Storm Water Reuse Proposal for FMSEAS Building

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December 8th, 2010

Global Sustainability

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We suggest the implementation of a storm water reuse system for the FMSEAS building

We started this project with clearly defined objectives, although they changed over the course of the semester. From day one, our main goal was to supplement the use of potable water with storm water in some way. Whether it was in a University building, a residential area, or a student garden, our goal was the same: reduce inefficient use of potable water. After meeting with Armando, we decided on implementing a storm water system in the proposed FMSEAS building would be the best approach because it would have the highest likelihood of actually being implemented by the University. At this point, our objectives were clear. We wanted to gather enough information about the project to construct a cost-benefit analysis and determine whether the system would be justified both financially and socially. Additionally, we hoped that our report would convince the committee that the idea was not only feasible, but necessary, hopefully persuading them to implement our design.

During the course of the semester we have researched storm water collection and put together a cost-benefit analysis of potential implementation. After we decided to use the FMSEAS building, we then found the amount of rain water collectible for use in the building. First, we found the collectible volume of rain water from the roof of the building. Then we determined the water needs of the building given its occupancy, number of toilets, and gallons per flush. Next, we had to determine the costs associated with installing the system including a cistern, a filtration system, and the amount and cost of the water we could potentially save. We determined the proper sized cistern, got estimates for filtration systems, and calculated future water costs avoidance. From our research and data we determined that it would take approximately 14* years for a gray water system to pay off if installed on the potential FMSEAS building. (*using limited inputs and conservative estimates--see analysis)

The amount of water wasted each year at the University must be curtailed

Fresh and potable water is a very scarce and important resource. Water is the foundation of life; we need it to produce food and survive. Many places in the world today do not have access to potable water, and even more places are recklessly and rapidly depleting their sources of water. Today, more than 1.1 billion people lack access to improved water supplies worldwide, and over 2.7 billion people lack proper sanitation. More astounding, in 2000 at least 1.7 million preventable deaths were attributed to unsafe water, sanitation, and hygiene practices. China, the American southwest, and many other regions around the globe have slowly been using their sources of fresh water at faster rates than they can be replenished. Also, we waste significant amounts of clean/potable water on activities such as watering and waste removal which do not require the use of clean water.

The major problem is a general misuse of potable water and lack of recycling of this precious resource. At UVA the amount of collectible rainwater water is close to the amount of potable water we actually use. Therefore we are paying for and wasting potable water on activities that do not actually require potable water. Instead activities such as flushing toilets and urinals could be performed using gray water (collected and filtered rainwater). The goal of our project is to reduce water use by the University and to save money at the same time. We want to consider an alternate plumbing system in the proposed FM/SEAS building which will utilize gray water for the flushing of toilets rather than drinkable water.

On a global scale we all have an interest in water conservation. On a local scale, such a project would not actually affect the users of restrooms and the building, but it would include

Facilities Management, the University, and anyone who pays for water use or cares for/maintains the building. The University and Facilities management are stakeholders because they would be paying for the installment of such a project and would be involved in actually implementing it. Further, Facilities Management and workers within the building would need to monitor the system to make sure it works properly and perform routine maintenance. Also, the project would have to meet Charlottesville building codes i.e. properly filter the gray water, color it, have twice the minimum amount of water, etc. The value created (cost avoided) by this project and captured by the University translates into value lost (decreased income) by Charlottesville utility (water) providers.

Finding an area of water conservation in which we could make a difference

In addressing our problem, we considered several different projects; even changing projects mid-semester after our mentor informed us about a proposed building in which we could possibly implement a system similar to the one we were discussing with him. Originally, we considered working with the Hereford Garden or the Student Garden by Observatory Hill. At the Hereford Garden, we planned to collect storm water from rooftops and use it to irrigate the garden. In the Student Garden, we planned to implement another cistern or help improve the efficiency of the existing cistern by installing a pump system operating on a timer (existing system depends on student volunteers to manually collect storm water from the collection site and physically transport it to the garden). We believed the Hereford Garden presented a promising opportunity for our project because it is a green community. After doing further research, however, we found that Hereford would be too large of a project. Collecting water from buildings was a serious issue given their enclosed water collection systems and strict building codes, and the president of Hereford seemed preoccupied with other projects. Disheartened with the realization that our project was shaping up to be the analysis of a project that would likely never be implemented, we reached out to Armando de Leon, the Sustainability Programs Manager for UVA. Armando suggested that we research the proposed FMSEAS building project and determine the financial feasibility of a similar storm water collection system to be used to supplement the grey water demand of the building.

