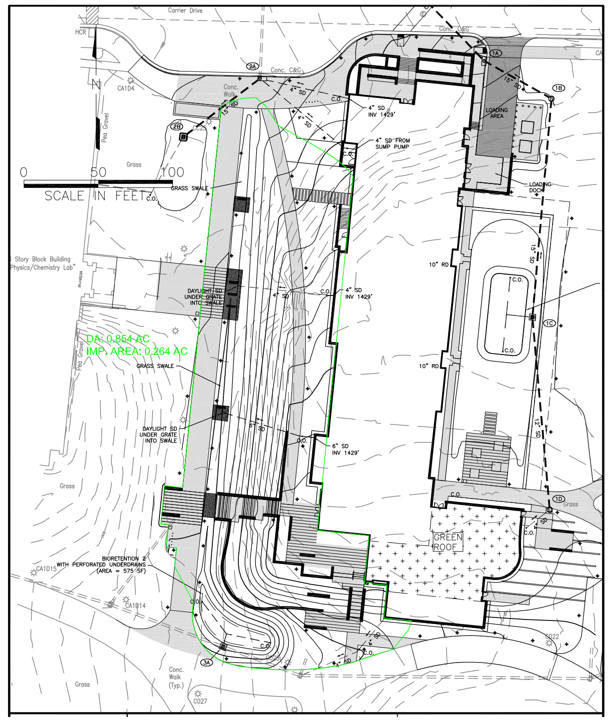

Figure 3. Rain garden 2 drainage area

Site Stormwater Quantity Control

	Drainage area (acres)	Impervious area (acres)	1" rainfall (gallons)
Rain Garden 1	1.192	.600	16,300
Rain Garden 2	.845	.264	7,172
Total Rain Garden	2.037	.864	23,472
Total Site	2.940	1.330	36,132

To calculate gallons of water for first 1" of rainfall:

1 acre-foot (1 acre of surface covered by 1 foot of water) = 326,000 gallons
acres * 326,000 / 12 = gallons

Limitations: This data was based on BMP calculations, not site measurements, so the actual performance of the site could vary from this statement.

References:

Boyd, Robert K. Erosion & Sediment Control and Stormwater Management Narrative and Stormwater Pollution Prevention Plan. Blacksburg: Anderson & Associates, 2010.

- ***Estimated to reduce annual roof runoff by 12% or 109,732 gallons with an extensive green roof that covers 16% of the roof area.***

Method: The various impacts of the extensive green roof were calculated using the Green Roof Energy calculator from the Green Building Research Laboratory.

Data:

Figure 4. Site plan with green roof outlined

Figure 5. Greenroof; image take from above on higher roof

Annual Roof Water Balance

	Conventional Roof	16% Green Roof System
Precipitation	41.8 in	41.8 in
Evapotranspiration	--	4.2 in
Irrigation	--	0.0 in
Net Runoff	41.8 in	36.8 in

To calculate percentage of runoff reduction:

total precipitation – net runoff = difference
difference / total precipitation * 100 = %
41.8 -36.8 = 5 inches
5 / 41.8 *100 = 12%

To calculate gallons of water for annual greenroof runoff:

1 acre-foot (1 acre of surface covered by 1 foot of water) = 326,000 gallons
36.8 in = 3.06 ft
greenroof = .11 acres
acres * 326,000 * 3.06 = gallons
.11 * 326,000 * 3.06 = 109,732 gallons

Limitations: This benefit is based on the available calculations provided by the Green Roof Energy calculator and does not include other environmental factors. Additionally, outcome of the calculator is based on simulations, which may vary from reality due to changes in soil moisture, growing media composition, compaction, etc.

References:

Boyd, Robert K. Erosion & Sediment Control and Stormwater Management Narrative and Stormwater Pollution Prevention Plan. Blacksburg: Anderson & Associates, 2010.

US Green Building Council. "Green Roof Energy Calculator (v. 2.0)." http://greenbuilding.pdx.edu/GR_CALC_v2 (accessed July 2, 2014).

Hicke, Jeffrey A. "Global synthesis of leaf area index observations: implications for ecological and remote sensing studies." *Global Ecology and Biogeography*: 191-205.

- ***Additional Green Roof Background and Calculations***

Figure 6. Leena Cho taking measurements on the green roof at JMU Biosciences building Source. Photos taken by Margaret Graham

Figure 7. Greenroof materials

Method: Data was collected during a site visit on 6/17/2014. Facilities manager Scott Wachter granted us access to the green roof to conduct our measurements. Spot temperature measurements were taken with a Raytek Raynger ST and air temperatures were taken with a Kestrel 3000. It was a sunny summer day, hotter than an average June day in Virginia.

Data:

Green roof comparative temperature measurements (ºF)

	Sedum	Black surface	White surface	Gravel	NOAA weather report
Spot temps	111	169	111	132	92
	108	167	114	132	67
	109		117	126	
			118		
Average	109.3	168	115	130	80
Air temps	97.6	123.5			

Measurements taken at 12:40pm on 6/17/2014

Limitations: These results are based on one set of measurements, and therefore calculations would vary with more data. The data also does not account for temperature variations due to seasons or extremes, which could not be measured within the research timeframe.