Finding the people and data most influential to our project

Working with the FMSEAS building was a more realistic and practical project because it is currently in the early development stages. We were excited that this new project, if financially/environmentally justifiable, could actually be implemented in the FMSEAS building. Our project involves collecting storm water with a cistern and using this water for flushing toilets in the new building, an often overlooked, but significant, use of water in office buildings. To calculate the potential water needs of the building we first met with Garth Anderson, Resource Center Manager, who provided us with the building blueprints. Next, we talked with the Office of University Building Codes and the project manager, Kate Meyer. We were given the building codes and LEED standards to follow. After determining the expected occupancy, number of toilets, and gallons per flush figures, we were able to calculate water needs. We talked with Kristin Carter to determine the best option for collecting the necessary water. We found that the optimal place to collect storm water would be from the building's rooftop. The storm water from the roof of the building can be diverted directly from the gutter system into a cistern at its base. Fortunately, the roof's collection potential and Charlottesville's average rainfall estimates from

NOAA (conservative estimates) coupled with the low demand for gray water in the FMSEAS building indicate that storm water supply will not be an issue for this project.

After determining that our project was theoretically feasible, we set out to determine its financial feasibility. Our next step was to find a suitable filtration system and holding tanks for the collected water. We researched filtration systems which met LEED gray water standards. Several possibilities presented themselves, however, after speaking with Bryna Dunn, Director of Sustainability Planning and Design at Moseley Architects in Richmond, we chose to use the filtration system (and corresponding price outlays) which she believed to be most appropriate. The water from the cistern needs to be filtered and colored. The water is colored to differentiate it from potable water. Then the filtered water is kept in a holding tank until it is pumped into the building through an alternate piping system to the restrooms.

Financial analysis shows the project is both environmentally and financially attractive

After crunching the numbers we found throughout the semester, we believe this project should be undertaken by the University. The following analysis shows our cash flow projections for the project, however, one must take into consideration the limitations of our analysis. Most importantly, we do not have access to the University's cost of capital, borrowing capacity and other financial budgeting information which should be used in this type of analysis. For this reason, our analysis uses a simple one-time capital expenditure for the installation of the system with an allowance added into this number for unexpected future maintenance and calculates a payback and internal rate of return based on cost savings from decreased water bills (based on historical data). The following chart shows our expected project's internal rate of return of 3% and payback period of 14.14 years (both of which would be more favorable if assumptions for debt financing had been used).

	Year						
	1	**2**	**3**	**4**	**5**	**…**	**20**
Cost Savings from Stormwater Utilization	578.04	578.04	578.04	578.04	578.04	578.04	578.04
Cost of Cistern (1000 gallon)	(1,000.00)	0.00	0.00	0.00	0.00	0.00	0.00
Cost of Filtration System w/ Holding Tank	(7,750.00)	0.00	0.00	0.00	0.00	0.00	0.00
Net Cash Flows	(8,171.96)	578.04	578.04	578.04	578.04	578.04	578.04
IRR (20 year)	**3%**						
Payback Period (years)	**14.14**						

After adjusting these projections for debt financing and allocating a nominal value to the environmental benefits of the project, we believe this University should absolutely move forward with this project. While we do not know the University's hurdle rates for new projects of this nature, if it can reduce this payback to less than 10 years (very probably with debt), we think it is a justifiable investment. Also, this type of project will be much less expensive if implemented during building construction vs. implementing the project five years after construction which would require drastic changes to the plumbing system and excavation and placement of large holding tanks (easily done during construction of the building foundation). As we increasingly realize the importance of sustainability in our world, it seems obvious at times that projects like this should be undertaken, however, in an economy driven by the invisible forces of supply and demand (the almighty dollar), the project can easily be overlooked. We hope that the university will take into consideration the value of its lessened environmental footprint with this project when looking at these financial forecasts and choose to accept this project.