References:

"NOAA's National Weather Service - National Climate." NOAA's National Weather Service - National Climate. http://www.nws.noaa.gov/climate/ (accessed June 18, 2014).

- ***Sequesters approximately 1.5 tons of carbon annually in 75 new native trees. These trees also intercept over 5,000 gallons of rainwater annually.***

Method: Carbon sequestration was calculated using the National Tree Benefits Calculator (http://www.treebenefits.com, accessed on 6/11/2014 by Margaret Graham) by entering the caliper measurements from the construction documents provided by Rhodeside & Harwell. The calculator requires input of diameter at breast height (DBH) while tree size at installation was reported in the construction documents by caliper-- also a trunk diameter measurement, but taken at a different height. In order to make use of the calculator, which provides estimations rather than precise data, caliper measurements were entered for the DBH field. Sequestration should increase over time as the trees grow.

Trees act as mini-reservoirs, controlling runoff at the source. Trees reduce runoff by:

- Intercepting and holding rain on leaves, branches and bark
- Increasing infiltration and storage of rainwater through the tree's root system
- Reducing soil erosion by slowing rainfall before it strikes the soil

Data: Chart of plant palette with Tree Benefit Calculator data

Scientific Name	DBH (inches)	Quantity of trees	CO_2 sequestered (lbs)	Total CO_2 (lbs)	stormwater intercepted (gallons)	stormwater runoff intercepted (gallons)
Acer rubrum	3.5	2	68	136	95	190
Acer pensylvanicum	2.5	1	39	39	54	54
Acer saccharum	2.5	1	54	54	54	54
Betula nigra	2	2	37	74	37	74
Betula papyrifera	1.75	1	16	16	31	31
Cercis Canadensis	2	3	24	72	18	54
Cornus florida	1.5	1	14	14	7	7
Carya glabra	2.5	1	45	45	69	69
Carya ovata	2.5	1	45	45	69	69
Carya tomentosa	2.5	1	45	45	69	69
Fraxinus 'Patmore'	3	1	85	85	87	87
Gymnocladus dioicus	2.5	1	45	45	69	69
Hamamelis x intern 'Arnold's Promise'	1.5	1	12	12	12	12
Liriodendron tulipifera	2.5	1	45	45	69	69
Metasequoia glyptostroboides	5	1	48	48	236	236
Magnolia grandiflora	4.5	1	74	74	155	155
Magnolia virginiana	3	8	50	400	106	848
Nyssa sylvatica	2.5	1	34	34	28	28
Oxydendron arboreum	0.75	3	7	21	4	12
Platanus occidentalis	2.5	1	45	45	69	69
Quercus alba	2.5	4	45	180	69	276
Quercus coccinea	3.5	4	83	332	120	480
Quercus lyrata	3.5	1	83	83	120	120
Quercus muhlenbergia	4	1	102	102	146	146
Quercus nutalli	3.5	3	83	249	120	360
Quercus phellos	3.5	1	83	83	120	120
Quercus rubra	2	1	26	26	44	44
Robinia pseudoacacia	2.5	1	61	61	62	62
Sassafras albidum	2.5	5	61	305	62	310
Taxodium disticum	2.5	3	17	51	77	231
Ulmus americana	2.5	1	31	31	35	35
Cedrus deodara	2.5	1	17	17	77	77
Cryptomeria japonica	1.5	5	6	30	24	120
Juniperus virginiana	1.75	2	9	18	38	76
Pinus echinata	2.5	1	17	17	77	77
Pinus taeda	3	2	23	46	104	208
Picea pungens	2	4	20	80	75	300
Pinus virginiana	3	2	32	64	131	262
				3124		5560

Limitations: The caliper of each tree on the project plant schedule was used as DBH in the Tree Benefit Calculator. When the height of tree was used in the plant schedule, the caliper was estimated. Additionally, not all trees included in this project were available in the Tree Benefit Calculator. Available trees were substituted to estimate calculations.

References:

"National Tree Benefit Calculator." National Tree Benefit Calculator. http://www.treebenefits.com/calculator (accessed June 11, 2014).

"Site Planting Plan." In *CISAT A3b Academic Building Working Drawings*. Alexandria: Rhodeside & Harwell, 2010.

"Water Trivia Facts." Home. http://water.epa.gov/learn/kids/drinkingwater/water_trivia_facts.cfm (accessed June 11, 2014).

- ***Estimated to save 9,700 kWh or $654 in energy costs annually compared to a dark roof and 1,330 kWh or $310 annually compared to a white roof through the installation of a green roof.***

Method: The various impacts of the extensive green roof were calculated using the Green Roof Energy calculator from the Green Building Research Laboratory.