Implementation measures the success and reach of our project

As the semester and our project draw to a close, we have laid the groundwork for the implementation of a storm water reuse system in the FMSEAS building and, hopefully, encouraged future research on and consideration of the many potential uses of storm water. From here, it remains to be seen whether or not the cost-benefit analysis and research will be convincing enough to persuade the building committee to adopt our design. Our payoff period of around 14 years is longer than we had hoped, but if the effects of debt financing, positive environmental externalities and project-specific costs considerations are incorporated into our analysis, the payoff will be much more favorable. We will consider our project even more successful if it prompts the University to consider implementation of our ideas on other projects in the future.

The University must measure intangible benefits beyond our financial analyses

Now that we have completed our cost-benefit analysis for this project, we must anxiously await the University's decision with regard to implementing the project. Our project is the first step of prompting the adoption of such gray water use practices at the University. Based on our calculations, such a system has a payback of around 14 years. The timeline will be determined by the University and the planning committee. Most recently, the project manager informed us that the building's location had been moved to a nearby, more level location to avoid pricier foundation work during construction. Issues in the planning and development stages of projects such as these slow down the process tremendously as they require a great deal of paper pushing to accommodate building inspectors, budget constraints, etc. (i.e. get through lots of red tape). Whenever these issues with the building's planned construction are resolved, we hope the University will consider our recommendation to implement this type of storm water reuse system when evaluating its environmental footprint.

We believe that the use of storm water will quickly provide financial benefits for this project. An analysis of a larger building with greater water usage would be an interesting follow-up on our project to gauge the reach of potential cost savings through economies of scale. If storm water was used for plumbing on larger buildings, they could save more water and the expenditures associated with installing the cisterns, plumbing, and filtration systems would be much more-easily justified by greater water cost avoidance in the future.

Our project taught us about sustainability, teamwork and project management

Coming in to this project, our group's goal was to supplement the use of potable water with storm water. We aimed to reduce unnecessary use of public water from utilities companies in instances where storm water can be utilized. We started the project by reaching out to several professors and employees at the University. In several instances, we found it difficult to obtain the information we needed for our project. Many of the people we were interested in meeting were unable or unwilling to meet with us. For parts of our project, we were passed from person to person seeking the information that we needed. Eventually, we were able to reach the right people. Luckily, the majority of people were more than willing to help, and even if they were not able to give us information, they usually directed us to someone that could.

There must be an economic incentive for firms or organizations to implement sustainable efforts. Sustainable acts must pay off over a period of time that is not too long, and it cannot have too high of a cost to deter potential consumers. Projects must consider everything from maintenance costs, installation, purchase of piping, tubing, cisterns, filtration systems, the cost of water and sewage, etc. The question then becomes the source of the funding. The University, city, or other organizations need to be convinced that the project is financially feasible.

In order to accomplish our goal, we came up with several ideas involving the implementation of storm water use on grounds. Initially, we aimed to install a cistern in the

Hereford Garden, and possibly even a drip-irrigation system. After discussing the project with the head of the garden, we realized that the project would have very negative returns due to stringent University requirements and building codes. Not only would we have to tap into building water systems, but we would need to install underground tubing and holding tanks. Since the garden uses such a large amount of water, we would need a cistern with a seemingly uncertain capacity range between 1,000 and 10,000 gallons which raises costs and makes the project even more unlikely to be implemented.

While determining whether to move forward with the project, we came into contact with Armando de Leon, the Sustainability Programs Manager in the Energy and Utilities Department. He proposed that we work on implementing a storm water system in the recently proposed FMSEAS building, which is still in the development stages. This project involved several challenges of its own, although the knowledge that our work could potentially make a difference in the University community made it much more manageable. This system, which uses storm water in its toilets, proves financially justifiable in the long-run. The key challenges we faced were determining where to draw the water from and the best way to collect and treat it. After meeting with Kristen Carter of Facilities Management, we found that the best collection option captures the storm water runoff from the roof of the FMSEAS building. This permits collection of storm water directly into a cistern located on the side of/below the building.

In designing and constructing this project, we realized while our goal was geared towards achieving sustainable water usage and reducing the waste of potable water which has become commonplace in our society, this project would only be carried forward by the University if it could be justified in nominal dollars and cents. This shifted the focus of our project, and we began to take long-term payback and internal rate of return into account. This eliminated the proposed Hereford Garden cistern after reaching the conclusion that the payback could not reasonably (without extremely over-optimistic assumptions) be justified, and the desired effect would be difficult to obtain as it reached beyond the scope of our capacity (drip-irrigation design and installation seemed extremely intimidating). Fortunately, we somehow came into contact with Armando, and he pointed us in the right direction.

If we could do the project over again, we would meet with Armando sooner, rather than later. Because we were not familiar with the structure of the University's management team, we did not realize the importance of Facilities Management. While each of our contacts added something to the project, it would have saved us a considerable amount of time if we had reached Armando sooner. In retrospect, it also would have benefited us to have researched future construction projects at the University. This would have provided us with more project options, as it is much easier to implement something pre-construction than post-construction. Overall, we learned a great deal about how Facilities Management works and how construction committees must take into consideration the various interests and motivations behind pursuing a project. With respect to our project, we hope that the University's planning committee will consider implementing this project in the interest of sustainability in addition to meeting its financial objectives.

APPENDIX I – Assumptions for Financial Analysis

FMSEAS Project Assumptions

		Base
1	Roof Square Footage	20,000
2	Expected Occupancy	49
3	Number of Toilets	4
4	Gallons of Water Used Per Flush	1.6
5	Average Flush per male per day	1
6	Average Flush per female per day	3
7	Average Gallons Used per Day	156.8
8	Average Gallons Used per Year	57232
9	Cost of Gallon Utility Water	$0.01
10	Average Cost per Day	1.58368
11	Average Cost per Year	578.0432
12	Average Annual Rainfall Charlottesville (inches)	44.82
13	Annual Collection Potential from Roof (gallons)	487696
14	Cost of 500 Gallon Cistern	500
15	Number of Cisterns Required	2
16	Cost of Filtration System w/ Holding Tank	7750

Sources

1
2 Kate Meyer, FMSEAS Building Project Manager
3 Kate Meyer, FMSEAS Building Project Manager
4 2006 International Plumbing Code: Ch. 4 Fixtures, Faucents and Fixture Fittings p. 28
5
6
7
8
9 Armando de Leon, Sustainability Programs Manager
10
11
12 National Oceanic and Atmospheric Association
13 Formula uses the month with the lowest rainfall estimate to avoid inflated collection projections and minimize assumed-supply risk
14 Cistern price range $280-$700 (http://www.plastic-mart.com/class.php?item=3609,)
15
16 Bryna Dunn, Moseley Architects

NOAA:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
3.71	3.30	4.05`	3.34	4.86	4.46	4.94	4.14	4.85	4.22	3.74	3.26	44.82

Appendix II – Site Map for FMSEAS Building Location

Appendix III – Bibliography

Andrew Green: Sustainability Coordinator for the Office of the Architect

Armando de Leon: Sustainability Programs Manager

Kristin Carter: Environmental Engineer for Facilities Management

Kate Meyer: Project Manager for the FMSEAS Building

Garth Anderson: Resource Center Manager

Bryna Dunn: Director of Sustainability, Planning, and Design of Moseley Architects

Dr. Jim Durand: Caretaker of the Hereford Garden

National Atmospheric and Oceanic Administration

U.S. Green Council LEED Project Estimator

2006 International Plumbing Code

Water in a Sustainable Economy by Gev Bergkamp and Claudia W. Sadoff

"After the Storm", EPA description of the stormwater runoff problem

http://uvagarden.wordpress.com/the-cistern-is-here/Rainwatermanagement.com

Mays, Larry W. *Stormwater Collection Systems Design Handbook*. New York: McGraw-Hill, 2001.