Data: Site measurements provided to Green Roof Energy calculator:
Total roof area: 29,620 sq ft
Growing media depth: 4 inches
Leaf Area index: .8
Green roof covers: 16% of roof (the rest being a white roof)
Not irrigated

Results of Green Roof Energy calculator:

	Annual Energy Savings compared to a Dark Roof (albedo = 0.15)	Annual Energy Savings compared to a White Roof (albedo = 0.65)
Electrical Savings	9703.9 kWh	1331.5 kWh
Gas Savings	-113.5 Therms	5.6 Therms
Total Energy Cost Savings	$653.67	$310.30

Limitations: According to the Green Building Research Laboratory, due to time of day pricing the apparent financial savings/costs may not APPEAR to reconcile with the total energy savings/costs.

References:
Boyd, Robert K. Erosion & Sediment Control and Stormwater Management Narrative and Stormwater Pollution Prevention Plan. Blacksburg: Anderson & Associates, 2010.

US Green Building Council. "Green Roof Energy Calculator (v. 2.0)." http://greenbuilding.pdx.edu/GR_CALC_v2 (accessed July 2, 2014).

<u>Social Performance Benefits:</u>

- ***Provides outdoor learning opportunities and social space for the average 4,242 students who take classes in the Bioscience Building each year.***

Method: Data was collected from the Biology department to determine how many students regularly interact with the outdoor space. The Biology department is the only department that conducts classes in the CISAT building.

Data: Biology department enrollment for school year 2013-2014

Fall 2013	Spring 2014	Semester Average
4135	4348	4242

Limitations: Surveys and site observations may have provided more detailed information, but were not conducive to the summer timeframe of our research when the academic building was not being used at its intended capacity.

References:
Sheila Santee, email message to the author, July 8, 2014

Cost Comparison

Many of the academic buildings adjacent to the Biosciences building are landscaped with turf and some trees. The Biosciences building is a unique site on the JMU campus, featuring native plants and a diversity of trees and shrubs. Many of the planting zones at the Biosciences building are concentrated around the building, and turf is used to integrate the site into the surrounding campus areas. The turf within the building site requires 2,077,514.4 gallons annually for irrigation, costing $4,650.10 in water utility costs. If the plantings zones were also turf, as is the case in many of the surrounding buildings, it would require 608,224.65 gallons and cost $1,361.39.

- ***Reduces annual irrigation water needs by 608,225 gallons, saving an estimated $1,361 in potable water costs.***

Method: Information was gathered from planting plans, local utility operators and university landscape managers to calculate irrigation savings. All of the buildings surrounding the Biosciences building are landscaped with turf. Therefore, the planting beds at the Biosciences building have a different maintenance strategy than anything in its proximity. We calculated how much water would be needed for irrigation if the planting beds were turf instead. The planting beds do not require any irrigation, and therefore save resources that are needed to maintain turf.

Growing season	Inches/week	Weeks	Rain Gardens (sf)	Swale (sf)	Other plantings (sf)	Gallons	$/1000 gallons	Irrigation cost
May/June	1.5	8	12600	2600	12630	207055.2	2.08	$430.67
July/August	1.5	9	12600	2600	12630	232937.1	2.32	$540.41
September/ October/November	0.75	13	12600	2600	12630	168232.35	2.32	$390.30
Total						608224.65		$1,361.39

Data:

Limitations: Although the plantings do not require irrigation, they do require maintenance costs that may exceed that of managing turf, such as weeding, pruning, replanting, and mulching.

References:

"Customer Accounts." City of Harrisonburg, VA. http://www.harrisonburgva.gov/water-accounts (accessed July 7, 2014).

Franklin Lucas, email message to the author, July 7, 2014.

Combined References

Boyd, Robert K. Erosion & Sediment Control and Stormwater Management Narrative and Stormwater Pollution Prevention Plan. Blacksburg: Anderson & Associates, 2010.

"Customer Accounts." City of Harrisonburg, VA. http://www.harrisonburgva.gov/water-accounts (accessed July 7, 2014).

Franklin Lucas, email message to the author, July 7, 2014.

Hicke, Jeffrey A. "Global synthesis of leaf area index observations: implications for ecological and remote sensing studies." *Global Ecology and Biogeography*: 191-205.

"National Tree Benefit Calculator." National Tree Benefit Calculator. http://www.treebenefits.com/calculator (accessed June 11, 2014).

"NOAA's National Weather Service - National Climate." NOAA's National Weather Service - National Climate. http://www.nws.noaa.gov/climate/ (accessed June 18, 2014).

Sheila Santee, email message to the author, July 8, 2014.

"Site Planting Plan." In *CISAT A3b Academic Building Working Drawings*. Alexandria: Rhodeside & Harwell, 2010.

US Green Building Council. "Green Roof Energy Calculator (v. 2.0)." http://greenbuilding.pdx.edu/GR_CALC_v2 (accessed July 2, 2014).

"Water Trivia Facts." Home. http://water.epa.gov/learn/kids/drinkingwater/water_trivia_facts.cfm (accessed June 11, 2014).